JAPAN INTERNATIONAL COOPERATION AGENCY

CEYLON ELECTRICITY BOARD(CEB)
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STUDY
OF
HYDROPOWER OPTIMIZATION
IN
SRI LANKA

FINAL REPORT

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APPENDIX-II

EIA Report
for
The Broadlands Hydropower Project

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ELECTRIC POWER DEVELOPMENT CO., LTD.

NIPPON KOEI CO., LTD.

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ENVIRONMENTAL IMPACT ASSESSMENT REPORT

FOR

THE BROADLANDS HYDROPOWER PROJECT

February 2004

Environmental Impact Assessment Report
for
the Broadlands Hydropower Project

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Annexes

* The Table of Contents has been prepared in accordance with the TOR shown by the Scoping Committee.

* Attachment of core logging data to the EIA report submitted to JICA is omitted, though it is required by the TOR, because they are already included in the part of Geology.

Executive Summary

Introduction

The study area is determined in the TOR as below.

- The river area: from 2km upstream of the proposed dam site in the Maskeliya river and the proposed weir site in the Kehelgomu river respectively, to about 5 km downstream of the powerhouse
- The bank area: both banks with about 2 km width each along the above river area
- The other area where significant impact on the environment caused by the project is anticipated

The study area has been divided into three Zones to conduct a study properly.

- Zone-1: the area that include the proposed weir/dam and powerhouse where the direct impact may be anticipated
- Zone-2: the area around the Zone-1 where less impact than the Zone-1 or indirect impacts may be anticipated
- Zone-3: the area in the study area other than Zone-1 and Zone-2.

1. Description of the Existing Environment

1.1 Physical resources

1.1.1 Land use

The following table shows the land use in Zone-1. Scrub (22.7%), house/homestead (19.7 %) and tea (14.6%) are the main land uses in the weir/dam area, and natural forest (33.0%), house/homestead (27.1%) occupy around 60% in the powerhouse area.

Land use	Weir/Dam area in Zone-1		Powerhouse area in Zone-1	
	Area (ha)	%	Area (ha)	%
House/ Homestead	22.9	19.7	22.5	27.1
Polpitiya powerhouse properties	9.0	7.7	-	-
Army properties - Polpitiya	2.5	2.1	-	-
Garden in scrub jungle	1.3	1.1	-	-
Paddy/ Marsh	0.5	0.4	1.6	1.9
Coconut	1.8	1.5	-	-
Tea	17.8	14.6	1.6	1.9
Tea & pepper	1.6	1.4	-	-
Rubber	-	-	0.3	0.4
Chena cultivation	-	-	0.1	1.1
Rubber in scrub	2.0	1.7	-	-
Mixed crop	3.6	3.1	3.5	4.2
Natural forest	6.2	5.3	27.3	33.0
Scrub	26.4	22.7	7.0	8.4
Jungle	6.4	5.5	11.1	13.4
Surface water	12.0	10.3	7.9	9.3
Exposed rock	0.1	0.1	-	-
Major road	1.8	1.5	-	-
Secondary road	0.5	0.4	-	-
Total	**116.4**	**100.0**	**82.9**	**100.0**

1.1.2 Land ownership

The following table shows the land ownership in Zone-1. Private lands occupy 33.4% and the government owns the rest 66.6%.

	Weir & Dam area		Powerhouse area		Total	
	Area (ha)	**(%)**	**Area (ha)**	**(%)**	**Area (ha)**	**(%)**
Private Lands	517	44.1	151	18.2	668	33.4
Government Lands						
Irrigation Department	119	10.1	77	9.3	196	9.8
Ceylon Electricity Board	94	8.0	0	0.0	94	4.7
Sri Lanka Army	26	2.2	0	0.0	26	1.3
Forest Department	393	33.5	602	72.5	995	49.7
Road Development Authority	34	2.0	0	0.0	23	1.1
Total	1,172	100.0	830	100.0	2,002	100.0

1.1.3 Mineral resources of the area

Material extraction for construction industry can be considered as the only commercial scale use of mineral resource in the study area. However, the current exploitation is limited to sand mining. There are no deposits of limestone (inland coral) or resources for export level dimension stones available in the study area.

1.1.4 Surface water quality

The water quality in the river was measured on the border of the study area and at the locations where the water quality may be affected by the Project (9 points in total) in October, February and May.

Parameter	Station number									Standards for minimum quality *	Standards for drinking water with simple treatment *
	1	2	3	4	5	6	7	8	9		
Temperature (^{0}C)	25.6 25.5 26.3	23.4 23.8 25.1	24.0 23.4 25.0	25.6 25.2 26.4	22.6 23.8 23.5	24.0 24.1 23.4	24.2 24.3 24.1	23.8 24.8 24.0	24.7 25.2 29.1	-	-
PH	6.4 6.9 7.6	6.1 6.9 7.9	6.5 6.8 8.1	6.7 7.2 7.9	6.9 7.1 7.6	6.2 7.1 7.6	6.3 7.2 7.8	6.1 7.2 7.6	6.8 6.9 7.3	5.0-8.5	6.5-8.5
Conductivity (µs/ cm)	40 98 43	52 98 56	29 31 28	50 93 54	29 36 30	30 36 29	29 37 28	27 37 30	28 35 27	7 x 10^4	-
Turbidity NTU	3 1 8	1 1 3	4 3 56	11 3 5	3 2 16	6 2 14	4 2 26	8 3 5	9 3 71	-	-
Dissolved Oxygen (mg/l)	7.1 7.5 7.4	7.3 7.1 7.5	7.3 7.0 7.4	7.1 7.1 7.4	7.7 7.4 7.4	7.6 7.0 7.2	7.4 6.6 7.3	7.5 6.6 7.2	7.3 6.7 7.2	3 (min)	6 (min)
TDS (mg/l)	50 67 43	41 70 74	30 25 26	44 58 44	33 51 16	57 29 45	40 15 57	30 46 39	35 38 4	-	-
TSS (mg/l)	3 2 5	2 5 <1	4 1 5	2 4 2	1 3 25	2 2 29	1 4 30	3 5 33	4 2 30	-	-
BOD (mg/l) 5d, 20 C	<1 0.6 0.3	<1 <0.1 0.6	<1 0.4 0.4	<1 0.4 0.6	<1 0.5 0.6	<1 0.3 0.3	1.1 0.2 0.5	1.1 0.1 0.9	<1 0.1 1.2	4 (max)	2 (max)
Total Nitrogen as N (mg/l)	< 2 < 2 < 2	< 2 < 2 < 2	< 2 < 2 < 2	< 2 < 2 < 2	< 2 < 2 < 2	< 2 < 2 < 2	< 2 < 2 < 2	< 2 < 2 < 2	< 2 < 2 < 2		
Total Phosphorus as P (mg/l)	0.003 0.004 0.026	0.005 0.006 0.020	0.003 0.014 0.027	0.004 0.023 0.019	0.021 0.004 0.024	0.025 0.016 0.034	0.011 0.002 0.037	0.017 0.006 0.041	0.017 0.004 0.025	0.7(max)	-
Fecal coliform (No of Colonies /100 ml)	85 75 133	304 135 260	127 85 74	163 65 92	155 93 158	175 115 102	85 116 178	95 167 188	215 177 198	-	250 des 600 max ** P=80%

Upper Column: Sampled during 26-28 October 2002 (intermediate season)
Middle Column: Sampled during 05-07 February 2003(dry season)
Lower Column: Samples during 25-26 May 2003(wet season)

* Environmental Quality Standards and Designation of water use in Sri Lanka- June 1992
Max = Maximum permissible level
Des. = Desirable highest level
** P=80% = 80% of the samples give a value that is equal to or less than the indicated limit

Based on the proposed standards, it can be stated that in all the nine (9) locations the water quality test results indicate very low levels of pollution. The waters of two streams are the well-oxygenated, cool waters with very low levels of solutes both organic and inorganic and very low levels of nutrients in all 9 locations. The low levels of fecal coliform count when compared to other rivers, indicate lesser impact of human on the river water quality although there are land clearings, a human disturbance in the catchments.

1.2 Ecological resources

1.2.1 Flora

The area of the powerhouse area of Zone-1 exhibits the most dense canopy coverage of scrub and forest vegetation. This could be considered as the less disturbed site when compared with the dam and weir area of Zone-1, which exhibits a much heavier distribution of settlements.

A total of 190 plant species belonging to 157 genera and 74 plant families are identified from Zone-1 including aquatic vegetation, which only counts 3 plant species in Zone-1. A total of 194 plant species are identified in Zone-2. The majority of the plants are tees in both Zones.

	Zone-1					Zone-2				
	Endemic	Threatened	Introduced	Naturalized	**Total**	Endemic	Threatened	Introduced	Naturalized	**Total**
Tree	17	5	44	47	**109**	18	3	37	51	**109**
Shrub	6	0	4	24	**36**	7	0	8	24	**39**
Herb	2	0	5	18	**29**	2	1	7	13	**23**
Climber	6	1	2	11	**16**	4	1	4	10	**19**
Epiphysis	0	0	0	0	**0**	0	0	0	4	**4**
Total	31	6	55	100	**190**	31	5	56	102	**194**

According to International Union of Conservation of Nature, IUCN (2000) the term 'threatened plants' denotes species which are (i) endangered (plants which are in danger of extinction and whose survival is unlikely) (ii) vulnerable (plants likely to become extinct in the near future) and (iii) rare (plants restricted to small geographically areas or small populations at a risk). Plant species that are suspected but not definitely belong to any of the above categories have also been also identified as 'threatened plants'. Among the identified species of this study, there are 8 threatened plants are tabulated with their occurrence.

Plant Species	**Occurrence**			**Remarks**
	Zone-1 (Weir/Dam)	**Zone-1 (Powerhouse)**	**Zone-2**	
Pericopsis mooniana (Nedun)	+	+		highly threatened timber
Coscinium fenestratum (Weni wel)	+	+	+	globally threatened medicinal
Syzyguim cylindricum	+	+	+	threatened
Dipterocarpus zeylanicus (Hora)		+		threatened
Gordonia speciosa (Ratu-mihiriya)		+	+	threatened
Sterculia zeylanica	+			threatened
S.lanceolatum			+	threatened
Cryptocoryne sp			+	threatened (aquatic)

It was noticed that some of these threatened plants were at a relatively young age and occur in isolation. Pericopsis mooniana and Dipterocarpus zeylanicus trees were good examples. This suggested that they had been planted a few years ago by the inhabitants.

1.2.2 Fauna

The area contains a variety of habitats and supports a high biodiversity. During the survey period a total of 149 species including threatened species was recorded.

Taxonomic Group	Zone-1 (Powerhouse)					Zone-1 (Weir and Dam)					Zone-2 & 3				
	T	En	Tr	In	Re	T	En	Tr	In	Re	T	En	Tr	In	Re
Odonata (dragon fly)	3	2	-	-	-	2	1	-	-	-	1	1	-	-	-
Lepidoptera (butterfly)	22	1	3		9	5	1	2	-	1	20	1	4	-	7
Gastropoda (gastropod)	6	3	2	1	1	3	3	3	-	-	5	2	2	1	-
Ostichthyes (fish)	8	3	2	1	4	3	2	1	-	-	5	3	2	-	-
Amphibia (amphibian)	5	1	1	-	3	8	4	3	-	6	2	-	-	-	-
Reptilia (reptile)	5	1	1	-	1	2	-	-	-	1	10	4	4	-	6
Aves (bird)	41	6	5	4*	10	44	5	5	5*	6	45	6	6	5*	7
Mammalia (mammal)	4	-	-	-	3	1	-	-	-	-	5	1	2	-	4

Remarks T : Total number En : Endemic species Tr: Threatened species In : Introduced species
Re : Species that are found only in this zone * : Migratory species

A total of 29 threatened species were recorded from the study area including two globally threatened species. Out of the study area 22 threatened species were recorded from powerhouse and weir & dam site (Zone-1) while the 19 species of threatened species were recorded from the surrounding areas (Zone-2 and 3).

Scientific Name	Common Name	NT	GT	Zone-1	Zone-2 & 3
Butterflies					
Troides darsius	Common birdwing	TR		+	+
Vindula erota	Cruiser	TR		+	+
Parthenos Sylvia	Clipper	TR		+	+
Mycalesis rama	Cingalese bush brown	HT		+	
Mycalesis visala	Tamil bush brown	TR		+	+
Molluscs					
Acavus superbus		TR		+	+
Acavus phoenix		TR		+	
Oligospira waltoni		TR		+	+
Freshwater fish					
Puntius pleurotaenia	Black lined barb	TR			+
Garra ceylonensis	Stone sucker	TR		+	+
Schistura notostigma	Banded loach	TR		+	
Frogs					
Adenomas kelaartii	Kelaart's dwarf toad	TR		+	
Limnonectes corrugatus	Corrugated frog	TR		+	
Limnonectes kirtisinghei	Kirtisinghe's frog	TR		+	
Reptiles					
Calotes leolephis	Forest lizard	TR			+
Otocryptis weigmani	Kangaroo lizard	TR		+	+
Cylindrophis maculates	Pipe snake	TR			+
Oligodon sublineatus	Kukri snake	TR			+
Birds					
Loriculus beryllinus	Lorikeet	TR		+	+
Psittacula calthropae	Layards parakeet	TR		+	+
Tockus gingalensis	Grey horn bill	TR		+	+
Megalima flavifrons	Yellow fronted barbet	TR		+	+
Pellorneum fuscocapillum	Brown capped babbler	TR		+	
Turdoides rufences	Rufous babbler	TR	LR:nt	+	
Dicoeum vincens	Legge's flowerpecker	TR			+
Urocissa ornata	Blue magpie	TR	EN		+
Mammals					
Ratufa macroura	Giant squirrel	TR	VU		+
Prionailurus viverrinus	Fishing cat	TR	LR:nt	+	
Lutra lutra	Otter	TR		+	

Remarks T : Threatened HT : Highly Threatened LR : Lower Risk near threatened

1.3 Human Environment

1.3.1 Administrative divisions and demographic characteristic

The study area lies on two provinces. One part where the planned weir and the dam lies on Ambagamuwa Korale Divisional Secretariat Division (DSD) in Kegalle District under the Sabaragamuwa Province. The other part where the powerhouse comes are in Yatiyantota DSD and Deraniyagala DSD in Kegalle District under Central Province. The population by age group and gender is shown below.

Age level	Zone-1			Zone-2		
	Total	Male	Female	Total	Male	Female
<5	76	35	41	64	29	35
6 -15	142	74	68	158	77	81
16 -20	115	56	59	85	40	45
21 -25	107	43	64	94	42	52
26 -35	154	67	87	193	105	88
36 -55	203	106	97	202	88	114
56 <	83	37	46	131	73	58
Total	880	418	464	927	454	473

1.3.2 Socio economic conditions

Income level of about 60% in both Zone-1 and Zone-2 ranged between Rs. 5,000 and Rs. 15,000. Income level of 29% in Zone-1 and 26% of Zone-2 are less than Rs. 5,000 per month. Income distribution is given below.

Income level (Rs./month)	Zone-1		Zone-2	
	No. of households	%	No. of households	%
<5,000	48	22.3	53	24.0
5,001 - 10,000	60	27.9	65	29.4
10,001 - 15,000	40	25.5	53	24.0
15,001 - 20,000	7	3.3	18	8.1
20,001 - 25,000	7	3.3	4	1.8
25,001 - 30,000	3	1.4	4	1.8
30,001 <	4	1.9	6	2.7
No response	46	21.4	18	8.1
Total	215	100.0	221	100.0

Main agricultural activities in both Zone-1 and Zone-2 are cultivation of plantation crops such as tea, rubber, and coconut, minor export crops such as pepper and clove, cultivation of fruits and vegetables and home gardening. Other perennial crops such as jak, better fruit and arecanut is also cultivated. Paddy cultivation was negligible in the study area. Usage of fertilizer and agro chemicals are at minimum levels and mainly used for tea.

Fishery activities as a source of income are not prominent in the study area. There are 22 households in Zone-1 and 16 households in Zone-2, who engage in fishery activities. However, only 4 households indicate that they are engaged in fishing for an income. Fishing is reported downstream as well as between the dam/weir site and powerhouse tailrace, the to-be affected area due to the Project. However, those households who do fishing for an income use the downstream. Anda, Petiya, Korali, Lulla and Magara are the kinds of fish catch in the river.

There are 37 business entities in Zone-1. Of the total businesses, 43% or 16 entities, including 2 tea shops and 2 eating places, were grocery stores. Total employment in businesses in Zone-1 (excluding owner's labour) has been estimated at 76, of which 54% was family workers. Type of businesses and employment are shown below.

Type of Business	Number of Entities	Number of Workers			
		Perma-nent	Casual	Family workers	Total
Grocery stores	16	1	5	20	26
Bricks & Cement based products	4	7	0	0	7
Lath machines and welding	1	0	1	1	2
Garage & service stations	1	0	1	1	2
Timber / firewood	2	0	10	0	10
Grinding mills	1	0	0	7	7
Exercise books & printing work	1	0	0	1	1
Farms	2	0	0	3	3
White water rafting	2	6	4	0	10
Other	7	0	0	8	8
Total	37	14	21	41	76

1.3.3 Existing infrastructure facilities and use

There is no water supply scheme in the study area. Almost all the households presently take water from natural springs in the surrounding hills. Some of the residents, either individually or collectively, tap suitable springs or streams in the higher levels by connecting water pipes to their households to take water. Water availability and source are shown below.

Zone-1					Zone-2				
Avail-able	Not Avail-able	Source			Avail-able	Not Avail-able	Source		
		Stream / Spring	Well	River			Stream / Spring	Well	River
215	0	159	13	43	215	6	195	20	0

In Zone-1, 82 % of housing units, and on Zone-2, 89% have some kinds of toilets. Toilet availability and the type are shown below.

Zone-1					Zone-2				
Avail-able	Not Avail-able	Type			Avail-able	Not Avail-able	Source		
		Water sealed	Pit hole	Unknown			Water sealed	Pit hole	Unknown
176	39	147	29	0	196	25	185	11	0

Electricity is available in 132 households (61.4%) in Zone-1 and 165 households (74.4%) in Zone-2. Others use kerosene lamps. Majority of people use wood as fuel for cooking, and some use kerosene for that.

1.3.4 Tourism

(1) Cultural area

The Project is to be located on one of the main routes (Colombo - Ginigathhena) to a famous cultural event called Siripada Pilgrimage. A part of the route to Siripada, from Kitulgala to Polpitiya is situated within the study area. The season begins in December and ends in May. Sri Sudharshanaramaya, located in the Kitulgala town is important in this cultural event as the monks and the pilgrims who take part in the ceremony with the holy statue are offered (alms) food at this temple.

(2) 'Bridge on the River Kwai' film site

The world famous film 'Bridge on the River Kwai' was filmed at Kitulgala 300m east from the Kataran Oya confluence. Now only the ruins of the bridge exist after being blown up in the film. There is no statistic data and the number of tourists who visit the site is unknown. However, this location has been identified in the provincial tourism plan and in which it has been proposed to develop tourism attractions based on this film site.

(3) Hiking and bird watching

The most popular hiking areas are located in the forest on the south bank of the river near Kitulgala Rest House located about 2km west to proposed powerhouse. The proposed Kelani Valley Reserve, which covers the mountain range in the south (left) riverbank, has a rich biodiversity. The endemic biodiversity specially with respect to birds feature attracts both local and foreign tourists. Makandawa Kurulukele (a part of the this forest falls within the study area and the closest border of the forest is about 500m West from the confluence of Kataran Oya) bird watching safari is one of the popular tourist attractions included in package tours. (4) Whitewater rafting

Adventure tourism such as mountain climbing, hiking, riding, tracking, whitewater rafting etc are becoming popular recreational activities among the local and foreign tourists.

There are three whitewater rafting companies operating in Kitulgala and provide the services for whitewater rafting and other water sports. This sport is carried out in the river from 10 to 12 hours on weekdays and from 14 to 16hours in holydays. The duration of the activity is about 1 to 2 hours. The stretch of the river from a point of about 1 km below the Polpitiya Powerhouse up to the suspension bridge at Kitulgala (about 3 km) provides an ideal setting for whitewater rafting activity

(5) Bathing and swimming

Several places in the main river and Kehelgamu Oya are used for bathing by tourists and largely by the pilgrims to Sripada. Out of them most popular bathing site is located near Kitulgala rest house. An area downstream from the proposed weir and another area consisting of rock pools located about 500m upstream from the confluence of Kataran Oya, are also used for swimming and bathing by local tourists.

2. Anticipated Environmental Impacts

2.1 Physical resources

2.1.1 Impact on land use

The illegal encroachment into state lands is a common phenomenon result during the pre-construction stages of many similar development projects. This impact may be anticipated in this project as well. The state lands within the project boundaries might be encroached with the prime intention of compensation and those outside the boundaries will be encroached as a result of land value increasing with new road and the bridge infrastructure under the proposed project.

2.1.2 Impact on surface water

(1) Organic pollution

During the construction period the effluents from the camp areas may be considered as important contributors to BOD. These may discharge sludge (canteen waste and bath room waste, etc) with high BOD. These effluents, if released directly to the stream or a river the BOD levels will go up and as a result decrease in DO level may be anticipated.

The septic pits and soakage pits, if sited without considering adequate absorption fields, appropriate distance to watercourses and peak flood levels may introduce high BOD seepage into streams and river water. In addition to above, the blasting process may generate effluents containing N and P. If

these effluents are disposed directly to watercourses an increase in N and P in the river might be anticipated. However, likelihood of producing eutrophication impacts such as algal blooms are low due to high flow velocity and dilution effects.

(2) Oil pollution

During construction periods, contaminated with oil and grease generated from construction areas may enter the river. The runoff may carry oil-contaminated water to river causing impairment to water quality.

2.2 Ecological Resources

2.2.1 Flora

(1) Impact on ecology

Since the edge of a particular vegetation type is always considered as a 'disturbed' vegetation due to human activities such as the usage for transportation and inhabitation, the 'edges' always possess weeds and invasive plants. In almost all the project activities in construction phase, the clearance of vegetation likely to occur to the 'edge' of the different vegetation types. i.e. the 'core' area is not affected or cleared. Even the powerhouse area lies within the boundary of the proposed forest reserve and only the edge is affected. Hence, the exact impact on the threatened species, endemic species, species richness of the site will be lesser/insignificant compared to a situation when the 'core' area, the dense forest, is disturbed.

However, the construction of disposal sites will have a much more detrimental impact on flora, depending on the material which will be disposed at these sites. The disposal of inorganic matter such as the construction material (bricks, aggregates, sand etc.) may alter the fertility of the soil. As a result, it will take a longer time than normal to regain the vegetation.

(2) Illegal felling

The large influx of labor during construction period may disturb dense forest, the 'core' area, and other state lands via activities such as illegal felling of trees outside the boundaries of project activities. Wild orchids (eg; Dendrobium macrostachyum) and medicinal plants such as Coscinicum fenestratum, Tiuospora cordifolia of high commercial value may also be vulnerable to illegal exploitation by the workers during this project. This may be considered as a significant impact on the species richness, diversity, threatened and endemic flora.

During operation period, vegetation clearance will not take place but the succession of vegetation will proceed, and the places of clearance will regain.

2.2.2 Fauna

(1) Terrestrial fauna

During construction phase the highly mobile species such as birds, which represent highest level of endemism and highest number of migrants species and mammals will most likely to move into undisturbed areas.

Anticipated impacts on threatened, endemic and migrant species are considered low due to number of reasons. The area to be cleared is located at the edge of the forest and therefore only a small patch of land will be cleared. Furthermore, the degree of current human disturbance is high in these areas so the species present already have tolerance to disturbances. The species with very high sensitivity do not live in these patches but in the dense forest and none of the project activities has direct impact on terrestrial fauna in the dense forest.

In the operation phase there will be no specific activities that have impacts on the terrestrial fauna. The roads will be usually avoided by species due to traffic. Other areas will be gradually replaced with fauna depending on the habitat availability.

(2) Aquatic fauna

During operation phase, the passage of water through the tunnel system will reduce the discharged flow of water in the river section between the proposed weir/dam and powerhouse site. The impacts may be more on fish species, as they require larger volume of water to live. Due to reduction of water flow during the operational phase larger species of fish may avoid the river section between the weir and the dam site. Also this reduction in the flow will change the conditions of the riverbed leading to some changes in the species richness, diversity and ecological balance.

Among the 10 fish species, 4 endemic and three threatened fish species were recorded in the river. The impacts may be considered important only for the river section as none of these species are restricted to Maskeliya Oya and hence the reduction in water volume is unlikely to drive any of these species towards extinction. Furthermore, most of the fresh water species that are endemic and threatened are found mostly in the tributaries that feed the river, which will not be impacted by the reduction of water flow.

2.3 Human environment

2.3.1 Impact on socio-economic conditions

During the construction period household income as well as expenditure levels would increase with enhanced income generating activities and creation of new employment opportunities by the Project.

There will be a substantial demand for skilled and unskilled labour for direct employment in the construction of the Project as well as in supply services. Current unemployment in the study area is high at 40% in the first quarter of 2003. These employment opportunities will be for short or medium term, but the experience and savings that may be gained by workers would facilitate to secure long-term employment opportunities elsewhere.

The impact on the agriculture is insignificant. In the dam/weir sites in Zone-1, some cultivated land such as tea plantation will be affected and the affected extent is low. In the powerhouse site in Zone-1 most of the land is taken from forest, thus the extent of agricultural land loss is low.

Consequent to increase household income and the influx of labour, the demand for food, goods and services will increase, and the Project will have a positive impact on businesses except whitewater rafting.

2.3.2 Resettlement

Sixteen (16) houses that have 17 families/shops will be demolished by the construction of the dam, conduit, road and powerhouse. They all agreed to have in-kind compensation, and they are willing to accept alternative site, a bare land of about 10 ha, close to their present location.

2.3.3 Impact on tourism

(1) Whitewater rafting

The river section between the dam/weir site the powerhouse site will be decreased, and therefore the rafting cannot be operated.

(2) ‘Bridge on the River Kwai’ film site

A new bridge and is proposed at the same place as the film site “Bridge on the River Kwai”. And it is planned that a hole in the rock and concrete block which were parts of the foundation of the bridge in the film will be preserved with several square meters of surrounding rocks. And an access road to the powerhouse is planned to be connected to the new bridge.

During construction tourists who intend to visit this site may face difficulties in accessing the location, but after construction the new access road will function as a facility to visit the site conveniently. In addition, in the other side of the river, there is forest that is expected to be designated as forest reserve

in the east of the powerhouse. And there is a place where various kinds of birds can be seen like a bird sanctuary in the west of the powerhouse. The bridge will make the access to those places easy, and it may increase the number of tourists who visit the film site as well.

(3) Bathing and swimming

The bathing places located in the river between the proposed weir/dam and the powerhouse, may have interruptions especially during dryer periods. However, the most popular bathing spots among tourists and pilgrims are located downstream of tailrace discharge point, and there will be little change in the flow there.

3. Proposed Mitigation Measures

3.1 Physical resources

3.1.1 Land use

It may be important that measures are taken to prevent possible illegal encroachments into state lands and compensation intended development in private lands within the boundaries of the project actions. This can be done by declaration of interim development period under legislation, under which the all the development activities within the particular zone declared will be controlled.

3.1.2 Surface water

(1) Organic pollution

The effluents from canteen, bathroom, etc. shall never be directly disposed into open waters. It may be best to send them through closed drains into suitably designed soakage pits and septic pits. Site for soakage pits and septic pits should be selected taking the followings into consideration: peak floods levels, soil overburden, ground water table, slopes, distance from the watercourse, etc. The garbage such as canteen waste, sanitary waste or any such domestic type waste shall never be disposed in on-site open disposal yards. They should be essentially stored in closed systems to prevent from rain and messing by animals such as cats, rats etc.

(2) Oil pollution

The location of the machinery service yard may be decided adequately away from the natural drainage paths (river, stream, springs etc) and above the maximum flood levels recorded within 3 to 5 years. General machinery maintenance guidelines should be prepared to have concrete procedure to maintain machinery, and education to the staff is also necessary.

3.2 Ecological resources

3.2.1 Flora

During construction phase, illegal tree felling should be prevented. An officer appointed by the divisional secretariat may control illegal activities hampering natural vegetation in the area. In addition, for cases found guilty should be treated according to the regulations felling of trees control act No.9, 1951 and its amended act No. 1 of 2000 and flora and fauna protection ordinance.

After construction the disturbed areas should be re-vegetated. The abandoned areas and open areas of the permanent facilities could be re-vegetated with forest species that can be found in both weir/dam sites.

The threatened species can be cut by getting official permission. Therefore, it will be possible to cut the threatened species if there is no way other than to cut it during construction. And it is suggested

that CEB plant the same species at a proper site.

3.2.2 Fauna

The impacts may be more on fish species, and ecological change is anticipated though it is not is unlikely to drive any of these species towards extinction. therefore, it will be necessary to secure environmental flow to minimize the impact. The environmental flow is the amount of water required to keep aquatic habitat with minimum changes. This depends on number of factors such as types of the aquatic ecosystems and their seasonal ecological variation. The actual figure requires detailed assessments on the long-term discharge data of the river system, and it will be decided after more examination. A valve will be installed at the proposed dam so as to ensure the environmental flow.

3.3 Human environment

3.3.1 Resettlement

The resettlement plan has been prepared based on the following principle.

-to ensure that affected residents and employees will improve or at least restore their income and livelihood to their original levels, and

-to ensure that new housing conditions of the affected people will exceed or at least restore to their original standards; the production conditions of affected enterprises and shops as well as working environment will be restored or improved.

After consultation with affected households and individuals by concerned, all the households agreed to have in-kind compensation and rehabilitation. During the filed interviews, all affected families pointed out that they are willing to accept alternative site close to their present location. a bare land of about 10 hectares, adjoining Broadlands Tea factory, bordering the main road and the river, were identified for their alternate site.

3.3.2 Tourism

(1)‘Bridge on the River Kwai’ film site

The proposed bridge is situated on the film site. Accordingly, attention should be paid so that the rock where the remnants of the monument may be preserved in the construction of the bridge. After construction the remnants will be highlighted to attract more tourists.

(2) Whitewater rafting

Compensation should be paid to whitewater rafting companies based on the related laws and regulations if they are registered to the Ceylon Tourism Board. Hotels and other groups who depend on rafting tourism activities can be compensated as well if they satisfy certain conditions. Negotiation between CEB and the related party will be held individually.

(3) Bathing and swimming

If there may be adverse effect on the most popular bathing spot, 2km downstream from the powerhouse site, the operation mode of the Broadlands power station will be altered in order to minimize the effect.

4. Proposed Monitoring Measures

4.1 Institutional framework

The project proponent (Ceylon Electricity Board) will establish Environmental Management Office (EMO). It will become the overall responsible body in the implementation of the mitigatory plan and monitoring plan, and functions as a self-monitoring agency. It will instruct the contractor(s) so that they will follow the stipulated mitigation plan. The Environmental Manager (EM) will be appointed to be responsible for all the monitoring activities. And it will be staffed with specialists to cover all the important fields respectively such as flora, fauna, water quality, public health, etc.

The Resettlement Committee will be established as a part of the EMO. It will conduct all the resettlement works following the resettlement plan.

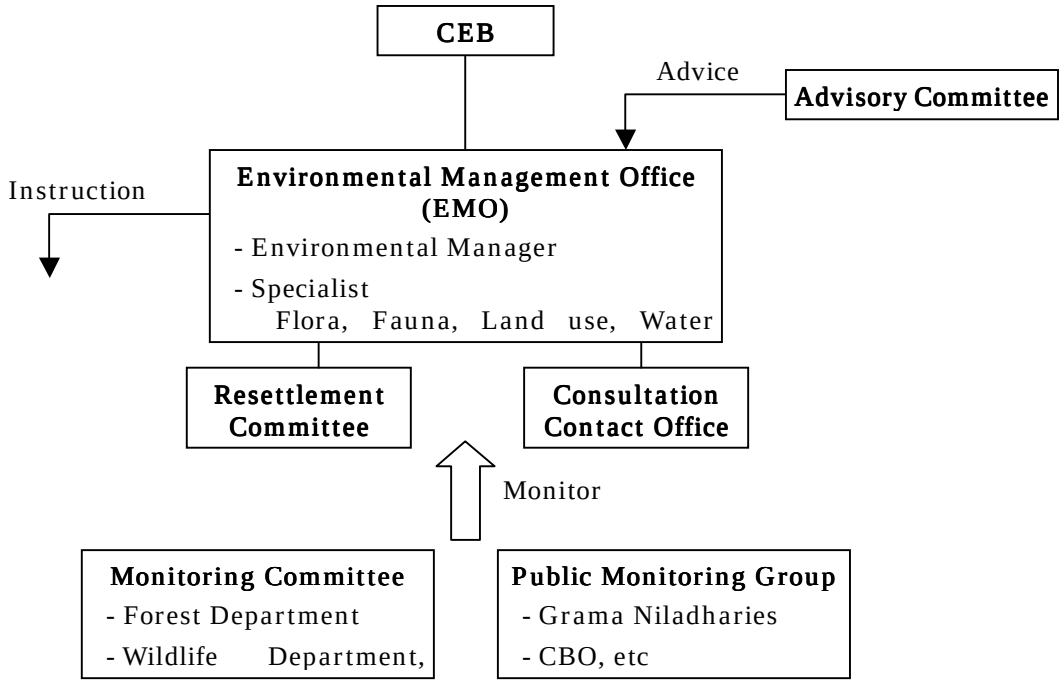
The Consultation Contact Office will be established as a part of the EMO as well. The residents can contact the office to have consultation or make grievances on any issues related to the Project.

The Monitoring Committee, of which members will be appointed by the Project Approving Agency (Central Environmental Authority), will consist of members from various line agencies and related local governments. They will monitor all the EMO's activities.

The Project may accommodate the Public Monitoring Group. The group may consist of Grama Niladharies, CBO members, priests, school head masters, divisional secretary members, etc.

The above Monitoring Committee and Public Monitoring Group will monitor all the activities of EMO, Resettlement Committee and Consultation Contact Office.

In addition, the Advisory Committee, which will have two (2) specialists (natural environment specialist, social environment specialist) will be established to give technical advice to the EMO in an independent position.



4.2 Methodology

Three main phases will be considered in the monitoring plan: Pre construction phase, Construction phase and Post construction / operation phase. Three main types of monitoring are considered in the monitoring plan.

- Baseline Monitoring: Prior to commencing construction activities, surveys are needed to ascertain the baseline levels of environmental parameters. The values of baseline conditions may be compared with values of subsequent monitoring period to assess changes. It will be conducted in the pre-construction phase for the items for which significant impact is anticipated using appropriate parameters.

- Impact Monitoring: The ecological, social, economic, and public health impact indicator parameters may be measured to understand the degree of impairment that might occur as a result of the project.

- Compliance Monitoring : The above monitored impact will be checked in view of compliance with recommendations of the Environmental Monitoring Programme, national standards and other environmental legislation.

The detail of monitoring such as methodology, indicators, duration, frequency and reporting schedule, etc. on the respective items will be stipulated in the monitoring plan and the monitoring will done based on that.

The EMO will prepare routine reports based on its work covering all the items shown below, for example, quarterly and annual reports and special reports which may be needed, and CEB's Project Office will arrange for distribution of these report to related national and international agencies.

5. Conclusion and Recommendation

The study has revealed that serious impacts on natural/social environment are not expected by the Project implementation. This is partly because the Project is relatively small development project in a limited project area and the number of houses to be demolished is small (16 houses), but to conduct proper mitigation measures is a precondition regarding some items. Therefore, proper compensation for relocation, various mitigation measures, proper monitoring and management of environment should carried out during both construction and operation stages.

Chapter 1 INTRODUCTION

1.1 Objective of the EIA

In general, the purposes of environmental impact assessment (EIA) are to ensure that development options under consideration are environmentally sound and sustainable and that environmental consequences are recognized and taken into account early in project design. The EIA process is conducted to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore and enhance the environment.

An EIA study has been done for the Broadlands Hydropower Project (hereinafter the Project), and the results of the above-mentioned EIA (hereinafter the EIA) are described in this report.

1.2 Extent and scope of the EIA

The TOR for the EIA was prepared by the CEA, which had been selected as the PAA (Project Approving Agency) of the Project. The requirement of the TOR is for the final EIA report which will be submitted to the PAA for approval of the Project.

On the other side, the EIA was done based on the results of the feasibility study of the Broadlands Hydropower Project in 2002 and 2003 by the JICA Study Team. Since the purpose of the feasibility study is to study technical feasibility, economical viability of the Project, the accuracy and preciseness of the study is limited to the level of this purpose.

Therefore, some items in the EIA study may not reach the required level, and these items need further study after more accuracy and preciseness will be ensured in the detailed design study.

1.3 Brief outline of the methodologies

A feasibility study for the Broadlands Hydropower Project was conducted by the JICA Study Team in 2002 and 2003, and the EIA was done as part of the feasibility study.

The fundamental study for the EIA was contracted out to National Building Research Organization (NBRO), which had been selected through competitive bidding.

The area to be covered by the study (hereinafter the study area) is designated as follows in the TOR:

1) The river area: from 2km upstream of the proposed dam site in the Maskeliya river and the proposed weir site in the Kehelgamu river respectively, to about 5 km downstream of the powerhouse
2) The bank area: both banks with about 2 km width each along the above river area
3) The other area where significant impact on the environment caused by the project is anticipated

The study area is zoned to the three areas according to the magnitude of the possible impact by the Project as shown below. The zoning is shown Fig.1.1.

Zone-1: Area where the people may be directly affected significantly, and some of them may/must be resettled

Zone-2: Area where people may be directly but not so significantly affected by the Project

Zone-3: Area where people may be indirectly affected by the Project

The study was phased as below.

- Phase 1 (Sep.2002 - Feb. 2003, mainly the study on the natural environment)
- Phase 2 (May 2003 - Sep.2003, mainly the study on the social environment)

Both studies were done through field survey, hearing from the related people, questionnaire and literature survey.

1.4 Government policy regarding the Project

The Government has been actively pursuing the primary objectives of accelerated economic growth and fair distribution of the benefits of such growth. Restoration of price stability, improving international competitiveness, promoting private investment, and addressing directly the problems of poverty and unemployment are the main elements of this strategy.

The power sector is organized under the Ministry of Irrigation and Power. The CEB is responsible for generation and transmission of electrical power in the whole country and distribution in areas other than those served by LECO.

In the context of the above national policy framework, the new policy package for the power sector aims to lower prices to the consumer and ensure a high level of service and supply reliability and to sustain an adequate level of investments in the power sector at all times, by harnessing the private sector investment particularly into the power generation sector.

These policies will ensure the realization of the sector's main objective to meet the demand for energy services at all times at least economic, social and environmental cost and thereby promote economic development and social well-being.

The elements of the overall energy development strategy accepted by the government of Sri Lanka are as follows:

- Providing the basic energy needs for Sri Lanka
- Choosing the optimum mix of energy resources to meet the energy requirements at the minimum costs the to the national economy.
- Optimisation of available energy resources to promote socio-economic development of the country.
- Conserving energy resources and elimination of wasteful consumption in the production and use of energy
- Developing and managing forest and non-forest wood fuel resources.
- Reducing dependence on foreign energy resources and diversifying the sources of energy imports.
- Adopting a pricing policy which enables the financing of energy sector development
- Ensuring continuity of energy supply and energy price stability
- Establishing the manpower capability to develop and manage the energy sector

1.5 Approval needed for the Project

The Project needs the approval of its EIA, and the procedure after submission of the EIA report is as shown below.

- Upon receipt of an Environmental Impact Assessment Report the PAA shall, within fourteen days, determine whether the matters referred to by the Terms of Reference are addressed, and if the Report is determined to be inadequate the PAA shall require the project proponent to make necessary amendments and re-submit the report, together with the required number of copies.
- Upon receipt of the Report, the PAA shall submit a copy thereof to the Authority and by prompt notice published in the Gazette and in one national newspaper published daily in the Shinhala, Tamil and English languages invite the public to make written comments, if any, thereon to the PAA within thirty days from the date of the first appearance of the notice, either in the Gazette or in the newspaper.
- It shall be the duty of the PAA, upon completion of the period of public inspection or public

hearing, if held, to forward to the project proponent comments received for review and response, within six days. The project proponent shall respond to such comments in writing to the PAA.

- Upon receipt of such responses, the PAA shall with the concurrence of the Authority within thirty days either-

  (i) grant approval for the implementation of the proposed project to specified conditions; or

  (ii) refuse approval for the implementation of the proposed project, with reasons for doing so.

In addition to the EIA, the Project may require obtaining clearance as per the Antiquities Ordinance (chapter 188) as amended by Act No 24 of 1988 cited as the project procedure regulation 01 of 2000.

Activities listed under the schedule of the act shall require an Archeological Impact Assessment (AIA) to be carried out to get the approval. The following activities, which are included in the above mentioned list, are part of the Project, therefore, the Project may require an AIA.

Activity of the schedule of the Section 47 to be read with Section 43A of Antiquities Ordinance Chapter 188 and amended by Act 24 of 1998	**Relationship with the Project**
Power generation and Transmission	The Project has those.
Mining and quarrying for stone, gravel sand clay or mineral extractions.	Tunneling, quarrying, foundation and other excavation work of the Project may correspond to them.

The Director General of the Department of Archeology is directly engaged in the grant of approval and the AIA shall be conducted by a professional body appointed by the Director General of Department of Archeology.

1.6 Compliance with the existing conservation plan

Kelani Valley Forest Reserve is being planned near the study area and the demarcation is being done. But it is predicted that the project site will not be included in the Reserve. It is the only conservation or development plan in the Study Area. Therefore, it is considered that the Project does not have any discrepancy with the existing plan.

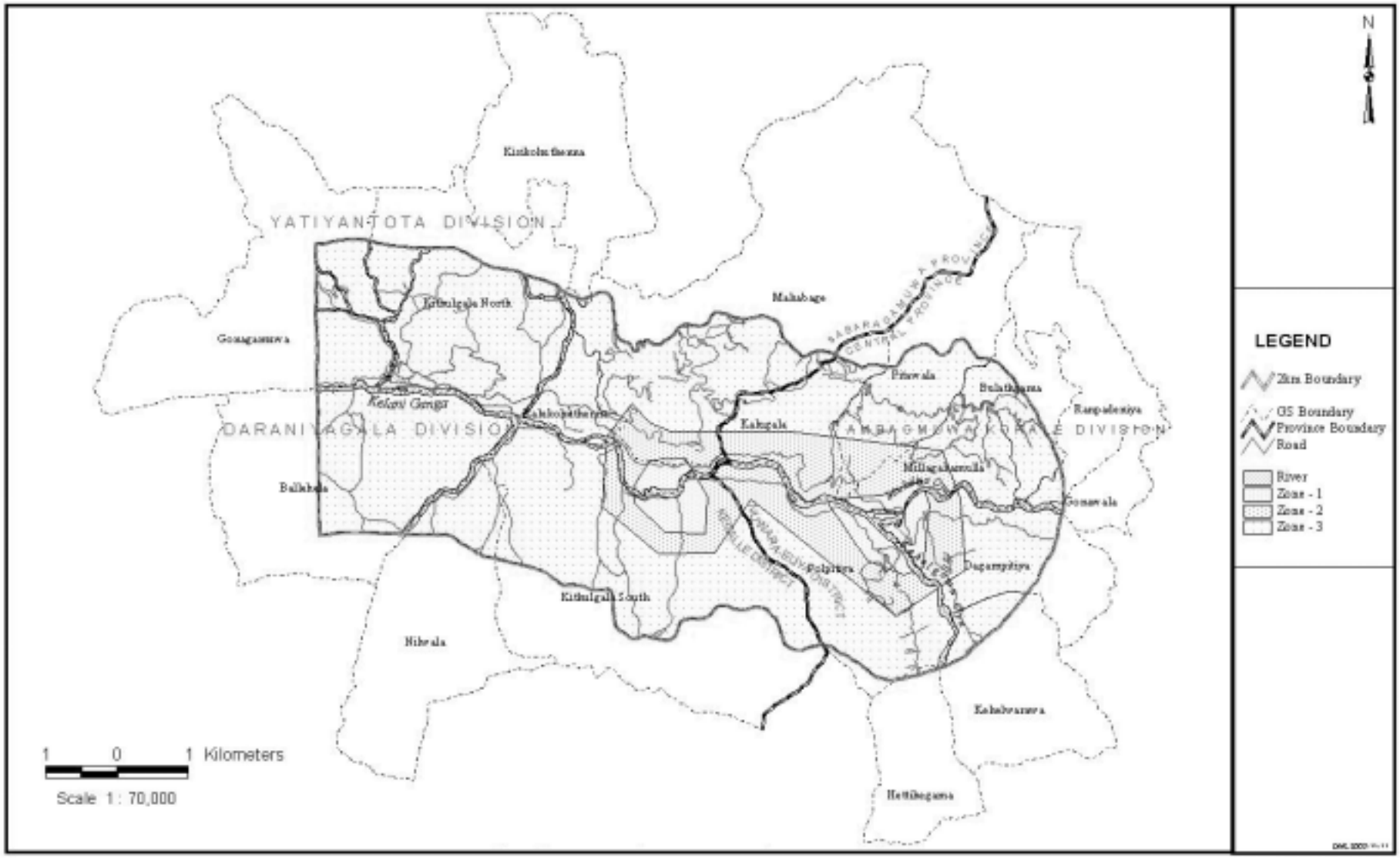


Fig.1.1 The Study Area

Chapter 2 PROJECT DESCRIPTION

2.1 Objective and Beneficiaries of the Project

The objective of the Project is to strengthen the power source for middle and/or peak demand. Electricity to be produced by the Project will be connected to the national grid, therefore, the beneficiaries are all the users in Sri Lanka.

2.2 Justification of the Project

As of 1999, total capacity of generating facilities owned by CEB was 1,574MW, which consisted of 1,135 MW or 15 hydropower stations and 439 MW or six thermal power stations.

Annual output by hydropower and that by thermal power were 4,175GWh and 1,910 Gwh, respectively. In addition to CEB's facilities, IPPs owned, as of 2000, three hydropower stations and three thermal power stations with the total capacity of 1.5MW and 133.3 MW, respectively. As shown by the figures in the above, Sri Lankan power sector depends heavily on hydropower, which accounts for 72% of the total generation capacity of the country.

According to the Long Term Generation Expansion Plan worked out in 1999, the growth of the maximum power demand has been predicted to be 7-9% annually. However, the development of hydropower in the future is not so much expected because of economical efficiency and environmental constraints. Therefore, it is obvious that thermal power generation necessarily takes the major role in the long term.

To cope with these problems, the role of hydropower in Sri Lanka should be altered from the power source for base demand to that for middle and/or peak demand. Although the potential hydropower in Sri Lanka is said to be around 2,000MW, more than 1,100MW has already been developed, and the number of remaining project sites which are prospective from the viewpoints of economical efficiency and natural/social environment is limited. However, development of hydropower is largely expected from the viewpoint of the energy security of the country with short domestic energy resources. And the Project is considered as the most prospective one as new hydropower source.

2.3 Description of the Project

2.3.1 Location of the Project

The project is situated in the margins of the central highlands of Sri Lanka in the Kelani river basin, about 65 km away from Colombo. The Main Dam and the other Weir would be located in the Ambagamuwa Korale division; Nuwaraeliya district of the Central Province and the powerhouse would be located in Yatiyantota division, Kegalle district in the Sabaragamuwa Province (Fig.2.1).

2.3.2 Scale of the Project

The hydropower expansion planning studies carried out under the CEB Master Plan - Study Two-1989 considered four prospective projects generating hydropower and the Boardlands hydropower project is one of them.

In this proposed project, a diversion weir will be erected in Kehelgamu Oya to divert its water to the Maskeliya Oya via an approximately 1km long tunnel. This weir is proposed to be located approximately a kilometer above the confluence of two streams.

The other diversion, which is the main dam of the project, will be erected in Maskeliya Oya, and purpose on this dam is to divert water collected from both the streams to the proposed powerhouse. The dam would be located downstream of the said tunnel and this location will be about 0.5 km downstream of the existing Polpitiya Power Station.

Water from the said main dam will be conveyed to the proposed 40 MW powerhouse, first via an aqueduct and through a tunnel. Combined length of the aqueduct and the tunnel is approximately 3 Km. The tailrace of the powerhouse will join the Kattaran Oya at a location close to its confluence with Maskeliya Oya. This location is situated approximately 3.5 km downstream of the confluence of Kehelgamu Oya and Maskeliya Oya. The 40 MW plant is expected to deliver an average annual power generation of 145 GWh.

The main features of the Project is shown in Table 2.1(at the end of this chapter).

2.3.3 Layout plan of the Project

The layout plan of the Project is shown in Fig. 2.2.

2.4 Methodology of Construction and Operation

2.4.1 Pre construction activities and surveys

The following three surveys were done as pre construction activities.

1. An environmental impact assessment (EIA)
   It is explained at the section of '1.3 Brief outline of the methodologies'.
2. A topographic survey
   A topographic survey was done to prepare 1:500 maps of the areas where main project activities will take place. The covered areas are almost the same as the Zone-1 in the EIA (Oct. 2002-Feb.2003).
3. A geological survey (Oct.2002-Feb.2003 and May 2003-Oct. 2003)
   A geological investigation was done at the sites where important structures; 1)weir and diversion tunnel, 2)main dam, 3)conduits, and 4)main tunnel, surge tank and powerhouse, will be constructed.

In addition, briefing/consultation were held for the related people. The activities are summarized as follows:

Table 2.2 Summary of held briefing/consultation

Date	Target people	No. of Participants
9, 18,2002	Officers of the relevant Divisional Secretary's Divisions and Pradesiya Sabas (*)	14
9, 26,2002	Kalugala, Dagampitiya and Polptiya GN Divisions	27
10, 9,2002	Polpitiya GN Division	25
10, 12,2002	Dagampitiya GN Division	7
12, 14,2002	Kithulgala South	10
10, 28,2002	Divisional secretaries of Yatiyantota and Ambegamuwa Kerale, Other relevant officers	8
11, 10,2002	All the relevant GNs	10
11, 06,2002	Officers of the relevant Pradesiya Sabas(*)	16
11, 11,2002	Inverstors (hoteliers, water rafting company, tea factory owners, industrialists)	10
11, 17,2002	Environmental officers	2
3, 10,2003	Relevant GMs and village headmen	8
3, 10,2003	Relevant GMs	5
11, 13,2003	All the relevant people (dam/weir site)	51
do	All the relevant people (powerhouse site)	31

2.4.2 Land preparation

All the trees are cut down first for land preparation after land acquisition. The surface soil, which is fertile with organic matters, is removed and stocked. Then excavation is conducted and produced aggregates are kept aside, to be used for other construction work if the timing and aggregates quality is appropriate. The kept surface soil is used for afforestation after all the construction works.

2.4.3 Procedures of rock blasting

Blasting will be carried out for excavation for the dam, intake, tunnel and others. Tunnel excavation works will be done day and night, but other open excavation works will be done in the daytime only. Precise excavation work plans including time schedule, stuffing, technologies, etc. will be discussed in the detailed study.

2.4.4 Infrastructure development

A bridge will be constructed across the river on the road from the national road to the power station. On the other site, it is planned the forest that spreads in the south area of the planned bridge will be designated as Kelani Valley Forest Reserve. Therefore, the bridge is expected to make access of the villagers and tourists to the Reserve easy. In addition, there is a forest like a bird sanctuary at west of the planned powerhouse. The access to the sanctuary will be improved as well by the bridge to be constructed.

2.4.5 Emergency response system

The emergency centers will be established at the weir/dam site and the powerhouse site respectively for all the emergencies including medical emergency, accidents, fire and others. The Safety Inspectors in two sites will be responsible for the respective emergency centers. They will ensure proper maintenance of all the facilities such as medical facilities/fire-fighting facilities in the centers and other locations in sites.

The closest small hospital to the sites is the Kitulgala Hospital and the main hospital is the Awissawella hospital. The closest fire brigade is located at Ratnapura. The Safety Inspectors will maintain links with outside hospitals/fire stations.

It is proposed for emergency medical procedures:

1) To have first-aid kits in all the important locations in the sites for treating injuries,

2) To train some key personnel in such locations in emergency medical treatment (first-aid) procedures, and ensure that at least one such person is at duty in a location at any given time,

3) To have qualified paramedics or nurses in the emergency centers,

4) To station suitable vehicles with drivers all the time in each of the two centers to transport injured or ill persons to the hospital when necessary, and

5) To liaise with close-by hospitals to ensure that they are staffed and equipped to treat patients form the sites all the time.

2.4.6 Phased implementation plan

The implementation is planned to be done in one phase. The implementation schedule is shown in Fig. 2.3.

2.5 Evaluation of alternatives

2.5.1 Consideration of alternatives

The alternative proposal was selected from the several options given in previous studies of for the Ceylon Electricity Board.

In 1986, a comprehensive study of the Broadlands Hydropower Project was carried out by the Central Engineering Consultancy Bureau (CECB). Seven options were analyzed in detail to study possibilities of locating dams and weirs at different sites, different layout of waterway, resultant reservoir capacities and available power for each option. These seven options included five different sites for locating dams and weirs.

Constraints that limited the suitability of options were:

- Geological conditions of terrain
- Retaining tail water conditions of Polpitiya powerhouse

  Submergence of tailwater channel of Polpitiya power station will lower its generation capacity. An elevation of 121 MSL is taken as the allowable limit (maximum permissible submergence) and the Full Supply Level and the High Flood Level of proposed dams and weirs are designed accordingly.
- Cost of construction of envisaged proposal
- Utilization of available drop and the flows in two streams of Kehelgamu Oya and Maskeliya Oya.

In the early stage of CECB's study, Option III and IV were ruled out with unfavourable geological conditions at the dam site B and C, respectively. Option I was ruled out for reasons of unfavourable geological conditions along the headrace tunnel on the right bank. Moreover, Option VI was also rejected because of being more expensive and cumbersome compared to Option VII. At last Option II was rejected because geological investigation found unfavorable conditions at the dam site As a result, these two options (V and VII) were considered to be important for comprehensive investigations and they are respectively:

Option V - Dam at location D (hydraulic height of 53 m) about 2.5 km down stream of the confluence, water conductor system along right bank of Kelani, powerhouse in the right bank of Kelani near Kitulgala Valley and a short tail channel discharging into Kelani.

Option VII- Dam at location E (hydraulic height of 21m) in Maskeliy Oya in between the Polpitiya powerhouse at and the confluence, weir in Kehelgamu Oya above the confluence, tunnel diverting water from weir to the dam, A water conductor system from the dam, powerhouse near Kattaran Oya and tailrace channel discharging into Kelani.

As for the option V, the length of the Kelani Ganga of which river flow will be decreased is much less than Option VII, but it requires more construction and was found to be less economical. It will have a large reservoir of 0.93 km2 that will inundate 87 families and about 14 ha of farmland, though Option VII will inundates 16 houses and no farmland.

Therefore, the option VII was taken as the main proposal taking everything into consideration.

2.5.2 Consideration of 'no project' alternative

Sri Lanka is facing absolute power shortage. Improvement of the life level and economic development cannot be expected without developing new electric sources, and it will cause dissatisfaction of the people. Therefore, to develop electricity is one of the most important issues in Sri Lanka.

It has been revealed by the EIA study that some significant negative impacts to the ecological conditions and human environment can be mitigated and no irreparable damage is predicted by the Project. Hence, the Project can be placed as one of the most prospective power development projects.

2.5.3 Access road to power station site

The access road to the proposed power station will be connected to the above mentioned new bridge. The road and the bridge will make access easy not only to the famous film site, but also to the bird watching area. Accordingly, positive impact on tourism can be expected.

2.6 Work Force

2.6.1 Labour requirement during construction

It is difficult to predict labour requirement at the F/S level because it depends on the way how the construction works are done and it is a matter of construction contractors. But it may be predicted to be between 1,000 and 2,000 persons based on the other dam projects' results.

2.6.2 Availability for labour

If the contractor provides accommodation for labour, labour may join the work from all over Sri Lanka. Without accommodation it may be expected that people who live within about 50 km may be available if bus service is offered.

The population and the unemployment rates are shown in Table 2.3 and Table 2.4. Considering those data it can be said that labour force will suffice.

Table 2.3 Population in the related Districts and Divisional Secretariats.

District/ `Divisional Secretariat	Total Population	Population over 18 yrs old
Nuwara-Eliya District	**700,083**	**443,786**
Ambagamuwa	202,432	128,154
Kegalle District	**779,774**	**529,742**
Deraniyagala	44,370	29,325
Yatiyantota	56,838	37,981

Source: Census of Population and Housing – 2001, Dept. of Census and Statistics

Table 2.4 Unemployment Rates in related provinces in 2001

	(%)
Sri Lanka	7.9
Central Province	8.4
Sabaragamuwa Province	10.9

2.6.3 Occupational health and safety

Work permit procedures

There will be procedures for work permits to secure safety of the work. The procedure is: 1) Site engineers shall forward requests for work permits to the Safety Inspectors before starting any work. 2) The Safety Inspector will then study the work plan and work procedures described by the engineers in the request, and it judged appropriate give their approval with recommendations on safety precautions to be taken. 3) The Safety Inspectors will follow the work implementation and ensure that recommended safety measures are followed. 4) Violations will be reported to the Environmental Management Office (EMO).

Training of staff for safe work

Training programmes for different work categories (for examples to welders, sand-blasting workers, explosive handlers, etc.) will be conducted as necessary. Training on proper use/handling of tools in work and knowledge in handling of electrical and pneumatic tools and their storage will be provided.

Fire training drill

Fire fighting drills will be conducted as decided by the Inspector for the two sites. Workforce in the site will be trained in emergency procedures and drills will be conducted to ensure the response of the all the workers in emergency and evacuation procedures.

Noise level control

The noise level could be considered as a significant aspect due to noise generated by construction activities such as extraction, soil boring, blasting, drilling, hammering, loading and unloading of waste, operation of metal quarry, damping sites etc. The expected noise levels due to these construction activities in the site area will increase up to about 80 to 105 dB (A) depending on the activities. It could cause workers at the site exposed to high noise levels (above 80 dB(A)) and leads to severe health problems depending on the exposure time. Therefore, workers working hours should be scheduled according to the ILO threshold limits given in the following.

Table2.5 ILO threshold limits

Noise level dB(A)	80	85	90	95	100	105	110	115
Max.exposure time per day	16	8	4	2	1	1/2	1/4	1/8

2.6.4 Facilities to be provided

As mentioned above, emergency centers will be required provided with suitable vehicles and drivers to be used in emergency cases. Fire fighting facilities are also necessary.

Proper storage facilities will be provided in all sites. For examples, safe storage for explosives, stores for materials where separate sections maintained for chemicals (concrete admixes, paints and thinners, oils and greases), fuels, etc. and all such storages will be under designated storekeepers. The fuel will be dispensed through a service station where fuel is stored in underground tanks and suitable fire fighting facilities such as foam and dry powder extinguishers and sand buckets are provided.

2.6.5 Envisaged human resources development

Human resource development is a matter of construction contractor, therefore, it is difficult to state about it in the F/S report. However, it is suggested that education on environmental and be done to all the people who will be involved in the Project.

Table 2.1 Main Features of the Project

General	
Catchment Area of Main Dam (including C.A. of Norton Bridge Dam)	201 km^2
Catchment Area of Kehelgamu Weir (excluding C.A. of Norton Bridge Dam)	176 km^2
Tailwater Level (at the outlet of draft tube)	EL 56.2 m
10,000-year Return Period Flood (Main Dam)	1,910 m^3/sec
1,000-year Return Period Flood (Main Dam)	1,440 m^3/sec
1,000-year Return Period Flood (Kehelgamu Weir)	1,310 m^3/sec
Reservoir	
Maximum Flood Level	EL 122.0 m
Full Supply Level	EL 121.0 m
Minimum Drawdown Level	EL 111.0 m
Total Storage Volume	216,000 m^3
Effective Storage Volume	198,000 m^3
Main Dam	
Type	Concrete gravity dam
Dam Crest Elevation	EL 124.0 m
Dam Crest Length	114.0 m
Dam Height	24.0 m
Dam Volume	30,800 m^3
Overflow Crest Elevation	EL 107.0 m
Spillway Gate	
Type	Tainter gate
No. of Gates	3
Width / Height	7.2 m / 15.0 m
Kehelgamu Weir	
Type	Concrete gravity dam
Dam Crest Elevation	EL 132.0 m
Dam Crest Length	48.0 m
Dam Height	19.0 m
Overflow Crest Elevation	EL 125.0 m
Overflow Crest Length	40.0 m
Intake Water Level	EL 125.0 m
Headrace	
Total length	3,384.8 m
Intake Tunnel	
Type	Concrete lined pressure tunnel
Length	155.8 m
Slope	0.0075
Cross Section	Standard horse-shoe shape (D = 5.4 m)
Cut-and- Cover Conduit	
Type	Steel lined pressure conduit
Length	693.8 m
Slope	0.0075
Cross Section	Circular section (D = 5.0 m)
Main Tunnel	
Type	(1) Steel lined pressure tunnel (2) Concrete lined pressure tunnel
Length	(1) 60.0 m (2) 2,475.1 m
Slope	0.0075

- Continued -

Cross Section	(1) Circular section (D = 5.0 m) (2) Standard horse-shoe shape (D = 5.4 m)

Surge Chamber

Diameter of Chamber	18.0 m
Height of Chamber	43.0 m
Up Surge Water Level	EL 130.93 m
Down Surge Water Level	EL 103.35 m

Penstock

Length	(about 250 m)
Diameter	4.6 m (before bifurcation) 3.3 m (after bifurcation)

Tailrace

Type	Trapezoid open channel
Length	(about 250 m)
Slope	0.02

Kehelgamu Diversion Tunnel

Type	Concrete lined non-pressure tunnel
Length	(about 850 m)
Slope	0.004
Section	Bonnet-shape (B = 2.7 m, H = 2.7 m)

Main Electro-Mechanical Equipment

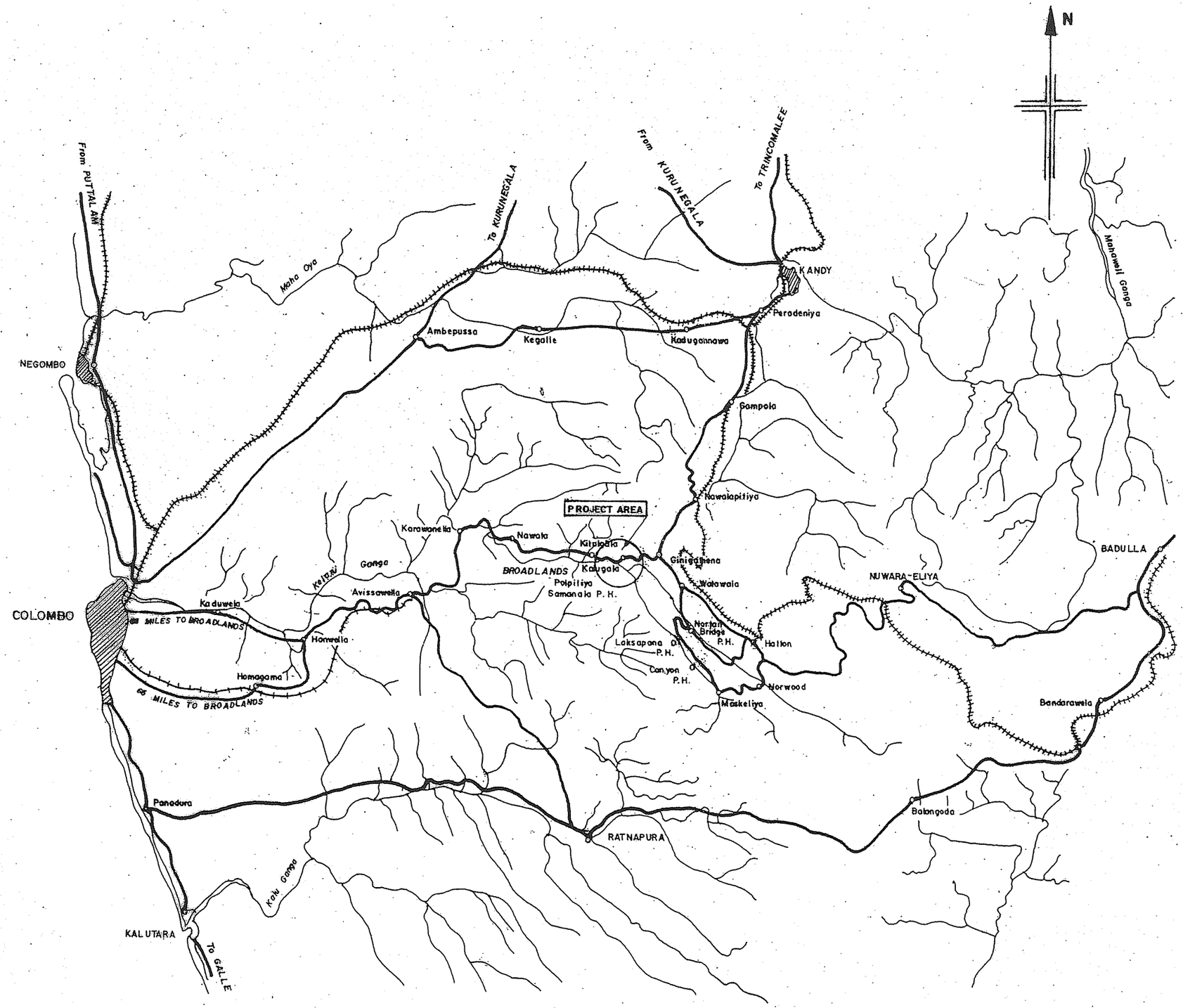
Turbine	
Type	Francis
No. of Unites	2
Rated Effective Head	56.9 m
Rated Discharge (per unit)	35.0 m^3/sec
Rated Speed	300 rpm
Runaway Speed	586 rpm
Generator	
Type	3-phase synchronous
No. of Units	2
Frequency	50 Hz
Synchronous Speed	300 rpm
Runaway Speed	586 rpm
Main Transformer	
Type	Y - Δ, Outdoor
No. of Units	2
Voltage	132 / 11 kV

Transmission Line

Type	132 kV overhead transmission line
Connected Line	132 kV Polpitiya-Kolonnawa line No.3
Connection	Go in/out connection with single bus

Communication Equipment

To Polpitiya	Optical fiber communication system
To Seethawaka	PLC communication system



BROADLANDS HYDROPOWER PROJECT

PROJECT LOCATION

Figure 2.1

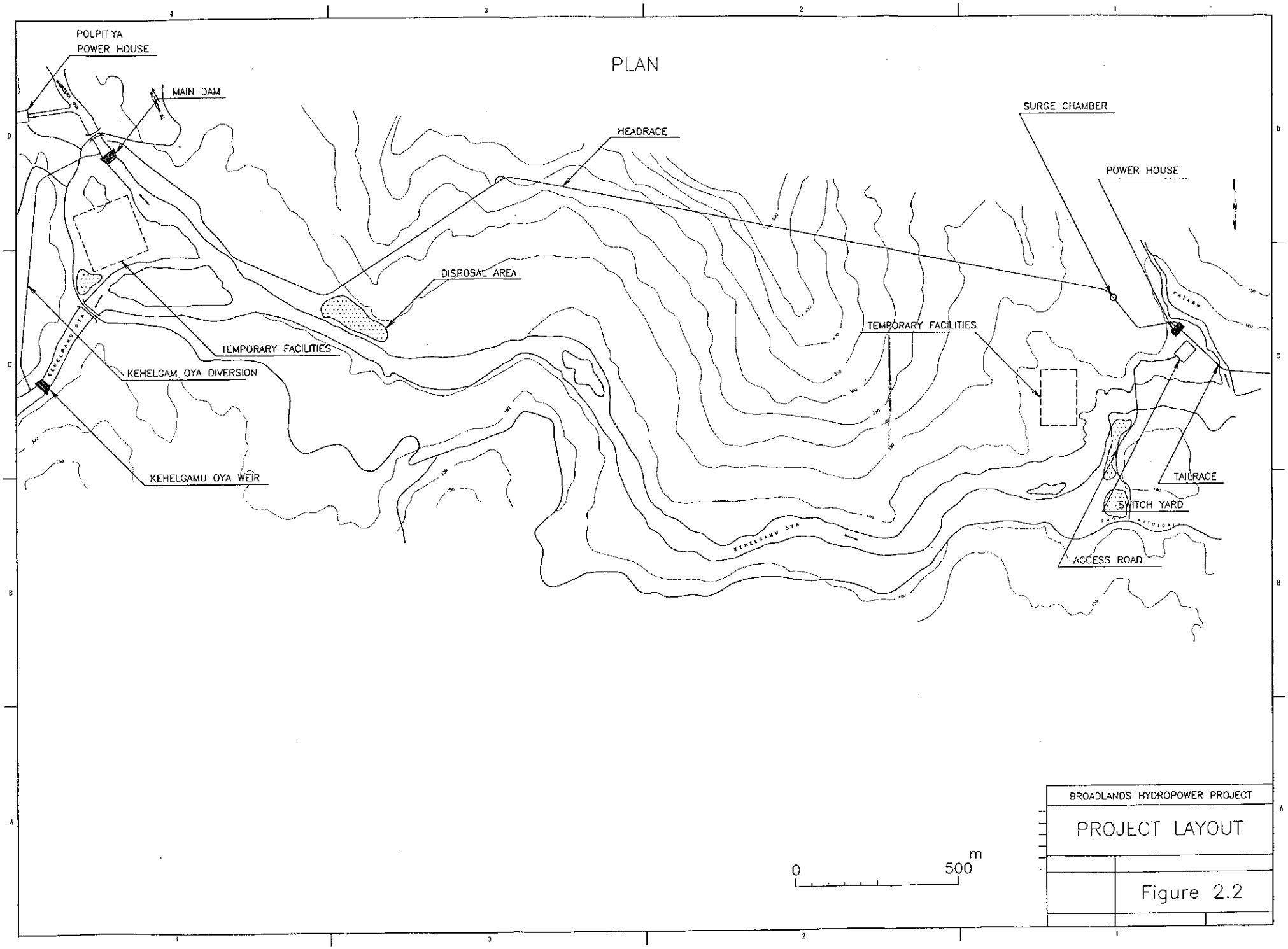
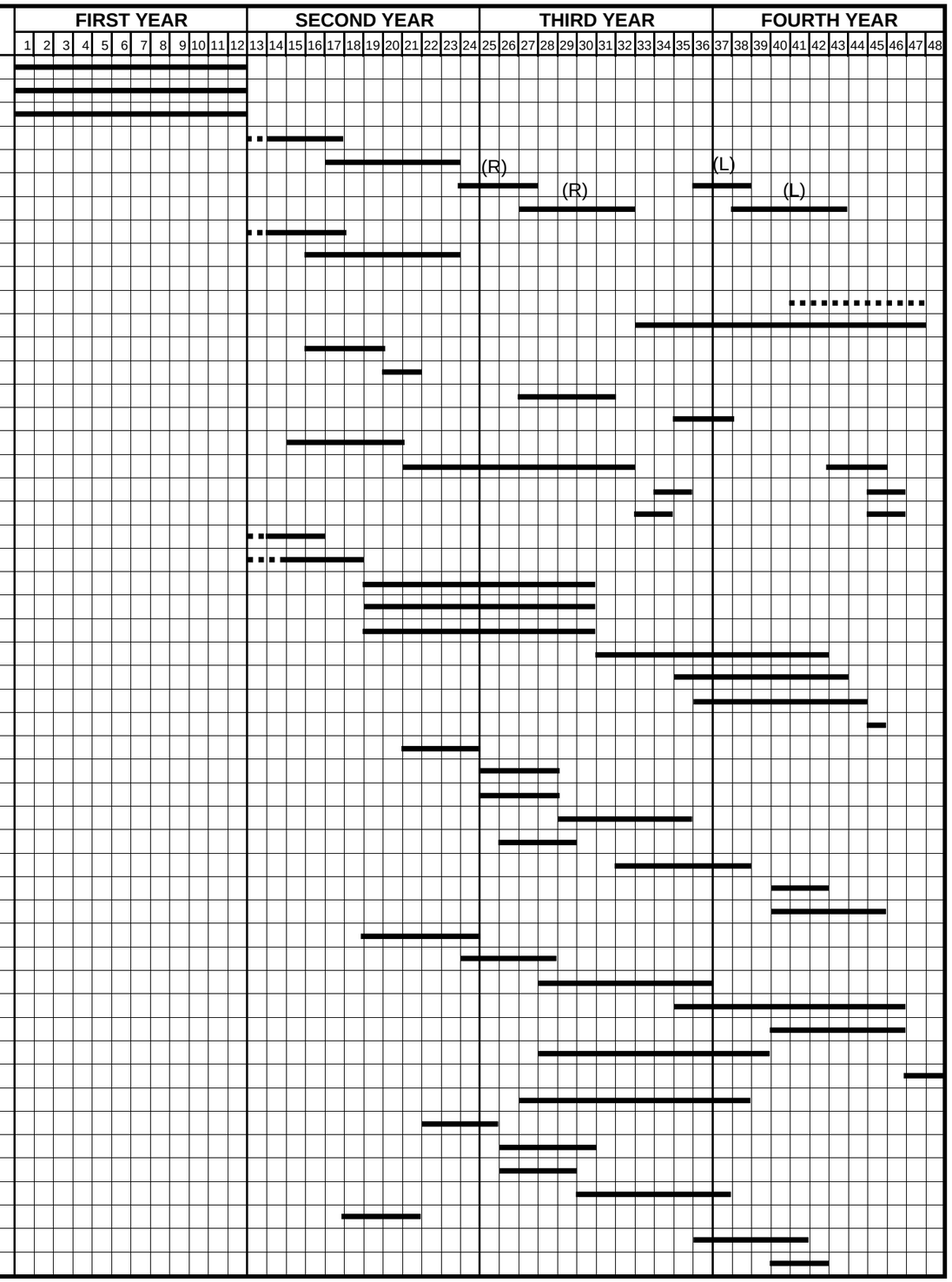

PLAN
POLPITIYA
POWER HOUSE
MAIN DAM
HEADRACE
SURGE CHAMBER
POWER HOUSE
DISPOSAL AREA
TEMPORARY FACILITIES
TEMPORARY FACILITIES
KEHELGAM OYA DIVERSION
KEHELGAMU OYA WEIR
TAILRACE
SWITCH YARD
ACCESS ROAD
KEHELGAMU OYA
0
500
m
BROADLANDS HYDROPOWER PROJECT
PROJECT LAYOUT
Figure 2.2

Figure 2.3 Construction Schedule

S/No.	WORK	No.	ITEM
1.	Preliminary Work	(I)	Construction Power Supply
		(II)	Access Roads & Bridges
		(III)	Buildings, Camps
2.	Dam & Spillway	(I)	R/B Excavation
		(II)	R/B Section Concreting
		(III)	River Excavation
		(IV)	Spillway, Piers & Appon Concreting
		(V)	R/B Excavation
		(VI)	R/B Section Concreting
		(VII)	Concreting Of Openings
		(VIII)	Crest Works
		(IX)	Erection Of States & Stop Logs
3	Intake Structure	(I)	Excavation For Intake Structure
		(II)	Tnnelling Up To The Surface Conduit
		(III)	Installation Of Steel Liner & Concreting
		(IV)	Erection Of Gate
4.	Cut & Cover Conduit	(I)	Excavation
	Construction	(II)	Installation & Concreting
		(III)	Sack Filling
		(IV)	Concreting & Grouting Tunnel Conduit
5.	Main Tunnel Construction	(I)	Inlet Portl Excavation
		(II)	Outlet Portal Excavation
		(III)	Excavation From U/S Face
		(IV)	Excavation From D/S Face
		(V)	Rock Solting, Shotcreting
		(VI)	Concrete Lining
		(VII)	Cavity Grouting
		(VIII)	Consolidation Grouting
		(IX)	Clean Up
6.	Surge Chamber Construction	(I)	Common Excavation Up To Rock
		(II)	Shaft Excavation In Rock
		(III)	Shotcreting & Rock Bolting
		(IV)	Concreting
7.	Steel Penstock	(I)	Excavation
		(II)	Erection Of Penstock
		(III)	Concreting & Back Filling
		(IV)	Erection & Concreting Of Tunnel Penstock
8.	Power House	(I)	Excavation For Power House
	& Switchyard	(II)	Concreting Sub Structure
	Construction	(III)	Concreting Intermediate Structure, Crane Beam & Roof
		(IV)	Installation Of E&M Equipment & Second Stage Concreting
		(V)	Concreting Super Structure & Architectural Features
		(VI)	Construction Of Switchyard
		(VII)	Testing & Commissioning
9.	Tailrace	(I)	Channel Improvement
10.	Kehelgamu Oya Diversion	(I)	Access Adit
		(II)	Tunnelling Up Stream
		(III)	Tunnelling Dowm Stream
		(IV)	Tunnel Lining
		(V)	Construction Of Access To Weir
		(VI)	Excavation & Converting Of Weir & Inlet Structure
		(VII)	Erection Of Gate



Chapter 3 DESCRIPTION OF THE EXISTING ENVIRONMENT

3.1 Physical resources

3.1.1 Topography and climate

The Project area is located in the Central Highlands, approximately 50 kilometers east of Colombo City. The area is widely underlain by Pre-Cambrian gneiss. Two tributaries of the Kelani River, Maskeliya Oya and Kehelgamu Oya, originate from the southwest slope of Mt. Kerigalpota (2,395 m) and flow northwestward. They join each other immediately downstream of the proposed dam site forming the Kelani River. After the confluence, the Kelani River flows to the west, and flows into the Indian Ocean, about 5 kilometers to the north of Colombo City.

The topography of the proposed study area is hilly, ranging between 600 -900m MSL. As it is located along the south-west margin of the central highlands, an abrupt elevational rise of about 40m is recognized on a 5km strip of land between Broadland and Kitulgala.

As the physiographic features of the mountains have a greater influence on the intensity, location, time and duration of monsoon rains this characteristic feature also contributes for a much higher rainfall to the lower reaches of the study area especially during the southwest monsoon period (May-September). This is because the surrounding mountains of the proposed site become the windward side for southwest monsoon and vice versa for the northeast monsoon, which results an orthographic uplift of the winds for the formation of clouds for interception.

Since the proposed study area climatically belongs to the wet zone of the island, it receives relatively a higher rainfall with an annual average between 2,000mm to 5,000mm. During the past 3 years (2000-2002), Kitulgala area received an annual average rainfall of 3,500 mm. The year round temperature reaches above 27°C with no seasonal changes and diurnal variations.

3.1.2 Meteorological parameters

The main meteorological parameters of the nearest observation stations are shown below. The rainfall has two peak seasons, May and October, through the year.

Table 3.1 Meteorological parameters

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature (°C)	Max. Mean	32.3	33.5	34.3	33.2	32.0	30.9	30.4	30.7	31.1	31.1	31.5	31.6
	Min. Mean	22.0	22.2	22.7	23.6	24.4	24.0	24.1	23.8	23.2	23.1	22.8	22.2
Relative Humidity (%)	Day	72.8	69.5	68.8	78.3	79.4	78.8	78.4	78.3	78.9	80.8	79.0	76.3
	Night	92.9	92.3	93.3	97.1	94.3	91.7	89.7	91.4	93.9	94.3	95.3	95.0
Rainfall (mm)		129	157	109	449	536	469	453	399	599	717	490	143

Source: Department of Meteorology
Remarks :
- Value of Temperature and Relative Humidity is the average of 8-year data (1995-2002) in Ratnapura
- Value of Rainfall is the average of 10-year data (1993-2002) in Wewlitalawa (north of Kithulugala)

3.1.3 Land use pattern

(1) Land use in Zone-1 (Powerhouse, Weir & Dam site)

In the fist approach, contour map to the scale of 1:500 prepared by for the Project was used as the base map for the preparation of land use map for Zone-1 in the study area. The land use data collected from field survey were used to prepare the map.

The main land use categories, subcategories and description are shown in Annex-1.

Table 3.2 shows the land use in Zone-1. In the weir / dams area, the notable land use is Scrub (26.4%),

House / Homesteads (19.7%) and Tea plantation (14.6%).

In the powerhouse area, the notable land use is Natural forest (32.9%) and House / Homesteads (27.1%), which is located close to the powerhouse site.

Table 3.2 Present Land Use

Land use	Weir/Dam area in Zone-1		Powerhouse area in Zone-1	
	Area (ha)	%	Area (ha)	%
House/ Homestead	22.9	19.7	22.5	27.1
Polpitiya powerhouse properties	9.0	7.7	-	-
Army properties - Polpitiya	2.5	2.1	-	-
Garden in scrub jungle	1.3	1.1	-	-
Paddy/ Marsh	0.5	0.4	1.6	1.9
Coconut	1.8	1.5	-	-
Tea	17.8	14.6	1.6	1.9
Tea & pepper	1.6	1.4	-	-
Rubber	-	-	0.3	0.4
Chena cultivation	-	-	0.1	1.1
Rubber in scrub	2.0	1.7	-	-
Mixed crop	3.6	3.1	3.5	4.2
Natural forest	6.2	5.3	27.3	33.0
Scrub	26.4	22.7	7.0	8.4
Jungle	6.4	5.5	11.1	13.4
Surface water	12.0	10.3	7.9	9.3
Exposed rock	0.1	0.1	-	-
Major road	1.8	1.5	-	-
Secondary road	0.5	0.4	-	-
Total	116.4	100.0	82.9	100.0

(2) Land use in Zone-1, 2 & part of Zone-3

In the other approach, map No. 68/1 to the scale of 1:10,000 prepared by the Survey Department under Agriculture Base Mapping Project (ABMP) and Aerial photographs to the scale of 1:20,000 taken in 1999 were used to study the land use in Zone-1, 2 & part (area covered by ABMP 68/1) of Zone-3. Data transferred from the aerial photographs were then updated by a field check.

Eleven (11) categories were used to describe the land use in the area, and those categories are described in Annex 1.

Table 3.3 shows the percent land use, their extent and percentage in Zone-1, 2 & part of Zone-3.

Table 3.3 Present land use in Zone-1,2 & part of Zone-3

Land use	Area (ha)	%
Homestead	388.6	46.2
Paddy	6.3	0.8
Coconut	1.9	0.2
Tea	33.5	4.0
Rubber	88.4	10.5
Mixed crop	59.0	7.0
Natural forest	121.9	14.5
Scrub	90.3	10.7
River/ Stream	49.9	5.9
Powerhouse	0.8	0.1
Rock	0.6	0.1
Total	841.1	100.0

Homesteads represent the highest (46.2%) percentage of land use. Next significant land use is Natural forest (14.5%) closely followed by Scrub (10.7%) and Rubber (10.5%).

(3) Land Ownership

Ownership of some of the lands could not be clearly specified due to ad hoc nature of programmes implemented by the government such as Swarnaboomi Deeds, Jayaboomi Deeds etc. Some of crown lands have been distributed and ownership has been transferred to the people who do not own any land under various programme implemented by the Government time to time. Another example is Jayaboomi Deed renewable on annual permit, given under Land Development Ordinance.

Encroached lands are also considered as government lands. The encroachers mainly occupy the crown lands such as reservations (forest/river). However, some of them have government permits.

All the roads and water bodies are owned by the Government. Land ownership in Zone-1 is shown in Table 3.5. All the above lands are shown as government lands in this table.

Table 3.5 Land Ownership in Zone-1

	Weir & Dam area		Powerhouse area		Total	
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)
Private Lands	517	44.1	151	18.2	668	33.4
Government Lands						
Irrigation Department	119	10.1	77	9.3	196	9.8
Ceylon Electricity Board	94	8.0	0	0.0	94	4.7
Sri Lanka Army	26	2.2	0	0.0	26	1.3
Forest Department	393	33.5	602	72.5	995	49.7
Road Development Authority	34	2.0	0	0.0	23	1.1
Total	1,172	100.0	830	100.0	2,002	100.0

3.1.4 Geology and soil

3.1.4.1 General geology of area and sub surface structure

(1) General

The Kelani River forms a deep valley at the project area. The riverbed is at an elevation of approximately 100 meters in this area and the slopes on both banks rise to ridges of higher than 500 meters in elevation. The Maskeliya Oya and Kehelgamu Oya form narrow valleys of about 50

meters wide at the riverbed, while riverbed of the Kelani River ranges from 70 to 100 meters in general.

Two landslide are seen approximately 200 meters downstream (intake tunnel-conduit) of the dam site and approximately 700 meters downstream of the confluence. Reservoir area of the proposed layout does not meet the landslide.

Small terraces at two different levels (30 meters and 60 meters in relative height) or more are distributed on the both banks.

The project area is located in the central highlands underlain by the Pre-Cambrian metamorphic rocks belonging to the highland series. The bedrock of the project area consists mainly of Pre-Cambrian gneiss, intercalated with thin bands of quartzite and limestone lenses (marble).

(2) Geologic component

a) Gneiss

Charnockitic gneiss, biotite gneiss and garnet-biotite gneiss are widely distributed in the project area. The characteristics of each type of gneiss are as follows.

Charnockitic gneiss

Charnockitic gneiss occurs at dam site. It is pale greenish gray to gray color, consists of quartz, feldspar and pyroxene, granulitic texture. Crack spacing is larger than 50 cm, and the rock is relatively resistant to weathering and hard.

Biotite gneiss

Biotite gneiss is widely distributed in the project area. Its color is light and dark gray bands consisting of quartz, feldspar and biotite in thin (0.1 to 5 cm) alternating layers. Crack spacing ranges from 10 to 50 cm. Biotite rich portions are brittle compared with other gneiss rocks.

Garnet-biotite gneiss

Garnet-biotite gneiss is distributed in the tunnel alignment. It is light grey in color with alumina rich minerals such as silimanite and garnet. The garnets are often large and sometimes provide a 'plum pudding' appearance. Biotite is also a major mineral in this gneiss. Crack spacing ranges from 10 cm to more than 50 cm. Garnet-biotite gneiss is hard, but its weathering resistance is moderately low.

b) Quartzite

Quartzite generally occurs in well-extended bands of 2 to 10 meters thick intercalated with gneisses. It is white to pale grey in color, hard, but brittle and highly jointed.

c) Limestone (including calcareous gneiss)

Limestone exists as white to pale grey, fine to course texture, well crystallized limestone bands or blocks. These are distributed in the area of the cut-and-cover conduit construction on the left bank of the Kelani River and in the area of the Kehelgamu Oya diversion tunnel (approximately sp 750) on the right bank of the Maskeliya Oya. Limestone is hard, but its weathering resistance relatively low. Thick overburden of limestone covers both banks of the Kelani River.

Thin calcareous veins intruding charnockitic gneiss are observed in geological drilling cares obtained from the dam site.

(3) Weathering and Alteration

Weathering is generally intense on the hillslopes of the project area, but it is less pronounced on the

steep left bank of the Kelani River (the proposed tunnel route).

(4) Geological Structure

The Precambrian rocks are complexly folded due to several episodes of metamorphism and deformation. The project area lies on the eastern limb of the Kitulgala syncline with a fold axis extending N-S to NNW-SSE. The foliation in the project area strikes mainly N-S, and dips steeply westward at the dam site （80°） and gently dips in the vicinity of the powerhouse（30-40°）.

(5) Recent River Deposits

Bedrock is exposed along the river and thickness of river deposits is inferred to be less than 5 meters in general. At the confluence of the Maskeliya Oya and Kehelgamu Oya, relatively thick deposits are distributed on the riverbed.

3.1.4.2 Seismic and resistively data and geophysical condition

Seismic data along the tunnel trace are shown in the following table.

Table 3. 6 Seismic velocities in selected sections along the tunnel trace

Line / Spread	Layer 1 Soil Cover	Layer 2 Highly weathered Bedrock	Layer 2/Layer 3 Slightly weathered Bedrock
SMT-12	516	1271	
SMT 13	387	1034	
SMT 14	438	822	
SMT 15	358	972	
SMT 17	301	657	(1437)
SMT 19	445	1531	
SMT 21	425		3594
SMT 24	613	1127	2034
SMT 27	551		2174
SMT 32	684		1917
SMT 34	385	1240	
SMT 36	600		3304
SMT 38	579	1609	
SMT 42	764	1159	
SMT 44	363		2688

3.1.4.3 Core logging data around tunnel area

Results of drilling works along the main tunnel are summarized in the following table. Geological map of the main structures area is shown in Annex 8, where the locations of the boreholes are shown as well. The borehole logs are shown in Annex.9.

Table. 3.7 Results summary of drilling works along the main tunnel

Holes	Length(m)	Geological condition (Rock class) (m)			
		D class	CL class	CM class	CH-B class
MT-1	35.54	0.00-9.83	9.83-19.00	19.00-34.00	34.00-35.00
MT-2	35.00	0.00-21.85	-	-	21.85-35.00
MT-3	25.57	0.00-4.30	4.30-7.00	7.00-14.00	14.00-25.57
MT-4	30.55	0.00-8.25	8.25-9.15	9.15-21.30	21.30-30.55
MT-5	30.25	0.00-11.00	11-30(CL-D)		
MT-6	40.10	0.00-38.00	(23.00-24.00)	38.00-38.10	38.10-40.0
MT-7	60.00	0.00-20.48	20.48-25.00	25.00-28.30	28.30-
MT-8	80.06	0.00-16.00	(12.12-14.38)	16.00-21.30	21.30-

Remark: B-class is the most suitable for excavation because it is freshest, hardest with least weathering and fissures. The order for the suitability can be expressed as D＜CL＜CM＜CH＜B.

3.1.4.4 Mineral resources of the area

The area consists of high-grade metamorphic rock having varying mineralogical compositions. Most of the rocks contain common rock forming minerals such as quartz, feldspar, biotitic, garnet, hornblende, etc. However, in some of the basement rocks, minor amount of graphite is present with no commercially exploitable quantity. No quartzite is present in economical quantity with the quartzo-feldspathic rocks found in the study area.

There are two shear zones identified crossing the Maskeliya Oya but geological invesigation along these shear zones revealed that there are no significant mineralization along them. However, some pegmatite bodies could be detected which consists of exploitable amount of quartz and feldspar with minor quantities of mica.

Kaolinite, one of the common major clay minerals are present within the residual soil overburden of the area at the locations that are underlain by the basement rock containing some feldspar since the mineral Kaolinite is the weathering product of Feldspar. At few locations of the riverbanks, a very little quantity of Kaolinite was observed which is also not exploitable economically. Kaolinite is one of the very common secondary minerals in Sri Lanka and hence the submergence or destruction of occurrences can be negligible.

Sri Lanka has no deposits of earth energy sources such as petroleum products, coal or natural gases.

Occurrence of precious and semiprecious stone

The known precious minerals are not present within these hard rocks in economically exploitable quantity. Hence ,based on this mineralogical survey and mineralogy resource information for precious stone deposits of Sri Lanka, it can be stated that the potential for gem mining is low. However, further detailed studies are required to confirm above.

Industrial minerals

The mineralogy resource information reveals that there are no identified industrial mineral resources in the area. The detailed field investigations confirms above that the major economical, precious and semi-precious minerals found in Sri Lanka such as ceramic raw materials (kaolin & ball clay, feldspar, vein quartz, silica sand, calcite), fertilizer minerals (dolomite, apatite), graphite, mica, gems and metallic minerals are not common in the study area or not present at economically extractable scale.

Construction minerals

Material extraction for construction industry can be considered as the only commercial scale use of mineral resource in the study area. However, the current exploitation is limited to sand mining. There are no deposits of limestone (inland coral) or resources for export level dimension stones available in the area. There are occurrences of clay deposits, which however, cannot be considered

economically extractable.

Sand deposits & mining

It is a common engineering geological phenomenon that a thick Colluvium deposit covers the most of the sloppy lands in the study area(Colluviums are the soil deposits that were developed by past earth slips). Many boulders are seen embedded in this Colluvium deposit. The study area lays more or less the upper portion of the river where the slope gradients are high. Since the water is flowing fast, the degree of erosion and transportation of sediments is dominated compared to the degree of deposition. Therefore, the possibility of developing sand deposits on the riverbed and at riverbanks is low. However, some small sand deposits could be observed on the bed and at the banks of river, which may have been formed during high flood periods.

3.1.4.5 Potential of having natural disasters

One landslide has been observed in the vicinity of the outlet of the intake tunnel, while no landslide in the proposed dam site, reservoir area, main tunnel and powerhouse site.

Location:	Left bank of the Kelani River approximately 200 meters downstream of the proposed dam site
Assumed size:	length = 300 m, width =200 m, depth=10~35 m
Descriptions:	Toe of the landslide is approximately 5~10 meters above riverbed level

The other remarkable landslides and past slope failures were observed in the left bank of the Kelani River approximately 700 meters downstream from the confluence Maskeliya Oya and Kehelgamu Oya, although they are outside of the structural foundations in the Project.

The following two landslide areas were observed in the project area:

1) Left bank of the Kelani River approximately 200m downstream of dam site

   Length = 300 m, Width =200 m, Depth=10~35 m (m (assessed value)

2) Left bank of the Kelani River approximately 700m downstream from the confluence of the Maskeliya Oya and Kehelgamu Oya

This area consists of three parts as below though these are outside of the proposed facilities.

Length=300 m, width=200 m, depth=20-30 m (assessed value)

Length=550 m, width=200-250 m, depth=15-35 m (assessed value)

Length=550 m, width=200-250 m, depth=15-35 m (assessed value)

3.1.5 Hydrology and water resources

3.1.5.1 River system and watercourses

The River system and watercourses of the Kehelgamu Oya, the Maskeliya Oya and the Kilani River are shown in Fig. 3.1.

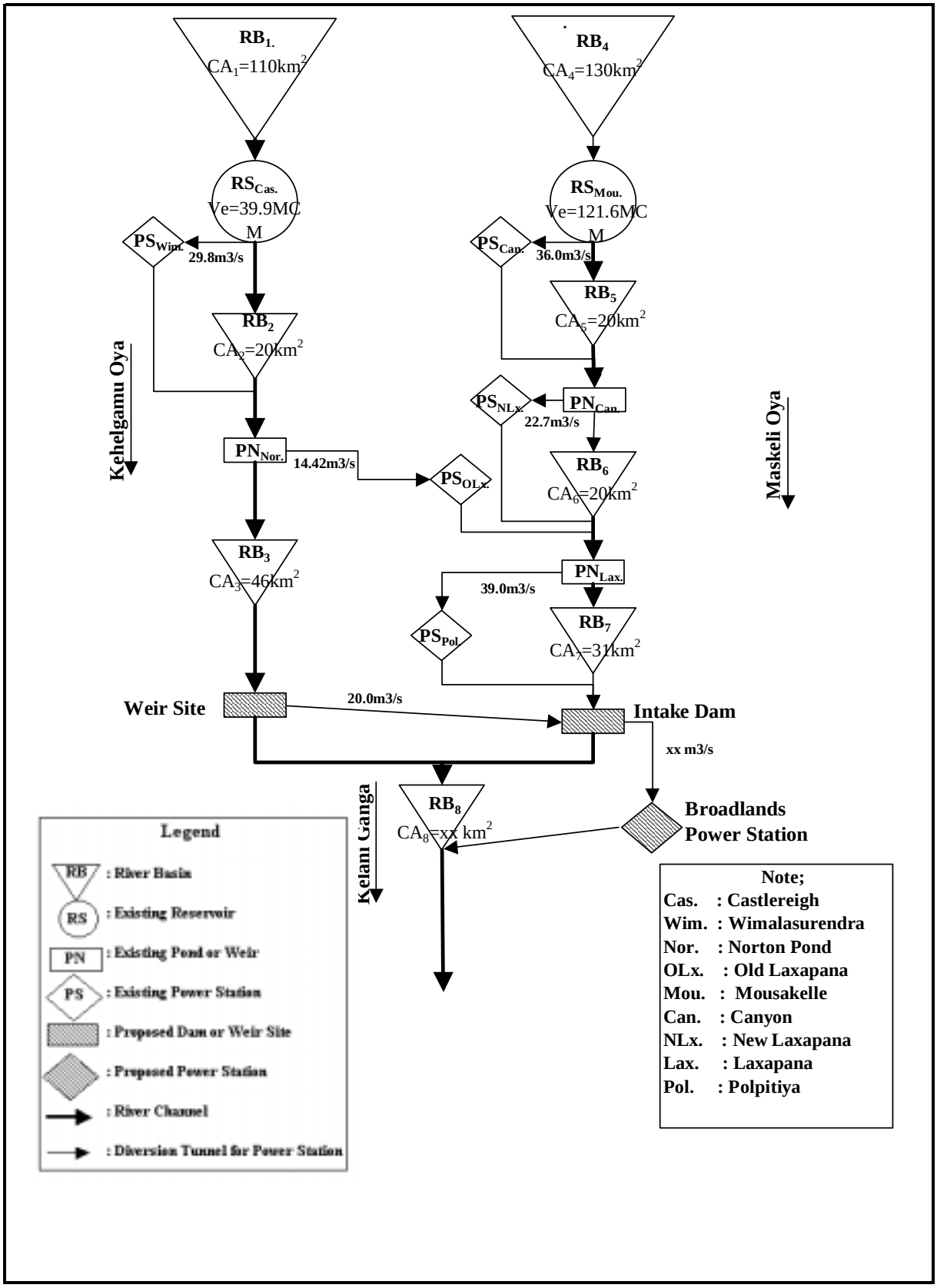


Fig. 3.1 River system and watercourses

3.1.5.2 Flood in the past

The highest flood level and peak discharge observed for the entire observation series at Kitulgala observation station has occurred on 1989-05-30 at 17.15. The height was 8.29 m (Gauge zero is at 52.72m above MSL), and the discharge was 1,936 m^3/s.

Inundated area was calculated with a computer program, "HEC-RAS". Conditions of calculation are as follows.

- Cross sections of the river: Topographical survey in 2002 by CECB
- Boundary of calculation:

  Kelani Ganga : Kitulgala gauging station (downstream boundary)

  Maskeliya Oya : Planned dam site (upstream boundary)

  Kehelgamu Oya : Planned weir site (upstream boundary)

- Boundary condition of calculation :

  Water Level: 61.01m MSL (the recorded maximum at Kitulgala gauging station)

  Discharge: 1,936m^3/sec (ditto)

The result of calculation shows that the inundated area before implementation of the project is about 591,000m2 (see Table 3.8).

After implementation of the project, because of impoundment of water in the reservoir, the inundated area will be increased by 37,693m2 (the water surface area of the reservoir at WL.121.0m) to about 638,000m2. However, the inundated area downstream of the dam and weir is not increased.

Table 3.8 Inundated Area before Implementation of the Project

Reach	River Sta	Section	Q (m^3/s)	W.S. Elev (m)	Top Width (m)	Chnl Length (m)	Inundated Area (m^2)	Remarks
Kehelgamu	CT-66	107	1,936	122.88	41.79	101.29	4,179.2	(Weir axis)
Kehelgamu	CT-67	106	1,936	117.73	40.73	134.69	5,911.5	
Kehelgamu	CT-68	105	1,936	114.02	47.05	63.85	5,480.6	
Kehelgamu	CT-69	104	1,936	111.98	124.62			
Maskeliya	CT-12	52	1,936	110.08	51.81	95.74	6,419.8	(Dam axis)
Maskeliya	CT-13	51	1,936	107.8	82.3	93.4	13,795.6	
Maskeliya	CT-14	50	1,936	105.63	213.11	144.47	26,661.2	
Maskeliya	CT-15	49	1,936	104.61	155.98	148.25	18,676.5	
Maskeliya	CT-16	48	1,936	102.98	95.98	115.86	11,115.0	
Kelan	CT-17	47	1,936	102.1	95.89	96.62	8,693.4	
Kelan	CT-18	46	1,936	101.07	84.06	103.51	7,823.3	
Kelan	CT-19	45	1,936	99.87	67.1	85.57	6,226.9	
Kelan	CT-20	44	1,936	99.44	78.44	97.95	6,718.9	
Kelan	CT-21	43	1,936	97.9	58.75	119.46	8,966.7	
Kelan	CT-22	42	1,936	95.69	91.37	147.37	16,026.5	
Kelan	CT-23	41	1,936	92.82	126.13	89.54	9,788.1	
Kelan	CT-24	40	1,936	89.34	92.5	88.46	8,705.3	
Kelan	CT-25	39	1,936	88.05	104.32	230.07	24,627.8	
Kelan	CT-26	38	1,936	86.55	109.77	95.99	11,947.9	
Kelan	CT-27	37	1,936	84.15	139.17	96.11	12,620.2	
Kelan	CT-28	36	1,936	81.91	123.45	73.08	7,791.1	
Kelan	CT-29	35	1,936	81.48	89.77	108.19	7,605.2	
Kelan	CT-30	34	1,936	79.56	50.82	91.98	7,491.8	
Kelan	CT-31	33	1,936	79.47	112.08	120.3	11,860.4	
Kelan	CT-32	32	1,936	78.22	85.1	125.45	11,203.3	
Kelan	CT-33	31	1,936	77.56	93.51	101.88	10,401.9	
Kelan	CT-34	30	1,936	77.94	110.69	88.6	8,710.7	
Kelan	CT-35	29	1,936	76.18	85.94	104.77	9,662.9	
Kelan	CT-36	28	1,936	75.6	98.52	91.8	9,591.3	
Kelan	CT-37	27	1,936	75.58	110.44	102.89	8,716.3	
Kelan	CT-38	26	1,936	73.66	58.99	102.18	6,708.6	
Kelan	CT-39	25	1,936	72.66	72.32	110.95	8,134.9	
Kelan	CT-40	24	1,936	71.46	74.32	112.59	9,142.3	
Kelan	CT-41	23	1,936	70.96	88.08	86.8	6,625.0	
Kelan	CT-42	22	1,936	68.44	64.57	94.7	6,633.7	
Kelan	CT-43	21	1,936	68.02	75.53	96.26	7,582.9	
Kelan	CT-44	20	1,936	67.63	82.02	110.15	11,499.7	
Kelan	CT-45	19	1,936	67.82	126.78	58.47	6,921.7	
Kelan	CT-46	18	1,936	66.63	109.98	147.54	16,863.8	
Kelan	CT-47	17	1,936	65.61	118.62	108.32	14,519.8	
Kelan	CT-48	16	1,936	65.48	149.47	98.45	14,516.0	
Kelan	CT-49	15	1,936	65.59	145.42	79.56	8,423.0	
Kelan	CT-50	14	1,936	63.45	66.32	109.11	8,331.1	
Kelan	CT-51	13	1,936	62.51	86.39	80.59	10,851.0	
Kelan	CT-52	12	1,936	62.53	182.9	112.72	15,920.6	
Kelan	CT-53	11	1,936	61.66	99.58	126.65	26,102.6	(Tailrace)
Kelan	CT-54	10	1,936	62.15	312.62	73.72	18,090.2	
Kelan	CT-55	9	1,936	62.12	178.16	124.12	17,449.4	
Kelan	CT-56	8	1,936	61.56	103.01	109.81	13,090.5	
Kelan	CT-57	7	1,936	61.56	135.41	63.57	7,456.4	
Kelan	CT-58	6	1,936	60.99	99.18	74.85	7,855.1	
Kelan	CT-59	5	1,936	60.96	110.71	86.88	9,908.7	
Kelan	CT-60	4	1,936	61.05	117.39	123.77	14,210.7	
Kelan	CT-61	3	1,936	61.14	112.24	109.7	10,774.2	
Kelan	CT-62	2	1,936	60.95	84.19	56.4	5,999.8	
Kelan	CT-63	1	1,936	61.01	128.57			(Kitulgara GS)
Total						**5,615.0**	**591,031.0**	

3.1.5.3 Existing irrigation and flood protection schemes

As a flood protection scheme, there is Mousakelle Dam, located upstream of Maskeliya Oya and its main features are as follows:

- Catchment area: 130 km^2
- Surcharge capacity: 23.43MCM

- Design flood inflow: 1,982 m^3/s
- Design flood outflow: 1,302 m^3/s

There are no existing irrigation schemes.

3.1.5.4 Surface water quality

The water quality measurement in the river was done so as to establish a baseline set of water quality data for water body. It was done on the border of the study area and at the locations where water quality may be affected by the Project. The river discharge was measured at the same time at the same locations since the discharge may also be changed by the Project, and there is a close relationship between twater quality and river discharge. It was judged that there is no need to measure the river discharge at stations 1, 2 and 9, as the river discharges in these locations will not be affected by the project actions. The border of the study area on Maskeliya Oya is 2.0 km upstream from the proposed dam site, but the point was not accessible, and instead about 2.5 km upstream from the proposed dam site was selected. The locations of water quality and discharge measurement are as shown in Table 3.9 and Annex 2.

A total of eleven(11) water quality parameters were decided as suitable indicators to assess the degree of water quality impairment. They included temperature, pH, conductivity, turbidity, dissolved oxygen, total dissolved solids, total suspended solids, biological oxygen demand, total nitrogen, total phosphate and fecal coliforms.

Table 3.9 Locations of water quality and discharge measurements

Station No.	Location	Coordinates (km)	Catchment Area (km^2)	Water Quality	River Discharge
1	About 2.5 km upstream of the proposed dam site (Maskeliya Oya)	68/01(165.340 * 195.540)	-	○	-
2	About 2 km upstream of the proposed weir site (Kehelgamu Oya)	68/01(166.000 * 198.150)	-	○	-
3	At the proposed dam site (Maskeliya Oya)	68/01(164.680 * 197.600)	199.26	○	○
4	At the proposed weir site (Kehelgamu Oya)	68/01(164.750 * 198.030)	166.44	○	○
5	Downstream of confluence of Maskeliya Oya and Kehelgamu Oya	68/01(163.670 * 198.230)	372.75	○	○
6	Middle point between Station 5 and Station 7	68/01(162.450 * 198.750)	375.70	○	○
7	Downstream of the Broadlands tailrace channel	68/01(160.900 * 198.750)	382.15	○	○
8	At the Kitulgala gauging station	68/01(164.800 * 198.960)	383.00	○	○
9	About 5 km downstream from the Broadlands tailrace channel	67/05(156.070 * 199.990)	-	○	-

Table 3.10 shows the water quality data of the rivers in dry season, wet season and the intermediate season.

Table 3.10 Water Quality Data

Parameter	Station number									Standards for minimum quality *	Standards for drinking water with simple treatment *
	1	2	3	4	5	6	7	8	9		
Temperature (^{0}C)	25.6 25.5 26.3	23.4 23.8 25.1	24.0 23.4 25.0	25.6 25.2 26.4	22.6 23.8 23.5	24.0 24.1 23.4	24.2 24.3 24.1	23.8 24.8 24.0	24.7 25.2 29.1	-	-
PH	6.4 6.9 7.6	6.1 6.9 7.9	6.5 6.8 8.1	6.7 7.2 7.9	6.9 7.1 7.6	6.2 7.1 7.6	6.3 7.2 7.8	6.1 7.2 7.6	6.8 6.9 7.3	5.0-8.5	6.5-8.5
Conductivity (µs/ cm)	40 98 43	52 98 56	29 31 28	50 93 54	29 36 30	30 36 29	29 37 28	27 37 30	28 35 27	7 x 10^4	-
Turbidity NTU	3 1 8	1 1 3	4 3 56	11 3 5	3 2 16	6 2 14	4 2 26	8 3 5	9 3 71	-	-
Dissolved Oxygen (mg/l)	7.1 7.5 7.4	7.3 7.1 7.5	7.3 7.0 7.4	7.1 7.1 7.4	7.7 7.4 7.4	7.6 7.0 7.2	7.4 6.6 7.3	7.5 6.6 7.2	7.3 6.7 7.2	3 (min)	6 (min)
TDS (mg/l)	50 67 43	41 70 74	30 25 26	44 58 44	33 51 16	57 29 45	40 15 57	30 46 39	35 38 4	-	-
TSS (mg/l)	3 2 5	2 5 <1	4 1 5	2 4 2	1 3 25	2 2 29	1 4 30	3 5 33	4 2 30	-	-
BOD (mg/l) 5d, 20 C	<1 0.6 0.3	<1 <0.1 0.6	<1 0.4 0.4	<1 0.4 0.6	<1 0.5 0.6	<1 0.3 0.3	1.1 0.2 0.5	1.1 0.1 0.9	<1 0.1 1.2	4 (max)	2 (max)
Total Nitrogen as N (mg/l)	< 2 < 2 < 2	< 2 < 2 < 2	< 2 < 2 < 2	< 2 < 2 < 2	< 2 < 2 < 2	< 2 < 2 < 2	< 2 < 2 < 2	< 2 < 2 < 2	< 2 < 2 < 2		
Total Phosphorus as P (mg/l)	0.003 0.004 0.026	0.005 0.006 0.020	0.003 0.014 0.027	0.004 0.023 0.019	0.021 0.004 0.024	0.025 0.016 0.034	0.011 0.002 0.037	0.017 0.006 0.041	0.017 0.004 0.025	0.7(max)	-
Fecal coliform (No of Colonies /100 ml)	85 75 133	304 135 260	127 85 74	163 65 92	155 93 158	175 115 102	85 116 178	95 167 188	215 177 198	-	250 des 600 max ** P=80%

Upper Column: Sampled during 26-28 October 2002 (intermediate season)
Middle Column: Sampled during 05-07 February 2003(dry season)
Lower Column: Samples during 25-26 May 2003(wet season)

* Environmental Quality Standards and Designation of water use in Sri Lanka- June 1992
Max = Maximum permissible level
Des. = Desirable highest level
** P=80% = 80% of the samples give a value that is equal to or less than the indicated limit

In Sri Lanka, designated use classes for water bodies are not declared yet, hence one unified set of pollution laws are applicable to water bodies in the whole island. However, a set of water quality norms cited as 'environmental quality standards and designation of water uses in Sri Lanka' prepared by the CEA/BKH Consulting Engineers 1992 have been proposed for inland surface water bodies of the country.

This defines 7 water use categories, namely, nature conservation, drinking water sources with simple treatment, bathing and water recreation, fisheries and protection of aquatic life, drinking water source with conventional treatment, irrigation and other agricultural uses and finally a general minimum quality class that makes water suitable for various other uses.

Based on the proposed standards, it can be stated that in all the nine (9) locations the water quality test results indicate very low levels of pollution. The waters of two streams are the well-oxygenated, cool waters with very low levels of solutes both organic and inorganic and very low levels of nutrients in all 9 locations. Hence, they support a natural medium for living and reproduction of fauna and flora that have a narrow range of tolerance to pollutants. The low levels of fecal coliform count when compared to other rivers, indicate lesser impact of human on the river water quality although there are

land clearings, a human disturbance in the catchments.

The low values for pollutants can be due to number of reasons, of which the following three reasons may be considered as important for the study area:

- The rich vegetation cover in the riverbank and tributaries and the catchments of the river act as an efficient filter for pollutants. Hence, many diffused pollutants are retained in the catchments without directly entering the water body.
- The steep gradient of the river and riverbed morphology provide ample aeration to degrade most pollutants entering the water body while keeping ambient levels of pollutants low.
- The rainfall data for the month of September indicates three (3) peak spells just before the sampling. These spells may have washed off and diluted the pollutants received by the system. Also, for the month of February the rainfall is low. Therefore, the level of pollution coming from the runoff is low. A series of sampling representing the seasons is necessary to obtain the actual quality status of the system.

3.1.5.5 Discharge measurement

The river discharge was measured using the standard methodology known as mid-section method at the six (6) points. The results are given in the Table 3.11.

Discharge during dry season (Feb.) is much less than that during wet season (Oct.) by 11%- 60%, but the water quality during dry season is not poor significantly. Therefore, it may be said that the water quality is not so deteriorated even when discharge is low.

Table 3.11 Measured Discharges at Each Station

Station	Date	Time	Cross sectional Area of flow (m^2)	Discharge through the section (m^3/sec)
3	2002-10-26	1000	67.42	25.10
	2003-02-05	1600	63.86	14.89
	2003-05-25	0700	70.66	19.32
4	2002-10-26	1600	24.54	9.53
	2003-02-05	1200	16.15	1.05
	2003-05-25	1100	20.70	3.10
5	2002-10-27	1100	88.61	34.98
	2003-02-06	0800	86.05	16.62
	2003-05-26	1000	108.47	36.46
6	2002-10-28	0800	91.66	35.42
	2003-02-06	1500	85.95	17.97
	2003-05-26	1600	99.55	37.80
7	2002-10-28	1200	59.19	36.26
	2003-02-07	0800	50.56	21.77
	2003-05-25	1500	56.00	25.41
8	2002-10-28	1500	99.98	36.35
	2003-02-07	1200	90.25	21.88
	2003-05-25	1700	96.63	25.89

3.1.5.6 Ground water level of the study area

A considerably high number of groundwater springs is originated from the forest and the home gardens. It is propounded that two factors; 1) Presence of steep slopes and 2) Properties of soil of the area and highly fractured rocky ground conditions may affect the fluctuation of the ground water table.

The two boreholes were completed on the gentle slopes on the right bank for groundwater measurement. A borehole was drilled on the steep slopes in the left bank. Further, another borehole drilled for geological sudy on the left bank was selected for groundwater measurement. The

measurement points are shown in Annex 2.

Table 3.12 Details of boreholes

Borehole mark	River bank	Coordinates		Height above MSL (m)	Depth (m)	Remarks
		N	E			
BR1	Right	198106	164264	108.088	12.00	
BR2	Right	198072	164256	106.526	12.00	
BL1	Left	198086	163921	134.730	16.10	
MT1	Left	198006	164037	124.787	34.40	for geological study

The river water level was also gauged so as to study the relationship between groundwater level and river water level. A gauging point at the river was identified in a flat area of the river closer to the boreholes where measurement can be conducted by fixing a gauge on a steady boulder. The location of the gauging point is shown below.

- N: 198058 E: 164199
- Height of the river bed above MSL(m): 96.109

Measurement of groundwater levels in the said boreholes and the river water level is carried out basically fortnightly in the study period. The results are shown in Table 3.13 and Fig.3.2.

Table 3.13 Measured groundwater and river water levels

Unit: m (height above Mean Sea Level)

Date (2003)	BR1	BR2	BL1	MT1	River
Mar.11	101.05	98.32	123.73	105.05	96.83
Mar.25	100.99	101.45	124.84	110.21	96.82
Apr.10	101.59	98.62	123.86	113.46	96.90
Apr. 23	104.94	99.84	124.05	115.87	96.98
May07	105.34	102.62	124.21	113.86	98.10
Jun.29	104.57	103.57	124.17	111.31	97.40
Jul.30	104.10	99.42	123.40	115.08	97.05
Aug.17	106.74	101.16	125.44	111.21	97.09
Sep.19	99.91	95.06	124.08	105.32	97.32
Sep.30	105.93	95.12	123.51	106.74	97.45
Oct.14	102.66	95.21	123.72	106.57	97.42
Oct.31	98.80	95.17	123.84	104.84	97.50
Nov.13	98.86	95.08	121.49	105.45	97.35
Nov.26	99.76	95.08	124.02	105.37	97.55

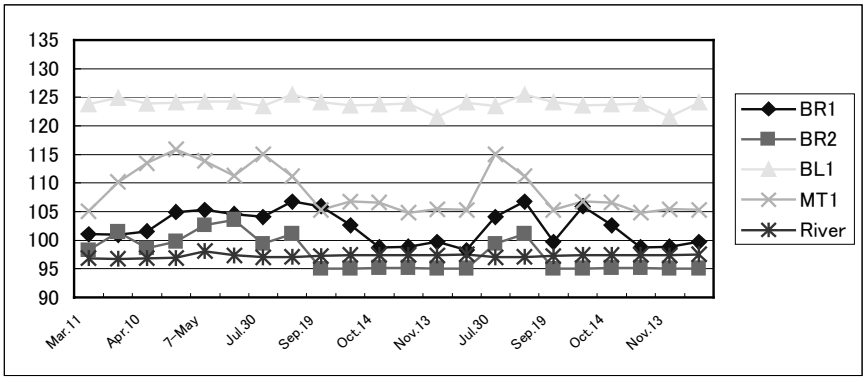


Fig 3.2 Measured groundwater and river water levels

The followings can be estimated based on the results.
- The groundwater level of the right bank holes, BR1 and BR2, showed almost concordant moving, which shows the existence of one aquifer of groundwater on the right bank.
- The groundwater level of the left bank holes, MT1 and BL1, showed discordant movements each other, which shows that two aquifers may exist on the left bank.
- There seems to be low correlation between the river water level and each hole's groundwater level.

Existing ground water distribution

Mainly the rainfall recharges the groundwater table in the study area. The well-grown vegetation cover found on either side of the riverbanks effectively intercepts the rainfall. The litter/humus layer characteristic to these forests has the ability to sponge much of the rainfall while controlling the rate of runoff and also recharge the ground water reserves.

In the study area the soil is in a colluvium bed with varying thickness. The presence of clay suggests the moderate permeability and water holding capacity of soils. Usually in metamorphic terrains, also characteristic to the study area, the groundwater occurs in several aquifer systems, in which the subsurface groundwater mostly occur in several purged aquifers or shallow water bearing systems either connected or separated with each other or else with the river water table and/or the deep-seated aquifer pockets. The existing fracture zones in the study area, which lie across the tunnel trace, are a likely path, which interlinks the subsurface ground water and deep-seated aquifers.

The area receives relatively a high rainfall throughout the year. As the catchments are a draining river basin, the groundwater table recharge by the river is considered negligible. In this basin, the runoff and a part of the groundwater drain into the river through streamlets and springs. During wet periods, the number of springs that appear on the slopes in both sides of the riverbanks is large and during the dryer months, this number is limited to a few. The natural catchment character makes the quality of water suitable for stringent water uses. In addition, the subsurface groundwater is important to the growth of riparian vegetation, of which the forest cover on the left bank is important.

Behavior of groundwater cannot be established by the groundwater studies due to inadequacy of spatial and temporal data on the ground water table and furthermore, the river flow is more dependent on the release of water from the two hydropower reservoirs, due to which the flow varies diurnally.

3.1.5.7 Ground water stratification and permeability

Fig.3.3 shows possible schematic profiles based on the above results and estimate.

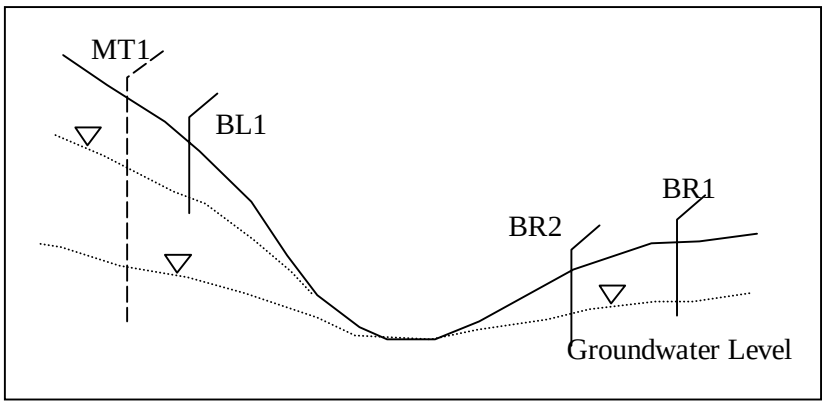


Fig.3.3 Schematic profiles of the groundwater in the survey area

Permeability data exists only for MT1. Water pressure teat was performed at the boring section between 30-35.54 m at MT1. Coefficient of permeability was 6 x 10^{-6}cm/sec. As for other holes, the permeability can be estimated based on the grain size of the soil to some extent.

3.2 Ecological resources

3.2.1 Special characteristics of the study area

In the study area, the dense vegetation cover of the surrounding mountains provide an ideal setting to intercept water vapor rich clouds and infiltrate rain water. The precipitation retained in the organic litter and surface layers of the soil forms several springs from steep slopes and thus maintains water flow of steams and tributaries during periods of less rainfall. Therefore, the proposed project site could be described as a cool, humid (average annual mean exceeding 85%) watershed environment, which also provides numerous favorable habitats for several plant and animal species.

Except in few patches where bedrock is exposed that no soil could be retained due to steepness, the entire mountain range is covered with vegetation either forested or planted. This helps to stabilize the slopes and minimize further erosion of the soil. The study area does not include any ecologically sensitive areas, marsh , wetlands or riverine forests.

3.2.2 Flora

3.2.2.1 Zone-1 and Zone-2

(1) Species composition

A total of 190 plant species belonging to 157 genera and 74 plant families are identified from Zone-1 including aquatic vegetation, which only counts 3 plant species. Out of the total plants listed, 57 species are recorded from home gardens while 66 species were common to both home gardens and forests. These not only included species common to the wet zone, but also some timber species such as *Melia azedarach* (Lunu- midella), and *Adenanthera pavonina* (Madatiya) that are abundant in the dry zone. Only 64 plant species are confined to forest patches. This reveals that these will be the plant species that could possibly be the remaining species of natural vegetation. This is not surprising since there is clear evidence for the secondary origin of vegetation in the study area. The majority of the plants are tree species, which accounted for 109 species (Table 3.14). A total of 194 plant species are identified in Zone-2. The composition is similar to that in Zone-1. Plants list in Zone-1 and Zone-2 is in Annex 3.

Table 3.14 Species composition in Zone-1 and Zone-2

	Zone-1					**Zone-2**				
	Endemic	Threatened	Introduced	Naturalized	**Total**	Endemic	Threatened	Introduced	Naturalized	**Total**
Tree	17	5	44	47	**109**	18	3	37	51	**109**
Shrub	6	0	4	24	**36**	7	0	8	24	**39**
Herb	2	0	5	18	**29**	2	1	7	13	**23**
Climber	6	1	2	11	**16**	4	1	4	10	**19**
Epiphysis	0	0	0	0	**0**	0	0	0	4	**4**
Total	31	6	55	100	**190**	31	5	56	102	**194**

(2) Endemism

Out of the identified plant species 28 species (17 trees, 6 shrubs, 3 climbers and 2 herbs) are endemic plants of Sri Lanka (Table 3.15). That is approximately 15% of the total species. Generally, wet zone natural forests of Sri Lanka exhibit about 23% endemism. Thus, the endemism in the study area seems to be low probably due to disturbances. Except for five (5) endemic species *Artocarpus nobilis* (Bedi del), *Cinnamomum dubium* (Wal kurundu), *Dipterocarpus hispida* (Bu hora), *Garcinia quesita* (Rath goraka), *Pothos hookeri* which occur both in homegardens and forests, all the other plant species (23 species) are confined to the forest. Majority of these are recorded from both the proposed powerhouse, dam and weir sites. *Sterculia zeylanica* was found only at dam and weir site while *Gordonia speciosa* and *Dipterocarpus zeylanicus* (Hora) were recorded only from the proposed

powerhouse site.

Table 3.15 Endemic plants found from the study site

Plant Family	Plant species
Acanthaceae	*Strobilanthes calycina Nees*
Anacardiaceae	*Mangifera zeylanica (Blume) Hook. f.*
Ancistrocladaceae	*Ancistrocladus hamatus (Vahl.) Gilg*
Araceae	*Lagenandra species. Dalz.*
Bombacaceae	*Pothos hookeri Schott*
	Cullenia ceylanica (Gardner) K. schum
Celastraceae	*Bhesa ceylanica (Arn. ex tHw.) Ding Hon*
Clusiaceae	*Garcinia quaesita Pierre*
Dipterocarpaceae	*Dipterocarpus hispidus Thw.*
	Dipterocarpus zeylanicus Thw.
Lauraceae	*Cinnamomum dubium Nees*
Melastomataceae	*Axinandra zeylanica Thw.*
	Memecylon clarkeanum Cogn.
	Memecylon varians Thw.
	Memocylon rivulare Bremer.
	Memocylon rostratum Thw.
	Sonerila silvatica Lundin
Moraceae	*Artocarpus nobilis Thw.*
	Ficus fergusoni (King) Worthington
Myristicaceae	*Horsfieldia iryaghedhi (Gaertn.). Warb*
Myrtaceae	*Syzygium cylindricum (wight) Alston*
Pandanaceae	*Freycinetia pycnophylla Solms*
	Pandanus ceylanicus Solms
Poaceae	*Ochlandra stridula Moon ex Thw.*
Rhizophoraceae	*Anisophyllea cinnamomoides Gaedner (Champion) Alston*
Rubiaceae	*Wendlandia bicuspidata (wight & Arn).*
Sterculiaceae	*Sterculia zeylanica Kosterm.*
Theaceae	*Gordonia speciosa (Gardner.) Choisy*

(3) Threatened plants

According to International Union of Conservation of Nature, IUCN (2000) the term ‘threatened plants’ denotes species which are (i) endangered (plants which are in danger of extinction and whose survival is unlikely) (ii) vulnerable (plants likely to become extinct in the near future) and (iii) rare (plants restricted to small geographically areas or small populations at a risk). Plant species that are suspected but not definitely belong to any of the above categories have also been included under the collective name ‘threatened plants’, shown with 'T' on the 'Taxonomic Status' column in Annex 3. Among the identified species of this study, there are 6 threatened plants, all of which are recorded from forests and the occurrence is tabulated in Table 3.16.

Table 3.16 List of threatened plants recorded

Plant Species	Occurrence			Remarks
	Weir & Dam area (Zone-1)	Powerhouse area (Zone-1)	Zone-2	
Pericopsis mooniana (Nedun)	+	+		highly threatened timber
Coscinium fenestratum (Weni wel)	+	+	+	globally threatened medicinal
Syzyguim cylindricum	+	+	+	threatened
Dipterocarpus zeylanicus (Hora)		+		threatened
Gordonia speciosa (Ratu-mihiriya)		+	+	threatened
Sterculia zeylanica	+			threatened
S.lanceolatum			+	threatened
Cryptocoryne sp			+	threatened (aquatic)

It was noticed that some of these threatened plants were at a relatively young age and occur in isolation. *Pericopsis mooniana* and *Dipterocarpus zeylanicus* trees were good examples. This suggested that they had been planted a few years ago by the inhabitants.

The study revealed the presence of one endangered orchid species, *Dendrobium macrostachyum* in Zone-1, of which trade has been banned according to the Convention on International Trade of Endangered Species (CITES) list prepared for Sri Lanka.

(4) Usage of plants

The plants are used by the inhabitants for several purposes. Some species provide supplementary food items and spices while some are used for medicinal purposes. Some of the climbers are used for packing while timber species provide the wood resource.

Table 3.17 Utilization of plants in the Zone-1

	Beverage	Food	Latex	Medicine	Packing	Religious purpose	Spice	Timber
Tree	3	25	1	9	4	3	4	12
Shrub	-	1	-	6	2	3	-	-
Herb	-	2	-	5	1	-	1	-
Climber	-	1	-	4	2	1	1	-

(5) Types of vegetation

Comparatively, the vegetation of proposed dam and weir site is highly disturbed due to the construction of the Polpitiya Power Station and CEB quarters. Thus, the area adjoining the southern bank of Kehelgamu Oya does not exhibit any kind of above vegetation types. However over the northern bank of the Kehelgamu Oya scanty patches of forests, home gardens and tea and rubber plantations occurs. The land associated with the southern bank of Maskeliya Oya of proposed dam and weir site exhibits some riverine vegetation, scrublands, home gardens and plantations. This area is the highly populated zone within the limits of the Zone-1. Therefore, no forests are reported from this area. The proposed powerhouse area is relatively rich in vegetation. Especially the occurrences of forest patches are more abundant.

The following vegetation types could be recognized within Zone-1.

Forests

There was no evidence for a continuous forest cover within the limits of the Zone-1. Instead, forest patches were found in connection with plantations, home gardens and scrublands. These do not cover a long distance.

In general the forest patches reach a maximum height about 15m and are able to stratify into canopy, sub canopy, shrubs and an undergrowth. The absence of the emergent as in the case of natural wet zone forests indicate the secondary origin and/or perhaps exploitation of the emergents (generally the Dipterocarps) by the villagers over the time. The canopy layer consists of trees that reach about 10-15m including most of timber species such as *Alstonia* species (Hawari nuga and Rukatthana), *Caryota urens* (Kitul), *Areca catechu* (Arecanut), *Trema orientalis* (Gedumba), *Artocarpus* species (Jak/ Del). The sub canopy layer is about 5-10m high and consists of some timbers such as *Vitex pinnata* (Milla), *Ficus* species (Nuga), *Humboltia laurifolia* (Gal Karanda), *Mangifera indica* (Mango), *Macaranga peltata* (Kenda), *Bredalia retusa* (ketakela), etc., and saplings of the canopy species. Forest shrubs include a scanty vegetation about 1.0 - 1.5 m high which includes species such as *Clidemia hirta* and *Panicum maximum, Lantana camera* (Gandapana) occasionally. The height of tree layers varied with the location of the study area. The forest undergrowth is a semi-decomposed litter layer, which accommodated mosses such as Selaginella species and Pogonatum species.

Table 3.18 Classification of the trees according to their canopy structure

Classification	Main plants
Canopy layer (10-15m)	Alstonia species (Hawari nuga and Rukatthana), Caryota urens (Kitul), *Areca catechu* (Arecanut), *Trema orientalis* (Gedumba), Artocarpus species (Jak/ Del)
Sub canopy layer (5-10m)	*Vitex pinnata* (Milla) Ficus species (Nuga) *Humboltia laurifolia* (Gal Karanda) *Mangifera indica* (Mango) *Macaranga peltata* (Kenda) *Bredalia retusa* (ketakela)
Forest shrubs	*Clidemia hirta* *Panicum maximum* *Lantana camera* (Gandapana)

Home gardens

The homegardens indicates a state of wilderness rather than of horticulture as they imitate a forest. Unlike plantations, all trees have not been planted and thus their distribution is not in a systematic manner. But the high densities of trees and the stratification of their canopies maintain the forest outlook. The homegarden is meant to grow on its own with unevenly distributed trees, shrubs of different age. The combination of species varies due to the selection according to human requirements as a home garden provides men with daily needs for a family. Therefore, homegardens are not entirely uniform.

Homegardens seen in the study area exhibit the vertical stratification as the canopy, sub canopy, shrubs and the herbaceous undergrowth. In general, canopy is dominated by the members of the plant family Arecaceae and also by the timber trees. The sub canopy consists of woody trees, many of which are food trees. *Persea americana* (Avocado), *Mangifera indica* (Mango), *Garcinia mangostina* (Mangosteen) are good examples. The shrub layer generally consists of woody species that reach a height about 2m such as *Coffea arabica* (Coffee), Citrus specie, etc.

Plantations

Patches of tea, rubber plantations are found in between the other vegetation types. Unlike the monoculture rubber plantations, tea plantations also accommodated species such as *Gliricidia sepium*, Albizia sp, Alstonia species as wind breakers.

Scrublands

Scrublands can be considered as an intermediate stage of forest succession commonly occurs at the boundaries of forests or towards homegardens or riverine vegetation. These have reached a height about 3-5m and consist of a canopy and shrub layer. *Trema orientalis* (Gedumba), *Gliricidia sepium* (Weta heeriya), *Macaranga peltata* (Kenda) are some of the tree species, which reach the canopy layer. Shrubs such as *Elattaria cardomomum* (Cardamom), *Clidemia hirta, Panicum maximum, Hibiscs furcatus* (Napiritta), *Osbeckia octandra* (Heen bovitiya) and saplings of the canopy species occur densely within these scrublands.

Riverine vegetation

The banks of Maskeliya Oya and its tributaries are almost rocky, often naked or covered with creepers such as *Mikania cordata* (Wathu palu), *Wedelia chinensis* (Ranwan keekiridiya),

Commelina diffusa (Gira pala) that extend from the adjacent areas. The riverine vegetation of the study area is confined to 2-10m wide strip of land either side of Maskeliya Oya. Parts of these lands are still being used for corridors / footpaths by the villages. Thus in some places as seen in the southern bank of Maskeliya Oya at the proposed powerhouse site (adjoining area of Kataran Oya) the river bank extends to a flat area dominated with grasses such as Axanopus species. In contrast, as seen in the proposed Dam site, the riverbank restricts to a narrow strip of land dominated by shrubs and creepers.

The shrubs include *Osbeckia octandra, Ludwigia perennis* (Wel karabu), *Pandanus zeylanicus, Freycinetia pyenophylla* (Keiya), *Oclandra stridula* (Bata), ferns such as *Nephrolepis, Blechnum, Blechnum, Dicranopteris liniaris* etc. Several Ficus species and other trees such as *Barringtonia racemos* (Diya midella), *Dillenia indica* (Hondapara) *Humboltia laurifolia* (Gal Karanda) occurred more closer to the Oya. The undergrowth of riverine and associated scrubland vegetation consists of scattered saplings of the trees often covered with creepers such as *Mikania cordata* (Wathu palu).

Aquatic vegetation

The reported aquatic vegetation consists of only 3 plant species. The aquatic vegetation is categorized into submerged plants and floating plants. The submerged plants could be the ones that are totally immersed/grow inside the water. These could be micro or macro plants attached to the bottom of the water body or to the banks.

Since Maskeliya Oya is a fast flowing water body, submerged and floating plants are not found from the Zone-1 of the proposed project site. Plants not really submerged but associated with the bank are Lagenandra species (Ketala), *Pandanus zeylanicus* and *Blyxa auberti*. The distribution of these plants are neither abundant nor regular as they are only found in few locations adjoining the river bank within the limits of Zone-1.

3.2.2.2 Zone-3

The flora of Zone-3 is quite similar to that of Zone-1 and Zone-2. Mosaics of home gardens, scrublands and rubber plantations contribute for the terrestrial vegetation of the northern parts of Zone-3. The southern part of Zone-3 seems much more rocky and includes patches of forests. Scanty patches of tea plantations and paddy cultivations are prominent towards the western range of Zone-3 while home gardens, forests and scrublands cover the eastern hills of the Zone-3. The riverine vegetation, which could be considered as a narrow strip of land either side of Maskeliya Oya, is dominated by scrublands. The banks of Maskeliya Oya and its tributaries are rocky except for few locations.

3.2.3 Fauna

(1) Background

In order to study terrestrial faunal diversity the line transect method was used, while to evaluate the fishery resource and fishing activities, interview survey method was utilized. A total of 17 line transect surveys were carried out in the study area. Some of the line transects were done twice during daytime and nighttime in order to record nocturnal species. A rough habitat map was constructed based on these observations. The taxonomic status of the species present was determined according to the latest literature published on the fauna and flora of Sri Lanka. The conservation status of the species was determined according to IUCN list of threatened fauna and flora and species listed in the CITES appendices. The following two publications were used to determine the global and national status respectively.

- Hilton-Taylor, C. (Compiler) (2000) *2000 IUCN Red List of Threatened Species*. IUCN, Gland, Switzerland and Cambridge, UK xviii + 61 pp.
- IUCN Sri Lanka (2000). *The 1999 List of Threatened Fauna and Flora of Sri Lanka*. Colmbo:

IUCN Sri Lanka viii + 114 pp.

(2) Existing Natural Habitats of Fauna

The main types of habitats observed during the survey can be divided to terrestrial and aquatic fauna. The terrestrial habitats are included tropical rain forest, riverine forest, plantations, open grasslands and home gardens. Home gardens in the area can be further categorized into two types as home gardens containing high percentage of cultivated tree species and home gardens containing a high percentage of forest tree species. Aquatic fauna inhabits mainly the river system (Kehelgamu Oya and Maskeliya Oya) and the associated streams.

(3) Rare, Threatened and Endemic Faunal Species

The area contains a variety of habitats as described above and therefore, supports a high biodiversity rich in endemic species. During the survey period a total of 150 species including 31 endemic species was recorded (Table 3.18).

Table 3.19 Summary information about the species in the study area

Taxonomic group	Total	Endemic	Threatened	Introduced	Migrant
Odonata (dragon fly)	3	2			
Lepidoptera (butterfly)	32	2	5		
Gastropoda (gastropod)	7	4	3	1	
Ostichthyes (fish)	10	4	3	1	
Amphibia (amphibian)	11	4	3		
Reptilia (reptile)	12	4	4		
Aves (bird)	67	10	9		7
Mammalia (mammal)	8	1	3		
Total	150	31	30	2	7

The respective distribution of these species in the three identified zones is given in Table 3.20.

Table 3.20 Summary information of the faunal distribution

Taxonomic Group	Zone-1 (Powerhouse)					Zone-1 (Weir and Dam)					Zone-2 & 3				
	T	En	Tr	In	Re	T	En	Tr	In	Re	T	En	Tr	In	Re
Odonata (dragon fly)	3	2	-	-	-	2	1	-	-	-	1	1	-	-	-
Lepidoptera (butterfly)	22	1	3		9	5	1	2	-	1	20	1	4	-	7
Gastropoda (gastropod)	6	3	2	1	1	3	3	3	-	-	5	2	2	1	-
Ostichthyes (fish)	8	3	2	1	4	3	2	1	-	-	5	3	2	-	-
Amphibia (amphibian)	5	1	1	-	3	8	4	3	-	6	2	-	-	-	-
Reptilia (reptile)	5	1	1	-	1	2	-	-	-	1	10	4	4	-	6
Aves (bird)	41	6	5	4*	10	45	6	6	5*	7	45	6	6	5*	7
Mammalia (mammal)	4	-	-	-	3	1	-	-	-	-	5	1	2	-	4

Remarks:

T : Total number En : Endemic species Tr :Threatened species
In : Introduced species Re : Species that are found only in this zone *: Migratory species.

This includes 16 species of aquatic species, which consist of 1 species of gastropod snail, 10 species of fish and 5 species of Ranid frogs. In addition, number of aquatic associates were also observed. These include 3 species of dragonflies, 9 species of birds and 1 species of mammal (Table 3.21).

Table 3.21 List of aquatic species and Aquatic associates in the study area

Scientific name	Common name	Zone-1	Zone-2 & 3
True Aquatic Species			
Gastropod mollusks			
Paludomus sp.	Freshwater snail		
Freshwater fish			
Puntius dorsalis	Long snouted barb		
Puntius pleurotaenia	Black lined barb		+
Puntius sinhala	Filamented barb	+	+
Garra ceylonensis	Stone sucker	+	+
Tor khudree	Marsheer		
Rasbora carveri	Carveri rasbora		
Schistura notostigma	Banded loach	+	
Poecilia reticulata	Guppy	+	
Lepidocephalichthys thermalis	Common spiny loach	+	
Awaous melonocephalus	Scribbled goby	+	
Frogs			
Limnonectes limnocharis	Paddy field frog	+	
Limnonectes corrugatus	Corrugated frog	+	
Limnonectes kirtisinghei	Kirtisinghe's frog	+	
Euphlyctis cyanophlyctis	Skipper frog	+	
Rana temporalis	Common wood frog	+	+
Aquatic associates			
Dragon flies and Damsel flies			
Euphaea splendens	Damselfly	+	+
Vestalis apicalis	Damselfly	+	
Trithemis aurora	Dragon fly	+	
Birds			
Phalacrocorax niger	Little cormorant	+	
Casmerodius albus	Large egret	+	
Egretta grazetta	Little egret	+	
Ardeola grayii	Pond heron	+	
Bubulcus ibis	Cattle egret	+	
Amaurornis phoenicurus	White breasted water hen	+	
Alcedo atthis	Common kingfisher	+	
Halcyon capensis	Stork billed kingfisher	+	+
Halcyon smyrnensis	White throated kingfisher	+	+
Mammals			
Lutra lutra	Otter	+	

A total of 31 endemic species (approximately 20% of all the species recorded) were recorded in the study area during the study period indicating that this area is rich in endemic species (Table 3.22). Highest number of endemicity was recorded among birds (9 species). Out of the study area, 23 endemic species were recorded from powerhouse and weir and dam site (Zone-1) while 19 endemic species were recorded from the surrounding areas (Zone- 2 and Zone-3).

Table 3.22 List of endemic fauna observed during the survey

Scientific name	Common name	Zone-1	Zone-2 & 3
Dragon flies and damsel flies			
Euphaea splendens	Damselfly	+	+
Vestalis apicalis	Damselfly	+	
Butterflies			
Troides darsius	Common birdwing	+	+
Mycalesis rama	Cingalese bush brown	+	
Molluscs			
Paludomus sp.	Freshwater snail		
Acavus superbus		+	+
Acavus sphoenix		+	
Oligospira waltoni		+	+
Freshwater fish			
Puntius pleurotaenia	Black lined barb		+
Puntius sinhala	Filamented barb	+	+
Garra ceylonensis	Stone sucker	+	+
Schistura notostigma	Banded loach	+	
Frogs			
Adenomus kelaartii	Kelaart's dwarf toad	+	
Limnonectes corrugatus	Corrugated frog	+	
Limnonectes kirtisinghei	Kirtisinghe's frog	+	
Rhacophorus cf. microtympanum	New Species?	+	
Reptiles			
Calotes liolepis	Forest lizard		+
Otocryptis wiegmanni	Kangaroo lizard	+	+
Cylindrophis maculates	Pipe snake		+
Oligodon sublineatus	Kukri snake		+
Birds			
Gallus lafayettii	Sri Lanka jungle fowl	+	+
Galloperdix bicalcarata	Sri Lanka spur fowl	+	
Loriculus beryllinus	Lorikeet	+	+
Psittacula calthropae	Layards parakeet	+	+
Ocyceros gingalensis	Grey horn bill	+	+
Megalaima flavifrons	Yellow fronted barbet	+	+
Pellorneum fuscocapillum	Brown capped babbler	+	
Turdoides rufescens	Rufous babbler	+	
Dicoeum vincens	Legge's flowerpecker		+
Urocissa ornate	Blue magpie		+
Mammals			
Macaca sinica	Toque monkey		+

A total of 30 threatened species were recorded from the study area including two globally threatened species (Table 3.23). Out of the study area 23 threatened species were recorded from powerhouse and weir & dam site (Zone-1) while the 19 species of threatened species were recorded from the surrounding areas (Zone-2 and Zone-3).

Table 3.23 List of threatened fauna observed during the survey

Scientific Name	Common Name	NT	GT	Zone-1	Zone-2 & 3
Butterflies					
Troides darsius	Common birdwing	TR		+	+
Vindula erota	Cruiser	TR		+	+
Parthenos Sylvia	Clipper	TR		+	+
Mycalesis rama	Cingalese bush brown	HT		+	
Mycalesis visala	Tamil bush brown	TR		+	+
Molluscs					
Acavus superbus		TR		+	+
Acavus phoenix		TR		+	
Oligospira waltoni		TR		+	+
Freshwater fish					
Puntius pleurotaenia	Black lined barb	TR			+
Garra ceylonensis	Stone sucker	TR		+	+
Schistura notostigma	Banded loach	TR		+	
Frogs					
Adenomas kelaartii	Kelaart's dwarf toad	TR		+	
Limnonectes corrugatus	Corrugated frog	TR		+	
Limnonectes kirtisinghei	Kirtisinghe's frog	TR		+	
Reptiles					
Calotes leolephis	Forest lizard	TR			+
Otocryptis weigmani	Kangaroo lizard	TR		+	+
Cylindrophis maculates	Pipe snake	TR			+
Oligodon sublineatus	Kukri snake	TR			+
Birds					
Galloperdix bicalcarata	Sri Lanka spur fowl	TR		+	
Loriculus beryllinus	Lorikeet	TR		+	+
Psittacula calthropae	Layards parakeet	TR		+	+
Tockus gingalensis	Grey horn bill	TR		+	+
Megalima flavifrons	Yellow fronted barbet	TR		+	+
Pellorneum fuscocapillum	Brown capped babbler	TR		+	
Turdoides rufences	Rufous babbler	TR	LR:nt	+	
Dicoeum vincens	Legge's flowerpecker	TR			+
Urocissa ornata	Blue magpie	TR	EN		+
Mammals					
Ratufa macroura	Giant squirrel	TR	VU		+
Prionailurus viverrinus	Fishing cat	TR	LR:nt	+	
Lutra lutra	Otter	TR		+	

Remarks

T: Threatened HT :Highly Threatened LR: Lower Risk near threatened

A total of 7 migrant species were recorded during the survey (Table 3.24). All seven species are migrant birds. Other studies have recorded several species of migrant fish such as eels and gobies. However, during this study no migrant fish species were recorded. During the survey, no special faunal migration paths were recorded.

Table 3.24 List of migratory birds observed during the survey

Scientific name	Common name	Zone-1	Zone-2 & 3
Pitta brachyura	Indian pitta		+
Hirundo rustica	Barn swallow	+	
Motacilla flava	Yellow wagtail	+	
Lanius cristatus	Brown shrike	+	+
Phylloscopus trochiloides	Greenish tree warbler	+	+
Acrocephalus dumetrorum	Blyth's reed warbler	+	
Muscicapa daurica	Brown flycatcher	+	+

(4) Animal movement pathways and migratory routs of birds

During the survey, neither animal movement pathways/corridors nor migratory routes/habitats of birds were recorded.

3.2.4 Forest and other natural protected areas

(1) Administrative framework

Nearly all the natural forests in the country are state-owned. They are jurisdictive over two Institutions, the Forest Department and the Department of Wild Life Conservation. Most of the natural forests that are administrated by the Forest Department have been designated as Forest Reserves or proposed Forest Reserves. The Forest Reserves are proclaimed reserves by gazette notification, which have been land- marked and set apart permanently to forestry.

The Kelani Valley Forest Reserve is now proposed. At present, the actual extent of Kelani Valley has not been clearly demarcated, but the forested mountain range extending towards south from the south bank of the Maskeliya Oya is going to be included.

The administrative structure for the proposed Kelani Valley Forest Reserve is shown in Fig 3.4. Since the forests of the study area are located in two districts, Kegalle and Nuwara Eliya, two District Forest Officers, one from Nuwara Eliya and the other from Kegalle are responsible for the proposed Forest Reserve. Usually all state-owned forest land is under the administrative control of Forest Department, and the Conservator of Forests, appointed by the Government, is provided with all powers to attend to all matters related to forests. Yatiyantota Range Forest Officer will monitor the enforcement of rules and regulations.

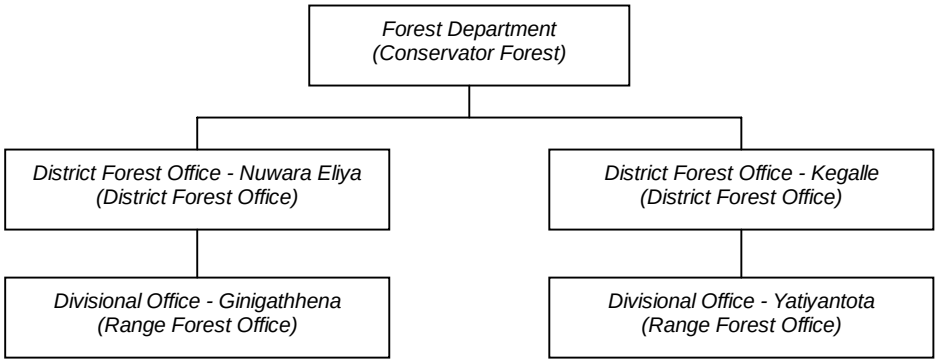


Fig.3.4 Administrative structure for the proposed Kelani Valley Forest Reserve

As far as the forested area of the proposed project is concerned, several encroachments have taken place in the past few decades and thus settlements have come up in the edges of the forest. Ownership of a part of these settlements was given to the occupants under the government Jayabhumi Deed Scheme in the past while the rest of the forest is operated as a Village Forest. In Jayabhumi, lands were given to the occupants for a hundred-year period, during which the occupants or their heirs can occupy the lands but cannot sell them. After the period, the occupants or the heirs will become legal owners of these lands.

All matters related to forests are subjected to the Forest Ordinance 16 /1907 and the amended Act 13/1966 including subsequent amendments made the last being Act No. 23 of 1995. The Act prohibits all destructive resource extractions of the forest including clearing of vegetation for any purpose. The villages are permitted to use forest for non-destructive extraction of resources on written permission granted by an authorized Forest officer. Such activities include tapping of Kitul for production of treacle, educational visits, bird watching and extraction of any other material from the forest. Removal of timber other than dead firewood is strictly prohibited. All construction activities, alteration of water resources, setting fire, quarrying and mining among others within the forest are also strictly prohibited under the Forest Ordinance.

(2) Deforestation

Apart from using the forest lands within the limits of Zone-1 and Zone-2 for home gardens, plantations, small cropping systems, there have been few recent observations of illicit felling of trees. The extraction of timber of these forests is carried out only by the Forest Department and there is no indication of utilization of the forest for timber. Illegal encroachment for housing or any type of mass clearing of forestland is not occurring at present. Such clearings are not observed even within the settlements within forest as the law prevents it.

However, the biodiversity of forests and scrublands at the edges are frequently disturbed due to the fact that it provides corridors and footpaths for transportation. Human inhabitance also influenced the construction of roads, footpaths, commercial buildings, power projects, schools etc. at the vicinity of the forests within Zone-1.

(3) Afforestation

Home gardens and plantations contributed for the afforestation of the Zone-1 and Zone-2. The forest outlook is maintained by the home gardens as they are equipped with high densities of trees with different heights.

3.3 Human Environment

3.3.1 Administrative divisions and demographic characteristic

The study area lies on two provinces. One part where the planned weir and the dam lies on Ambagamuwa Korale Divisional Secretariat Division (DSD) in Kegalle District under the Sabaragamuwa Province. The other part where the powerhouse comes are in Yatiyantota DSD and Deraniyagala DSD in Kegalle District under Central Province.

A questionnaire survey of each household was conducted as shown below. Almost all the description in the following sections is based on the results of the above survey.

Zone-1: All the housing units =215

Zone-2: Sample housing units = 221 (36.5 % of the total housing units)

The population by age group and gender is shown below. Economically disadvantageous and handicapped people are not found in Zone-1 at present.

Table 3.25 Population by age group and gender

Age level	Zone-1			Zone-2		
	Total	Male	Female	Total	Male	Female
<5	76	35	41	64	29	35
6 -15	142	74	68	158	77	81
16 -20	115	56	59	85	40	45
21 -25	107	43	64	94	42	52
26 -35	154	67	87	193	105	88
36 -55	203	106	97	202	88	114
56 <	83	37	46	131	73	58
Total	880	418	464	927	454	473

The race distribution is summarized below.

Table 3.26 Race distribution

Race	**Zone-1**		**Zone-2**	
Sinhara	863	98.1 %	921	99.1 %
Tamil	17	1.9 %	6	0.9 %
Total	880	100.0 %	927	100.0 %

3.3.2 Socio economic conditions

(1) Income levels, distribution and sources

Income level of about 60% in both Zone-1 and Zone-2 ranged between Rs. 5,000 and Rs. 15,000. Income level of 29% in Zone-1 and 26% of Zone-2 are less than Rs. 5,000 per month. Income distribution is given below.

Table 3.27 Income level distribution

	Zone-1		**Zone-2**	
	No. of households	**%**	**No. of households**	**%**
<5,000 (Rs/month)	48	22.3	53	24.0
5,001 - 10,000	60	27.9	65	29.4
10,001 - 15,000	40	25.5	53	24.0
15,001 - 20,000	7	3.3	18	8.1
20,001 - 25,000	7	3.3	4	1.8
25,001 - 30,000	3	1.4	4	1.8
30,001 <	4	1.9	6	2.7
No response	46	21.4	18	8.1
Total	**215**	**100.0**	**221**	**100.0**
Average	10,063 Rs/month		11,378Rs/month	
Median	7,850 Rs/month		8,000 Rs/month	

The income source distribution is as below.

Table 3.28 Income source distribution

Source	Share in total income (%)	
	Zone-1	Zone-2
Main Occupation	78.8	84.9
Sub-occupation	4.2	6.2
Transfers from abroad	5.8	0.9
Rental income	3.7	0.0
Government Transfers	1.5	2.1
Home garden produce	0.7	3.3
From NGOs	0.6	0.4
Other sources	4.7	2.2
Total	**100.0**	**100.0**

(2) Household expenditure by use category

Expenditure of about 60% in both Zone-1 and Zone-2 ranged between Rs. 2,500 and Rs. 7,500. Expenditure distribution is given below.

Table 3.29 Household expenditure

	Zone-1		Zone-2	
	No. of households	%	No. of households	%
< 2,500 (Rs/month)	8	3.4	16	7.2
2,500 - 5,000	53	24.7	69	31.2
5,001 - 7,500	72	33.5	58	26.2
7,501 - 10,000	30	14.0	29	13.1
10,001 -12,500	21	9.8	22	10.0
12,501 - 15,000	4	1.9	9	4.1
15,001 <	5	2.3	14	6.3
No response	22	10.2	4	1.8
Total	**215**	**100.0**	**221**	**100.0**
Average	6,708 Rs/month		7,515 Rs/month	

Table 3.30 shows the distribution of household expenditure. The highest expenditure is food, and the second highest expenditure is transportation with the share of 8-9% in both Zone-1 and Zone-2. The expenditure on education, medicine and clothing is also significant in the both areas.

Table 3.30 Household expenditure

Expenditure Item	Share in total expanse (%)	
	Zone-1	Zone-2
Food	60.9	57.7
Rent	0.3	0.1
Water	0.1	0.1
Electricity	2.8	2.5
Clothes	6.6	5.0
Transport	8.8	8.4
Education	7.0	6.4
Medicine	6.5	5.5
Loan Repayment	4.0	8.6
Entertainment	0.9	1.9
Others	2.1	3.9
Total	**100.0**	**100.0**

(3) Employment by sector

Labour force participation can be estimated as below based on the population of 10 years and above in respective Zones.

Table 3.31 Labour force participation

	Zone-1	Zone-2
Population of 10 years and above: (a)	742	774
Labour force participation: (a) x 49.6%	368	384

Remark: Labour force participation rate in rural sector is 49.6% (Source:'Bulletin of Labour Force Statistics- 1st quarter 2003)

Table 3.32 shows employment by sector. Out of the employed people, employment in agriculture, forestry and fishery sectors account for 40-42% in both Zone-1 and Zone-2. The construction sector closely follows accounting for 14-15% in both areas. The size of the whole work force is not known.

Table 3.32 Employment by sector

Sector	Zone-1		Zone-2	
	No. of Persons	%	No. of Persons	%
Agriculture	58	39.7	75	41.7
Agriculture, forestry and fishing	58	39.7	75	41.7
Manufacturing	34	23.3	47	26.1
Manufacturing	6	4.1	13	7.2
Construction	20	13.7	27	15.0
Electricity, gas and water	8	5.5	7	3.9
Services	54	37.0	58	32.2
Wholesale, retail trade and restaurant	9	6.2	12	6.7
Public Administration and defense	13	8.9	13	7.2
Transport, storage and communications	11	7.5	10	5.6
Finance, Insurance and Real Estate	5	3.4	4	2.2
Community and Social Services	4	2.7	7	3.9
Others	12	8.2	12	6.7
Total	**146**	**100.0**	**180**	**100.0**

(4) Agriculture activities

Main agricultural activities in both Zone-1 and Zone-2 are cultivation of plantation crops such as tea, rubber, and coconut, minor export crops such as pepper and clove, cultivation of fruits and vegetables and home gardening. Other perennial crops such as jak, butter fruit and arecanut are also cultivated. Total extent under plantation crops and minor export crops has been estimated to be 26.9ha (66.5 acres). Paddy cultivation was negligible in the study area. Usage of fertilizer and agro chemicals are at minimum levels and mainly used for tea.

(5) Fishery activities

Fishery activities as a source of income are not prominent in the study area. There are 22 households in Zone-1 and 16 households in Zone-2, who engage in fishery activities. However, only 4 households indicate that they are engaged in fishing for an income. Fishing is reported downstream as well as between the dam/weir site and powerhouse tailrace, the to-be affected area due to the Project. However, those households who do fishing for an income use the downstream. Anda, Petiya, Korali, Lulla and Magara are the kinds of fish catch in the river.

(6) Use of natural resources

Use of natural resources is at minimal level except for firewood.

As for forest, over 90% of households in Zone-1 and 77% in Zone-2 use firewood mainly for cooking purpose, but large quantity of firewood is also found in home gardens. The estimated quantity of firewood used per year is 2,000 m^3 (for 197 households) in Zone-1 and 1,500 m^3 (for 151 households). It has also been observed that forest is being used for hunting of wildlife, but it is an illegal activity and exact number of persons engaged in hunting is not reported. In addition, a few households use nearby forest for timber, medical plants and kitul.

There are 17 households who indicated river sand mining mainly for house construction, and 4 business entities that engaged in manufacture of cement-based products, and mining river sand is needed for their business.

(7) Indigenous/local industries

Manufacture of kithul products using trees in the nearby forest and reservation areas has been an indigenous industry in the study area. There are 3 households in Zone-1 engaged in the manufacture. Further, there is one household in Zone-1 engaged in woodcarving.

(8) Business characteristics

A field survey on business was conducted covering all business activities in Zone-1. Of the total businesses, 43% or 16 entities, including 2 tea shops and 2 eating places, were grocery stores. Total employment in businesses in Zone-1 (excluding owner's labour) has been estimated at 76, of which 54% was family workers. Type of businesses and employment are shown in Table 3.33

Table 3.33 Type of Businesses and Employment in Zone-1

Type of Business	Number of Entities	Number of Workers			
		Permanent	Casual	Family workers	Total
Grocery stores	16	1	5	20	26
Bricks & Cement based products	4	7	0	0	7
Lath machines and welding	1	0	1	1	2
Garage & service stations	1	0	1	1	2
Timber / firewood	2	0	10	0	10
Grinding mills	1	0	0	7	7
Exercise books & printing work	1	0	0	1	1
Farms	2	0	0	3	3
White water rafting	2	6	4	0	10
Other	7	0	0	8	8
Total	**37**	**14**	**21**	**41**	**76**

The average sales revenue per business entity is Rs. 42,688 per month. There are 4 business entities, whose monthly sale revenue exceeds Rs. 100,000 per month. Distribution of sales revenues is shown in Table 3.34.

Table 3.34 Distribution of sale revenue

Sales Revenue per month (Rs)	No. of Entities	%
< 1,000	1	2.7
1,001 - 5,000	11	29.7
5,001 - 10,000	4	10.8
10,001 - 20,000	6	16.2
20,001 - 30,000	1	2.7
30,001 - 40,000	2	5.4
40,001 - 50,000	4	10.8
50,001 – 100,000	4	10.8
100,001 <	4	10.8
Total	**37**	**100.0**

Main customer of about 70% of businesses are people living in the same area, while about 13% of businesses cater to people living in adjacent villages and towns as well.

Table 3.35 Type of customers

Type of Customers	No of Businesses	%
People in the same area	27	69.2
People in adjacent villages & towns	5	12.8
Local and foreign tourists	4	10.3
Public and private institutions	2	5.1
Other	1	2.6
Total	**39**	**100.0**

Special Needs for Businesses

There are two businesses based on timber / firewood extracted from the nearby forest. River sand is being used by 4 businesses engaged in manufacture of cement based products. These businesses were also reluctant to relocate their business. Many businesses are using electricity from the national grid for lighting and other purposes. The two white water rafting companies are based on the river stretch flowing through the study area.

Option for Resettlement

Of the 37 businesses in Zone-1, nine(9) entities have indicated that their businesses can not be relocated mainly due to difficulties in finding a suitable alternate place. Of the total, 22 businesses have opted for relocation, but subject to provision of fairly suitable alternate place. The balance six (6) businesses have opted for relocation, without indicating any specific condition. About half of the businesses have indicated the loss of customers as the major constraint for relocation. The businesses based on timber / firewood have indicated the difficulty of obtaining licenses for a new place, as the location is crucial for granting licenses for such activities.

3.3.3 Existing settlement and land use forms

Existing settlement is summarized in Table 3.36(at the end of this chapter). Land use forms are described in '3.1.3.Land use pattern' and, house/homestead occupy 19.7% and 27.1 % in the weir/dam site and powerhouse site in Zone-1 respectively as shown in Table 3.2. The ownership of those lands is shown in Table 3.37. Around 64% of households own their homesteads. In the other side, around 16% of households are encroachers. The 19 families who did not respond to the question also could be identified as encroachers.

Table 3.37 Ownership of homestead

Type	No. of households	Share (%)
Private land (owned)	137	63.7
Private land (rented)	4	1.9
Governmental quarters	21	9.8
Encroachment (Government estate land)	26	12.1
Encroachment (reservation)	8	3.7
No response	19	8.8
Total	**215**	**100.0**

3.3.4 Existing infrastructure facilities and use

(1) Water supply and water use

There is no water supply scheme in the study area. Almost all the households presently take water from natural springs in the surrounding hills. Some of the residents, either individually or collectively, tap suitable springs or streams in the higher levels by connecting water pipes to their households to take water. Water availability and source are shown in Table 3.38.

Table 3.38 Water availability and water source

Zone-1					Zone-2				
Available	NA	Source			Available	NA	Source		
		Stream /Spring	Well	River			Stream /Spring	Well	River
215	0	159	13	215	215	6	195	20	0

NA: Not available

The water in the stretch in the study area is extracted for irrigation of crops by very few individual farmers during dry periods. There is no irrigation systems operated or proposed for the Kelani river basin in this area. Water is not extracted for any production based industrial activities in the river stretch under consideration.

(2) Sanitation

In Zone-1 area 82 % of housing units have some kinds of toilets. Out of those 147 households have water sealed toilets and other have pit hole toilets. Although some households do not have toilet facilities but the people of these households use toilets which belong to their parents. Toilet availability and the type are shown in Table 3.39.

Table 3.39 Toilet availability and type

Zone-1				Zone-2			
Available	NA	Type		Available	NA	Type	
		Water sealed	Pit hole			Water sealed	Pit hole
176	39	147	29	196	25	185	11

(3) Electricity

Electricity is available in 132 households (61.4%) in Zone-1 and 165 households (74.4%) in Zone-2. Others use kerosene lamps. Majority of people use wood as fuel for cooking, and some use kerosene for that.

Table 3.40 Electricity availability

Zone-1		Zone-2	
Available	NA	Available	NA
132	83	165	56

(4) Transport

The main road bordering the study area is Colombo - Ginigathena road (national highway A7, Awissawella-Hatton-Nuwara Eliya road). This road has two (2) lanes with a width of 5.5m. The past traffic counts are listed below. These values are averaged from one-week traffic counts excluding extraordinary traffic conditions.

Table 3.41 Traffic counts

Year	1990	1996	1998
Count in vehicles per day	420	670	1141

Source: Road Development Authority

There is no plan for immediate upgrading because the traffic in this road is considered to be low. The proposed powerhouse will be linked with this main road via a new access road and a bridge.

The road to Polpitiya (B189, Kalugala-Polpitiya road) links the national highway A7 to the area proposed for dam and weir sites. This road is also a low traffic road and the only available traffic count is 272 per day taken at Kalugala in 1996. The proposed dam site in Maskeliya Oya will be linked to this road via a new access road.

Other than those, there is road leading from Polpitiya to Laxapana, the B25.

(5) Communication

Postal service is available and post office is situated within Zone-2. Telephone is not in common use in both Zone-1 and Zone-2 as shown below.

Table 3.42 Telephone availability and type

Zone-1				Zone-2			
Available	NA	Type		Available	NA	Type	
		Ordinary	Mobile			Ordinary	Mobile
18	197	13	5	21	177	21	0

(6) Schools

There is no school in Zone-1.There is one school named Polpitiya Primary School in Zone-2. Laxapana Central School and Ginigathhena Maha Vidyalaya, both of which have primary and secondary schools, are located in Zone-3.

3.3.5 Water right and fishery right

The people in the study area do not have water rights or fishery rights. They only have access to the natural resources traditionally.

3.3.6 Current development trends and growth

In terms of the provincial level development and plan, the Sabaragamuwa Provincial Council has identified the Kitulgala area as a place of tourist attraction and in fact it can be observed that Kitulgala

area is a developing area where local and foreign tourists are attracted in large numbers. However, no specific development project proposal has been developed on that.

Yatiyanthota Pradesiya Sabha in Yatiyantota DSD, a local authority in the project area, has approved a development plan for this area in 2001. This plan has identified an area close to the proposed powerhouse site at the left bank of the river for development, to conserve it as a bird sanctuary. This is also still in a planning stage.

In terms of agriculture, there are no major or minor projects proposed in this area. Tea small holding projects are also not available.

No highways have been proposed in this area. In addition, there are no plans available presently on housing schemes, township development or industrial development parks.

3.3.7 Mineral extraction

Sand is the only construction material presently extracted from the study area. However, extraction is restricted as only a few individuals are working. This low level of extraction is due to two reasons. First reason is that the river sand extraction is controlled by the Mineral & Mining Act of the country., and only a limited number of permits is issued. Second reason is inaccessibility to existing sand deposits. The accessible extraction sites are located close to proposed weir site and both the upstream and down stream of the river at the discharge point of the Kataran Oya. Both of them are very small-scale traditional sand mining sites, which are operated by one or two persons. This is done occasionally. After every heavy rainy season, the rate of accumulation of sand deposits increases as result of sudden increase of debris load transported by the stream. However, after the establishment of dam and weir structures, accumulation of sand deposits at these two sites would be changed.

Stone aggregates

Currently operating quarry sites are not situated inside and close to the study area (Zone-1 and Zone-2). However, there had been a very small-scale quarry site. Boulders, which were removed from the Colluvium overburden, are currently used in crushing stone aggregates for construction activities to make rubble and metal.

3.3.8 Tourism

Historic Archeology

Within the two divisions, Yatyantota and Ambagamuwa Korale there are number of archaeologically important places. The evidences of history are as old as during the period of King Nissanka Malla (12th century A.D.) and from then a series of historical evidences are identified by the Archeological Department as archeologically important sites. The archeologically important sites in the study area are given in the Table 3.43. The location of these site are shown in Annex 4 Tourism map.

Table 3.43 List of Archeologically important sites in the study area

Archeologically / Culturally important site	Approximate direct distance
Belilena, Kitulgala	2km N from the main river
Sri Sudharshanaramaya, Kitulgala	2.2 km NW from the Confluence of the Kataran Oya
Pilimalena Raja Maha Viharaya, Theligama	4.7km NW from the confluence of the Kataran Oya
Shaila Bimbaramaya, Ginigathhena	2.6 km NE of weir of the Kehelgamu Oya
Liyantota Devalaya, Ginigathena	1.4km SE of the weir of Kehelgamu Oya

Cultural and heritage tourism

Both local tourists and foreign tourists visit cultural and heritage places and those of religious worship.

Archeologically important sites in the country are also a main attraction of foreign tourists. Many tourists and pilgrims who travel to Siripada, the sacred mountain that is also referred to as the Adam's Peak and other places of worship located in the Central Province take the Colombo-Ginigathhena route. Excursion to prehistoric archeological site at Belilena, Kitulgala is also an event popular among tourists who visit Kitulgala.

The Project is to be located on one of the main routes (Colombo - Ginigathhena) to a famous cultural event called Siripada Pilgrimage. The season begins in December and ends in May. Sri Sudharshanaramaya, located in the Kitulgala town is important in this cultural event as the monks and the pilgrims who take part in the ceremony with the holy statue are offered alms food at this temple. In addition, this temple is a resting place for other pilgrims who worship Siripada. A part of the route to Siripada, from Kitulgala to Polpitiya is situated within the study area.

The 'Bridge on the River Kwai' film site

The world famous film 'Bridge on the River Kwai' shot at Kitulgala 300m east from the Kataran Oya confluence. Now only the ruins of the bridge exist after being blown up in the film. There is no statistic data and the number of tourists who visit the site is unknown. However, this location has been identified in the provincial tourism plan, in which it has been proposed to develop tourism attractions based on this film site.

Natural tourism

The proposed project site between Kitulgala to Polpitiya is located in the margins of central highlands. Tourists, who visit upcountry travel via Kitulgala, pass the project location. Most of them stay in Kitulgala for a short duration, one to two days in the hotels and use restaurants in the area. Many tourists specifically select this route when traveling to central highlands due to a number of reasons. The eye catching pictorious scenic value in the environment, facilities for short stays, and activities for recreation are some among them. As a result, hotels, restaurants, and commercial activities related to tourism, both permanent and seasonal, have come up in the study area.

The proposed Kelani Valley Forest Reserve, which covers the mountain range in the south (left) riverbank, has a rich biodiversity. The endemic biodiversity specially with respect to birds feature attracts both local and foreign tourists. Hence, bird watching, mountain hiking and trekking are the main entertainment activities in the location linked to tourism. In Kitulgala, Makandawa Kurulukele (a part of the this forest falls within the study area and the closest border of the forest is about 500m west from the confluence of Kataran Oya) bird watching safari is one of the popular tourist attractions included in package tours.

There are no waterfalls along the stretch of the river from proposed weir and dam sites to the powerhouse site. Only Makulu Ella (fall) is located within the study area on the tributary of the Kelani River.

Adventure tourism such as mountain climbing, hiking, riding, trekking, etc are becoming popular recreational activities among the local and foreign tourists. Also water sports such as swimming, diving and bathing among the entertainment activities linked to water recreation in the Maskeliya Oya, Kehelgamu Oya and the main river. Occasionally, tourists entertain game fishing.

Whitewater rafting

There are three whitewater rafting companies operating in Kitulgala and provide the services for whitewater rafting and other water sports. They are Adventure Lanka Sports Private Limited, Rafter Retreat Limited and Wild holiday, and the activity is popular among tourists. This sport is carried out in the river from 10 to 12 hours on weekdays and from 14 to 16 hours in holydays. The duration of the activity is about 1 to 2 hours. The activity is low during the dry periods. The stretch of the river from a point of about 1 km below the Polpitiya Powerhouse up to the suspension bridge at Kitulgala (about 3 km) provides an ideal setting for whitewater rafting sports activity.

Swimming and bathing

Several places in the main river and Kehelgamu Oya are used for bathing by tourists and largely by the pilgrims to Sripada. Out of them most popular bathing site is located near Kitulgala rest house, 2km downstream from the Kataran Oya confluence. An area consisting of rock pools located about 500m upstream from the Kataran Oya confluence and about 150 m downstream from the proposed weir are also used bating and swimming by local tourists.

3.3.9 Air quality, noise and vibration

Seven locations were identified for the active sampling of ambient SO_2, NO_2, NO, O_3 and Suspended Particular Matter (SPM). Monitoring was done on 8 hourly basis except O_3 which was done 1 hourly basis. The results are given in Table 3.44. The results indicate a relatively high level of air pollution close to the Awissawella-Hatton main road indicating the vehicular emission as the major source of air pollution in the area.

Table 3.44 Results of air quality monitoring

	SO_2	**NO_2**	**NO**	**O_3**	**SPM**
Standard *	120	150	-	200	350
	80	100	-		300
L1	11.01	4.09	1.46	3.49	18.18
L2	11.59	2.47	0.73	1.18	24.69
L5	12.06	4.08	1.36	0.22	12.35
L6	8.50	1.27	0.98	-	30.77
L12	11.10	2.73	1.09	-	18.18
L15	-	-	-	-	14.71
L18	11.57	2.43	1.09	-	15.92

*SO_2, NO_2,SPM: upper column: time average is 8 hr
lower column: time average is 24 hrs
O_3: time average is 1 hr

The existing noise level measurements were carried in the selected locations. The survey results show that the study area has noise levels of Leq 50-57dB(A) close to river bank, 65-70 dB(A) close to the main road and the tea factory and 45-50 dB(A) at rural areas during the daytime and night time as well. Relatively high noise at nighttime was mainly due to natural noise by wind, river flow, insects and vehicular noise. Those monitoring/measurement points are shown in Annex 5.

Table 3.45 Results of noise level measurement

	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15
Day	66	48	56	51	49	55	63	66	71	50	63	54	66	51	66
	57	45	54	49	40	54	58	64	47	48	61	52	42	41	43
Night	66	52	57	56	57	62	60	66	63	-	63	56	60	50	58
	58	50	55	54	49	54	54	65	47	-	61	53	50	47	50

Upper column: L eq =The equivalent noise level generated during the sampling period.
Lower column: L_{90}=The equivalent noise level that exceeded more that 90% of the sampling period.
Measurement date: 27th and 28th, August and 3rd and 4th, September 2003

No vibration measurement have been carried out because any vibration that is not accepted in the context of vibration

Table 3.36 Existing Settlement in the Study Area

DS Division	GN Division	Number of Villages	Total			Zone- 1			Zone - 2			Zone - 3		
			Area (ha)	Popul-ation	Housings	Area (ha)	Popul-ation	Housing Units	Area (ha)	Popul-ation*	Housing Units*	Area (ha)	Popul-ation*	Housing Units*
Ambagamuwa Korale	Dagampitiya	2	275.9	1,172	319	43.7	186	33	62.6	266	72	169.5	720	196
	Millagahamulla	7	210.1	845	253	24.4	98	22	61.4	247	74	124.4	500	150
	Polpitiya	2	473.4	1,158	332	48.0	117	87	170.7	418	120	254.7	623	179
	Kalugala	6	238.7	921	289	0.1	0	0	110.7	427	134	127.9	493	155
	Bulathgama	4	109.2	1,670	457							109.2	1,670	457
	Rampadeniya	2	17.1	1,468	366							17.1	1,468	366
	Gonawala	1	2.4	26	6							2.4	26	6
	Kehelwarawa	1	48.6	909	279							48.6	909	279
	Hettihegama	1	1.0	0	0							1.0	0	0
Yatiyantota	Kitulgala South	6	860.9	1,365	424	52.2	83	23	103.0	163	51	705.7	1,119	348
	Kalukohuthenna	5	166.9	1,363	351	28.2	230	50	27.4	224	58	111.4	910	234
	Mahabage	6	439.9	1,189	357	2.6	7	0	64.2	174	52	373.1	1,008	303
	Gonagamuwa	2	184.7	1,427	388							184.7	1,427	388
	Kitulgala North	6	489.9	1,684	352							489.9	1,684	352
	Kirikohuthenna	1	1.3	0	0							1.3	0	0
Deraniyagala	Ballehena	1	411.3	713	245							411.3	713	245
	Nilwala	1	123.8	1,403	434							123.8	1,403	434
TOTAL			**4,055.1**	**17,313**	**4,852**	**199.2**	**721**	**215**	**600.0**	**1,919**	**561**	**3,256.0**	**14,673**	**4,092**

Remark: * = Estimated

Chapter 4 ANTICIPATED ENVIRONMENTAL IMPACT

4.1 Overview

To study the significance of the impacts due to Project, the project actions were first identified. They were grouped into two main phases, the actions in construction phase and those in operational phase. Implementation of each of these main project actions will involve number of sub actions, which are responsible in triggering environmental impacts. Table 4.1 interprets the interaction between main actions and those sub actions.

Then the anticipated impacts on respective environmental items were examined taking all the project actions into consideration, and the results are shown in the following sections of 4.2, 4.3 and 4.4.

The magnitude and importance were explained numerically for respective environmental items and respective project main activities using a matrix named Leopold Matrix. Those are shown in Table 4.2 (pre-construction & construction phase) and Table 4.3 (operation phase). Tables of 4.1, 4.2, and 4.3 are shown at the end of this chapter.

4.2 Impact on physical environment

4.2.1 Land use pattern

(1) Pre-construction phase

The illegal encroachment into state lands is a common phenomenon during the pre-construction stage of many similar development projects. This impact may be anticipated in this project as well. The state lands within the project boundaries might be encroached with the prime intention of gaining compensation and those outside the boundaries will be encroached as a result of land value increasing with new road and the bridge infrastructure under the Project. Also, the low value land uses within the project boundaries may be converted to high value land uses such as conversion of scrublands to homesteads, commercial land uses, etc. with the intention of obtaining higher compensation rates. In uncontrolled situations the impact may lead to significant negative changes in these environmentally sensitive land uses.

(2) Construction phase

Forest and scrub

These land use contribute approximately 45% of the total land in Zone-1. Both construction activities in the weir/dam and powerhouse area will clear an area of forest and scrub land uses. The areas cleared will be high compared to other land uses. Overall impact on these land uses may be considered low considering the fact that the areas of land utilized for proposed project actions is comparatively small.

Homesteads

The construction of access road on the right riverbank at powerhouse site will permanently change the homesteads land use along a stretch of about 700m. Also construction of the culvert and the road between the dam and the headrace tunnel utilize the homesteads along a stretch of about 1km. Sixteen (16) houses will be demolished, of which details are described in the section ‘4.4.4 Resettlement’.

Plantation (rubber/ tea/ coconut)

The construction of facilities such as culvert between dam and the headrace tunnel will affect the tea plantations and the land uses in affected areas will be lost permanently. However, this will not lead to significant change in the said land use, as areas cleared will be small.

(3) Operational phase

The construction of the two access roads, from the national highway at weir/dam area and the powerhouse area and the construction of the bridge at powerhouse site are considered as positive factors for change in land use. Provision of motorable access infrastructure will encourage the development of settlements while increasing the homesteads land use. Hence, conversion of other land uses to homesteads may be anticipated and is considered as a significant beneficial impact in the long run.

4.2.2 Geology and soil

4.2.2.1 Impact due to erosion, siltation and sediment run-off

(1) Construction phase

Soil contamination

Large number of heavy construction machinery will be engaged in the construction. There will be two such machinery service yards, one at weir/dam and the other at the powerhouse site. If these oil and grease is released to the environment unintentionally it may contaminate the soils. Though these contaminations are localized, such soil contaminations are considered important as it may contaminate the local sources of ground water.

If the worn batteries with lead and cadmium from the construction machinery, certain construction admixtures with the label indicating toxic, the spoilt material or empty containers containing those toxic material are disposed on-site, it may contaminate the soil. Among them impact of those long-term persistence chemicals such as heavy metals, lead and cadmium, may be important as they can enter into food chains.

The explosive chemicals used in the blasting also have some effects on the soil contamination as they contain nitrogen compounds. However, they may be more important as water pollutant than soil due to its mode of action. The hydropower project does not intend to use any other hazardous or toxic chemicals. However, certain accessories and admixtures used may contain toxic substances.

Soil erosion

Slope erosion

The construction of road and temporary facilities involves excavation of topsoils and clearance of vegetation. The topsoil layer on this slopes contain soils rich in organic littler, in which the soil particles are firmly held in a well-developed root network. This system helps to maintain a gradual water infiltration and hence current soil erosion levels are very low. The low erosivity of slopes is reflected by the very low suspended solids values (less than 5mg/l) in the water quality data. The excavation during construction may remove this protective cover exposing and disintegrating the underneath thick soil overburden. The erosion in the project area is dominated by the rainfall as the area receives a high rainfall (2000mm to 5000mm), in which the kinetic energy of the raindrops falling on the soil will detach the particles from the soil surface. Also the falling raindrops compact the soil. Such compacted soils could suddenly loose their capacity to infiltrate water and when this happens, the runoff will become higher. Furthermore, since the project actions are to be carried on steep slopes erosion will be high due to high velocity (hydraulic energy) of the runoff. However, the area proposed for excavation is comparatively small, due to above mentioned reasons negative impacts of erosion are considered as insignificant.

Of the activities, construction of culvert between the dam and the headrace tunnel, the steel penstocks and the tailrace canal may be considered important in the slope erosion as the disturbances to surface cover is comparatively high.

River bank erosion

The construction of the bridge at the powerhouse side and the disposal yard at weir/dam site may clear vegetation at the river banks leading to erosion of bank. The impacts due to bridge may be considered low as not much vegetation is cleared. However, the bank erosion due to proposed disposal yard at weir/dam site and that on the right bank may be considered as locally significant as considerable extent of river bank vegetation (100m) will be cleared for this activity.

The construction of the weir, dam, two detention ponds and the tailrace canal at the powerhouse site may clear river bank vegetation and will involve excavation of the surface soil. At both the locations, the weir and dam have an exposed bedrock and part of which will be blasted to form two small detention ponds. Hence, riverbank erosion at these two points is limited to those at the surface soil layers. Similarly, impacts are little at tailrace discharge as the area to be cleared is low.

Sediment deposition

The erosion from disturbed construction yards may carry sediment rich runoff during rains. A part of the sediments in the runoff will settle on the gentle slopes and flat lands. The sediment deposition on land looses the fertility of the soil. However, the area that would be covered by deposited sediment is low due to two reasons. One is that the area of land to be cleared is small and hence cannot produce a larger sediment layer deposition. Secondly, the steepness of slopes in the project activity areas generates high potential surface runoff that could drive the sediment transport up to the river and hence impacts due to sediment depositions on land may be considered as low.

The surface soil cover of the disposal yards, which are identified temporarily, may contaminate with sediments that are contained in the spoilt materials, etc. These will be covered with sediments and hence become infertile after the construction phase. The negative impacts of this is considered important as the loss of fertility may hamper latter re-plantation of these plots.

(2) Operational phase

Soil contamination

In the operational phase the soil contamination can be considered negligible, as there would be no operation of heavy machinery.

Soil erosion

The discharge at the tailrace canal may create a new erosion section at both banks and the riverbed.

Sediment deposition

The weir and the dam will function as physical barriers against transport of sand to downstream. The anticipated impacts may be more in the Kehelgamu Oya because the existing dam of Polpitya powerhouse already functions as a barrier against sediment transport across in Maskeliya Oya. Deposition processes behind these structures will tend to stop sand supply to the downstream. However, the reduction of downstream transport of sediment would be low, as the gates at the bottom of the proposed dam will be opened regularly to release sediments.

Passage of water through tunnel system may reduce peak flow along the river section between the dam and the powerhouse sites. These reduced flows will decrease flushing intensity of the river system during flash flows enabling accumulation of sediments coming from the tributaries. The contribution from tributaries may be low due to low erodability of soil and thick vegetation cover on the slopes. However, sand formation of this section is dependent on the adequacy of fluvial action required for sand sorting process.

Further, accumulation of sand in the above section may reduce the downstream replenishment leading to reduction on the potential downstream deposits. However the extent and the location of sand

deposits vary with time depending on factors such as rate of erosion, rainfall intensity and duration, flow regime of the river, fluvial actions gradient of the river section, etc.

As number of factors are responsible for the formation of sand, estimating actual impacts based on a short-term studies always have a high margin of error. However, based on the professional judgment the significance may be considered low to moderate.

Riverbed conditions

The damming of water at weir and dam and passage of water in the tunnels reduce the discharge of water in the river section between the weir/dam and the powerhouse. This will change the sediment mobilization in this river section. Accordingly, sediment transport by surface runoff will not be carried down the river. Furthermore, the riverbed change may have indirect impacts on the other environmental resources such as water quality, sand formation, aquatic flora and fauna.

4.2.2.2 Impact on mineral resources

The only mineral resources found in the area at extractable levels are river sand and stone aggregates which are used in construction industry. Hence, the impacts on precious stone and gem deposits, process raw materials, fertilizer minerals of national or local importance are considered to be minimum.

Sand

Construction activities at the weir may decrease the sand deposition in the downstream locations. Since the river flow is only partly blocked, the impacts may be considered as negligible. River sand mining is reported at household level for construction purposes, and the impact on social environment will be minimum as well.

Stone aggregates

The construction of weir, dam, tunnel between the weir and the dam, headrace tunnel, surge chamber, penstock and tailrace canal, etc. yield stone aggregates from rock blasting. Of which the tunneling activities will yield several thousand-meter cubes of aggregate mass at both weir, dam and powerhouse sites. These may be used for various construction activities depending on its suitability.

4.2.2.3 Other Impacts

(1) Increase of flood threat

The dam will not have flood regulation function, therefore, flood threat will not change.

(2) Loss of soil stability and increase of the landslide risk

Identify the landslide risk level in the project area

A landslide related to the Project was observed at the left bank of the Kelani River approximately 200 meters downstream of the dam site. Excavation of the outlet portal of the intake tunnel or cut-and-cover conduit may trigger movement of the landslide, although the site inspection did not reveal the landslide to be active. A shift of the tunnel outlet toward the Kelani River side may be necessary to avoid the landslide.

4.2.3 Hydrology and water resources

4.2.3.1 Impact on Surface Water

Salinization

Since the proposed dam is a small runoff river type one with a small detention pond and water passage through a closed tunnel system, impacts of salinization may be considered as minimum.

Salt-water intrusion

Kelani river is currently experiencing the salinity intrusion problems during dry periods. The impacts on salinity intrusion is important as the Greater Colombo water supply main intake is located approximately 14km upstream of the river mouth at sea. However, changes in the river flow regime due to operation of the power project at this location have little influence on the current salinity intrusion issue due to number of reasons and of which two may be important to justify the situation. The Project has no storage reservoirs, and the Project is to be located at about 50 to 100m MSL elevation away from 65km from the sea and the disturbance to flow is felt only within 3km stretch of river in this area.

(1) Construction phase

Reduction and Oxidation (Red- ox) conditions and organic pollution

The effluents from the camp areas may be considered as important contributors to BOD increase. These may discharge sludge (canteen waste and bath room waste, etc) with high BOD. These effluents, if released directly to the stream or a river the BOD levels will go up and as a result decrease in DO level may be anticipated.

Also, the septic pits and soakage pits if sited without considering adequate absorption fields, appropriate distance to watercourses and peak flood levels may introduce high BOD seepage into streams and river water. The water quality impairment due to above may be limited to narrow section of the river as the river has an excellent self-purification capacity. However, even localized impacts are considered as significant because the water satisfies a number of uses.

The poor sanitary conditions and practices in the construction areas such as open garbage disposal on-site, open defecation by the labour force, etc. may produce runoff containing high BOD load. These may enter the streams and the main river. As a result, the BOD levels may go up while decreasing the DO levels.

Fecal pollution

This has been a common but less emphasized issue in many large construction projects in the country. The influx of labour to construction areas of both weir/dam and powerhouse may defecate on-site. These feacal matters may enter the watercourse with runoff during rains leading to feacal pollution in the river water. The potential impacts due to this is considered significant as the river water is used for many purposes such as tourism, community, water supply, etc.

Nutrient enrichment

The effluents mentioned for red-ox conditions and organic pollution contain nutrients as well. In addition to above, the blasting process may generate effluents containing N and P. If these effluents are disposed directly to watercourses an increase in N and P in the river might be anticipated. However, likelihood of producing eutrophication impacts such as algal blooms are low due to high flow velocity and dilution effects.

Sediment Pollution

The project actions with excavation, uprooting trees and disturbance to soil overburden are responsible for sediment pollution in the river. The sediment load to river is dependent on number of other factors such as rainfall intensity, hydraulic energy of the runoff and sediment interception by the buffer zone actions, etc. The high rainfall intensity and steep slopes characteristic of the Project location might increase sediment load in the river from disturbed soil surfaces. The increase in the suspended solids load in the river downstream is considered important as it might cause impairment to water uses.

The construction of the weir, dam and bridge and the disposal yard at weir/dam may involve excavation of surface over burden in the riverbank. During this process, if special attention is not paid, the excavated soil may fall into river creating shock loads of sediments in the river causing locally significant water quality impairment.

Disposal of construction materials such as concrete mixture is an important issue. There may be instances that sometimes certain construction material may become spoilt, specially the concrete mixtures. If specific concern is not paid to the environmentally safe disposal, these may be disposed into river and or on its banks for convenience. If such things happen there will be a shock load of sediment in the river leading to locally significant water quality impacts.

Oil pollution

As explained in the section in 4.2.2.1, contaminated with oil and grease generated from construction areas may enter the river. The runoff may carry oil-contaminated water to river. The impairment to water quality due to oils and grease is considered significant.

Toxic pollution

Hydropower projects usually do not use or produce toxic materials. Still there is limited situation that certain toxic material is contained in the accessories and certain construction material, etc. Under proper handling the chance of release of these pollutants to environment is considered zero. As indicated in the soil contamination by toxic materials, the worn batteries and material carrying label "toxic" may cause water pollution if discharged environmentally unsafe.

(2) Operational phase

The access roads and related facilities, and temporary facilities in the operation phase have no impact on water resources. However, as explained earlier under 'land and earth resources' impact started at the construction phase will continue in the operation phase if not mitigated properly. Number of permanent facilities may be important for water quality in the operation phase.

Red-ox conditions an organic pollution

The dissolved oxygen level of the river may change at several locations due to operation of power project. The dissolved oxygen levels may drop due to retention of water at the weir and the dam (reduction in natural reoxygenation) exertion of BOD by bottom sediments and passage of water through tunnel system. Accordingly, reduction in the DO levels may be expected in the tailrace discharge.

Also drop in the DO levels as may be anticipated in river section between the weir/dam and powerhouse due to reduction in self-reoxygenation capacity. This drop in DO occurs due to change in discharge velocity and accumulation of sediment in the riverbed over time. However, the reduction of DO may be considered marginal compared to those occur in the large dam project as this is just a runoff river type, and also, the low BOD levels in the river water may keep the oxygen demand low.

The large dam projects have experienced in the release of iron and manganese from the sediment due to deoxygenation of hypolimnon at the reservoirs. However, it is of less importance to this project as

this is a runoff river type one with shorter detention time of water.

Another phenomenon called oxygen super saturation due to spillage of excess water over dam that occur in larger dam project may not be important in this project as the maximum height of the weir/dam is small, 24m.

Nutrient enrichment

The reduction in river flow and accumulation of sediments in the riverbed may change the nutrient levels in the river water. Hence, there is a likelihood of increase in the impacts of nutrients. However, the impact may be considered marginal as the percentage of agricultural lands, which use fertilizer in the catchments area are very low.

Sediment pollution

During the maintenance the sediment accumulated in the bottom of the dam and the weir will be released to river. Spontaneous release heavy sediment loads into river water may lead to water quality impairment such increased turbidity, oxygen depletion etc. However, in the maintenance it has been decided that the mud vales would be released so that the release of large sediment loads to the river is prevented and accordingly the impacts become insignificant.

4.2.3.2 Impact on groundwater

(1) Construction phase

Clearance of vegetation and excavation may have impacts on the infiltration of rainwater and the surface runoff. However, the change in groundwater table due to these can be considered low, as only a small area of land will be disturbed for the Project.

Since the proposed tunnel is to be excavated across a shear zone with fractured rock layer, groundwater leaking in the subsurface might be anticipated during the excavation of tunnels while reducing the soil moisture levels. However, due to the nature of groundwater system believed to be prevailing in the study area, the impacts due to this can be considered localized and low. Usually, during tunneling, precautions are taken to minimize such leaks. Hence such situations can be considered as temporary. Large excavations, especially in the fractured rocks, might open up pockets containing ground water and drain its water. This might result temporary or occasionally prolonged drying up of soil in localized patches. Impacts due to this may also be considered low as most of the project actions on excavations occur on the lower reaches of slopes closer to riverbed.

(2) Operational phase

The passage of water through the tunnel system might dry up the section of the river between the dam and the confluence of Kataran Oya. The issue of drawdown of ground water table due to loss of water in the river section can be considered limited to a few localized patches in the most dryer months (e.g. March) as high rainfall spread throughout the year and nature of the groundwater behavior believed to be occurred in the area can well compensate such losses.

The river stretch at just upstream of the Polpitiya Powerhouse is a typical case to observe impacts of riverbed drying. The absence of visible signs of drying of vegetation in the reserve on the either side of the river in the past decade indicate the insignificant level of impact on the ground water table due to project actions.

4.3 Impact on the ecological resources

4.3.1 Impact on flora

(1) Construction phase

1) Terrestrial flora

The anticipated project activities in the construction phase such as the construction of access roads at weir/dam site and powerhouse site, culvert between the dam and headrace tunnel, penstock, the tailrace canal and the disposal sites involve clearance of relatively large stretches of vegetation. The anticipated impacts on flora due to the above project actions will be relatively higher in the powerhouse area compared to that of the weir/dam area, since the vegetation of powerhouse area is relatively diverse and richer than that of the weir/dam site.

The construction of roads at weir/dam site will affect scrublands and plantations while at the powerhouse site, forest, scrublands, home garden and riverine vegetation will be cleared. The clearance of vegetation in powerhouse site may eliminate common species such as Vitex altissima (Milla), Alstonia macrophylla (Hawari Nuga), Trema onculalis, Bredelia retusa, Ficus hispida (Kotadimbula), etc. from the site. Some endemic species such as Mangifera zeylanica (Etamba), Culina ceylanica(Kataboda), Bhesa ceylanica(Pelang), Horsfieldia iryaghedhi (Malaboda), etc. will also be cut for these project activities.

The construction of the culvert and its access roads will have a relatively lesser disturbance on vegetation as the weir/dam site is populated and thus the vegetation types are sparsely disturbed. However, a little amount of scrublands, plantations, riverine vegetation and home gardens could be affected.

The construction of the penstock at the powerhouse site will disturb the forest vegetation while the construction of tailrace cannel will also affect forest and scrublands.

The vegetation clearance for the construction of the disposal site within the powerhouse area would affect the forest, whereas disposal yard near the access road between national highway to riverbank at powerhouse site will affect home gardens, scrublands and the disposal yard at the weir/dam site will affect riverine vegetation and plantations.

Fragmentation

It seems that the vegetation clearance for the above mentioned project activities is not likely to cause a significant fragmentation of the vegetation due to the following reasons. In almost all project activities, the clearance of vegetation has been assigned (likely to occur) to the ‘edge’ of the different vegetation types. i.e. the ‘core’ area is not affected or cleared but the area closer to the boundaries are affected. Even in the powerhouse area that lies within the boundary of the proposed forest reserve, only the edge is affected. In such conditions, it is unlikely that the patchiness of the vegetation type is increased.

Threatened and Endemic species

Since the edge of a particular vegetation type is always considered as a ‘disturbed’ vegetation due to human activities such as the usage for transportation and inhabitation, the ‘edges’ always possess weeds and invasive plants. Hence, the exact impact on the threatened species, endemic species, species richness of the site will be lesser/insignificant compared to a situation when the ‘core’ area, the dense forest, is disturbed.

Since the project activities include clearance of a small percentage of the total forested area towards the edge, the impact on threatened and endemic species could be considered as low and thus be ranked as insignificant.

Species richness, diversity and ecological balance

The anticipated impacts on species richness and diversity are almost similar to those stated above under threatened and endemic species. The ecological balance will not be much affected due to clearance of vegetation except for the occurrence of erosion due to the loss of vegetation cover.

However, the construction of disposal sites will have a much more detrimental impact on flora, depending on the material which will be disposed at these sites. The disposal of inorganic matter such as the construction material (bricks, aggregates, sand, etc.) may alter the fertility of the soil. As a result, it will take a longer time than normal to regain the vegetation. Thus, the ecological balance may be disrupted by the disposal sites than by the clearance of vegetation as well as by the soil infertility. However, as mentioned earlier a small percentage of land is affected by the dumping of disposable items and thus the overall impact from the project on ecological balance could be considered as low and insignificant.

Illegal felling

The large influx of labour during construction period may disturb dense forest, the 'core' area, and other state lands via activities such as illegal felling of trees out side the boundaries of project activities. Wild orchids (eg; Dendrobium macrostachyum) and medicinal plants such as Coscinicum fenestratum, Tiuospora cordifolia of high commercial value may also be vulnerable to illegal exploitation by the workers during the Project. This may be considered as a significant impact on the species richness, diversity, threatened and endemic flora.

2) Aquatic flora

The aquatic system will be disturbed at two locations during construction of permanent facilities; weir, dam and the bridge across the river. However, these clearances are restricted only to smaller patches and there is no such considerable aquatic flora within Zone-1. Hence, the impacts could be considered as insignificant. No aquatic endemic and threatened species will be affected.

It is very unlikely that the aquatic vegetation associated with the riverbanks (i.e. species such as Lagenandra and Pandanus sp. etc.) will be affected by the construction of the above mentioned permanent facilities.

(2) Operational phase

1)Terrestrial flora

Fragmentation

During operational phase vegetation clearance will not take place but the succession of vegetation will proceed, and the places of clearance will regain vegetation with time. Hence, the effect on fragmentation may remain more or less similar to that explained for construction phase.

Threatened and endemic species

There are no specific activities in the operation phase that will have any detrimental impacts on the threatened and endemic flora.

Species richness diversity and ecological balance

With succession, the abandoned areas will be gradually replaced with plant species depending on the habitat variability, and thus species richness, diversity and ecological balance will be

recovered with time.

2) Aquatic flora

During the operation phase the dam and the weir will act as physical barriers and furthermore, passage of water through the tunnel system will reduce the discharge in the river section between weir/dam site and the powerhouse. The impact resulted due to these actions is not expected to affect the aquatic flora as there is no such diversity/species richness in the aquatic ecosystem in the study area.

4.3.2 Impact on fauna

(1) Construction phase

1) Terrestrial fauna

All construction activities produce noise, vibration and nuisance due to operation of machinery and mobilization of work force. This will result in a temporary shift in the ecological balance and species richness and diversity of mobile species (birds and mammals) in the surrounding areas of the proposed project actions. Hence, short-term impacts may be anticipated.

Also, the influx of labour force during the construction phase may engage in illegal poaching and may disturb the habitats in the dense forest. This might cause significant impacts on endemic and threatened species as well. Hence, the impact during construction period due to disturbance by the labour force is considered significant.

Fragmentation

Effects are similar to those explained under terrestrial flora.

Threatened, endemic and migrant species

Clearance of vegetation for all the activities except the construction of tunnels would have impacts on the terrestrial fauna in the proposed weir/dam and powerhouse sites.

Anticipated impacts due to above are relatively higher in the powerhouse area when compared to those in the dam and weir areas due to the fact that the land area to be cleared for project activities in the powerhouse site is higher than that of dam and weir sites. During construction phase the highly mobile species such as birds, which represent highest level of endemism and highest number of migrants species, and mammals will most likely to move into undisturbed areas.

Anticipated impacts on threatened, endemic and migrant species are considered low due to number of reasons. The area to be cleared is located at the edge of the forest and therefore only a small patch of land will be cleared. Furthermore, the degree of current human disturbance is high in these areas so the species present already have tolerance to disturbances and the species with very high sensitivity do not live in these patches but in the dense forest and none of the project activities has direct impact on terrestrial fauna. Hence, the impacts due to construction of temporary and permanent facilities on threatened, endemic, migratory species can be considered insignificant.

Species richness diversity and ecological balance

The anticipated impacts due to above activities are relatively higher in the powerhouse area when compared to those in dam area due to two reasons. First, the comparatively higher level of species richness and diversity are recorded in the powerhouse site compared to weir and dam sites. Second, relatively a larger land area will be cleared for powerhouse facilities.

However, the direct impacts of project activities at both weir/dam site and powerhouse site during construction phase is considered low and hence insignificant due to the same facts stated under threatened, endemic and migrant species for terrestrial fauna.

Breeding /feeding places and migratory routes

No major breeding or feeding grounds are observed in proposed locations for the weir, dam and powerhouse. Also, no specific migratory routes were noted during the field survey. Hence, likelihood of affecting them including the possible impact by the transmission lines and others may be considered low.

2) Aquatic fauna

All the project activities generate sediments and other pollutants such as oil and grease, etc. during the construction phase. The runoff carrying sediments and pollutants may enter the river system causing water pollution impacts. This will have a significant impact on the life processes of aquatic fauna.

Fragmentation

The aquatic system will be disturbed at two locations during the construction of permanent facilities, mainly the weir and dam.

The disturbances created at the weir and dam may hamper the passage of mobile species in the river at these two locations. However, during the construction period a complete blockage will not occur, as the flow will be allowed thorough one half of the river section. Hence, complete fragmentation of population will not result. Accordingly, the impacts may be considered as low.

Threatened endemic and migratory species

Construction of permanent facilities, weir, dam and the bridge across the river may cause disturbance to aquatic fauna due to excavations, blasting and operation of heavy machinery in the river. The anticipated impacts on endemic and threatened species may be considered low due to three main reasons. First, the area impacted is very small when compared to length of the river stretch. Second, only a few endemic and threatened aquatic species were recorded from the river stretch likely to be impacted. Third, larger species have the ability to move quickly into other less disturbed areas during the period of construction. Hence, impacts to the aquatic fauna during construction phase may be considered low.

Species richness diversity and ecological balance

The direct impacts of the project actions on above are localized and hence may be considered low due to the facts stated under threatened, endemic and migratory species.

Breeding / feeding places and migratory routes

Most of the aquatic insects breed and complete their life cycle in the river system while mobile species such as fish move into small tributaries to breed. Compared to length of the river stretch, the localized disturbances caused at dam, weir and bridge site during the construction phase may be considered low. Migratory routes of migrant fish may get affected at the dam site and weir site. Since passage of water is allowed from one half of the river and only a few migratory species of fish reach the elevation where dam and the weir is going to be located, the impacts may be considered as low.

(2) Operational phase

1) Terrestrial fauna

Fragmentation

During operational phase vegetation, clearance will not take place. The places abandoned such as the quarry and disposal yards, will regain vegetation over time. Hence, the fragmentation effect may continue similar to those explained for construction phase until the ecosystem establishes through natural succession process.

Threatened, endemic and migratory species-

There are no specific activities in the operation phase that have impacts on the terrestrial fauna. The roads will be usually avoided by species due to traffic. Other areas will be gradually replaced with fauna depending on the habitat availability.

Species richness diversity and ecological balance

The anticipated impacts are similar to those stated for threatened endemic and migratory species.

Breeding /feeding places and migratory routes

It will take several decades to regain vegetation on the cleared areas. Depending on the stage of succession fauna will gradually occupy the affected habitats. As there are no major activities during this operational phase impact on breeding / feeding places and migratory routes are insignificant.

2) Aquatic fauna

Fragmentation

The aquatic system will be disturbed at two locations due to construction of permanent facilities, namely the weir and the dam. These two will function as physical barriers and will permanently divide the river into two sections. However, the impacts may be important at the weir site Kehelgamu Oya as the existing dam at Polpitiya has already fragmented the Maskeliya Oya. The significance of impact on population fragmentation require more detailed long-term assessment and hence based on the best professional judgment it may be safe to state that the impacts are significant.

Threatened endemic and migratory species

The passage of water through the tunnel system will reduce the discharged flow of water in the river section between the proposed weir/dam and powerhouse site. The impacts may be more on fish species, as they require larger volume of water to live. Among the 10 fish species, 4 endemic and three threatened fish species were recorded in the river. The impacts may be considered important only for the river section as none of these species are restricted to Maskeliya Oya and hence the reduction in water volume is unlikely to drive any of these species towards extinction. Furthermore, most of the fresh water species that are endemic and threatened are found mostly in the tributaries that feed the river, which will not be impacted by the reduction of water flow.

Species richness diversity and ecological balance

Due to reduction of water flow during the operational phase larger species of fish may avoid the river section between the weir and the dam site. Also this reduction in the flow will change

the conditions of the riverbed leading to some changes in the species richness, diversity and ecological balance.

The actual extent of the changes may require long-term studies, and therefore, it may be safe to state that the impacts are locally significant.

Breeding / feeding places and migratory routes

The reduction in water flow may likely to change the ecology of this section of the river. Hence the feeding site of larger species of fish is likely to be affected resulting in locally significant impacts. However, breeding places of the most of fish species will not be affected, as they are located in the tributaries of the river, which will not be affected by the project activities.

The construction of weir may completely block the routes of migratory fish. The impacts may be considered low due to number of reasons. Sri Lanka has few migratory fish and only few species have been recorded in the area by previous studies. Due to the natural high gradient of the river section the migration of fish to these locations are unlikely.

4.3.3 Impact on forest

(1) Construction phase

1) Powerhouse area

All the permanent and temporary facilities of the proposed powerhouse site and a part of the access road to the powerhouse from the national highway are to be located within the boundary of the forest reserve. These will require clearance of about 25 ha of forested area between the left bank of the Maskeliya Oya and the right bank of Kataran Oya.

Quality and the quantity of forest

The total extent of the proposed Kelani Valley Forest Reserve within the study area is not known at this moment as the mapping and declaration of spatial boundaries by the Forest Department is not yet completed. But it is regarded as around 355ha, and the area to be cleared for constructing the proposed powerhouse facilities can be calculated as about 7 % of the total area of the Reserve. Thus, it will be a small patch when compared to the size of the Forest Reserve. Furthermore, the proposed facilities are to be located at the edge of the forest reserve, an area that has already been disturbed by the human activities. Hence, the impacts on the quantity or the quality of the forest due to construction and operation of powerhouse facilities may not be considered as significant.

Utilization by the community

The community in the powerhouse area depends on the forest for medicinal herbs and edible foods such as leafy vegetables and tubers for day to day needs. The construction and operation of the powerhouse facilities will terminate community interaction with this part of the forest. Therefore, for extraction of resources, the community may have to seek alternative locations with similar vegetation. The communities may have to travel a little farther than now for the same. However, the project actions will not hamper current utilization of forest resources in the other areas of the forest during both construction and operation phases. Thus, the impacts may not be considered significant.

2) Dam/weir area

Certain lands supposed to be within the boundaries of forest do not have forest cover due to past human actions. Accordingly only Forest Reserve is referred to in this section

The permanent and temporary facilities of the proposed dam and weir sites including the access roads do not fall within the limits of the Forest Reserve. Hence, the direct impacts by the construction of these facilities on the forest are insignificant. The headrace tunnel, since constructed underground in the rock in areas covered with forest has no direct impact on the forest.

(2) Operational phase

If there is no reforestation program proposed for the Project, the land used for all permanent facilities will remain without forest. In the powerhouse site, most of the facilities (including a part of the camp area) are permanent structures, and therefore, its forest cover and associated resource utilizations will be lost permanently. Accordingly, communities who depend on this part of the forest may have to seek alternative locations.

The land used for temporary facilities will be abandoned. In the absence of a forestation program under the Project, it may take several decades to regain its current state causing long-term impact on the forest cover in the locations.

4.4 Impact on human environment

4.4.1 Impact on socio economic conditions

4.4.1.1 Impact on employment opportunities and others

(1) Employment opportunities

There will be a substantial demand for skilled and unskilled labour for direct employment in the construction of the Project as well as in supply services. These employment opportunities by the Project will be for short or medium term, but the experience and savings that may be gained by workers during the employment periods would facilitate to secure long-term employment opportunities elsewhere.

(2) Impact on agricultural and economic activities

In the dam/weir sites, some cultivated land such as tea plantation will be affected and the affected extent is low. In the powerhouse site most of the land is taken from forest, thus the extent of agricultural land loss is low. As a result the impact on the agriculture is insignificant.

Since the outside labour force coming for a construction activities may demand for necessities for existence the people will be benefited. Farmers can earn extra money by selling food for workers. Locally available fruits will have good market. And there may be demand for accommodation, and those who have extra rooms in their house can rent out them.

There will be little impact anticipated by the water flow decrease between the weir/dam and powerhouse during operation phase on the people who fish for an income, because they mainly fish downstream of the powerhouse.

(3) Impact on business

During the construction period household income as well as expenditure levels would increase with enhanced income generating activities and creation of new employment opportunities in the Project.

Consequent to increase household income and the influx of labour, the demand for food, goods and services will increase. With the inception of the Project, their will be more demand for grocery shops and small business activities like welding shops, bicycle repair shops, hairdressers, communication centers, tea boutiques and restaurants. The Project will have a positive impact on businesses except for whitewater rafting (details are given in ‘4.4.6 Impact on tourism’)

4.4.1.2 Change in property values

It is general consensus that the property value in the project area will increase with the project implementation mainly due to the improvement of infrastructure, in particular the construction of access roads.

4.4.1.3 Community severance

The permanent displaced people will loose their neighbours and they will be isolated. But the Attam system (interdependency) practice by neighbours to help each other in their livelihoods is not practiced by these families, and they independently manage the livelihood. Therefore, the impact by community severance is not significant in view of livelihood.

4.4.1.4 General social groups especially benefited or harmed

Employment opportunities will be increased as stated above. Therefore, unemployed people will be benefited.

Increase of employment opportunities means influx of labour from outside at the same time, and there will be demand for human recreational activities. These people staying during construction period will have sexual activities with people in the area and that may spread sexually transmitted diseases, sometimes unwanted pregnancy.

Illicit drugs may come to the villages, and that will be harmful to especially youth of the area. Availability of alcohol and tobacco may absorb young people, and that may harmful.

Children are fond of watching and experiencing new things coming to the village. If children are not well informed and well protected they may go to construction site and fall into trouble.

4.4.1.5 Accessibility

Accessibility to some villages near the project site will be improved with construction or improvement of access road. This will facilitate fast mobility of goods and services and labour. Marketability of agricultural produces in this area may also improve.

4.4.1.6 Impact on water right and fishery right

Accessibility to fishing in the river section between the dam/weir and the tailrace may be restricted though they do not have legal fishing right.

4.4.2 Impact on existing settlement and land use forms

Campsite

There are two candidates as campsite. The present conditions are:

Inoya Estate: This is a private land with an extent of 13 acres (5.3 ha) of scrubland. This land is sloping and situated in the right bank side of the main road between the 40th and 41st km posts, and about 5 km from Polpitiya. Water and electricity is available.

Poruwa Watta : This is a private land with an extent of 10 acres (4.0 ha), presently used as a rubber plantations, whose age is about 6 years. This land is situated in the right bank side of the main road near the 45th km post, and about 4 km from Polpitiya. Electricity and telephone is available.

Both of them are not close to the present communities, and therefore, there is not much impact on the communities. In view of flora and fauna, no severe impact is anticipated.

Quarry site

The proposed quarry site is located at the south east of the weir site (See Annex 7). Access road from the main road to the quarry site is half way available. However, there are houses along the access road and several houses at the south side of the quarry site. Therefore, they will have significant impact and they may have to resettle temporarily if the existing access road is used.

Others

People staying near the construction sites will be affected by some project activities like material transportation that create dust, blasting activities that create vibrations. Some of the impacted people may have to resettle temporarily.

4.4.3 Impact on existing infrastructure facilities and use

4.4.3.1 Impact on traffic

There will be an increase in the volume of traffic, and it may have some disturbance especially to a small stretch of roads such as B189 and B25, which are in and around weir/dam site in Zone-1.

In terms of the impact by traffic, increase of traffic would result in bad impacts due to dust generated, difficulty for elderly peoples and children to travel on the road due to poor road conditions, and it may further lead to an increase in the road accidents. Continuous transportation may create noise pollution and it will badly affect the people living by the side of the roads.

4.4.3.2 Impact on others

Since schools, post offices, clinic, community hall, temple are not in Zone-1, the major project area, there will not be impacts. No major negative impacts on existing infrastructure facilities are anticipated.

4.4.4 Resettlement

Sixteen (16) houses that have 17 homes/shops will be demolished by the construction of the dam, conduit, road and powerhouse. Almost all demolished houses are single-story houses. More than 80% of the houses are permanent structures, and the rest are cement block structure. There will be neither affected infrastructure nor farmland. The impacted households and commercial entities can be summarized below.

Table 4.4. Details of the houses to be demolished

	No. of houses	**Included homes/shops**	**Land area (perch)**	**Floor area (ft^2)**	**No. of rooms**
Weir/dam site	13	10 homes	50*	588*	2.6*
		1 home /retail shop	160	672	3
		1 home /welding shop	40	650	3
		1 home/tea shop	160	400	2
		1 grocery	5	200	1
Powerhouse site	3	3 homes	213*	471*	3.0*

* Average

There are four (4) shops, of which three (3) are cum homes. All of them have only family labours.

There will be no impacts on household livelihood by resettlement because their occupations are electrician (4 households), army worker (2 households), driver, mason and others, which will not be impacted by resettlement. And resettlement will not make them inconvenient to go to schools/working places.

4.4.5 Impact on development trends and growth

4.4.5.1 Impact due to high security arrangements

The residents of the area will have to face some inconvenience due to high security arrangements. For example, there may be security checks when people come into or go out from a certain area. But this would not be a big issue since the residents near Polpitiya power station have the experience of this. The people living new powerhouse area do not experience such security arrangement presently, and this will be a new experience for them and their free movement may be disturbed to certain extent.

4.4.5.2 Restriction for new development

There are cases where a new project such as highway development or industrial development is restricted because another project is planning. But in case of the study area, there are no new planned project, and therefore, no other projects are restricted.

4.4.6 Impact on tourism

(1) Construction phase

The 'Bridge on the River Kwai' film site

A new bridge is proposed at the same place as the film site "Bridge on the River Kwai". And it is planned that a hole in the rock and concrete block which were parts of the foundation of the bridge in the film will be preserved with several square meters of surrounding rocks. And an access road to the powerhouse is planned to be connected to the new bridge.

Therefore, during construction tourists who intend to visit this site may face difficulties in accessing the location, but as stated later it is expected that the Project will have positive impact during operation period.

Archeologically important sites

There may be impacts due to vibration induced by the blasting activity on archeologically important buildings located within the close proximity of the study area.

Culturally important sites

There are no direct impacts associated with the famous cultural function, Sripada pilgrimage.

Whitewater rafting

The rafting cannot be operated during operation as stated later because of decrease of the river flow. The activity during construction could be possible if the water flow will not blocked, but it will not be comfortable for the tourists because of noise and traffic increase caused by construction work. Therefore, it will be realistic to stop the activity before construction.

Bathing and swimming

The construction of bridge may interrupt the bating site around the bridge. However, the impacts may be considered as insignificant as this location is not popular much among the tourists and pilgrims.

The construction of the proposed weir may have some disturbance to the bathing spot, located about 150m downstream of the proposed weir, used by the pilgrims. The direct impacts may be little on this location. However, there may be certain indirect impact by possible impairment of

water quality.

However, no impact is anticipated at the most popular place 2km downstream from the bridge.

Camping and hiking

There are no camping, hiking and ecological picnicking activities in the weir/dam site. Hence, the impacts may be considered as insignificant.

The locations proposed for the access roads and other temporary facilities at powerhouse site within the forest boundary have no direct impacts on the above tourist activities, as those tourism activity areas do not overlap with the powerhouse activity areas. Hence, the negative impacts on above resources are considered low.

Hotels

The hotels located within the study area are not affected by the construction activities, as they are located outside the boundaries of the proposed project actions. However, the reduction in the flux of tourists is expected as stated above, and accordingly the tourists who use the hotels and restaurants may be decreased causing negative impacts.

Other than above the following overall direct impacts may occur.

Impairment to water quality

If water pollution is induced by sediments, oil, fecal contamination due to influx of labour force, garbage and litter introduced to river during construction, it may hamper all the activities related water including bathing and swimming. Also, visual pollution and impairment to aesthetic quality of the river may result in negative impacts on tourism and cultural pilgrimage activities. The negative impacts resulted may be considered as significant during the peak tourist seasons December to April, and pilgrimage seasons December to May.

Noise and vibration

The noise and vibration caused during blasting and operation of machinery and manpower may cause nuisance to tourists who engage in entertainment activities especially in the powerhouse area. That may be considered as a locally significant negative impact on the tourism resource.

Nuisance due to traffic

The increased vehicles such as heavy trucks loaded with construction material introduced to national highway during construction phase may cause nuisance to travelers who use the road for tourist purposes and pilgrimage to Sripada. The negative impact due to nuisance can be considered low to moderate to tourism and cultural activities. However, if this traffic operates during the ceremonial procession day, the negative impacts due to traffic on that particular cultural event may be considered as highly significant.

(2) Operational phase

The impact on other tourism and cultural resources except those mentioned below may be considered as minimum as most of the temporary sites except the road and the bridge will be abandoned after the construction phase.

The 'Bridge on the River Kwai' film site

The new access road will function as a facility to visit the site conveniently. In addition, in the other side of the river, there is forest that is expected to be designated as Forest Reserve in the

east of the powerhouse. And there is a bird watch area in the west of the powerhouse. The bridge will make the access to those places easy, and it may increase the number of tourists who visit the film site as well.

Whitewater rafting

The river section between the dam/weir site the powerhouse site will be decreased, and therefore the rafting cannot be operated.

Bathing and swimming

The bathing places located at 150 downstream form the proposed weir and 500 m upstream of the Kataran Oya confluence, may have interruptions during dryer periods. However, the most popular bathing spots among tourists and pilgrims are located downstream of tailrace discharge point, and there will be little change in the flow there.

Camping and hiking

In the powerhouse site, areas with powerhouse facilities will be kept as a high security zone. The impact due to this is considered low because those hiking areas are located above the proposed permanent facilities. Therefore, likelihood of declaration of rock pool areas of the Kataran Oya as a security zone is low. There are no impacts on camping, hiking and ecological picnicking due to operation of power project facilities at weir/dam site or other more important areas in the forest.

Hotels

There are no direct impacts in the operational phase. However, loss of whitewater rafting activity may reduce flux of tourists to the hotels in the study area, which may be considered as a significant impact.

4.4.7 Impact on air quality, noise and vibration

(1) Air quality

During construction period, the key potential sources of air pollution could be identified as follows:

- Fugitive dust generation from activities such as cleaning and reclamation of lands, earth cuttings, transportation of materials, construction of tunnels canals, buildings, etc.

- Emissions from drilling, blasting, operation of quarry sites, dumping sites, etc.

- Exhaust emissions from vehicles and other machineries servicing the construction activities

- Traffic emission due to extra vehicles, which could be generated in main roads

- Open burning of solid waste generated within the site area

- Domestic emissions from campsites, officer's bungalows, canteens, etc.

(2) Noise

The construction noise levels will also be affecting on the neighboring areas especially at the residences near to constructions sites. The noise levels will be higher at the construction sites such as weirs, tunnel moths, access roads, quarry sites, disposal sites, powerhouse area and campsites, etc. The impact will be higher at Polpitiya area than the other areas since the density of the residential houses are higher. Therefore, possible noise abatement measures should be

taken to minimized the surrounding noise level at the boundary of the working site at least to 75 dB(A) in day time and 50 dB(A) in night time that maximize permissible levels stipulated by CEA (Annex 6).

(3) Vibration

In the construction stage of the proposed project, there is a possibility to cause discomfort, pain, annoyance to humans and damage and destruction to sensitive equipments in near by houses or buildings due to vibration which is generated by activities such as hammering, drilling, excavation, blasting and by vehicular movements etc. The impact may be higher especially at the quarry sites and tunnel construction areas. The high vibration will cause structural damages in human reactions.

The structural damage due to vibration would be higher in the area since the houses in the area are not properly structured to prevent vibration damage. However, vibration impact on human would be minimum due to low population in the area. Therefore, possible vibration mitigation actions should be adopted to achieve the permissible levels given in the standards.

Table 4.1 Matrix of main project actions and sub project actions

Sub actions/Main actions	1 Access Roads and Related Facilities	1.1 Access Roads from the national high way to the power house site	1.2 Bridge across the Kelani river at the power house site	1.3 Access road from the national highway to the weir site at the	1.4 Road along the culvert between dam and the headrace tunnel	2 Temporary facilities	2.1 Aggregate Crushing plant	2.2 Concrete mixing facilities	2.3 Machinery service yards	2.4 Camp sites	2.5 Quarry site	2.6 Disposal yard (Temporarily identified)	3 Permanent facilities	3.1 Concrete Weir at Kehelgamu Oya	3.2 Concrete Dam at Maskeliya Oya	3.3 Water tunnel connecting the dam and the weir	3.4 Concrete culvert connecting the dam and the headrace tunnel (cast	3.5 Headrace tunnel connecting the culvert and the surge tank	3.6 Surge chamber at the end of the tunnel	3.7 Steel penstock . connecting the Surge tank and the power house	3.8 Power house building and the switch yard	3.9 Tailrace canal connecting the power house and the Kelani river	3.10 Transmission line connecting the switch yard and the exiting
Construction phase																							
Clearance of vegetation		✔	✔	✔	✔		✔	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Removal of vegetation		✔	✔	✔	✔		✔	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Blasting rocks and boulders		✔	✔	✔	✔									✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Aggragate crashing							✔																
Change in the slope angles		✔	✔	✔	✔		✔	✔	✔	✔	✔	✔		✔	✔		✔		✔	✔	✔	✔	
Change in natural runoff pattern		✔					✔	✔	✔	✔	✔	✔		✔	✔		✔		✔	✔	✔	✔	
Storage of materials							✔	✔	✔	✔	✔	✔											
Transport of materials							✔	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Sludge disposal										✔													
Sewage disposal		✔								✔													
Consturutcion effluent disposal								✔	✔		✔					✔		✔					
Spoiled material disposal							✔	✔	✔			✔											
Dredging river			✔												✔	✔							
Impounding water																							
Obstruction of flow																							
Passage of water										✔													
Disposal of garbage																							
Change in the flow conditions																							
Operating phase																							
Impounding water														✔	✔								
Obstruction of flow														✔	✔								
Passage of water																✔	✔	✔	✔	✔		✔	

Table 4.2 Matrix for Environmental Items and Project actions (Pre-construction & Construction phase)

Environmental Items \ Projecft Actions	**1 Access Roads and Related Facilities**	1.1 Access Roads from the national high way to the power house site	1.2 Bridge across the Kelani river at the power house site	1.3 Access road from the national highway to the weir site at the	1.4 Road along the culvert between dam and the headrace tunnel	**2 Temporary facilities**	2.1 Aggregate Crushing plant	2.2 Concrete mixing facilities	2.3 Machinery service yards	2.4 Camp sites	2.5 Quarry site	2.6 Disposal yard (Temporarily identified)	**3 Permanent facilities**	3.1 Concrete Weir at Kehelgamu Oya	3.2 Concrete Dam at Maskeliya Oya	3.3 Water tunnel connecting the dam and the weir	3.4 Concrete culvert connecting the dam and the headrace tunnel (cast	3.5 Headrace tunnel connecting the culvert and the surge tank	3.6 Surge chamber at the end of the tunnel	3.7 Steel penstock . connecting the Surge tank and the power house	3.8 Power house building and the switch yard	3.9 Tailrace canal connecting the power house and the Kelani river	3.10 Transmission line connecting the switch yard and the exiting	**4 Other related actions**	**5 Whole project**
Land Use Pattern																										
Encroachment																									4 / 4	
Geology and Soil																										
Soil contamination									3 / 2							1 / 1		1 / 1								
Slope erosion		1 / 1		1 / 1	1 / 1												2 / 2					2 / 2			
River bank erosion			1 / 1																							
Sediment deposition												2 / 2														
Mineral Resources																										
Sand																										
Hydrology and Water Resources																										
Red-ox conditions & organic pollution										2 / 2																
Fecal pollution																									3 / 3	
Nutrient enrichment																1 / 1	1 / 1	1 / 1								
Sediment pollution		2 / 2	2 / 2	2 / 2	2 / 2									2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2	2 / 2				
Oil pollution																										
Toxic pollution									3 / 3																	
Groundwater																										
Flora																										
Terrestrial flora	Fragmentation																									
	Threatened and endemic species	1 / 1		1 / 1															1 / 1	1 / 1	1 / 1					
	Species richness and diversity	1 / 1		1 / 1	1 / 1					1 / 1	1 / 1	3 / 3		1 / 1	1 / 1	1 / 1		1 / 1	1 / 1	1 / 1	1 / 1					
	Illegal felling																								4 / 4	
Aquatic flora																										
Fauna																										
Terrestrial fauna	Fragmentation																									
	Threatened, endemic and migrant species	1 / 1		1 / 1	1 / 1					1 / 1	1 / 1	1 / 1		1 / 1	1 / 1	1 / 1		1 / 1						3 / 3	3 / 3	
	Species richness and diversity																		3 / 3	3 / 3	3 / 3					
	Breeding/feeding places, habitats, migrant routes																									
Aquatic fauna	Fragmentation													1 / 1	1 / 1											
	Threatened, endemic and migrant species													1 / 1	1 / 1											
	Species richness and diversity													1 / 1	1 / 1											
	Breeding/feeding places, habitats, migrant routes																									
Forest																										
Quantity and quality		1 / 1		1 / 1	1 / 1														1 / 1	1 / 1	1 / 1					
Utilization by the community																			1 / 1	1 / 1	1 / 1					
Human environment																								2 / 2	-3 / -3	
Socio eonomic conditions																										
Exsiting settlement and land use forms											3 / 3														2 / 2	
Infrastructure facilities																										
Resettlement																									5 / 5	
Development trend and growth																									1 / 1	
Air qualitiy, noise and vibration		2 / 2	2 / 2	2 / 2	2 / 2		5 / 3	5 / 3	5 / 3	1 / 1	5 / 5	2 / 2		3 / 3	3 / 3	3 / 3	3 / 3	3 / 3	3 / 3	3 / 3	3 / 3	3 / 3	3 / 3	3 / 3	3 / 3	
Tourism																										
Bridghe on the River Kwai' film site		5 / 5	5 / 5																							
Other cultural places																										
Whitewater rafting																										
Bathing and swimming			1 / 1											1 / 1												
Other natural places																										
Hotels																									3 / 3	

A number in the upper left corner of each box indicates the Magnitude of the possible negative impact (5 represents the greatest and 1 the least), and a number in the lower right corner of each box indicates the Importance of the possible negative impact (5 represents the greatest and 1 the least) without any mitigation measures.

A minus number means possible positive impact.

Table 4.3 Matrix for Environmental Items and Project actions (Operation phase)

Environmental Items \ Projecft Actions	**1 Access Roads and Related Facilities**	1.1 Access Roads from the national high way to the power house site	1.2 Bridge across the Kelani river at the power house site	1.3 Access road from the national highway to the weir site at the	1.4 Road along the culvert between dam and the headrace tunnel	**3 Permanent facilities**	3.1 Concrete Weir at Kehelgamu Oya	3.2 Concrete Dam at Maskeliya Oya	3.3 Water tunnel connecting the dam and the weir	3.4 Concrete culvert connecting the dam and the headrace tunnel (Cast in excavated trench and buried)	3.5 Headrace tunnel connecting the culvert and the surge tank	3.6 Surge chamber at the end of the tunnel	3.7 Steel penstock , connecting the Surge tank and the power house	3.8 Power house building and the switch yard	3.9 Tailrace canal connecting the power house and the Kelani river	3.10 Transmission line connecting the switch yard and the exiting	**4 Other related actions**	**5 Whole project**
Land Use Pattern																		
Encroachment																		2 / 2
Geology and Soil																		
Soil contamination																		
Slope erosion																		
River bank erosion															1 / 1			
Sediment deposition							1 / 1	1 / 1										
Mineral Resources																		
Sand																		
Hydrology and Water Resources																		
Red-ox conditions & organic pollution							1 / 1	1 / 1										
Fecal pollution																		
Nutrient enrichment																		
Sediment pollution																		
Oil pollution																		
Toxic pollution																		
Groundwater																		
Flora																		
Terrestrial flora	Fragmentation																	
	Threatened and endemic species																	
	Species richness and diversity																	
	Illegal felling																	
Aquatic flora																		
Fauna																		
Terrestrial fauna	Fragmentation																	
	Threatened, endemic and migrant species																	
	Species richness and diversity																	
	Breeding/feeding places, habitats, migrant routes																	
Aquatic fauna	Fragmentation						3 / 3	2 / 2										
	Threatened, endemic and migrant species																2 / 2	
	Species richness and diversity																3 / 3	
	Breeding/feeding places, habitats, migrant routes						1 / 1	1 / 1										
Forest																		
Quantity and quality																		
Utilization by the community																		
Human environment																		
Socio eonomic conditions																		-1 / -1
Exsiting settlement and land use forms																		1 / 1
Infrastructure facilities																		
Resettlement																		2 / 2
Development trend and growth																		
Air qualitiy, noise and vibration																		
Tourism																		
Bridghe on the River Kwai' film site		-2 / -2	-2 / -2															
Other cultural places																		
Whitewater rafting																		5 / 5
Bathing and swimming							1 / 1										1 / 1	
Other natural places																		
Hotels																		2 / 2

A number in the upper left corner of each box indicates the Magnitude of the possible negative impact (5 represents the greatest and 1 the least), and a number in the lower right corner of each box indicates the Importance of the possible negative impact (5 represents the greatest and 1 the least) without any mitigation measures.
A minus number means possible positive impact.

Chapter 5 PROPOSED MITIGATORY MEASURES

5.1 Introduction

The mitigatory measures proposed in this section will fall into following categories:

- Changing project sites, routes, operational methods, processes, and timing.
- Introduction of pollution control measurers and resource optimization
- Restoration measures to recover damages
- Compensation to provide acceptable alternative resources for lost resources

The project proponent may agree to mitigate any other impact that may not be identified in the EIA but found during the implementation of construction and operation phase.

5.2 Mitigation of impact on physical resources

5.2.1 Land use pattern

It may be important that measures are taken to prevent possible illegal encroachments into state lands and compensation intended development in private lands within the boundaries of the project actions. This can be done by declaration of interim development period under legislation, under which the all the development activities within the particular zone declared will be controlled.

5.2.2 Geology and soil

5.2.2.1 Land and soil

Impacts may be significant during construction period, therefore, the following measured are proposed during construction phase.

(1) Soil contamination

Oil and grease contamination control

The location of the machinery service yard may be decided adequately away from the natural drainage paths (river, stream, springs, etc) and above the maximum flood levels recorded within 3 to 5 years. Also, treatment facilities shall be decided above the peak flood levels to prevent possible inundations during heavy floods. The optimum distance may be decided in the design stage by considering the operational feasibility.

The machinery service yard should have a suitable surface lining to prevent all possible infiltration of oil into soil layer. An adequate slope should be kept to drain all the wash water in the cleaning operation.

All cleaning materials, used oil containers, used oils should be separately stored and disposed through a environmentally safe disposal mechanism.

The runoff of the adjoining facilities should not be combined with runoff from the machinery service yard. The drainage capacity should be decided to accommodate the runoff from peak rainfalls in order to prevent possible over flowing of drains water during heavy rains.

All the effluents including the runoff from the machinery service yard should be treated to remove oil by installing oil traps and silt traps. The oil collected from the oil traps and the sludge from the silt traps and settling tanks and flocculation tanks shall never be disposed within the construction area. These also should be disposed in the similar manner as per the oil-contaminated wastes.

The final effluent shall meet the General Standard for Discharge of Effluents into Inland Surface Waters (Gazette Extraordinary of the Democratic Socialist Republic of Sri Lanka 1990/02/02).

General maintenance guidelines should be prepared, and staff should be educated to keep the guidelines. The main points in the guidelines are:

- The machinery should be repaired and maintained with a special attention so that all possible oil leaking during operation of machinery in the construction yards may be minimized.
- All machinery maintenance activities especially changing oils and greases application should be essentially carried out within a machinery service yard.
- Any accidental spillages on the soil should be immediately soaked into saw dust to minimize the spreading and should be removed with the contaminated part of the soil.

Toxic material control

The worn batteries of the machinery service yard should be safely stored and disposed through a environmentally safe method.

Any spoil material containing toxic substances or empty container carrying label 'toxic' or an indication similar to that shall be used, stored and disposed off separately in an environmentally safe manner. This category shall include even the household pesticides.

(2) Soil Erosion

Measurers are proposed to control erosion on slopes and riverbanks.

Slope erosion control

Slope erosion control measures are proposed for all project actions that involve soil excavation and disturbance to slopes. Control methods for erosion types; raindrop erosion and runoff erosion, are recommended. The former can be mitigated by preventing direct contact of raindrops with the soil surface and the latter by increasing infiltration of runoff and lining soil surface with such as cement, geotextiles, etc. However, erosion control by increased infiltration is not recommended very much due to susceptibility of slopes to landslides.

Mitigatory measures are considered at two stages; control erosion during construction and that after construction. The latter is important to implement specially for temporary sites that will be abandoned after construction. The mitigatory measurers should be implemented appropriately on those abandoned sites after construction.

<u>Raindrop erosion mitigation</u>

Access roads may be constructed in several sections. The excavated surface in first section may be immediately treated with subsequent aggregate layers so that the erosion of underneath soils may be minimized.

Similarly, other areas where cement or bitumen lining is to be applied shall be immediately covered with subsequent aggregate layers so that the erosion of underneath soils are minimized. Areas with higher erosivity (steep slopes, loose soils, etc.) may also be treated with a soil protection covers such as vegetation geotextiles and stone chips or combinations as soon as possible.

When none of above can be done immediately due to certain limitations, excavated surfaces may be protected as much as possible with impermeable covering material (polythene) to minimize possible raindrop erosion during rains.

Excavation during dry periods is recommendable, though it may not be practical in the project area due to high rainfall intensity and economical infeasibility.

Runoff erosion control

The method proposed here although mainly concentrates on the runoff erosion, at the same time these structures control raindrop erosion as well. It is important to follow the natural contour pattern of the slope when designing the mechanical erosion control structures.

The following structures for runoff erosion mitigation are recommended:

- Contour earth embankments

These can be constructed on contours on either flat or steep slopes, to retain the soils on slopes. It is important to treat all surfaces with vegetation and/or geo-textiles.

- Stone terraces on contour

This method of erosion control is considered as very effective for the project area as to protect the slopes from soil erosion. Masonry walls or gabion walls could be used to protect the soils from erosion. This method may be suitable for the stabilization of shallow unstable slopes as it can stand high intensity rainfall.

- Vegetation control

Use of vegetation alone on slopes may have limited applications due to steepness of the slopes and high rainfall intensity. Hence, the plants will be washed away before the vegetation has an opportunity established a strong root system to protection against erosion. However, this may be effective when combined with other mechanical control methods such as stone terraces a geo-textiles (should be a suitable one that promotes vegetation), etc. Grasses with deep root system may be more effective in the control of erosion in the area. A grass named vetiver, commonly used in upcountry may be a suitable plant.

- Drains

Usually drainage is well considered at the design stage for the construction of permanent facilities as poor drainage has impacts on the foundations. However, for temporary structures, much concern is not given to drainage due to economical reasons. Since these project activities are to be carried out in relatively steep unstable slopes and in an area with high rainfall, it is recommended adequate drainage is included in the detail. Hence, drainage systems even in the temporary facilities should be built with sufficient long-term durability.

The capacity of the drains should be decided based on the rainfall intensity and surface runoff pattern of the area. Also, it may be important to consider natural drainage pattern of the slopes when deciding drains to carry surface runoff. Unlined surface drains may be avoided due to high erositivity and slope instability risk.

Riverbank erosion control

Usually riverbank erosion control measurers are well taken into consideration in the design of weir/dam and the detention pond as the bank erosion has direct detrimental impacts on stability of these structures. Hence, they are not addressed under this section.

- Proposed disposal yard

The location for the proposed disposal yard (one at weir/dam site and one at the right river bank, powerhouse site) was temporarily identified, and may not be suitable as it would clear an about 100m stretch of land along the bank of the river in the steep slopes. Also as required by the Irrigation Department a reasonable width of land should be left as a river reservation. Hence, an alternative location should be decided in further study.

- River bank erosion control in the river at the tailrace canal discharge

Two mitigatory measurers are proposed to control bank erosion in the river at tailrace discharge. One is that the flow of the tailrace discharge is released with a narrow angle to the existing river flow direction so that the turbulent velocity eddies that aggravate bank erosion may be minimized. Also, depending on the state of erosion on either side of the riverbank, a suitable length may be protected by appropriate structures such as gabions, concrete lining, etc.

(3) Sediment deposition

The four temporary disposal yards after construction may require to be treated for replantation. However, accumulation of silt from disposed matter may loose the soil fertility hampering replantation practices. Hence, the surface soil layer needs to be removed if vegetation is recommended. The removed soil may be used as a suitable land filling material provided that extreme care has been taken to prevent contaminations with oil and grease and other pollutants. The existing surfaces should be treated with Slope Agricultural Land Technology (SALT) method to improve the fertility. During this period, suitable peripheral methods should be employed to prevent sediment runoff until the vegetation is reestablished.

Remark: SALT= a method under which slope is protected by masonry retaining walls, grass, drain, afforested trees which are all provided in parallel to contours

5.2.2.2 Mineral resources

Certain impacts may be anticipated only on the sand resource. As indicated in sand resource utilization during operational phase, mitigatory measures could be proposed to minimize the impacts if the extraction is going to affect significantly.

Stone aggregates

It has been already decided at the planning stage to use the aggregate resulted from the tunneling for construction of structures as much as possible. The possibility of using boulders of the colluvium deposits open up during other construction activities such as culverts, roads, dumping yard, etc. may also be considered after assessing their suitability. Similarly the large volume of aggregates resulted during the construction of weir, dam, surge chamber, etc. may also be used for various project activities depending on its suitability. Proper disposal yard should be developed for the aggregate that is not used.

5.2.3 Hydrology and water resources

5.2.3.1 Surface water

The following all the mitigatory measures will be implemented during construction phase.

(1) Organic pollution and nutrient enrichment control

Disposal of sewage

Usually a large number of work force reside in the camps. In many such temporary site the usual practice to treat sewage is to use septic systems. The developer shall consider appropriately SLS 745 1986 Sri Lanka Standard code of practice for design and construction of septic tanks.

Effluents and sewerage generated from campsites shall never be directly disposed into open waters. It may be best to send them through closed drains into suitably designed soakage pits and septic pits.

Consideration should be paid to the site selection for soakage pits and septic pits. In development projects, the design codes of soakage and septic pits accommodate a considerable amount of waste management. Hence, only other environmentally concerned aspects specific to the location are highlighted below.

- The both septic and soakage pits location should be decided above the 3 to 5 year peak floods levels.

- Sufficient adsorption field should be provided to retain and degrade pollutants in the effluent before entering the ground water flow.

- Pits should be decided on sufficiently thick soil overburden (about 30m) to provide adequate absorption fields.

- Special attention should be paid on the ground water table and accordingly adequate gap should be maintained between the absorption field and the ground water table.

- The soils should be well permeable to prevent overflow during heavy rains.

- Steep slopes less than 15° is preferable for location of pits.

- Maximum distance should be considered between the watercourse and the outer boundary of the septic system and at least a minimum of 30m is recommended as a general guide.

Open garbage disposal prevention

The garbage such as canteen waste, sanitary waste or any such domestic type waste shall never be disposed in on-site open disposal yards. They should be essentially stored in closed systems to prevent from rain and messing by animals such as cats, rats, etc. The storage structures should be designed considering the peak flood levels. The garbage should be disposed through environmentally safe disposal manner and the developer shall state the method of disposal. Also the labour force should be made adequately aware to prevent careless scattered garbage disposal such as disposal of lunch sheets, waste food, polythene, etc. Hence, developer shall exercise extreme control of housekeeping within the construction area and the camp areas.

Open defecation prevention

The open defecation practice should be prevented in the construction areas. For that it may be necessary to provide adequate awareness and good sanitary management within the site. In this regard, the developer may get the services of the public health officer in the Kitulgala area to arrange a suitable onsite sanitation awareness programme for labour force.

(2) Sediment pollution control

The measures for sediment pollution control have been stated in ‘5.2.2.1 Land and soil’. Some erosion is unavoidable. Hence, the resultant sediment in the runoff should be trapped before entering the

watercourses as stated below.

The effective performance of the sediment traps is dependent on its maintenance. The areas and structures assigned to function as sediment traps should be maintained regularly. In addition, the silt removed shall be disposed in an environmentally acceptable manner.

Use of natural vegetation as a sediment trap

It has been observed that the area has a well grown riparian vegetation on both sides of the watercourses. The developer should take extreme care to preserve adequate width of this riparian vegetation, which is a buffer zone, to function as a sediment filter. The suitable width may be decided so that all the visible sediment may be retained at the first 25% of the buffer zone.

Use of sediment traps

Permanent facilities and roads design in hilly areas usually contain the silt traps in the drainage network. Hence, this section focuses on consideration of silt traps for temporary yards and other areas that are usually not covered under detailed construction designs.

Temporary sediment traps can be introduced in areas where erosion is unavoidable. The diagram below gives cross section of a suitable sediment trap. Stone riprap may be stocked to form a belt perpendicular to the runoff direction. The outlet of the sediment trap shall be designed filled with same riprap to filter the sediment. These may be suitable to prevent sediment release from temporary sites and roads. These should be cleaned and maintained regularly for its effective performance.

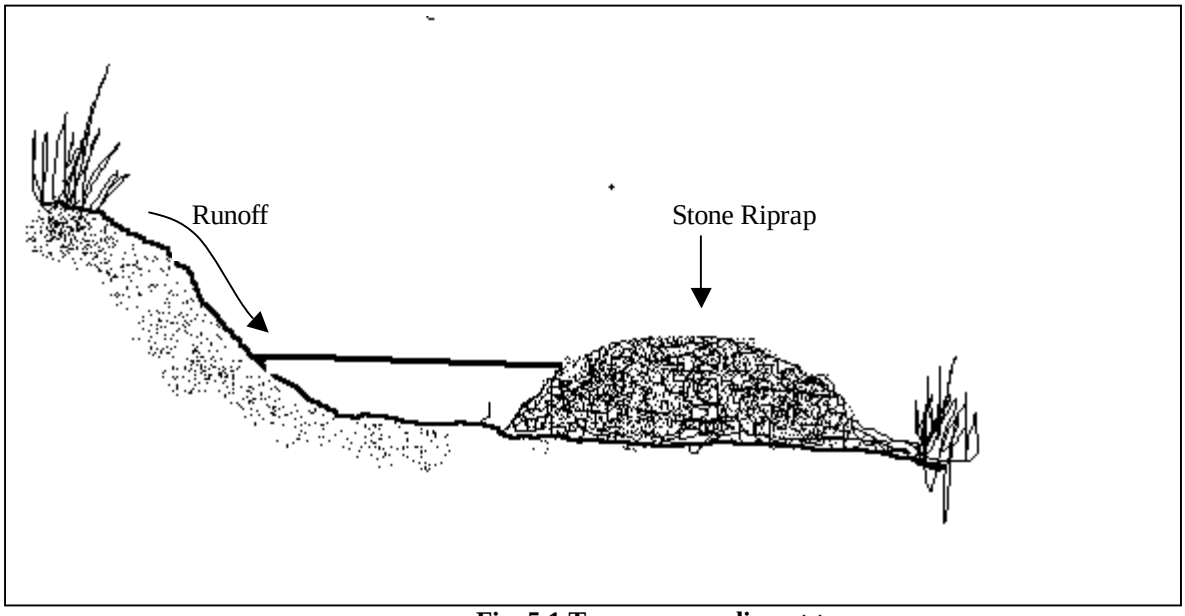


Fig. 5.1 Temporary sediment trap

Sediment basins

These temporary basins can be introduced at lower elevation of the construction site to trap sediments. After construction when the area has been stabilized, they can be graded down to become part of the landscape.

Sediment control in the disposal yards

Disposal yards used to dispose soil need special treatment with adequate sediment control

methods. Hence, sediment traps proposed earlier should be established to minimize all possible sediment runoff.

In addition special attention should be paid to minimize possible fall of excavated soils into river. The machinery operators should be made adequately aware of the need to control such soil falls into river. The spoilt construction material or any excavated material shall never be disposed into river or stored even temporally in the riverbank area.

5.2.3.2 Ground water

(1) Construction phase

Sealing of leaks during the tunneling is usually carried out as a part of tunneling. Hence, it is advised that an immediate action should be taken to seal such leaks whenever a significant leak is noted.

(2) Operation phase

Possible localized drying of riverbank vegetation, if any, can be compensated by the release of the environmental flow as required by the mitigation of other impacts. Hence, no additional mitigatory measures are proposed under this.

5.3 Mitigation of impact on ecological resources

5.3.1 Flora

Terrestrial flora

During construction illegal tree felling should be prevented. The mitigatory measurers are similar to those explained for forest resource within the forest reserve. In other surroundings, an officer appointed by the divisional secretariat may control illegal activities hampering natural vegetation in the area. In addition, for cases found guilty should be treated according to the regulations of felling of trees control act No.9, 1951 and its amended act No. 1 of 2000 and flora and fauna protection ordinance.

After construction the disturbed areas should be re-vegetated. The abandoned areas and open areas of the permanent facilities could be re-vegetated with forest species that can be found in the weir/dam sites. As indicated under mitigatory measurers for forest resource, a selected width on either side of the roads could also be vegetated with these forest species. Hence, at the design stage suitable peripheral buffer area should be included either side of the roads.

5.3.2 Fauna

Re-vegetation of disturbed areas with forest species to create new habitats

The proposed mitigatory measures are similar to flora and forest (5.3.1 & 5.3.3).

Terrestrial fauna

Noise and vibration control during construction

Maximum effort should be made to minimize the noise during construction. Accordingly, unnecessary shouting by the work force, noise by the engine revering, accelerations, vehicle hones, etc. could be minimized. The noisy operations during night should be avoided. Accordingly, work force should be made adequately aware of the importance of noise and vibration control in nature conservation. CEB may arrange relevant awareness programmes with the help of Department of Forest and Department of Wildlife Conservation. The operation shall adhere as much as possible to noise control standards ‘National Environmental

(Noise control) Regulations No. 01 of 1996'.

Blasting should be essentially carried out with sufficient mitigatory measurers to control noise and vibrations. Hence, standard methodologies applied for control blasting should be applied.

Prevention of poaching during construction

The poaching should be strictly prohibited within the forest. The work force should be given adequate awareness on ecological importance of fauna and regulatory framework with respect to poaching of wild fauna as per the flora and fauna protection ordinance. CEA can arrange awareness programmes in this regard. This can be carried out with the help of Forest Department and the Department of Wildlife Conservation.

Re-vegetation after construction

Re-vegetation of disturbed areas with forest species will create new habitats.

Aquatic fauna

Mitigation of water pollution impacts during construction

The mitigatory measurers proposed for land and earth resources to prevent soil contamination and erosion and those proposed under for water quality water environment will be applicable to mitigate anticipated impacts on aquatic fauna due to water pollution.

Securing environmental flow

There is going to be a river section that has less river water flow between the weir/dam site and the powerhouse site. It is obvious it will have impact on the ecological conditions of the aquatic fauna, therefore, it will be necessary to secure environmental flow. The environmental flow is the amount of water required in the stream to keep aquatic habitat with minimum changes. This depends on number of factors such as types of the aquatic ecosystems and their seasonal ecological variation. The actual figure requires detailed assessments on the long-term discharge data of the river system, and it will be decided after more examination. A valve for the environmental flow will be installed at the proposed dam to ensure the environmental flow.

In addition, it will be required to keep the riverbed downstream of the proposed dam as it was as much as possible. Accordingly, the dam gate will be made open so that the deposits on the pond will be flushed down during flood period. It is also necessary so as to keep the proposed capacity of the pond. And it is required so as to prevent malaria because ponds that may occur in the riverbed because of discharge decrease will be suitable habitat for malaria mosquitoes, therefore, ponds water should be flushed down.

5.3.3 Forest

(1) Construction phase

1) Powerhouse area

Minimization of damage during the clearance of land

The clearance, removal and transportation of timber should be subjected to prior written approval of Forest Department. The proponent should provide the exact details of project activities within the reserve forest with exact locations and land requirements to the Forest Department. Based on project details and the completed EIA, a set of conditions to be implemented during construction and operation the power project will be issued by the District Forest Office (DFO). All the project activities within the reserve forest should strictly

comply with the set of conditions issued by the district forest office.

The contractors who will be awarded the forest clearance activity should be made aware of set conditions issued by the DFO and they shall adhere to the conditions. Signing a suitable MoU and an agreement between the developer and the contractor shall ensure adherence to this. Implementation of above will minimize degree of damage to the forest resource due to direct project activities.

2) The other parts of the forest

Minimizing any potential illegal felling

Work force and contractors of the project should be adequately made aware of the rules and regulations on illegal felling of trees within forest reserve as per the Forest Ordinance 16/1907 and its Amended Act 13/1966 including subsequent amendments made, the last being Act No. 23 of 1995. They also should be informed about the penalties involving in any such illegal forest activity.

The developer may declare a boundary (project area and a suitable buffer zone), only within which the work force can mobilize, while prohibiting entry into other parts of the forest without permission.

(2) Operation phase

1) Restoration of lost resources

The locations such as camp sites, disposal yards, banks along the tailrace canal area, either sides of the roads, around the powerhouse building area and the buffer areas acquired for the project, etc. will be abandoned after the construction phase. Restoration of natural vegetation is expected, but it may take several decades. Accordingly, afforestation is recommended. The locations mentioned above can be vegetated with forest species found in the locality. Accordingly, about 30% of the area (camp yard, disposal yard, powerhouse building site and periphery of the road, etc.) utilized for the project activities may be restored with the forest species, which were lost during clearance. Afforestration is recommended in areas of camp yard, disposal yard, powerhouse building site and periphery of the roads, etc.

5.4 Mitigation of impact on human environment

5.4.1 Land acquisition

CEB should acquire lands that are necessary for the Project, and the total area will be 350 ha. Land could be obtained by two ways.

1. Direct purchase from owners

CEB deals with the owner and enter into negotiation for the purchase of their lands. The basic documents for negotiation should be a valuation report from a recognized valuer who would have to give all particulars relating to the land. If agreement is reached between the owner and the CEB, notarial deeds in favour of the CEB could be executed by a notary.

2.Compulsory acquisition under statutory power of the state

Acquisition work has to be handed over to an Acquisition Officer who invariably will be the Divisional Secretary of the area. An estimated cost of acquisition has to be obtained from the chief government valuer and arrangement will be made with the Acquiring Officer.

5.4.2 Resettlement

The resettlement should be proceeded based on 'Sri Lanka National Involuntary Resettlement Policy'. The main policy principles stipulated in the above Poicy are as follows:

- Where involuntary resettlement is unavoidable, affected people shoud be assisted to re-establish themselves and imporove their quality of life.

- Affected persons should be fully involved in the selection of relocaiotn sites, livelihood compensation and development options at the earliest opportuniry.

- Resettlement land should be an option for compenstaion in the case of loss of land; in the absence of replacement land cash compensation should be an option for all affected persons.

- Compensatin for loss of land, structures, other assets and income should be based on full replacement cost and should be paid promptly. This should include transaction costs.

- Common property resouces and community and public services should be provided to affected people.

- Affected people who do not have documented title to land should receive fair and just treatment.

- Project Executing Agencies should bear the full costs of compensation and resettlement.

The most important point is to ensure that affected residents and employees will improve or at least restore their income, livelihood and new housing conditions to their original levels; the business conditions of affected enterprises and shops as well as working environment will be restored or improved. And all the compensation procedure should be finished at least one month before the actual construction work.

As for relocation host site, the most prospective one is Broadlands Estate (See Annex 7). It is located near the Broadlands tea factory and between the main road and the river. This land is an old tea plantation and is presently abandoned. The land has drinking water, electricity and road access to market places. The land is generally flat and has a mild slope from the road to the river. The initial inquires reveal that most of the affected people in the weir/dam site prefer to resettle in this land. A land located in the other side of the road, Kalugala Estate, is also available.

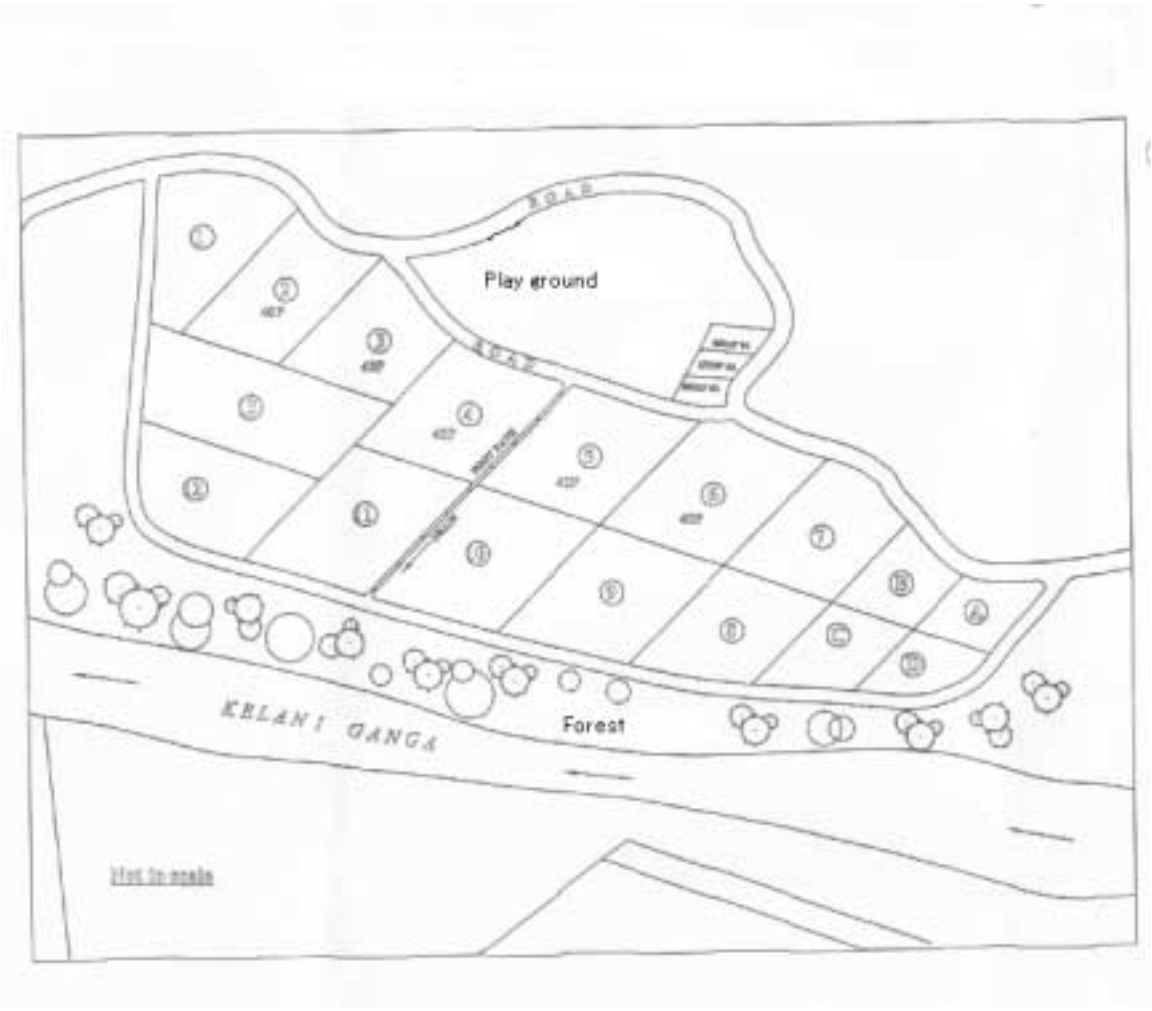


Fig. 5.2 Arrangement example of the relocation host area

In the powerhouse site, there is no suitable land nearby. Therefore, the people to resettle in the powerhouse site will chose to resettle in the Broadlands Estate or to move to other place.

The total homestead area of the relocated households is around 3.8 ha, but it is recommendable that CEB will prepare 8 ha (20 acres) of land on safe side. The land of equivalent area as their present land will be given to respective households. And it is preferable that not a house but money will be given to respective households so that they can build their own houses. Money to be given is calculated based on the present house value.

Accordingly, the building type and size of homes will depend on the decision of each household. Current cost of building construction is in the region of Rs.750 to Rs.1,800/sq.ft.

The existing businesses will be given plots of land facing the main road (plots A,B,C,D in Fig.5.2) so they have advantage of developing their business. They also have opportunities to move to the busier places to expand their business after getting

House rent will be given for a period of about six months to all the households to be resettled to vacate their present homes and build new homes. House rent and other necessary costs will be paid to the people who will have to resettle temporarily during construction phase as well.

5.4.3 Security arrangement

There can be a possibility of people loitering in the construction areas, and this can be prevented by proper fencing and security arrangements around the work sites.

5.4.4 Tourism

Whitewater rafting

Compensation should be paid to whitewater rafting companies based on the related laws and regulations if they are registered to the Ceylon Tourism Board. Hotels and other groups who depend on rafting tourism activities can be compensated as well if they satisfy certain conditions. Negotiation between CEB and the related party will be held individually.

'Bridge on the river Kwai' film location site

The proposed bridge is situated on the film site. Accordingly, attention should be paid so that the rock where the remnants of the monument are present may be avoided and preserved in the construction of the bridge. After construction the remnants will be highlighted to attract more tourists.

Archeologically important site

The potential impacts on temples located within the close proximity of the project activities will be minimized by employing vibration control measures. 'The interim vibration standards for Sri Lanka' shall be adhered. Also developer shall comply the recommendations that will be given in the Archeological Impact Assessment (AIA), if an AIA is conducted.

Cultural activities

According to initial surveys the ceremonial procession travels to Holly Mountain, Sripada and return back to Ratnapura on the two full moon poya days of the month of December and May. The traffic related to construction of power project may be avoided in these two days of the year during the total construction period. The exact schedule dates of this festival can be confirmed by the Honorable priest of the Sri Sudharshanaramaya at Kitulgala town. The CEB should take necessary steps with the contractors to implement this.

Swimming and bathing

If there may be adverse effect on the most popular bathing spot, 2km downstream from the powerhouse site during operational phase, the operation mode of the Broadlands power station will be altered in order to minimize the effect.

5.4.5 Air quality, Noise and vibration

(1) Air quality

Anticipated impact and mitigatory measures can be summarized as below.

Table 5.1 Anticipated impact and Mitigatory measures

Anticipated Impact	Mitigatory Measures
Fugitive dust generation from cleaning and reclamation of lands earth cuttings.	• Watering of exposed areas at least thrice a day, may be morning, afternoon and evening. • Introduction of speed limits for vehicles in construction areas.
Fugitive dust generation from the transportation of material.	• Introduction of speed limits for vehicle transporting materials and wastes. • Keep transport materials under wet conditions as far as possible.
Emission from machinery servicing the construction activities.	• Screening of areas with an appropriate materials with proper dimensions.
Open burning of solid waste.	• Open burning of solid waste in the site should be restricted to the extent of maximum possible. Burying of non - toxic waste, re-using or re-cycling of waste could be adopted. • Toxic waste could be disposed with the assistance of local government. If the waste has high calorific value the waste could be given to any interested party to use as a fuel.
Emission from vehicles	• Proper vehicular inspection and maintenance programme could be adopted. • At the time of selection of a contractor for hiring of vehicles, proper attention must be given to the emission levels of vehicles. (Vehicle should comply with the Vehicle Exhaust Emission Standards gazetted under Extraordinary Gazette No. 1295/11 on June 30, 2003.
Emissions from drilling and blasting.	• Screening of areas with an appropriate materials with proper dimensions. • Control blasting and drilling.
Emissions from quarry sites and dumping sites.	• Screening of areas with an appropriate materials with proper dimensions. • Keep transport materials under wet conditions as far as possible. • Introduction of speed limits for vehicles in site areas.

(2) Noise

Construction of noise barriers is the most common mitigation measure that associated with the concept of noise abatement. Therefore, constructions of temporary noise barriers around the areas where main activities such as tunnel construction sites, quarry sites, workshops, etc. are recommended. These noise barriers can be constructed temporarily by construction of walls, using sand bags, using soil barriers or with noise screens, etc. In addition, maintaining of a thick green belt will drastically bring down the noise level. This option is visually pleasing and blends with their surroundings. Construction activities at night time should be limited to low noise activities if such construction at night time is required.

(3) Vibration

Control blasting in quarry sites and tunnel construction sites, constructions of temporary ground separators around the drilling or hammering areas where possible are recommended. These ground separations can be constructed temporary by dredging soil around and separation with styrofoam or by sand bags, etc.

Other mitigatory measures that could be adopted in control of vibration pollution are;

-, To use low vibratory equipment such as hydraulic jacking type vibration pile and based pile system, where possible,

- To position equipment as far as practical from vibration sensitive receivers and

- To provide safety equipment to workers.

Chapter 6 ENVIRONMENTAL COST BENEFIT ANALYSIS

6.1 Financial plan

The financial cost, benefit and financial evaluation indices for the Project are shown in Table 6.1 (at the end of this chapter).

6.2 Comparison of the proposed plan and alternative

Table 6.2 shows the comparison between the Alternative VII (the proposed one) and V (the most prospective one out of the rest 6 alternatives). The project cost of Alt.V is larger than the one of the Alt.VII by 28.4% though the installed capacity is the same. It means there is no doubt that Alt VII is more predominant in the financial view as well.

Table 6.2 Comparison between Alt. VII and Alt V

Item	Alternative VII (Dam Site E)	Alternative V (Dam Site D)
Dam	H = 24m, L = 100m	H = 58m, L = 350m
High Water Level (HWL)	EL. 121m	EL.121m is physically possible, but taking the submerged area into account, it should be EL.111m or lower.
Effective Storage Capacity	0.24 x $10^6 m^3$	1.00 x $10^6 m^3$
Operation	Run-of-river type (in essentials)	Regulating pond type
Installed Capacity	**40MW**	**40MW**
Expected Annual Energy	Firm 52.85GWh Secondary 92.38GWh Total 145.23GWh	Firm 51.87GWh Secondary 92.07GWh Total 143.94GWh
Project Cost (as of 1986)	**Rs. 1,638Million**	**Rs. 2,104Million**
Geological Conditions	Nothing special	- There is concern that the stability of a landslide on the left bank may be deteriorated by reservoir filling. - Deep weathered zones in the both abutment require large quantity of excavation, cause increase of cost.
Submergence, relocation	About 20 households on the expected waterway route must be relocated.	- About 2km highway must be relocated. - There are many households and cultivated fields in the pondage area. - Study on stability of foundations of pylon near the reservoir is required

Remark: Based on the main features and layout in the F/S, 1986

6.3 Valuation of environmental cost and benefit

6.3.1 Valuation of environmental cost

(1) Loss of scrubland and forest

Methodology for valuation: Benefit transfer method

A closed secondary forest could contain (biomass and soil) carbon. This storage prevents global warming, and the destruction of the forest imposes a global damage cost. The cost can be calculated as shown below.

Table 6.3 Cost for loss of scrub land and forest

Description	Value
Carbon contained in a secondary forest	152 t/ha [*1]
Cost for carbon	20 $/t [*2]
Extent of forest	15 ha [*3]
Exchange rate	96 Rs/$
Total cost	**4,377,600 Rs**

[*1] Source: Houghton R.A. et al (1987) The influx of carbons from terrestrial ecosystem to the atmosphere in 1980 due to change in and use: geographic distribution of the global flux' cited in E.P.N.Udayakumara (2002) Economic evaluation of selected environmental impacts of Samanalawewa Hydro electric project, MSc thesis submitted to the Department of Foresty and Environmental Science, Univ. of Sri Jayewardenepura

[*2] Source: Turner(1984)

[*3] On the assumption that the total forest area that is lost will be 25ha, and an area of 10ha will be restored.

(2) Loss of home garden productivity

Methodology for valuation: Benefit transfer method

A total extent of 16 ha of home garden is considered to be out of production due to the Project, and the cost can be calculated as shown in Table 6.4.

Table 6.4 Cost for loss of home garden productivity

Description	Value
Cost	535,929 Rs/ha [*1]
Extent of home gardens	16 ha
Total cost	**8,574,864 Rs/yr**

[*1] Source: Gunawardena, 2003

(3) Loss of forest products

Methodology for valuation: Social survey

The estimates have been made based on the assumption that the collection of forest products would not be compensated by any other area.

Table 6.5 Cost for loss of forest products

Kind of products	Value
Fuel wood	938,500 Rs/yr
Timber	6,000 Rs/yr
Kitul products	16,000 Rs/yr
Medicinal plants	300 Rs/yr
Total cost	**960,800 Rs/yr**

(4) Loss of whitewater rafting

Methodology for valuation: Market price method

The average annual visitation rates for the site was obtained and the average fees for the water sport was obtained from the existing data sources. The total value of the activity is calculated by multiplying the unit value by the annual number of visitors.

There are three (3) rafting companies, but data cannot be obtained from one of them. Accordingly, the calculation was done on the assumption that the total value of the third company (Company C) is the same as the average of the rest two (2) companies (Company A and Company B).

Table 6.6 Cost for loss of whitewater rafting

Company	Average No. of visitors[*1] (persons/month)	Rate (Rs/person) Foreign	Local	Total value (Rs/year)
Company A	150	1800	1300	3,150,000
Company B	100	2000	1500	2,340,000
Company C[*2]				2,745,000
Total	-	-	-	**8,235,000**

[*1] On the assumption that the local visitors represent 10% of the total number of visitors
[*2] On the assumption that the total value is the same as the average as Company A and Company B

(5) Loss of scenic view of the river

Methodology for valuation: Contingent valuation method

The impacts on scenic views during and after the construction phase in the powerhouse area is considered important as the views capture natural forest in its background.

The mean WTP (Willingness to Pay) for preventing the loss of river flow for perpetuity has been estimated from the survey data from 20 households. Its annual equivalent can be obtained by multiplying by the social rate of time preference (10%).

Table 6.7 Cost for loss of scenic view of the river

Description	Value
WTP (Rs/person)	890 Rs/person
Economically active people	3 persons/household [*1]
Households to be affected	60 households
Total cost	160,200 Rs
Annual cost	**16,020 Rs/yr**[*2]

[*1] Estimated value
[*2] Obtained by multiplying by the social rate of time preference (10%) which is a technical term used for the discount rate prevailing in the country, and gives an annual aggregated value.

(6) Resettlement

Cost for resettlement can be summarized as shown in Table 6.8.

Table 6.8 Cost for resettlement

(Unit: million Rs.)

Description	Value
Preliminary work (awareness rising, survey, finding suitable land, etc.)	2.0
Land acquisition (250,000 Rs/acre * x 20 acre)	5.0
Compensation for houses (500,000 Rs/household x 16 households)	8.0
Land development (road, play ground, etc.)	4.0
Environmental conservation (reforest, drain, etc.)	2.0
Infrastructure (water supply, electricity, etc)	3.5
Socio-cultural work	4.0
Total	**28.5**

* price range is Rs.800,000 to Rs.350,000/acre

6.3.2 Environmental benefit of the Project

(1) Carbon dioxide emission reduction

JICA Study Team prepared a project design document (PDD) of Clean Development Mechanism (CDM) in the 'Study of Hydropower Optimization in Sri Lanka' employing the Broadlands Hydropower Project as a model project.

The emission reduction was calculated based on the following assumptions.

1) Basic case: The power source development will be done in accordance with CEB's Report on Long

Term Generation Expansion Plan (LTGEP).

2) With project case: The Broadlands Hydropower Project, which is not included in the LTGEP, will be implemented to replace the other projects included in the LTGEP. The replacement will be done in order of the project cost (the most expensive project will be replaced by the Broadlands Hydropower Project).

3) Construction of Broadlands Hydropower Project begins at 2003, and its operation begins at 2007.

The carbon dioxide to be emitted in both basic case and with project case is shown in Table 6.9. Green house effect gases other than carbon dioxide were converted to the equivalent carbon dioxide and included in the calculation (shown with the unit:CO_2e, which means CO_2equivalent). Reduced emission and the cost for the reduced emission are shown in the same table as well.

Table 6.9 Carbon dioxide emission comparison and cost calculation

Year	Basic case (tonne CO_2e /year)	With Project Case (tonne CO_2e /year)	Reduced Emission (tonne CO_2e /year)	Cost* (US$/tonne CO_2e)
2007	68,168	14,984	53,184	290,095
2008	62,301	29	62,272	339,666
2009	62,351	29	62,322	339,939
2010	67,529	29	67,500	368,182
2011	63,677	29	63,648	347,170
2012	63,222	29	63,193	344,689
2013	72,736	29	72,707	396,582
2014	69,431	29	69,402	378,556
2015	81,871	29	81,842	446,411
2016	79,666	29	79,637	434,384
2017& after2017	99,669	29	99,640	543,492

*: Cost = Reduced emission x 20$/t x 12/44
(20$/t: Cost for carbon, See Table 6.3)
(12/44 : a conversion rate from carbon to carbon dioxide using atomic weights)

6.4 Environmental cost benefit analysis

Environmental cost can be summarized as follows: All the cost except 'Loss of home garden' should be multiplied by a conversion rate 0.9 so as to convert from financial costs to economic costs, because they are domestic costs .Conversion to US$ was done using the rate of Rs96=1US$.

Table 6.10 Summary of environmental costs

Item	Financial cost (1,000 Rs/yr)	Economic cost (1,000 US$/yr)	Cost occurrence
(1) Loss of scrubland and forest	4,378	41	1st year
(2) Loss of home garden	8,575	80	All the project life
(3) Loss of forest products	961	9	All the project life
(4) Loss of recreation	8,235	77	All the project life
(5) Scenic view	16	0	All the project life
(6) Resettlement	28,500	267	-1st year

The economic costs for the benefit are already shown in Table 6.9, but the Feasibility Study of the Broadlands Hydropower Project was done on the assumption that the Project begins at 2007, and its operation begins at 2011. Therefore, there will be no reduced emission of the carbon dioxide from 2007 to 2011, and instead the carbon dioxide emitted by construction should be put into consideration during the same period. The cost for carbon dioxide is an international cost, therefore, they can be used as an economic cost as it is. The results of cost benefit analysis of the ordinary case and the case including environmental consideration are shown in Table 6.11 and Table 6.12 respectively. The EIRR is 10.25% for the former case, and 10.60% for the latter case.

Table 6.1 Financial Cost, Benefit and Financial Evaluation Indices

(Unit: US$1000)

Year in order		Year	Cost				Benefit			Balance
			Construction & Replacement		Operation		Annual	VAT	Net	
			Hydropower Plant	Transmission Line	& Maintenance	Total	Revenue		Revenue	
-1		2007	11,050	0	0	11,050	0	0	0	-11,050
1		2008	29,216	0	0	29,216	0	0	0	-29,216
2		2009	39,005	176	0	39,181	0	0	0	-39,181
3		2010	32,745	176	0	32,921	0	0	0	-32,921
4	1	2011			1,124	1,124	8,509	774	7,736	6,612
5	2	2012			1,124	1,124	8,509	774	7,736	6,612
6	3	2013			1,124	1,124	8,509	774	7,736	6,612
7	4	2014			1,124	1,124	8,509	774	7,736	6,612
8	5	2015			1,124	1,124	8,509	774	7,736	6,612
9	6	2016			1,124	1,124	8,509	774	7,736	6,612
10	7	2017			1,124	1,124	8,509	774	7,736	6,612
11	8	2018			1,124	1,124	8,509	774	7,736	6,612
12	9	2019			1,124	1,124	8,509	774	7,736	6,612
13	10	2020			1,124	1,124	8,509	774	7,736	6,612
14	11	2021			1,124	1,124	8,509	774	7,736	6,612
15	12	2022			1,124	1,124	8,509	774	7,736	6,612
16	13	2023			1,124	1,124	8,509	774	7,736	6,612
17	14	2024			1,124	1,124	8,509	774	7,736	6,612
18	15	2025			1,124	1,124	8,509	774	7,736	6,612
19	16	2026			1,124	1,124	8,509	774	7,736	6,612
20	17	2027			1,124	1,124	8,509	774	7,736	6,612
21	18	2028			1,124	1,124	8,509	774	7,736	6,612
22	19	2029			1,124	1,124	8,509	774	7,736	6,612
23	20	2030			1,124	1,124	8,509	774	7,736	6,612
24	21	2031			1,124	1,124	8,509	774	7,736	6,612
25	22	2032			1,124	1,124	8,509	774	7,736	6,612
26	23	2033			1,124	1,124	8,509	774	7,736	6,612
27	24	2034			1,124	1,124	8,509	774	7,736	6,612
28	25	2035			1,124	1,124	8,509	774	7,736	6,612
29	26	2036			1,124	1,124	8,509	774	7,736	6,612
30	27	2037			1,124	1,124	8,509	774	7,736	6,612
31	28	2038		0	1,124	1,124	8,509	774	7,736	6,612
32	29	2039		176	1,124	1,300	8,509	774	7,736	6,436
33	30	2040		176	1,124	1,300	8,509	774	7,736	6,436
34	31	2041			1,124	1,124	8,509	774	7,736	6,612
35	32	2042			1,124	1,124	8,509	774	7,736	6,612
36	33	2043	7,754		1,124	8,878	8,509	774	7,736	-1,142
37	34	2044	11,723		1,124	12,846	8,509	774	7,736	-5,110
38	35	2045	12,401		1,124	13,525	8,509	774	7,736	-5,789
39	36	2046			1,124	1,124	8,509	774	7,736	6,612
40	37	2047			1,124	1,124	8,509	774	7,736	6,612
41	38	2048			1,124	1,124	8,509	774	7,736	6,612
42	39	2049			1,124	1,124	8,509	774	7,736	6,612
43	40	2050			1,124	1,124	8,509	774	7,736	6,612
44	41	2051			1,124	1,124	8,509	774	7,736	6,612
45	42	2052			1,124	1,124	8,509	774	7,736	6,612
46	43	2053			1,124	1,124	8,509	774	7,736	6,612
47	44	2054			1,124	1,124	8,509	774	7,736	6,612
48	45	2055			1,124	1,124	8,509	774	7,736	6,612
49	46	2056			1,124	1,124	8,509	774	7,736	6,612
50	47	2057			1,124	1,124	8,509	774	7,736	6,612
51	48	2058			1,124	1,124	8,509	774	7,736	6,612
52	49	2059			1,124	1,124	8,509	774	7,736	6,612
53	50	2060	-18,216	-118	1,124	-17,210	8,509	774	7,736	24,946
Total			125,676	588	56,184	182,448	425,469	38,679	386,790	204,342
In the condition of discount rate at 10 %:										
Present value:						94,473	57,625			-42,087
Internal rate of return (FIRR):										4.85%
B/C										0.61

Table 6.11 Economic Cost, Benefit and Evaluation Indices (1/2)
(Ordinary case)

(Unit: US$1000)

Year in order		Year	Cost				Benefit			Balance
			Construction & Replacement		Operation & Maintenance	Total	Power Benefit	Energy Benefit	Total	
			Hydropower Plant	Transmission Line						
-1		2007	8,740	0	0	8,740	0	0	0	-8,740
1		2008	22,727	0	0	22,727	0	0	0	-22,727
2		2009	30,328	137	0	30,465	0	0	0	-30,465
3		2010	25,430	137	0	25,568	0	0	0	-25,568
4	1	2011			875	875	2,063	9,069	11,132	10,257
5	2	2012			875	875	2,063	9,069	11,132	10,257
6	3	2013			875	875	2,063	9,069	11,132	10,257
7	4	2014			875	875	2,063	9,069	11,132	10,257
8	5	2015			875	875	2,063	9,069	11,132	10,257
9	6	2016			875	875	2,063	9,069	11,132	10,257
10	7	2017			875	875	2,063	9,069	11,132	10,257
11	8	2018			875	875	2,063	9,069	11,132	10,257
12	9	2019			875	875	2,063	9,069	11,132	10,257
13	10	2020			875	875	2,063	9,069	11,132	10,257
14	11	2021			875	875	2,063	9,069	11,132	10,257
15	12	2022			875	875	2,063	9,069	11,132	10,257
16	13	2023			875	875	2,063	9,069	11,132	10,257
17	14	2024			875	875	2,063	9,069	11,132	10,257
18	15	2025			875	875	2,063	9,069	11,132	10,257
19	16	2026			875	875	2,063	9,069	11,132	10,257
20	17	2027			875	875	2,063	9,069	11,132	10,257
21	18	2028			875	875	2,063	9,069	11,132	10,257
22	19	2029			875	875	2,063	9,069	11,132	10,257
23	20	2030			875	875	2,063	9,069	11,132	10,257
24	21	2031			875	875	2,063	9,069	11,132	10,257
25	22	2032			875	875	2,063	9,069	11,132	10,257
26	23	2033			875	875	2,063	9,069	11,132	10,257
27	24	2034			875	875	2,063	9,069	11,132	10,257
28	25	2035			875	875	2,063	9,069	11,132	10,257
29	26	2036			875	875	2,063	9,069	11,132	10,257
30	27	2037			875	875	2,063	9,069	11,132	10,257
31	28	2038		0	875	875	2,063	9,069	11,132	10,257
32	29	2039		137	875	1,012	2,063	9,069	11,132	10,120
33	30	2040		137	875	1,012	2,063	9,069	11,132	10,120
34	31	2041			875	875	2,063	9,069	11,132	10,257
35	32	2042			875	875	2,063	9,069	11,132	10,257
36	33	2043	6,001		875	6,876	2,063	9,069	11,132	4,256
37	34	2044	9,074		875	9,949	2,063	9,069	11,132	1,183
38	35	2045	9,611		875	10,486	2,063	9,069	11,132	646
39	36	2046			875	875	2,063	9,069	11,132	10,257
40	37	2047			875	875	2,063	9,069	11,132	10,257
41	38	2048			875	875	2,063	9,069	11,132	10,257
42	39	2049			875	875	2,063	9,069	11,132	10,257
43	40	2050			875	875	2,063	9,069	11,132	10,257
44	41	2051			875	875	2,063	9,069	11,132	10,257
45	42	2052			875	875	2,063	9,069	11,132	10,257
46	43	2053			875	875	2,063	9,069	11,132	10,257
47	44	2054			875	875	2,063	9,069	11,132	10,257
48	45	2055			875	875	2,063	9,069	11,132	10,257
49	46	2056			875	875	2,063	9,069	11,132	10,257
50	47	2057			875	875	2,063	9,069	11,132	10,257
51	48	2058			875	875	2,063	9,069	11,132	10,257
52	49	2059			875	875	2,063	9,069	11,132	10,257
53	50	2060	-14,107	-91	875	-13,323	2,063	9,069	11,132	24,455
Total			97,805	457	43,750	142,012 0	103,129	453,470	556,599	414,587
In the condition of a discount rate of 10 %:										
Present value:						73,587			75,385	1,799
Internal rate of return (EIRR):										10.25%
B/C										1.02

Table 6.12 Economic Cost, Benefit and Evaluation Indices (2/2)
(Including environmental consideration)

(Unit: US$1000)

Year in order		Year	COST						Total	BENEFIT		Total	Balance
			Construction, Replacement & Operation	(Envitonment)				Resettle-ment		Power & Energy	Environment Reduced Emission of CO2		
				Loss of Scrub & Forest	Loss of Home Garden	Loss of Forest Product	Loss of Recreation						
0		2007	8,740					267	9,007	0	-8	-8	-9,016
1		2008	22,727	41	80	9	77		22,934	0	-21	-21	-22,955
2		2009	30,465		80	9	77		30,631	0	-28	-28	-30,659
3		2010	25,568		80	9	77		25,734	0	-24	-24	-25,757
4	1	2011	875		80	9	77		1,041	11,132	347	11,479	10,438
5	2	2012	875		80	9	77		1,041	11,132	345	11,477	10,436
6	3	2013	875		80	9	77		1,041	11,132	397	11,529	10,488
7	4	2014	875		80	9	77		1,041	11,132	379	11,511	10,470
8	5	2015	875		80	9	77		1,041	11,132	446	11,578	10,537
9	6	2016	875		80	9	77		1,041	11,132	434	11,566	10,525
10	7	2017	875		80	9	77		1,041	11,132	543	11,675	10,634
11	8	2018	875		80	9	77		1,041	11,132	543	11,675	10,634
12	9	2019	875		80	9	77		1,041	11,132	543	11,675	10,634
13	10	2020	875		80	9	77		1,041	11,132	543	11,675	10,634
14	11	2021	875		80	9	77		1,041	11,132	543	11,675	10,634
15	12	2022	875		80	9	77		1,041	11,132	543	11,675	10,634
16	13	2023	875		80	9	77		1,041	11,132	543	11,675	10,634
17	14	2024	875		80	9	77		1,041	11,132	543	11,675	10,634
18	15	2025	875		80	9	77		1,041	11,132	543	11,675	10,634
19	16	2026	875		80	9	77		1,041	11,132	543	11,675	10,634
20	17	2027	875		80	9	77		1,041	11,132	543	11,675	10,634
21	18	2028	875		80	9	77		1,041	11,132	543	11,675	10,634
22	19	2029	875		80	9	77		1,041	11,132	543	11,675	10,634
23	20	2030	875		80	9	77		1,041	11,132	543	11,675	10,634
24	21	2031	875		80	9	77		1,041	11,132	543	11,675	10,634
25	22	2032	875		80	9	77		1,041	11,132	543	11,675	10,634
26	23	2033	875		80	9	77		1,041	11,132	543	11,675	10,634
27	24	2034	875		80	9	77		1,041	11,132	543	11,675	10,634
28	25	2035	875		80	9	77		1,041	11,132	543	11,675	10,634
29	26	2036	875		80	9	77		1,041	11,132	543	11,675	10,634
30	27	2037	875		80	9	77		1,041	11,132	543	11,675	10,634
31	28	2038	875		80	9	77		1,041	11,132	543	11,675	10,634
32	29	2039	1,012		80	9	77		1,178	11,132	543	11,675	10,497
33	30	2040	1,012		80	9	77		1,178	11,132	543	11,675	10,497
34	31	2041	875		80	9	77		1,041	11,132	543	11,675	10,634
35	32	2042	875		80	9	77		1,041	11,132	543	11,675	10,634
36	33	2043	6,876		80	9	77		7,042	11,132	543	11,675	4,633
37	34	2044	9,949		80	9	77		10,115	11,132	543	11,675	1,560
38	35	2045	10,486		80	9	77		10,652	11,132	543	11,675	1,023
39	36	2046	875		80	9	77		1,041	11,132	543	11,675	10,634
40	37	2047	875		80	9	77		1,041	11,132	543	11,675	10,634
41	38	2048	875		80	9	77		1,041	11,132	543	11,675	10,634
42	39	2049	875		80	9	77		1,041	11,132	543	11,675	10,634
43	40	2050	875		80	9	77		1,041	11,132	543	11,675	10,634
44	41	2051	875		80	9	77		1,041	11,132	543	11,675	10,634
45	42	2052	875		80	9	77		1,041	11,132	543	11,675	10,634
46	43	2053	875		80	9	77		1,041	11,132	543	11,675	10,634
47	44	2054	875		80	9	77		1,041	11,132	543	11,675	10,634
48	45	2055	875		80	9	77		1,041	11,132	543	11,675	10,634
49	46	2056	875		80	9	77		1,041	11,132	543	11,675	10,634
50	47	2057	875		80	9	77		1,041	11,132	543	11,675	10,634
51	48	2058	875		80	9	77		1,041	11,132	543	11,675	10,634
52	49	2059	875		80	9	77		1,041	11,132	543	11,675	10,634
53	50	2060	-13,323		80	9	77		-13,157	11,132	543	11,675	24,832
Total			142,012		4,240	477	4,081	267	151,118	556,599	26,158	582,757	431,639
In the condition of a discount rate of 10 %													
Present value:									75,363			78,532	3,169
Internal rate of return (EIRR):													10.44%
B/C:													1.04

Chapter 7 PROPOSED MONITORING MEASURES

7.1 Institutional framework

The project proponent (Ceylon Electricity Board) will establish Environmental Management Office (EMO). It will become the overall responsible body in the implementation of the mitigatory plan and monitoring plan, and functions as a self-monitoring agency. It will instruct the contractor(s) so that they will follow the stipulated mitigation plan. The Environmental Manager (EM) will be appointed to be responsible for all the monitoring activities. And it will be staffed with specialists to cover all the important fields respectively such as flora, fauna, water quality, public health, etc.

The Resettlement Committee will be established as a part of the EMO. It will conduct all the resettlement works following the resettlement plan.

The Consultation Contact Office will be established as a part of the EMO as well. The residents can contact the office to have consultation or make grievances on any issues related to the Project.

The Monitoring Committee, of which members will be appointed by the Project Approving Agency (i.e. Central Environmental Authority), will consist of members from various line agencies and related local governments. They are skilled or authorized to evaluate the implementation of monitoring plan in the respective fields. They will monitor all the EMO's activities.

The Project may accommodate the Public Monitoring Group. The group may consist of Grama Niladharies, CBO members, priests, school head masters, divisional secretary members, divisional cultural officers, etc.

The above Monitoring Committee and Public Monitoring Group will monitor all the activities of EMO, Resettlement Committee and Consultation Contact Office.

In addition, the Advisory Committee, which will have two (2) specialists (natural environment specialist, social environment specialist) will be established to give technical advice to the EMO in an independent position.

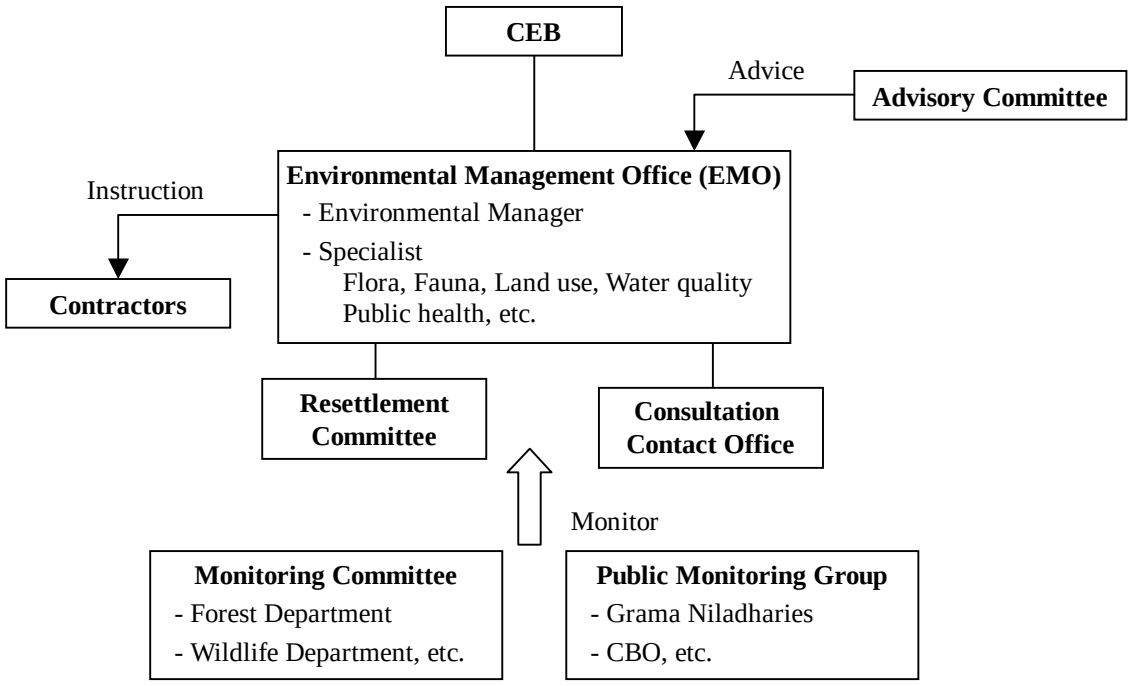


Fig. 7.1 Institutional arrangements for implementation of monitoring plan

7.2 Methodology

(1) Monitoring objectives

The monitoring is carried out to achieve following main objectives:

- To ensure that mitigatory measures are implemented in conformity with the recommendations of the EIA,
- To maintain the impacts within the legal standards and
- To provide timely warning of potential environmental damages so that remedial actions can be taken before impacts result

(2) Phases and types of monitoring

Phases

Three main phases will be considered in the monitoring plan.

- Pre construction phase
- Construction phase
- Post construction / operation phase

Types

Three main types of monitoring are considered in the monitoring plan.

- Baseline Monitoring

  Prior to commencing construction activities, surveys are needed to ascertain the baseline levels of environmental parameters. The values of baseline conditions may be compared with values of subsequent monitoring during the construction, operation and post construction period to assess changes. It will be conducted in the pre-construction phase for the items for which significant impact is anticipated.

- Impact Monitoring

  The ecological, social, economic, and public health impact indicator parameters may be measured to understand the degree of impairment that might occur as a result of the Project.

- Compliance monitoring

  The above monitored impact will be checked in view of compliance with recommendations of the Environmental Monitoring Programme, national standards and other environmental legislation.

(3) Reporting

The EMO will prepare routine reports for example, quarterly and annual reports and special reports which may be needed,based on its work covering all the items required. CEB's Project Office will arrange for distribution of these reports to related national and international agencies.

The monitoring on the respective items will be done based on the methodology, indicators, duration, frequency and reporting schedule and format shown in Table 7.1.

Table 7.1 List of monitoring actions (1/4)

Pre-construction phase

Area	Monitoring object	Actions	
Land use pattern	Violations of Interim development plan	Monitoring methodology	Field audits for compliance
		Monitoring indicators	Encroachments and developments within the interim development zone
		Duration	From the effective date of the development plan up to the construction phase
		Frequency	Daily
		Reporting schedule and format	Monthly review reports
Tourism resources	White water rafting -Payment of compensation	Monitoring methodology	Monitor adherence to propose compensation scheme
		Monitoring indicators	Terms and conditions of the scheme
		Duration	As decided by planners
		Frequency	To be decided
		Reporting schedule and format	Status reports
Water Environment	Surface water quality –Baseline survey Chemical and physical parameters	Monitoring methodology	Analyzing water samples at location Nos. 2, 5 and 7 and a suitable location at Katarun Oya and tributaries at weir/dam site
		Monitoring indicators	TSS, DO, TP, Feacal coliform count, BOD, Ammonical Nitrogen, Nitrite and Nitrate Nitrogen
		Duration	Two months before commencement of construction
		Frequency	Monthly
		Reporting schedule and format	One status report
Fauna	Baseline survey	Monitoring methodology	Conduct field aquatic ecological survey
		Monitoring indicators	Species composition, diversity, existing habitat structure, indicators of stresses etc
		Duration	As decided by the fauna specialist
		Frequency	Once before the commencement of the project
		Reporting schedule and format	Annual reports

Table 7.1 List of monitoring actions (2/4)

Construction phase

Area	Monitoring object	Actions	
Land and soil	Soil contamination by oil and grease	Monitoring methodology	Field audits to check the compliance
		Monitoring indicators	General maintenance guidelines
		Duration	Throughout the construction period
		Frequency	Daily
		Reporting	Monthly review reports
	Oil and grease levels in effluents from machinery service yard	Monitoring methodology	Compliance to requirements of liquid effluent quality
		Monitoring indicators	Terms and conditions of the scheme
		Duration	As decided by planners
		Frequency	To be decided
		Reporting schedule and format	Status reports
	Monitoring disposal of toxic materials	Monitoring methodology	Monitor adherence to environmentally safe storage, handling and disposal of toxic materials
		Monitoring indicators	The conditions specified by the toxic material storage, handling and disposal plan
		Duration	Throughout the construction period
		Frequency	Daily
		Reporting schedule and format	Monthly compliance report
	Monitoring adherence to soil erosion protection measurers	Monitoring methodology	Field audits to check the compliance
		Monitoring indicators	Specifications indicated in the proposed erosion control plans
		Duration	Throughout the construction period
		Frequency	Daily
		Reporting schedule and format	Annual reports
Mineral resource	Use and disposal of stone aggregates	Monitoring methodology	Field audits to check compliance
		Monitoring indicators	Specifications given in the proposed reuse and disposal plan
		Duration	During the construction period
		Frequency	Weekly
		Reporting schedule and format	Monthly review reports
Water Environment	Construction of septic systems, waste disposal systems and sediment traps	Monitoring methodology	Field audits to check the compliance
		Monitoring indicators	Specifications indicated in the of section Water Environment on the construction of above
		Duration	Throughout the construction period of the above mentioned items
		Frequency	Daily
		Reporting schedule and format	Monthly compliance reports
	Disposal of waste including garbage, liquid effluents, open defecation, sediment into water bodies	Monitoring methodology	Field audits to check the compliance
		Monitoring indicators	Specifications indicated in the of section Water Environment on above
		Duration	Throughout the construction period of the above mentioned items
		Frequency	Daily
		Reporting schedule and format	Monthly compliance reports
	Surface water quality	Monitoring methodology	Visual surveys
		Monitoring indicators	Floating garbage, garbage disposal at the river bank, oil slicks, appearance of unusual bacterial scums or blue green algal scums, anoxic zones and fish kills
		Duration	Throughout the construction phase
		Frequency	Daily- Zone 1, weekly- Zone 2
		Reporting schedule and format	Monthly review reports
	Surface water quality –Chemical and physical /micro biological parameters	Monitoring methodology	Analyzing water samples collected at location numbers 2, 5 and 7 and a suitable location at Kataran Oya and tributaries at weir/am site
		Monitoring indicators	TSS,DO,TP, Feacal cliform count, BOD, Ammonical Nitrogen, Nitrite and Nitrate Nitrogen
		Duration	Throughout the construction period
		Frequency	Monthly
		Reporting schedule and format	Monthly/Quality status reports

Table 7.1 List of monitoring actions (3/4)

Construction phase -continued

Area	Monitoring object	Actions	
Water environment	Liquid effluent quality	Monitoring methodology	Analysis of effluent samples collected from the machinery service yard
		Monitoring indicators	TSS, pH, BOD, Oil and Grease, Ammonical Nitrogen, COD
		Duration	Throughout the construction
		Frequency	Quarterly
		Reporting schedule and format	Compliance reports
Flora	Illegal felling and extraction of ecological resources	Monitoring methodology	Filed audits in the study area
		Monitoring indicators	Attempted Violations of the regulations of the fauna flora protection ordinance
		Duration	During the construction period
		Frequency	Daily
		Reporting schedule and format	Monthly review reports
Fauna	Change in the aquatic ecosystem between dam/weir and powerhouse	Monitoring methodology	Field aquatic ecological survey
		Monitoring indicators	Species composition, diversity, existing habitat structure, etc
		Duration	Throughout the construction period
		Frequency	Once a year
		Reporting schedule and format	Annual repots
	Poaching in the reserve forest	Monitoring methodology	Filed audits in the proposed reserve areas within the close proximity of the project actions
		Monitoring indicators	Attempted land violations of the fauna flora protection ordinance
		Duration	During the construction period
		Frequency	Daily
		Reporting schedule and format	Monthly review reports
Forest	Forest clearance for project actions	Monitoring methodologies	Field audits
		Monitoring indicators	Conditions issued by the Forest Department
		Duration	Throughout the construction phase
		Frequency	Daily
		Reporting schedule and format	Monthly compliance reports
	Illegal felling of forest trees	Monitoring methodology	Filed audits in the proposed reserve areas within the close proximity of the project actions
		Monitoring indicators	Attempts and Violations of the regulations of the Forest Ordinance, Felling of trees ordinance
		Duration	During the construction period
		Frequency	Daily
		Reporting schedule and format	Monthly review reports
Tourism	Preservation of 'Bridge on the river Kwai' film site	Monitoring methodology	Field construction audits for compliance
		Monitoring indicators	Specifications of the construction plan designed to preserve the film location
		Duration	Throughout the construction period of the bridge
		Frequency	Daily
		Reporting schedule and format	Single compliance report
	Traffic impacts on Cultural Activities	Monitoring methodology	Field Audits to check the compliance
		Monitoring indicators	Specifications of the proposed traffic schedule during the ceremonial procession
		Duration	Throughout the construction period
		Frequency	Two days per year
		Reporting schedule and format	Two compliance reports in December and May
Human environment	Community survey	Monitoring methodology	Interviewing the communities
		Monitoring indicators	Complaints on the change of life
		Duration	Throughout the construction phase
		Frequency	Quarterly and emergency situations
		Reporting schedule and format	Quarterly review reports
	Noise and vibration by construction activities (residential areas and archeologically important sites)	Monitoring methodology	Measuring noise and vibration
		Monitoring indicators	As per the national standards
		Duration	Throughout the construction phase
		Frequency	Quarterly compliance reports
		Reporting schedule and format	Regular Monitoring

Table 7.1 List of monitoring actions (4/4)

Operation phase

Area	Monitoring object	Actions	
Water environment	Surface water quality –Chemical / physical and microbiological parameters	Monitoring methodology	Analyzing water samples collected at location numbers 2, 5 and 7 and a suitable location at Kataran Oya and tributaries at weir/dam site
		Monitoring indicators	TSS,DO,TP, Feacal coliform count, BOD, Ammonical Nitrogen, Nitrite and Nitrate Nitrogen
		Duration	18 months
		Frequency	quarterly
		Reporting schedule and format	quarterly status reports
Flora	Re-plantation of areas cleared for temporary facilities and other	Monitoring methodology	Field audits to check adherence to proposed replantation plan
		Monitoring indicators	Area of re-planted, way of maintenance
		Duration	Specifications in the replantation plan
		Frequency	As specified in the plan
		Reporting schedule and format	As specified in the plan
Fauna	Change in the aquatic ecosystem structure in the affected parts of the river system	Monitoring methodology	Conduct field aquatic ecological survey
		Monitoring indicators	Species composition, diversity, existing habitat structure, indicators of stresses etc
		Duration	As decided by a fauna specialist
		Frequency	As decided by a fauna specialist
		Reporting schedule and format	Annual repots
Forest resource	Afforestation	Monitoring methodology	Field audits for Compliance
		Monitoring indicators	Specifications given in the reforestation plan
		Duration	As specified in the plan
		Frequency	Daily during the tree planting period, then frequency could be reduced
		Reporting schedule and format	Monthly compliance reports during the planting period then frequency could be reduced

Chapter 8 CONCULUSION AND RECOMMENDATION

The study has revealed that serious impacts on natural/social environment are not expected by the Project implementation. This is partly because the Project is relatively small development project in a limited project area and the number of houses to be relocated is small (16 houses ; 19 households/shops). And to conduct proper mitigation measures is a precondition regarding some items to avoid serious impacts by the Project. Therefore, proper compensation for relocation, various mitigation measures, proper monitoring and management of environment should carried out during both construction and operation phases.

Annexes

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

FOR

THE BROADLANDS HYDROPOWER PROJECT

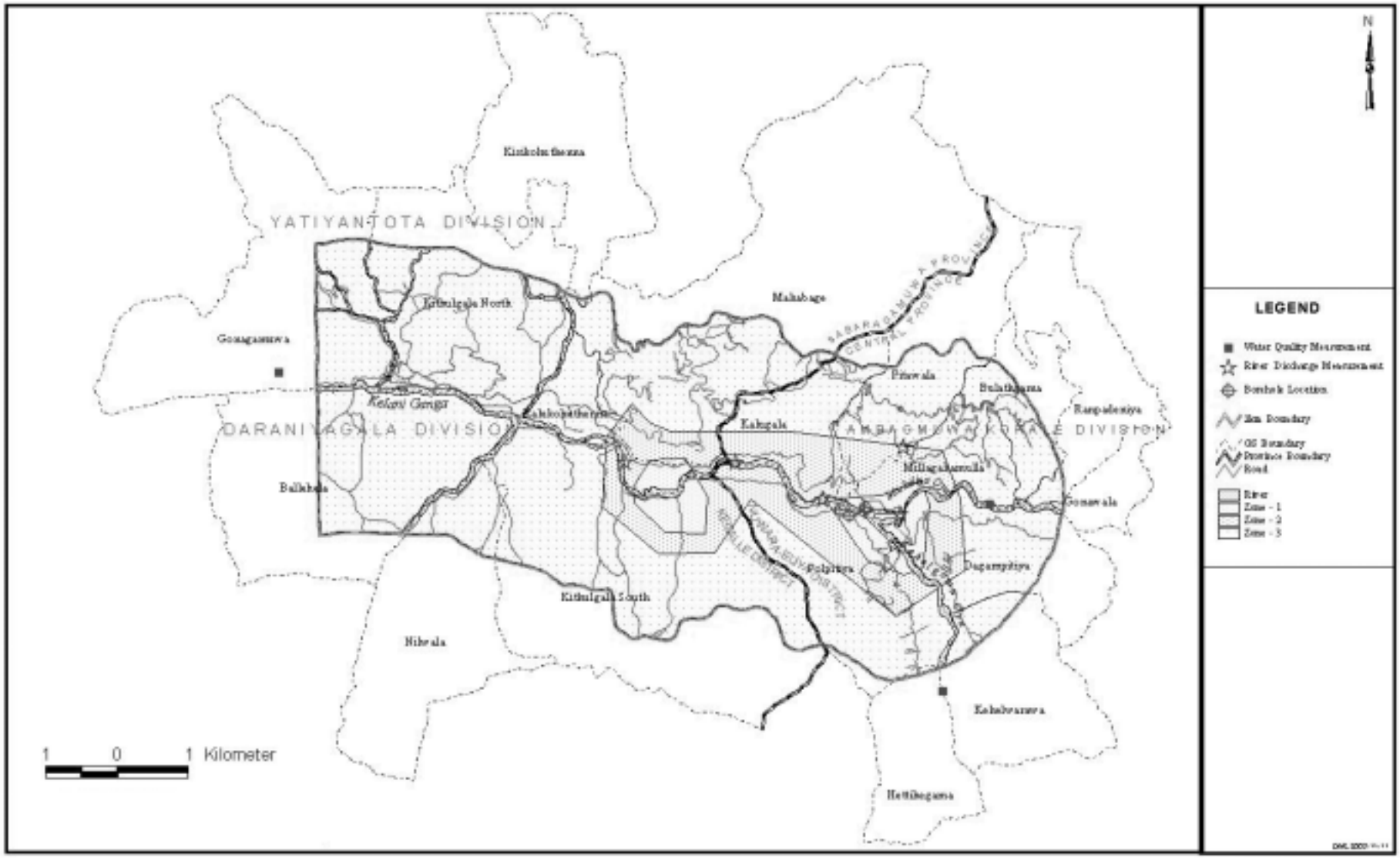
Annex 1 Land use categories

a. Zone-1

Main category	Sub category	Descriptions for land use sub categories
Settlement and related activities	Houses/ Homesteads	A building which is occupied presently, permanently or temporary living with a vegetation of mixed crops are included this category
	Factory	A building which is used for process or manufacture goods included this category
	Religious places	A place, that is used by people for their worship comes under this category. This can be a temple, church, kovil or mosque
	Polpitiya powerhouse properties	All the elements of the CEB without high-tension lines (high-tension lines are shown in a map separately) are included this category such as powerhouse, quarters, buildings, switch yards and their lands
	Army properties - Polpitiya	All the elements of the army camps are included in this category without separately their activities
Plantation / Vegetation & Other	Garden in scrub jungle	Garden can be seen in the scrub jungle. These gardens are established in the recent past
	Chena cultivation	These lands are used seasonally to grow vegetable; Cassawa, Kurakkan etc
	Paddy/ Marsh	Most of the low lands in this are used as paddy field in the past but at present, these lands abandoned and become marshland. However, the irrigated on rain fed paddy cultivated lands and marshes are included in this
	Coconut	Coconut plantations by Estate or State Sector Agency and privately as small holdings are included in this category
	Tea	Tea plantations, planted by Estate or State sector Agency and privately as small holdings are included this category
	Tea & pepper	Tea and pepper plantation are shown in same block together. These pepper grow as shade trees for the tea plantation
	Rubber	Rubber plantations planted by Estate or State Sector Agency and privately as small holdings are included in this category
	Rubber in scrub jungle	These lands are mostly abandoned rubber lands, however scrubs can be seen in the land blocks
	Mixed crops	Lands used for mixed crops of tea, rubber, coffee, pepper, coconut etc. are included to this category. The difference between this and the homestead is, homestead has a main component a permanent or semi permanent residential house
	Natural forest	These forests are naturally grown. Vegetation is consistd of various varieties which are grown in the upcountry wet zone forest
	Scrub	These areas have tree bushes. At present, these can be scrubs. This land used is highly vulnerable to changes such as into tea plantation, chena., Homestead or any other uses
	Jungle	These are consist of medium size trees and not large as in the forest. The thickness of the jungle is lower than forest
	Surface water	All the surface water bodies are included into this category. Rivers, streams, ponds etc. These are shown in blue colour in the map
	Exposed rock	Rocks which are exposed to the surface are included in this category.
Amenities and Utilities	Main road	The Grade A road running through the study area. This road shown as a main road
	Secondary road	The secondary road of Pitawala to Laxapana running through the study area, this road shown as secondary road. This is a “B” Grade road
	Gravel road	There are some gravel road in the study area. There are gravel paved and link with the secondary road and/ or main roads
	Foot path	These paths used to walk. These cannot be used to motor vehicles. These road mainly used to visit homes
	High-tension line	The power distribution lines are mainly shown in this area

b. Zone-1, 2 & part of Zone-3 areas

Main category	Sub category	Descriptions for land use
Settlement and related activities	Homesteads	The homestead category includes land blocks with house and home garden are categorized as homesteads. Plants such as coconut, arecanut, jak, mango, banana etc and lands with land plots of 10 perch (0.025 Ha) up to 800 perch (12.35 Ha). This land use has a permanently occupied house
	Powerhouse	This area consists of Polpitiya Powerhouse premises. Powerhouse and the appurtenant facilities such as conduits, power lines etc. are included under this.
Plantation / Vegetation & other	Paddy	The land use categorized under paddy contain irrigated or rain fed paddy land Some of those lands are cultivated in both seasons of the year and, some others have abandoned and become marsh lands
	Coconut	This land is managed by the Estate or State Sector. 80% of the land area is covered with coconut trees were considered under this category
	Tea	Category represents the Tea plantations grown by the Estate, State Sector or individual small holders
	Rubber	Rubber plantations which are grown by the Estate or State or individual small holders are included
	Mixed crops	This category consist of plants including coconut, jak, arecanut, minor export crops etc
	Natural forest	Category of land consists of variety of natural vegetation grown in the upcountry wet zone forest
	Scrub	This category consist of bushes in natural vegetation grown in the wet zone.
	River/ Stream	This category consists all the water bodies, water ways etc
	Exposed rock	Rocks which are exposed to the surface are included in this category.



Annex 2 Measurement points for surface water and groundwater

Annex 3 List of Plants recorded in Zone-1 and Zone-2

Plant Family	Botanical Name	Vernacular Name	Habit	TS	Use	Occurance – Zone 1						Occurance – Zone-2		
						Dam & Weir			Power House					
						Fo	Hg	Aq	Fo	Hg	Aq	Fo	Hg	Aq
Acanthaceae	*Strobilanthes calycina* Nees	Nelu	S	E	++	*				*		*		
	Strobiolanthes lupulina Nees	Nelu	S	N	++							*		
Anacardiaceae	*Anacardium occidentale* L.	Cashew (E)	T	I	F					*				
	Mangifera indica L.	Mango (E)	T	I	F		*			*		*	*	
	Mangifera zeylanica (Blume) Hook. f.	Etamba	T	E	++	*			*					
	Semecarpus gardneri Thw.		T	E	++							*		
	Semecarpus walkeri Hook. f.		T	E	++							*		
	Spondias dulcis Sol. ex Parkinson	Embarella	T	I	F					*			*	
Ancistrocladaceae	*Ancistrocladus hamatus* (Vahl.) Gilg	Gona Wel	C	E	P		*		*	*		*		
Annonaceae	*Xylopia championii* Hook. f .& Thoms	Dat- ketiya	T	E	++							*	*	
Apiaceae	*Centella asiatica* (L.) Urban	Gotukola	H	N	M		*			*				
Apocyanaceae	*Allamanda catharitica* L.	Wal Rukattana	T	I	M		*			*			*	
	Alstonia macrophylla Wall. ex G. Don	Hawari Nuga	T	I	W	*	*		*	*		*	*	
	Alstonia scholaris (L.) R. Br	Rukattana	T	N	MW	*			*	*		*	*	
	Pagiantha dichotoma (Roxb.) Markgraf	Divi Kaduru	T	N	M	*			*			*	*	
	Plumeria obtusa L.	Temple Tree (E)	T	I	R		*			*			*	
	Tabernaemontana divaricata (L.) R. Br. ex Roem & Schult	Watu-sudda	S	I	R		*			*			*	

Plant Family	Botanical Name	Vernacular Name	Habit	TS	Use	Occurance – Zone 1						Occurance – Zone-2		
						Dam & Weir			Power House					
						Fo	Hg	Aq	Fo	Hg	Aq	Fo	Hg	Aq
Araceae	*Cryptocoryne sp.* Fischer ex Wydler	Kethala	H	E,t	O									*
	Lagenandra spp. Dalz.		H	E	++			*			*			*
	Lasia spinosa	Kohila	H	N	F							*		
	Pothos hookeri Schott		C	E	++	*	*		*	*		*		
Arecaceae	*Areca catechu* L.	Arecanut (E)	T	I	F	*	*		*	*		*	*	
	Borassus flabellifer L.	Palmyrah (E)	T	I	FP					*				
	Calamus sp L.	Wewel	C	N	PO							*		
	Caryota urens L.	Kitul Palm (E)	T	N	F	*	*		*	*		*	*	
	Cocos nucifera L.	Coconut (E)	T	I	F		*			*			*	
	Phoenix dactylifera L.	Date Palm (E)	T	I	F					*				
Aristolochiaceae	*Thottea siliquosa* (Lam.) Ding. Hou		S	N	++	*						*		
Asparagaceae	*Asparagus falcatus* L.	Hathawariya	C	N	M	*	*		*	*		*	*	
Asteraceae	*Wedalia chinensis* (Osbeck) Merr.	Ranwan – keekiridiya	H	N	++	*			*	*		*	*	
	Mikenia cordata (Burm) Robinson	Wathu-palu	S	N	++	*			*			*	*	
	Eupatorium odaratum L.		S	N	++	*						*	*	
Begoniaceae	*Begonia cordifolia* (Wight.)Thw.	Gal Ambala	H	N	++	*			*			*		
Bignoniaceae	*Oroxylum indicum* (L.) Vent	Thotila	T	N	++	*			*	*			*	
	Spathodia campanulata Beauv		T	I	++		*						*	

Plant Family	Botanical Name	Vernacular Name	Habit	TS	Use	Occurance – Zone 1						Occurance – Zone-2		
						Dam & Weir			Power House					
						Fo	Hg	Aq	Fo	Hg	Aq	Fo	Hg	Aq
	Tabebuia serratifolia (Vahl) Nicholson		T	I	++		*						*	
	Tecoma stans (L.) Kunth	Kelani tissa	T	I	++		*			*			*	
Bixaceae	*Bixa orellana* L.	Rata- kaha	T	I	++		*			*		*		
Blechnaceae	*Blechnum orientale* L.	Paththara	H	++	++	*	*		*					
Bombacaceae	*Bombax ceiba* L.	Katu Imbul	T	N	P	*				*			*	
	Ceiba pentandra (L.) Gaertn.		T	N								*		
	Cullenia ceylanica (Gardner) K. Schum	Kataboda	T	E	++	*			*				*	
	Durio zibethinus Murr	Duriyan	T	I	F		*			*		*		
Bromeliaceae	*Ananas comosus* (L.) Merr	Pineapple (E)	H	N	F		*			*		*		
Caricaceae	*Carica papaya* L.	Papaw (E)	T	I	F		*			*				
Celastraceae	*Bhesa ceylanica* (Arn. ex Hw.) Ding Hon	Pelang	T	E	++	*			*			*		
	Glyptopetalum zeylanicum Thw.		T	N	++				*	*				
Clusiaceae	*Clusia rosea* Jacq.	Madol	T	N	++	*			*			*		
	Garcinia echinocarpa Thw.		T	N	++	*			*	*		*		
	Garcinia mangostana L.	Mangosteen (E)	T	I	F		*			*		*	*	
	Garcinia quaesita Pierre	Rath Goraka	T	E	F	*	*		*	*		*	*	
	Mesua ferrea L.	Na	T	N	R	*			*			*		

Plant Family	Botanical Name	Vernacular Name	Habit	TS	Use	Occurance – Zone 1						Occurance – Zone-2		
						Dam & Weir			Power House					
						Fo	Hg	Aq	Fo	Hg	Aq	Fo	Hg	Aq
Combretaceae	*Terminalia bellirica* (Gaertn.) Roxb.	Bulu	T	N	M					*			*	
	Terminalia catappa L.	Kottamba	T	N	F		*			*			*	
Commelinaceae	*Commelina diffusa* Burm. f.	Gira Pala	H	N	M	*	*		*	*		*	*	
Connaraceae	*Connarus monocarpus* L.	Radaliya	S	N	M	*			*					
Cycadaceae	*Cycas circinalis* L.	Madu	T	N	++					*				
Datiscaceae	*Tetrameles nudiflora* R. Br.	Niguna	T	N	++		*		*	*		*	*	
Davaliaceae	*Nephrolepis* sp. Schott		H	++	++	*	*		*	*				
Dilliniaceae	*Dillenia indica* L.	Hondapara	T	N	++	*			*			*		
	Tetracera sarmentosa (L.) Vahl.	Koross Wel	C	N	P	*			*	*		*	*	
Dipterocarpaceae	*Dipterocarpus hispidus* Thw.	Bu Hora	T	E	W	*			*	*		*	*	
	Dipterocarpus zeylanicus Thw.	Hora	T	E,t	W				*					
Dracaenaceae	*Dracaena thwaitesii* Regel.		S	N	++	*			*	*		*		
Ebanaceae	*Diospyros insignis* Thw.	Porawa –mara	T	N	++	*			*	*		*	*	

Plant Family	Botanical Name	Vernacular Name	Habit	TS	Use	Occurance – Zone 1						Occurance – Zone-2		
						Dam & Weir			Power House					
						Fo	Hg	Aq	Fo	Hg	Aq	Fo	Hg	Aq
	Diospyros racemosa Roxb.	Kalluwelle	T	N	++				*			*		
Elaeocarpaceae	*Elaeocarpus serratus* L.	Weralu	T	N	F		*		*	*		*	*	
Euphorbiaceae	*Aporusa lindleyana* (wight.) Baill	Kebella	T	N	M	*			*					
	Aporusa lanceolata (Tul). Thw	Heen Kebella	T	E	++							*		
	Bridelia retusa (Dennst.)Alston	Ketakela	T	N	++	*	*		*	*		*	*	
	Croton aromaticus L.	Wel Keppetiya	S	N	++	*	*			*		*		
	Croton hirtus L′. Herit	Val Tippili	H	I	++							*	*	
	Debregeasia wallichiana	Madu Kenda	T	N	++							*		
	Hevea brasiliensis (A. Juss.) Muell. Arg.	Rubber (E)	T	I	L		*			*		*	*	
	Homonoia riparia Lour.	Ham parila	S	N	++	*			*			*		
	Macaranga peltata (Roxb.) Muell. Arg.	Kenda	T	N	W	*	*		*	*		*	*	
	Mallotus philippensis (Lam.) Muell. Arg.	Molabe	T	N	++	*			*			*		
	Mallotus rhamnifolius (Willd.) Muell. Arg.		S	N	++	*			*					
	Mallotus tetracoccus (Roxb.)Kurz.	Bu Kenda	T	N	++	*	*		*	*		*	*	
	Manihot esculenta Crantz	Cassava (E)	S	I	F		*			*			*	
	Ricinus communis	Castor (E)	S	I	M								*	
	Sauropus androgynus (L.) Merr.	Mella dunkola	S	N	++	*			*					
Fabaceae	*Acacia caesia* (L.) Willd	Hinguru Wel	C	N	++	*	*		*	*		*	*	
	Acacia melanoxylon R. Br.		T	I	++					*				
	Adenanthera pavonina L.	Madatiya	T	N	W		*			*		*	*	
	Albizia falcataria (L.) Fosberg.	Rata Mara	T	I	W		*			*				
	Bauhinia variegata L.	Koboleela	T	I	R		*			*				
	Caesalpinia pulcherrima (L.) Sw	Manora mal	T	I	++		*			*		*	*	

Plant Family	Botanical Name	Vernacular Name	Habit	TS	Use	Occurance – Zone 1						Occurance – Zone-2		
						Dam & Weir			Power House					
						Fo	Hg	Aq	Fo	Hg	Aq	Fo	Hg	Aq
	Cassia occidenrtalis L.	Peni -tora	T	N	M								*	
	Cassia spectabilis DC	Kaha kona	T	I	++		*			*			*	
	Cassia tora L.	Pethi –tora	T	I	M		*		*	*			*	
	Crotolaria incana L.		H	I	++								*	
	Entada pusaetha DC	Pus wel	C	N	++	*			*	*		*		
	Desmanthus virgratus (L.) Willd		H	I	++		*			*				
	Desmodium heterocarpon (L.) DC	Eth-Undupiyaliya	H	N	M		*			*		*	*	
	Desmodium triflorum (L.) DC	Heen Undupiyaliya	H	N	M							*	*	
	Desmodium triquetrum		C	N	++	*								
	Erythrina variegata L.	Erabadu	T	N	M		*			*				
	Gliricidia sepium (Jacq.) Walp	Weta Heeriya	T	I	++		*			*			*	
	Humboldtia laurifolia (Vahl).Vahl.	Gal Karanda	T	N	++	*			*			*		
	Lagerstoemia speciosa (L.) Pers.	Murutha	T	N	++	*			*	*		*		
	Mimosa invisia Mart		C	I	++							*	*	
	Mimosa pudica L.	Nidikumba	H	I	++		*			*		*	*	
	Pericopsis mooniana (Thw.) Thw.	Nedun	T	N, ht	W	*			*					
	Tadehagi triquetrum (L.) Oshashi	Baloliya	S	N	++							*	*	
Flacourtiaceae	*Flacourtia inermis* Roxb.	Lovi	T	I	F					*			*	
	Hydnocarpus venenata Gaertn	Makulu	T	E	++							*		
Gleicheniaceae	*Dicranopteris liniaris* (Burm.f.)Underwod		H	++	++	*			*			*	*	
Hydrocharitaceae	*Blyxa auberti* Rich.	Heen Binthal	H	N	++			*			*			*

Plant Family	Botanical Name	Vernacular Name	Habit	TS	Use	Occurance – Zone 1						Occurance – Zone-2		
						Dam & Weir			Power House					
						Fo	Hg	Aq	Fo	Hg	Aq	Fo	Hg	Aq
Hypoxidaceae	*Curculigo orchioides* Gaertn.	Iriweriya	S	N	++	*			*					
Lamiaceae	*Hyptis sauveolensis* (L.) Poit.		S	I	++								*	
	Plectranthus zatarhendi (Forssk.)E.A.Bruce	Iriweriya	H	N	M		*							
Lauraceae	*Cinnamomum dubium* Nees	Wal Kurundu	T	E	++	*	*		*	*		*	*	
	Cinnamomum vernum J. Presl.	Cinnamon (E)	T	N	S	*	*		*	*			*	
	Litsea longifloia (Nees) Trimen	Rat Keliya	T	E	++							*		
	Persea americana Miller	Avacado (E)	T	I	F		*			*			*	
Lecythidaceae	*Barringtonia racemosa* (L.) spreng.	Diya Midella	T	N	++	*			*			*		
Leeaceae	*Leea indica* (Burm f.) Merr	Gurulla	T	N	++							*	*	
Loganiaceae	*Strychnos benthamii* C. B. Clarke		S	E	++							*		
	Strychnos tetragona A. W. Hill		S	E	++							*		
Loranthaceae	*Dendrophthoe falcate* (L. f.) Ethingsh	Pilila	Ep	N	++							*	*	
Lythraceae														
Magnoliaceae	*Michelia champaca* L.	Sapu	T	I	W		*			*			*	
Malvaceae	*Hibiscus rosa-sinensis* L.	Shoe Flower (E)	S	I	R		*			*			*	
	Hibiscus furcatus Roxb.	Napiriththa	C	N	++		*		*	*		*	*	
	Urena lobata L.	Patta Epala	H	N	++		*		*	*				

Plant Family	Botanical Name	Vernacular Name	Habit	TS	Use	Occurance – Zone 1						Occurance – Zone-2		
						Dam & Weir			Power House					
						Fo	Hg	Aq	Fo	Hg	Aq	Fo	Hg	Aq
Melastomataceae	*Axinandra zeylanica* Thw.	Kekiri Wara	T	E	++	*			*					
	Clidemia hirta (L.) D. Don		S	I	++	*	*		*					
	Melastoma malabathricum L.	Ma- bowitiya	S	N	++							*	*	
	Memecylon clarkeanum Cogn.		S	E	++	*			*	*		*		
	Memecylon hookeri Thw.	Kewitiya-kera	S	N	++				*			*		
	Memecylon varians Thw.		S	E	++	*			*					
	Memocylon rivulare Bremer.		S	E	++	*			*					
	Memocylon rostratum Thw.	Heen Kuratiya	T	E	++	*			*			*		
	Miconia calvescens DC.		T	I	++					*				
	Osbeckia aspera (L.) Blume	Bowitiya	S	N								*		
	Osbeckia octandra (L.) DC	Heen Bovitiya	S	N	M		*		*	*		*	*	
	Sonerila silvatica Lundin		H	E	++	*			*			*	*	
Meliaceae	*Cipedessa baccifera* (Roth) Miq	Hal Bembiya	T	N								*		
	Melia azedarach L. s.l.	Lunu Midella	T	N	W	*			*	*		*	*	
	Swietenia macrophylla King	Mahogani (E)	T	I	W	*	*		*			*	*	
Menispermaceae	*Anamirta cocculus* (L.) Wight & Arn	Titta Wel	C	N								*	*	
	Coscinium fenestratrum (Gaertn.)Colebr.	Weni Wel	C	N ,gt	M	*			*			*	*	
	Tinospora cordifolia (Gaertn.)Colebr.	Rasakinda	C	N	M		*							
Moraceae	*Artocarpus heterophyllus* Lam.	Jak (E)	T	I	F	*	*		*	*		*	*	
	Artocarpus incisus L. f.	Rata Del	T	I	F		*			*			*	
	Artocarpus nobilis Thw.	Bedi Del	T	E	++	*	*		*	*		*	*	
	Ficus dibersiformis Miq		C	E								*		
	Ficus exasperata vahl.	Bu thaliya	T	N	++	*			*			*		
	Ficus fergusoni (King) Worthington	Kos Nuga	T	E	++	*			*			*		

Plant Family	Botanical Name	Vernacular Name	Habit	TS	Use	Occurance – Zone 1						Occurance – Zone-2		
						Dam & Weir			Power House					
						Fo	Hg	Aq	Fo	Hg	Aq	Fo	Hg	Aq
	Ficus hispida L. f.	Kotadimbula	T	N	M	*	*		*	*		*	*	
	Ficus racemosa L.	Attikka	T	N	M	*			*	*		*	*	
	Ficus tinctoria Forst. f.	Wal ehatu	T	N	++	*			*	*		*	*	
	Ficus tsjahela Burm f.	Kiri Pela	T	N								*		
Musaceae	*Musa* x *paradisiaca* L.	Banana (E)	H	I	FP		*			*			*	
Myristicaceae	*Horsfieldia iriya* (Gaertn.) Warb.	Irya	T	N	++	*			*			*		
	Horsfieldia iryaghedhi (Gaertn.). Warb	Malaboda	T	E	++	*			*			*		
Myrtaceae	*Psidium guajava* L.	Guava (E)	T	I	F		*			*			*	
	Syzygium aromaticum (L.) Merr. & Perry	Clove (E)	T	I	S		*			*			*	
	Syzygium cylindricum (wight) Alston	Rose –apple (E)	T	E,t	++	*			*			*		
	Syzygium lanceolatum		T	N,t								*		
	Syzygium malaccense (L.) Merr. & Perry		T	I	F		*			*			*	
	Syzygium rubicundum Wight & Arn	Karaw	T	N								*		
Ochnaceae	*Gomphia serrata* (Gaertn.) Kanis	Bo Kera	T	N	++	*			*	*		*	*	
	Ochna jabotapita L.	Mal Kera	T	E								*		
Onagraceae	*Ludwigia perennis* L.	Wel Karabu	H	N	++				*					
	Ludwigia peruviana (L.) Hara		H	I								*		
Orchidaceae	*Arundina graminifolia* (D. Don) Hochr.		H	N	++	*	*					*		
	Dendrobium macrostachyum Lindley.		Ep	N	++				*			*		
	Malaxis versicolor (Lindley)		H	N								*		

Plant Family	Botanical Name	Vernacular Name	Habit	TS	Use	Occurance – Zone 1						Occurance – Zone-2		
						Dam & Weir			Power House					
						Fo	Hg	Aq	Fo	Hg	Aq	Fo	Hg	Aq
	Abeywick													
	Pholidota pallida Lindley		H	N	++	*			*			*		
	Sarcanthus peninsularis		Ep	N								*		
Oxalidaceae	*Averrhoa bilimbi* L.	Biling	T	I	S		*			*			*	
Pandanaceae	*Freycinetia pycnophylla* Solms	Wiya Keiya	C	E	++	*			*			*		
	Pandanus ceylanicus Solms	Keyiya	S	E	P			*			*	*		
Passifloraceae	*Passiflora edulsis* Sims.	Passion Fruit (E)	C	I	F					*				
Periplocaceae	*Hemidesmus indicus* (L.) R. Br	Iramusa	H	N	M					*				
Piperaceae	*Piper betle* L	Betel (E)	C	I	R					*				
	Piper sylvestris Lam	Wal Gammiris	C	N	++	*			*			*		
	Piper nigrum L.	Black Pepper (E)	C	I	S		*			*			*	
Poaceae	*Arundinaria spp* Michx		H	N	++	*			*					
	Axanopus spp P. Beauv		H	N	++	*			*					
	Bambusa vulgaris Schrader ex Wendl	Una	T	I	PW		*					*		
	Ochlandra stridula Moon ex Thw.	Bata	S	E	P	*			*			*		
	Oriya sativa L.	Wee	H	N									*	
	Panicum maximum L.	Guinea grass	H	I	++	*						*	*	
Polypodiaceae	*Drynaria quercifolia* (Bory).J. Sim		H	+		*			*					

Plant Family	Botanical Name	Vernacular Name	Habit	TS	Use	Occurance – Zone 1						Occurance – Zone-2		
						Dam & Weir			Power House					
						Fo	Hg	Aq	Fo	Hg	Aq	Fo	Hg	Aq
Rhamnaceae	*Ziziphus oenoplia* (L.) Miller	Heen Eraminiya	S	N	M	*	*		*	*		*	*	
	Ziziphus rugosa Lam.	Maha eraminiya	S	N	M	*			*	*				
Rhizophoraceae	*Anisophyllea cinnamomoides* Gaedner (Champion)Alston	Weli Piyanna	T	E	++	*			*			*		
Rubiaceae	*Coffea arabica* L. (Champion) Alston	Coffee (E)	T	I	B		*			*		*	*	
	Gaertnera vaginans (DC) Merr.		S	N	++	*			*					
	Hedyotis fruiticosa L.	Weraniya	S	N	M	*	*		*	*		*	*	
	Ixora coccinea L.	Rath mal	S	N	MR				*	*		*		
	Mussaenda frondosa L.	Mussanda	S	N	++	*	*		*	*		*	*	
	Psydrax dicoccos Gaertn.	Gal Karanda	T	N	++	*			*					
	Wendlandia bicuspidata (wight & Arn).	Ruvan Edala	T	E	++	*			*					
Rutaceae	*Aegle marmelos* (L.) Correa	Beli	T	N	F					*				
	Citrus aurantifolia (Christm. & Panzer) Swingle	Embul Dodan	T	I	F		*			*			*	
	Citus grandis (L.) Osbeck	Grapefruit(E)	T	I	F		*			*				
	Murraya koenigii (L.) Spreng	Karapincha	T	N	S					*				
	Toddalia asiatica (L.) Lam.	Kudu Mirissa	S	N	++	*			*			*		
	Clausena indica (Dalz) Oliver	Migon Karapinchcha	T	N	++							*		
Sabiaceae	*Meliosma simplicifolia* (Roxb.) Walp	El Bedda	T	N	++							*		

Plant Family	Botanical Name	Vernacular Name	Habit	TS	Use	Occurance – Zone 1						Occurance – Zone-2		
						Dam & Weir			Power House					
						Fo	Hg	Aq	Fo	Hg	Aq	Fo	Hg	Aq
Sapindaceae	*Allophylus cobbe* (L.) Rausch	Kobbe	S	N	++							*		
	Dimocarpus longan Lour.	Mora	T	N	F							*		
	Filicium decipiens (Wight & Arn,) Thw.	Pihimbiya	T	N	++	*				*			*	
	Harpullia arborea (Blanco) Radlk.	Na Embul	T	N	++		*		*	*		*	*	
	Nephiliun lappaceum L.	Rabutan	T	I	F	*				*		*	*	
	Pometia pinnata J. R. & G. Forst.	Gal Mora	T	N	++				*			*	*	
Sapotaceae	*Pouteria campechiana* (kunth.) Baehni.	Rata Lawalu	T	I	F					*				
	Palaquim grande (Thw.) Engl		T	E	++							*		
Smilacaceae	*Smilax zeylanica* L.	Kabarasa	C	N	M				*			*	*	
Sterculiaceae	*Pterospermum suberifolium* (L.) Willd	Welang	S	N	++	*			*			*		
	Sterculia balanghas L.	Nawa	T	N	P				*			*		
	Sterculia zeylanica Kosterm.		T	E, t	++	*								
	Theobroma cacao L.	Cocoa (E)	T	I	B	*			*	*		*	*	
Theaceae	*Camellia sinensis* (L.) Kuntze	Tea (E)	T	I	B				*	*			*	
	Gordonia speciosa (Gardner.) Choisy	Ratu-mihiriya	T	E,t	++		*		*			*		
Thymelaeaceae	*Gyrinops walla* Gaertn.	Wala –patta	T	N	++				*			*	*	
Tiliaceae	*Microcos paniculata* L.	Kohu Kirilla	S	N	++	*	*		*	*		*	*	
	Muntingia calabura L.	Jam	T	I	F								*	

Plant Family	Botanical Name	Vernacular Name	Habit	TS	Use	Occurance – Zone 1						Occurance – Zone-2		
						Dam & Weir			Power House					
						Fo	Hg	Aq	Fo	Hg	Aq	Fo	Hg	Aq
Ulmaceae	*Trema orientalis* (L.) Blume	Gedumba	T	N	++	*	*		*	*		*	*	
Urticaceae	*Debregeasia wallichiana* (Wedd.)Wedd.	Madu Kenda	T	N	++	*			*					
Verbenaceae	*Callicarpa tomentosa* (L.) Murr	Eela gas	S	N	++	*			*				*	
	Clerodendron infortunatum L.	Pinna	S	N	++		*		*	*		*	*	
	Clerodendron paniculatum L.	Pagoda flower (E)	S	N	++		*		*	*		*	*	
	Lantana camara L.	Gandapana	S	I	++		*			*		*	*	
	Vitex altissima L. f..	Milla	T	N	W	*	*		*	*		*	*	
Zingiberaceae	*Costus speciosus* (Koenig.) Smith	Thebu	H	N	++	*			*			*	*	
	Elattaria cardomomum (L.) Maton.	Cardamom (E)	H	N	S	*			*					
XXXXXX	XXXXXXXXXXXXXXXXXXX	XXXXXX	XX	XX	XX	XXXXXXXXX			XXXXXXXXXX			XXXXXXXXXXX		

Abbreviations

Habit - C- climber
H- herb
S- shrub
T- tree
Ep- epiphyte

TS- Taxonomic Status
E- endemic
I –introduced
N- native/indigenous
t – threatened
ht- highly threatened
gt- globally threatened
++-information not found

Vernacular name : given in Sinhala unless stated (E) for English names

Use- B- beverage
F- food
L-latex
M- medicine
P- packing
R- religious purpose
S – spice
W- timber
O – ornamental

Occurrence- * indicates presence
Fo –Forest including scrublands and riverine vegetation
Hg – Homegarden
Aq – Aquatic vegetation

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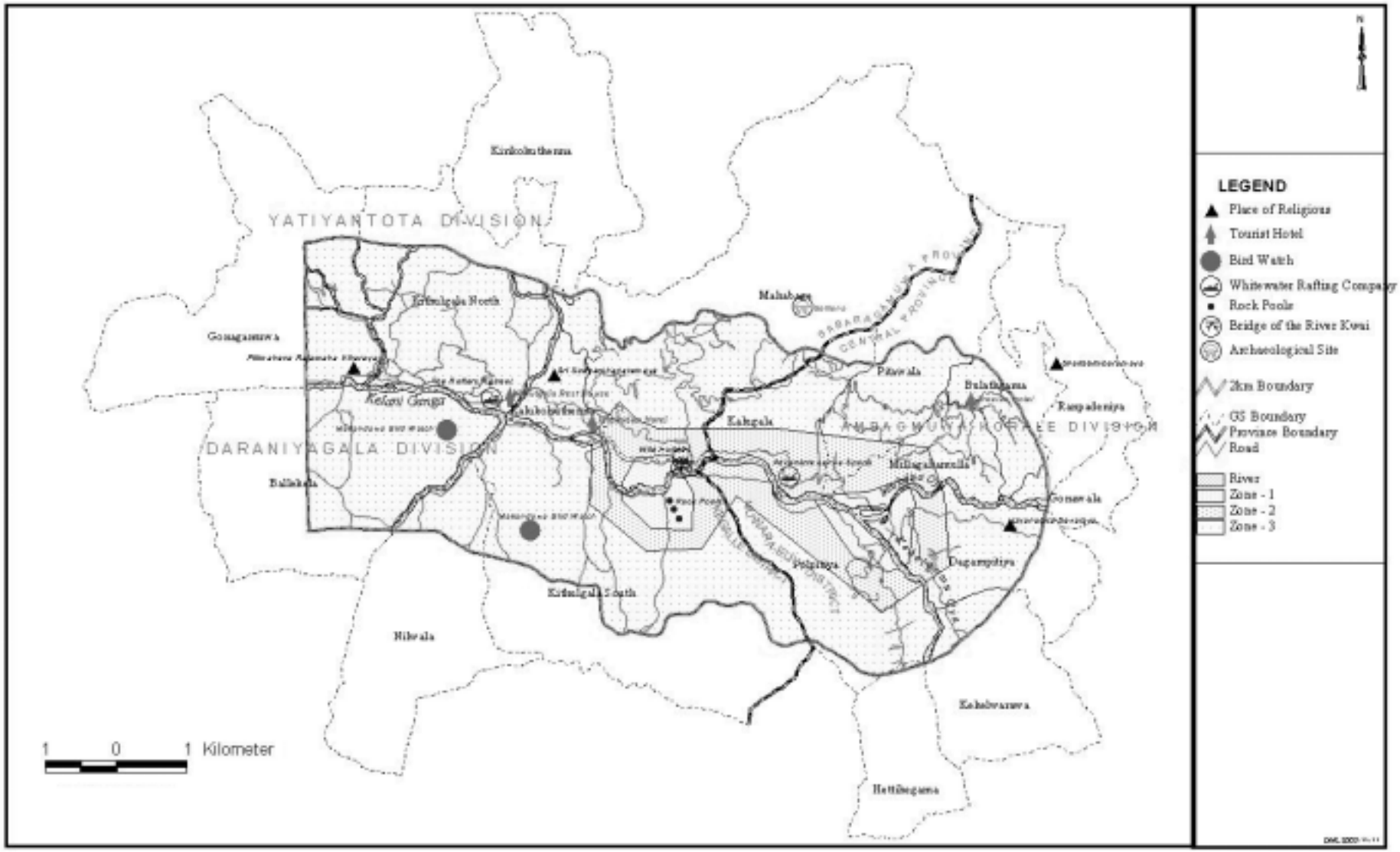
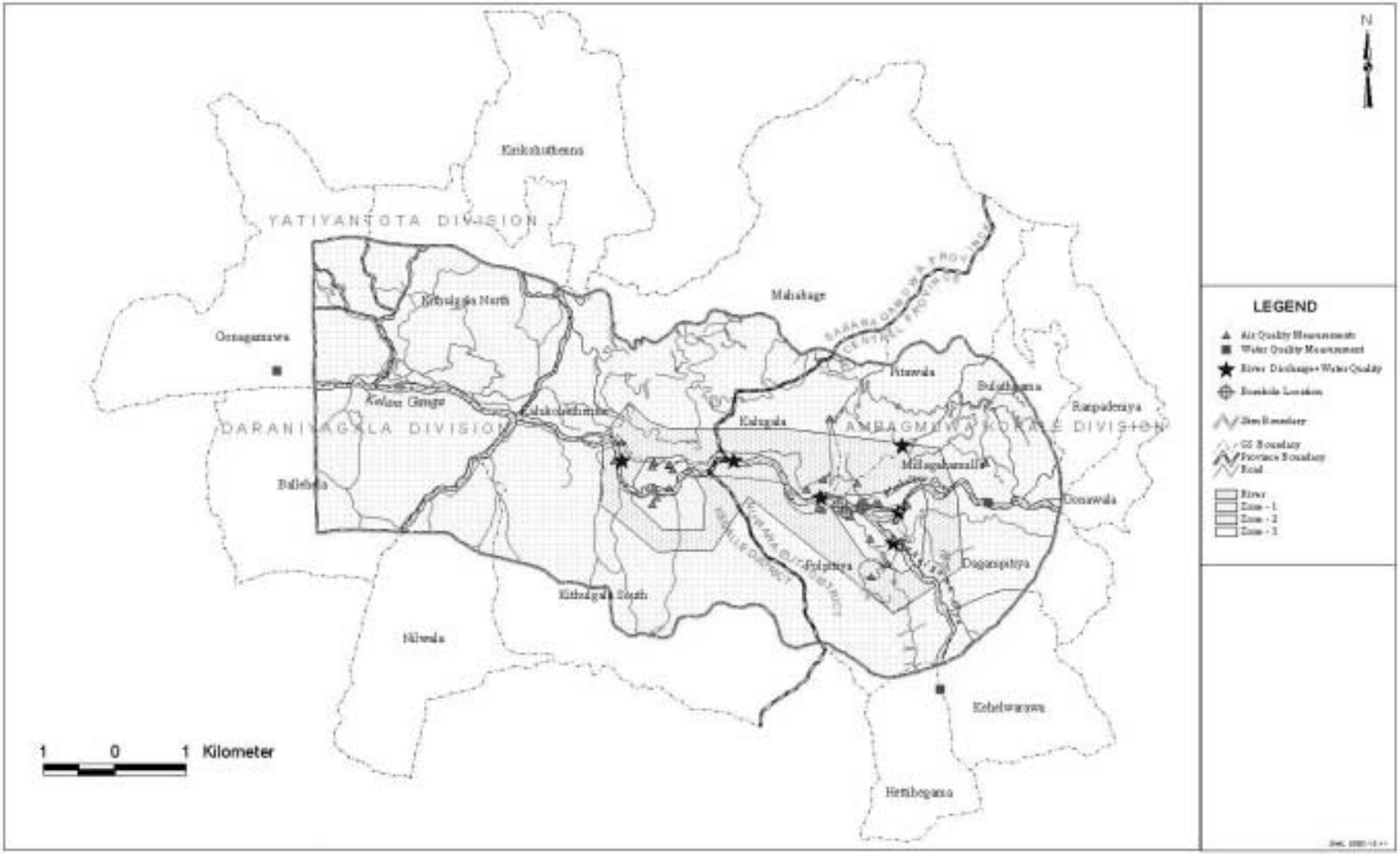


Annex 4 Tourism map



Annex 5 Measurement points for air quality and noise

Annex 6 Related maximum permissible noise levels

Schedule I

Area	L_{Aeq}' *T - Day Time*	L_{Aeq}' *T- Night Time*
Low Noise	55	45
Medium Noise	63	50
High Noise	70	60
Silent Zone	50	45

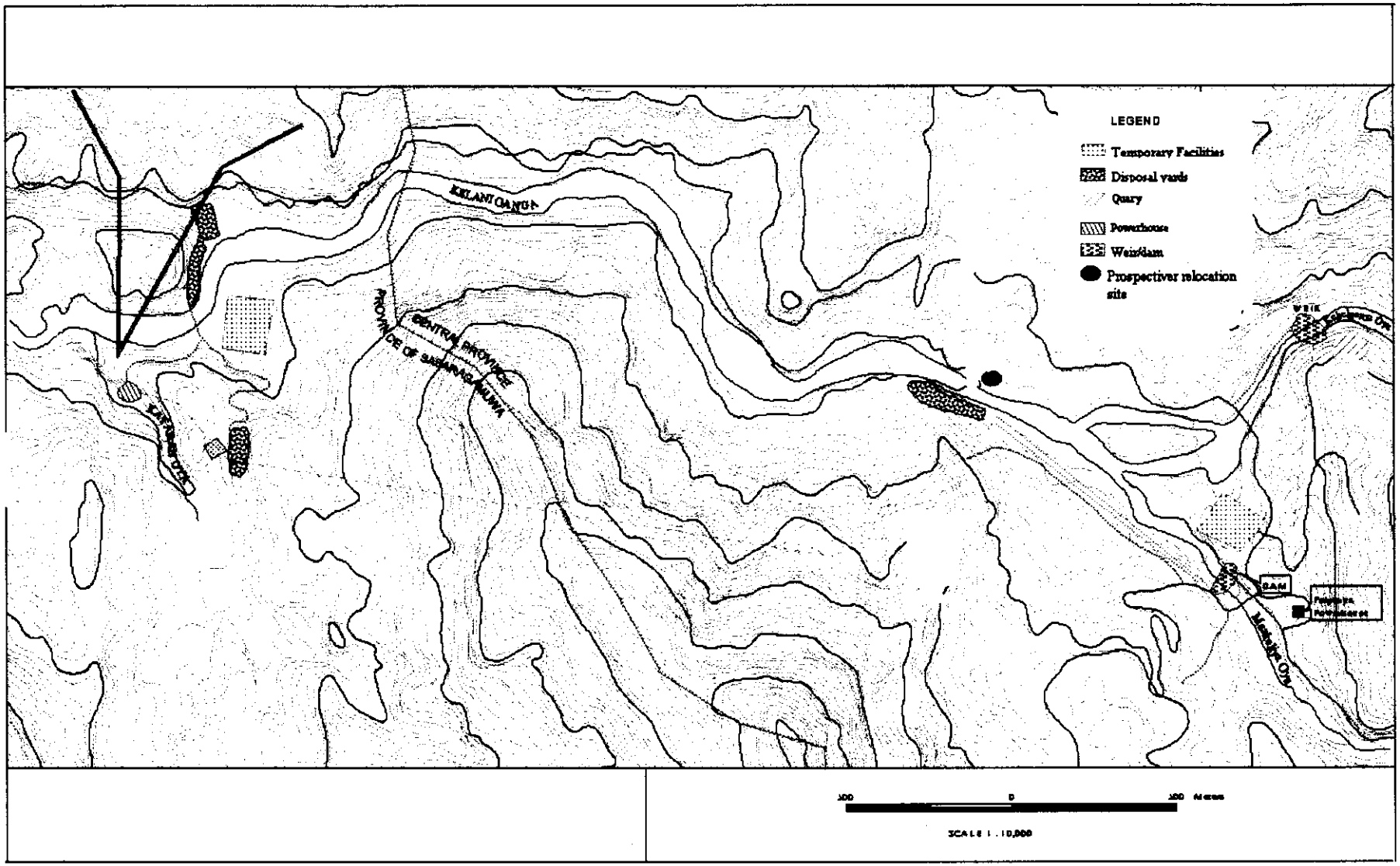
Schedule III

	L_{Aeq}' *T - Day Time*	L_{Aeq}' *T- Night Time*
For Construction Activities	75	50

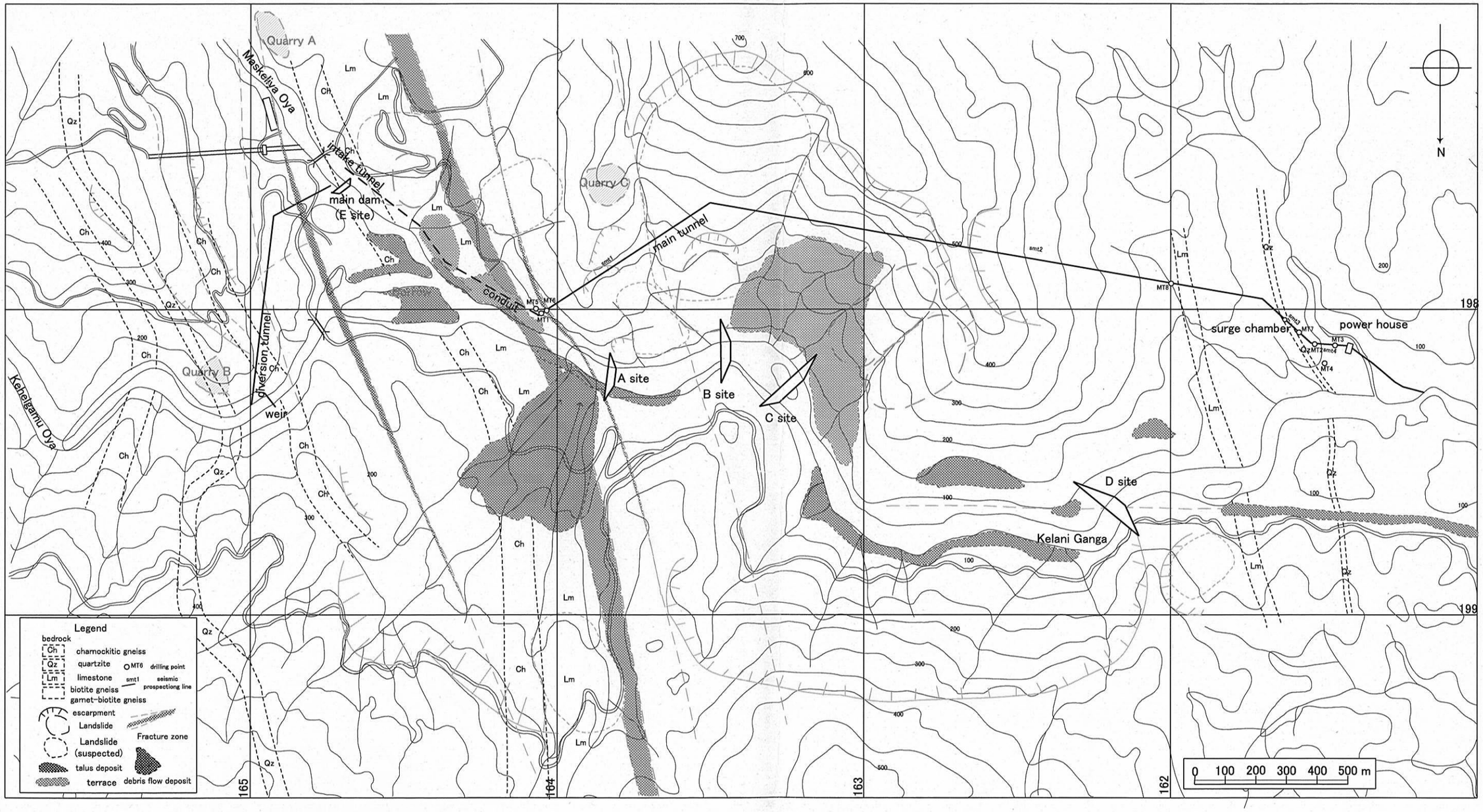
Schedule IV

Area	L_{Aeq}' *T - Day Time*	L_{Aeq}' *T- Night Time*
Rural Residential	55	45
Urban Residential	60	50
Noise Sensitive	50	45
Mix residential	63	55
Commercial	65	55
Industrial	70	60

Source: Extraordinary Gazette No. 924/12 stipulated by CEA, 23.05.1996.



Annex 7 Layout of the proposed project



Annex 8 Geological Map of the Project Area

Annex 9 Core Logging Data

The Quantities of the Existing Core-drilling Holes (by JICA)

Serial No.	No. of Hole	Location	Angle (degree)	Coordinates		Elevation (El-m)	Depth (m)	Stage (phase)
				X	Y			
	DT-1	Diversion weir, dam axis, left bank	90	198,303.675	164,981.324	122.771	25.500	1st
	DT-2	Diversion tunnel	45	197,605.418	164,804.155	139.440	60.000	2nd
	MB-1	Dam site E, dam axis, right bank	90	197,640.971	164,717.431	122.585	40.770	1st
	MB-2	Dam site E, dam axis, riverbed	90	197,626.567	164,701.313	109.430	40.130	1st
	MB-3	Dam site E, dam axis, riverbed	50	197,602.979	164,673.670	107.225	50.000	1st
	MB-4	Dam site E, dam axis, left bank	90	197,585.707	164,658.747	116.814	40.000	1st
	MB-5	Dam site E, dam axis, left bank	90	197,564.127	164,631.381	138.601	30.150	2nd
	CT-1	Cut and cover conduit	90	197,638.873	164,584.150	121.883	20.000	1st
	CT-2	Cut and cover conduit	90	197,892.802	164,321.890	113.713	15.500	1st
	CT-3	Cut and cover conduit	90	197,713.476	164,465.645	106.730	20.350	2nd
	CT-4	Cut and cover conduit	90	197,938.506	164,261.681	103.040	20.000	2nd
	MT-1	Main tunnel, inlet portal	90	198,008.066	164,028.099	124.491	35.540	1st
	MT-2	Main tunnel, penstock	90	198,150.331	161,508.252	100.007	35.000	1st
	MT-3	Main tunnel, outlet portal	90	198,139.480	161,448.998	77.842	25.570	1st
	MT-4	Main tunnel, outlet portal	90	198,200.832	161,468.184	87.558	30.550	1st
	MT-5	Main tunnel, inlet portal	90	198,005.489	164,050.587	123.838	30.250	2nd
	MT-6	Main tunnel, inlet portal	90	197,995.307	164,015.436	134.126	40.100	2nd
	MT-7	Main tunnel, surcharge tunk	90	198,111.429	161,591.171	124.040	60.000	2nd
	MT-8	Main tunnel, linearment	90	197,955.406	161,984.829	154.587	80.060	2nd
	TR-1	Tail race	90	198,240.940	161,313.227	65.845	25.300	2nd
	BQ-1	Quarry B	90	198,278.868	165,079.076	176.102	25.050	2nd
	BQ-2	Quarry	90	198,200.350	164,757.367	157.017	25.100	2nd

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- DIVERSION TUNNEL,KEHELGAMU OYA,LEFT BANK

B.H No.: DT 01

DRILLING DATA		BOREHOLE DATA	KEY		LEGEND FOR GRAPHIC LOG
STARTED :	**20/12/02**	X-COORDINATE :164,981.324m	**JOINT ROUGHNESS**	JOINT SEPARATION	Sand
COMPLETED :	**29/12/02**	Y-COORDINATE :198,303.675m	VR= very rough R: rough SR: slightly rough S= smotth SL=slickensided	V= very tight T= tight MO= moderately open O= open	Clay Fresh to slightly weathered charnockite Highly to mod weathered charnockite Fresh to slightly weathered biotite gneiss Highly to mod weathered biotite gneiss Quartzite Calc gneiss Boulder
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) : 122.771m			
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) :97.271m	**JOINT SPACING**	OTHER SYMBOLS	
CORE BARREL, BIT :	**NQ**	FINAL DEPTH :25.50m	VW= very widely> 2m W= widely MW= moderately wide C= Closely VC= very closely	SL/CW - Soil & Completely Weathered HW - Highly Weathered MW - Moderately Weathered SW - Slightly Weathered TCR - Total Core Recovery RQD - Rock Quality Designation GWL - Ground water Level	TCR / ROD / WEATHERING SL/CW HW MW SW
FOREMAN :	**KRNK**	INCLINATION : Vertical			
LOGGED BY :	**BMAPM**	BEARING : -			

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR, LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N`VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
						0.00															
						0.45	31									Brown colour, densed,clayey silty sand with weathered rock particles					
1					1.00																1
					23 / 12																
					1.40											1.45m					
					29 / 12			Joint at 1.91m(45^0) (Partly weathered joint surface)								Fresh to slightly weathered rock of biotite gneiss		30	12		
2																2.00m					2
	20							Vertical joint at 2.26-2.50m(Fresh tight joint surface)								Fresh rock of biotite gneiss			64		
								Joint at 2.50m(65^0) (Smooth joint surface filled with greenish material)			1		Nil								
3																					3
											4		0.40								
											7		0.70								
									1.45	6.45	10		1.90	0	$5*10^{-6}$						
4																					4
											7		1.10								
											4		0.90								
											1		0.40								
5			Grey																		5
								Joint at 5.43m(55^0) (Weathered rough joint surface)											80		
								Joint at 5.92m(55^0) (Iron stained joint surface)													
6																					6
	21																				
7																7.00m					7
								Sub vertical joint at 7.12-7.50m(Fresh tight joint surface)								Fractured, fresh rock of biotite gneiss			46		
								Joint at7.68m(20^0) (Iron stained, rough joint surface)								(Rock broken into pieces due to joints)					
8											1		0.80			8.00m					8
											4		0.80			Fresh rock of biotite gneiss					
											7		1.20								
									6.45	11.45	10		1.60	0	$4*10^{-6}$						
9											7		0.90								9
											4		0.60								
	22										1		0.50			9.40m					
10																Fresh rock of garnetiferous quartz rich gneiss					10
11			Greyish white													11.00m					11
																Fresh rock of garnet biotite gneiss Some pyrites available					
12																					12
13																					13

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROUGHNESS, PERSISTENCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
								Foliation joint at13.20m(65^0) (Smooth slickensided joint)			1		Nil			Fresh rock of garnet biotite gneiss Mica rich band from 14.00-14.30m			60		
								Joint at13.33m(58^0) (Fresh joint surface)			4		0.10								
14	23							Joint at13.93m(45^0)(Fresh joint surface)			7		0.40								14
								Foliation joint at14.09m(40^0)	11.45	16.45	10		1.10	0	$3*10^{-6}$	14.20m					
								(Fresh joint surface)			7		0.50			Fresh rock of quartzite Some garnets					
											4		Nil								
15	27										1		Nil								15
16																16.00m					16
								Subvertical joint at 16.55-16.75m								Fresh rock of quartz rich biotite gneiss			38		
	28							(Rough, irregular joint filled with thing film of greenish material & this goes along biotite													
17								rich band,Mica & pyrites available at the joint)													17
								Joint at16.78-16.94m(70^0)(Rough,irregular joint surface)											65		
								Joints at 17.57(60^0) & 17.77(40^0)			1		Nil			17.73m					
18								(Joints partly filled with calcitic gauge)			4		0.60			Fresh rock of Calc gneiss					18
											7		0.60			18.15m			48		
								Subvertical joint at 16.55-16.75m	16.45	21.45	10		0.90	0	$2*10^{-6}$	Fresh rock of biotite gneiss					
								(Joint filled with calcitic gauge)			7		0.30			18.88m					
19											4		Nil			Fresh rock of Calc gneiss					19
											1		Nil								
			Greyish white													19.94m					
20																					20
								Joints at 20.18m(20^0),20.18m(50^0),								Fresh, fractured rock of quartz rich					
								20.22m(55^0),20.27m(60^0)								garnetiferous biotite gneiss					
								Joints at 20.28-20.43m(73^0),													
21								20.50-20.68m(73^0), 20.84-20-21.00m(73^0)													21
								(Joints partly filled with calcitic gauge)													
								Joints at 21.10-21.30m(70^0),								21.50m					
								20.31-21.49m(70^0), 21.50-22.00m(70^0)								Fresh, fractured rock of quartz rich					
22								(Joint filled with calcitic gauge)								garnetiferous biotite gneiss					22
											1		Nil			Rock broken into pieces due to					
											4		0.80			major joint pattern					
											7		1.10								
23									21.45	25.50	10		1.60	0	$5*10^{-6}$						23
								Sub vertical joint at 23.30-23.64m			7		0.80			23.20m			40		
								(Joint partly filled with calcitic gauge)			4		1.10			Fresh, fractured rock of quartz rich					
											1		0.30			garnetiferous biotite gneiss					
24																					24
								Foliation joint at24.57m(40^0) (Joint goes													
								along biotite rich layer)													
25																					25
								Foliation joint at25.32m,25.48,											44		
	29							25.53m(450)(Fresh joint surface)								25.60m					
26								**BOREHOLE COMPLETTED AT 25.60M**													26
27																					27
28																					28
29																					29
30																					30

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT
BOREHOLE LOG FOR ENGINEERING PURPOSES

cecb ENGINEERING GEOLOGY — LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- Divertion Tunnel | **B.H No.:DT 2** | **Page 1 of 4**

DRILLING DATA		BOREHOLE DATA
STARTED :	2003/7/7	X-COORDINATE :164,804.155m
COMPLETED :	2003/12/7	Y-COORDINATE :197,605.418m
MACHINE TYPE :	TONE	ELEVATION (COLLAR) :139.440m
DRILLING METHOD :	ROTARY	ELEVATION (BOTTOM) :
CORE BARREL, BIT :	NX	FINAL DEPTH :60.00m
FOREMAN :	MRAMHP	INCLINATION : Angle 45°
LOGGED BY :	SRMS/RMLKR	BEARING :

KEY

JOINT ROUGHNESS
VR= very rough
R: rough
SR: slightly rough
S= smotth
SL=slickensided

JOINT SPACING
VW= very widely> 2m
W= widely
MW= moderately wide
C= Closely
VC= very closely

JOINT SEPARATION
V= very tight
T= tight
MO= moderately open
O= open

OTHER SYMBOLS
SL/CW - Soil & Completely Weathered
HW - Highly Weathered
MW - Moderately Weathered
SW - Slightly Weathered
TCR - Total Core Recovery
RQD - Rock Quality Designation
GWL - Ground water Level

LEGEND FOR GRAPHIC LOG
Sand
Decomposed mica
Garnet biotite gneiss
Quartzo feldspathic gneiss
Charnockite
Granitic Gneiss
Quartzite
Calc gneiss/Crystalline Lime stone
Calc gneiss

TCR | ROD | WEATHERING: SL/CW, HW, MW, SW

DEPTH (m)	DRILLING: DAILY ADVANCE	CASING/CEMENT	DRILL WATER (COLOUR, LOSS)	RATE OF DRILLING	WATER LEVELS	SPT VALUES: DEPTH(m)	SPT VALUES: 'N' VALUE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROUGHNESS, PERSISTENCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	DEPTH (M) TO BOTTOM	PRESSURE (BARS)	MANOMETER READING	WATER LOSS	(total)liters)/time(min)	Lugeon Unit (Lu)	Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION	MOSAIC LOG	RECOVERY: CORE RECOVERY %	R.Q.D. %	WEATHERING	DEPTH (m)
1			Brown														Fine to coarse grained,moderate dense,brown,clayey silty sand (Some gravels available) (Top soil layer) 0.52					1
			Grey														Fresh charnockitic gneiss (Boulder) 1.55		81			
2																	Fine to medium grained, brown sand (Sludge sample)					2
3																						3
4																						4
5																						5
6																						6
7			Brown																			7
8	7				8.32 08/07																	8
9																						9
10																						10
11																						11
12																						12
13																	13.00					13

FEASIBILITY STUDY OF THE BROADLANDS HYDRO POWER PROJECT
BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION

LOCATION :- Divertion Tunnel | **B.H No.:DT 2** |

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	DRILLING: SPT VALUES DEPTH(m)	DRILLING: SPT VALUES N' VALUE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: Manometer Reading	PERMEABILITY: WATER LOSS (total)(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: ROCK TYPE, COLOUR, GRAIN SIZE, TEXTURE AND STRUCTURE (MASSIVE, CLEAVED, FOLIATED, LINEATED, FLOW BANDED, GNEISSOSE, PORPHYRITIC, ECT: SCALE AS FOR JOINT SPACING), WEATHERING,ALTERATION,MINOR LITHOLOGICAL CHARACTERISTICS, STRENGTH,JOINTS	MOSAIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14			Brown													Fine to medium grained, brown sand (Sludge sample) 13.72					14
15			Greyish brown		15.24 09/07											Fine grained, brown sand (Mica & weathered feldspar available) (Insitu formation) (Sludge sample) (Highly decomposed material)					15
16																				16
17																				17
18			Light brown																	18
19																				19
20	8																			20
21					20.48 12/07															21
22																				22
23																				23
24																				24
25			Greyish brown																	25
26																				26
27																				27
28																				28
29																				29
30																30.00				30

FEASIBILITY STUDY OF THE BROADLANDS HYDRO POWER PROJECT
BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- Divertion Tunnel | **B.H No.:DT 2** |

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	DRILLING: SPT VALUES DEPTH(m)	DRILLING: SPT VALUES N' VALUE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: Manometer Reading	PERMEABILITY: WATER LOSS (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: ROCK TYPE, COLOUR, GRAIN SIZE, TEXTURE AND STRUCTURE (MASSIVE, CLEAVED, FOLIATED, LINEATED, FLOW BANDED, GNEISSOSE, PORPHYRITIC, ECT: SCALE AS FOR JOINT SPACING), WEATHERING,ALTERATION,MINOR LITHOLOGICAL CHARACTERISTICS, STRENGTH,JOINTS	MOSAIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
31	9		Greyish brown													Fine grained, brown sand (Mica & weathered feldspar available) (Insitu formation) (Sludge sample) (Highly decomposed material)					31
32																					32
33																					33
34																					34
35																34.00 Fine grained, brown sand (Mica & weathered feldspar available high % of micas) (Insitu formation) (Sludge sample) (Highly decomposed material)					35
36																					36
37																					37
38																					38
39																					39
40																40.03 Brown mica layer (Flackey grains) (Sludge sample) (Highly decomposed material)					40
41																					41
42																					42
43																					43
44																					44
45																					45
46	11		Redish brown																		46
47																47.00					47

FEASIBILITY STUDY OF THE BROADLANDS HYDRO POWER PROJECT
BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- Divertion Tunnel | **B.H No.:DT 2** |

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLIN	DRILLING: WATER LEVELS	DRILLING: SPT VALUES DEPTH(m)	DRILLING: SPT VALUES N' VALUE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: Manometer Reading	PERMEABILITY: WATER LOSS (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: ROCK TYPE, COLOUR, GRAIN SIZE, TEXTURE AND STRUCTURE (MASSIVE, CLEAVED, FOLIATED, LINEATED, FLOW BANDED, GNEISSOSE, PORPHYRITIC, ECT: SCALE AS FOR JOINT SPACING), WEATHERING,ALTERATION,MINOR LITHOLOGICAL CHARACTERISTICS, STRENGTH,JOINTS	MOSAIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
48																Brown mica layer (Flackey grains) (Sludge sample) (Highly decomposed material)					48
49																					49
50																					50
51																					51
52																					52
53																53.00					53
54			Redish brown													Reddish brownish mica layer (Flackey grains) (Sludge sample) (Highly decomposed material)					54
55																					55
56																					56
57																					57
58																					58
59																					59
60	12															60.00					60

Bore hole completed at 60.00m

61																					61
62																					62
63																					63
64																					64

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- MAIN DAM AXIS,RIGHT BANK

B.H No.: MB 01

DRILLING DATA		BOREHOLE DATA	
STARTED :	**25/10/02**	X-COORDINATE :	164,717.431m
COMPLETED :	**2002/11/4**	Y-COORDINATE :	197,640.971m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :	122.585m
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) :	81.815m
CORE BARREL, BIT :	**NQ**	FINAL DEPTH :	40.77m
FOREMAN :	**WLN**	INCLINATION :	Vertical
LOGGED BY :	**BMAPM**	BEARING :	-

KEY

JOINT ROUGHNESS
VR= very rough
R: rough
SR: slightly rough
S= smotth
SL=slickensided

JOINT SPACING
VW= very widely> 2m
W= widely
MW= moderately wide
C= Closely
VC= very closely

JOINT SEPARATION
V= very tight
T= tight
MO= moderately open
O= open

OTHER SYMBOLS
SL/CW - Soil & Completely Weathered
HW - Highly Weathered
MW - Moderately Weathered
SW - Slightly Weathered
TCR - Total Core Recovery
RQD - Rock Quality Designation
GWL - Ground water Level

LEGEND FOR GRAPHIC LOG

Sand
Clay
Fresh to slightly weathered charnockite
Highly to mod weathered charnockite
Fresh to slightly weathered biotite gneiss
Highly to mod weathered biotite gneiss
Quartzite
Calc gneiss
Boulder

TCR | ROD | WEATHERING (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILL WATER (COLOR, LOSS)	RATE OF DRILLING	WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N`VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	DEPTH (M) TO BOTTOM	PRESSURE (bars)	WATER LOSS	(total(liters)/time(min))	Lugeon Unit (Lu)	Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	R.Q.D. %	WEATHERING	DEPTH (m)
						0.00										Brown to whitish brown colour					
						0.45	6									clayey silt with few quartz sand					
1			Light brown													1.00m					1
	25							Joint at 1.40m(30^0)(Joint surface weathered into rock & rough joint filled with silty clay)								Highly weathered rock 1.48m					
2			Dark brown to dark grey													Fresh rock of charnockitic gneiss 2.36m					2
					2.25			Joint at 2.41m(60^0) & 2.53m(55^0)								Highly to mod . weathered rock of acidic charnock					
					2.60			(Weathered, rough joint surfaces)													
					27 / 10			Subvertical joint at 3.00m(Highly weathered,								Moderately weathered rock of					
3								rough joint surface filled with clayey material)								biotite schist 2.95m					3
								Joint at 3.35m(55^0)(Joint surface weathered								Highly weathered rock/Rock in pieces		71			
								into rock & rough joint filled with white gauge)								Fresh rock of charnockitic gneiss					
								Joint at 3.75m(35^0)(Fresh tight joint)													
4																					4
5								Joint at 5.16m(48^0) (partly iron stained smooth joint surface)													5
											1		0.50								
								Joint at 5.85m(48^0) (Fresh joint filled with			4		2.10								
6								thing film of brownish material)			7		5.50								6
									4.35	9.08	10		16.00	3	$4*10^{-5}$	Quartz rich band from 6.15m-7.30m					
											7		5.80								
											4		1.90								
7	26										1		0.20								7
								Joint at 7.31m(15^0)(Fresh tight joint)													
8																					8
9			Light grey																		9
	27																				
10																					10
											1		Nil								
											4		Nil								
											7		0.02								
11									9.08	14.22	10		0.05	0	$1*10^{-7}$						11
	29										7		0.03								
											4		Nil								
											1		Nil								
12																Biotite rich band from11.93m to					12
																12.38m					
13																					13

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14																Fresh rock of charnockitic gneiss					14
15																					15
16											1		Nil								16
											4		Nil								
											7		0.02								
17									14.22	19.31	10		0.60	0	$2*10^{-7}$						17
											7		0.03								
											4		Nil								
											1		Nil								
18																					18
19																					19
	30																				
20																Biotite rich band from19.56m to 20.13m					20
											1		Nil								
21											4		Nil								21
								Joint at 21.46m(60^0) (Fresh joint filled with			7		0.02								
								thing film of yellowish material)	19.31	24.17	10		0.50	0	$1*10^{-7}$						
											7		0.20								
22	31										4		Nil			Biotite rich band from 21.95m to					22
								Foliation joints at 22.27,22.29 &			1		Nil			22.14m					
								22.32m(15^0) (Rough joint filled with thing													
23								film of greyish material)													23
24																					24
	1																				
25																					25
26											1		Nil								26
											4		0.01								
											7		0.03								
27									24.17	29.74	10		0.06	0	$1*10^{-7}$						27
											7		0.02								
											4		Nil								
											1		Nil								
28																					28
29																					29
30																					30

Light brown

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
31																Fresh rock of charnockitic gneiss					31
	2										1		Nil								
											4		Nil								
											7		0.04								
32									29.74	34.27	10		0.08	0	$2*10^{-7}$						32
											7		0.05								
											4		Nil								
33											1		Nil								33
34																					34
35																					35
			Light brown																		
36											1		Nil								36
											4		Nil								
											7		0.30								
37									34.27	40.77	10		0.09	0	$2*10^{-7}$						37
											7		0.04								
											4		0.01								
	3										1		Nil								
38																					38
39																					39
40																					40
	4															40.77m					
41								**BOREHOLE COMPLETTED AT 40.77M**													41
42																					42
43																					43
44																					44
45																					45
46																					46

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :-MAIN DAM AXIS,LEFT BANK — **B.H No.: MB 03**

DRILLING DATA		BOREHOLE DATA	
STARTED :	**2002/12/6**	X-COORDINATE :	164,673.670m
COMPLETED :	**21/12/02**	Y-COORDINATE :	197,602.979m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :	107.225m
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) :	57.225m
CORE BARREL, BIT :	**NX**	FINAL DEPTH :	50.00m
FOREMAN :	**MRAMHP**	INCLINATION :	Inclined (50^0)
LOGGED BY :	**BMAPM**	BEARING :	-

KEY

JOINT ROUGHNESS	JOINT SEPARATION
VR= very rough	V= very tight
R: rough	T= tight
SR: slightly rough	MO= moderately open
S= smotth	O= open
SL=slickensided	
JOINT SPACING	OTHER SYMBOLS
VW= very widely> 2m	SL/CW - Soil & Completely Weathered
W= widely	HW - Highly Weathered
MW= moderately wide	MW - Moderately Weathered
C= Closely	SW - Slightly Weathered
VC= very closely	TCR - Total Core Recovery
	RQD - Rock Quality Designation
	GWL - Ground water Level

LEGEND FOR GRAPHIC LOG

Sand; Clay; Fresh to slightly weathered charnockite; Highly to mod weathered charnockite; Fresh to slightly weathered biotite gneiss; Highly to mod weathered biotite gneiss; Quartzite; Calc gneiss; Boulder

TCR | ROD | WEATHERING (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR, LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N`VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
					0.00											Fresh rock of charnockitic gneiss					
					From 17th																
1																					1
					1.23																
					7 /12																
											1		Nil								
2											4		Nil								2
					2.38						7		0.03								
	6				2.60			Joint at 3.64m (30^0) (Fresh, tight joint)	0.65	5.00	10		0.05	0	$1*10^{-7}$						
					10 /12						7		0.02								
3											4		Nil								3
											1		Nil								
4																					4
5	7							Joint at 5.03m (60^0) (Partly chloritized, tight joint)													5
6																					6
			Grey								1		Nil								
7											4		Nil								7
											7		0.03								
									5.00	10.00	10		0.05	0	$1*10^{-7}$	Biotite rich band at 7.36m-7.56m					
											7		0.03								
8	9										4		0.01								8
											1		Nil								
9																					9
10																					10
											1		Nil								
11	10										4		Nil								11
											7		0.03								
									10.00	15.00	10		0.05	0	$1*10^{-7}$						
											7		0.04								
12											4		0.01								12
											1		Nil								
13																					13

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :-MAIN DAM AXIS,RIGHT BANK — **B.H No.: MB 02**

DRILLING DATA		BOREHOLE DATA	
STARTED :	2002/10/11	X-COORDINATE :	164,701.313m
COMPLETED :	18/10/02	Y-COORDINATE :	197,626.567m
MACHING TYPE :	TONE	ELEVATION (COLLAR) :	109.430m
DRILLING METHOD :	ROTARY	ELEVATI ON (BOTTOM) :	69.300m
CORE BARREL, BIT :	NQ	FINAL DEPTH :	40.13m
FOREMAN :	WLN	INCLINATION :	Vertical
LOGGED BY :	BMAPM	BEARING :	-

KEY

JOINT ROUGHNESS
- VR= very rough
- R: rough
- SR: slightly rough
- S= smotth
- SL=slickensided

JOINT SPACING
- VW= very widely> 2m
- W= widely
- MW= moderately wide
- C= Closely
- VC= very closely

JOINT SEPARATION
- V= very tight
- T= tight
- MO= moderately open
- O= open

OTHER SYMBOLS
- SL/CW - Soil & Completely Weathered
- HW - Highly Weathered
- MW - Moderately Weathered
- SW - Slightly Weathered
- TCR - Total Core Recovery
- RQD - Rock Quality Designation
- GWL - Ground water Level

LEGEND FOR GRAPHIC LOG
- Sand
- Clay
- Fresh to slightly weathered charnockite
- Highly to mod weathered charnockite
- Fresh to slightly weathered biotite gneiss
- Highly to mod weathered biotite gneiss
- Quartzite
- Calc gneiss
- Boulder

TCR | ROD | WEATHERING (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR, LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N`VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
1								Joint at 0.30-0.46m(70°) Joint at 0.52m(20°) (partly iron stained rough joint surfaces) Joint at 1.22m(40°) (Iron stained rough joint surfaces) Joint at 1.42-1.58m(70°) Joint at 1.68-1.76m(70°)(Iron stained,								Fresh rock of charnockitic gneiss		75	57 75 84		1
2					1.70 18 / 10			slightly weathered joint surfaces)											37		2
					2.20						1		0.35								
					2.45						4		2.02								
3					2.60 12 / 10						7		3.80								3
					3.10			Parallel joints at 3.64m & 3.67m(5°)	1.00	5.30	10		6.35	1	$2*10^{-5}$					
					13,14 /10			(Iron stained, weathered joint surfaces)			7		4.10							
	11										4		1.98							
4											1		0.42								4
5																					5
6																					6
			Whitish grey																		
7											1		0.01								7
											4		0.02								
											7		0.03								
	12								5.30	9.85	10		0.05	0	$1*10^{-7}$						
											7		0.04								
8											4		0.01								8
											1		Nil								
9																					9
	13																				
10																					10
											1		Nil								
											4		0.01					Biotite rich band at 10.82m-10.92m				
11											7		0.03								11
									9.85	14.80	10		0.05	0	$1*10^{-7}$						
											7		0.02								
											4		0.01								
12											1		Nil								12
13																					13

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14																Fresh rock of charnockitic gneiss					14
15																					15
	14																				
16																					16
								Joint at 16.37m(45^0)			1		Nil			Biotite rich band at 16.35m-16.55m					
								(Smooth mica rich joint surface)			4		0.01								
											7		0.02								
17									14.80	19.54	10		0.04	0	$1*10^{-7}$						17
											7		0.03								
											4		0.01			Biotite rich band at 17.35m-17.46m					
											1		Nil								
18																Biotite rich band at 17.89m-18.05m					18
19																					19
20																					20
								Foliation joints at 20.82 &20.86m (30^0)			1		Nil								
21								(Fresh, tight joints)			4		Nil								21
											7		0.01								
			Whitish grey						19.54	24.05	10		0.03	0	$9*10^{-8}$						
											7		0.02								
22											4		Nil								22
	15										1		Nil								
23																					23
																23.22m					
																Fresh rock of pegmatite					
																23.66m					
24																Fresh rock of granulitic biotite gneiss					24
								Foliation joint at 24.72m (30^0)													
25								(Fresh, tight joint)													25
											1		Nil								
											4		0.01								
26											7		0.02								26
									24.05	29.93	10		0.04	0	$9*10^{-8}$						
											7		0.03								
											4		Nil								
27											1		Nil								27
28																					28
	16																				
29																					29
30																					30

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR;LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
31																Fresh rock of granulitic biotite gneiss					31
32											1		Nil								32
											4		0.01								
											7		0.02								
33									29.93	35.25	10		0.04	0	$1*10^{-7}$						33
											7		0.02								
											4		Nil								
34											1		Nil								34
35			Whitish grey																		35
36																					36
	17										1		Nil								
37											4		0.01								37
											7		0.02								
									35.25	40.13	10		0.04	0	$1*10^{-7}$						
38											7		0.02								38
											4		0.01								
39											1		Nil								39
40	18							**BOREHOLE COMPLETTED AT 40.13M**								40.13m					40
41																					41
42																					42
43																					43
44																					44
45																					45
46																					46

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :-MAIN DAM AXIS,LEFT BANK

B.H No.: MB 04

DRILLING DATA		BOREHOLE DATA	
STARTED :	**26/12/02**	X-COORDINATE :	164,658.747m
COMPLETED :	**2003/1/1**	Y-COORDINATE :	197,585.707m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :	116.814m
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) :	76.814m
CORE BARREL, BIT :	**NX**	FINAL DEPTH :	40.00m
FOREMAN :	**MRAMHP**	INCLINATION :	Vertical
LOGGED BY :	**BMAPM**	BEARING :	-

KEY

JOINT ROUGHNESS
- VR= very rough
- R: rough
- SR: slightly rough
- S= smotth
- SL=slickensided

JOINT SPACING
- VW= very widely> 2m
- W= widely
- MW= moderately wide
- C= Closely
- VC= very closely

JOINT SEPARATION
- V= very tight
- T= tight
- MO= moderately open
- O= open

OTHER SYMBOLS
- SL/CW - Soil & Completely Weathered
- HW - Highly Weathered
- MW - Moderately Weathered
- SW - Slightly Weathered
- TCR - Total Core Recovery
- RQD - Rock Quality Designation
- GWL - Ground water Level

LEGEND FOR GRAPHIC LOG
- Sand
- Clay
- Fresh to slightly weathered charnockite
- Highly to mod weathered charnockite
- Fresh to slightly weathered biotite gneiss
- Highly to mod weathered biotite gneiss
- Quartzite
- Calc gneiss
- Boulder

TCR | RQD | WEATHERING (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR, LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N`VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
0						0.00										Yellowish brown soft silty clay (Top soil)					0
						0.45	8									0.45m					
1																Yellowish brown soft sandy clay					1
																1.00m					
					1.68											Boulder of weathered rock					
					28 /12	1.55										(Boulder has crushed into pieces)					
2					1.95	2.00	17									2.00m					2
					29 /12											Yellowish brown,soft, silty clay					
																Highly to moderately weathered					
3			Light brown		3.85											rock of garnet biotite gneiss					3
					27 /12																
4																					4
								Joint at 4.48m(65^0)(Weathered ,rough,											
								filled with clayey silt)											
5	26							100% water loss at 4.48m								4.88m		85			5
																Fresh rock of charnockitic gneiss					
6																					6
7											1		Nil								7
											4		0.02								
											7		0.05								
8									5.40	10.00	10		0.08	0	$2*10^{-7}$						8
											7		0.06								
											4		0.03								
											1		Nil								
9			Grey																		9
					9.39											9.28m					
					31 / 12											Fresh rock of pegmatite					
10																					10
					10.19											11.10m					
					1 / 1																
11											1		Nil			Fresh rock of charnockitic gneiss					11
											4		0.04								
											7		0.08								
12	27								5.00	15.00	10		0.13	0	$3*10^{-7}$						12
											7		0.09								
											4		0.40								
											1		Nil								
13																					13

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14								Joint at 14.20m (60^0) (Fresh, tight joint)								Fresh rock of charnockitic gneiss					14
15								Joint at15.04m(10^0) (Partly iron stained rough joint surface)													15
16								Foliation joints at 16.50 & 16.53m (60^0) (Fresh, tight joints)													16
17											1		Nil								17
					17.23						4		0.03								
					30 / 12			Joint at 17.63m (50^0) (Fresh, tight joint)			7		0.06								
	28								15.00	20.00	10		0.10	0	3*10^{-7}						
18								Joint at 17.92m (45^0) (Fresh, tight joint)			7		0.06								18
								Foliation joints at 18.06,18.15,18.23,			4		0.04			Biotite rich layers appeared & rock			63		
								18.48 &18.93m (60^0)			1		Nil			is jointed along this layers					
								(Fresh, tight joints)													
19								Foliation joint at 19.25m (50^0)													19
								(Fresh, tight joint)													
20																					20
21																					21
								Rock in pieces due to joints											46		
								(Chloritized, tight joint-may be foliation joints)								Rock in pieces(From 21.00-21.56m)					
			Grey								1		0.02			Maximum-5cm					
22								Joint at 22.33-22.52m (75^0)(Chloritized, tight joint)			4		0.16								22
								Foliation joint at 22.68-22.98m (75^0)			7		0.28						30		
								(Chloritized,slickensided, tight joint)	20.00	25.00	10		0.45	0	1*10^{-6}						
								Joint at 22.80m (30^0) (Chloritized, tight joint)			7		0.30								
23								Joints at 22.90 & 22.96m (50^0)			4		0.18								23
								(Chloritized,slickensided, tight joint)			1		0.03						70		
								Vertical joint at 23.00-23.30m (50^0)													
								(Fresh, tight joint)													
24																					24
25	29																				25
26																					26
											1		Nil								
											4		Nil								
27											7		0.04								27
									25.00	30.00	10		0.08	0	3*10^{-7}						
											7		0.05								
											4		0.02								
28											1		Nil								28
29																					29
30																					30

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR;LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
31															Fresh rock of charnockitic gneiss					31
											1	Nil								
											4	0.03								
32											7	0.18								32
									30.00	35.00	10	0.25	0	$6*10^{-7}$						
											7	0.19								
											4	0.04								
33											1	Nil								33
34	30																			34
35			Grey												34.80m Fresh rock of calc. gneiss					35
															Mica rich band at 35.59-35.73m &					
															core is partly washed out at this ban					
36																				36
																			85	
								Joints at 36.55 & 36.88m(45^0)												
								(Joint filled with thing film of calcitic gauge)			1	Nil								
37											4	0.03								37
											7	0.18							73	
									35.00	40.00	10	0.25	0	$6*10^{-7}$						
								Vertical joint at 37.65-37.92m			7	0.19								
38								(Joint filled with thing film of calcitic gauge)			4	0.04								38
											1	Nil								
39															39.00m					39
															Fresh rock of charnockitic gneiss					
40	31														40.00m					40
								BOREHOLE COMPLETTED AT 40.00M												
41																				41
42																				42
43																				43
44																				44
45																				45
46																				46

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :-DAM AXIS,LEFT BANK | **B.H No.: MB5** |

DRILLING DATA		BOREHOLE DATA
STARTED :	**18-09-03**	X-COORDINATE :164,631.381 m
COMPLETED :	**26-09-03**	Y-COORDINATE :197,564.127 m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :138.601 m
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) :m
CORE BARREL, BIT :	**NQ**	FINAL DEPTH :30.15 m
FOREMAN :	**UKSJ**	INCLINATION : Vertical
LOGGED BY :	**SRMS/RMLKR**	BEARING : -

KEY

JOINT ROUGHNESS
VR= very rough
R: rough
SR: slightly rough
S= smotth
SL=slickensided

JOINT SPACING
VW= very widely> 2m
W= widely
MW= moderately wide
C= Closely
VC= very closely

JOINT SEPARATION
V= very tight
T= tight
MO= moderately open
O= open

OTHER SYMBOLS
SL/CW - Soil & Completely Weathered
HW - Highly Weathered
MW - Moderately Weathered
SW - Slightly Weathered
TCR - Total Core Recovery
RQD - Rock Quality Designation
GWL - Ground water Level

LEGEND FOR GRAPHIC LOG
Sand
Clay
Garnet biotite gneiss
Quartzo feldspathic gneiss
Charnockite
Granitic gneiss
Quartzite
Calc gneiss/Crystaline lime stone
Boulder

TCR | ROD | WEATHERING: SL/CW, HW, MW, SW

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR, LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total)(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
1	18		Brown													Fine to coarse grained brown silty sand with road aggregate 0.20 Fine to coarse grained yellowish brown to reddish brown clayey sand (small amount of gravels & organic material avaliable) 1.75					1
2		2.20			2.20 20/03											Brown fine to coarse grained silty sand (some amount of gravel & pebbles available) 2.20					2
3								Joint at 3.17m (60°) Joint surface weathered & rough												3
4	19				3.75 23/09 4.35 21/09											Fresh charnocktic gneiss 4.10					4
5								Joint at 4.10m (50°) & 4.55m(Highly weathered jointed zones)	3.25	8.50	Large amount of water takes through joints Unable to develop pressure					Fresh charnocktic gneiss (Core loss at 4.10-4.55m) 5.00		22	22		5
6	20				6.35 26/09			Joint at 5.85m (45°) (Tight smooth joint surface)								Fresh charnockitic gneiss At 6.80m some amount of graphite available 7.00			73		6
7																					7
8	21		Witish Grey					Joint at 7.37m (35°) Joint at 7.38m (30°)and 7.44m (40°) (Tight fresh joint surfaces, filled with black			1 4	Nil Nil									8
9	22				8.60 25/09			thin film of secondary materials) Joint at 8.00m (Joint surface slightly weathered in to rock & filled with thin film of dark brown secondary materials)	8.50	13.30	7 10 7 4 1	Nil Nil Nil Nil Nil		0	0	Fresh charnocktic gneiss 10.00					9
10																					10
11	23															Fresh charnocktic gneiss (some amount of garnet avaiable) 12.00					11
12																					12
13																Fresh quartz rich charnocktic gneiss (qtz grain size relatively large) 13.00					13

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :-DAM AXIS,LEFT BANK | **B.H No.:MB5** |

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR/LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14								Joint at 13.78m(40^0)								Fresh quartz rich charnocktic gneiss					14
								((Tight joint filled with thin film								(qtz grain size relatively large)					
								of grey and black secondary materials)													
15											1		Nil								15
											4		Nil								
											7		Nil								
16									13.50	19.20	10		Nil	0	0						16
											7		Nil			16.00					
											4		Nil								
17											1		Nil								17
18	24																				18
19																Fresh quartz rich garnet biotite					19
																gneiss					
20																					20
											1		3.3								
21											4		5.7								21
											7		7.3								
			Whitish brown						19.50	25.50	10		10.6	2	10^{-5}						
22											7		7.7								22
											4		6.1								
23											1		3.4								23
																23.84					
24																			16		24
	25																				
25																Fresh garnet biotite gneiss				82	25
26																26.00					26
27																					27
																Fresh quartz rich garnet biotite					
28																gneiss					28
																(relatively quartz % high)					
29																					29
30	26															30.15					30

Bore hole completed at 30.15m

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

cecb — LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- CONDUIT TRACE

B.H No.: CT 1

DRILLING DATA		BOREHOLE DATA	
STARTED :	**21/11/2002**	X-COORDINATE :	164,584.150m
COMPLETED :	**24/11/2002**	Y-COORDINATE :	197,638.873m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :	121.883m
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) :	101.883m
CORE BARREL, BIT :	**NX**	FINAL DEPTH :	20.00m
FOREMAN :	**MRAMHP**	INCLINATION :	Vertical
LOGGED BY :	**BMAPM**	BEARING :	-

KEY

JOINT ROUGHNESS	JOINT SEPARATION
VR= very rough	V= very tight
R: rough	T= tight
SR: slightly rough	MO= moderately open
S= smotth	O= open
SL=slickensided	
JOINT SPACING	OTHER SYMBOLS
VW= very widely> 2m	SL/CW - Soil & Completely Weathered
W= widely	HW - Highly Weathered
MW= moderately wide	MW - Moderately Weathered
C= Closely	SW - Slightly Weathered
VC= very closely	TCR - Total Core Recovery
	RQD - Rock Quality Designation
	GWL - Ground water Level

LEGEND FOR GRAPHIC LOG

Sand; Clay; Fresh to slightly weathered charnockite; Highly to mod weathered charnockite; Fresh to slightly weathered biotite gneiss; Highly to mod weathered biotite gneiss; Quartzite; Calc gneiss; Boulder

TCR | RQD | WEATHERING (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILL WATER (COLOR, LOSS)	RATE OF DRILLING	WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N'VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
						0.00										Brown to muddy brown, sandy silty clay (some weathered rock fragments) 0.45m					
						0.45	4														
1																Yellowish brown colour,loose, clayey silty sand (some weathered rock fragments) 1.55m					1
						1.55															
2						2.00	5									Yellowish brown colour,soft sandy clay 2.00m					2
																Redish yellowish brown, loose,silty clayey sand (Lateritic Soil)					
3																					3
						3.00															
						3.45	7														
4																4.00m					4
																Yellowish brown,soft sandy clay					
						4.55															
5						5.00	4									5.00m					5
																Redish brown to yellowish brown, loose,clayey silty sand					
6																					6
					6.28	6.00															
					24/11	6.45	8														
					6.78																
7					23/11																7
						7.55															
8						8.00	2									8.00m					8
																Whitish brown micacious, very smooth,soft feldspathic inorganic clay (Highly decomposed formation)					
9					9.10																9
					22/11	9.00															
						9.45	4														
10	21																				10
						10.55															
11						11.00	9														11
						11.55															
						11.72	50HB									11.72m					
12																Fresh rock of charnokitic gneiss		78	36		12
			Grey					Joints at 12.00m(50°) &12.33m(30°) (iron stained, rough joint surfaces)													
13																					13

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14											1		Nil			Fresh rock of charnokitic gneiss					14
											4		Nil								
											7		0.05								
									12.50	15.35	10		0.07	0	$3*10^{-7}$						
											7		0.04								
											4		Nil								
15											1		Nil								15
	22															15.35m					
																Fresh rock of charnokitic gneiss					
																(High content of quartz)					
16								Joint at 15.72m(40^0)								15.88m-16.00m weatheredportion.		81	81		16
								(Iron stained rough surface)													
								Joint at 16.46m(32^0) (tight joint)													
17			Grey								1		Nil								17
											4		0.12								
											7		0.20			Weathered portion from 17.67m to					
									15.35	20.00	10		0.28	0	$7*10^{-7}$	17.80m					
18											7		0.23								18
											4		0.13								
											1		Nil			18.51m					
																Highly to moderately weathered rock					
19																of charnokitic gneiss			71		19
																19.17m					
																Fresh rock of charnokitic gneiss					
								Joint at 19.85m(60^0) (fresh tight joint)											57		
20	23															20.00m					20
								BOREHOLE COMPLETED AT 20.00M													
21																					21
22																					22
23																					23
24																					24
25																					25
26																					26
27																					27
28																					28
29																					29
30																					30

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

cecb — LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- CONDUIT TRACE

B.H No.: CT 2

DRILLING DATA		BOREHOLE DATA	
STARTED :	2002/2/11	X-COORDINATE :	164,321.890m
COMPLETED :	2002/9/11	Y-COORDINATE :	197,892.802m
MACHING TYPE :	TONE	ELEVATION (COLLAR) :	113.713m
DRILLING METHOD :	ROTARY	ELEVATION (BOTTOM) :	98.213m
CORE BARREL, BIT :	NX	FINAL DEPTH :	15.50m
FOREMAN :	MRAMHP	INCLINATION :	Vertical
LOGGED BY :	BMAPM	BEARING :	-

KEY

JOINT ROUGHNESS
- VR= very rough
- R: rough
- SR: slightly rough
- S= smotth
- SL=slickensided

JOINT SPACING
- VW= very widely> 2m
- W= widely
- MW= moderately wide
- C= Closely
- VC= very closely

JOINT SEPARATION
- V= very tight
- T= tight
- MO= moderately open
- O= open

OTHER SYMBOLS
- SL/CW - Soil & Completely Weathered
- HW - Highly Weathered
- MW - Moderately Weathered
- SW - Slightly Weathered
- TCR - Total Core Recovery
- RQD - Rock Quality Designation
- GWL - Ground water Level

LEGEND FOR GRAPHIC LOG
- Sand
- Clay
- Fresh to slightly weathered charnockite
- Highly to mod weathered charnockite
- Fresh to slightly weathered biotite gneiss
- Highly to mod weathered biotite gneiss
- Quartzite
- Calc gneiss
- Boulder

TCR | RQD | WEATHERING (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILL WATER (COLOR, LOSS)	RATE OF DRILLING	WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N'VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	DEPTH (M) TO BOTTOM	PRESSURE (bars)	WATER LOSS	(total(liters)/time(min)	Lugeon Unit (Lu)	Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	R.Q.D. %	WEATHERING	DEPTH (m)
1			Light brown		1.52											Highly to moderately weathered boulder of gneissic rock (Rock in pieces due to weathering and drilled with T/C casing bit)		66			1
					6 / 11											1.70m					
2					2.10											Fresh rock of charnockitic gneiss with little amount of garnets (From 1.70m to1.75m rock has slightly weathered)					2
					2.21			Joints at 2.21m(50°) ,2.50m(45°),													
					2.29			2.53m(60°) & 2.83m(40°)													
					9 / 11			(Fresh tight joints)													
3	2																				3
								Joint at 3.05m(57°) (Fresh tight joint)													
											1		Nil								
4	6										4		0.05								4
											7		0.08			4.17m					
									2.50	7.00	10		0.12	0	$3*10^{-7}$	Fresh rock of garnetiforous biotite gneiss					
											7		0.07								
5								Sub vertical joint at 5.46-5.73m(weathered			4		0.04								5
								rough joint surface)			1		Nil						44		
								Joint at 5.87m(65°) (Tight, slightly iron													
								stained joint surface)													
6								Sub vertical joint at 5.73-5.92m(Slightly													6
								weathered, rough, iron stained joint surface)												83	
								Joint at 6.65m(50°) (Tight, slightly iron													
								stained joint surface)													
7																7.00m					7
																Fresh rock of garnetiforous biotite gneiss (Biotite% is less Quartz% & garnet% are high)					
8																					8
								Joint at 8.80m(55°) (Fresh tight joint)			1		Nil								
9	7										4		Nil								9
											7		0.02								
			Grey						7.00	12.00	10		0.05	0	$1*10^{-7}$	9.56m					
											7		0.03			Fresh rock of charnockitic gneiss					
10											4		0.02								10
											1		Nil								
11																					11
12																					12
13																					13

DEPTH (m)	DRILLING					SPT RESULTS		JOINTS	PERMEABILITY						GENERAL DESCRIPTION	GRAPHIC LOG	RECOVERY		WEATHERING	DEPTH (m)
	DAILY ADVANCE	CASING/CEMENT	DRILL WATER (COLOR,LOSS)	RATE OF DRILLING	WATER LEVELS	DEPTH	N' VALUVE	NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	DEPTH (M) FROM TOP	DEPTH (M) TO BOTTOM	PRESSURE (bars)	WATER LOSS	(total(liters)/time(min)	Lugeon Unit (Lu)	Coefficient of Permeability (cm/s)	rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints		CORE RECOVERY %	R.Q.D. %		
14	8		Grey						12.00	15.50	1 4 7 10		Nil Nil 0.02 0.05	0	$2*10^{-7}$	Fresh rock of charnockitic gneiss					14
15	9										7 4 1		0.04 0.02 Nil			15.50m					15
16								**BOREHOLE COMPLETTED AT 15.50M**													16
17																				17
18																				18
19																				19
20																				20
21																				21
22																				22
23																				23
24																				24
25																				25
26																				26
27																				27
28																				28
29																				29
30																				30

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

ENGINEERS DUBLIN cecb — LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- CONDUIT TRACE | **BH No: CT 3** |

DRILLING DATA		BOREHOLE DATA
STARTED :	**2003/9/28**	X-COORDINATE :164,465.645 m
COMPLETED :	**2003/10/1**	Y-COORDINATE :197,713.476 m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :106.730 m
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) : m
CORE BARREL, BIT :	**NQ**	FINAL DEPTH : 20.35 m
FOREMAN :	**UKSJ**	INCLINATION : Vertical
LOGGED BY :	**SRMS/RMLKR**	BEARING : -

KEY

JOINT ROUGHNESS
VR= very rough
R: rough
SR: slightly rough
S= smotth
SL=slickensided

JOINT SPACING
VW= very widely> 2m
W= widely
MW= moderately wide
C= Closely
VC= very closely

JOINT SEPARATION
V= very tight
T= tight
MO= moderately open
O= open

OTHER SYMBOLS
SL/CW - Soil & Completely Weathered
HW - Highly Weathered
MW - Moderately Weathered
SW - Slightly Weathered
TCR - Total Core Recovery
RQD - Rock Quality Designation
GWL - Ground water Level HB -Hammer bounced

LEGEND FOR GRAPHIC LOG
Sand
Clay
Garnet biotite gneiss
Quartzo feldspathic gneiss
Charnockite
Granitic gneiss
Quartzite
Calc gneiss/ Crystaline lime stone
Boulder

TCR | RQD | WEATHERING (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR, LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS (total)(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
0															Fine to medium grained, yewllowish brown,silty sand(Top soil layer) 0.30					0
0.5															Boulder (Fresh gneissic rock) 0.50		75			0.5
1																				1
1.5						1.50									Fine to coarse grained, brown, clayey silty sand (Some large rock fragments avilable, may be broken pieces of boulder)					1.5
2						1.95	5													2
3						3.00	>5													3
3.33						3.15	HB													3.33
3.5					3.50 29/9										Boulder (Garnet biotite gneiss) 3.40		95			3.5
4															Fine to coarse grained, light brown, silty sand (Some gravels and rock fragments avilable) 4.2					4
4.5	28																			4.5
5					4.60 1/10										Fresh to highly weathered garnet biotite gneiss (Boulder)		50			5
5.7																				5.7
6															Fine to medium grained, brown, silty sand (Sludge sample) (Some large rock fragments avilable, may be broken pieces of boulder) (Some weathered micas available)					6
7																				7
7.25															Fine to coarse grained,brown,silty sand (Some gravels and rock fragments avilable) 8.00					7.25
8																				8
9			Pale brown												Fine to medium grained, brown, silty sand (Sludge sample) (Some weathered micas available)					9
10																				10
11																				11
12															12.00					12
12.5															Fine to medium grained, brown,silty sand (Sludge sample) (Some gravels and rock fragments available) 13.00					12.5
13																				13

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- CONDUIT TRACE | **B.H No.: CT 3** |

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14	29															Fine to medium grained, brown,silty sand (Sludge sample) 14.00					14
15			Brown			15.00 15.05	>15 HB									Fine to medium grained, brown,silty sand 15.00					15
16																Fine to medium grained, brown,silty sand (Some gravels and large rock fragments avilable)					16
17		16.95														16.95					17
18	30		Light grey to brown					(Due to joints and weathering rock broken into pieces,could'n determine exact positions of the joints due to core loss)								Slightly to moderately weathered crystaline lime stone (Some hornblende,biotite and diopsite available) 1		50	48		18
19																Fresh to highly weathered crystaline lime stone (Some hornblende and micas available) 19.00		74	35		19
20	1															Moderately to highly weathered crystaline lime stone (Some amount of weathered micas available) 20.35		27			20

Bore Hole completed at 20.35m

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

cecb LABORATORY & SITE INVESTIGATION UNIT

LOCATION :-CONDUTE TRACE | **B.H No.: CT4** |

DRILLING DATA		BOREHOLE DATA
STARTED :	**2003/10/7**	X-COORDINATE :164261.681 m
COMPLETED :	**2003/10/11**	Y-COORDINATE :197938.506 m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :103.040 m
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) : m
CORE BARREL, BIT :	**NQ**	FINAL DEPTH :20.00 m
FOREMAN :	**UKSJ**	INCLINATION : Vertical
LOGGED BY :	**SRMS/RMLKR**	BEARING : -

KEY

JOINT ROUGHNESS
VR= very rough
R: rough
SR: slightly rough
S= smotth
SL=slickensided

JOINT SPACING
VW= very widely> 2m
W= widely
MW= moderately wide
C= Closely
VC= very closely

JOINT SEPARATION
V= very tight
T= tight
MO= moderately open
O= open

OTHER SYMBOLS
SL/CW - Soil & Completely Weathered
HW - Highly Weathered
MW - Moderately Weathered
SW - Slightly Weathered
TCR - Total Core Recovery
RQD - Rock Quality Designation
GWL - Ground water Level

LEGEND FOR GRAPHIC LOG
Sand
Clay
Garnet biotite gneiss
Quartzo feldspathic gneiss
Charnockite
Granitic gneiss
Quartzite
Calc gneiss/Crystaline lime stone
Boulder

TCR | RQD | WEATHERING (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILL WATER (COLOR, LOSS)	RATE OF DRILLING	WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
1					0.40 7/10										Fine to coarse grained,brown clayey silty sand Some amount of gravels & rock fragments available					1
						1.50									1.50					
2						1.95	1								Fine to coarse grained, yellowish brown clayey silty gravelly sand 2.00					2
3					2.2 10/10	3.00														3
	7					3.45	7													
4																				4
5															Fine to coarse grained, yellowish brown clayey silty sand Some rock fragments & coarse gravels available					5
6						6														6
						6.45	9													
7																				7
	8					7.50														
						7.95	8													
8															8.00					8
9						9.00									Fine to coarse grained, light brown clayey silty sand Weathered feldspars & micas available (Highly decomposed material)					9
						9.45	20								9.50					
10																				10
						10.50														
						10.95	17													
11															Light brown to white clayey sandy silt. Weathered feldspars & micas available (Highly decomposed material)					11
12						12.00														12
						12.45	23													
	9																			
13															13.00					13

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :-CONDUTE TRACE | **B.H No.: CT4** |

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILL WATER (COLOR,LOSS)	RATE OF DRILLING	WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALLUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14			Dark brown			14.00 14.45	11									Light brown to white clayey sandy silt. Weathered feldspars & micas available (Highly decomposed material) 14.50					14
15																Light brown clayey silt Weathered feldspars & micas available (Highly decomposed material)					15
16						16.00 16.45	11									16.45					16
17			Brown													Brown clayey sandy silt Weathered feldspars & micas available (Highly decomposed material)					17
18	10	18.3														18.25					18
19			Whitish grey													Fresh rock of crystaline limestone					19
20	11															20.00					20
								Bore Hole Completed at 20.00m													
21																					21
22																					22
23																					23
24																					24
25																					25
26																					26
27																					27
28																					28
29																					29
30																					30

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- MAIN TUNNEL | **B.H No.: MT 1**

DRILLING DATA		BOREHOLE DATA	
STARTED :	2002/10/11	X-COORDINATE :	164,028.099m
COMPLETED :	19/10/02	Y-COORDINATE :	198,008.066m
MACHING TYPE :	TONE	ELEVATION (COLLAR) :	124.491m
DRILLING METHOD :	ROTARY	ELEVATION (BOTTOM) :	88.951m
CORE BARREL, BIT :	NX	FINAL DEPTH :	35.54m
FOREMAN :	MRAMHP	INCLINATION :	Vertical
LOGGED BY :	BMAPM	BEARING :	-

KEY

JOINT ROUGHNESS
- VR= very rough
- R: rough
- SR: slightly rough
- S= smotth
- SL=slickensided

JOINT SPACING
- VW= very widely> 2m
- W= widely
- MW= moderately wide
- C= Closely
- VC= very closely

JOINT SEPARATION
- V= very tight
- T= tight
- MO= moderately open
- O= open

OTHER SYMBOLS
- SL/CW - Soil & Completely Weathered
- HW - Highly Weathered
- MW - Moderately Weathered
- SW - Slightly Weathered
- TCR - Total Core Recovery
- RQD - Rock Quality Designation
- GWL - Ground water Level

LEGEND FOR GRAPHIC LOG
- Sand
- Clay
- Fresh to slightly weathered charnockite
- Highly to mod weathered charnockite
- Fresh to slightly weathered biotite gneiss
- Highly to mod weathered biotite gneiss
- Quartzite
- Calc gneiss
- Boulder

TCR | RQD | WEATHERING (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR, LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N`VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
1						0.00										Brown to yellowish brown colour, soft, sandy silty clay with pebbles & fine to coarse grained quartzitic sand 1.10m					1
						0.46	3														
2						1.50										Dark brown colour,soft, silty clay with highly weathered rock fragments Some plant roots					2
						1.95	5														
3																Boulder 2.65m					3
																Dark brown colour, silty clay with highly weathered rock fragments 3.10m					
						3.10															
4						3.55	11									Whitish brown colour, medium dense, fine to coarse grained silty sandy material (May be completely weathered rock)					4
						4.50															
5						4.95	12									4.95m					5
6																Light brown to yellowish brown colour, medium dense to dense , fine to medium grained, silty sandy material					6
						6.00															
7	11					6.45	14														7
						7.50															
8						7.85	46HB									7.85m					8
																Boulder 8.00m					
																Whitish brown, colour completely weather fine grained, silty material 8.47m					
																Boulder 8.66m					
9																Whitish brown, colour completely					9
						9.00										weathered, fine grained, silty materia					
						9.45	34									Weathered rock fragments available 9.83m					
10																Highly to moderately weathered biotite shist with garnets Rock in pieces due to weathering (Rock in pieces) 10.70m		53 50			10
11	12		Light brown													Highly to moderately weathered quartzo feldspathic gneiss with coarse quartz grains & garnets (Rock in pieces)		40			11
12																		43			12
13																					13

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14			Light brown									100% W.L. AT 13.85			Highly to moderately weathered quartzo feldspathic gneiss with coarse quartz grains & garnets (Rock in pieces)		26			14
15																	36			15
16																	39			16
17																	27			17
18					17.95												20			18
					16/10												45			
19	15														18.88m Highly to moderately weathered charnockitic gneiss 19.20m					19
20															Highly to moderately weathered quartzo feldspathic gneiss with garnets (Rock in pieces)		80			20
																	44			
21					21.16												24			21
					19/10															
22																	42			22
23					23.32										Highly to moderately weathered quartzo feldspathic gneiss with garnets		37			23
					23.46															
					17/10															
24																	32			24
25																	34			25
26															26.00m Moderately weathered rock of charnockitic gneiss		65	20		26
27	16														27.00m Highly to moderately weathered quartzo feldspathic gneiss with garnets		36			27
28								Sub vertical joints at 28.30mto 28.46m (Weathered,rough, Iron stained joint surface) Joint at 28.95m(70^0) (Weathered,rough, Iron stained joint surface)									84	27		28
29															29.48m		71	63		29
30	17														Slightly weathered quartzo feldspathic gneiss with garnets					30

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
31																Same above rock,quartz bands & biotite rich layers available 30.47m Highly weathered quartzo feldspathic gneiss with garnets (Rock in pieces)		58 35	41		31
32											1 4 7		0.52 1.35 2.06					44			32
33									30.00	35.54	10 7		2.72 2.19	0	$6*10^{-6}$	33.00m					33
34								Sub vertical joint from 33.68m to 33.92m (Weathered joint surface) Foliation joint at 34.52m(15^{0}) (Slightly weathered,rough,brownish joint surface)			4 1		1.42 0.60			Moderately to slightly weathered quartzo feldspathic gneiss with garnets (Rock in pieces) 34.00m Fresh quartzo feldspathic gneiss with garnets 34.48m Fresh garnetiferous biotite gneiss		58			34
35	18															Fresh to slightly weathered quartzo feldspathic gneiss with garnets 35.54m					35
36								**BOREHOLE COMPLETTED AT 35.54M**													36
37																					37
38																					38
39																					39
40																					40
41																					41
42																					42
43																					43
44																					44
45																					45
46																					46
47																					47

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

cecb — LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- PENSTOCK

B.H No.: MT 2

DRILLING DATA		BOREHOLE DATA
STARTED :	**15/10/2002**	X-COORDINATE :161,508.252m
COMPLETED :	**25/10/2002**	Y-COORDINATE :198,150.331m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :100.007m
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) :65.007m
CORE BARREL, BIT :	**NQ**	FINAL DEPTH :35.00m
FOREMAN :	**KRNK**	INCLINATION : Vertical
LOGGED BY :	**BMAPM**	BEARING : -

KEY

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R: rough
SR: slightly rough
S= smotth
SL=slickensided

JOINT SPACING
VW= very widely> 2m
W= widely
MW= moderately wide
C= Closely
VC= very closely

JOINT SEPARATION
V= very tight
T= tight
MO= moderately open
O= open

OTHER SYMBOLS
SL/CW - Soil & Completely Weathered
HW - Highly Weathered
MW - Moderately Weathered
SW - Slightly Weathered
TCR - Total Core Recovery
RQD - Rock Quality Designation
GWL - Ground water Level

LEGEND FOR GRAPHIC LOG
Sand
Clay
Fresh to slightly weathered charnockite
Highly to mod weathered charnockite
Fresh to slightly weathered biotite gneiss
Highly to mod weathered biotite gneiss
Quartzite
Calc gneiss
Boulder

TCR | RQD | WEATHERING (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR, LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N`VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
						0.00										Dark brown, silty clay with tree roots					
						0.45	3									(Top soil layer) 0.45m					
1																Redish brown, loose, silty fine to coarse sand with rock fragments 1.50m					1
	15																				
						1.50										Light redish brown dense silty fine					
2						1.95	25									to coarse sand with some weathered					2
																rock fragments. (high percentage of quartz)					
3																3.45m					3
						3.45										Dark brown, medium dense, clayey					
4						3.90	17									silt					4
																Dark yellowish brown, clayey fine to					
	16				4.45											coarse moderately dense sand 4.40m					
5																Boulder of weathered gneissic rock					5
																Brown completely weathered material(silty sand) 5.45m					
6						5.70										Light reddish brown, dense, silty fine to coarse sand with weathered					6
						6.15	24									feldspathic particles.					
	17															(Insitu formation)					
7																7.75m					7
						7.65															
8						7.75	35HB									Dense completely weathered material (Brown silty sand) 8.25m					8
																Weathered rock boulder 8.45m					
9			Yellowish grey													Completely weathered material (sludge sample- is fine to coarse					9
	18															silty sand with weathered feldspar particles)					
10																					10
11																					11
12																					12
13																					13

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14																Completely weathered material (sludge sample-is fine to coarse silty sand with weathered feldspar particles)					14
15	19																				15
16																					16
17	20		Yellowish grey																		17
18																					18
19																					19
20																					20
21																					21
22	21							Vertical joint at 21.80m-21.90m (Tight and iron stained)								21.80m Fresh to slightly weathered rock of biotite gneiss			17		22
23								Vertical joint from 22.05m-23.00m(partly tight fresh joint)			1 4 7		0.40 0.60 0.90			(From 22.05m-22.30m rock is broken into pieces because of vertical joints) 23.35m					23
24									21.80	26.80	10 7		1.40 0.60	0	$4*10^{-6}$	Fresh rock of biotite gneiss 24.25m					24
25	22							Joint at 25.05m(40^0) Sub vertical from 25.05m-25.55m(slightly weathered discoloured joint surface)			4 1		0.30 0.30			Fresh to slightly weathered rock of biotite gneiss From 25.05m-25.55m rock is broken into pieces and slightly weathered due to joints. In this joited portion quartz content is high. 26.40m			69		25
26			Grey																		26
27																Fresh rock of biotite gneiss.					27
28											1 4		Nil Nil								28
29	23							Joint at 28.51m (37^0) (Fresh joint partly filled with whitish guage)	26.45	31.45	7 10 7 4 1		Nil 0.08 Nil Nil Nil	0	$2*10^{-7}$	29.51m Fractured fresh quartzite					29
30								Fracturing starts at 29.51m													30

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing) weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
31																Fractured fresh quartzite 30.25m Fresh rock of quartzite.			85		31
32								Joint at 32.32m(25°) (Partly iron stained rough joint surface)			1		Nil							32
33			Grey					Joint at 32.83m(35°) (partly iron stained rough joint)	31.45	35.00	4 7 10		Nil Nil 0.02	0	7*10^{-8}					33
34	24										7 4 1		Nil Nil Nil							34
35	25							**BOREHOLE COMPLETED AT 35.08M**								35.08m					35
36																					36
37																					37
38																					38
39																					39
40																					40
41																					41
42																					42
43																					43
44																					44
45																					45
46																					46
47																					47

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- PENSTOCK | **B.H No.: MT 3**

DRILLING DATA		BOREHOLE DATA	
STARTED :	**28/11/2002**	X-COORDINATE :	161,448.998m
COMPLETED :	**05/12/2002**	Y-COORDINATE :	198,139.480m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :	77.842m
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) :	52.272m
CORE BARREL, BIT :	**NQ**	FINAL DEPTH :	25.57m
FOREMAN :	**WLN**	INCLINATION :	Vertical
LOGGED BY :	**BMAPM**	BEARING :	-

KEY

JOINT ROUGHNESS	JOINT SEPARATION
VR= very rough	V= very tight
R: rough	T= tight
SR: slightly rough	MO= moderately open
S= smotth	O= open
SL=slickensided	
JOINT SPACING	OTHER SYMBOLS
VW= very widely> 2m	SL/CW - Soil & Completely Weathered
W= widely	HW - Highly Weathered
MW= moderately wide	MW - Moderately Weathered
C= Closely	SW - Slightly Weathered
VC= very closely	TCR - Total Core Recovery
	RQD - Rock Quality Designation
	GWL - Ground water Level

LEGEND FOR GRAPHIC LOG

Sand; Clay; Fresh to slightly weathered charnockite; Highly to mod weathered charnockite; Fresh to slightly weathered biotite gneiss; Highly to mod weathered biotite gneiss; Quartzite; Calc gneiss; Boulder

TCR | RQD | WEATHERING (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILL WATER (COLOR, LOSS)	RATE OF DRILLING	WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N'VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
0						0.00										Reddish brown, dense, silty fine to coarse sand with some gravels.					0
						0.45	8														
1																					1
2						1.95															2
						2.40	54														
3																3.00m					3
																Reddish brown, dense, silty fine to coarse sand					
4					5.10	3.90										4.15m					4
					29/12	4.15	76HB														
	28															Highly to moderately weathered garnet-quartzo feldspathic gneiss.					
5																5.20m					5
																Moderately to highly weathered rock of biotite gneiss.(Rock in pieces max.9cm & min.<1cm)		81			
6																6.00m					6
											1		Nil			Moderately to highly weathered rock of biotite gneiss. Rock in pieces					
					7.70						4		0.60								
					3/ 13						7		1.60					75			
7									4.15	9.15	10		4.00	1	$1*10^{-5}$	7.00m					7
											7		1.20			Highly to moderately weathered rock of garnet-quartzo feldspathic gneiss.					
	29										4		0.50								
8											1		Nil								8
																		75			
9			Grey																		9
																		94			
10																					10
											1		1.00								
											4		1.50					80			
11											7		1.60								11
									9.15	14.15	10		3.00	1	$8*10^{-6}$						
					11.60						7		2.10								
					4 / 12						4		1.50					72			
12											1		0.90								12
					13.10													75			
13					5 / 12																13

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14	3		Grey													Highly to moderately weathered rock of garnet-quartzo feldspathic gneiss. 14.00m		49			14
15								Joint at 14.80m(40°) (partly weathered joint surface)								Fresh rock of garnet biotite gneiss. 15.60m			80		15
16											1		Nil			Weathered garnet biotite gneiss 15.85m			60		16
											4		1.10			Fresh rock of garnet biotite gneiss.					
											7		1.30								
									14.15	19.15	10		2.00	0	$5*10^{-8}$						
17								Joints at 16.81m(15°) &16.90m(20°) (weathered rough joint surfaces)			7		1.40								17
											4		0.90								
											1		0.40								
18								Sub vertical joint at 17.95m to 18.29m (Tight joint)													18
19																19.00m			42		19
																Fresh rock of quartz rich garnet biotite gneiss. 20.00m			47		
20								Vertical joint at 20.09m-20.4m (Partly iron stained) Here the rock is in pieces due to that joint.													20
21	4										1		Nil			Fresh rock of garnet biotite gneiss.					21
											4		Nil								
								Joint at 21.40m-21.49m(55°)			7		Nil								
22								(fresh tight joint)	19.15	24.15	10		0.02	0	$5*10^{-8}$				86		22
											7		Nil								
											4		Nil								
											1		Nil								
23																23.00m					23
																Moderately weathered garnet biotite gneiss					
24																24.00m			68		24
																Fresh rock of garnet biotite gneiss.					
								Joint at 24.80m(40°) (fresh tight joint)													
25								Sub vertical joint at 24.80m- 25.50m (Partly tight joint)	24.15	25.50	10		0.00	0	0				76		25
	5															25.57m		57			
26								**BOREHOLE COMPLETED AT 25.57M**													26
27																					27
28																					28
29																					29
30																					30

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- PENSTOCK | **B.H No.: MT- 4**

DRILLING DATA		BOREHOLE DATA	KEY	
STARTED :	**29/10/2002**	X-COORDINATE :161,468.184m	**JOINT ROUGHNESS**	JOINT SEPARATION
COMPLETED :	**11/11/2002**	Y-COORDINATE :198,200.832m	VR= very rough R: rough SR: slightly rough S= smotth SL=slickensided	V= very tight T= tight MO= moderately open O= open
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) : 87.558m	**JOINT SPACING**	OTHER SYMBOLS
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) : 57.008m	VW= very widely> 2m W= widely MW= moderately wide C= Closely VC= very closely	SL/CW - Soil & Completely Weathered HW - Highly Weathered MW - Moderately Weathered SW - Slightly Weathered TCR - Total Core Recovery RQD - Rock Quality Designation GWL - Ground water Level
CORE BARREL, BIT :	**NQ**	FINAL DEPTH :30.55m		
FOREMAN :	**KRNK**	INCLINATION : Vertical		
LOGGED BY :	**BMAPM**	BEARING : -		

LEGEND FOR GRAPHIC LOG

Sand
Clay
Fresh to slightly weathered charnockite
Highly to mod weathered charnockite
Fresh to slightly weathered biotite gneiss
Highly to mod weathered biotite gneiss
Quartzite
Calc gneiss
Boulder

TCR | RQD | WEATHERING (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILL WATER (COLOR, LOSS)	RATE OF DRILLING	WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N'VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
1						0.00 0.45	8									Yellowish brown, loose fine to mediu silty sand. Some coarse sand also available 1.00m					1
2						1.95 2.40	15														2
3																Reddish brown, moderately densed fine to coarse silty sand with some weathered rock fragments					3
4	29					3.90 4.35	15									4.00m Reddish brown, densed silty,fine to coarse quartzitic sand with some pebbles					4
5																5.00m Dark reddish brown, fine sandy clayey,silt					5
6						5.85 6.30	27									6.00m Light reddish brown, densed silty,fin to coarse quartzitic sand with some pebbles					6
7					7.70 3 / 11																7
8		2				7.80 8.25	31									8.25m					8
9																Highly weathered rock of garnet biotite gneiss Highly weathered rock in pieces		53 68			9
10			Greyish yellow															64			10
11																		64			11
12																		68			12
13																					13

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14															Highly weathered rock of garnet biotite gneiss Highly weathered rock in pieces		60 60			14
15					15.30 15.60												70			15
16	3				8 / 11										16.27m		40			16
17	4		Greyish yellow		16.45 9 ,10,11/ 11										Highly weathered rock of biotite gneiss, Rock in pieces					17
18								Foliation joints at 17.17,17.21,17.31m(50°) (Weathered,rough, joint surfaces) Foliation joint at 18.08m(50°) (Tight,rough, joint)							Moderately weathered rock of biotite gneiss 18.48m		82 70	39		18
19	5										1 4 7	Nil 0.40 0.60			Highly weathered rock of garnet biotite gneiss, Rock in pieces		54			19
20									18.30	21.90	10 7 4 1	1.10 0.60 0.30 0.10	0	$4*10^{-6}$			82			20
21	8							Foliation joints at 21.08,21.13m(45°) (Weathered,rough, joint surfaces)							20.92m Fresh rock of biotite gneiss Few garnets available From 21.00 to 21.70m biotite% is hig			78		21
22																				22
23								Sub vertical joint from 23.20m-23.70m										25		23
24								(Tight joint) Sub vertical joint from 23.79m-23.95m (Tight joint)			1 4 7	Nil Nil 0.02								24
25	9		Whitish grey						21.90	27.05	10 7 4 1	0.05 0.02 Nil Nil	0	$2*10^{-7}$						25
26															Biotite rich layer from 25.43-26.60m					26
27																				27
28	10										1 4 7	Nil Nil 0.03								28
29								Foliation joint at 28.87m(42°) (Fresh, tight joint)	27.05	30.55	10 7 4 1	0.06 0.02 Nil Nil	0	$2*10^{-7}$	Fresh,quartz rich, biotite gneiss Few garnets available					29
30																				30

DEPTH (m)	DRILLING					GPT RESULTS		JOINTS	PERMEABILITY						GENERAL DESCRIPTION	GRAPHIC LOG	RECOVERY		WEATHERING	DEPTH (m)
	DAILY ADVANCE	CASING/CEMENT	DRILL WATER (COLOR,LOSS)	RATE OF DRILLING	WATER LEVELS	DEPTH	N' VALUVE	NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	DEPTH (M) FROM TOP	DEPTH (M) TO BOTTOM	PRESSURE (bars)	WATER LOSS	(total{liters}/time{min}	Lugeon Unit (Lu)	Coefficient of Permeability (cm/s)	rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints		CORE RECOVERY %	R.Q.D. %		
	11		Whitish grey													Fresh,quartz rich, biotite gneiss 30.55m					
								BOREHOLE COMPLETED AT 30.55M												
31																				31
32																				32
33																				33
34																				34
35																				35
36																				36
37																				37
38																				38
39																				39
40																				40
41																				41
42																				42
43																				43
44																				44
45																				45
46																				46
47																				47

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

cecb — LABORATORY & SITE INVESTIGATION UNIT

LOCATION :-MAIN TUNNEL | **B.H No.: MT5** |

DRILLING DATA		BOREHOLE DATA
STARTED :	**2003/8/22**	X-COORDINATE :164,050.587 m
COMPLETED :	**2003/9/3**	Y-COORDINATE :198,005.489 m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :123.838 m
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) :m
CORE BARREL, BIT :	**NQ**	FINAL DEPTH :30.25 m
FOREMAN :	**WLN**	INCLINATION : Vertical
LOGGED BY :	**SRMS/RMLKR**	BEARING : -

KEY

JOINT ROUGHNESS
- VR= very rough
- R: rough
- SR: slightly rough
- S= smotth
- SL=slickensided

JOINT SPACING
- VW= very widely> 2m
- W= widely
- MW= moderately wide
- C= Closely
- VC= very closely

JOINT SEPARATION
- V= very tight
- T= tight
- MO= moderately open
- O= open

OTHER SYMBOLS
- SL/CW - Soil & Completely Weathered
- HW - Highly Weathered
- MW - Moderately Weathered
- SW - Slightly Weathered
- TCR - Total Core Recovery
- RQD - Rock Quality Designation
- GWL - Ground water Level

LEGEND FOR GRAPHIC LOG
- Sand
- Clay
- Garnet biotite gneiss
- Quartzo feldspathic gneiss
- Charnockite
- Granitic gneiss
- Quartzite
- Calc gneiss/Crystaline lime stone
- Boulder

TCR | ROD | WEATHERING (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR, LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
						0.00									Fine to coarse grained,loose,silty					
						0.45	4								sand .Some gravels available 0.45					
1																				1
						1.50									Fine to coarse grained,loose,					
2						1.95	5								gravelly sand					2
															Some highly weathered rock					
															fragments					
3	22					3.00														3
						3.45	5								3.45					
4																				4
															Fine to coarse grained, reddish					
						4.50									brown silty sand					
5						4.95	4													5
					5.60 24/08															
						5.50														
6	23					5.95	42								6.30					6
															Fine to coarse grained, reddish					
7						7.00									brown silty sand					7
						7.45	26								Some highly weathered rock					
															fragments					
8															(Highly decomposed material)					8
	24														8.25					
				Light greish brown											Highly weathered biotite gneiss		20			
9															(Boulder ?)					9
															9.25					
						9.25														
						9.70	58								Fine to coarse grained, brown silty					
10															sand.Some highly weathered rock					10
															fragments					
						10.80									(Highly decomposed material)					
11						11.25	45													11
															11.25					
				Complete loss of water											Fresh to slightly weathered garnet		32			
															biotite gneiss 11.75					
12																	44			12
															Fresh to moderately weathered					
															garnet biotite gneiss					
															(Rock brocken into pieces)					
13															13.00					13

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

cecb — LABORATORY & SITE INVESTIGATION UNIT

LOCATION :-MAIN TUNNEL | **B.H No.: MT5** |

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILL WATER (COLOR/LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N` VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14	25		Light grey to light brown		13.20 26/08											Biotite gneissic rock brocken into pieces 13.25 Fresh to highly weathered garnet biotite gneiss (Rock brocken into pieces along the joints) 15.00					14
15																					15
16																Fine to coarse grained, dark brown silty sand (Highly decomposed material) 17.30					16
17	26																				17
18			Light cream													Slightly to moderately weathered garnet biotite gneiss 19.25		33			18
19	27																	40			19
20																Fresh to moderately weathered garnet biotite gneiss.(Garnet % is high) 20.05			53		20
21																Fine to medium grained, brown silty sand (Highly decomposed material Sludge sample) 21.25					21
22			White to light brown													Fresh to moderately weathered , garnet rich quartazo feldspathic gneiss. 22.75			60		22
23																Fine to medium grained, brown silty sand (Highly decomposed material-Sludge sample) 23.60					23
24																Fresh to moderately weathered ,garnet rich quartazo feldspathic gneiss. 24.00			55		24
25																Fine to medium grained, brown silty sand (Highly decomposed material Sludge sample) 25.65					25
26																Fresh to moderately weathered ,garnet biotite gneiss. 25.95		46			26
27																Fine to medium grained, brown silty sand (Highly decomposed material Sludge sample) 27.50					27
28																Mod. to highly weathered ,garnet biotite gneiss/27					28
29		28.9														Fine to medium grained, brown silty sand. Some gravels & rock fragments available (Highly decomposed material Sludge sample)					29
30																					30

BOREHOLE COMPLETED AT 30.25M

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT
BOREHOLE LOG FOR ENGINEERING PURPOSES

cecb — LABORATORY & SITE INVESTIGATION UNIT

LOCATION :-MAIN TUNNEL | **B.H No.: MT 6** |

DRILLING DATA		BOREHOLE DATA
STARTED :	**2003/9/6**	X-COORDINATE :164,015.436 m
COMPLETED :	**2003/9/16**	Y-COORDINATE :197,995.307 m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :134.126 m
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) :m
CORE BARREL, BIT :	**NQ**	FINAL DEPTH :40.10 m
FOREMAN :	**WLN**	INCLINATION : Vertical
LOGGED BY :	**SRMS/RMLKR**	BEARING : -

KEY

JOINT ROUGHNESS
VR= very rough
R: rough
SR: slightly rough
S= smotth
SL=slickensided

JOINT SPACING
VW= very widely> 2m
W= widely
MW= moderately wide
C= Closely
VC= very closely

JOINT SEPARATION
V= very tight
T= tight
MO= moderately open
O= open

OTHER SYMBOLS
SL/CW - Soil & Completely Weathered
HW - Highly Weathered
MW - Moderately Weathered
SW - Slightly Weathered
TCR - Total Core Recovery
RQD - Rock Quality Designation
GWL - Ground water Level

LEGEND FOR GRAPHIC LOG
Sand
Clay
Garnet biotite gneiss
Quartzo feldspathic gneiss
Charnockite
Granitic gneiss
Quartzite
Calc gneiss/Crystalline Limestone
Boulder

TCR | RQD | WEATHERING: SL/CW, HW, MW, SW

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR, LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
0						0.00															0
						0.45	1										Fine to coarse grained,dark brown , loose clayey silty sand (Top soil layer) 0.45					
1																	Fine to coarse grained,brown, clayey silty sand with weathered rock fragments 1.00					1
			Light brown														Fine to coarse grained,brown, dense silty sand with weathered rock fragments					
2						1.50											2.15					2
	6					1.95	57										Moderate to highly weathered biotite gneiss (may be a boulder)		90			
3																	Fine to coarse grained silty sand with highly weathered rock fragments					3
						3.00																
						3.45	61										3.90					
4	7																Fresh to highly weathered garnet biotite gneiss 4.1		80			4
																	Medium to coarse grained brown sand with mica (Sludge sample)					
5			Dark Brown to gray														(Highly decomposed rock) 5.00					5
																	Fresh to highly weathered garnet biotite gneiss 5.3		77			
6						5.75											Fine to coarse grained,light brown, silty sand with weathered feldspar and mica					6
						6.20	16										(Highly decomposed rock) 6.65					
7																	Fine to medium grained,brown silty sand with mica (Sludge sample) 7.00					7
																	Moderate weathered to highly weathered garnet biotite gneiss 7.20		50			
8																	Fine to medium grained,brown silty sand with weathered mica (Sludge sample) 7.70					8
9																	Fine to coarse grained,yellowish brown silty sand with weathered feldspar and mica (Highly weathered rock)					9
						9.25																
						9.70	74															
	8																					
10			Light brown														10.20					10
																	Fine to coarse grained,reddish brown clayey silty sand					
						10.65																
11						11.10	33										(Weathered rock fragments) 11.00					11
																	Fine to medium grained,brown silty sand (Sludge sample) 11.30					
12																	Fine to coarse grained,brown, silty sand with mi 12.00					12
						12.40																
						12.60	>50										Fine to coarse grained,light brown, silty sand with weathered feldspar					
13																	13.00					13

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT
BOREHOLE LOG FOR ENGINEERING PURPOSES

cecb LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- MAIN TUNNEL | **B.H No.: MT 6** |

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14			Brown to Light gray													Fine to coarse grained,light brown, silty sand with weathered feldspar 13.50 Highly weathered biotite gneiss 14.00		40			14
15																Fine to medium grained,brown, silty sand with weathered mica (Sludge sample) (May be decomposed rock) 15.00 Highly weathered biotite gneiss		55			15
16	9															Fine to coarse grained,dark brown, silty sand with mica (Sludge sample) 15.80 Fine brown silt (Sludge sample) 16.00					16
17																Fine to coarse grained,dark brown, silty sand with mica (Sludge sample) 17.30					17
18																Fine to coarse grained,light brown, silty sand with weathered feldspar and mica (Sludge sample) 18.30					18
19			Light creamy red													Fine to coarse grained,dark brown, silty sand with weathered feldspar and mica (Sludge sample)					19
20																					20
21	10																				21
22			Whitish brown(at 22.65m Complete water loss)													22.00 Yellowish brown silty sand(Sludge sample) Fresh to moderately weathered garnet biotite gneiss 22.50		64			22
23																Fine to coarsegrained,brown silty sand with weathered mica(Sludge sample) 23.00					23
24	12															Fresh to moderately weathered garnetiferrous quartzo feldspathic gneiss 23.35 Fresh to moderately weathered biotite gneiss 24.25		60 27			24
25																Moderate to highly weathered garnet biotite gneiss 25.55		29			25
26			Light to dark brown													Fine to coarse grained,dark brown, silty gravelly sand with weathered mica (Sludge sample)					26
27																					27
28																28.20					28
29	13				28.45 16/9											Fine to coarse grained,dark brown silty gravelly sand with highly weathered rock fragment (May be weathered rock) 29					29
30			Gray to brown													Fine to medium grained,dark brown, silty sand with weathered mica (Sludge sample) 30.00					30

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT
BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- MAIN TUNNEL | **B.H No.: MT 6** |

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
31																Fine to coarse grained,dark brown, silty gravelly sand with rock fragments					31
																31.20					
32																Fine to coarse grained,dark brown silty gravelly sand					32
																32.70					
33																Fine to coarse grained,dark brown silty sand with weathered mica (Sludge sample)					33
34			Light brown to dark brown																		34
35	14																				35
36																					36
37			Light gray to dark brown																		37
																37.80					
38		38.00														Slight to highly weathered garnet biotite gneiss		85			38
																38.00					
39			Light gray(38.95m complete water loss)													Fresh garnet biotite gneiss (High % of Quartz)		93	93		39
40	15							Joint at 40.10(sub horizontal) joint surface slightly weathered into rock								40.10					40
								BOREHOLE COMPLETED AT 40.10m													
41																					41
42																					42
43																					43
44																					44
45																					45
46																					46
47																					47

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT
BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- SURGE TANK | **B.H No.: MT 7** |

DRILLING DATA		BOREHOLE DATA
STARTED :	**2003/9/17**	X-COORDINATE :161,591.171 m
COMPLETED :	**2003/10/6**	Y-COORDINATE :198,111.429 m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :124.040 m
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) :m
CORE BARREL, BIT :	**NX**	FINAL DEPTH :60.00 m
FOREMAN :	**MRAMHP**	INCLINATION : Vertical
LOGGED BY :	**SRMS/RMLKR**	BEARING : -

KEY

JOINT ROUGHNESS
VR= very rough
R: rough
SR: slightly rough
S= smotth
SL=slickensided

JOINT SPACING
VW= very widely> 2m
W= widely
MW= moderately wide
C= Closely
VC= very closely

JOINT SEPARATION
V= very tight
T= tight
MO= moderately open
O= open

OTHER SYMBOLS
SL/CW - Soil & Completely Weathered
HW - Highly Weathered
MW - Moderately Weathered
SW - Slightly Weathered
TCR - Total Core Recovery
RQD - Rock Quality Designation
GWL - Ground water Level

LEGEND FOR GRAPHIC LOG
Sand
Clay
Garnet biotite gneiss
Quartzo feldspathic gneiss
Charnockite
Granitic gneiss
Quartzite
Calc gneiss/Crystalline Lime Stone
Boulder

TCR | RQD | WEATHERIN (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR, LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
1						0.00									Fine to coarse grained,reddish brown,loose clayey,silty sand(Top soil layer) 0.45					1
						0.45	6								Fine to coarse grained,reddish brown, silty sand (More % of coarse grains available)					
2						1.55														2
						2.00	8													
3						3.00									3.00					3
						3.45	16								Fine to coarse grained,red to pink, clayey silty,sand (Some gravels available)					
4																				4
						4.55														
5	17					5.00	12													5
6						6.00														6
						6.45	7													
7			Brown																	7
						7.55									7.68					
8					7.89 18/9	7.68	>50								Fine to medium grained,reddish brown silty sand (Some weathered micas available)					8
9					9.04 19/9	9.00														9
						9.27	>50													
10																				10
						10.55														
11					10.92 21/9	11.00	42								11.00					11
															Fine to coarse grained,reddish brown,dense Quartz sand					
12						12.00														12
	18					12.38	>50													
13															13.00					13

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- SURGE TANK | **B.H No.: MT 7** | **Page 2 of 4**

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	PT RESULT: DEPTH	PT RESULT: N'VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14						13.00										Fine to medium grained,brown silty sand (Some weathered micas available)					14
						13.45	16														
15						15.00															15
						15.45	14														
16																					16
						16.55															
17			Brown			17.00	18										17.50				17
18																Fine to medium grained,light brown silty sand (Some weathered micas available) (May be highly decomposed rock)					18
						18.00															
						18.24	>50														
19					18.95 22/9																19
						19.55															
20	19					19.60	>50										20.48				20
21		20.48	Light brown to light grey													Moderate to highly weathered biotite gneiss		35 18			21
22																					22
23																	23.00				23
																Slightly to moderately weathered biotite gneiss		22			
24																	24.00				24
																Moderate to highly weathered biotite gneiss		20			
25	21							(Core loss due to weathered zone from 25.0 to 25.45m) Joint at 25.45(irregular) highly weathered in to rock								25.00					25
																Slightly to moderately weathered biotite gneiss (Pegmatitic feature appeared) (Core loss due to weathered zone)		58	44		
26								Joint at 25.85m(30^0) joint surface			1		-			26.00					26
								slightly weathered into rock)			4		0.05			Slightly weathered biotite gneiss (Some garnets available)		25			
											7		0.25								
27									25.50	29.00	10		0.63	0.1	$3x10^{-6}$						27
											7		0.30								
								(Joint set has developed from 27.50			4		0.14					80	60		
								to 28.33m along the foliation planes			1		0.03			27.50					
28								foliation planes, joint intensity 5/m)								Slightly weathered biotite gneiss (In some places pegmatitic feature appeared)		90	50		28
																28.33					
																Fresh biotite gneiss (Quartz % is high)		100	100		
29	22		Light grey																		29
30																30.00					30

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

cecb LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- SURGE TANK | **B.H No.: MT 7** |

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	PT RESULT: DEPTH	PT RESULT: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total{liters}/time{min})	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
																Fresh biotite gneiss		100	100		
											1		-			(Quartz % is high)					
								Joint at 31.48m(25^0) (tight joint)			4		0.08								
31								Joint at 31.63m(35^0) (tight joint-			7		1.30								31
								surface filled with thin film of white material)	29.00	34.36	10		1.56	0.20	3x10^{-6}	Fresh garnet biotite gneiss			95		
	23							Joints at 32.05 & 32.25m(15^0)			7		1.38								
								Joint at 32.65(50^0)			4		0.42								
32								Joint at 32.90(20^0)(tight joints-			1		0.02								32
								surfaces slightly weathered into rock)											82		
								Joint at 32.94(45^0) (tight joint ,surface													
								filled with white secondary material)													
33								Joint zone from 32.97 to 33.10m													33
								(Joint surfaces slightly weathered into rock)								Fresh biotite gneiss		90	70		
								Joint from 33.25 to 33.35m(55^0)													
								Suface filled with grey thin film								(Quartz & garnet rich layer from 33.40 to 33.47m)					
34								Joint at 33.50(subvertical) tight joint								(Small amount of garnet avilable section from					34
	24							surface slightly weathered into rock								34.00 to 34.36m) 34.36					
								Joint at 34.00(40^0) tight joint			1		-			Fresh biotite gneiss		83	39		
								Foliation joint at 34.36(30^0)			4		0.03			(Biotite % is high)					
35								Highly jointed zone(subvertical &			7		0.16			(Small biotite bands available)					35
								subhorizontal) from 34.36 to 36.40m	34.25	39.00	10		0.25	0.0	6x10^{-7}						
								(joint surfaces filled with black material,			7		0.17								
								Rock has broken into pieces due to joints)			4		0.05								
36								Joint at 34.90(35^0) (surface filled with			1		-								36
								thick white material)													
																36.40					
																Fresh biotite gneiss		100	100		
37	25															(Quartz % is high)					37
																(Small amount of garnet avilable)					
38																					38
39			Light grey					Joint from 39.22 to 39.66m(subvertical)														39
								surface filled with white secondary material			1		-						64		
											4		0.20								
											7		0.10								
40	27								39.00	44.00	10		0.15	0.0	3x10^{-7}	40.00					40
								Joint at 40.98m(30^0) (tight folition joint)			7		0.12			Fresh garnet biotite gneiss			98		
											4		0.40			(Quartz % is high)					
											1		-								
41																					41
																			75		
								Joint from 42.22 to 42.41m(vertical)													
42	28							(surface filled with white secondary material)													42
								Joint at 42.73m(30^0) (tight joint-												100	
								surface filled with grey secondary material)													
43																43.00					43
								Joint at 43.45m(30^0)								Fresh biotite gneiss					
								Joint at 43.75m(45^0)								(Small amount of garnet available)			90		
								(surfaces filled with black secondary material)													
44	29							Joint from 44.0 to44.20m(subvertical)													44
								Joint at 44.80m(30^0)								44.20					
								(surface filled with dark grey material)								Fresh biotite gneiss					
																(Quartz % is high)					
45											1		-								45
											4		0.04						100		
											7		0.15								
									43.90	49.00	10		0.20	0.0	4x10^{-7}						
46											7		0.16			46.00					46
											4		0.04			Fresh biotite gneiss					
											1		-								
47																47.00					47

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT
BOREHOLE LOG FOR ENGINEERING PURPOSES

cecb LABORATORY & SITE INVESTIGATION

LOCATION :- SURGE TANK | **B.H No.: MT 7** |

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,L	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	PT RESULT: DEPTH	PT RESULT: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH FROM TOP	PERMEABILITY: DEPTH TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
48																Fresh garnet biotite gneiss					48
	30																				
49								Joint from 49.30 to 49.55m(subvertical-tight joint surface filled with grey material)												49
								Joint at 49.78m(30^0) (surface filled with dark grey material)								49.40		52		
50								Joints from 49.90 to 50.15 & 50.20 to 50.47m(80^0) (surface filled with dark grey material)			1	-				Fresh biotite gneiss				50
																	50.47				
51								Joint at 50.53m(subhorizontal-tight joint)			4	0.02				Fresh garnet biotite gneiss (Quartz % is high)				51
	1										7	0.10									
									49.00	54.00	10	0.14	0.0	3x10^{-7}					100		
											7	0.10									
											4	0.03									
52											1	-									52
								Joints from 52.45 to 52.62 & 52.72 to 52.80m(80^0)(tight joints)										74		
53	2							Joint at 53.52m(30^0) (Trimolite available along the joint)													53
																			100		
54											1	-									54
											4	0.02									
											7	0.08									
55									54.00	59.00	10	0.13	0.0	3x10^{-7}							55
											7	0.09									
											4	0.04									
56	4										1	-									56
57								Joint at 57.61(30^0) (fresh,tight joint)													57
											1	-							65		
58											4	-									58
											7	0.05									
									57.50	60.00	10	0.08	0.0	3x10^{-7}							
								Joint at 59.53(40^0)(fresh,tight joint-			7	0.06									
59	5							surface filled with grey secondary material)			4	0.02									59
								Joint from 59.88 to 60.00m(subvertical) (surface filled with light grey material)			1	-									
60	6							Joint at 60.00m(20^0)(tight & fresh joint)								60.00					60

Bore hole completed at 60.00m

61	61
62	62
63	63
64	64

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT
BOREHOLE LOG FOR ENGINEERING PURPOSES

cecb LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- MAIN TUNNEL | **B.H No.: MT 8** |

DRILLING DATA		BOREHOLE DATA
STARTED :	**2003/12/8**	X-COORDINATE :161,984.829 m
COMPLETED :	**2003/9/9**	Y-COORDINATE :197,955.406 m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :154.587 m
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) : m
CORE BARREL, BIT :	**NX**	FINAL DEPTH :80.06 m
FOREMAN :	**MRAMHP**	INCLINATION : Vertical
LOGGED BY :	**SRMS/RMLKR**	BEARING : -

KEY

JOINT ROUGHNESS
VR= very rough
R: rough
SR: slightly rough
S= smotth
SL=slickensided

JOINT SPACING
VW= very widely> 2m
W= widely
MW= moderately wide
C= Closely
VC= very closely

JOINT SEPARATION
V= very tight
T= tight
MO= moderately open
O= open

OTHER SYMBOLS
SL/CW - Soil & Completely Weathered
HW - Highly Weathered
MW - Moderately Weathered
SW - Slightly Weathered
TCR - Total Core Recovery
RQD - Rock Quality Designation
GWL - Ground water Level

LEGEND FOR GRAPHIC LOG
Sand
Clay
Garnet biotite gneiss
Quartzo feldspathic gneiss
Charnockite
Granitic gneis
Quartzite
Calc gneiss/Crystaline lime stone
Boulder

TCR | RQD | WEATHERING (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR, LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS (total{liters}/time{min})	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
1						0.00									Fine to medium grained,dark brown, clayey silty sand (Top soil layer) 0.55					1
						0.45	5								Slightly weathered garnet hornblend gneiss (May be a boulder) 1.60		40			
2	12				1.45 12/8	2.00 to 2.24	>50								Fine to medium grained, brown, dense,silty sand (Some weathered micas available) 2.24					2
3					2.88 19/8										Fine to medium grained, light brown, silty sand (Sludge sample) (Some weathered micas available)					3
4																				4
5																				5
6																				6
7			Brown																	7
8					7.53 13/8															8
9																				9
	13														9.50					
10															Fine to coarse grained, light grey, silty sand (Sludge sample) (Some weathered micas and feldspars available) (May be highly decomposed rock)					10
11																				11
12															12.18					12
13					12.84 7/9										Fresh slightly weathered, biotite gneiss (Small amount of garnets available) 13.0		37	21		13

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DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total{liters}/time{min})	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14																Fresh slightly weathered, biotite gneiss (Small amount of garnets avilable) 14.38		24	16		14
15			Brown													Fine to coarse grained, light grey, silty sand (Sludge sample) (Some weathered micas and feldspars available) (May be highly decomposed rock)					15
16		16.0						Joint at 16.18m (sub horizontal) (irregular, joint surface weathered			1 4		- 0.43			16.00					16
17	15							into rock) Joint at 17.78m (sub horizontal) (irregular joint) Joint at 17.28m (10°)	16.50	20.00	7 10 7 4		0.85 1.28 0.86 0.45	0.3	$4x10^{-6}$	Fresh garnet biotite gneiss 17.00		95	90		17
18								(joint surface slightly weathered into rock) Joint from 17.52 to 17.56m (Weathered zone)			1		-			Fresh biotite gneiss (Small amount of garnets avilable)		97	85		18
19			Light grey					Joint at 18.56m(sub vertical) (joint surface weathered into rock)								19.00		71	50		19
20	19							Joint at 19.06m (subhorizontal) (tight joint,surface filled thin film of reddish brown material)								Fresh Quartz rich garnet biotite gneiss 20.00		98	86		20
21								(Highly jionted zone from 20.0 to 21.0m core loss due to joints)			1		-			Fresh to moderately weathered Quartz richgarnet biotite 21.00		63	30		21
22	20		Grey					Joint at 21.07(sub horizontal) (irregular, joint surface slightly weathered into rock)	19.50	24.55	4 7 10 7 4 1		0.30 0.87 1.85 1.37 0.82 0.15	0.3	$5x10^{-6}$	Fresh Quartz rich garnet biotite gneiss (Quartz rich bands from 22.67 to 22.72m from 23.83 to 24.24m from 24.36 to 25.00m from 25.35 to 25.55m from 26.90 to 27.10m from 29.00 to 29.20m)		100	90 100		22
23																					23
24																					24
25								Joint at 25.26m (35°) (joint surface filled thin film of grey secondary material)													25
26																					26
27			Light grey						24.60	29.00	1 4 7 10 7 4 1		- - 0.07 0.12 0.08 0.03 -	0.0	$3x10^{-7}$						27
28	22																				28
29																					29
30	23															30.00					30

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DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total)liters/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
31											1		-			Fresh Quartz rich garnet biotite gneiss		100	100		31
											4		-								
											7		0.04			(Quartz rich bands					
									29.00	34.00	10		0.06	0.0	$2x10^{-7}$	from 31.40 to 31.52m					
											7		0.05			from 34.92 to 35.04m)					
32											4		-								32
											1		-								
																(Pegmatitic features appaered from 36.75 to 37.15m)					
33																					33
34	26																				34
35																					35
											1		-								
36											4		0.03								36
											7		0.05								
									34.00	39.00	10		0.12	0.0	$3x10^{-7}$						
											7		0.06								
37	27							Two parellel joints at 37.36 & 37.93m(45^0)			4		0.05				37.00				37
								(joint surfaces filled with thick film of white secondary material)			1		0.02			Fresh biotite gneiss			91		
								Joint at 37.75m (50^0)													
38								(joint surface filled thin film of black secondary material)								(Pegmatitic features appaered from 38.16 to 38.86m)					38
								Joint at 37.53m (45^0) tight joint													
39	28		Light grey														39.00				39
								Joint at 39.75m (45^0)								Fresh biotite gneiss			68		
								(joint surface filled by thin grey film)								(Biotite % is high)					
								Joint at 40.30m (50^0)													
40								(joint surface filled by thin black material)													40
								Joint at 40.80m (50^0) (slicken sided joint)													
								(joint surfaces filled with thin film of black secondary material)													
41																					41
											1		-						100		
											4		0.06								
											7		0.09								
42									39.15	44.63	10		0.15	0.0	$4x10^{-7}$						42
											7		0.09								
											4		0.05								
											1		-								
43																					43
44																					44
	30																				
											1		-								
45											4		0.02								45
								Joint from 45.70 to 46.30m(vertical)			7		0.06								
									44.50	49.00	10		0.17	0.0	$5x10^{-7}$	(Biotite rich layer from 45.70 to 46.95m)					
											7		0.09						70		
46											4		0.04								46
											1		-								
								Joint at 47.07m (30^0)													
								(joint surfaces filled with thin film of grey secondary material)													
47																	47.00				47

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DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total)(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
48																Fresh biotite gneiss (Biotite % is high) (Small amount of garnets available)		100	90		48
								Joint at 48.58m (irregular) (joint surface filled with thin film of grey secondary material)								(Biotite rich layer from 48.05 to 50.30m)					
49	31		Light grey					Joint at 50.70m (irregular) (joint surface filled with thin film of black secondary material)													49
50								Joint at 51.18m (60°) tight joint Joint at 51.40m (30°) tight joint (joint surface filled with thin film of black secondary material)			1 4 7		- - 0.07							50
51	1								49.00	54.00	10 7 4 1		0.12 0.08 0.02 -	0.0	3x10⁻⁷						51
52								Joint at 52.26 & 53.97m (30°) tight joint (joint surfaces filled with thin film of grey secondary material)								(Biotite rich layer from 52.34 to 53.28m)			90		52
53			Grey																		53
54																54.00					54
																Fresh biotite gneiss			100		
55																					55
56											1 4 7		- - 0.08								56
57	3								54.00	59.00	10 7 4 1		0.14 0.08 0.03 -	0.0	4x10⁻⁷						57
58																					58
59																			91		59
60			Light grey					Joint at 59.30m (35°) tight joint joint surface filled with thin film of black secondary material Joint at 60.95m (40°) tight fresh joint													60
61											1		-						100		61
62								Joint at 62.05m (70°) tight joint joint surface filled with thin film of dark grey secondary material	59.00	64.00	4 7 10 7 4		0.03 0.09 0.18 0.10 0.04	0.0	5x10⁻⁷				32		62
63								Joint from 62.30 to 62.47 (60°) tight joint joint surface filled with thin film of black secondary material			1		-						100		63
	4																				
64																64.00					64

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DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
65											1		-			Fresh biotite gneiss		100	100		65
											4		0.04								
66											7		0.09								66
									64.00	69.00	10		0.20	0.0	$5x10^{-7}$						
											7		0.10								
											4		0.05								
67											1		0.02								67
68			Light grey																		68
69	5										1		74.0								69
											4		80.0								
									69.00	74.00	5	100%	95.0	10.8	$2x10^{-4}$						
70								Two parellel joints at 70.80 & 80.86m			4		82.0								70
								(tight,joint surfaces filled with thin film of			1		80.0								
								dark grey secondary material)													
71																			81		71
								Joint zone from 71.55 to 71.70m													
								(irregular joint surfaces filled grey and													
								white secondary material)											66		
72								(pyrite avaslable along the joint surfaces)													72
								Joint at 72.10m (sub horizontal)													
			0% to 100%					(joint surface filled with white thin film)													
73								Joint at 72.30m (50^0)													73
								(joint surface filled with grey thin film)													
			Loss 100%					Joint at 72.52m (40^0)											92		
								(Garnets available along the surface)													
74	6							Two parellel joints at 73.55 & 74.85m(40^0)													74
								(joint surface filled with grey thin film)													
75								Joints from 75.44 to 75.49m(subvertical)			1		-							75
								& at 76.70(45^0) & at 76.90(60^0)			4		0.03					78		
								(joint surfaces filled with grey thin film)			7		0.10								
									73.50	78.46	10		0.17	0.0	$4x10^{-7}$						
76								Joints at 77.0 & 77.13m(40^0)			7		0.13								76
								(joint surfaces filled with grey thin film)			4		0.05								
								Joints at77.30 & 77.50m(50^0) tight joints			1		0.02								
								Joints at78.02 & 78.16m(45^0) tight joints													
77			Light grey					Joints at 78.68m(30^0)													77
								(joint surfaces filled with grey thin film)											89	53	
								Joints at 78.76m(30^0)										77.56			
								(joint surface slightly weathered into rock)								Fresh biotite gneiss		94	83		
78	7							Joints at 78.79,78.85,79.0,79.1,79.18,			1		-			(Small amount of garnets available)					78
								79.25,79.34,79.4,79.55,79.77,79.88m			4		0.04								
								(horizotal) slightly slicken sided joints			7		0.09								
																		78.46			
									78.00	80.06	10		0.15	0.1	$7x10^{-7}$	Fresh garnet biotite gneiss		100	100		
79								Joint from 79.10 to 79.61m (subvertical)			7		0.09								79
								(tight joint)			4		0.03								
								(Due to these joints in section from			1		-								
								78.46 to 80.06 rock has broken													
80	8							into pieces)													80
								Bore hole completed at 80.06m													
81																					81

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- TAILRACE | **B.H No.: TR 1** |

DRILLING DATA		BOREHOLE DATA
STARTED :	**2003/10/10**	X-COORDINATE :161313.227 m
COMPLETED :	**2003/10/16**	Y-COORDINATE :198240.940 m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :65.845 m
DRILLING METHOD	**ROTARY**	ELEVATION (BOTTOM) :m
CORE BARREL, BIT	**NX**	FINAL DEPTH : 25.30m
FOREMAN :	**MRAMHP**	INCLINATION : Vertical
LOGGED BY :	**SRMS/RMLKR**	BEARING : -

KEY

JOINT ROUGHNESS
VR= very rough
R: rough
SR: slightly rough
S= smotth
SL=slickensided

JOINT SPACING
VW= very widely> 2m
W= widely
MW= moderately wide
C= Closely
VC= very closely

JOINT SEPARATION
V= very tight
T= tight
MO= moderately open
O= open

OTHER SYMBOLS
SL/CW - Soil & Completely Weathered
HW - Highly Weathered
MW - Moderately Weathered
SW - Slightly Weathered
TCR - Total Core Recovery
RQD - Rock Quality Designation
GWL - Ground water Level

LEGEND FOR GRAPHIC LOG
Sand
Clay
Biotite gneiss
Quartzo feldspathic gneiss
Charnockite
Granitic gneiss
Quartzite
Calc gneiss/Crystalline Limestone
Boulder

TCR | ROD | WEATHERING: SL/CW, HW, MW, SW

DRILLING: DEPTH (m)	DAILY ADVANCE	CASING/CEMENT	DRILL WATER (COLOR, LOSS)	RATE OF DRILLING	WATER LEVELS	SPT RESULTS: DEPTH	N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	TO BOTTOM	PRESSURE (bars)	WATER LOSS (total(liters)/time(min))	Lugeon Unit (Lu)	Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	R.Q.D. %	WEATHERING	DEPTH (m)
						0.00									Fine to coarse grained,brown,loose,silty					
						0.45	6								sand with some gravels(Top soil layer)0.45					
1															Fine to coarse grained,brown,silty sand					1
															1.55					
						1.55									Medium to coarse grained brown ,dense,					
2						2.00	48								gravelly sand 2.00					2
															Fine to coarse grained, reddish brown,sand					
															(Some amount of coarse graines & gravels					
3			Brown												available)					3
						3.00									3.00					
						3.27	>50								Highly weathered to highly decomposed rock 3.27					
															Fine to coarse grained,light brown,silty sand					
															(Sludge sample) (Some weathered micas					
4															available)					4
						4.50									4.50					
						4.68	>50								Highly weathered to highly decomposed rock 4.68					
5															Fine to coarse grained,light brown,silty sand					5
					5.38										(Sludge sample) (Some weathered micas					
					11/10										available) (May be highly weathered rock)					
															5.48					
6	10	6.00													Highly to moderaterly weathered boitite gneiss		59			6
															(High % of Quartz and feldspars) 6.00					
															Highly to moderaterly weathered boitite gneiss		35			
7			Light grey																	7
								(Rock has broken into pieces and core									27			
					7.84			loss observed due to weathered zones												
8			Water loss at 7.56m		14/10			and joints section from 5.48 to 9.00m)												8
					8.15												34			
					17/10										9.00					
9								Joint from 9.0 to 9.05m(weathererd zone)							Fresh biotite gneiss		##	70		9
								Joint at 9.44m(40^0) (tight foliation joint)							(Quartz % is high)					
	11							Joint at 9.60m(subhorizontal-tight joint)												
								Joints at 9.76 &9.80m(45^0) (tight joint)												
10	12							Joint at 9.95m(45^0) (white patches												10
								observed along the joint surface)			1	-			Fresh biotite gneiss			95		
											4	0.03								
								Joint at 10.79m(30^0) (tight joint)			7	0.08								
11			Light grey					(joint developed along biotite rich layer)	9.50	14.00	10	0.15	0	4x10^{-7}						11
								Joints at 10.79 & 11.70m(30^0) tight joints			7	0.09								
								(joints developed along biotite rich layer)			4	0.04								
											1	-								
12																		100		12
13															13.00					13

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cecb LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- TAILRACE | **B.H No.: TR 1** |

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14	14							Joints at 13.54 & 13.90m(25°)(tight joints)								Fresh biotite gneiss					14
																14.00					
								Joint from 15.0 to 15.08m(70°) (tight joint)								Fresh biotite gneiss					
								Joints at 15.27m(30°) (tight foliation joint)								(Quartz % is high)					
15								Two parellel joints at 15.63 & 15.72m(45°) (tight joints)								15.00					15
											1	-				Fresh biotite gneiss			80		
											4	-									
											7	0.06									
16									14.00	19.00	10	0.13	0	$3x10^{-7}$		16.00					16
											7	0.07				Fresh biotite gneiss			100		
											4	0.02				(Quartz % is high)					
											1	-									
17																17.00					17
								Joint from 17.15 to 17.33m(subvertical-tight joint)								Fresh biotite gneiss			62		
								Joint from 17.73 to 17.89m(80°) (tight joint)													
18																					18
								Joint at 18.23m(30°) (tight foliation joint)											100		
19	15																				19
			Light grey																		
20																					20
											1	-									
											4	-									
21											7	0.03									21
								Joint at 21.27m(30°) (tight foliation joint-	19.50	25.30	10	0.07	0	$2x10^{-7}$				90		
								joints developed along biotite rich layer)			7	0.04									
								Joint at 21.46m(30°)(tight joint)			4	-									
22											1	-									22
								(Compositional layers have folded											100		
								from 21.53 to 21.73m)													
23																					23
24	16																				24
25																					25
	17															25.30					

Bore hole completed at 25.30m

26																					26
27																					27
28																					28
29																					29
30																					30

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- QUARRY | **B.H No.: BQ1** |

DRILLING DATA		BOREHOLE DATA
STARTED :	**2003/7/21**	X-COORDINATE :165,079.076 m
COMPLETED :	**2003/7/27**	Y-COORDINATE :198,278.868 m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :176.102 m
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) :m
CORE BARREL, BIT :	**NX**	FINAL DEPTH :25.05 m
FOREMAN :	**MRAMHP**	INCLINATION : Vertical
LOGGED BY :	**SRMS/RMLKR**	BEARING : -

KEY

JOINT ROUGHNESS
VR= very rough
R: rough
SR: slightly rough
S= smotth
SL=slickensided

JOINT SPACING
VW= very widely> 2m
W= widely
MW= moderately wide
C= Closely
VC= very closely

JOINT SEPARATION
V= very tight
T= tight
MO= moderately open
O= open

OTHER SYMBOLS
SL/CW - Soil & Completely Weathered
HW - Highly Weathered
MW - Moderately Weathered
SW - Slightly Weathered
TCR - Total Core Recovery
RQD - Rock Quality Designation
GWL - Ground water Level

LEGEND FOR GRAPHIC LOG
Sand
Clay
Garnet biotite gneiss
Quartzo feldspathic gneiss
Charnockite
Granitic gneiss
Quartzite
Calc gneiss/Crystaline lime stone
Boulder

TCR | **RQD** | **WEATHERING** (SL/CW, HW, MW, SW)

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR, LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
						0.00									Fine to coarse grained brown clayey					
						0.45	8								silty sand (Top soil layer) 0.45					
1															Fine to coarse grained brown clayey silty sand					1
															1.50					
						1.50														
2						1.95	11								Fine to coarse grained reddish brown					2
															silty quartz sand					
															(High % of coarse grains)					
3															(Some quartz gravels available)					3
						3.00														
						3.45	18													
4					4.26 21/07															4
															4.50					
						4.50									Fine to coarse grained pinkish brown					
5						4.95	15								silty sand					5
															(Some quartz gravels available)					
6																				6
						6.00														
	21		Brown			6.45	14													
7																				7
						7.50														
8						7.95	15													8
															7.95					
															Fine to coarse grained pinkish brown clayey silty sand					
9															(Some gravels and weathered					9
						9.00									feldspars available)					
						9.45	20													
10																				10
															10.50					
						10.50									Fine to coarse grained, brown					
11						10.95	23								silty sand					11
															(Some weathered feldspars available)					
12																				12
						12.00									12.00					
						12.45	57								Fine to coarse grained, pink, very dense,silty sand (Some gravels available) 12.45					
13																				13

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :- QUARRY | **B.H No.: BQ1** |

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total)liters)/time(min)	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
								NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)								rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints					
14	23		Brown		13.58 23/07	13.50 to 13.73	>51									Fine to coarse grained ,brown,silty sand (Sludge sample) 13.95					14
15					14.75 26/07											Fresh to slightly weathered ,impure Quartzite (Rock has broken into pieces) 16.00		8			15
16	25																				16
17			Light brown Loss 100%-0%													Fresh ,impure Quartzite (Rock has broken into pieces) 17.05		19			17
18								Sub horizontal joints available inbetween 17.05m to 18.16m,(Couldn't determine exact possition due to core loss) joint surfaces filled with thin film of black secondary material							Fresh, garnety ferrous Quartzo feldspathic gneiss) (Rock has broken into pieces due to sub horizontal joints) 18.16		83	59		18
19								Sub horizontal joints available inbetween 18.16m to 20.60m,(Couldn't determine exact possition due to core loss) joint surfaces filled with thin film of dark brown secondary material							Rock changing zone fresh to slightly weathered, Quartzo feldspathic gneiss to impure Quartzite) 20.60		21	9		19
20																					20
21	26		Light brown													Fresh to slightly weathered ,impure Quartzite (Small amount of micas available) 22.75		16	9		21
22																					22
23								Sub vertical joints available inbetween 22.75m to 25.05m,(Couldn't determine exact possition due to core loss) joint surfaces filled with thin film of greyish black secondary material							Fresh Quartzite (In some places rock has broken into pieces due to sub vertical joints)		27	19		23
24																		56			24
25	27															25.05					25

Bore hole completed at 25.05m

26	26
27	27
28	28
29	29
30	30

GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :-QUARRY | **B.H No.: BQ 2'** |

DRILLING DATA		BOREHOLE DATA
STARTED :	**2003/10/2**	X-COORDINATE :164,757.367 m
COMPLETED :	**2003/10/5**	Y-COORDINATE :198,200.350 m
MACHING TYPE :	**TONE**	ELEVATION (COLLAR) :157.017 m
DRILLING METHOD :	**ROTARY**	ELEVATION (BOTTOM) :m
CORE BARREL, BIT :	**NQ**	FINAL DEPTH : 25.10 m
FOREMAN :	**WLN**	INCLINATION : Vertical
LOGGED BY :	**SRMS/RMLKR**	BEARING : -

KEY

JOINT ROUGHNESS	JOINT SEPARATION
VR= very rough	V= very tight
R: rough	T= tight
SR: slightly rough	MO= moderately open
S= smotth	O= open
SL=slickensided	
JOINT SPACING	**OTHER SYMBOLS**
VW= very widely> 2m	SL/CW - Soil & Completely Weathered
W= widely	HW - Highly Weathered
MW= moderately wide	MW - Moderately Weathered
C= Closely	SW - Slightly Weathered
VC= very closely	TCR - Total Core Recovery
	RQD - Rock Quality Designation
	GWL - Ground water Level

LEGEND FOR GRAPHIC LOG

Sand, Clay, Garnet biotite gneiss, Quartzo feldspathic gneiss, Charnockite, Granitic gneiss, Quartzite, Calc gneiss/Crystalline Lime stone, Boulder

TCR | RQD | WEATHERING: SL/CW, HW, MW, SW

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILL WATER (COLOR, LOSS)	RATE OF DRILLING	WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS	PERMEABILITY: (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: Rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritlic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
0						0.00															0
						0.45	4									Fine to coarse grained, brown,loose clayey silty sand (Top soil layer) 0.45					
1																Fine to coarse grained, reddish brown,clayey silty sand (Some rock fragments available) 1.00					1
2																Fine to coarse grained, yellowish brown,clayey silty sand (Some weathered rock fragments available) 2.00					2
3					2.90 2/10											Fine to coarse grained, light yellow,clayey silty sand (Highly weathered rock) 3.00					3
4			Yellow		3.90 3/10											Medium to coarse grained yellowish brown silty sand (Sludge sample) (Some weatherred feldspars available) 3.65					4
																Highly weathered to highly decomposed granitic gneiss 4.65					
5																Fine to coarse grained, light brown,sandy silty clay					5
6																Fine to coarse grained yellowish brown silty sand (Sludge sample) 6.60					6
7			White to light yellow													Highly weathered to highly decomposed granitic gneiss (In some places rock weathered into clay)7.0					7
8																Fine to coarse grained, light yellow, silty sand (Sludge sample) 8.00					8
																Highly weathered granitic gneiss (Rock has broken into pieces due to weathering)					
9																Fine to medium grained, light yellow, silty sand (Sludge sample) 9.00					9
10																Highly weathered to highly decomposed granitic gneiss 10.00					10
	2															Fine to coarse grained, light yellow, silty sand 10.					
11																Highly weathered to highly decomposed hornblende biotite gneiss(High % of hornblende) 11.00					11
																Highly weathered to highly decomposed granitic gneiss 11.70					
12			Dark grey to white		12.8 4/10											Fine to coarse grained, light yellow, silty sand (Some weathered feldspars available) 12.40					12
		12.4														High to moderately weathered granitic gneiss 13.00		80			
13																					13

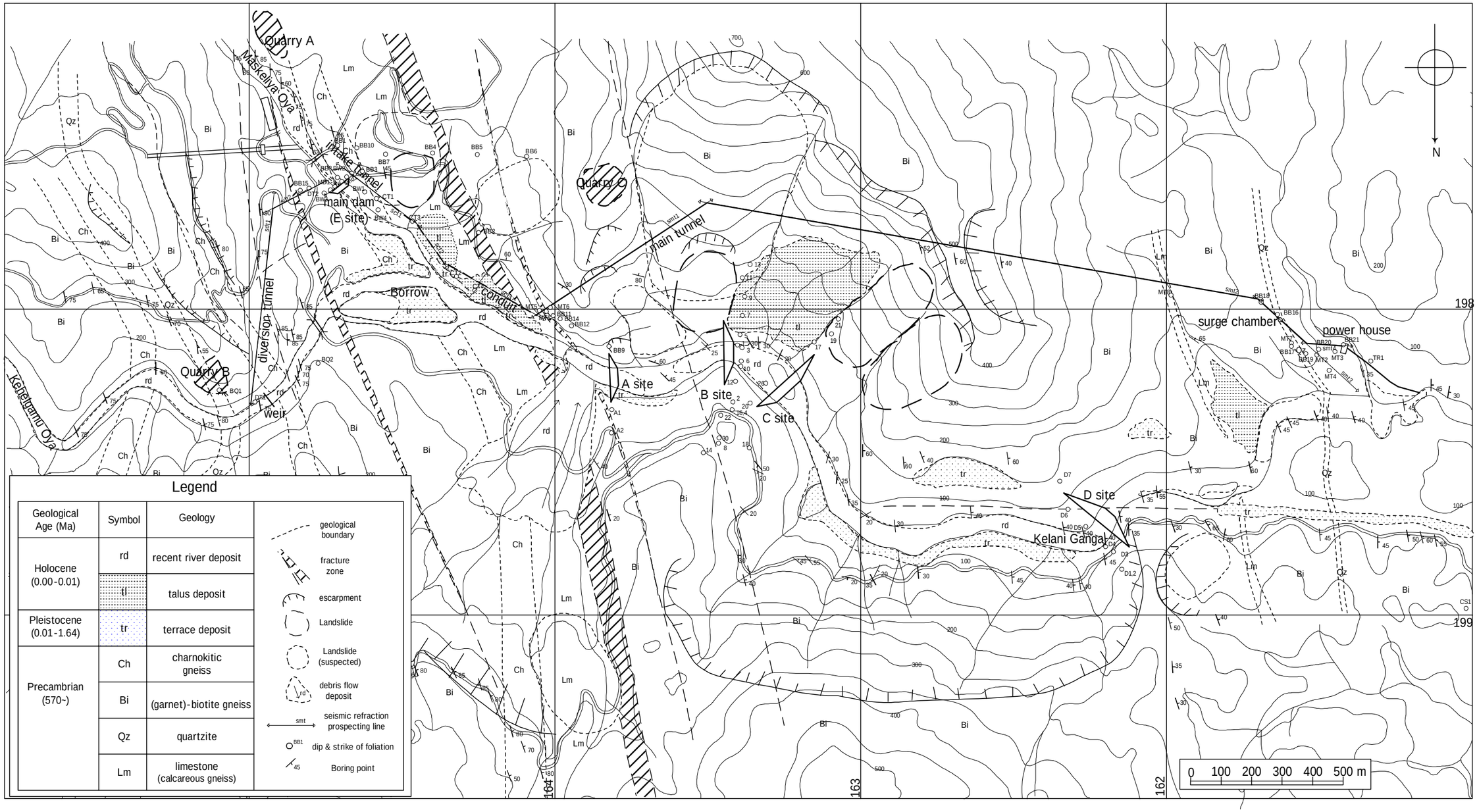
GEOLOGICAL INVESTIGATION FOR THE BROADLANDS HYDROPOWER PROJECT

BOREHOLE LOG FOR ENGINEERING PURPOSES

LABORATORY & SITE INVESTIGATION UNIT

LOCATION :-QUARRY | **B.H No.: BQ 2'** |

DEPTH (m)	DRILLING: DAILY ADVANCE	DRILLING: CASING/CEMENT	DRILLING: DRILL WATER (COLOR,LOSS)	DRILLING: RATE OF DRILLING	DRILLING: WATER LEVELS	SPT RESULTS: DEPTH	SPT RESULTS: N' VALUVE	JOINTS: NO OF JOINTS, SETS, TYPE, SPACING, ORIENTATION, CONNECTIONS, (ROGHNESS, PERSISTANCE, SEPARATION, FILL TYPE, AND THICKNESS SLICKENSIDED)	PERMEABILITY: DEPTH (M) FROM TOP	PERMEABILITY: DEPTH (M) TO BOTTOM	PERMEABILITY: PRESSURE (bars)	PERMEABILITY: WATER LOSS (total(liters)/time(min))	PERMEABILITY: Lugeon Unit (Lu)	PERMEABILITY: Coefficient of Permeability (cm/s)	GENERAL DESCRIPTION: rock type, colour, grain size, texture and structure (massive, cleaved, foliated, lineated, flow banded, gneissose, porphyritic,etc: scale as for joint spacing), weathering, alteration, minor lithological characteristics, strengths, joints	GRAPHIC LOG	RECOVERY: CORE RECOVERY %	RECOVERY: R.Q.D. %	WEATHERING	DEPTH (m)
14			Light grey to white					Joint 14.00 & 14.32 (subhorizontal) (joint surfaces weathered into rock & filled with black material) Two parellel joints from 14.0 to 14.12 & from14.17 to 14.32m(80^0)(joint surfaces moderately weathered into rock & formed redish brown material)							High to moderately weathered granitic gneiss (Rock broken into pieces due to weathering & joints) (Some hornblende & biotite rich layer observed) 14.00		77	33		14
15								(Rock has broken into pieces due to subhorizontal & sub vertical joints in section from 15.0 to 16.0m, joint intensity 7/m ,joint surfaces weathered into rock)							Fresh to moderately weathered granitic gneiss (Biotite rich layer available along the joint from (vertical)14.38 to 15.00m) 15.00		78	25		15
16			Light brown to white					Joint from 16.13 to 16.28m(60^0) (joint surface weathered into rock & filled with thick black secondary material)							Slight to moderately weathered granitic gneiss		88			16
17								Two parellel joints at 16.70 & 16.73m(55^0) (Surfaces filled by yellowish brown material) Sub vertical joint from 16.32 16.73 (joint surfaces slightly weathered into rock)							17.00					17
18	3							Joint from 16.78 to 16.90m(60^0) (joint surface weathered into rock & filled with black secondary material)							Fesh granitic gneiss		100	100		18
19			Light grey					Joints at 19.0,19.2,19.32,19.55m (subhorizontal) (joint surfaces weathered into rock)									89	89		19
20								Weathered zone from19.62 to 20.0m (Core loss is due to this zone)							19.62 Slight to moderately weathered granitic gneiss		100	53		20
21			Light brown to white					Joints at21.22 & 22.00m(35^0) (tight joints, weathered into rock)									39			21
22	4							Joint at21.45m(70^0) (tight joint, surface filled with yellow material)							(Inbetween section from 20.06 to20.59m rounded patches formed due to solution activities and due to this rock has moderately weathered)		100	100		22
23			Light brown to light grey					Joint at22.65m(subhorizontal-irregular joint surface highly weathered into rock)							22.65 Fresh to slightly weathered granitic gneiss (In some places rock has discoloured due to solution activities)			90		23
24								Joints at23.28m(10^0) & 23.72(15^0) (joints weathered into rock) (surfaces filled with dark brown material) Tight joint from23.4 to 23.65(vertical)							24.00 Fresh to highly weathered granitic gneiss (In some places rock has discoloured due to solution activities)		85	62		24
25	5							(Rock has broken into pieces due to joints & weathering in section from 24.00 to 25.10m, joint intensity 6/m)							25.10			26		25
								Bore hole completed at 25.10m												
26																				26
27																				27
28																				28
29																				29
30																				30



* Including geological investigations conducted in 1980s.

Location Map of Geological Investigations