PREFACE

Mullaperiyar Dam is a composite gravity structure of 115 years old. This dam constructed at a time when the dam engineering was in its infancy, has already served its useful life. Nature's law of deterioration has played its role in Mullaperiyar Dam also. No amount of rejuvenation of a storage structure by any means can perpetuate it. Years of continuous ageing has reduced the strength and vitality of the Mullaperiyar Dam. Continuous loss of the binding material, lime, due to leaching action has made the dam porous and less dense.

Increased seismicity in the Mullaperiyar region in the recent past and the reported probability of occurrence of high magnitude flood in the reservoir have transformed the otherwise weak dam to a high risk one. A collapse of this old dam will trigger a cascading failure of the three dams of the Idukki project and will endanger the lives and properties of thousands of people residing in the thickly populated districts of central Kerala

Official regulations and codes of practices in design and construction of dams are undergoing continuous revisions on account of evolution of new techno-scientific knowledge as well as increasing sense of social responsibility. In consequence, many existing dams do not comply with current standards, requirements and safety concepts. The 115 year old Mullaperiyar dam is a classic example of such an ageing dam.

It is the bounden duty of a State to protect the lives and properties of its people. State of Kerala is also fully aware of its obligation to continue supply of Mullaperiyar waters to the needy farmers of Tamil Nadu.

For achieving these twin goals, State of Kerala has taken a decision to build a new dam below the present Mullaperiyar Dam to replace it. This report is intended to establish the technical and practical feasibility of building such a replacement dam.

Chief Engineer
Investigation & Design

CONTENTS

1.0 INTRODUCTION

1.1 GENERAL

River Periyar, the longest of all the rivers in the State of Kerala, and also the largest in potential, having a length of 244 km originates in the Sivagiri group of hills at an elevation of about +1830 m above MSL. This river basin is the second largest basin of Kerala State with a drainage area of 5398 sq km of which 114 sq km in the Anamalai fold lies in the State of Tamil Nadu. The Periyar Basin lies between 090 15′ N to 100 20′ N and longitude 760 10′ E to 770 30′E. From its origin, Periyar traverses through an immense cliff of rocks in a northerly direction receiving several streamlets in its course. About 48 km downstream, the Mullayar joins the main river at an elevation of +854 m above MSL. Afterwards, the river flows westwards and at about 11 km downstream of the confluence of Mullayar and Periyar, the river passes through a narrow gorge, where the present Mullaperiyar Dam is constructed in 1895. The name Mullaperiyar is derived from a portmanteau of Mullayar and Periyar.

Below the Mullaperiyar Dam, the river flows in a winding course taking a north westerly direction. On its travel down, it is

enriched by many tributaries like Kattappana Ar, Cheruthoni Ar, Perinjankutty Ar, Muthirapuzha Ar and Idamala Ar. Lower down of Malayatoor; the river takes a meandering course and flows calmly and majestically for about 23 km through Kalady and Chowara and reaches Alwaye. Here, the river bifurcates into the Managalapuzha branch and the Marthanda Varmabranch. The Managalapuzha branch flows in a northwesterly direction and is joined by Chalakudy Ar at Puthenvelikara. After receiving Chalakudy Ar, the Periyar expand itself into a broad sheet of water at Munambam and finally falls into the Arabian sea. The Marthanda Varma branch flows in a southerly direction. This branch splits up into two and flows through the industrial belt in the basin and ultimately falls into the Vembanad Lake at Varapuzha. Thus the entire length of the Periyar River flows through the territory of the State of Kerala before it empties into the Arabian Sea.

Majority of the hydro power projects of Kerala including the giant Idukki Hydro Electric Project (780 MW) are located in this river basin. The Central Kerala and Metropolitan City of Kochi heavily depend on this river for its irrigation, industrial and drinking water requirements. River Periyar is rightly considered as the life line of Kerala.

The Old Mullaperiyar Dam constructed by the British Engineers is the in oldest dam the State of Kerala. The archaic design and primitive

construction methods coupled with the natural deterioration due to ageing have rendered the old structure unsafe and has become a constant threat to the lives and properties of thousands of people residing in its downstream. As the State of Kerala is duty bound to protect the lives and properties of its citizens, a decision was taken by the State of Kerala to build a new dam at downstream to replace the old Mullaperiyar Dam. This report is for establishing the technical feasibility of constructing such a replacement dam.

1.2 NEED FOR THE PROJECT

The old Mullaperiyar Dam is a composite gravity structure with an inner hearting portion of about 62% of the total volume constructed of lime surkhi concrete. The hydraulic lime used for the construction contained a large quantity of unburnt lime to the extent of about 40%. As the dam was built during a time when the dam engineering was at its infancy, many of the major technical and construction requirements applicable to modern gravity dams were not followed in its design and construction. Galleries for facilitating drainage and grouting were not provided, as also the design did not take care of seismic forces. Heavy and continuous seepage of water started appearing right from the first filling of the reservoir. Measures like guniting the upstream face of the dam and grouting the body of the dam were resorted to check the seepages during 1935 and 1961. During 1980s further strengthening measures like cable anchoring, adding weight at top by reinforced concrete capping, plain cement concrete backing, etc were carried out in the old dam to apparently improve the structural stability of the old dam. In the meantime, the spillway capacity was increased to negotiate the floods. The Full Reservoir Level (FRL) was also reduced to +136 ft in 1979 to reduce the load on the dam as well as for giving more room for flood storage. This

reduced FRL is being maintained even today. In spite of the above strengthening measures, the dam has not gained adequate strength to function further. Genuine apprehension regarding the safety of the dam persists in the minds of the people residing downstream and becomes aggravated during the rainy season.

In this background, State of Kerala decided to ascertain the safety of this century old dam as per modern standards. For this purpose, IIT, Delhi was entrusted with the task of evaluating the hydrological safety. IIT, Delhi after detailed evaluation of PMF and flood routing study, concluded that the present Mullaperiyar Dam is hydrologically unsafe. The studies entrusted with IIT, Roorkee has found out that the present dam is structurally unsafe to withstand the impact of the probable earthquakes that can reasonablybe expected to occur in the vicinity of the dam.

Idukki Hydro Electric Project with a gross storage of about 2000 MCM is existing just downstream of the Mullaperiyar Dam. Collapse of the Mullaperiyar Dam will trigger a cascading failure of the Idukki group of dams resulting in an unimaginable degree of devastation in the thickly populated districts of central Kerala.

The century old Mullaperiyar Dam has already outlived its useful life. The consequence of any failure of this dam could be catastrophic

and its outcome beyond all human imagination. In view of the definite conclusions of the scientific studies conducted by National Institutions of repute and the persistent threat which the dam poses, it is imperative that this structure requires urgent decommissioning for discharging the responsibility of the State to protect the lives and properties of its citizens. From 1895 onwards, State of Tamil Nadu is utilizing the waters of Mullaperiyar Dam for irrigation and drinking water requirements. State of Kerala does not desire to deprive Tamil Nadu of the Mullaperiyar waters on which their needy farmers are greatly dependent.

State of Kerala has taken a decision to build a new dam downstream of the present Mullaperiyar Dam to achieve the twin goals of protecting the lives and properties of its people and for ensuring continued supply of water to Tamil Nadu.

1.3 LOCATION AND ACCESS

The old Mullaperiyar Dam is located in Peerumedu Taluk of Idukki District of State of Kerala. It lies inside the Periyar Tiger Reserve area. The new dam is proposed to be located at 366 m below the centerline of the existing dam. The centre line of the proposed alignment of the new dam is oriented at about 50 East of North. The proposed structure consists of a main dam and a

saddle dam on the left flank. The right bank end of the main dam lies at Latitude 9031'48"N and Longitude 77008'33"E and the left bank end of the saddle dam lies at Latitude 9031'26"N and Longitude 77008'33"E. The present alignment tends at N100W-S100E and runs parallel to the axis of the existing dam.

The nearest airport is Cochin International Airport at Nedumbassery, which is 180 km away from the dam site. The nearest railway station is Kottayam, 110 km away. By road, one can reach Vandiperiyar through NH-220 and from there to Vallakadavu (located 8 km away) through Moozhiyar (Gavi) road.
From Vallakadavu, the dam site can be reached by travelling 5 km along a forest jeep road. This existing road is to be suitably improved to facilitate transportation of required tools and plant and construction materials.

1.4 OUTLINE OF THE PROJECT

The catchment area intercepted by the old dam is 624 sq. km, which lies entirely in the territory of State of Kerala. The new dam intercepts an additional catchment of 0.502 Sq.km. The total catchment area of the new dam is thus 624.5 Sq. km. The new dam proposed below the existing dam is a concrete gravity structure having a length of 370.10 m and a height of 53.22 m from the

deepest foundation. A saddle dam of length 137.00 m and height of 25.00 m will also be needed on the left flank abutting into the hill portion in between. If the intermediate hillock is found not sound enough to butt the dams, the same may have to be strengthened suitably or removed and the dam constructed as one monolith. The present water diversion structures viz. leading channel, intake arrangement, tunnel, etc. will remain unchanged as they are located separately on the upstream area of the reservoir and hence not forming part of the existing dam. As such, the present arrangement of water diversion to Tamil Nadu willcontinue to function uninterruptedly during the construction ofthe new dam and also after its commissioning.

1.5 CLIMATE

There are no well defined seasons in Kerala State. The Summer and Winter are practically controlled by the South West and North East monsoons which are peculiar to the west coast of India. The Autumn and Spring seasons are practicably indistinguishable in regard to the climatic conditions. The South West monsoon remains active after middle of May upto September, while North East monsoon between October and middle of December. The period from January to middle

of May is generally dry and the months of March and April form hot summer.

The average rainfall in the catchment is 2204 mm and the two periods of monsoons generally account for 76.22%of the annual rainfall based on the data from 1985-2010.

The catchment experienced a flood with volume of 34103 Mcft (155.87 cm in the catchment) for 21 days in July 1924. The catchment experienced another flood with a volume of 5118Mcft (23.38cm in the catchment) for a duration of 2days in January 1943, and again experienced a flood for 6-7 days with a volume of 13283 Mcft (60.67 cm in the catchment) in June 1961. The one day maximum observed point rainfall in a station (lat $10^0$06'N and long $77^0$04'E), very near to Mullaperiyar catchment, was observed on 16/7/1924 as 31.7 cm

(Page 47 of the Central Water Commission Dam safety project Generalized PMP Atlas published by WAPCOS). The value read from the same Atlas in Figure 18 for 15/7/24 is 24cm. The estimates of one day PMP on page 15 of the WAPCOS Atlas of three stations near this catchment are 58.88 cm (Peermade residency), 64.16 cm (Peermade Taluk) and 48.3 cm at (Sivagiri). The data indicates that the area is situated in high rainfall zone and is referred to as Zone 101 in the WAPCOS Atlas.

1.6 HYDRO METEOROLOGICAL DATA

The existing Mullaperiyar Dam is having a catchment area of 624 sq. km, which is a hilly area covered with thick dense forest. The new dam intercepts an additional catchment of 0.5 sq. km. The entire catchment area of 624.5 sq. km of the new dam lies in the territory of the State of Kerala.

The rainfall over a period of years indicates that the dam area is situated in a high rainfall zone, ie, in zone 101 of the WAPCOS Atlas. South West and North East monsoons are very distinct in this region. The Periyar catchment is mostly influenced by the South West monsoon, which occurs in the months of June to August. The mean annual rainfall at the Periyar Dam site is 2420 mm (1916-1976). The 75% dependable runoff from the above catchment is around 21 TMC (1910-2005). The additional catchment of 0.5 sq km will give a further proportionate runoff of 0.017 TMC.

The 75% dependable diversion from the Mullaperiyar reservoir to the Vaigai basin for a period of last 45 years (1963-2008) is 17.7 TMC. Even though the FRL was reduced to +136 ft in 1979 and is being maintained at that level even today, the 75% dependable diversion during the period 1979-2008 is 19.5 TMC. Even though the dependable

diversion since 1963 is 17.7 TMC with a higher FRL, a dependable diversion of 19.5 TMC was able to be achieved with a reduced FRL of +136 ft, due to adoption of better reservoir operation policy. Hence it can be seen that 93% of the dependable yield (19.5 TMC out of 21 TMC) is being diverted with the reduced FRL of +136 ft from the present reservoir to Tamil Nadu. This is an indication that the level of +136 ft is the optimum FRL for the Mullaperiyar reservoir. This aspect will be confirmed by a hydrology working table and included in the Detailed Project Report.

1.7 PHYSICAL AND GEOLOGICAL FEATURES

Geomorphologically, the right flank of the valley along the dam axis can be divided in to four stretches. The first stretch, close to the river bed is having a gentle slope and is covered with loose soil with boulders. Beyond this stretch, there are two levels of terraces covered with silty sand, with thicknesses more than 5m. Above this stretch up to FRL, slope is very gentle and is covered with soil and a few boulders. Beyond FRL, slightly weathered Migmatitic Charnockite is exposed. The left flank of the valley rises at a fairly steep angle and is covered with more than 10 m thick over burden comprising of silty sand.

There is a master joint at the river bed tending N 70° E-S 70° W with a sub vertical dip towards NW. A major shear trending in N 40° W- S40° E is manifested in the form of a depression in the river bed.

The stream bed has a width of about 75 m and is covered with fine sediments admixed with boulders of assorted sizes. Flow of water in the stream bed is limited to the seepage from the existing dam on the upstream side.

The tectonic features near to the sites are the Periyar fault, Ottapalam Kuttampuzha fault and Kattagudi Kokkal Palani fault. There are several faults, shear zone and lineaments around the site which are seismogenic. The region preserves all the elements of the well developed Archean continental crust such as granulites, grantic gneisses and greenstone belts. The Cauvery shear zone is the most extensive tectonic feature that has been interpreted as an ancient suture zone.

The hill slopes are covered with loose soil with boulders. Rock type is mostly charnockite, massive to foliated with NNE-SSW strike and moderate dips to ESE. The rocks exhibit broad open folds. Patches of migmatities are also noticed.

The River Periyar in the upper most reaches flows towards north with a dendritic drainage pattern. As it reaches the reservoir area the flow

direction is deflected towards west. However, the Vandanmedu region to the north preserves the northerly flowing drainage pattern.
The river stretch from Vallakadavu to Neriamangalam indicates a structurally controlled pattern with a main channel following WNW and NNE orientation.

Historically and instrumentally recorded data on earthquake shows that the area of Mullaperiyar and its neighborhood lies in a region prone to earthquakes of slight to moderate intensity. The occurrences of earthquakes in the Mullaperiyar region are associated with the tectonic of various seismogenic sources present in the region. The new dam site lies in Zone III as per the Seismic Zoning Map of India, where a maximum intensity of VII according to Comprehensive Intensity Scale (MSK-64) is expected.

1.8 SALIENT FEATURES

1.8.1 LOCATION

State	:	Kerala
District	:	Idukki
Taluk	:	Peerumedu
Village	:	Manjumalai
Access Road	:	The proposed site is 5 km from Vallakadvu,which is 8 km away from Vandiperiyar.
Rail	:	Nearest Railway station is Kottayam 110 km away from the project site.
Air	:	Nearest Airport is Cochin International Airport at Nedumbassery, 180 km from the project site.

1.7.2 GEOGRAPHICAL CO-ORDINATES

GTS No	:	58G/2
Latitude	:	9031′26′′-9031′48′′
Longitude	:	77008′33′′

1.7.3 RIVER BASIN

Basin	:	Periyar
River	:	Periyar

1.8.4 HYDROLOGY

Total Catchment Area	: 624.5 sq. km.
Average Annual Rainfall	: 2420 mm
75% Dependable Yield	: 594.7 MCM (21 TMC)
Design Flood (PMF)	: 8676 Cumecs (3.064 lakh cusecs)

1.8.5 RESERVOIR

MWL	: +873.20M (+155 ft)
FRL	: +867.41m(+136 ft)
MDDL	: +857.66 m(+104 ft)
Gross Storage at FRL	: 321.48 MCM(11353c Mcft) including 143 Mcft additional storage due to new dam.
Gross Storage at MDDL	: 146.46 MCM (5172 Mcft) - including 80 Mcft additional storage due to new dam
Live Storage at FRL	: 175.02 MCM (6181 Mcft)
Water Spread Area @ FRL	: 4678.42 acres + 22.228 ha
Water Spread Area @MWL	: 8588.84 acres + 25.630 ha

1.8.6 DAM & SPILLWAY

Type of Dam	: Concrete Gravity
Top Level of Dam	: +874.69 m (+160 ft)

Deepest Bed level	:	+821.47 m(-14.60 ft)
Height of Main dam	:	53.22 m(174.60 ft)
Length of Main dam	:	370.10 m(1214 ft)
Height of Saddle dam	:	25.00 m(82 ft)
Length of Saddle dam	:	137.00 m(449.50 ft)
Type of Spill way	:	Ogee Type in the Main dam
Length of Spillway	:	305.90 m(1003.60 ft)
Crest Level of Spillway	:	+867.41 m(+136 ft)
Energy Dissipation	:	Type II basin with basin Blocks

1.7.7 WATER CONDUCTOR SYSEM

Length of Leading channel	:	1628.2 m(5342 ft)
Length of Tunnel	:	1794.4 m(5887 ft)
Sill Level of Tunnel	:	+857.66 m(+104 ft)
Shape of Tunnel	:	Horse Shoe,concrete lined
Discharge capacity	:	59.47 cumes (2100 cusecs)

2.0 TECHNICAL FEASIBILITY

2.1 EARLIER INVESTIGATIONS

As early as in 1979, a team of engineers headed by the then Chairman, CWC had made a specific recommendation to construct a new dam as a permanent solution. In pursuance of the above recommendation, a joint team of engineers of Kerala and Tamil Nadu made a reconnitary survey of the area downstream of the existing Mullaperiyar Dam. The team located a technically suitable site for a new dam 1300 ft downstream of the present dam where a new dam could be constructed without affecting the safety of the old one. As part of further investigation, 19 boreholes were also taken during the period 1981-82 and found that good rock is available for founding the dam. But this proposal for construction of a new replacement dam was however not pursued at that time.

2.2 SANCTIONS AND STATUTORY CLEARANCES

For ensuring the safety of the people residing downstream of the old Mullaperiyar Dam, Government of Kerala took a decision to construct a new dam downstream of the present one. Subsequently suitable allocation of funds was provided in the budget of 2007-08 for carrying out the preliminary investigations and studies in this regard. Administrative Sanction was accorded for conducting detailed investigations for studying the feasibility of the new dam and a new Sub Division was exclusively formed for this purpose with headquarters at Kumili vide G.O. (MS) No.52/2007/WRD dated 13/08/2007.

As the dam is to be located inside a wild life sanctuary, permission from National Wild Life Board (NWLB) is a mandatory requirement for carrying out any non forestry activities. State Board of Wild Life of the State of Kerala forwarded on 2nd March 2009 a proposal to NWLB with a recommendation to accord sanction for carrying out surveys and investigations in the wild life sanctuary for the new dam. Subsequent to this, Government of Kerala approached the NWLB for permission to carry out the required investigations. The 16th Meeting of the Standing Committee of NWLB held on 16th September 2009 granted permission for carrying out detailed investigations.

Meanwhile, the Kerala Legislative Assembly unanimously passed a resolution on 24th July 2009 for the construction of a new dam for ensuring the safety of its people as well as for facilitating continued supply of water to the State of Tamil Nadu.

2.3 RECONNAISSANCE SURVEY

Preliminary investigation revealed the possibility of three alignments within a kilometer downstream of the existing Mullaperiyar Dam and in the territory of the State of Kerala. They were identified at distances of 366.00 m, 622.80 m and 749.90 m from the centre line of the present dam.

COMPARISONS OF THE ALIGNMENTS AT A GLANCE

Features	**Distance of alignment from the existing dam**		
	366.00 m	**622.80 m**	**749.90 m**
Length of dam	Main-370.10 m Saddle-137.0 m	Main-623.90 m Saddle-Nil	Main-367.60 m Saddle-177.0 m
Bed level (MSL)	+ 828.00 m	+828.30 m	+826.60 m
Height of dam (from river bed)	46.70 m	46.40 m	48.10 m
Submergence area	22.23 ha	47.93 ha	54.34 ha

In the case of all the three alignments, spillway can be accommodated in the body of the main dam itself and in the river course. There is no necessity for rehabilitation or resettlement of evictees as all the three sites are located well within the wild life sanctuary area with no inhabitants. Also the three alignments lie outside the buffer zone (1000 ft) of the existing dam, contained in the rules and regulations of the Ministry of Defense, Government of India.

2.4 FINALISATION OF THE ALIGNMENT

Various merits and demerits of the three alignments are studied in great depth for selecting the final alignment. The following paragraphs contain a summary of the practical and technical points considered for each alignment in this regard.

The alignment at chainage 749.90 m is the farthest alignment from the existing dam. The advantages of this alignment are the probable economy in the cost of construction due to reduced length of main dam and the additional safety for carrying out excavation and construction as it is far away from the existing dam. However, the area of submergence of forest land in the wild life sanctuary is the maximum among the three, almost double the quantity of the closest alignment.

The alignment at chainage 622.80 m has the advantage of a straight alignment without a saddle. However, the length of the dam is 623.90 m, the longest of the three. This will invariably increase the cost of construction and is not advisable from economic point of view. The submergence area of forest land in
the wild life sanctuary is also more.

The closest alignment to the existing dam is the one at chainage 366.00 m. It has the advantage of minimum submergence of forest land in the wild life sanctuary. Also the total length of the dam (including saddle) is the minimum among the three and has the definite advantage of the alignment intersecting the contours more or less perpendicularly. It is also worth mentioning that a joint team of engineers of Kerala and Tamil Nadu had identified the same alignment as early as in 1980s and found the same technically the most suitable location for building a replacement dam without affecting the safety of the existing dam.

A Panel of Experts appointed by Government of Kerala, after inspecting and evaluating the merits and demerits of the above three suggested alignments, also recommended adoption of the closest alignment at chainage 366.00m for the replacement dam.

Topographical survey for the new dam alignment was conducted using Total Station. The area between the existing dam and 650 m downstream of the proposed new dam alignment was covered by the survey up to an elevation of +920 m. Accordingly a topographical map of the dam site with 2 m contour interval on 1:1000 scale was prepared.

2.5 GEOLOGICAL INVESTIGATIONS

As part of preliminary geological investigations for finding the quality of the rock available along the finally selected alignment, five boreholes were got drilled through M/s LBS Centre for Science & Technology, Thiruvananthapuram. The Subsoil Investigation Report of M/s LBS Centre for Science & Technology is appended as Annexure - A. According to the Report, the value of ultimate unconfined compressive strength of the rock extracted from the bore holes is 2400t/m2. They have recommended that it is possible to found the proposed dam on the hard rock present at the site.

The borehole explorations done by M/s LBS were witnessed by the Scientists of Centre for Earth Sciences Studies (CESS), Trivandrum and Geological Survey of India (GSI).

The GSI was entrusted with the geological mapping of the area of the new dam site. They have submitted their 'Report on Preliminary Geotechnical Investigation of New Mullaperiyar Dam' in August 2010. This Report is appended as Annexure – B. According to GSI, the preliminary study of the new dam site indicates that the proposed site is suitable for locating the dam.

On the right flank, fresh rock would be available at shallow depths of about 6 m. However, for the left flank it would be at deeper levels of more than 10 m. They also recommended drilling of 10 additional boreholes along the dam alignment as part of further investigation.

The rock samples from the five boreholes were also tested in the Laboratory of College of Engineering, Thiruvananthapuram for the purpose of further confirmation. The test results are appended as Annexure – C.

2.6 TECHNICAL FEASIBILITY

Topographical Survey carried out clearly establishes that the gorge identified at 366.00 m downstream of the existing Mullaperiyar Dam can be closed by a main dam of length 370.1 m and a small saddle dam on left flank having a length of 137.00 m. This alignment can also accommodate the spillway in the main dam in the river portion itself.

As it is located 366 m below the existing dam, the construction works can be carried out without endangering the safety of the existing old structure. Water can continue to be drawn by State of Tamil Nadu as is being done now without any hindrance during the construction of the new dam. After commissioning the new dam, the reservoir can be made one by suitably decommissioning the whole or part of the existing dam. The existing intake arrangements need no change and can be continued to function even after commissioning of the new dam.

The study reports of GSI and M/s LBS clearly establish the adequacy of the strength and related qualities of the foundation rock at the proposed site for constructing a concrete gravity dam of required height. Hence the geological soundness of the selected site for founding a new dam is established.

As mentioned earlier in para 1.5, the new dam structure will also facilitate the diversion of water needed for irrigation to State of Tamil Nadu, without any reduction in the quantity presently being diverted. Due to the additional storage, a slight improvement in the water management can also be expected.

From the above, it can be concluded that the present alignment at 366.00 m downstream of the existing Mullaperiyar Dam is technically, geologically and hydrologically feasible for the construction of a new replacement dam.

3.0 DESIGN

3.1 DAM

A concrete gravity structure is proposed for the new Mullaperiyar Dam. The dam site lies in seismic zone III as per the seismic zoning map of India incorporated in Indian Standard Criteria for Earthquake resistant design of structures IS 1893 (Part I):2002. The probable intensity of earthquake in seismic zone III corresponds to
VII according to Comprehensive Intensity Scale MSK-64. Site specific seismicity of the Mullaperiyar region was studied by the Earthquake Engineering Department, IIT, Roorkee. The seismic hazard assessment was carried out using deterministic as well as probabilistic approach. The Peak Ground Acceleration (PGA) value under the MCE condition is recommended as 0.21g. The preliminary design of the new dam is being done by pseudo static method of analysis following the provisions of the Indian Standard Criteria for Design of Solid Gravity Dams (IS 6512:1984). Before taking up construction, the adequacy of this design will be confirmed by carrying out a 2D plain stress static and dynamic analysis considering dam foundation interaction using Finite Element Method (FEM) in an integrated manner under MCE condition.

The structure is proposed as a combination of main dam and a saddle dam on the left flank, both of them abutting on to a hill in between. In the light of the preliminary geological investigations, the height of the main dam from the foundation rock is 53.22 m with a length of 370.10 m. The height of saddle dam on the left flank from the foundation rock is 25.00 m with a length of 137.00m.

The FRL of the reservoir is fixed as +867.41 m from MSL (+136 ft from the present reference point). The MWL is +873.20 m from MSL (+155 ft). Allowing required freeboard as per clause 4.1 of IS 11223:1985; the top of the dam is fixed as +874.69 m (+160 ft).

3.2 SPILLWAY

The Spillway arrangements are designed for negotiating the Probable Maximum Flood (PMF). Civil Engineering Department of IIT, Delhi was entrusted with the work of determining the PMF of the Mullaperiyar catchment. The PMP is determined as 687.8 mm using hydro meteorological approach considering the maximum two day storm experienced in the catchment in July 15-16, 1924. The PMF is derived using the above PMP and the value is 8676 cumecs (3.064 lakh cusecs).

An ogee type spillway in the main dam body is considered and the preliminary flood routing studies are attempted. While considering

the flood routing studies the outflow is limited to 3454.7 cumecs (1.22 lakh cusecs) on considerations of the carrying capacity of the river downstream. Keeping the crest level of the spillway as +867.41 m (136 ft) and limiting the MWL to +873.20 m (155 ft), the length of spillway (including piers) required is found to be 305.90 m. Type II basin with basin block arrangements is proposed for energy dissipation.

3.3 RIVER SULICES

It is proposed to provide river sluices/scour sluices of appropriate sizes at suitable locations in the main dam to release water for maintaining the environmental flow during lean months and for flushing out the accumulated silt during the flood seasons.

3.4 ADDITIONAL STORAGE

The construction of the new dam creates an additional gross storage of 143 Mcft at +867.41 m (136 ft). The effective additional storage at this level is 63 Mcft. This additional storage will be an added advantage to negotiate the inflows.

3.5 INTAKE AND WATER CONDUCTOR SYSTEM

The present water diversion structures viz. leading channel, intake arrangement, tunnel etc. will remain unchanged as they are located independently of the old dam as well as new dam structure on the upstream area of the reservoir

4.0 INFRASTRUCTURE

4.1 CONSTRUCTION MATERIALS

The materials required for the construction of the concrete gravity dam are available locally. Considering the present shortage of natural sand, it is proposed to use crushed/manufactured sand (M-sand). The quarry for broken stones and crushed sand has been identified at Chenkara, located at a distance of 35 km from the dam site. The samples from this quarry were tested at the Kerala Engineering Research Institute (KERI), Peechi and found satisfactory. Cement and Steel can be bought locally and transported to the site.

4.2 PLANT & COLONY LAYOUT

The batching plant, office buildings, staff quarters, etc. can be accommodated in the left bank of the river, downstream of the alignment of the dam. Locations of cement store, workshop, labour sheds, water tank, stockyard for steel, stockyard for aggregates and belt conveyors, etc. are marked in a contour map (see Plate -3). The buildings will be of temporary nature and will be dismantled after the commissioning of the new dam. Final decision on the location of various components of plant and colony will be taken in consultation with the wild life authorities.

4.3 CONSTRUCTION PROGRAMME

After getting the clearance from the Hon'ble Supreme Court and also after availing all the mandatory sanctions, construction of the new dam will be taken up. Experienced contractors will be entrusted with the construction works. The bar chart showing the construction schedule is attached.

The construction schedule prepared is a realistic one achievable by employing modern construction machinery and latest management techniques. The construction schedule also includes dismantling of old dam and its related activities including the removal of debris. This is included along with the schedule of progress of construction of the dam. A total of 4 years is estimated for the completion of project.

4.4 FUTURE UTILIZATION OF FACILITIES CREATED (BUILDING)

Most of the buildings to house labourers, materials, construction staff etc are proposed as temporary structures which can be easily erected and dismantled. The number of permanent buildings will be reduced to the minimum so as to cause minimum disturbance to the environment.

4.5 RIVER DIVERSION ARRANGEMENTS

The new Mullaperiyar dam is proposed to be constructed at a distance of 366 m from the existing dam. Overflow from the existing reservoir will happen only during flood season when state of Tamil Nadu is not able to draw water due to rains in that area. This overflow will last only for a few of days and the quantity of water spill will not be substantial. Construction of new dam can be carried out by providing a diversion conduit of suitable size in a low block in the river portion. This diversion conduit can be plugged when the construction of the new dam is completed.

4.6 COMMUNICATION SURVEY

Adequate communication facilities are already available to the nearest cities of the dam site by air, rail and road. No new communication surveys are needed now for new routes.

As stated earlier, the dam site can be reached by road NH 220 up to Vandiperiyar and from there to Vallakkadavu by travelling 8 km through Moozhiyar (Gavi) road and thereafter through 5 km forest road (Jeep road). It is proposed to improve the 3m wide existing Jeep road to a concrete carriage way of 5 m width, with 1.5m wide

shoulders on either side with necessary widening at the hairpin bends. This road will serve as the access to the new dam area. Construction of a three-span concrete bridge of length 60 m and 5 minor culverts are also proposed to ensure all weather accessibility to the dam site. Survey is needed for aligning this road, bridges and culverts. For electrical power, 3-phase line is available up to Vallakkadavu. From there electricity is to be made available to the dam site by laying underground cables. Necessary survey is to be undertaken for finalizing the best route alignment for the cable.

4.7 RIGHT OF WAY

As stated in para 4.2.1, a new road is to be aligned and constructed. This road will reach up to the top of the new dam. Another road is to be aligned from the front of the old spillway to reach the Vallakkadavu New Dam road. Suitable gradient is to be provided to this road to enable easy transport of dismantled dam materials. The existing dam from the old dam top to the spillway front is to be suitably formed.

5.0 LAND & ENVIRONMENT

5.1 LAND REQUIREMENT

5.1.1 Catchment

The catchment area intercepted by the old dam is 624 sq km as estimated from the Survey of India Toposheets using GIS techniques, which lies entirely in the territory of State of Kerala. The new dam intercepts an additional catchment of 0.502 Sq.km. The total catchment area of the new dam is thus 624.5 Sq. km.

The new dam submerges an additional area of 22.23 ha at an FRL of 136 ft. The total land required for diversion including submergence area, locating plant, machinery and temporary buildings is 50 ha. The entire area is forest land inside the Periyar Wild Life Sanctuary with no habitation. So there will not be any necessity for rehabilitation and resettlement. For diversion of the above forest land, statutory clearances from Ministry of Environment & Forests, National Wild Life Board, etc will have to be obtained. A Comprehensive Environmental Impact Assessment (CEIA) pertaining to the forest land additionally needed for diversion for building the new dam is being arranged.

5.2 ENVIRONMENT & ECOLOGY

The forest area required to be diverted for the construction of the new dam is recognizable into four biotopes viz. the river course, the eucalypt plantation (on the east bank of the river course), the semi-evergreen forest (on the west bank of the river course) and the low altitude grassland (west of the semi-evergreen forest).

The river course is practically devoid of a natural flow of water and there are many tiny stagnant pools separated by rocks and boulders. This area is composed of impoverished, remnant riparian vegetation, consisting mainly of weeds.

The Eucalypt Plantation situated on the east bank of the river course is apparently in its second rotation coppice. The trees are small and a good number of them in pole stage. A good portion of the plantation is apparently part of the grassland afforestation initiative. The plantation on the east bank naturally merges with the natural grasslands and the rocky landscape of the hill.

Semi-evergreen forests, situated on the right bank of the river course is an ecotonal vegetation, intermediate between evergreen and moist deciduous forests, and therefore characteristically comprise of floral elements of both the forest types. On the whole, the vegetation is neither evergreen nor moist deciduous in physiognomy.

It should also be noted that contrary to the profusion of large diameter trees in undisturbed natural forests, none of the trees in the site has a diameter more than 30 cm. This means that the vegetation is a new growth established subsequently, after the disturbance that occurred in the area during the construction of the existing dam.

Grassland, adjoining the Semi-evergreen forests, is vast barren expanse clothed with gregarious growth of the common low elevation grass species, which are characteristic of the moist deciduous forests.

A Comprehensive Environmental Impact Assessment (CEIA) is necessary for evaluating the impact of the proposed construction of the new dam on the environment and ecology of the area. This study is proposed to be carried out through reputed scientific agencies after the preparation of the DPR.

6.0 DECOMMISSIONING OF OLD DAM

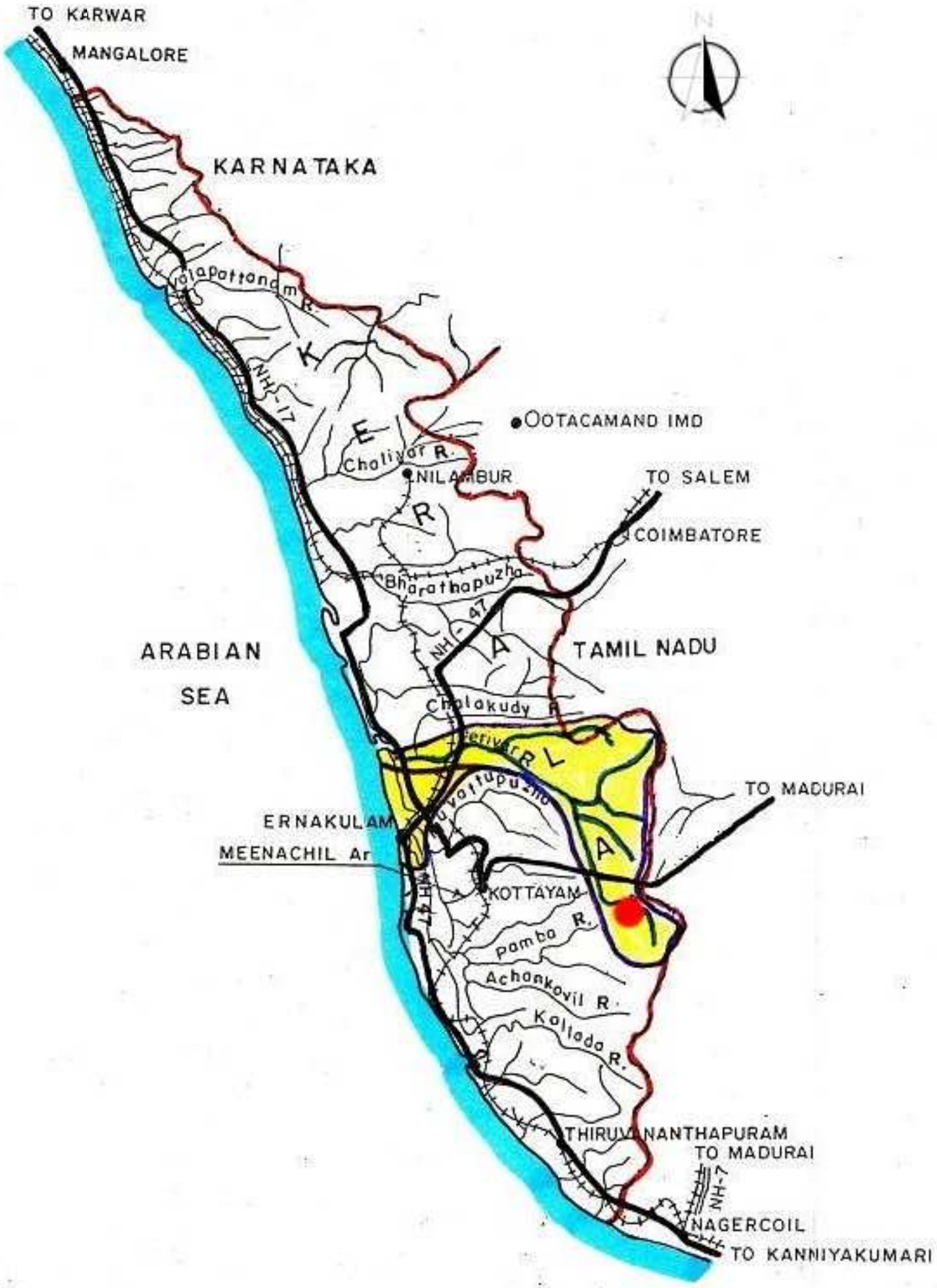
On completion of the new dam, the existing old dam will have to be decommissioned partially or fully for enabling the present reservoir to spread up to the new dam. The old dam will be dismantled step by step vertically downwards and the debris removed with minimum disturbance and damage to the environment. As the site is in forest area, suitable alternate site for dumping the debris and for

construction of new roads / improvement of roads etc will be decided in close consultation with the forest authorities, environmentalists, people's representatives etc amicably avoiding any sort of controversy.

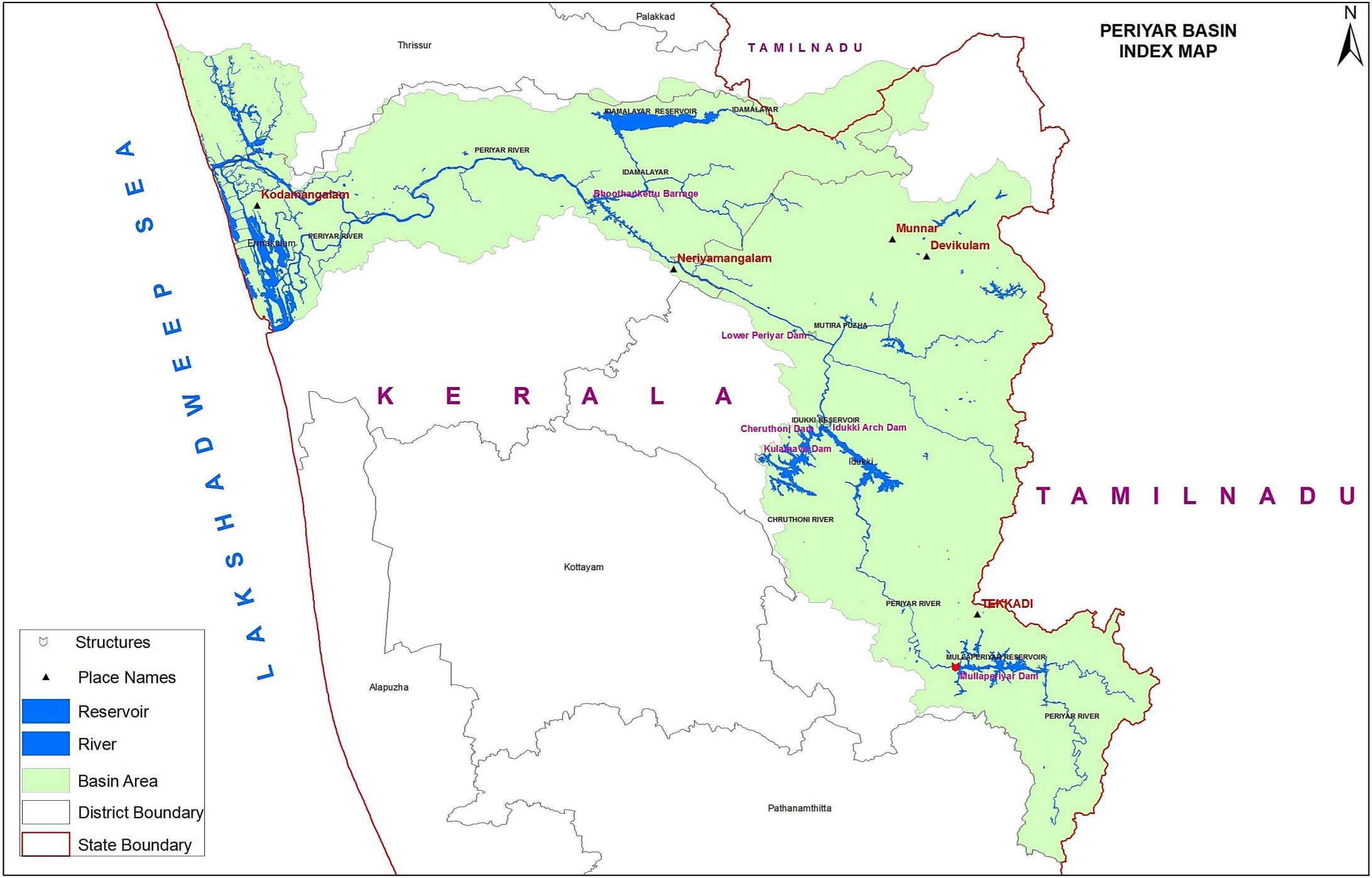
There are several Indian and Foreign firms who are well experienced in such dismantling works. Necessary action will be taken sufficiently early to carry out the dismantling work through the most qualified and experienced agency. This aspect will be discussed in detail in the Detailed Project Report.

7.0 FINANCIAL ASPECTS

As per the present schedule of rates and based on the preliminary designs, the cost of the new dam including provisions for decommissioning of the old dam is estimated at Rs.663 crore. The entire work is proposed to be completed within a period of 4 years after receiving all statutory clearances. Adequate flow of funds from State financial resources will be maintained for the speedy implementation of the Project.



LOCATION MAP


PERIYAR BASIN
INDEX MAP
N
Palakkad
Thrissur
TAMILNADU
IDAMALAYAR RESERVOIR
IDAMALAYAR
PERIYAR RIVER
IDAMALAYAR
Bhoothathkettu Barrage
Kodamangalam
PERIYAR RIVER
Ernakulam
Munnar
Devikulam
Neriyamangalam
MUTIRA PUZHA
Lower Periyar Dam
K E R A L A
IDUKKI RESERVOIR
Cheruthoni Dam
Idukki Arch Dam
Kulamavu Dam
Idukki
T A M I L N A D U
CHRUTHONI RIVER
Kottayam
PERIYAR RIVER
TEKKADI
MULLAPERIYAR RESERVOIR
Mullaperiyar Dam
PERIYAR RIVER
Alapuzha
Pathanamthitta
L A K S H A D W E E P S E A
Structures
Place Names
Reservoir
River
Basin Area
District Boundary
State Boundary