Appendix 12.1 Geology evaluation of the most promising site Maha 3 (geology survey (phase 2))

In this Appendix are detailed the result the Geology survey (phase 2) and the evaluation made by JICA Study team on the geology over the Maha 3 site.

The major interest in the geology survey in this Study (Development Planning on Optimal Power Generation for Peak Demand in Sri Lanka) is to 1) conduct the investigation which contributes to the selection of the most promising site from all listed candidates, and 2) reveal the geology features and risks lying in the candidate sites, and above all, most likely in the most promising site Maha 3.

The procedures in geology work is

- 1st grade evaluation of 11 candidate sites for extraction of some promising sites mainly based on the existing materials available (existing geology maps, aeropohotographs, etc.).
- Geology survey (phase 1), evaluation of 3 sites for extraction of most promising site, based on mainly of surface geology survey focused on the promising 3 sites
- Geology survey (phase 2), evaluation of 1 most prosmising site, based on the obtained data and newly conducted drillings.

The outcome of each evaluation has been described in detail at : "9.2.4 Each candidate site geology" to "9.6.4 Evaluation from Geological Aspects" for the 1st grade evaluation, "10.3.2 Geology (Maha 2)", "10.4.2 Geology (Maha 3)", and "10.5.2 Geology (Halgran 3)" for geology survey (phase1) for the Geology survey (phase 1), and "appendix 12" here, for the results of Geology survey (phase 2).

The whole work has been carried out by predetermined schedule, and because of the time restraint of the project study timeline, it was so decided that the result of the geology survey (phase 2) does not give effect on the selection of the most promising site. The selection was made on the timing when the survey (phase 1) was completed. So, rather the phase 2 survey was aimed at providing preceeding information which can contribute pre FS stage study in advance, making certain if there lays no critical disadvantages with the chosen site to go forward.

In the following paragraphs the major findings in the geology survey (phase 2) are explained. They hade been derived from the subcontract work survey for which CECB had been assigned. However, as some of the outcomes of their work were without solid evidences which had been required on the contract, and judged not fully trustworthy, thus JICA Study Team has compiled its own evaluation in this Appendix.

A.12.1 Site geology

The whole surface geology of Maha 3 site was described in Chapter 10.

It mainly comprises granitic gneisses and biotite gneiss. The general trend of unit layers is in NW-SE with moderately dipping NE. This supports the general conception of existing 100,000 geology map that the area is on north wing of antiform.

The upper dam site is situated at the NE facing open valley. The reservoir area is in the NW of upper dam site where 2 streams are joining into from NW and SW thus forming relatively open basin of paddy fields around the confluence zone. The fresh to slightly weathered biotite gneiss basically forms the foundation

of whole dam axis, but it can be a little more (moderately) weathered in right abutment. The surface area is covered by the sandy clay material of residual origin of rocks. The left abutment right above the dam crest is wide talus comprising rocks and sandy clay depositing on the residual soil. The residual soil and the talus as well around dam axis had been thought to be relatively thin at the time of the geology survey (phase 1). The average trend of geology layers is in NW-SE with moderately dipping NE. The lineament along the valley (NW-SE) was drawn from aerophotograph. Although surface overburden prevents actual features of faulting in general, no such fractures were found in bed rock.

The water route heads to NNW thus turning to NNE basically under the solid mountainous ridge zone upto the lower reservoir along Maha Oya. 2 small lineaments along NE-SW streams are found crossing the route. The route geology comprises of biotite gneiss, and partially holds granitic gneiss along the water route.

The lower dam site and reservoir is located along Maha Oya river. The whole reservoir forms deep V shape valley, with minor streams running perpendicular to the main stream in the reservoir area.

The biotite gneiss is the major foundation rock on left bank to the river bed, and the granitic gneiss is the major unit on the right abutment. They are both slightly weathered to fresh on the foundation, but there covers residual soil on the surface on the left bank, and talus on the right bank. The residual soil and the talus extends small in thickness. The obvious major lineament is seen along Maha Oya along the sharp valley extending NW-SE. 2 NE-SW lineaments are also found perpendicular across the lower reservoir. The NW-SE lineament was interpreted as the major fault fracture zone in the 100,000 map. However no evidence of recent faulting was observed with respect to these lineaments within the project site at the time of this geological mapping. The limestone inter bed thought to lie along the fault was also not confirmed during the survey. It is partly because the area is covered by the thin alluvium and residual soil, and it also may be partly because such fault may be inactive at ages though exists.

A.12.1.2 Details of the geology survey (phase 2)

The topography and geology investigation surveys conducted in this Study are listed below. The both surveys of phase 1 and phase 2 are detailed. They consist of topographical mappings, the surface geology surveys, drilling surveys, and laboratory testings. The contents for each are shown in Table A.12.1.2-1.

Table A.12.1.2-1 (1) Survey contents of Topography survey (phase 1) and Geology survey (phase 1)

Survey Item	Quantity	Remarks
Topography Survey (T-1)	1:5,000 scale	Mapping for 3 promising areas
	5.53 km^2	ie. Maha 3 (1.14km^2), Maha 2 (1.82km^2), Halgran 3 (2.57km^2)
Topography Survey (T-2)	1:1,000 scale	Detailed Mapping for 1 most promising site
	1.0 km^2	ie. Maha 3 (1.0km^2)

Table A.12.1.2-1 (2) Survey contents of Topography survey (phase 1) and Geology survey (phase 2)

Survey Item	Quantity	Remarks
Geological Survey (G-1)	1:10,000 scale	Surface Geology Survey for 3 promising areas
	42 km^2	ie. Maha 2 & Maha3 (10km^2), Halgran 3 (15km^2)
		Collection of available data and maps
		Aerophotograph, satellite image study
		Geological mapping and study
Geological Survey (G-2)	6 holes	Drilling Survey for 1 most promising site
	306.13 m	ie. Maha 3
		6 holes (right bank, river bed, left bank for Upper & Lower damsite)
		Core drillings, Geological logging, Permeability test
		Laboratory test for rock cores

A.12.1.3 The evaluation/outcome of the drilling surveys

The surface preliminary geology survey (reconnaissance survey) had been made in phase 1 on the 3 promising sites (the detailed results are in chapter 10). The phase 2 survey was done aiming at the preceding knowleges of the subsurface geology before the pre-FS study to come, and identifying the geologic risks in advance as well. The phase 2 survey included drilling surveys and laboratory tests.

Figure A.12.1.3-1 shows the locations of the drillings on the site geology map. The drilling sites were 6 in total, comprising 3 holes at the upper dam axis and 3 holes at the lower dam axis. On each axis there are planned 1 hole at right bank, 1 hole at left bank, and 1 hole at the river bed. Each bank's drill shall be aligned to drill vertically as deep enough so as to reach its river bed elevation.

The result of the drilling is shown in Table A.12.1.3-1. The Lugeon test result is in Table A.12.1.3-2.

The detailed data are not attached in this Appendix, and the JICA Study Team has compiled its own Suumary report that includes the essential outcome plus its own evaluation. The reasons the Study Team has made the Summary report is because the subcontractor report was not satisfactorily completed and had lacked various important evidences and considerations required. The Summary report JICA Study Team made includes lithology logs, core photographs, permeablitily test, and laboratory test summary and datasheets.

Table A.12.1.3-1 (1) Result of geological drillings at Maha 3 site (Upper dam site)

Area	Borehole number	Location	Depth (m)	Geology		Weathering		Core recovery (%)	RQD (%)	Ground water (m)
Maha 3 Upper Dam site	BHU-1	Left bank	55.18	0.00-3.00	Residual soil	0.00-3.00	Completely weathered	0	0	9.3
				3.00-55.18	Biotite Gneiss	3.00-27.00	Highly weathered	0	0	
						27.00-32.40	Moderately to highly weathered	<25	<20	
						32.40-32.80	Highly weathered, Waterloss	0	0	
						32.80-47.05	Moderately to slightly weathered	<20	<10	
						47.05-55.18	Slightly weathered to fresh	≈100	≈100	
	BHU-2	Riverbed	50.36	0.00-0.40	Alluvial deposit	0.00-0.40	Completely weathered	0	0	0.3
				0.40-1.40	Granitic Gneiss	0.40-1.40	Highly weathered	60	0	
				1.40-7.70	Biotite Gneiss	1.40-7.70	Moderately to slightly weathered	50~100	0~80	
				7.70-50.36	Ganitic Gneiss	7.70-15.90	Fresh	90~100	80~100	
						15.90-27.72	Slightly weathered	60~90	20~90	
						27.72-50.36	Fresh	90~100	80~100	
	BHU-3	Right bank	50	0.00-3.00	Residual soil	0.00-3.00	Completely weathered	0	0	6.9
				3.00-32.83	Granitic Gneiss	3.00-9.00	Highly weathered	0	0	
						9.00-11.71	Moderately to Slightly weathered	80~100	40~80	
						11.71-32.83	Fresh to slightly weathered	≈100	≈100	
				32.83-50.00	Biotite Gneiss	32.83-50.00	Fresh to Slightly weathered	≈100	≈100	

Table A.12.1.3-1 (2) Result of geological drillings at Maha 3 site (Lower dam site)

Area	Borehole number	Location	Depth (m)	Geology		Weathering		Core recovery (%)	RQD (%)	Ground water (m)
Lower Dam site	BHL-1	Left bank	50.22	0.00-2.00	Residual soil	0.00-2.00	Completely weathered	0	0	5.9
				2.00-12.60	Biotite Gneiss	2.00-8.70	Highly weathered	0~20	0~10	
						8.70-12.60	Moderately to slightly weathered	50~70	≈30	
				12.60-33.50	Granitic Gneiss	12.60-13.87	Slightly weathered	≈80	≈80	
						13.87-33.50	Fresh	100	≈100	
				33.50-50.22	Biotite Gneiss	33.50-41.32	Fresh	90~100	80~100	
						41.32-44.32	Slightly weathered	50	20	
						44.32-46.02	Moderately weathered	40~60	0	
						46.02-50.22	Slightly weathered	70~90	30~50	
	BHL-2	Riverbed	50.13	0.00-1.50	Alluvial deposit	0.00-0.70	Completely weathered	0	0	2.80
						0.70-1.04	Boulders	-	-	
						1.04-1.50	Completely weathered	0	0	
				1.50-25.38	Biotite Gneiss	1.50-2.35	Moderately weathered	90	0	
						2.35-4.32	Slightly weathered	60	40	
						4.32-25.38	Fresh	≈100	≈100	
				25.38-50.13	Charnockitic Gneiss	25.38-50.13	Fresh	100	100	
	BHL-3	Right bank	50.24	0.00-0.30	Talus deposit	0.00-0.30	Completely weathered	0	0	19.8
				0.30-1.50	Residual soil	0.30-1.50	Completely weathered	0	0	
				1.50-50.24	Biotite Gneiss	1.50-2.75	Highly weathered	0	0	
						2.75-3.15	Slightly Weathered	70	40	
						3.15-50.24	Fresh	≈100	≈100	

Table A.12.1.3-2 Result of permeability tests (Lugeon tests)

Area	Borehole number	Depth (m)	Lugeon Value	Ground water (m)
Maha 3 Upper dam site	BHU-1	28.30-33.30	7.68	9
		34.00-39.00	6.16	9.3
		40.00-45.00	4.73	9.3
		45.40-50.40	1.14	9.3
		50.10-55.10	0.04	9.3
	BHU-2	2.60-7.60	0.23	0.3
		8.60-13.65	0.07	0.3
		13.65-17.55	0.05	0.3
		18.00-23.00	0.14	0.3
		22.70-27.72	0.13	0.3
		27.90-32.90	0.05	0.3
		32.65-37.65	0.05	0.3
		37.43-42.43	0.03	0.3
		42.60-47.66	0.03	0.3
	BHU-3	10.90-15.90	0.57	8.7
		15.70-20.70	0.11	6.9
		20.63-25.63	0.09	6.9
		24.60-29.60	0.07	4.85
		29.60-34.60	0.12	4.85
		34.63-39.63	0.07	3.9
		40.15-45.16	0.09	3.9
		45.00-50.00	0.08	3.85

Area	Borehole Number	Depth Range(m)	Lugeon Value	Ground water (m)
Lower dam site	**BHL-1**	12.40-17.40	0.57	4.75
		17.58-22.58	0.08	4.7
		22.07-27.07	0.08	5.45
		27.00-32.00	0.04	5.45
		32.18-37.18	0.05	5.9
		36.32-41.32	0.32	4.14
		41.02-46.02	1.74	4.8
		45.22-50.22	1.01	4.25
	BHL-2	4.32-9.32	0.1	2.4
		8.97-13.97	0.1	2.7
		14.12-19.12	0	2.7
		19.09-24.09	0.1	2.7
		24.19-29.18	0.05	2.65
		29.43-34.43	0.03	2.8
		34.37-39.37	0.04	2.62
		39.57-44.57	0.02	2.7
		45.13-50.13	0.05	2.6
	BHL-3	4.00-9.00	0.1	3.2
		9.00-14.00	0.07	3.2
		14.00-19.00	0.05	15.37
		19.09-24.09	0.04	15.38
		24.18-29.18	0.04	15.3
		29.38-34.38	0.03	16.02
		34.08-39.08	0.07	16.02
		39.28-44.28	0.04	17.5
		45.24-50.24	0.04	19.8

In A.12.1.4 onwards, geotechnical evaluation was detailed.

It was noted that:

- Aerophotograph interpretations were made by the JICA Study Team.

  (2 photographs' pair covering the area for stereographic projection was not filed to the JICA Study Team for Halgran 3 site from the subcontractor. This implies no work had been made by the subcontractor for the interpretations because such pair is indispensable for stereographic analysis. And it also implies those desciptions made in their report for aerophotograph were false without proper work. Thus this work was made by the JICA Study Team by ownly acquired photos)
- Construction material site survey was not trustworthy.

  (This survey had been not conducted until long after the period of the contract. The certain descritptions had been put into the draft report at last for the first time after the repeated inqury from the JICA Study Team, but had contained various inconsistencies such as 1) candidate site much nearer to upper reservoir is selected for lower reservoir material site, 2) locatin of same coordinates is used for both quarry and clay, etc. Thus this survey outcome was judged not adoted.)
- The rock class classification by the subcontractor is tentative one and has no solid groundings.

  (The interpretation such as "B" or even "A" was shown in their products of lithology logs and geology cross sectios, however such notation was not based on any appropriate groundings at this stage, and in

actuality shall be much lower in relevant classes in CRIEPI. Thus the JICA Study Team concludes it was merely "tentative" classification made by CECB and needs to be corrected appropriately in the next stage.

- The rock core recovery had shown relatively poor drilling operation.

  (Many cores shows low recovery and low RQD but the subcontractor had replied to the JICA Study Team that this was caused by mechanical cracks from drilling and that it was in harder rank as "CH" or even "B"or "A". So it has created the keen discrepancy between core photograhs and the rock classfications by the subcontractor. Many ratings of "joint spacing", "weathering", "hardness", "core recovery" and "RQD" are inconsistent. This had been left as they were in the lithology logs at this stage, however the JICA Study Team does not approve them and suspends its judgements with the recommendation that this shall be re-evaluated in forecoming drillings in next stage as well with more skilled engineers.

  Moreover, some drilling cores, although certain core recovery had been recorded for those sction depths, had been missing in the core photographs the subcontractor had submitted. Those core photos (44.92-48.37m for BHL-1 (core recovery was 60-80% for majority of this section), 29.18-32.93m for BHL-3 (core recovery was 100% for this section)) were not submitted until the end of the work against the repeated requests from the JICA Study Team to the subcontractor. The storage of cores and submission of photos are fundamental task of the geology survey drillings by the subcontractor. But this was judged not kept.

  Furthermore, same core section photo was submitted duplicatedly twice as if they were sequential in the core box (14.38-14.70m core of BHU-2 in core photos did not exist in the "daily log photo" submitted from the site. Even worse the 14.38m mark on the corebox was originally 14.70m in the daily log and photo but was overwritten and changed by the subcontractor. This duplicacy had been informed by the JICA Study Team but the subcontractor had not admitted its manipulatin until the JICA Study Team showed them the evidences of those daily logs.)

- The laboratory tests were not trustworthy in many aspects.

  (The subcontractor had rejected to take and submit the test specimen photos prior and after each test for most of the tests (except UCS and tensile strength) although this had been on the Specification and repeatedly requested from the JICA Study Team before, during, and after the test in writings. No conditions naturally were clear, as a result, for each test. Moreover, same samples had been repeatedly used for multiple tests which were in nature deteorating test quality, such as: 1) alkali reactivity and oven dry density test used same sample, and nomatter which one is first it affects conditions of samples from original state for the second test, or 2) the coarse sample used for Los Angels test had been applied for soundness test next, but "surprisingly", test depths for soundness were 24.93-26.15m selected from Los Angels tests' 24.82-26.15m, and that is hardly explainable how to select smaller section for soundess test from tested crushed mixed coarse sample of Los Angels test roller. Those contradictions had been asked to the subcontractor but no appropriate reply was made from them.

  The BHU-1 sample test was conducted for the sections the JICA Study Team HAD NOT directed. (Although the test sections had been delivered to the subcontractor in writings in advance, they tested

the sections not related to the ordered depths without having any approval or consent.)

The JICA Study Team had reviewed the subcontractor products including report.
Although the basic findings had been refered from the subcontractor report and products, but the geotechnical evaluation was made in principle by the JICA Study Team independently, as some of the subcontractor's works had been judged not satisfactory as shown above.

A.12.1.4 Geotechnical evaluations and findings of the Maha 3 site

(1) The upper damsite

The suface geology derived from the geology survey (phase 1) has prevailed that the whole areas is covered by biotite gneiss, with completely weathered residual soil materials of rock origins on the surface superficially. The general geologic layers' trends are in NW-SE directions (strikes) with NE dipping. The straight shape lineament along the valley (NW-SE) was drawn from aerophotograph but no such fractures was found in bed rock at the time of the surface survey. The left bank forms very steep escarpment cliffs made by this lineament reaching as high as EL. 870m or above which has provided much colluvium as talus just under neath of the cliffs. These talus deposits lie on the residual soils on the right bank. The right bank as well forms the solid thick mountain ridges above EL.835m. the damsite situates it self at the NE facing open valley. The right bank slope is at 30-40 degree whereas the left bank slope is low as 15-20 degree.
The tentatively the site is planned and studied at the assumption of rock fill type dam of damheight 61m with EL. 821m at damcrest. 3 holes have been drilled.

1) The left bank of the upper dam axis

The geology at the drill hole BHU-1 (EL.799m) has been identified as below from the result of the lithology log prepared in the survey (phase 2).

- The completely weathered rock: resisual soils (RS1) : depth 0-3m
- Biotite gneiss, highly weathered : underneath RS1, depth 3-27m
- Biotite gneiss, moderately weathered : underneath above, depth 27-32m
- Total water loss, highly weathered zone : underneath above, depth 32-33m, water level raised to borehole mouth (0m from 9.4m)
- Biotite gneiss, moderately weathered : underneath above, depth 33-47m
- Biotite gneiss, slightly weathered to fresh : underneath above, depth 47-55m

As there had been no suitable place to locate borehole, this BHU-1 was placed on the immediate below of the lineament escarpment cliff at the top of the talus deposit. The evaluation was such that the geology was all highly weathered biotite gneiss below 3m, but it may have been understood as talus deposit to some depths as there had been aquired almost no cores along this depth zone.

The permeability of this biotite gneiss had been able to be obtained at 28.30m onward. The 7.68 Lu was the largest at the 28.30-33.30m along the water loss zone, but the figure itself was not so significant. The Lu decreased in depth after this zonc, like 6.16 to 1.14 Lu and had become as low as 0.04 Lu at the bottom of 50.10-55.10m where the rock was fresh-slightly weathered. The elevation of the water loss zone was EL. 767.6 to 767.1m, and thus corresponds to the river bed elevation + 3m. The water level of the borehole was shallow as 9.0-9.3m throughout the work exept total water loss zone when the water had risen to the surface.

2) The river bed at the dam axis

The geology at the drill hole BHU-2 (EL.766m) has been identified as below from the result of the lithology log prepared in the survey (phase 2).

- The river bed deposit materials (alluviums) : depth 0-0.4m
- Granitic gneiss, highly weathered : underneath above, depth 0.4-1.4m
- Biotite gneiss, moderately – slightly weathered : underneath above, depth 1.4-7.7m
- Granitic gneiss, slightly weathered - fresh : underneath above, depth 7.7-50m

The river depsit has more or less 1m in thickness. The rock basement soon becomes fresh or slightly weathered below 8m in depth with moderate to slightly weathered zone from 1m to 8m (CM class). The rock basement which forms the basement of dam lies in 3 to 5m in depth which is relatively shallow. The permeability of the rock was 0.3 Lu along almost all depths of 2.6 – 47.7m, showing nearly impermeable features.

3) The right bank of the upper dam axis

The geology at the drill hole BHU-3 (EL.804m) has been identified as below from the result of the lithology log prepared in the survey (phase 2).

- The completely weathered rock: resisual soils (RS1) : depth 0-3m
- Granitic gneiss, highly weathered : underneath RS1, depth 3-9m
- Granitic gneiss, moderately - slightly weathered : underneath above, depth 9-12m
- Granitic to Biotite gneiss, slightly weathered to fresh : underneath above, depth 12-50m

Although the weathered zone ranges as thick as 9m in depths, the rock basement of rather fresh conditions lies at 9 to 12m. the water level was 6.9m deepest during the work, but it had risen to 3.85m when it drilled at 20m onwards

The permeability was as low as impermeable around 0.1-0.6 Lu at nearly all depths of 11 to 50m.

The geological section showing rock classes along the upper dam axis comprising 3 drillholes was prepared shown in Figure 12.1.1.4-1.

The fine rock basement was confirmed at the right abutment through riverbed with fine biotite gneiss (CH at CRIEPI classification) in relatively shallow depth. However on the left abutment, it was found the depth to the sound rock basement went as large as 47m. The poor rock cover was thicker than previously had been anticipated. Presumably it is considered from the present information available that left slope of the dam site has a thick talus deposit supplied from the steep height cliffs accompanied with the probable mass movement of that deposit toward river.

It is specifically noted that NW-SE straightshaping lineament extending alongside of the left abutment at higher elevation forming very sharp straight cliff. This implies the underlying fault and the colluviums collapsed from the cliff largely deposit on the left slope as talus deposit. The drilling site (BHU-1) was set on the talus deposit but the deposit was previously not anticipated limited in thickness at the time of the geology survey (phase 1).

However, the BHU-1 drilled in the geology survey (phase 2), a little upstream from dam axis by 20m revealed there lies thick soil deposits of 27m in depths, with confirmation of the rock material around that depth but still having very little core recoveries (≦20% at 33.3-47.0m, ≦10% at 39.0-45.7m). It never reached the fresh rock surface until 47m depth.

The 47m depth fresh rock surface corresponds to the nearly -13m beneath river bed elevation, when the interval of this zone of no/little recovery as “very poor zone”.

One more noticeable feature was that the BHU-1 had encountered the total water inflows at 32m depth which corresponds just above the river bed elevation (ie. +2 - +3m above the river bed level).

Apart from geology, the topography survey (phase 2) with 1:1,000 sclae at the upper reservoir made it clearer the shape of the left ridge slope forms low angle slope of <20 degree, and the end of the deposit at bottom forms even lower as <5 degree showing almost flat geometries.

In evaluating the whole features above, though they are still limited in accuracies and quantities, it is a likely assumption that

- the left abutment at dam site has the talus deposits a certain thickness of the collapsed materials,
- that those deposits (the talus deposits in conjunction with the beneath completely weathered residual rocks) have slipped (or collapsed) moving towards river bed with the borders at the 32m depth zones in which ground water is eunning through, and
- that the tail end of the mass has formed the flat end shape.

The zones beneath 32m depth, between 32 to 47m, which has almost no core recoveries are, possibly 1) the zones of old ancient suface weathered residuals before the talus had collapsed and deposited, 2) some weak zones caused due to genetic origins (ex. 39.0 to 45.7m zone contains large concentrated felsic materials of biotite or amphibole (hornblende) along foliations. Those are prone to be dissolved / deteriorated), 3) the zones caused by the structural origin (the deep weathered materials due to the faulting). The exact cause is not known at the present stage.

(It may be not likely the whole mass to the 47m depth has slided/collapsed as it reaches -13m beneath river bed surface but cannot be denied completely.)

It is extremely regretting to say that the drilling work which had been conducted by the subcontractee

(CECB) was revealed to be reraltively poor in acquiring cores in good conditions. Thus, it is not 100% excluded if they had missed obtaining cores for the particular interval without any geological reasons.

As explained all above, it is summarized that the right bank to the riverbed comprise the shallow good biotite basement (of CH or above), and the left bank comprises deeper basement than had been anticipated with thick weaker zone from the surface. The thick deposit on the left bank of the talus deposit or anticipated land sliding body may possibly affect the stability of the reservoir rim during operation if it was remained after the excavation, through water level changes.

However, the fresh solid rocks were confirmed at the depth 47m onwards in BHU-1. On the surface the left abutment ridge peaks at the steep rock faces along the straight cliffs with fresh biotite gneiss outcrops around EL. 870m, and obviously the groundwater table is expected to rise towards the peak. In conclusion the water sealing capability is expected to be secured.

(2) The lower damsite

The lower dam site and reservoir is located along Maha Oya river, which runs along the NW-SE. The whole reservoir forms deep V shape valley. The biotite gneiss consists the foundation rock at the damsite, but with granitic gneiss at the higher elevation above the dam crest at both the right and the left abutment.
The residual soil and the talus deposit cover the surface. The major geologic trend directs NW-SE strike with NE dips, which is the same as the upper reservoir. The clear lineament along the Maha Oya river had been identified by the aerophotographs and in the existing geology map (1:100,000), but it was not confirmed by the surface geology survey (phase 1). The both abutments consist of the firm large mountain ridges of above EL. 450m on the right and above EL.1,200m on the left.
The rock fill type dam has been studied at the site with the dam height 68m with dam crest at EL. 308m.
The 3 drill holes were excavated in the survey (phase 2).

1) The left bank of the upper dam axis

The geology at the drill hole BHL-1 (EL.296m) has been identified as below from the result of the lithology log prepared in the survey (phase 2).

- The completely weathered rock: resisual soils (RS1) : depth 0-2m
- Biotite gneiss, highly weathered : underneath RS1, depth 2-9m
- Granitic gneiss, moderately - slightly weathered : underneath above, depth 9-14m
- Granitic gneiss, slightly weathered to fresh : underneath above, depth 14-34m
- Biotite gneiss, slightly weathered to fresh : underneath above, depth 34-50m

The rock basement lies in 9m in depth. The solid hard basement extends underneath with a slight weathering. The permeability of the rock ranges from 0.1 to 1.7 Lu all over depths of 12 –to 50 m showing nearly impermemeable features. The ground water level was shallow as 4 to 6m.

2) The river bed at the dam axis

The geology at the drill hole BHL-2 (EL.237m) has been identified as below from the result of the lithology log prepared in the survey (phase 2).

- The river bed deposit materials (alluviums) : depth 0-1.5m
- Biotite gneiss, moderately weathered : underneath above, depth 1.5-2.4m
- Biotite gneiss, slightly weathered : underneath above, depth 2.4-4.3m
- Biotite gneiss, fresh : underneath above, depth 4.3-25m
- Granitic gneiss, fresh : underneath above, depth 25-50m

The river depsit has a little more than 1m in thickness. The rock basement soon becomes fresh or slightly weathered below 2.3m in depth. The rock was moderately weathered (CM class) between 1.5 and 2.3m which forms the basement of dam. Thus the basement was relatively shallow.

The permeability of the rock was 0.0 to 0.1 Lu along almost all depths of 4.3 – 50.1m, showing nearly impermeable features.

3) The right bank of the upper dam axis

The geology at the drill hole BHL-3 (EL.288m) has been identified as below from the result of the lithology log prepared in the survey (phase 2).

- Talus deposit : depth 0-0.3m
- The completely weathered rock: resisual soils (RS1) : depth 0.3-1.5m
- Biotite gneiss, highly weathered : underneath RS1, depth 1.5-2.8m
- Biotite gneiss, slightly weathered : underneath above, depth 2.8-3.2m
- Biotite gneiss, fresh : underneath above, depth 3.2-50m

The rock basement was shallow and the silightly weathered rock lies in a little shallower than 3m in depths. The water level dropped from 3 to 15m at depths of 14 to 19m. It reached 19.8m at the bottom. But the permeability was 0.03 to 0.1 Lu all over the depths of 4 to 50m showing almost impermeable features.

The geological section showing rock classes along the lower dam axis comprising 3 drillholes was prepared shown in Figure 12.1.4-1..

All these findings above have concluded that the fine rock basement of biotite gneiss (CH at CRIEPI classification) was confirmed at both right and left abutment along the lower dam site. The NW-SE trending fault had been estimated in the exsiting geology map and aerophotograph interpretation, but was not recognized in the drillings so far.

At the present stage there seem no critical issues in the geotechnical terms for the proposed dam axis location.

(3) The water route

Only the surface geology survey had been conducted at the water route and the power house areas in the survey (phase 1), and no drilling surveys had been done.
The major geology was the biotite gneiss which compose the most of the route. Some granitic gneiss distributes itself around the area at 200m downstream of the surge tank site, but it shows the solid fresh massive features. The both biotite and granitic rocks were fresh to slightly weathered at outcrops. The weathered residual soils covers the surface almost all over the water route, but was interpereted thin by 1m from the surface geology survey.
It should be noted that the area was located at the north wing of the anticline of NW-SE trending axis. Thus the major trend of the geology (such as the layers and the foliations) were the NW-SE strikes with NE dips. The actual trends were N30-40 W with 30-40 NE. This trend was almost parallel to the water route, especially along the upstream half, and is not favorable in excavating tunnel.
Also, 2 NE-SW lineaments were identified crossing the water route along the way. But the suface landform does not show much erosions along these that no serious influence were anticipated from the outlook at this stage.
In conclusions, although the diections of the water route is not favorable in excacvations, but the rock classes along the route including shallower headrace route is considered CH class, and CH to B class at deeper penstock and downstream areas inclusing power house. There anticpates no serious geologic issues along the water route.

(4) The underground power house

The underground power house comprises biotite gneiss. In general it is considered to be CH to B class rocks in the depths of the power house, so no special geologic issues are anticipated in principle.
However, the biotite gneiss in nature develops foliations that there may raise issues of physical anisotropies by foliations, proness to separations along foliation planes, etc. It is that the major directions for the biotite gneiss are NW-SE with NE dip. This directions must be cared and avoided in principle that no pararell allocation/alignment of the powerhouse (long axis) along this directions shall be made basically from geotechnical points.
It is understood that the direction/layout of the water route has a fewer choices to avoid such geolgic trends. So it is advised to make those preceding surveys to identify and prepare well ahead in designs, on the issues like detailed geologic structures, anisotropies and exceeding directions of the foliations, easiness to peels/separation along planes, mechanical strengths, elastic moduluses, etc. utilizing drillings and laboratory testings.

A.12.1.5 Construction materials

The laboratory tests were conducted using rock cores taken from drillings in the view to utilize the results for the foregoing stage's costruction material surveys with providing typical properites required for the

coarse aggregates. The test of soil materials was not conducted at this stage.

The result was summarized in Table A.12.1.5-1. The detailed results are shown in the Table A.12.1.5-2, and the test data sheets of the each laboratory tests the Summary report was prepared for.

(The details were mentioned in the Summary report. It should be mentioned that the subcontractor had failed to submit the evidences of the most of the following tests against the contract Specification and the repeated requirements from JICA Study Team, including test specimen photos prior and after each test, grading of each fraction (sieve) for coarse aggreagate from original samples. Some samples showed illogical results and some others were sampled and tested contradictorily thus omitted. Thus, JICA Study Team suspends the judgement whether the tests had been conducted properly or not, until the facts are clear in the next stage survey. So the following results should be considered as "references".

Table A.12.1.5-1 The result of the laboratory tests

test item		ASTM	sample	average	max.	min.	criteria	values in Sri Lanka	evaluation
coarse aggregate									
specific gravity		C127	13	2.72	2.80	2.65			
dry density	kg/m3	C127	13	2,655	2,750	2,520	≧2,500		good
saturated density	kg/m3	C127	13	2,679	2,770	2,570			
Water absorption	%	C127	13	0.84	1.70	0.40	≦3.0		good
Soundness	%	C88	4	1	2	1	≦10	0.6-3.5	good
Alkali reactivity		C289	4	110.1	185.7	52.1			innocuous
Abrasion (n=100)	%	C131	4	17	27	11			
Abrasion (n=500)	%	C131	4	55	74	45	≦40	42-62	a little high
rock core									
dry density	kg/m3	D2216	16	2,718	2,861	2,607	≧2,500		good
saturated density	kg/m3	D2216	16	2,723	2,864	2,611			
UCS	Mpa	D7012	15	49.25	100.43	22.07		74.9-159.2	low
Tensile strength	Mpa	D3967	15	6.78	14.30	1.61		5.2-10.8	good
			*1) Typical range for biotite gneis, by Engineering properties of Sri Lankan rocks (2009)						

The result shows that most of the properties meet the required conditions for coarse aggregates. UCS (unconfined compressive strength) values generally had shown smaller in values (though scattered) The reasons for this may be 1) some fractures had been created when the specimen had been prepared, 2) the separations of the foliations had been occurred as most of rocks had been biotite gneiss having developed foliations. Actually it often was observed the concentrations of biotites or amphiboles (hornblende) along the foliations, which make the foliations prone to get peeled (for example, 37-47m cores of BHU-1 show such features).

At this stage, it is not appropriate to consider those results are coorect, and requires further additional tests as the UCS values of the general solid basement biotite gneiss are much higher (70-160MPa), and as it implies the rock at the site also should have indicated much higher values if it has no potential cracks.

The alkali reactivity test (chemical method) showed no problems (all samples were innocuous). It should be noted that granitc gneiss showed 50 mmol/l in reduction in alkalinity where as biotite gneiss showed 150 to 190 mmol/l, much higher in values. In general the more biotites the rocks contains the more absorptions they have thus likely to get detrimental. They are prone to get alternated and lutaceous.Gneiss

are often used as the coarse aggregate materials next to granites rocks but in cases they are biotite gneiss they are prone to get lutaceous by inclusions of biotites. They also have anisotropies. Attentions should be paid for the selections of quarries sites.

A.12.1.6 Future tasks (Tasks for Feasibitlity Study)

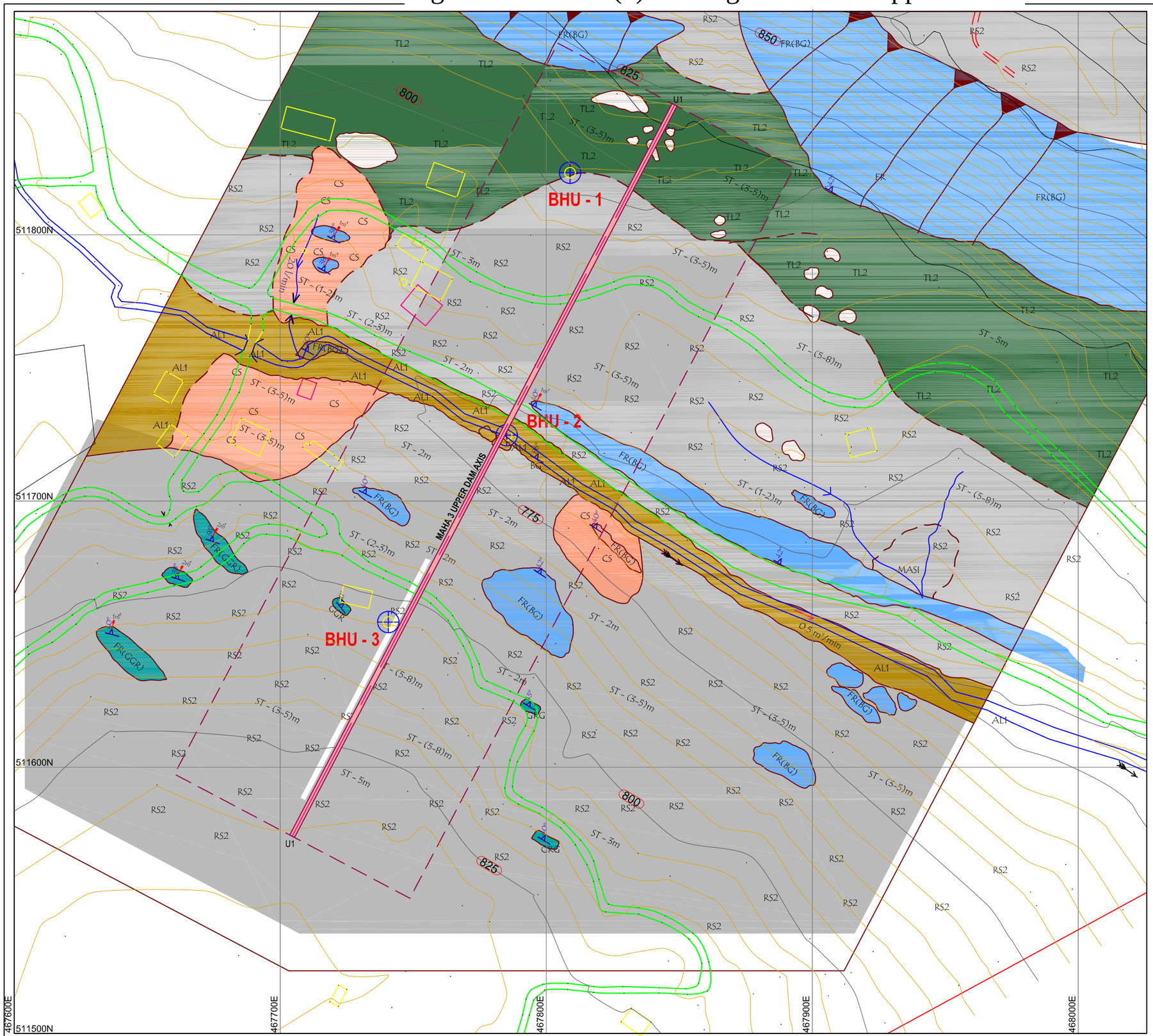
The numbers of drillings at this study are limited (3 holes at upper dam site, 3 holes at lower dam site). The left dam abutment where the certain thickness of the talus with possible mass movement is not considered the best suitable locations, but the detailes information are not known for the whole reservoir areas.

When available, the left bank at upper streams and lower streams of the present dam axis shall be investigated for their subsurface conditions. At minimum 1 hole each at upper and lower area are recommended so as to clarify the distributions of the possible talus deposits, potential faults with probable fractures, the rise of the ground water tables on the left abutment, and the rock basement features. The areas of investigations may range 250m to upstreams and 300m to downstreams as there are anticipated solid rock basement in shallow depths with some steep ridges on the left bank heading towards river bed.

(The site in 250m upstream may be inferior to that of 300m downstream from the comparison of the right ridges shape)

The survey conducted by the subcontractor had been unfortunately in many aspects unsatisfactory. The subsurface information along the dam axis and the mechanical and physical properties of the underground rocks must be taken in the future stage, and it is appropriate to consider the presently obtained data may be used as supplemental information and re-evaluated when much more densed data is ready.

Also, drilling surveys at intake, outlet, water route, seismic surveys along whole water route, drilling surveys at the power house, construction material surveys are required in due course.



LEGEND;

- BOUNDARY BETWEEN MATERIAL TYPES
- STRIKE & DIP OF FOLIATION
- ROCK ESCARPMENT
- TREND & PLUNGE OF JOINT
- STREAMS WITH FLOW RATE
- PROPOSED DAM AXIS
- ROAD

N

ROCK TYPES :-

BG	- BIOTITE GNEISS
GRG	- GRANITIC GNEISS

ROCK WEATHERING STAGES :-

FR	- FRESH ROCK
SW	- SLIGHTLY WEATHERED

SOIL TYPES :-

RS2	- RESIDUAL CLAY - 2 SANDY SILTY CLAY
CS	- COLLUVIUM SANDY SILTY CLAY MIXED WITH 0.5 - 1 m ROCK FRAGMENTS 20% ROCK BOULDERS
TL2	- TALUS MATERIALS - 2 0.5 - 2 m ROCK BOULDERS SCATTERED OVER SANDY SILTY CLAY WITH 20% ROCK BOULDERS
AL1	- ALLUVIAL DEPOSIT - 2 ROUNDED GRAVELLY SAND WITH 0.5 - 1m BOULDERS

BORE HOLE LOCATION

	EASTING	NORTHING	ELEVATION
BHU - 1	467808.96	511823.35	798.96
BHU - 2	467785.14	511724.75	765.92
BHU - 3	467740.64	511654.55	804.18

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DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

JICA STUDY TEAM

Project: **TOPOGRAPHY SURVEY AND GEOLOGICAL INVESTIGATION SURVEY FOR DEVELOPMENT PLANING ON OPTIMAL POWER GENERATION FOR PEAK DEMAND IN SRI LANKA**

Title: **GEOLOGY MAP ALONG MAHA 3 UPPER DAM AXIS**

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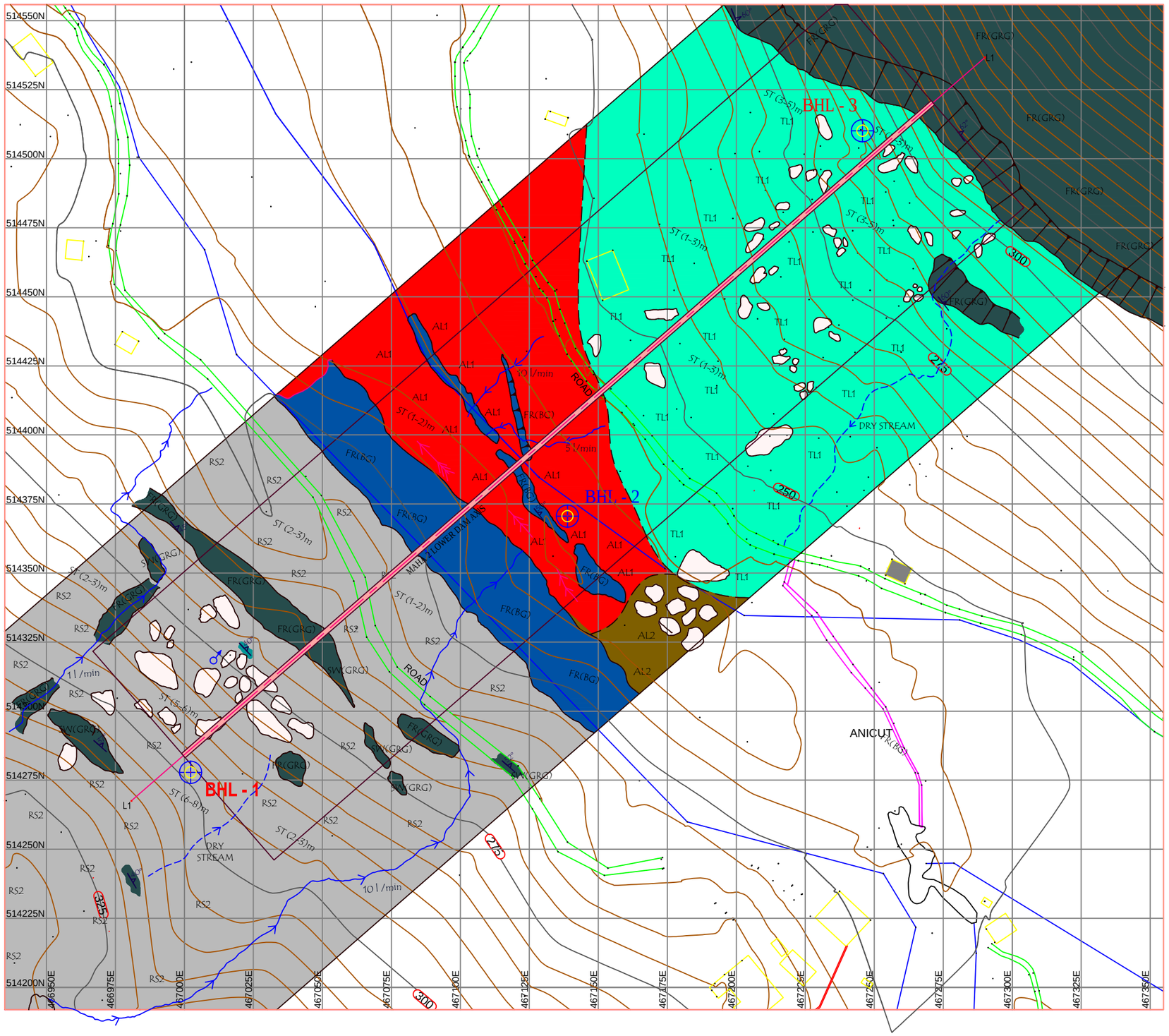
CAD File	D - / DRAWINGS		
Sheet Size: A2	Drawing No.: MAH / JICA / EPCD / GSB - 003		Rev. No.: -

Figure A.12.1.3-1 (2) Drilling location on lower dam



LEGEND;

- BOUNDARY BETWEEN MATERIAL TYPES
- STRIKE & DIP OF FOLIATION
- ROCK ESCARPMENT
- TREND & PLUNGE OF JOINT
- 10 l/min - STREAMS WITH FLOW RATE
- PROPOSED DAM AXIS
- ROAD

N

ROCK TYPES :-

- BG - BIOTITE GNEISS
- GRG - GRANITIC GNEISS

ROCK WEATHERING STAGES :-

- FR - FRESH ROCK
- SW - SLIGHTLY WEATHERED

SOIL TYPES :-

- RS2 - RESIDUAL CLAY - 2 SANDY SILTY CLAY
- TL1 - TALUS MATERIALS - 1 2 - 8 m ROCK BOULDERS EMBEDDED WITH SANDY SILTY CLAY 20% ROCK BOULDERS
- AL1 - ALLUVIAL DEPOSIT - 2 ROUNDED GRAVELLY SAND WITH 0.5 - 1m BOULDERS
- AL2 - ALLUVIAL DEPOSIT - 2 2 - 8 m ROCK BOULDERS WITH GRAVELLY SAND

BORE HOLE LOCATION

	EASTING	NORTHING	ELEVATION
BHL - 1	467002.2840	514277.8300	295.9770
BHL - 2	467138.8611	514370.5353	236.5490
BHL - 3	467245.7639	514510.0797	288.4776

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Title: **GEOLOGY MAP ALONG MAHA 2 LOWER DAM AXIS**

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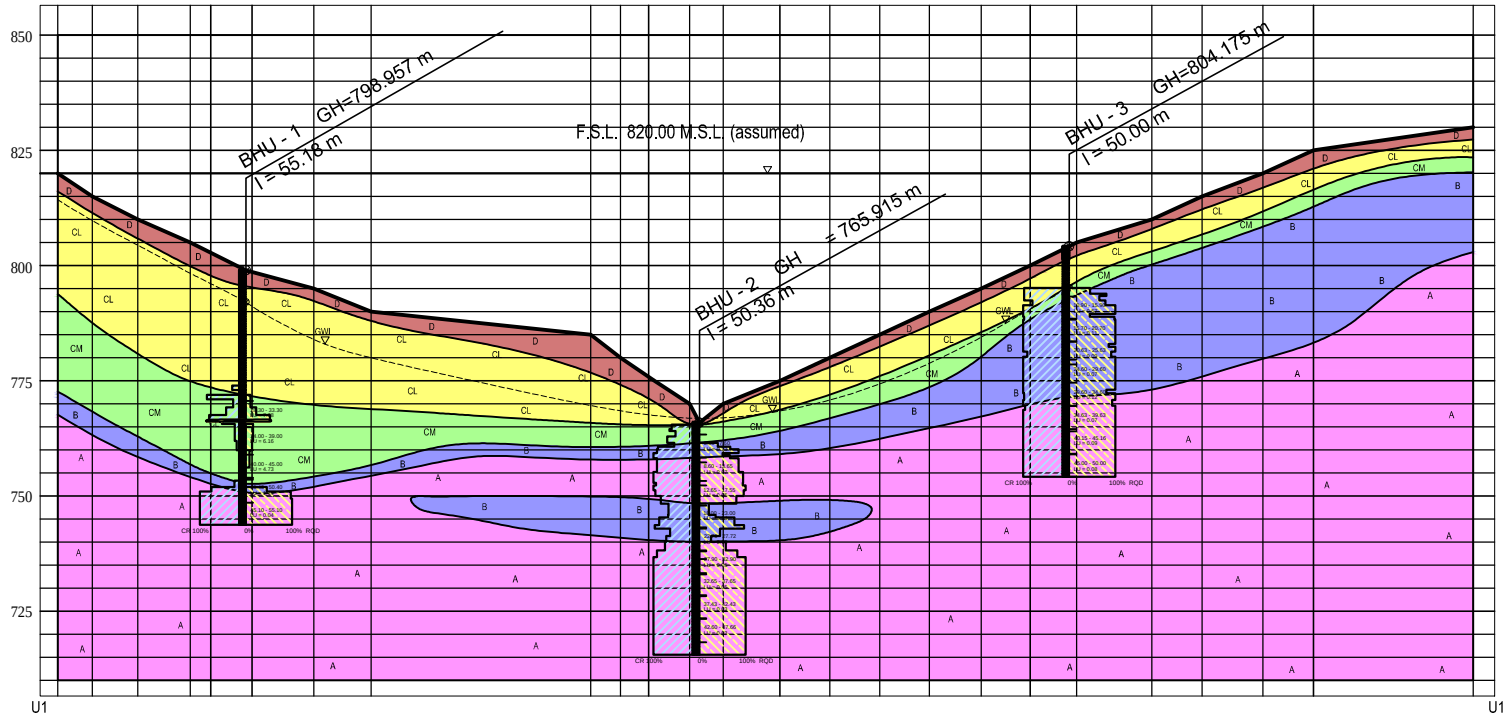
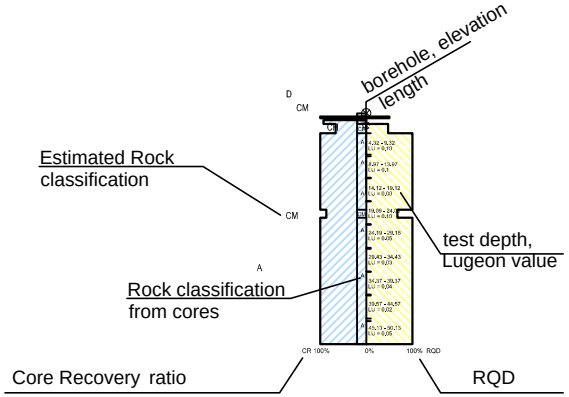
Sheet Size: A2	Drawing No.: MAH / JICA / EPCD / GSB - 001			Rev. No.: -

U1 - U1 Dam Axis

Geological Section Based on tentative Rock Mass Classification by CECB



CLASS	CONDITION OF ROCK
A	Fresh and hard, no deterioration in the rock - forming minerals. Crack spacing larger than about 30cm.
B	Fresh and hard. Weathering along clacks. Crack spacing larger than about 15cm.
C_L	Feldspar is deteriorated, but quartz particles are hard. When struck by hummer breaks into pieces. In the form of small pieces, rock pieces remain. No circular core.
C_M	Breaks when struck by hammer. Deterioration of feldspar developed. Clay is sandwiched along the opening face. Crack spacing smaller than 5cm
D	Extremely soft. Very friable and tends to powderize. Residual soil form



Note)
The ROCK MASS CLASSIFICATIONS on this section were applied by CECB but were not supported by firm evidence, thus JICA Study Team considers these only as tentative and not corresponding to solid criterias inluding CRIEPI.

Rev.	Date	Desd	Description	Drwn	Chk'd	App'd

DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
JICA STUDY TEAM

Project: TOPOGRAPHY SURVEY AND GEOLOGICAL INVESTIGATION SURVEY FOR DEVELOPMENT PLANING ON OPTIMAL POWER GENERATION FOR PEAK DEMAND IN SRI LANKA

Title: GEOLOGICAL SECTION BASED ON TENTATIVE ROCK MASS CLASSIFICATION BY CECB - MAHA 3 UPPER DAM AXIS

CENTRAL ENGINEERING CONSULTANCY BUREAU
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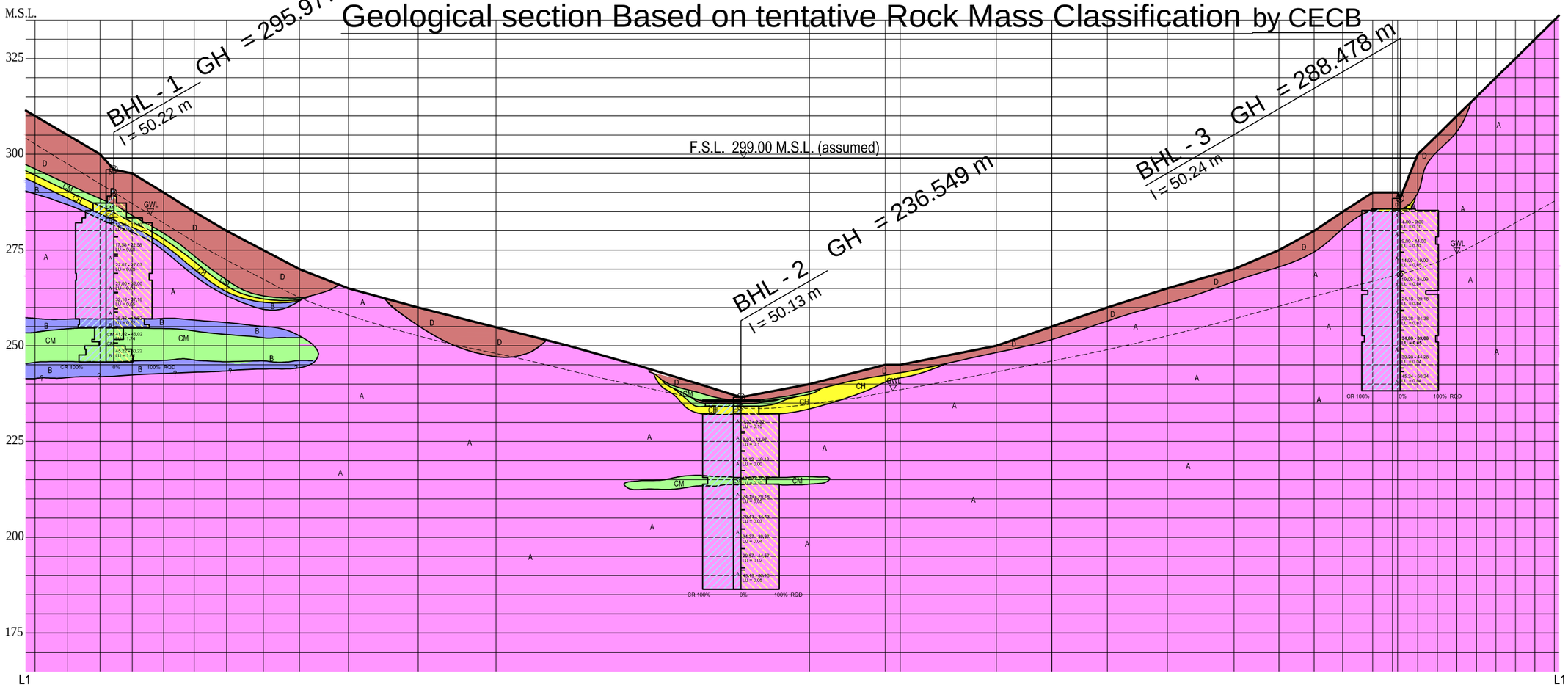
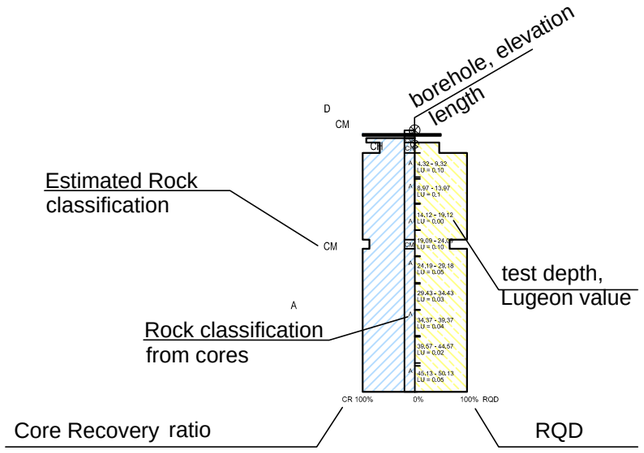
CAD File	D - / DRAWINGS		1 : 750	OCT - 2014	-
Sheet Size	Drawing No.				Rev. No.
A2	MAH / JICA / EPCD / GSB - 001				-

L1 - L1 Dam Axis

Geological section Based on tentative Rock Mass Classification by CECB



CLASS	CONDITION OF ROCK
A	Fresh and hard, no deterioration in the rock - forming minerals. Crack spacing larger than about 30cm.
B	Fresh and hard. Weathering along clacks. Crack spacing larger than about 15cm.
C_H	Relatively hard. Biotite and feldspar are somewhat deteriorated. Crack spacing larger than about 5cm.
C_M	Breaks when struck by hammer. Deterioration of feldspar developed. Clay is sandwiched along the opening face. Crack spacing smaller than 5cm
D	Extremely soft. Very friable and tends to powderize. Residual soil form



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DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

JICA STUDY TEAM

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Title: **GEOLOGICAL SECTION BASED ON TENTATIVE ROCK MASS CLASSIFICATION BY CECB - MAHA 2 LOWER DAM AXIS**

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Sheet Size: A2	Drawing No.: MAH / JICA / EPCD / GSB - 002			Rev. No.: -

Table A.12.1.5-2 Detailed results of laboratory tests

Borehole	total test depth section	rock type	Rock class (by CECB tentative classification)	dry density. Saturated density, water content for rock mass.			oven dry density, surface saturated density, absorption for coarse aggregate				UCS	tensile strength	soundness	alkali reactivity test (chemical method)	abrasion (Los Angels)
				rock core			coarse aggregate from core				rock core	rock core	coarse aggregate from core	coarse aggregate from core	coarse aggregate from core
ASTM No.				D2216	D2216	D2216	C127	C127	C127	C127	D7012	D3967	C88	C289	C131
				moisture %	dry density kg/m^3	saturated density kg/m^3	apparent specific gravity	dry density kg/m^3	saturated density kg/m^3	absorption %	MPa	MPa	loss %	reduction of alkalinity mmol/l	abrasion value % (100, 500 rev)
BHL01	8.7-10.7m	Biotite Gneiss	CM	0.1	2,844.16	2,853.70					40.58	1.61			
	10.7-12.6m	Biotite Gneiss	CH				2.73	2,620	2,660	1.4					
	15.75-22.58m	Biotite Gneiss	A	0.0	2,698.34	2,703.80	2.74	2,670	2,700	0.8	22.07	5.61	1	149.2	15, 53
	36.51-41.32m	Biotite Gneiss	A	0.0	2,731.22	2,739.15									
BHL02	2.35-3.05m	Biotite Gneiss	CH								23.00	4.71			
	4.32-8.5m	Biotite Gneiss	A	0.0	2,746.45	2,750.03	2.76	2,680	2,710	1.0	30.43	8.35			
	36.57-40.9m	Biotite Gneiss	A	0.0	2,686.41	2,690.61	2.78	2,710	2,730	0.8	25.89	7.08	1	185.7	13, 50
BHL03	5.12-9.90m	Biotite Gneiss	A	0.1	2,860.93	2,864.11	2.76	2,710	2,730	0.6	49.40	4.20			
	14.42-19.0m	Biotite Gneiss	A										2	52.1	27, 74
	20.0-28.14m	Biotite Gneiss	A	0.1	2,788.79	2,793.00	2.8	2,750	2,770	0.6	28.84	4.67			
BHU03	10.8-11.72m	Granitic Gneiss	B	0.1	2,628.64	2,634.83	2.65	2,570	2,600	1.0					
	11.72-12.77m	Granitic Gneiss	B								49.66	5.69			
	24.63-29.32m	Granitic Gneiss	A	0.1	2,706.79	2,711.64	2.69	2,630	2,650	0.7	67.14	7.28	2	50.1	13, 49
	38.01-42.63m	Biotite Gneiss	A	0.1	2,621.33	2,625.19	2.67	2,630	2,640	0.6	29.01	7.95			
BHU02	5.0-6.4m	Biotite Gneiss	B	0.1	2,722.04	2,726.41					26.80	6.30			
	10.7-15.9m	Granitic Gneiss	A	0.1	2,612.72	2,620.38	2.66	2,610	2,620	0.7	100.43	5.04			
	32.2-41.3m	Granitic Gneiss	A	0.1	2,607.02	2,611.49	2.66	2,600	2,620	0.8	68.96	7.41	1	53.3	11, 45
BHU01	27.800-37.500	Biotite Gneiss	CM	1.1	2,687.20	2,694.82	2.65	2,520	2,570	1.7	77.60	10.64			
	49.500-50.510	Biotite Gneiss	A	0.1	2,770.97	2,772.58	2.77	2,730	2,740	0.4	86.57	7.23			
	51.205-55.190	Biotite Gneiss	A	0.2	2,772.04	2,774.16	2.77	2,720	2,740	0.5	39.16	14.30			
Total No. of samples to be used				**16**	**16**	**16**	**13**	**13**	**13**	**13**	**15**	**15**	**4**	**4**	**4**

(Note: red letter samples were judged inappropriate thus ommitted)

(Note: others were also unclear in test procedures/conditions thus reference only (except UCS and tensile))

APPLICATION NO	

CENTRAL ENVIRONMENTAL AUTHORITY

BASIC INFORMATION QUESTIONNAIRE

(Essential information to determine the environmental approval requirement of projects)

1. **Name of the Project:**

   Development of Pumped Storage Power Plant at Maha 3 in Sri Lanka (Tentative)

2. **Name of the Developer: (Company/firm/individual):**

   Ceylon Electricity Board

   Postal Address: General Manager, Ceylon Electricity Board,

   No 540, Sir Chiththampalam A GardinarMawatha, Colombo 02.

   Phone No: *0112320953/0112325340.* ***Fax No:****0112323935*

   Contact person

   Name: *Mrs T.A.K Jayasekera*

   Designation: *Deputy General Manager (Transmission and Generation Planning)*

   Phone No: *0112324842* ***Fax No:*** *0112324842*

3. **Brief description of the project (Use a separate sheet):**

   Attach copy (ies) of pre-feasibility / feasibility study report (s) if available

   (refer to Attachment 01)

4. **Scale / magnitude of this project:**

   The project is a hydro power development project. Expected installed capacity of an underground power station is 600MW. The development involves the construction of two (upper and lower) dams/ponds.

   Two cases of the unit capacity of the power station are currently proposed. The general features of the Project are shown in the following table.

   The details of other facilities (e.g. quarries, dumping area, access road, switch yard) are to be determined in the next stage.

   (e.g. For a road project: length of the trace; Tourist hotel: No of rooms; Agriculture project: Extent of land etc.)

General features of the Maha 3 project

Candidate Site		unit	Maha 3 case1	Maha 3 case2
Installed Capacity		MW	600	600
Unit Capacity		MW	200	150
Number of Units		unit	3	4
Peak Generating Time		hours	6.14	6.17
Gross Head		m	521.04	521.44
Rated Head		m	493.37	483.95
Rated Discharge		m^3	142.64	147.10
Upper Pond	Latitude		7°06'23"	7°06'23"
	Longitude		80°28'49"	80°28'49"
	Catchment Area	km^2	1	1
	Reservoir Area	km^2	0.22	0.22
	Crest Elevation	E.L.-m	821.0	820.5
	High Water Level	E.L.-m	815.0	814.5
	Low Water Level	E.L.-m	794.5	791.3
	Drawdown	m	20.5	23.2
	Sediment Level	E.L.-m	782.3	782.3
	Gross Capacity	MCM	3.71	3.60
	Available Capacity	MCM	3.15	3.27
	Dam Height	m	59	59
	Crest Length	m	260	260
Lower Pond	Latitude		7°07'50"	7°07'50"
	Longitude		80°28'49"	80°28'49"
	Catchment Area	km^2	35	35
	Reservoir Area	km^2	0.24	0.24
	Crest Elevation	E.L.-m	298.5	297.5
	High Water Level	E.L.-m	292.5	291.5
	Low Water Level	E.L.-m	276.4	273.0
	Drawdown	m	16.1	18.5
	Sediment Level	E.L.-m	263.2	263.2
	Gross Capacity	MCM	6.22	5.78
	Available Capacity	MCM	3.20	3.30
	Dam Height	m	73.5	72.5
	Crest Length	m	380	380
Headrace Tunnel				
	Inner Diameter	m	5.60	4.00
	Length	m	960	960
	Nos. of lines	-line	1	2
Penstock Tunnel				
	Inner Diameter	m	4.30	3.10
	Length	m	993	996
	Nos. of lines	-line	1	2
Tailrace Tunnel				
	Inner Diameter	m	6.10	4.40
	Length	m	415	415
	Nos. of lines	-line	1	2
Access Tunnel to PH				
	Length	m	900	900

5. **Main objective(s) of the Project:**

It is to sustainably meet the growing peak hour electricity demand in Sri Lanka.

6. Investment and funding sources:

It is tentatively planned to receive a Japanese yen loan scheme for its implementation.

7. Location of the Project:

i. **Pradeshiya Sabha:** Upper Pond in Ganga Ihala Korale and Lower Pond in Aranayake

ii. **Divisional Secretariat:** Upper Pond in Ganga Ihala Korale and Lower Pond in Aranayake

iii. **District:** Upper Pond in Kandy and Lower Pond in Kegalle

iv. **Provincial Council:** Upper Pond in Central and Lower Pond in Sabaragamuwa

Provide a location map indicating the project site, access to the site, surrounding development and infrastructure within 500m of the site (1:50,000 scale)

Figure 01: Location of the Project Site[US1]

It indicates the site in the Sheet Number 81 of the Survey Department of Sri Lanka

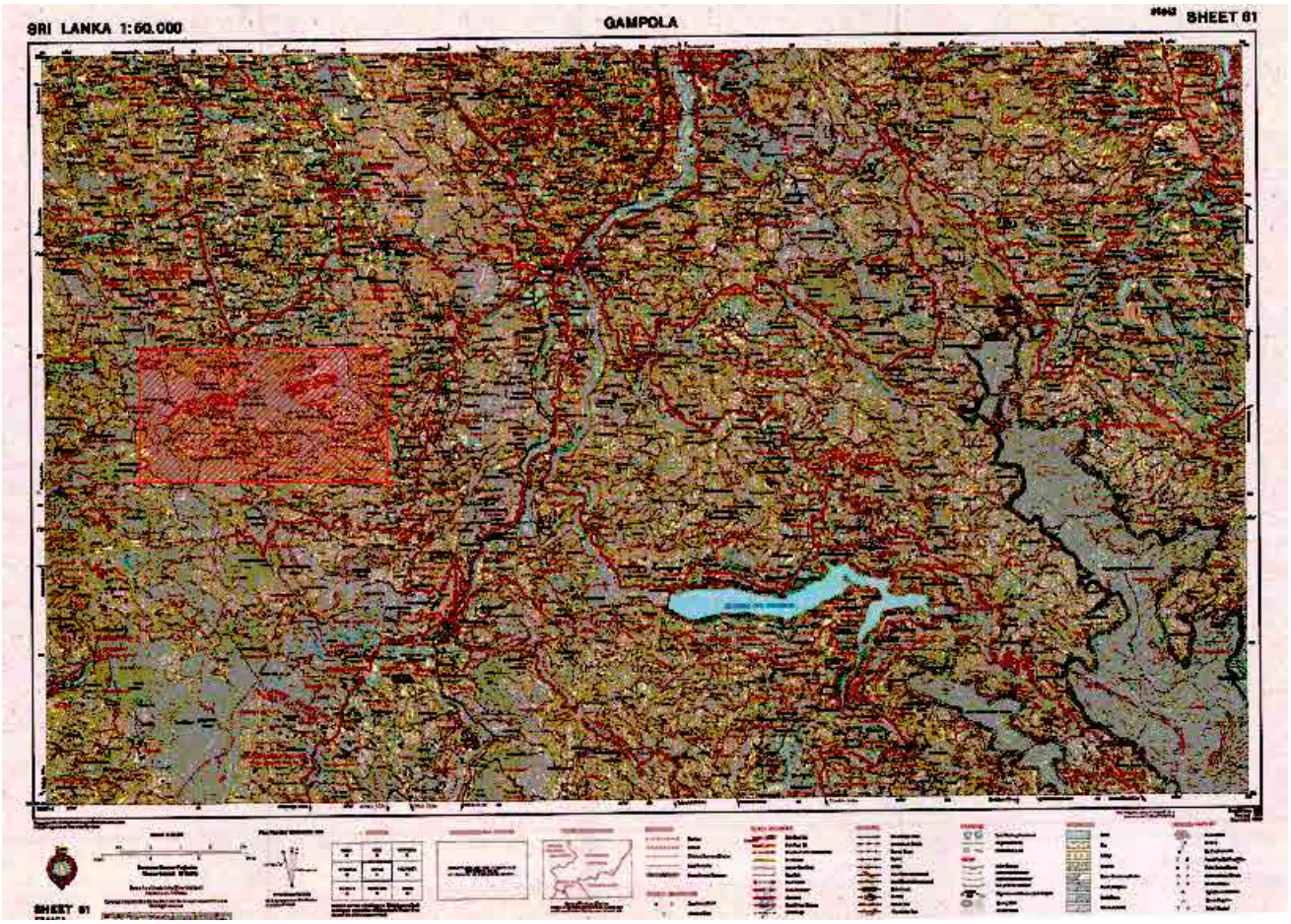


Figure 02: Topographical Map of the Project Site

It indicates the site in the original scale (1:50,000) of the Survey Department of Sri Lanka

8. Extent of the project area (in ha):

Maha Upper Pond (inundation area): 22 ha.

Maha Lower Pond (inundation area): 24 ha.

9. Does the project wholly or partially fall within any of the following areas?

Area	Yes	No	Unaware
100 m from the boundaries of or within any area declared under the National Heritage Wilderness Act No of 1988		√	
100 m from the boundaries of or within any area declared under the Forest Ordinance (Chapter 451)	√		
Coastal zone as defined in the Coast Conservation Act No 57 of 1981		√	
Any erodible area declared under the Soil Conservation Act (Chapter 450)	√		
Any Flood Area declared under the Flood Protection Ordinance (Chapter 449)		√	
Any flood protection area declared under the Sri Lanka Land Reclamation and Development Corporation Act 15 of 1968 as appended by Act No 52 of 1982		√	
60 meters from the bank of a public stream as defined in the Crown Land Ordinance (Chapter 454) and having width of more than 25 meters at any point of its course	√		
Any reservations beyond the full supply level of a pond		√	
Any archaeological reserve, ancient or protected monument as defined or declared under the Antiquities Ordinance (Chapter 188)			√
Any area declared under the Botanic Gardens Ordinance (Chapter 446)		√	
Within 100 meters from the boundaries of or within any area declared as a Sanctuary under the Fauna and Flora Protection Ordinance (Chapter 469)		√	
100 meters from the high flood level contour of or within a public lake as defined in the Crown Land Ordinance (Chapter 454) including those declared under section 71 of the said Ordinance		√	
Within a distance of one mile of the boundary of a National Reserve declared under the Fauna and Flora Protection Ordinance		√	

10. Present ownership of the project site:

State	private	Other-specify
Yes (partial)	Yes (partial)	

If state owned, please submit a letter of consent of the release of land from the relevant state agency

11. **Present Land use:** The description of main land use types are given below.

Upper Pond

Maha upper 3 site consists of mosaic of habitats including rock out crops, tea plantations, *Pinus* plantations and home gardens. The site is located in a tea plantation area thus the bulk of the land of the project area is under tea cultivation. Some settlements surround the tea plantation and tea is grown in the home gardens in the homesteads as a cash crop. The habitat characteristics are described below:

Rock outer crops

They are a special type of habitat in the area. This represents about 10% of the total land area. These types of habitats are created in places where the overlying soil cover is removed through erosion, and when the rock is exposed, or crop out. Such exposure happens most frequently in areas where erosion is rapid. Floristic richness of this habitat is poor and the species encountered include *Clusia rosea, Panicum maximum*, *Nothopegia beddomei* and *Ficus hispida*. *Clusia rosea* is considered as an invasive species and in mid country areas they have great potential of spreading into degraded lands.

Tea lands

Tea (*Camelia sinensis*) lands have occupied the major portion of lands in uplands of left bank side. Tea bushes occupy about 90% of the land cover of the plantation area. The rest of the area is mostly covered with some shade plants such as *Gravillea robusta*, *Erythrina subumbrans* and small herbaceous weedy species.

Pine plantations

Exotic *Pinus carribea* plantations have been established in steep slopes to reduce the soil erosion and also to serve as a source of timber. Monoculture *Pinus* trees growing up to 30m-35m forms a discontinuous canopy. Undergrowth of the plantation is devoid of any vegetation cover, the forest floor is covered with the pine needles, making they are susceptible to frequent fires.

Home gardens

Tea is a major crop grown in most home gardens together with other garden crops such as jack fruit (*Artocarpus heterophyllus*), arecanut (*Areca catechu*), pepper (*Piper nigrum*) and banana (*Musas* sp). In certain gardens some crops such as manioc and sweet potatoes are grown for domestic consumption. They are poorly developed multi-storey home gardens. More exotic and agricultural crop species are found in this habitat. Generally, there are several plant layers; canopy 20m, sub-canopy 10m and shrub/herb layer up to 2m could be recognized. Often the structure is fast changing in time and space due to weeding, pruning, fencing, digging etc.

Only two species of plants which are of conservation importance were found in the project impact area.

Lower Pond.

The project impact zone consists of riverine forests, secondary forests, home gardens and a rubber plantation. In some areas the rubber plantation has not been maintained properly and remains as an abandoned state. Detailed description of the habitats sampled is given below:

Riverine forests

These areas are less influenced by Human activities. The vegetation zone is somewhat dense and wide (10m -35m) and steep in the upper reaches of the inundation area of the proposed pond and over 5 m-10m wide in flat areas of the stream. Vegetation height is about 10-25 m with partly closed canopy belt of forests. Species such as *Chlorocarpa pentaschista*, *Ficus racemosa*, *Mangifera zeylanica*, *Mesua ferrea* and *Leea indica* are the dominant tree species in this habitat. A sub-canopy (10 m) and a layer of shrubs/herbs (0.5-2 m) can also be distinguished.

Secondary forests

The natural forests in these areas which have been heavily exploited over the years and now they remain as secondary forests. They are less influenced by human activities. The forest structure is more or less developed into a four strata system; canopy (20m), sub-canopy (15m), shrubs (5m) and herbs (1m or less). Much of the secondary forests are distributed in abandoned private lands and also in some areas which are owned by the government. *Alstonia microphylla*, *Nothopegia beddomei*, *Grewia helicterifolia*, *Ficusra cemosa*, *Bribelia retusa*, *Smicarpus* spp,

Alstonia scholaris and *Hydnocarpu svenenata* are some of the dominant species in the secondary forest.

Home gardens

The home gardens in lower elevation are associated mostly with paddy fields. There, tree crop are dominated by a multipurpose vegetation community. Multi-storey home gardens are located in the settlement area on lands of Arama village. Generally, there are several plant layers; canopy 20m, sub-canopy 10m and shrub/herb layer 2m could be recognized. More exotic and agricultural crop species are found in this habitat. Perennial crops, mainly spices, are grown in a mixed cropping system of dense vegetation. Multipurpose trees, shrubs, herbs and climbers deliberately intermixed and managed for better yields. They provide luxuriant habitats for animals, especially birds by harboring a variety of food plants at various height levels.

Rubber Plantation

Rubber (*Hevea brasiliensis*) lands occupy a smaller portion of lands in uplands. This monoculture plantation has a simple structure; just the trees of about 20m height occupying about 90% of the land cover of the plantation area. The rest of the area is mostly covered with small herbaceous weedy species, up to 50cm height. In addition, scattered shade trees growing up to 10m are present. This undergrowth represents only about 5% of the land area.

12. **Present Land use: (please tick the relevant cage/s**

Land use Type		Land use Type	
Paddy	√	Marsh/Mangrove	None
Tea	√	Scrub/Forest	√
Rubber	√	Grassland/Chena	√
Coconut (in home gardens)	√	Built-up area	None
Other Plantations/ Garden	√	Other (roads)	√

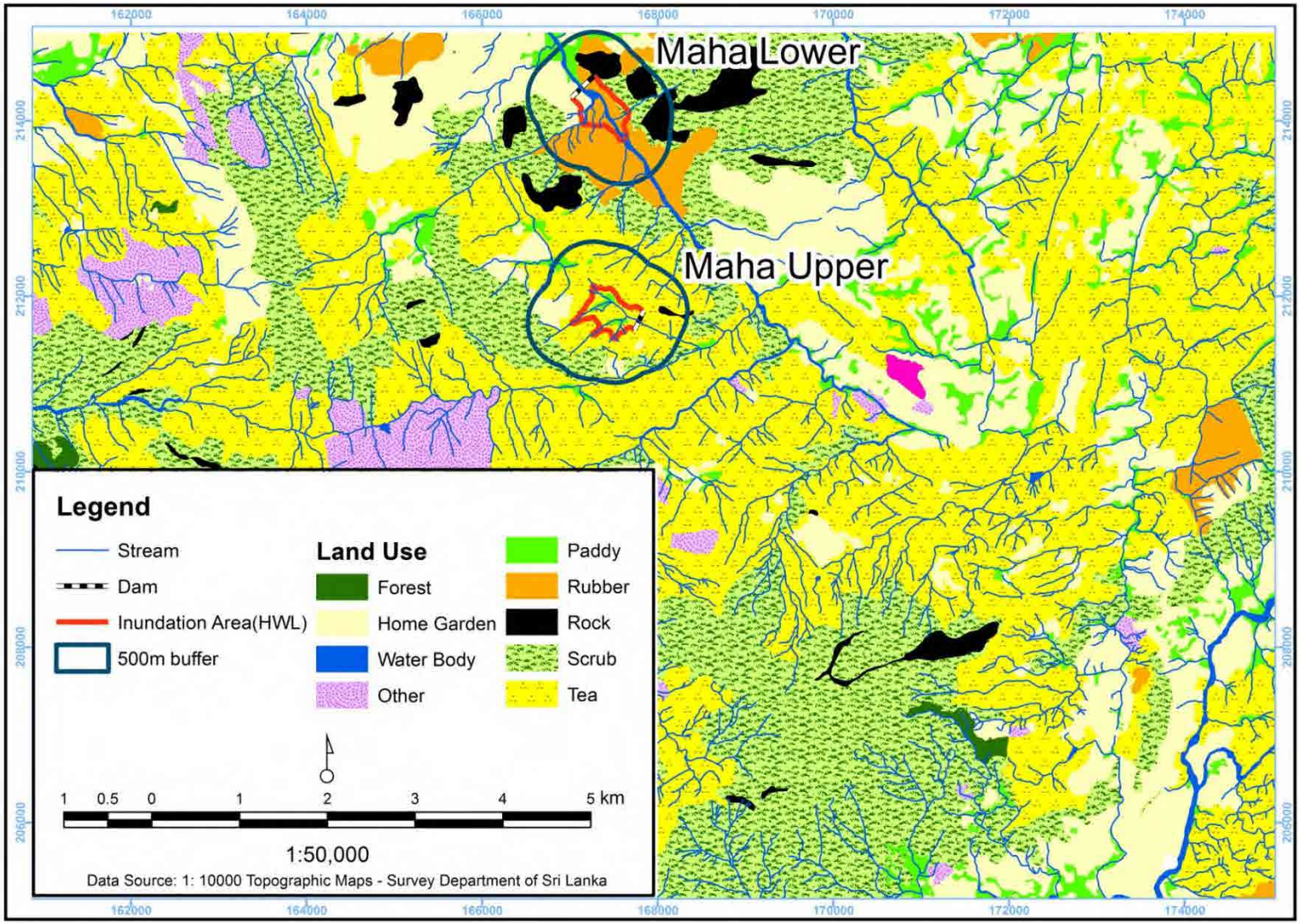


Figure 03: Land Use of project sites

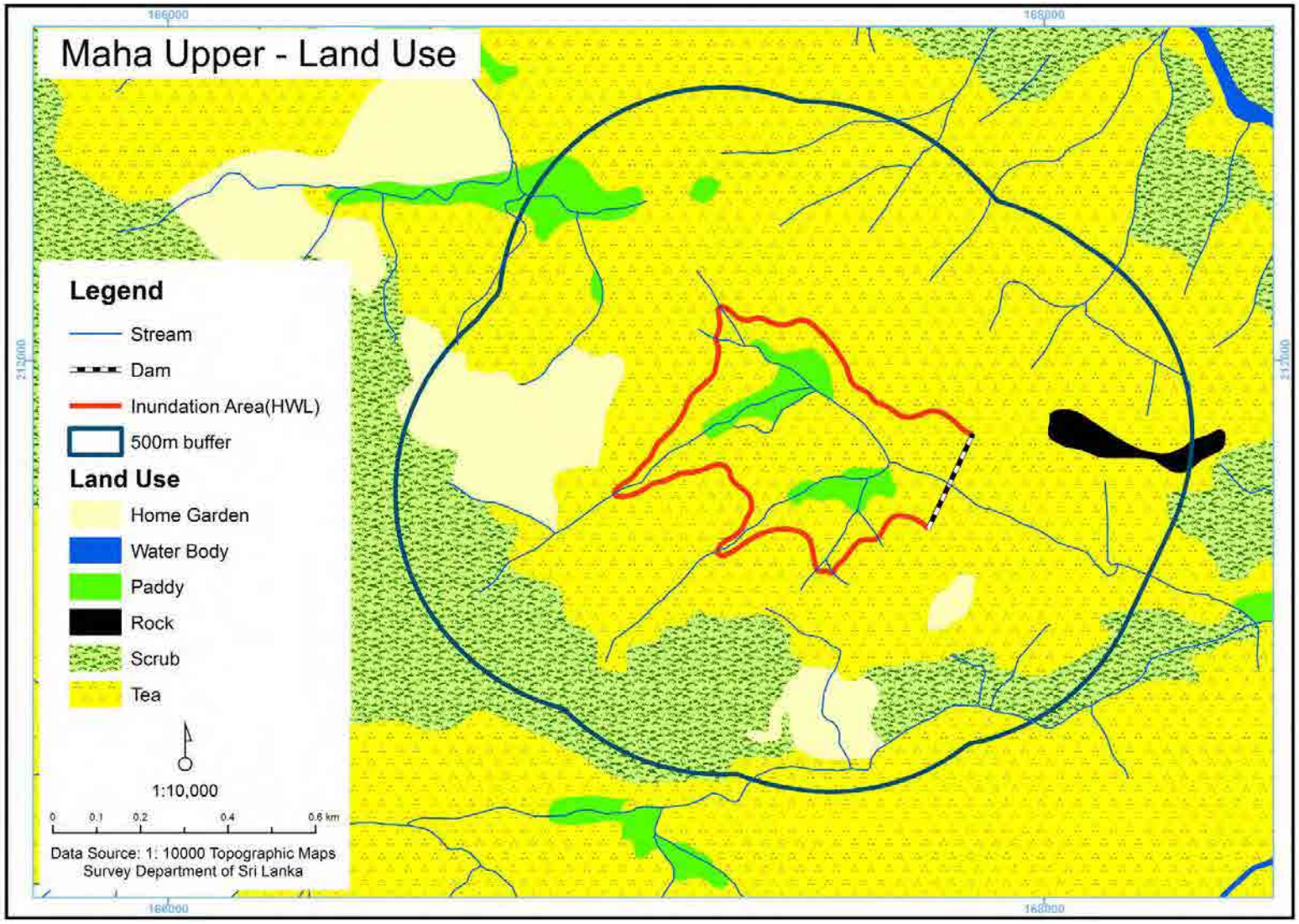


Figure 04: Land Use of Maha Upper Pond site

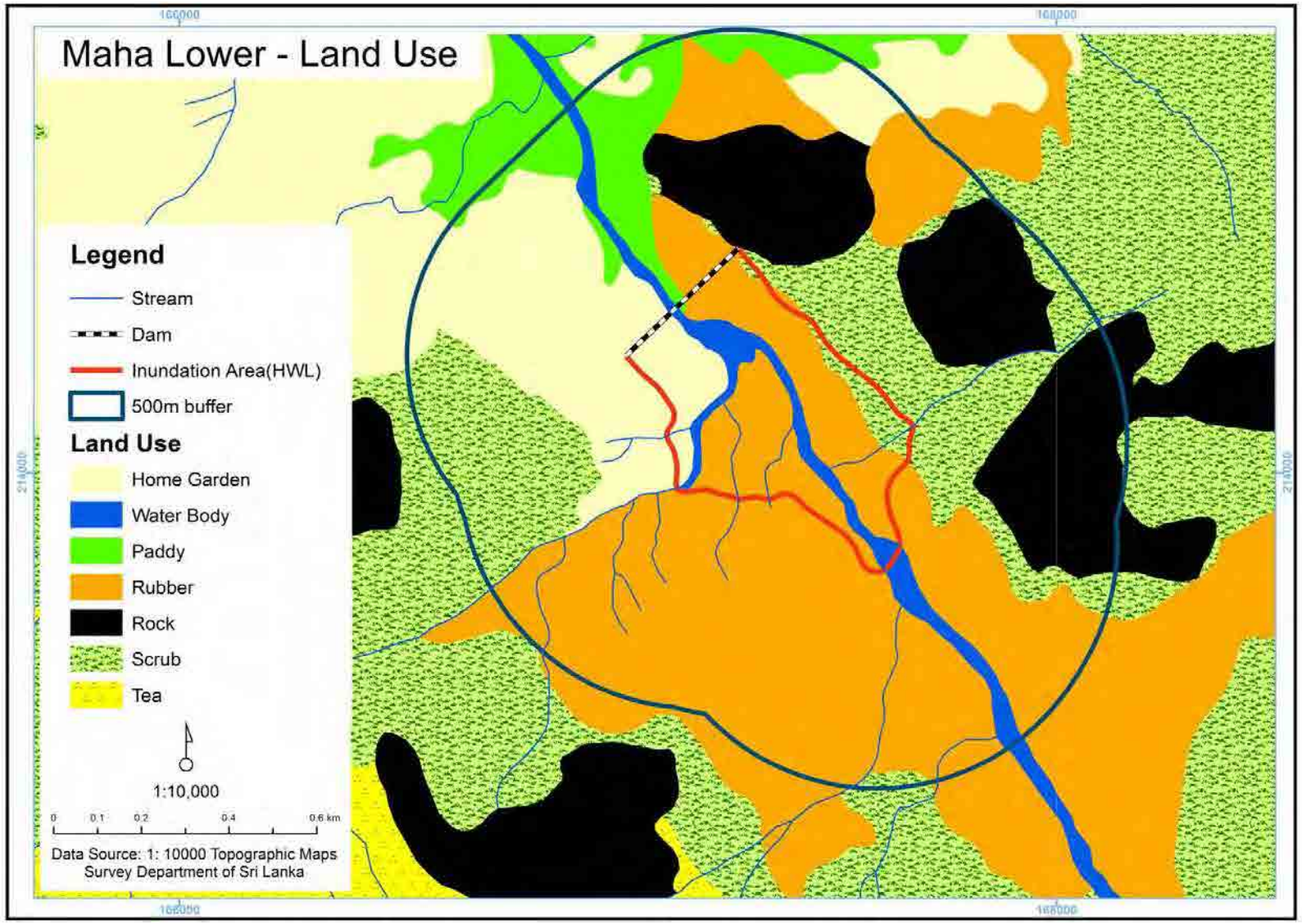


Figure 05: Land Use of Maha Lower Pond site

13. Does the site/Project require any

	Yes	No	If yes give the extent (in ha)
Reclamation of land, wetlands		√	
Clearing of forest	√		1 ha of 3.1 ha forest
Felling trees	√		Scattered Trees are found in 23.23 ha of the home gardens with tea and rubber in both Maha Upper and Lower Pond and in 3.1 ha of the forest patch in Maha Lower Pond. The actual count of trees has not been made.

14. Does the project envisage any resettlement

Yes	No	If yes, give the number of families to be resettled
√		39 households are located within the two inundation areas (28 households in Maha Upper and 11 households in Maha Lower ponds)

15. Does the project envisage laying of pipelines

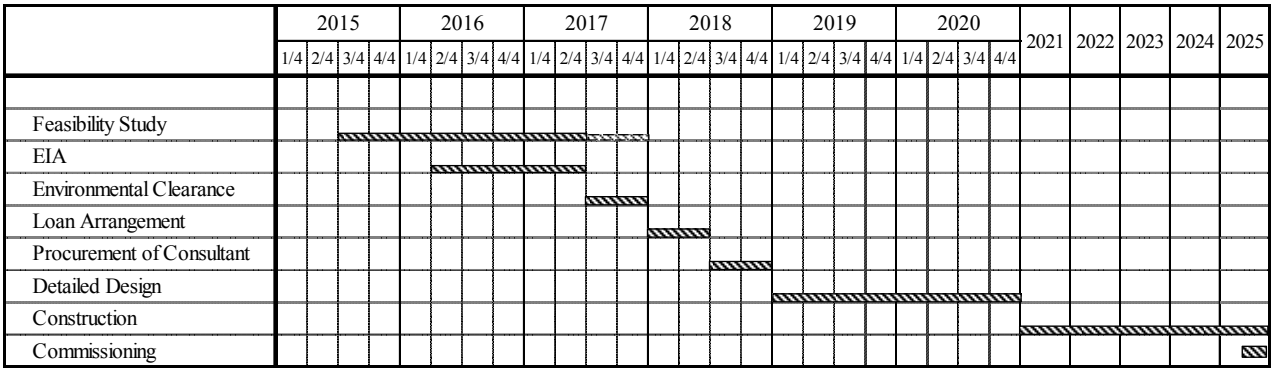
Yes	No	If yes, give the length of the pipeline (km)
	√	

16. Does the project involve any tunnelling activities

Yes	No
√	

** Note: See Figure 03 for location of Tunnel Trace*

17. Proposed timing and schedule including phased development:



18. Applicable laws, regulations, standards and requirements covering the proposed project:

i. National Environment Act No. 47 1980 and subsequent amendments
ii. Land Acquisition Act No. 9 of 1950 and subsequent amendments
iii. National Involuntary Resettlement Policy
iv. Soil Conservation Act No. 25 of 1951 and subsequent amendments
v. Provincial Council Act 42 of 1987
vi. Fauna and Flora Protection Ordinance No. 2 of 1937 and Fauna and Flora (Amendment) Act No. 49 of 1993
vii. Forest Ordinance No 13 of 1966 and subsequent amendments

19. Clearances/ permits obtained or should be obtained from relevant state agencies and/or local authorities. (attach required copies of the same)

i. Pradeshiya Sabha (Ganga Ihala Korale and Aranayake)
ii. Department of Wildlife Conservation
iii. Forest Department
iv. Irrigation Department
v. National Water Supply and Drainage Board
vi. Road Development Authority
vii. Land Reclamation Commission
viii. National Building Research Organization
ix. Geological Survey and Mines Bureau
x. Divisional Secretariats (Ganga Ihala Korale and Aranayake)
xi. Natural Resource Management Centre, Department of Agriculture
xii. Sustainable Energy Authority
xiii. Disaster Management Centre

The above Information is accurate and true to the best of my knowledge. I am aware that this information will be utilized in decision-making by the relevant state authorities.

....

Date Signature of Applicant

FOR OFFICE USE ONLY

1. Date of receipt of the application:
2. A site inspection done,

   If yes,

   Date of the inspection: .....

   Name(s) of the officer(s):

   Inspection fee

   Amount: Rs ..... Date of Payment: .....

   Receipt No: .....

   Special comments regarding significant environmental concerns (Based on site inspection):
3. Require approval under part IVC of NEA?

   (i.e. Need to go through the EIA/IEE process)

Yes	No

4. If need to go through the IEA process appropriate PAA:

   .....
5. Other Remarks:

ATTACHMENT

Attachment 01

Outlines of Development of Pumped Storage Power Plant at Maha 3 in Sri Lanka (Tentative)

1. Introduction

According to the Annual Report 2012 of Central Bank of Sri Lanka, it anticipates that the improvement activities of infrastructure and the growth of tourism industry will make the growth rate of GDP continuously increase at around 8% (2014: 7.8%, 2015: 8.2%). The electric power demand is expected to keep on substantially increasing, accordingly.

The peak power demand in Sri Lanka prevails in the evening time up to 22 o'clock mainly by power demand for lighting and is also driven up by the improvement of the electrification rate. Hydro power plants that account approximately 40% of electric power generated in Sri Lanka may act as power generators for peak power demand under normal circumstances. However, in order to make up for the capacity degradation in power supply for peak power demand during dry season as evidenced in 2012 or to allow planned significant introduction of renewable energy by absorbing its power variation, Ceylon Electricity Board (CEB) has planned a study on the development of pumped storage power plant as power generation for peak power demand as part of utilization of domestic energy.

The Detailed Planning Sturdy for Pumped Storage Power Generation in Sri Lanka is conducted by the assistance of Japan International Cooperation Agency from March 2013 to January 2015. The following items are main scope of the Study:

- to practice electric power demand projection for 15-20 years after the year 2013 and to confirm the necessity of power generation for peak power demand by comparison with existing power development plan;
- to propose optimal power generation for peak power demand (including combination of options) after comprehensive study on economic efficiency, technical, topographical and environmental restriction, and impact on power system in Sri Lanka of options for peak power demand, such as pumped storage, gas combined cycle, new hydropower for peak demand, expansion of existing hydropower, electricity interchange with Indian network; and,
- to select conclusively the most promising site from the views of environmental and social aspects, technical aspects (including and topographical and geological investigations), and economical aspects after the following activities: (1) confirming that pumped storage is the most suitable option for Sri Lanka as power generation for peak power demand; (2) listing up around 10 potential pumped storage sites including the study sites of CEB; and, (3) selecting three prevailing site from the potential sites in accordance with the evaluation criteria to be established.

2. Maha 3

2.1 Discussions on alternatives - selection of the most promising site

A Strategic Environmental Assessment was conducted to select the most promising site for the development of the pumped storage power plant. Three Stakeholders Meetings (SHM) were held: to discuss the contents of the Study and alternatives; and, to collect opinions from stakeholders to reflect them in the Study.

The pumped storage and the existing hydropower expansion project were selected as the optimal option for peak demand in the SHM-1 held in June, 2013. Eleven candidate sites of the pumped storage were also introduced in the SHM-1.

The three promising sites were selected as the promising sites after the first screening. In the SHM-2 held in November, 2013, the pumped storage scheme in Maha area was selected as one of the three promising sites.

Maha 3 was selected as the most promising site as the result of the second screening. It was selected out of four promising sites evaluating from the following four main criteria: 1. Technical aspects; 2. Economic aspects; 3. Natural environmental aspects; and 4. Social environmental aspects. Table 1.1-1 shows the score given to each main evaluation criterion. In the Table 1.1-1, the rows of "Even" show the score by "Even case" (1. Technical evaluation + 2. Construction Costs) : (3. Natural environment + 4. Social environment) = 50 : 50. The rows of "Env." show the score by environment weighed case; (1. Technical evaluation + 2. Construction Costs) : (3. Natural environment + 4. Social environment) = 30 : 70. Maha 3 was evaluated as rank 1 in both cases. These results were discussed and agreed in the SHM-3 held in May, 2014.

Table 1.1-1 Results of the Promising Sites Evaluation

	Halgran 3		Maha 2		Maha 3		Loggal	
	Even	Env.	Even	Env.	Even	Env.	Even	Env.
1. Technical Evaluation	15.50	9.30	22.00	13.20	21.75	13.05	12.50	7.50
2. Economic Evaluation	18.75	11.25	18.75	11.25	25	15	6.25	3.75
3. Natural Environment	7.25	10.15	9.68	13.552	10.75	15.05	7.2	10.08
4. Social Environment	17.5	24.5	10.35	14.49	13.75	19.25	9.4	13.16
Total	59.00	55.2	60.78	52.492	71.25	62.35	35.35	34.49
Rank	3	2	2	3	1	1	4	4

2.2 Outlines of Maha 3

2.2.1 General Features of Maha 3

Table 1.2.1-1 shows general features of the pumped storage scheme in Maha 3 site. As shown, both the unit capacity 200 MW and 150 MW are applicable for this site in view of the pump-turbine manufacturing limitation. Shown values are reviewed based on the data obtained by the topographic survey 1/1,000 conducted after SHM-3. In attachment-1, the plan, the profile and main features of civil structures are shown.

Table 1.2.1-1 General Features of Maha 3 Pumped Storage scheme

Candidate Site	unit	Maha 3	
		case1	case2
Installed Capacity	MW	600	600
Unit Capacity	MW	200	150
Number of Units	unit	3	4
Peak Generating Time	hours	6.14	6.17
Gross Head	m	521.04	521.44
Rated Head	m	493.37	483.95
Rated Discharge	m^3	142.64	147.10

2.2.2 Outlines of Geology in Maha 3

The followings are the summarized outcome of the geology survey phase 1 and phase 2.

(1) Upper dam site

The fine rock basement was confirmed at the right abutment through riverbed with fine biotite gneiss (CH at CRIEPI classification) in relatively shallow depth.

On the left abutment, the depth to the sound rock basement went as long as 47m. It is considered that the left slope of the dam site has a thick talus deposit supplied from the steep height cliffs accompanied with the probable mass movement of that deposit toward the river.

From the above-mentioned features, it can assume that

- the left abutment at the dam site has the talus deposits a certain thickness of the collapsed materials;
- those deposits (the talus deposits in conjunction with the beneath completely weathered residual rocks) have slipped (or collapsed) moving towards river bed with the borders at the 32m depth zones in which ground water is running through; and,
- the tail end of the mass has formed the flat end shape.

The fresh solid rocks were confirmed at the depth 47m onwards in BHU-1. On the surface the left abutment ridge peaks at the steep rock faces along the straight cliffs with fresh biotite gneiss outcrops at around elevation of 870m, and obviously the groundwater table is expected to rise towards the peak. In conclusion the water sealing capability is expected to be secured.

(2) Lower dam site

The fine rock basement of biotite gneiss (CH at CRIEPI classification) was confirmed at both right and left abutments along the lower dam site. At the present stage it seems that there are no critical issues in the geotechnical terms for the proposed dam axis location.

(3) Water route and Underground powerhouse

The water route consists of biotite gneiss and granite gneiss. The surface geology survey was conducted, and the general trends of the geological structures (NW-SE strikes with NE dips) were found unfavorable in terms of the tunnel excavation and stabilities. However, the rock conditions at the depths at the water route tunnels (including headrace tunnel) are considered to be good enough (CH class or better), and geo-technically no critical issues may be encountered due to such structures.

The underground powerhouse comprises biotite gneiss. Although cares should be taken for the anisotropies of the foliations and the surface joint conditions which shall be investigated at later stages, the rock itself is anticipated to have no particular geological issues at this stage as the powerhouse basement.

(4) Construction materials

The laboratory tests were conducted using rock cores taken from drillings in the view to utilize the results for the foregoing stage's construction material surveys with providing typical properties required for the coarse aggregates.

The result shows that most of the properties meet the required conditions for coarse aggregates. UCS (unconfined compressive strength) values generally had shown smaller in values compared to the general solid basement biotite gneiss, thus require further additional tests.

2.2.3 Outlines of the Environments in Maha

(1) Status of the fauna and flora

1) Inundated forest area (including natural, secondary forest, and home garden)

Upper dam/pond	Lower dam/pond
The total inundated area is 23.2 ha. There are riverine forest (0.06 ha), home garden	The total inundated area is 23.7 ha. There are secondary forest (3.1 ha), home

with tea plantation (6.1 ha). The total area of the forests is 6.2 ha, and the ratio of the forests to the pond is 26.7%.	gardens with rubber (16.3 ha), and rubber plantation (0.9 ha). The total area of the forests is 20.3 ha, and the ratio of the forests to the pond is 85.7%.

2) Faunal endangered species (including aquatic species)

	Upper dam/pond				Lower dam/pond			
Global / Sri Lanka	CR	EN	VU	Others	CR	EN	VU	Others
CR	0	0	0	0	0	0	0	0
EN	0	0	0	1	0	1	0	4
VU	0	1	0	2	0	2	0	10
Others	0	1	0	8	0	1	0	17

3) Floral endangered species (including aquatic species)

	Upper dam/pond				Lower dam/pond			
Global / Sri Lanka	CR	EN	VU	Others	CR	EN	VU	Others
CR	0	0	0	0	0	0	0	0
EN	0	0	0	0	0	0	0	0
VU	0	0	0	2	0	2	0	10
Others	0	0	0	0	0	0	0	4

4) Ecosystem

Upper dam/pond	Lower dam/pond
Monoculture area: abandoned rice fields, abandoned tea plantation and tea plantation Secondary ecosystem (single stratum): home garden with tea plantation, shrubs. Secondary ecosystem (multiple strata): secondary and poor riverine forest (0.06 ha) Natural habitat: non	Monoculture area: rice fields (with very small area) and rubber planation Secondary ecosystem (single stratum): non Secondary ecosystem (multiple strata): secondary forests and home gardens with rubber. Their total area is 19.4 ha, and the ratio of them to the pond is 81.9%. Natural habitat: non

(2) Status of the local communities

1) Number of those who to be resettled

Upper dam/pond	Lower dam/pond
There are 28 families who to be resettled. There are 27 families who will be indirectly affected by the project in the buffer zone.	There are 11 families who to be resettled. There are 88 families who will be indirectly affected by the project in the buffer zone.

2) Area of land to be acquired

Upper dam/pond	Lower dam/pond
Abandoned paddy : 3.05ha Abandoned tea plantation : 0.52ha Home garden with tea : 6.12ha	Forest : 3.13ha Paddy : 0.05ha Land of hydropower plant : 0.15ha

Tea plantation : 13.22ha Riverine forest : 0.06ha Scrub : 0.25ha Total : 23.22ha	Rubber plantation : 0.87ha Rubber with Home garden : 16.25ha Total : 23.52h

3) Number of those who to be affected by losing livelihood

Upper dam/pond	Lower dam/pond
28 families who live in the directly affected area will lose livelihood.	11 families who live in the directly affected area will lose livelihood.

4) Public facilities (e.g. school, road)

Upper dam/pond	Lower dam/pond
There are no public facilities in the directly affected area.	There are no public facilities in the directly affected area.

5) Poor people and minorities

Upper dam/pond	Lower dam/pond
7 out of 28 families who will be affected by the project receive the government aid of Samurudhi can be considered as poor people.	3 out of 11 families who will be affected by the project receive the government aid of Samurudhi can be considered as poor people.

6) Water utilization

Upper dam/pond	Lower dam/pond
Some families use river water for drinking and for agriculture purpose in the directly affected area.	Some families use river water for drinking and irrigation purpose in the directly affected area, and 2 small scale hydropower plants also use river water in the directly affected area.

(3) Status of the industries

1) Agriculture (including tree & rubber plantation)

Upper dam/pond	Lower dam/pond
Home garden (6.12 ha), and tea plantation (13.22 ha) Total: 19.34 ha	Forest (3.13 ha), paddy (0.05ha), rubber plantation (0.87 ha), home garden with rubber (16.25 ha) Total: 20.30 ha

2) Tourism (e.g. water fall)

Upper dam/pond	Lower dam/pond
There are no tourism spot or tourism resources in the directly affected area.	There are no tourism spot or tourism resources in the directly affected area. There is a water fall which is seen from the proposed lower pond, the direct distance from the site is around 2 km. It is located outside of the buffer zone. The local authority has a tourism development plan by utilizing the water fall. The

	related infrastructure development of surrounding area will be possible through a joint development scheme with the PSPP project in future. This kind of joint venture may give positive impacts on the area.

(4) Culture and landscape

1) Religious, and/or cultural facilities, burial ground

Upper dam/pond	Lower dam/pond
There are some burial grounds in the directly affected area by the project.	There are no religious and cultural facilities in the directly affected area by the project.

2) Landscape

Upper dam/pond	Lower dam/pond
Mixed scenery of well-maintained tea plantation and abandoned tea plantation covers both directly and indirectly affected areas. Except that scenery, there is no landscape resource which has to be protected.	A water fall is seen from the proposed pond site which 2 km is away, and the proposed project can mitigate the impact on the viewpoint and landscape resource.

2.2.4 Construction Costs

Table 1.2.3-1 shows the construction costs of Maha 3 pumped storage power project. It is calculated according to "Guideline and Manual for Hydropower Development (JICA, 2011)" which is generally applicable to rough estimation at the preliminary study stage. Reviewed pumped storage scheme based on the topographic survey conducted in the upper ponds and the lower pond area is reflected into the calculation.

Table 1.2.3-1 Construction Costs of Maha 3

	Item/Project	200MW 3units (US$)	150MW 4units (US$)	Remarks
1.	Preparation and Land Acquisition	4,994,007	5,125,380	
	(1) Access Roads			@550,000US$/km
	(2) Compensation & Resettlement			
	(3) Camp & Facilities	4,994,007	5,125,380	3. Civil Works * 2%
2.	Environmental Mitigation Cost	7,491,011	7,688,070	3. Civil Works * 3%
3.	Civil Works	249,700,365	256,268,986	
4.	Hydromechanical Works	54,550,427	57,433,434	
5.	Electro-Mechanical Equipment	194,800,000	202,500,000	
6.	Transmission Line	3,900,000	3,900,000	
	Direct Cost	515,435,810	532,915,870	
7.	Administration and Engineering Service	77,315,372	79,937,381	Direct Cost * 15%
8.	Contingency	51,543,581	53,291,587	Direct Cost * 10%
9.	Interest during Construction	32,929,905	34,046,663	Σ(1-8)*0.38*i*T
	Total Cost	677,224,668	700,191,501	
	Power Output (kW)	600,000	600,000	
	USD per kW	1,129	1,167	

2.2.5 Economic and Financial Evaluation.

(1) Economic Evaluation

Economic evaluation was conducted from a viewpoint of national economy for the optimum project plan identified in this study, by using Economic Internal Rate of Return (EIRR) and Net Present Value (NPV). The sensitivity analysis was carried out as shown in Table 1.2.5-1.

The economic internal rate of return (EIRR) is 21.5%. Thus, economic viability of the Project is high from national economy's view point. The results of sensitivity analysis show that impacts caused by changes in key factors are not significant to EIRR and NPV.

Table 1.2.5-1 Results of Economic Sensitivity Analysis

Case	Description	EIRR (%)	NPV (US$ Mil)
E-1	Base Case	21.5%	695.4
E-2	Initial Construction Cost 10% Up	19.3%	624.0
E-3-1	Generation 10% Up	22.8%	795.1
E-3-2	Generation 10% Down	20.1%	595.7
E-4	Coal Price for Pump-up 10% Up	20.7%	634.2
E-5	Fuel Price for Alternative Thermal Gas-turbine 10% Down	19.2%	534.5

(2) Financial Evaluation

Financial viability of the Project was evaluated from a CEB's financial viewpoint. The sensitivity analysis was carried out as shown in Table 1.2.5-2.

For the base case, FIRR on investment (all equity finance basis) was calculated as 2.8%, and NPV with 10% discount rate was US$ minus (-) 464.1 million. FIRR is merely above weighted average interest rate of 2.69%, consisting of JICA ODA loan of 1.4% for 85% investment cost and local loan of 10% for 15% investment cost. The Project does not make loss but only a small profit. Low profitability of peak supply may be considered inevitable, because of higher cost and not large enough peak tariff adjustment factor.

In Case F-5, that is to change peak tariff index from 1.25 to 1.50, FIRR improves to a certain degree. This may be a realistic option to improve financial viability of the Project by introducing gradual increase of peak tariff index in order to give time to domestic consumers for familiarizing new tariff system (Currently, peak-time tariff is not applied to domestic consumers, but already in operation to other category of consumers).

Table 1.2.5-2 Results of Financial Sensitivity Analysis

Case	Description	FIRR (%)	NPV (US$ Mil)
F-1	Base Case	2.8%	-464.1
F-2	Initial Construction Cost 10% Up	2.3%	-538.2
F-3-1	Generation 10% Up	3.5%	-431.4
F-3-2	Generation 10% Down	2.1%	-496.9
F-4	Coal Price for Pump-up 10% Up	1.4%	-525.4
F-5	Peak Tariff Index Increase from 1.25 to 1.50	6.2%	-276.2

(End of the document)

Draft Scoping Table of the Proposed Pumped Storage Power Plant Development at Maha area

The table is a draft and the contents of the table shall be revised when the project is planned in the details in the early stage of its feasibility study.

In some categories, more than one evaluation is given because the categories have several items to be looked at for their impacts.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
Pollution	1	Air pollution	B-	D	Pollutants from construction machines and heavy transportation vehicles, dust from the earth works are expected. Air pollution (dust) is expected at quarry site.	There are no works and activities which cause may air pollution.
	2	Water pollution	B-	B-	The turbidity of river during the rainy season is expected. Cleaning water for machines and vehicles, drainage water with soil and sewage from construction site and camp are expected.	The water levels of the reservoirs change every day because of its operation pattern of a pumped storage power station, and it is expected that the reservoirs are not eutrophicated so much. Since the sludge in the bottom of the reservoirs are not released to the downstream, water pollution in the downstream area is not expected.
	3	Waste	B-	B-	Industrial solid wastes and domestic wastes (camp) are expected.	Industrial solid wastes and domestic wastes (management quarter) are expected.
	4	Soil pollution	B-	D	Oil and other chemicals from construction machines and vehicles may contaminate soil.	There are no works and activities which may contaminate soil.
	5	Noise / vibration	B-	D	Noise and vibration from construction machines / vehicles, and blasting works are expected. Blasting works are also expected at quarry site.	Turbines are the main source of the noise and vibration. They are located at underground facility and no negative impact is expected.
	6	Ground	D	D	There are no works and activities which may	Geological formation is solid and it is not

Category	No.	Expected impact	Evaluation		Explanation on the evaluation	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
		subsidence			cause ground subsidence. Geological formation is solid and it is not expected any ground subsidence.	expected any ground subsidence.
	7	Offensive odors	D	D	There are no works and activities which may produce offensive odors.	There are no works and activities which may produce offensive odors.
	8	Bottom sediments	D	D	There are no works and activities which may cause contamination of bottom sediments.	There are no works and activities which may cause contamination of bottom sediments.
Natural environment	9	Protected areas	D	D	There are not any protected areas (Department of Wildlife Conservation, and Forest Department, and Central Environment Authority), Ramsar Wetlands, Biosphere Reserves, and World Natural Heritage Sites in and around the site. There is no Ramsar site in the downstream of the lower dam and reservoir.	There are no works and activities which may cause negative impacts on protected areas.
	10	Ecosystems	A-	B-	There are endangered species are recorded at both dam/reservoir sites. Further studies are required to know their status and mitigation measures (including monitoring plan) must be recommended.	The upper dam is located in the small catchment. There is a big waterfall upstream of the lower dam. It is therefore considered that impacts on anadromous fishes are limited if any. There may be negative impacts caused by alien species.
			B-	C-	Only first infilling to the reservoir is necessary, and after the first filling, the water overflows to the downstream during the rainy season. It is therefore expected that negative impact is limited. There may be negative impacts caused by alien	Impacts caused by domestic animals including cats and dogs, and poaching are unknown.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					species.	
			C-	D	Impacts caused by domestic animals including cats and dogs, and poaching are unknown.	There are no works and activities which may cause negative impacts on the ecosystems.
			D		There are no natural habitats in the Project site (the upper site: mainly abandoned tea plantations and paddy fields; the lower site: mainly home garden and paddy fields). The Project site is not within the Important Bird Areas. It is expected there is no impact on vegetation cover by tunnel construction works.	
	11	Hydrology	C-	C-	If the tunnels go through aquifers, ground water level may come down.	Ground water level may change because of the reservoir at each site.
	12	Geology / geography	C-	B-	If the dam construction works requires huge amount of aggregates, negative impacts on geographical features at quarry are expected.	The catchment area does not produce lots of earth and sand because of its geological formation. It is therefore expected that impact on downstream riverbed caused by sedimentation in the reservoirs is limited.
			D	D	Risk of earthquakes is low.	There are no works and activities which may cause negative impacts on geology / geography.
Social environment	13	Involuntary resettlement	B-	D	**Before construction:** Involuntary resettlement is expected at both sites. There are 28 families in the upper reservoir site, and 11 families in the lower reservoir. Although routes and site of access roads and quarry are planned to avoid resettlement as much as possible, they may cause resettlements.	There are no works and activities which cause resettlement.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
			D		**Construction stage:** There are no works and activities which may cause resettlement.	
	14	Poor people	C	B+	**Before construction:** Since there may be poor people within the PAPs, a detailed survey on social environment is required to confirm their existence and the scale and nature of impacts if any.	The poor people may obtain more opportunities to access to social services and markets because of the new access road.
	15	Indigenous or ethnic minority	D	D	There are neither indigenous people nor ethnic minorities in the area.	There are neither indigenous people nor ethnic minorities in the area.
	16	Local economies, such as employment, livelihood	B-	B+	**Before construction:** There are changes in the local economies because of resettlement.	There are beneficial impacts on the local economies if livelihood and income restoration programs are implemented adequately for displaced persons / poor families in the affected area.
			B+		**Construction stage:** There are beneficial impacts on the local economies because of employment of unskilled labors and procurement of minor materials.	
	17	Land use and utilization of local resources	B-	D	**Before construction:** There are changes in the land use and utilization of local resources because of resettlement and land acquisition.	Since water flow during the rainy season does not change significantly, impacts are limited if any.
				B+		There are beneficial impacts on water utilization from the reservoir to provide more stable water to irrigation systems, and drinking water systems.
	18	Water usage	B-	C	If there are water utilization activities in the downstream area, muddy waters during the rainy season may cause impacts in the downstream. It	Upper reservoir: Although there is another reservoir just downstream of the upper reservoir, the catchment area of the upper

Category	No.	Expected impact	Evaluation		Explanation on the evaluation	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					is necessary to conduct a survey to confirm the scale and nature of impacts in the downstream area.	reservoir is small and it is expected that impact is limited if any. Lower reservoir: Only first infilling to the reservoir is necessary, and after the first filling, the water overflows to the downstream during the rainy season. It is therefore expected that impact is limited if any.
	19	Existing social infrastructures and services	B-	D	There is a possibility that roads and bridges may be damaged because of heavy transportation vehicles. Traffic jams and accidents are expected.	There are no works and activities which may cause impacts on the existing social infrastructures and services.
			C-		There are no schools and hospitals near both dam/reservoir sites but it has not been surveyed on schools and hospitals near related facilities. It may be negative impacts on schools and hospitals near the related facilities.	
	20	Social institutions such as social infrastructure and local decision making institutions	B-	D	There are impacts on the social institutions because of resettlement.	There are no works and activities which may cause impacts on the social institutions.
	21	Uneven distribution of benefits and damages	B-	D	**Before construction:** Uneven distribution of benefits and damages may happen among the PAPs.	There are no works and activities which may cause uneven distribution of benefits and damages.

Category	No.	Expected impact	Evaluation		Explanation on the evaluation	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					Construction stage: Without appropriate and acceptable guidelines of employment qualification and procurement of minor materials, it may give unfair impression to the local people and may cause social conflict among them.	
	22	Local conflicts of interest	B-	D	**Before construction:** Because of resettlement, social conflict may happen among the PAPs. **Construction stage:** Without appropriate and acceptable guidelines of employment qualification and procurement of minor materials, it may give unfair impression to the local people and may cause social conflict among them.	There are no works and activities which may cause local conflicts of interest.
	23	Cultural heritages	D	D	There is neither World Cultural Heritage Site nor other cultural heritage in and around the Project site.	There are no works and activities which may cause negative impacts on cultural or religious heritages.
			B-		There is a kovil (hindu temple) within the upper reservoir site, and it needs to be relocated. There is no such a religious facility in the lower site.	
	24	Landscape	B-	B-	There is a change in the landscape because of dam and reservoir construction.	Although existence of new structures (i.e. dams, reservoirs and other facilities) make the landscape changed, appropriate mitigation measures reduce the negative impact to harmonize the dams and others with natural and social surrounding landscape.
	25	Gender	C	C	Although it is not expected negative impacts on gender issues, it is required to conduct a survey	Although it is not expected negative impacts on gender issues, it is required to conduct a survey

Category	No.	Expected impact	Evaluation		Explanation on the evaluation	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
					on social environment to confirm the scale and nature of the impacts if any.	on social environment to confirm the scale and nature of the impacts if any.
	26	Children's rights	C	C	It is not expected negative impacts on children's rights gender issues. For example, child labor is prohibited by an act. It is, however, required to conduct a survey on social environment to confirm the scale and nature of the impacts if any.	Although it is not expected negative impacts on children's rights gender issues, it is required to conduct a survey on social environment to confirm the scale and nature of the impacts if any.
	27	Infectious diseases such as HIV/AIDS	B-	B-	Infectious diseases may be spread because of the inflow of labor from outside.	Water-borne and / or mosquito-borne diseases may occur but the impacts are expected to be limited.
	28	Labor conditions	B-	D	It is necessary to give sufficient consideration to labor conditions of construct workers.	There are no works and activities which may cause negative impacts on labor conditions.
Others	29	Accidents	B-	B-	It is necessary to give sufficient consideration to accidents during the construction works.	Traffic accidents may increase because of new access road.
	30	Trans-boundary impacts / global warming	B-	B-	CO_2 is released because of tree felling in the reservoir area and it gives negative impact on global warming, but the impact is limited.	Greenhouse gases may be released from the reservoirs, but limited because of the nature of the power generation mechanism of the PSPP.
			D	B-	No trans-boundary impacts are expected.	The plant needs electricity for pumping up water from the lower reservoir to the upper reservoir. The electricity is expected to come from a coal-fired power plant as a base load power generation facility in 2025 in Sri Lanka. A preliminary calculation how much the PSPP emits CO_2 has been conducted by the JICA Study Team based on the data in Japan and the conditions in Sri Lanka. The result is 418g-CO_2/kWh. According to the data in Japan, the amount of the emission from a LNG-fired power plant in

Category	No.	Expected impact	Evaluation		Explanation on the evaluation	
			Con.	O&M	Construction (Con.) Stage (If impacts are expected before this stage, explanations are given.)	Operation and Maintenance (O&M) Stage
						Japan is 564 g-CO_2/kWh (average).
	31	Transmission lines	D	D	**Before construction:** An assessment of the route of the transmission line with 1,000 m buffer zone has been conducted, and the results shows that the impacts on the natural and social environments are expected to be small or limited. The route does not go through any protected areas or IBAs. Migratory routes of birds are not reported.	There are no works and activities which may cause negative impacts on surrounding environments.

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive /negative impact is unknown (A further examination is needed, and in the impact could be clarified as the study progress).

D: No impact is expected.

Project for
Maha Pumped Storage Power Plant Development, Sri Lanka[1]

Terms of Reference
Environmental Impact Assessment Study

TENTATIVE AND DRAFT ONLY

1. PROJECT

1.1 Objectives of the Project

The objectives are to be described at the early stage of the feasibility study of the Project.

One of the objectives of the Project is to conduct the Project under the relevant Sri Lanka Laws and Policies and the "Guidelines for Environmental and Social Considerations (2010)" by the Japan International Cooperation Agency (JICA).

1.2 Outline of the Project (including the site description)

To be described at the early stage of the feasibility study of the Project.

2 ENVIRONMENTAL IMPACT ASSESSMENT STUDY

2.1 Introduction

An Environmental Impact Assessment Study (herein after referred to as the EIA Study) shall be conducted to prepare an EIA report for the Project. A draft Resettlement Action Plan (RAP) for the Project shall also be prepared as part of the EIA Study.

The draft EIA report and draft RAPs shall be prepared under the relevant Sri Lankan Laws /Policies and the "Guidelines for Environmental and Social Considerations (2010)" by the Japan International Cooperation Agency (JICA).

2.2 Components of the EIA Study

The EIA Study shall consist of the following components. However, the components are subject to change under the Terms of Reference (TOR) prepared by the Central Environment Authority, Sri Lanka.

[1] It is a tentative name of the Project, and is subject to change.

- Baseline Survey shall be conducted at each upper and lower dam/reservoir site and the proposed transmission line route to collect necessary data for the EIA Study.
- Stakeholders meetings (SHM. i.e. public consultations) shall be conducted at the sites by the Ceylon Electricity Bureau (CEB) to propose mutual agreeable conditions and practical mitigation measures, the SHM shall be held at least twice in the course of the EIA Study;
- An expert committee shall be set up by CEB for discussing methodology to understand the statuses of endangered species found in the sites and a management plan to mitigate impacts on these species. The meetings of the expert committee shall be supported by the JICA Study Team;
- EIA shall be conducted based on the technical, economic and environmental aspects of the Project and tangible mitigation measures;
- EIA report shall be prepared;
- Draft RAP shall be prepared; and,
- JICA Environmental Checklist on the Project shall be prepared.

2.3 Study Area

The Study Area is tentatively defined as the following, but they are subject to change under the TOR prepared by the Central Environment Authority, Sri Lanka.

Maps shall be provided by the JICA Study Team.

- Dam/reservoir sites: 500 meters from the high water of the reservoirs and from dam sites (or watershed boundary) are considered to be the boundary of the affected area.
- Tunnel: A width of 100 meters between the upper and lower reservoirs
- Related facilities: switch yard, quarry site, dumping site, and access road
- Transmission line: About 3 km of a route from a proposed switch yard to the existing transmission line

3. SCOPE OF THE WORKS

The contents of the works below are tentative and subject to change under the TOR prepared by the Central Environment Authority, Sri Lanka.

3.1 Assisting the JICA Study Team

The Consultant shall assist the JICA Study Team and its members to conduct the Project whenever necessary.

Especially before conducting the Study, the Consultant shall discuss the scoping of the Project with the JICA Study Team. The scoping table (tentative) is attached as Appendix 1.

3.2 Baseline Survey on the Physical Conditions

The following baseline data are collected at each dam/reservoir site (except for the transmission line):

- Ambient air quality (2 sites at each dam/reservoir site: 8 sites for the EIA Study)
- Ambient water quality of the river (2 sites at each dam/reservoir site: 4sites for the EIA Study)
- Noise (2 sites at each dam/reservoir sites: 4sites for the EIA Study)

NOTE: Number of sampling sites and points may increase.

3.3 Baseline Survey on the Natural Environment

Several endangered species listed in the Red list of Sri Lanka (2012) have been recorded at the upper and lower dam/reservoir sites. The Consultant shall conduct comprehensive baseline surveys to understand the status of these species and their habitats.

Methodology, results of the survey, and management plan shall be discussed at the expert committee. The Consultant is required to support CEB to hold the meetings of the expert committee (e.g. logistics and preparation of discussion papers) in close consultation with the JICA Study Team.

The Consultant shall propose a tangible plan to minimize and mitigate the impacts to these species as part of the management plan in the EIA report.

3.4 Baseline Survey on the Social Environment

The Consultant shall conduct a comprehensive Baseline Survey on the Social Environment to prepare the draft EIA report and a draft RAP.

The details of the questionnaires for the Baseline Survey shall be discussed with the JICA Study Team.

3.5 Public consultations

The Consultant shall assist CEB to hold SHMs at each dam/reservoir site and transmission line route.

According to the JICA Guidelines, SHM should be held at least twice: the one at the time when the scoping (draft) is prepared; and the other when the draft EIA report is prepared.

3.6 Formulation of the EIA report

The Consultant shall prepare the EIA report with a draft RAP in English (refer to Appendix 2 for their contents, and to Appendix 3 for the main different points between the Sri Lankan Resettlement Policy and the JICA Guidelines).

3.7 Formulation of the JICA Environmental Checklist

The Consultant shall prepare the JICA Environmental Checklist (Appendix 4) for the Project.

4. WORK SCHEDULE

The work schedule has not yet decided. The duration of the EIA Study including the reporting is tentatively 12 to 13 months.

It is important to cover breeding and non-breeding seasons of the endangered species in the Study Area.

The details of the schedule shall be described in the TOR of the Contract.

5. REPORTING

All the survey results and relevant analysis shall be submitted to the Client by hard copy documents and digital data. Executive summaries shall be attached to all reports.

All reports shall be written in English.

The details of the reports including their schedule shall be described in the TOR of the Contract.

All reports and documents shall be professionally edited by a third party editor before the submission.

6. EQUIPMENT, INSTRUMENTS, TOOLS, MATERIALS, STAFF AND LABORERS

All equipment, instruments, tools, materials, staff and laborers necessary of the EIA Study shall be prepared by the Consultant. If the Consultant has obtained any certificate for the survey equipment from an agency concern, the Consultant shall submit a copy of the certificate to the Client.

7. COST OF TRANSPORTATION, ACCOMMODATION AND OTHER EXPENSES

The Consultant shall bear the cost of all transportation including local transportation of the staff of the Consultant, laborers, equipment to/from the sub-project sites.

The Consultant shall bear the cost of all accommodation and other expenses at its own expenses.

The details of them shall be described and agreed by the Contract.

8. SAFETY AND SECURITY

The consultant shall take every necessary measure to provide safety and security for its staff and laborers at the sub-project area at her own expenses.

The details of it shall be described and agreed by the Contract.

9. MEASUREMENT OF PAYMENT

Measurement and payment for the EIA Study shall be made for all items on lump-sum

basis. The contract prices for every item shall include all costs of man power, material and all other things required to perform all of the specified works.

End of the document.

Appendix 1

Scoping table (tentative) of the Project by the JICA Study Team

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Appendix 2

Contents of the EIA report (tentative)

1. Methodology of the EIA Study	
2. Description of the Project	
	(1) Upper dam/reservori site
	(2) Lower dam/reservori site
	(3) Transmission line
3. Framework of Environmental Impact Assessment in Sri Lanka	
	(1) Legal Framework
	(2) Institutional Framework
	(3) Standards (ambient air, ambient water, noise)
4. Alternative for each sub-project	
	(1) Upper dam/reservori site
	(2) Lower dam/reservori site
	(3) Transmission line
5. Baseline Survey	
	(1) Physical and Natural Environment
	(2) Social Environment
6. Scoping of the Project	
7. Environment and Social Impact Analysis of the Project	
	(1) Upper dam/reservori site
	(2) Lower dam/reservori site
	(3) Transmission line
8. Environmental Assessment	
	(1) Upper dam/reservori site
	(2) Lower dam/reservori site
	(3) Transmission line
9. Mitigation Measures and Costs	
	(1) Upper dam/reservori site
	(2) Lower dam/reservori site
	(3) Transmission line
10. Environment and Social Management and Monitoring Plan	
	(1) Upper dam/reservori site
	(2) Lower dam/reservori site

	(3) Transmission line
11. Stakeholders Meetings	
	(1) Upper dam/reservori site
	(2) Lower dam/reservori site
	(3) Transmission line

NOTE: Tunnel and other related facilities are described either in "(1) Upper dam/reservoir site" or in "(2) Lower dam/reservoir site" sections.

Contents of the draft RAP (tentative)

NOTE: The draft RAP should be formulated for EACH dam/reservoir site.

1 Necessity of Resettlement and Land Acquisition	
2 Description of the Project	
	(1) Upper dam/reservori site
	(2) Lower dam/reservori site
3 Legal Framework of Environmental Impact Assessment in Sri Lanka	
	(1) National Legal Framework
	(2) Comparison between the JICA's Guidelines and Sri Lankan Resettlement Policy (refer to Appendix 3. The Consultant is required to review the contents and add/correct the contents if necessary)
	(3) Basic concept of the resettlement for the Project
4 Scope of the Resettlement Impact	
	(1) Census
	(2) Demographic situation
	(3) Asset and land use
	(4) Socially vulnerable people
5 Measures of Compensation and Support to the Project Affected Persons	
	(1) Compensation
	(2) Rehabilitation of living standard
	(3) Entitlement Matrix
6 Grievance Redness Mechanism	
7 Environment and Social Impact Analysis of each sub-project	
	(1) Upper dam/reservori site
	(2) Lower dam/reservori site
8 Institutional Framework of the RAP	
9 Schedule of the Resettlement and land Acquisition	
10 Cost Estimation and Financial Source	
11 Monitoring Program for the RAP	
12 Public Consultation (stakeholders meetings)	

Appendix 3

Comparison between the Sri Lankan Resettlement Policy and the JICA Guidelines

(prepared by the JICA Study Team on 01 July 2013)

Item	Sri Lankan Resettlement Policy	JICA Guidelines
Resettlement Action Plan (RAP)	In case that number of resettled households is 20 or more, a RAP is prepared.	The project proponent is obliged to prepare a RAP. If number of resettled household is small (e.g. one household), the RAP can be simplified one. RAP is firstly prepared as part of EIA Report.
Compensation for land resettlement	Cost is calculated at prevailing market prices.	Full replacement cost must be applied as much as possible.
Compensation for non-registered residents	The land acquisition act does not have any provision on this issue.	All residents before cut-off-date are eligible.
Grievance redress mechanism	No specific opportunity is provided.	Project proponent is obliged to have a grievance redness mechanism.

Appendix 4

JICA Environmental Checklist: Hydropower Stations, Dams and Reservoirs

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) (b) (c) (d)	(a) (b) (c) (d)
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a) (b)	(a) (b)
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a)	(a)
2 Pollution Control	(1) Water Quality	(a) Does the water quality of dam pond/reservoir comply with the country's ambient water quality standards? Is there a possibility that proliferation of phytoplankton and zooplankton will occur? (b) Does the quality of water discharged from the dam pond/reservoir comply with the country's ambient water quality standards? (c) Are adequate measures, such as clearance of woody vegetation from the inundation zone prior to flooding planned to prevent water quality degradation in the dam pond/reservoir? (d) Is there a possibility that reduced the river flow downstream will cause water quality degradation resulting in areas that do not comply with the country's ambient water quality standards? (e) Is the discharge of water from the lower portion of the dam pond/reservoir (the water temperature of the lower portion is generally lower than the water temperature of the upper portion) planned by considering the impacts to downstream areas?	(a) (b) (c) (d) (e)	(a) (b) (c) (d) (e)
	(2) Wastes	(a) Are earth and sand generated by excavation properly treated and disposed of in accordance with the country's regulations?	(a)	(a)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
3 Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a)	(a)
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) Is there a possibility that the project will adversely affect downstream aquatic organisms, animals, plants, and ecosystems? Are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Is there a possibility that installation of structures, such as dams will block the movement of the migratory fish species (such as salmon, trout and eel those move between rivers and sea for spawning)? Are adequate measures taken to reduce the impacts on these species?	(a) (b) (c) (d)	(a) (b) (c) (d)
	(3) Hydrology	(a) Is there a possibility that hydrologic changes due to the installation of structures, such as weirs will adversely affect the surface and groundwater flows (especially in "run of the river generation" projects)?	(a)	(a)
	(4) Topography and Geology	(a) Is there a possibility that reductions in sediment loads downstream due to settling of suspended particles in the reservoir will cause impacts, such as scouring of the downstream riverbeds and soil erosion? Is there a possibility that sedimentation of the reservoir will cause loss of the storage capacity, water logging upstream, and formation of sediment deposits at the reservoir entrance? Are the possibilities of the impacts studied, and adequate prevention measures taken? (b) Is there a possibility that the project will cause a large-scale alteration of the topographic features and geologic structures in the surrounding areas (especially in run of the river generation projects and geothermal power generation projects)?	(a) (b)	(a) (b)

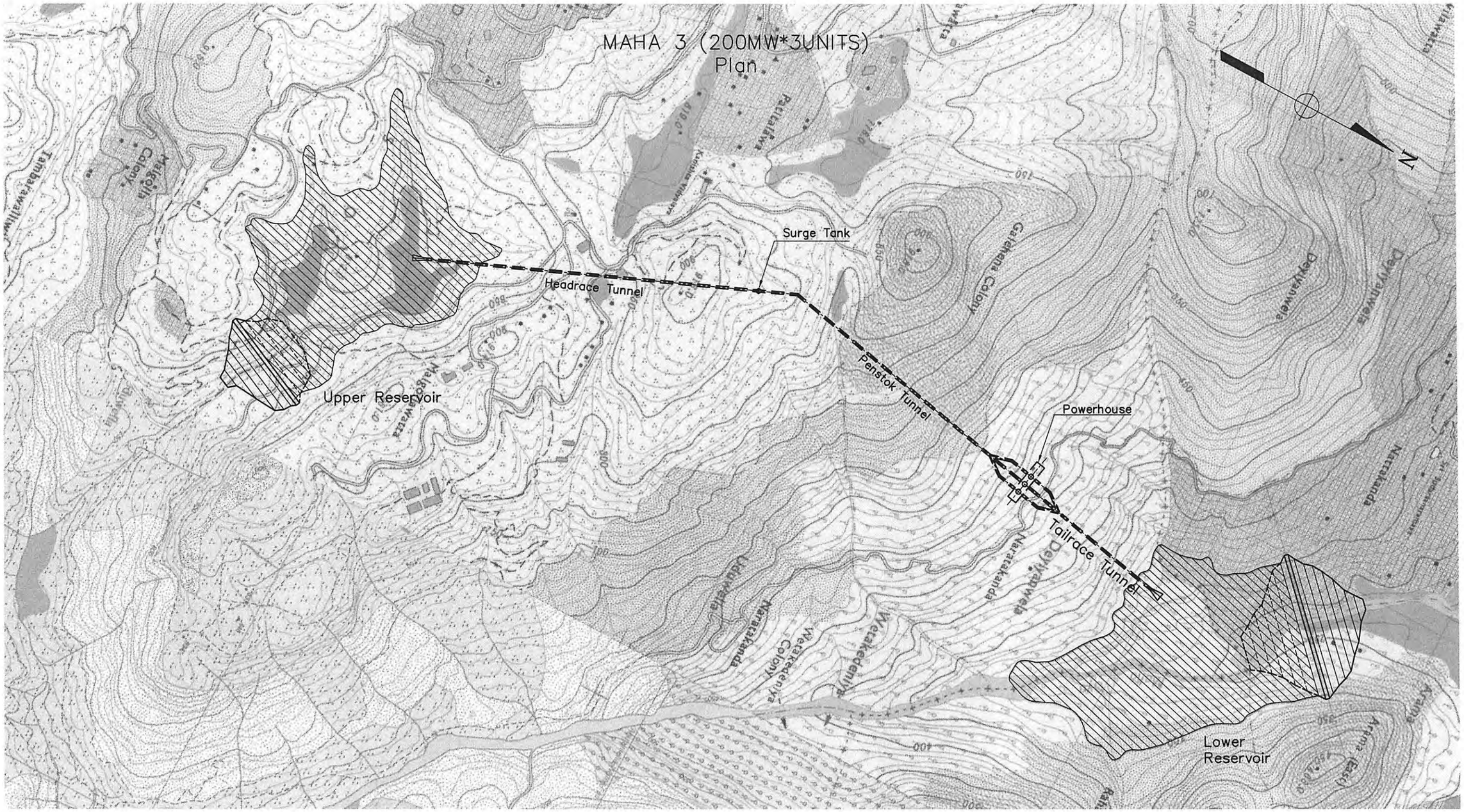
Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Are the compensations going to be paid prior to the resettlement? (e) Are the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a) (b) (c) (d) (e) (f) (g) (h) (i) (j)	(a) (b) (c) (d) (e) (f) (g) (h) (i) (j)
	(2) Living and Livelihood	(a) Is there any possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? (b) Is there any possibility that the project causes the change of land uses in the neighboring areas to affect adversely livelihood of local people? (c) Is there any possibility that the project facilities adversely affect the traffic systems? (d) Is there any possibility that diseases, including infectious diseases, such as HIV, will be brought due to the immigration of workers associated with the project? Are adequate considerations given to public health, if necessary? (e) Is the minimum flow required for maintaining downstream water uses secured? (f) Is there any possibility that reductions in water flow downstream or seawater intrusion will have impacts on downstream water and land uses? (g) Is there any possibility that water-borne or water-related diseases (e.g.,	(a) (b) (c) (d) (e) (f) (g) (h)	(a) (b) (c) (d) (e) (f) (g) (h)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		schistosomiasis, malaria, filariasis) will be introduced? (h) Is there any possibility that fishery rights, water usage rights, and common usage rights, etc. would be restricted?		
4 Social Environment	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a)	(a)
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a)	(a)
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources to be respected?	(a) (b)	(a) (b)
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a) (b) (c) (d)	(a) (b) (c) (d)
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce the impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce the impacts?	(a) (b) (c)	(a) (b) (c)
	(2) Accident Prevention Measures	(a) Is a warning system established to alert the inhabitants to water discharge from the dam?	(a)	(a)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
5 Others	(3) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a) (b) (c) (d)	(a) (b) (c) (d)
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Forestry Projects checklist should also be checked (e.g., projects in the mountains including large areas of deforestation). (b) In the case of dams and reservoirs, such as irrigation, water supply, and industrial water purposes, where necessary, pertinent items described in the Agriculture and Water Supply checklists should also be checked. (c) Where necessary, pertinent items described in the Power Transmission and Distribution Lines checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities).	(a) (b) (c)	(a) (b) (c)
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a)	(a)

1) Regarding the term “Country’s Standards” mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are requested to be made. In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).
2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

MAHA 3 (200MW*3UNITS)
Plan



Upper Reservoir (200MW×3units)		
Latitude		7°06'23"
Longitude		80°28'49"
Catchment Area	km^2	1
Reservoir Area	km^2	0.22
Crest Elevation	E.L.-m	821.0
High Water Level	E.L.-m	815.0
Low Water Level	E.L.-m	794.5
Drawdown	m	20.5
Sediment Level	E.L.-m	782.3
Gross Capacity	MCM	3.71
Available Capacity	MCM	3.15
Dam Height	m	59
Crest Length	m	260

Lower Reservoir (200MW×3units)		
Latitude		7°07'50"
Longitude		80°28'49"
Catchment Area	km^2	35
Reservoir Area	km^2	0.24
Crest Elevation	E.L.-m	298.5
High Water Level	E.L.-m	292.5
Low Water Level	E.L.-m	276.4
Drawdown	m	16.1
Sediment Level	E.L.-m	263.2
Gross Capacity	MCM	6.22
Available Capacity	MCM	3.20
Dam Height	m	74
Crest Length	m	380

Waterways (200MW×3units)			
Headrace Tunnel			
	Inner Diameter	m	5.60
	Length	m	960
	Nos. of lines	-line	1
Penstock Tunnel			
	Inner Diameter	m	4.30
	Length	m	993
	Nos. of lines	-line	1
Tailrace Tunnel			
	Inner Diameter	m	6.10
	Length	m	415
	Nos. of lines	-line	1
Access Tunnel to PH			
	Length	m	900

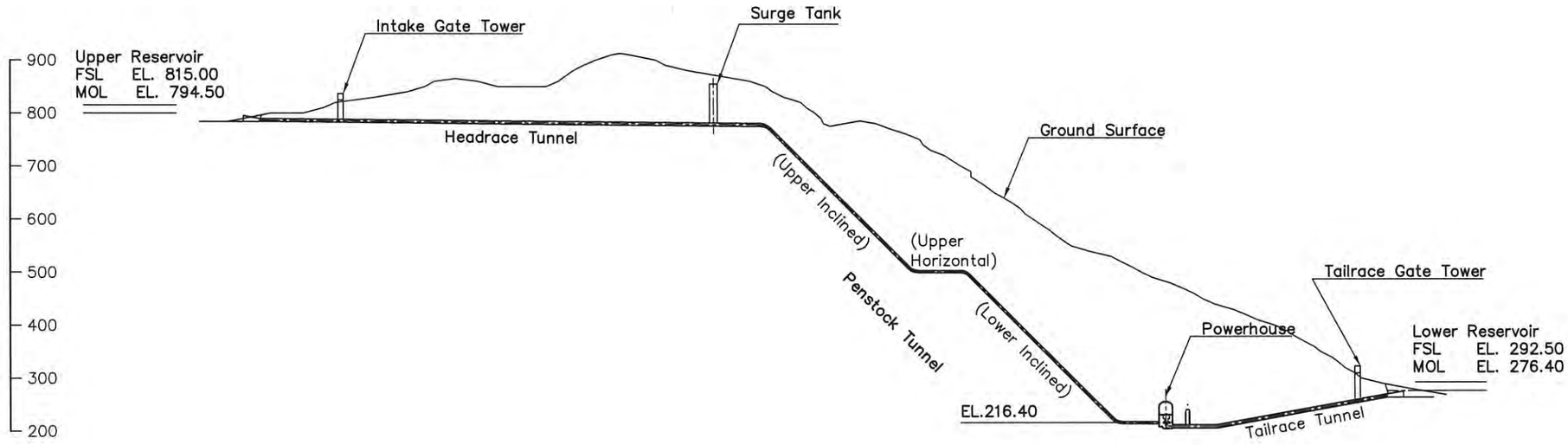
Electric Power Development Co., Ltd

MAHA 3
200MW/unit*3unit
Plan

Appendix 12.5–1

January, 2015

MAHA 3 (200MW*3UNITS)
Profile



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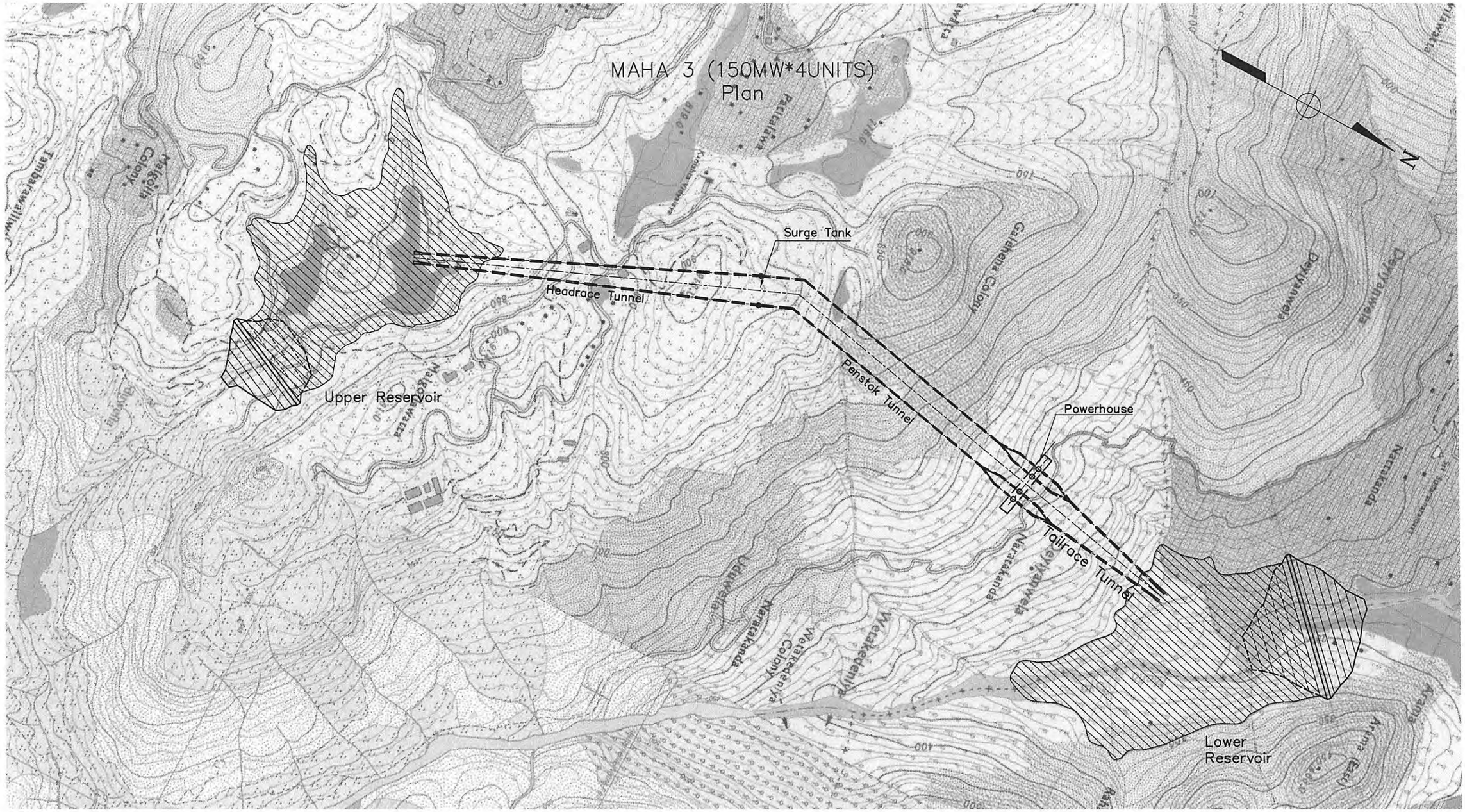
MAHA 3 200MW/unit*3unit Profile	
Appendix 12.5-2	
	January, 2015



Upper Reservoir (150MW×4units)		
Latitude		7°06'23"
Longitude		80°28'49"
Catchment Area	km^2	1
Reservoir Area	km^2	0.22
Crest Elevation	E.L.-m	820.5
High Water Level	E.L.-m	814.5
Low Water Level	E.L.-m	791.3
Drawdown	m	23.2
Sediment Level	E.L.-m	782.3
Gross Capacity	MCM	3.60
Available Capacity	MCM	3.27
Dam Height	m	59
Crest Length	m	260

Lower Reservoir (150MW×4units)		
Latitude		7°07'50"
Longitude		80°28'49"
Catchment Area	km^2	35
Reservoir Area	km^2	0.24
Crest Elevation	E.L.-m	297.5
High Water Level	E.L.-m	291.5
Low Water Level	E.L.-m	273.0
Drawdown	m	18.5
Sediment Level	E.L.-m	263.2
Gross Capacity	MCM	5.78
Available Capacity	MCM	3.30
Dam Height	m	73
Crest Length	m	380

Waterways (150MW×4units)		
Headrace Tunnel		
Inner Diameter	m	4.00
Length	m	960
Nos. of lines	-line	2
Penstock Tunnel		
Inner Diameter	m	3.10
Length	m	996
Nos. of lines	-line	2
Tailrace Tunnel		
Inner Diameter	m	4.40
Length	m	415
Nos. of lines	-line	2
Access Tunnel to PH		
Length	m	900

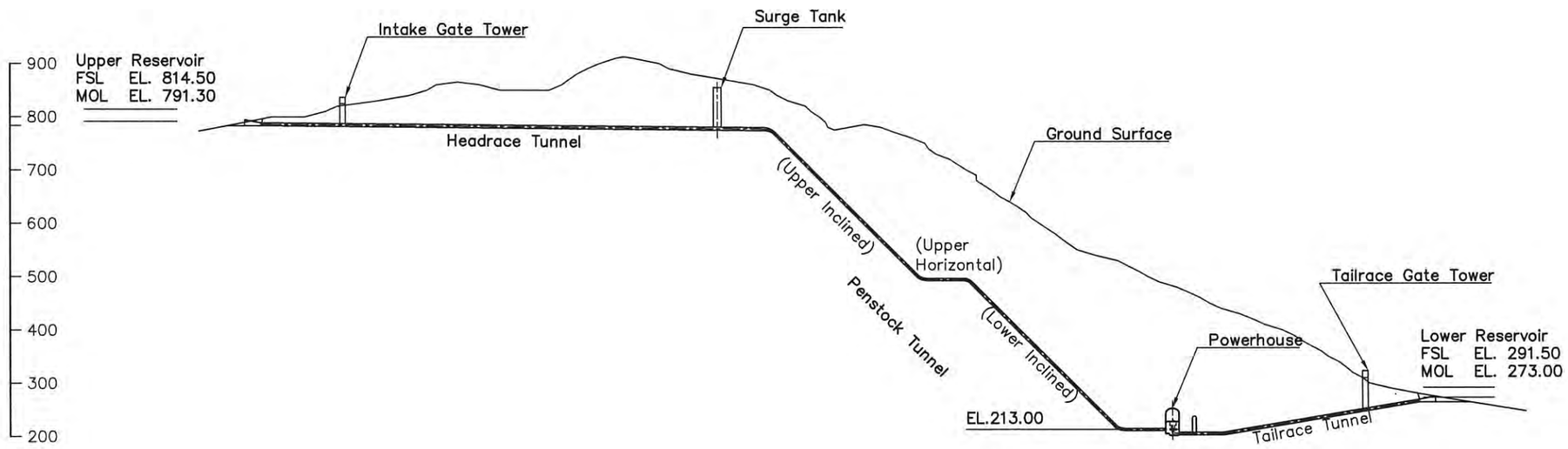
Electric Power Development Co., Ltd

MAHA 3
150MW/unit*4unit
Plan

Appendix 12.5-3

January, 2015

MAHA 3 (150MW*4UNITS)
Profile



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MAHA 3 150MW/unit*4unit Profile
Appendix 12.5−4
January, 2015