Additional Environmental Studies

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Sri Lanka: Green Power Development and Energy Efficiency Improvement Investment Program

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ADDITIONAL STUDIES ON NATURAL ENVIRONMENT FOR REVIEW OF FEASIBILITY STUDY AND PREPARATION OF DETAILED DESIGN AND BIDDING DOCUMENTS
MORAGOLLA HYDROPOWER PROJECT, SRI LANKA

Final Report 1

Water quality in the Mahaweli Ganga - upstream and downstream of the proposed dam at Moragolla

Prepared by
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Prepared for
NIPPON KOEI Co Ltd - Moragolla Hydropower Project

July 2013

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Executive Summary

Introduction

The Ceylon Electricity Board (CEB), the institution responsible for electricity generation, transmission, distribution and retailing in the country, plans to develop a new hydropower scheme in Moragolla, Kandy with a designed capacity of 30.0 MW. The proposed project envisages construction of a 35 m high dam across the Mahaweli Ganga at Weliganga.

Nippon Koei Co. Ltd., the consultant appointed by CEB to review the feasibility study and prepare designs and bidding documents for the Moragolla Hydropower Project, appointed the National Building Research Organization (NBRO) to conduct additional studies on the natural environment. This work is one of several studies conducted in order to update and upgrade the previous EIA study to comply with the ADB safeguard policy (Safeguard Policy Statement, ADB 2009).

In this regard, the water quality of the Mahaweli Ganga was studied with the intention of: investigating the present water quality upstream and downstream of the proposed dam in order to determine the nature, extent and sources of pollution, to predict the likely impacts of the Moragolla HP Project during the operational stage and to propose mitigation measures for likely negative impacts.

The river water in the study area is used for bathing by the local people and also for some industry and irrigation. The potential pollution sources include one point pollution source: the wastewater outfall of Crysbro Broiler Farm, sand mining sites and diffuse pollution from small tea plantations on either side of the river upstream.

Monitoring river water quality

Water samples were collected at 10 locations from upstream of each of the rivers from the confluence of the Kotmale Oya and the Mahaweli River to downstream of the confluence of Atabage Oya and Mahaweli River, on ten locations on 06.03.2013 during low flow season (dry season) and on 15.05.2013 during the high flow season (wet season). In situ measurements of pH, Temperature, Dissolved Oxygen, and Turbidity were undertaken and BOD_5, Ammonia, Nitrate, Total Phosphorus, Total Suspended Solids, Faecal Coliforms and Total Coliforms were analyzed in the NBRO laboratory. Sampling and analysis were carried out according to National and International Standard Methods. Water quality status and seasonal variations are reported and compatibility with proposed national standards; “Ambient Water Quality – EA1P-DHV-2000” is assessed.

Status of river water quality

In general, increased levels of several determinands were observed in the wet season compared to the dry season. Notably high levels were observed in wet season for Nitrates, Ammonia, Total Coliforms, Total Suspended Solids and Total Phosphorus. Levels of pH, DO, BOD_5, Nitrates, Ammonia and Total Phosphorus of all samples were observed to be within the acceptable limits of the standards in the categories considered namely, Drinking water with simple and conventional treatment, Bathing, Fish and aquatic life, and irrigation and agriculture in both seasons. Bacteriological counts of the water were found to be in a range which exceed the safe limits for the above categories , however with some deviations and hence, water in this part of the Mahaweli River is not suitable for drinking (after simple or conventional treatment) or bathing, because of its high bacterial content. The field observations and analysis of wastewater of Crysbro Broiler farm provide evidence of potentially high pollutant levels, specially: Biochemical Oxygen Demand, Total Suspended Solids, and faecal coliforms and oil and grease.

Water quality impacts due to power plant operation

The water quality of the proposed reservoir after impoundment is likely to be affected due to the accumulation of sediments and nutrients. The proposed reservoir would receive sediments from the upstream area, due to ingression of silt-laden runoff water, especially during the wet season when the average rainfall is relatively high. High amount of nutrient - bound sediments might trigger eutrophication in the proposed reservoir and accumulation of the floating, and the settleable (organic) debris would also impair the water quality. In contrast, reduction of Faecal Coliform counts and Suspended Solids can be anticipated due to their natural decay after longer retention in the reservoir. Reduction of these constituents will have a positive impact on the downstream water quality. The entry of floating debris of plant and anthropogenic origin, was observed to be a possible source of contamination, and this would increase the organic content, nutrients and suspended load in the reservoir with potential impacts on water quality and the power generation turbines.

Water quality downstream of the dam is likely to be affected by impacts such as flow reduction, reduction of sediment load, altered nutrient flux during the operational stage. Since the Crysbro Broiler Farm discharges its wastewater into this part of the Mahaweli River, significant deterioration of the quality can be anticipated due to inadequate dilution, especially in the dry season. The irrigation water supply, Dunhinda Ela, is likely in the downstream to be affected, because water contaminated with the broiler farm wastewater may enter into the irrigation water canal and pose potential health problems. Impacts on the drinking water sources, in the downstream area are insignificant as there are no drinking water intakes between the proposed dam and the tailrace outlet. It may take 30 years or more for the sediment in the reservoir to reach the spillway crest level. The sediment further accumulated needs to be removed without extreme increases in sediment load in the downstream. Release of the intended environmental flow, $1.5 m^3/sec$, will have a significant positive impact on the river water quality up to the tailrace outlet. Nevertheless, the analysis of wastewater of Crysbro Broiler Farm suggests possibility of exceeding tolerance limits for industrial wastewater discharge standards.

Proposed mitigation measures

In the operation phase, floating debris is suggested to be discharged downstream with water over the flap gate mounted on one of the spillway gates. Debris built up at the intake trashrack can be removed by a mechanical rake. The sediment accumulated above the spillway crest level will be removed by mechanical dredging or sediment sluicing through the spillway gates at the high flow season or the combination thereof. Regular monitoring of Crysbro Broiler Farm's effluent to ensure the enforcement of stipulated industrial discharge limits and relocation of the effluent outfall downstream of the proposed tailrace outlet are recommended as alternative mitigation measures to minimize the downstream water quality impacts due to above wastewater discharge during the operational stage.

1. Introduction

The Ceylon Electricity Board (CEB) plans to develop a new 30.0 MW hydropower project at Moragolla in Kandy District. The scheme involves construction of a 35 m high concrete gravity dam (with a 5-gate spillway) across the Mahaweli Ganga at Weliganga, to create a 38.5 ha (1.98 MCM) reservoir with a Full Supply Level (FSL) at 548 msl. The water from the reservoir will be diverted through a 3.1 km underground tunnel, surge shaft and penstock on the left bank of the river, to a powerhouse and outfall located opposite the confluence with the Atabage Oya.

The CEB intend seeking international financial support for the project implementation and potential funders include the Asian Development Bank (ADB). For this purpose, CEB has appointed Nippon Koei Co. Ltd in joint venture with Nippon Koei India Pvt Ltd to review the Feasibility Study and prepare detailed designs and bidding documents for the project. Review of the EIA indicated that further studies were needed in order to update and amend the document to comply with ADB safeguard policy (Safeguard Policy Statement, ADB 2009).

The Nippon Koei Co. Ltd, Moragolla Hydropower Project appointed the National Building Research Organization (NBRO) to conduct the following additional studies on natural environment:

- Water quality of the Mahaweli Ganga
- Aquatic ecology of the Mahaweli Ganga
- Groundwater quality and distribution along the proposed tunnel route
- Updated land-use mapping

This report presents the study conducted for river water quality as described in Terms of Reference (ToR) shown in **Annex 1,** which addresses following aspects:

- Water quality in the river upstream and downstream of the proposed dam site at Moragolla during the low flow season in March 2013 and May 2013; at the start of high flow season
- Sampling, analysis and Quality Control procedures
- Local and seasonal variations in the water quality in the Mahaweli Ganga
- Likely water quality impacts in the reservoir during and after impoundment, with a discussion of likely seasonal variations
- Likely water quality impacts downstream during scheme operation
- Mitigation measures

2. Scope of the study

The ToR required river water quality to be monitored in two seasons namely, dry season- low flow condition and wet season- high flow condition. Accordingly, two sampling events were planned. Monitoring in dry and wet seasons was conducted in March and May, 2013 respectively.

In the sampling program, 10 locations were employed for the collection of water samples at approximately 500 m intervals along the river. These extended from 500 m above the confluence between the Kotmale Oya and Mahaweli Ganga (one station at the confluence and one station

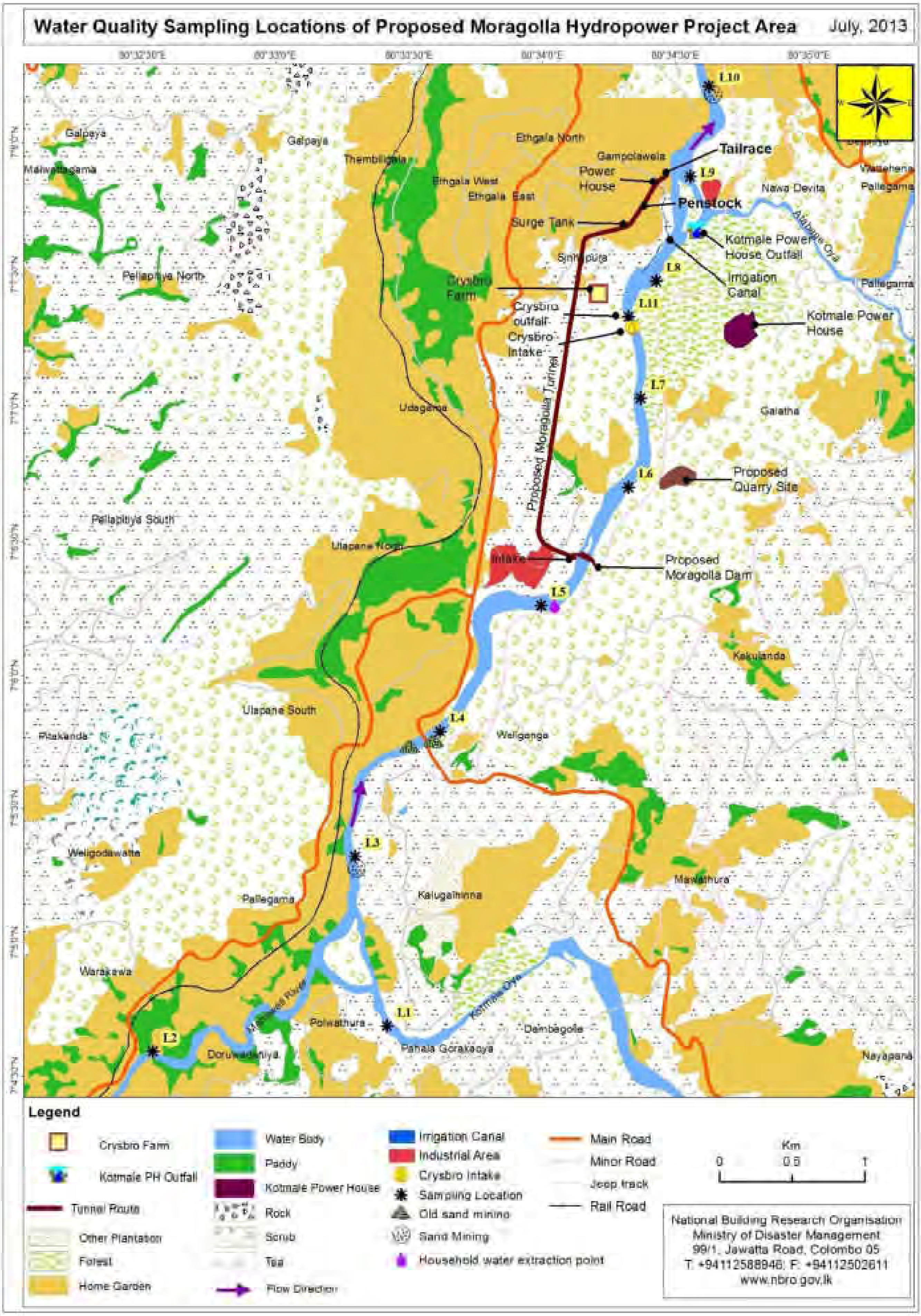
500 m upstream in both rivers) to 500 m downstream of the confluence with the Atabage Oya. The locations were chosen with the intention to capture baseline water quality of the river immediately upstream and downstream of the proposed Moragolla dam and the reservoir. Duplicate samples were supposed to be collected from all 10 locations within a day.

3. Justification for selection of sampling points

The project staff of NBRO (refer **Annex 2**) visited the study area on the 1st, 2nd and 5th March 2013 to decide sampling locations. In these site visits, it was found that access to some sampling locations indicated in the ToR was difficult due to steep terrain conditions. It was also noticed that proposed upstream locations around the confluence inundate during high-flow conditions as floodplain is wide in this river section. The sampling points 1, 2 and 3 specified in the ToR were changed accordingly (refer Fig.1, **Annex 3**: L1, L2 and L3). The water quality at these sampling points can be considered representative of those specified in the ToR, as there were no major inputs from tributaries between the two.

Although, the ToR specified a sampling point at Crysbro Broiler Farm wastewater outfall, this could not be established due to the following site-specific reasons (a) the Crysbro Broiler Farm has installed a pipeline to divert its wastewater directly into the river, down a very steep slope and this line was observed to be severely damaged during the days of sampling (b) during all sampling sessions there was no discharge from this outfall although it was observed in the initial survey (refer **Annex 4**). A new sampling point replacing the one specified in the ToR (point L8) was then established in the river immediately downstream of the Crysbro wastewater outfall to capture the effects of any discharge from it.

Considering the expected influence of wastewater released from Crysbro Broiler Farm on water quality in the river, an additional visit was made on 2nd July 2013 to locate the wastewater outfall of this farm as there were no indications of any discharge to the waterways from the outfall during previous visits. In this visit, the NBRO team observed a small path carrying wastewater from the farm (refer Fig. 2) getting collected downhill (refer Fig. 2.2). Water samples from this downhill location were collected as access to uphill is very unsafe. This location is assigned, L11 (refer Fig.1 and **Annex 3**).



Water Quality Sampling Locations of Proposed Moragolla Hydropower Project Area
July, 2013
Tailrace
Power House
Penstock
Surge Tank
Kotmale Power House Outfall
Irrigation Canal
Crysbro Farm
Crysbro outfall
Crysbro Intake
Kotmale Power House
Proposed Moragolla Tunnel
Proposed Quarry Site
Intake
Proposed Moragolla Dam
L1
L2
L3
L4
L5
L6
L7
L8
L9
L10
L11
Galpaya
Thembiligala
Ethgala North
Gampolawela
Ethgala West
Ethgala East
Nawa Devita
Pellapitiya North
Pellapitiya South
Udagama
Galatha
Ulapane North
Ulapane South
Kekulanda
Weliganga
Weligodawatta
Pallegama
Kalugalhinna
Mawathura
Warakawa
Polwathura
Pahala Gorakaoya
Dambagolle
Doruwadeniya
Nayapana
Kotmale Oya
Mahaweli River
Legend
Crysbro Farm
Kotmale PH Outfall
Tunnel Route
Other Plantation
Forest
Home Garden
Water Body
Paddy
Kotmale Power House
Rock
Scrub
Tea
Flow Direction
Irrigation Canal
Industrial Area
Crysbro Intake
Sampling Location
Old sand mining
Sand Mining
Household water extraction point
Main Road
Minor Road
Jeep track
Rail Road
Km
0
0.5
1
National Building Research Organisation
Ministry of Disaster Management
99/1, Jawatta Road, Colombo 05
T: +94112588946; F: +94112502611
www.nbro.gov.lk

Fig. 2.1 Flow path of Crysbro Broiler Farm wastewater effluent

Fig. 2.2 Accumulation point of the wastewater

Fig. 2.3 Accumulated oil and grease scum of the wastewater

Fig. 2.4 Floating feathers and oil in the wastewater accumulation point

Fig. 2 Downhill collection point of Crysbro Broiler Farm wastewater

4. The river uses and potential pollution sources

4.1 The river uses

The river water is used for several purposes in the length covered by this survey. These include bathing (local people), industrial use and irrigation. Two bathing spots were observed in the proposed reservoir area during surveys. The water intake of the Crysbro Broiler Farm (abandoned during field surveys) and an irrigation supply named Dunhida Ela are located about 2 km downstream of the proposed dam site. (Refer Fig. 1, **Annex 3**).

4.2 Potential pollution sources

Wastewater discharges
The only point pollution source in the study area near stations L3 and L10 (Fig.1) is the wastewater discharge from the Crysbro Broiler Farm (refer **Annex 3**).

Sand mining activities
There are two active sand mining sites in the study area. The sand is mined manually by using a locally fabricated basin like device fixed to a long bamboo pole. The river bed is scooped using this device, the collected sand is then loaded into floating barges made of bamboo and taken elsewhere. The sand mining activity causes: (a) increased short-term turbidity at the mining site due to re-suspension of sediment during sand removal operations, (b) alteration to river morphology and river bank erosion in the long run. Sand mining activities were not observed during the initial water quality sampling work.

Tea plantations
Isolated small scale plots of tea plantations were observed alongside and adjacent to the river bank, around sampling locations L1, L2, L3 and L8. These plantations use agrochemicals[1] such as fertilizers and pesticides. The runoff contaminated with agrochemicals may pollute the river.

5. Sample collection, transportation and preservation

To reflect the low and high flow water quality conditions, samples were collected on 06.03.2013 (during dry season) and 15.05.2013 (after recent rainfall). All samples were collected between 7.30 am and about 4.00 pm because river flow conditions could change in a short period of time depending on precipitation in the upper catchment. The samples of wastewater discharge from Crysbro Broiler Farm were collected on 02.07.2013. It was done during the high low season and the point of collection was location L1. **Figure 1 and Annex 3** show the sampling locations and **Annex 5** provides the GPS reference and a description of each site.

Sample collection, preservation, transportation and analysis for physicochemical parameters were carried out according to the Standard Methods[2]. The bacteriology (Faecal Coliforms and Total Coliforms) sampling and analysis were done according to the Specification for Potable Water[3]. Different devices were used in sampling depending on the method requirement. Accordingly, samples for general water quality parameters were collected by flinging a clean

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[1] The recommended Nitrogen and Phosphorus fertilizer applications for tea plantations are: Nitrogen, 10kg/ha , P_2O_5 60kg/ha , Source:www.fertilizer.org/ifa/content/download/9002/133893
[2] Standard Methods for the Examination of Water and Wastewater, American Public Health Association, AWWA, WEF, 20th Edition, 1998.
[3] Specification for potable water, bacteriological requirement, Sri Lanka Standards,614:1983, part 2

plastic bucket, tied to a rope, to the flowing water stream. Bottles having a ground-glass stopper and flared mouth were used for the collection of water samples for the determination of Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) whilst pre sterilized bottles were used for the collection of samples for bacteriological analysis. Duplicate water samples were collected from each location within 10 minutes from the collection of first sample. Accordingly, the sampling covered collection of 22 samples from 11 locations.

The water samples collected for water quality parameters except for DO, BOD and bacteriological analysis were transferred securely into clean plastic screw-top containers, and those collected for Dissolved Oxygen were fixed at site by adding $MnSO_4$ and alkali-iodize – azide reagents. All samples were labelled with location No, date and specific parameter to be analysed. Carefully packed samples in separate cooler boxes with ice were then transported to the NBRO laboratory, Colombo on the same day. A temperature of 4 -10^0 C was maintained during transportation. In the laboratory, the samples were stored at 4^0 C until analysis was performed.

6. Analysis of samples for water quality parameters

The ToR instructs that the water should be analyzed for the total of nine water quality parameters, namely, Total Suspended Solids, Biochemical Oxygen Demand (BOD_5), Nitrate, Phosphate, Total Coliforms, Faecal Coliforms, Temperature, Dissolved Oxygen and Turbidity. Considering the presence of forest river cover[4], the slow stream flow in certain sections, rock pools and the nature of anthropogenic pollution sources, Ammonia[4] content in the water was also measured. Instead of Phosphates, samples were analyzed for Total Phosphorus[5]. The pH, Temperature and Turbidity were measured at site using calibrated meters. The analysis was commenced on the following day of the sampling event of each session and continued 7 days. **Annex 6** presents the methodology followed in sampling and analysis.

7. Existing water quality

7.1 Seasonal variation of water quality

Tables 1 and 2 of **Annex 7** contain the results of the analysis of river water quality in the wet and dry seasons, and the data are shown graphically in Fig 3. This shows that at most stations the concentration of most of the analysed parameters increases quite significantly in the wet season, in comparison with the dry. Thus values of dissolved oxygen are generally higher under high flow conditions because of increased atmospheric exchange caused by high surface turbulence. However values of suspended solids, plant nutrients (nitrate and phosphate) and other contaminants such as ammonia and faecal and total coliform bacteria are also higher in the wet season, most likely because of runoff of soil containing fertilizers and other material of anthropogenic origin. The significantly higher counts of total coliform than faecal coliforms

[4] Water draining from forest catchment generally contains high ammonia levels. Most of the nitrogen found in forest runoff originates from the decay of plants and animals waste products including animal urine. Ammonia Nitrogen is the early form of nitrogen resulting from biological breakdown of biological waste products. Since it is readily oxidized to either nitrite or nitrate under aerobic conditions, high amounts of this pollutant may indicate a fairly fresh or recent pollution event.

[5] Phosphorus occurs in dissolved organic and inorganic forms or attached to sediment particles. Phosphate is an inorganic dissolved form and readily taken by aquatic flora, but other forms can be used when phosphates are unavailable.

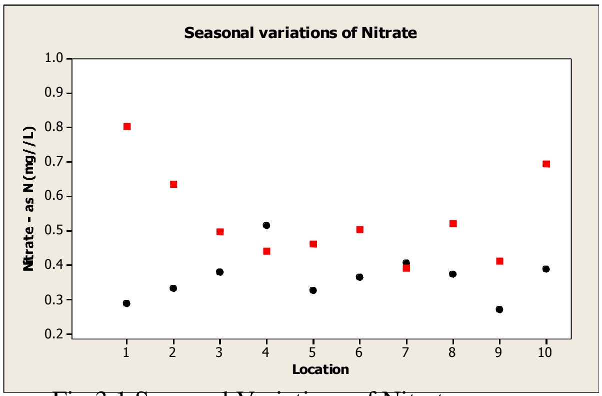


Fig 3.1 Seasonal Variations of Nitrate

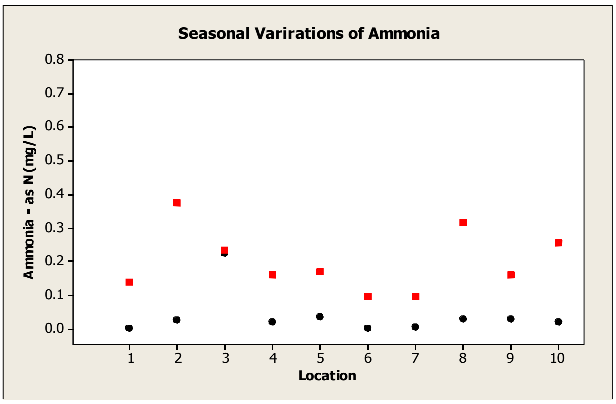


Fig 3.2 Seasonal Variations of Ammonia

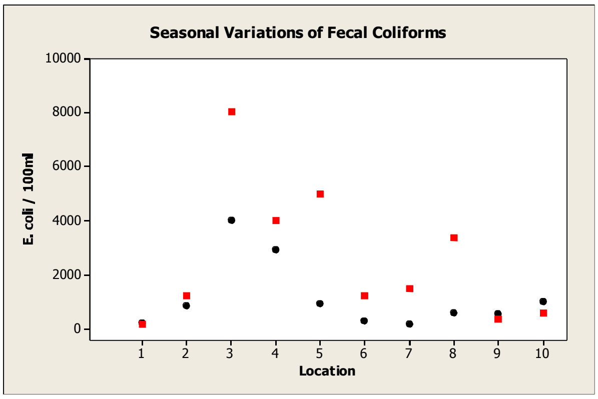


Fig 3.3 Seasonal Variations of Faecal Coliforms

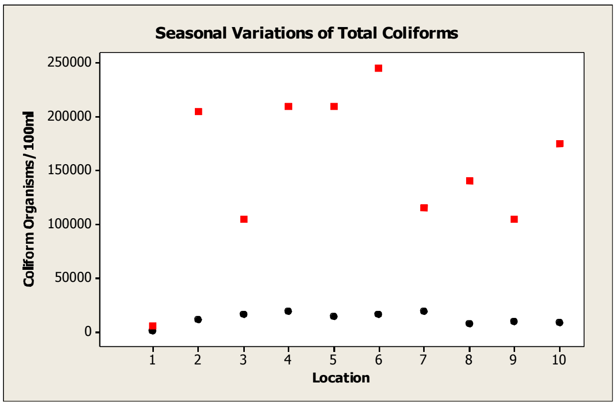


Fig 3.4 Seasonal Variations of Total Coliforms

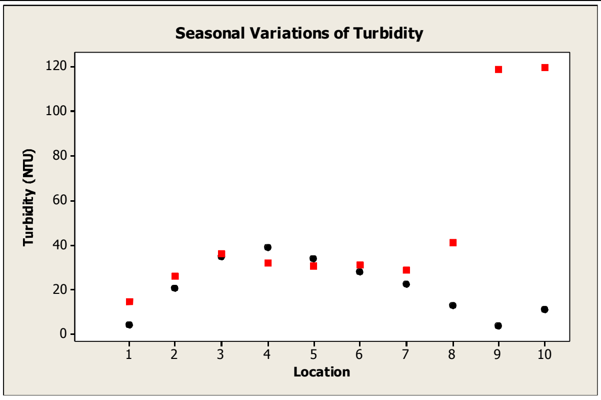


Fig 3.5 Seasonal Variations of Turbidity

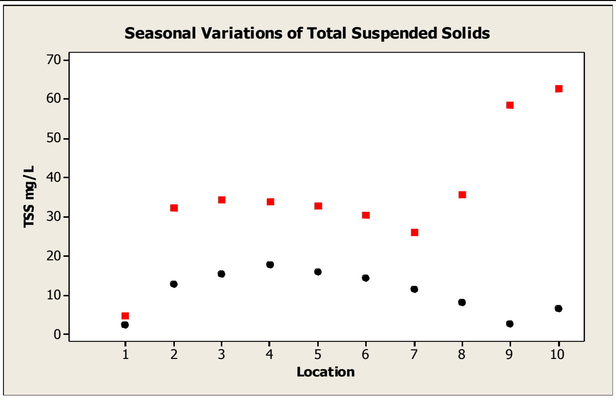


Fig 3.6 Seasonal Variations of Total Suspended Solids

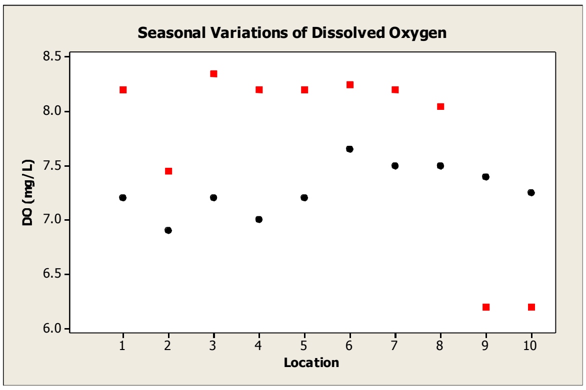


Fig 3.7 Seasonal Variations of Dissolved Oxygen

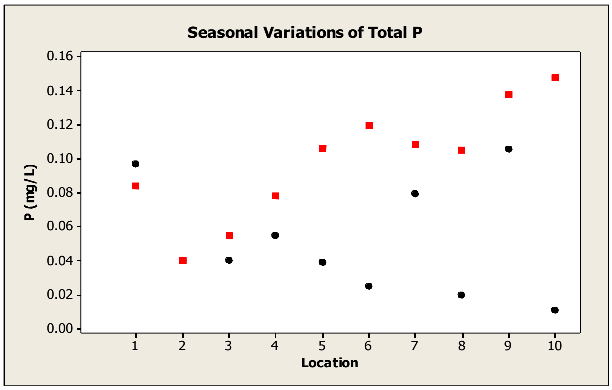


Fig 3.8 Seasonal Variations of Total Phosphorous

Fig. 3 Seasonal variations in surface water quality parameters (* 1-10 depict the sampling locations L1-L10)
Dry season data are shown in black while wet season data are shown in red)
(Values are the average of two duplicate samples)

indicates that most of this material is unrelated to sewage contamination, and is probably mainly from fertilizers washed in with soil and plant debris.

Other notable results are the high values of both turbidity (120 NTU) and suspended solids (60 mg/litre) at Stations L9 and L10 in the wet season, presumably caused by the discharge of water retained in the Kotmala reservoir during the dry season (see location of tailrace outfall in Fig 1). For the same reason, dissolved oxygen is significantly reduced at these stations at this time, because oxygen is depleted by decomposition of organic matter in water under longer-term storage.

7.2 Suitability of water for different uses

The country has no gazetted ambient water quality standards for designated uses at present, but a Proposed Standard; "Ambient Water Quality – EA1P-DHV-2000", is available. This standard was therefore used for comparative purposes to indicate the quality of the water in the river reach. The proposed standard specifies seven user categories:

- Category 1 - Nature conservation
- Category 2 - Drinking water with simple treatment
- Category 3 - Bathing
- Category 4 - Fish and aquatic life
- Category 5 - Drinking water with conventional treatment
- Category 6 - Irrigation and agriculture
- Category 7 - Minimum Quality

These comparisons suggest that the quality of water at all ten locations conform with all six uses (Categories 2-7) with respect to pH, DO, BOD, Nitrate and Total Phosphorus in both seasons. Locations L1 (Kotmale Oya) and L9 (below Atabage Oya) also conform with Category 2 water use (for drinking after simple treatment) in both seasons with respect to faecal coliforms, and locations L6-L9 conform with this use in the low flow season. However in contrast, most values of turbidity and total coliforms exceed the Category 2 limits in both seasons; and levels of suspended solids (for which there is no standard) are also quite high, being above 10 mg/litre at L2-L7 during the low flow season and above 25 mg/litre at all stations except L1 during high flows.

The results also show that at all locations in both seasons the water is not suitable for bathing or use in irrigation, as coliform counts exceed the limits for Category 3 and Category 6 waters. At most locations the water is also not suitable for drinking after simple treatment (Category 2) or conventional treatment (Category 5), as limit values for both faecal and total coliforms are exceeded. L1 (Kothmala Oya) is the only station where the water is suitable for drinking with simple treatment in both seasons.

7.3 Wastewater quality of Crysbro Broiler Farm effluent discharge

The quality of Crysbro Broiler Farm effluent was tested for same parameters as for river water quality, except Total Phosphorus, for which dissolved phosphates were tested instead. The results were then compared with relevant discharge standards, as shown in Annex 8. Of the 7 parameters tested for which tolerance limits are given in the standards, the sample of Crysbro effluent complied with the limits for pH, temperature, ammonia, and dissolved phosphorus, but exceeded the standard with respect to BOD_5, Total Suspended Solids and faecal coliforms. This analysis indicates that the Crysbro Farm discharges inadequately treated wastewater that is high in organic content, faecal bacteria and suspended solids.

7.4 Existing status of water quality in the Mahaweli Ganga

The results presented in Annexes 7 and 8 and Fig 3 and discussed in Sections 7.1-7.3 suggest that water quality in this part of the Mahaweli Ganga is quite mixed, with certain parameters that are indicative of good water quality (neutral pH, high DO and low BOD), but some parameters that are characteristic of poorer quality water (high Turbidity, Total Suspended Solids and Coliform bacteria). There is some evidence of pollution from run-off of fertilizers (containing N and P) and other anthropogenic materials (high Faecal Coliforms), but the results do not suggest that the river is grossly polluted. Concentrations of most of the analysed determinands increase in the wet season: Dissolved Oxygen because of increased aeration from turbulent water; and Nitrates, Phosphorus, Ammonia, Coliforms, TSS and Turbidity because of runoff of soil and contaminants from the land. The results indicate that the Crysbro outfall releases water that is high in organic content, suspended solids and faecal bacteria and exceeds the standards for these parameters. The influence of water from the tailrace discharge of Kotmale Reservoir can be seen in high levels of turbidity and suspended solids in the immediate downstream area, and reduced dissolved oxygen, caused by the release of water retained in the reservoir in the dry season. Comparing the results with the water quality standards recommended for specific uses suggests that water in this part of the Mahaweli Ganga is not suitable for drinking (after simple or conventional treatment), bathing or irrigation, especially because of its high turbidity and bacterial content. The field observations and the analysis of wastewater from the Crysbro Broiler Farm indicate wastewater discharges with inadequate treatment (refer Fig. 2).

8. Anticipated impacts on water quality

8.1 Likely water quality impacts in the reservoir after impoundment

The main operational phase action in the project is impoundment of water in a reservoir by a dam. This will result in retention of a water mass upstream of the dam to about 2 km. The Moragolla reservoir will operate as a "run-off-river" river scheme, where the relatively small reservoir will act as a regulatory pond, not a storage basin. For most of the rainy season (May-November) there will be sufficient water to generate power almost constantly, and the excess water will flow from the reservoir through the spillway gates, so water will remain in the reservoir for a short time only. During the dry season (December –April) the Moragolla scheme will be operated primarily to satisfy peak electricity demand for a few to several hours on most days. Water therefore will be retained in the reservoir for longer periods during the dry season, so water quality could fluctuate, as discussed below.

Impacts on water quality and sediments movement

The damming and impoundment of water in the reservoir will result in aggregation of sediment on the upstream side of the dam as heavier particles will sink and settle on the reservoir bed. This will reduce the sediment content in the reservoir water and in the water diverted for power generation and discharged through the tailrace. The proposed Moragolla Reservoir is likely to receive a high load of suspended solids from the Mahaweli Ganga upstream from Nawalapitiya catchment during the wet season, where average rainfall in the southwest monsoon is 445 mm, compared with 147 mm[6] in the dry season**.** The results from the present survey show increased Suspended Solids in water in the wet season in comparison to dry season (refer Fig 3.6), most probably due to ingression of silt-laden runoff water into the river. Furthermore, a reduction in Faecal and Total Coliform bacteria counts in the tailrace discharge can be anticipated due to natural decay after retention of water in the reservoir. The reduction in both sediments and Faecal Coliform bacteria will have positive impact on the downstream water quality. The accumulation of sediment, however, should be taken into account in planning, design and operation of the reservoir.

The accumulated sediments may also contain organic and nutrient-bound particles, especially Phosphorus (the limiting nutrient for algal growth), and there is therefore a likelihood of increased levels of these nutrients in the reservoir as well as in the tailrace discharge.

The above mentioned impacts of eutrophication and low oxygen levels are not expected to be highly significant however, and will depend on several factors such as hydraulic retention, reservoir circulation, inputs of organic matter, nutrients, rainfall, wind conditions, reservoir sediment management, reservoir operation etc. Moragolla being a "run - of - river" reservoir, the water will have low retention in both seasons and will not be subjected to sufficient retention to cause the above mentioned impacts.

Entry of debris into reservoir

During the survey, heavy loads of debris were observed trapped in natural depressions along either side of the river. They consist of dead plant material, plastic bottles, polythene and other anthropogenic matter (refer **Annex 4**) left stranded after the previous high flow season. The floating and settable organic material may decompose and impair the water quality by increased BOD and Suspended Solids, and lower Dissolved Oxygen levels. Furthermore, influx of plastics and other inert debris into the reservoir may hamper power generation operations if left unattended.

8.2 Likely downstream water quality impacts during scheme operation

The river reach downstream of dam is likely to be affected by impacts such as flow reduction, reduction in sediment load, altered nutrient flux due to presence of the physical barrier imposed by the dam and the upstream impoundment. The water quality impacts specific to this project are indicated below.

As explained in Section 8.1 above, throughout most of the wet season, water will be retained in the reservoir area for a relatively short time, so there are unlikely to be major changes in water quality, apart from small improvements that may arise from reductions in the sediment and bacterial content as a result of natural settlement and decay respectively. Throughout the dry season however, water will be retained for longer periods, so there could be changes in water quality, the nature and extent of which will depend on the factors mentioned above. In general the water flowing downstream at this time is expected to be lower in sediment and bacterial content, but also lower in oxygen because of the decay of organic matter in the reservoir and limited atmospheric replenishment at the surface. There will also be reductions in the quantity of water flowing downstream in the dry season, when water will flow through the tailrace and into the river only when power is generated (ie a few to several hours on most days). The only water flowing from the dam at this time will be the $1.5 m^3/s$ environmental flow.

[6] Revised Feasibility Study Report (Draft) Moragolla Hydropower Project Volume 1- Main Report-Nippon Koei Co., Ltd in Joint venture with Nippon Koei India Pvt. Ltd

Water quality impacts due to reduction in river flow between proposed dam and the tailrace

The impoundment will reduce natural stream flow along the river reach of 3 km from the proposed dam to the tailrace outfall. The reduced flow is likely to have an impact on the river water quality as wastewater from the Crysbro Broiler Farm is discharged in to the river reach to be affected by low flow during generation of hydropower. In the dry season, the low stream discharge may be inadequate to dilute the pollutants in the wastewater. The BOD, Suspended Solids, Oil and grease from the wastewater will increase the levels of these pollutants in the river, and may cause a reduction in dissolved oxygen from the decomposition process. Furthermore, Faecal Coliform counts in the river reach up to the tailrace are likely to rise.

Impact on the irrigation water

The likely impacts noted above could be significant on the water in the irrigation canal (Dunhida Ela) because the river water contaminated with waste from Crysbro Broiler Farm may enter the irrigation water supply posing potential health problems for people who come into contact with the water. The impacts however, may not be highly significant during wet season because Moragolla project is a "run-of-river" reservoir and will spill frequently during this time.

Impacts on downstream drinking water sources

The likely impacts on the drinking water sources are insignificant as there are no drinking water intakes between proposed dam and the tailrace outlet. The Crysbro Broiler Farm water intake is located downstream of the dam above their wastewater discharge location. This location is abandoned at present and therefore there is no impact.

Impacts on aquatic fauna

The river water contaminated with pollutants will have an impact on the natural aquatic fauna and flora downstream. The water quality impacts on aquatic fauna are discussed in the ecology report.

9. Proposed mitigation measures

The impact analysis above revealed some impacts that are significant on water quality and water uses. They include impacts due to: entry of debris into reservoir, sediment management activities and downstream water quality impacts and those on downstream water quality due to Crysbro Broiler Farm wastewater. The mitigation measures are proposed in this section to minimise these impacts.

9.1 Mitigation of likely water quality impacts in the reservoir after impoundment

Mitigation of impacts due to entry of debris into reservoir

The Moragolla dam will be equipped with a flap gate on the top of one of the spillway gates. The floating debris in the vicinity of the dam will be discharged with water over the flap gate. Debris built up at the intake trashrack can be removed by a mechanical rake equipped at the intake.

Mitigation of impacts due to sediment management activities

The design of the Moragolla dam does not have a facility for the flushing of retained sediment. It may take 30 years or more for the sediment in the reservoir to reach the spillway crest level which is 8m below the minimum operation level of the reservoir. The sediment further accumulated will then be removed by mechanical dredging or sediment sluicing through the spillway gates at the high flow season or the combination thereof.

9.2 Mitigation of likely downstream water quality impacts

The following mitigation measures are proposed to minimize likely downstream water quality impacts due to project actions in the operation phase.

Release of Environmental flow

A release of 1.5m^3/sec Environmental flow has been considered in the project feasibility to compensate downstream water uses. This environmental flow will provide some dilution for incoming pollutants including those from Crysbro Broiler Farm wastewater. The analysis of wastewater however, suggests that this industry might discharge wastewater containing pollutants exceeding stipulated tolerance limits. The dilution to be provided by the above environmental release and other inputs from tributaries therefore may not be adequate to maintain good water quality in the river reach up to the tailrace. Mitigation options indicated below are proposed to minimize potential impacts of Broiler farm wastewater on water quality in the river.

Alternative 1 - Monitoring to ensure enforcement of stipulated discharge limits for Crysbro Broiler Farm wastewater

Action by the project agencies in coordination with the Central Environmental Authority is suggested to ensure that the Crysbro industry discharges treated wastewater in compliance with stipulated discharge standards at all times. This option is considered reasonable due to the following: a) the wastewater of Crysbro Broiler Farm is the only point pollution source in the area with potentially high impact on downstream water quality; b) the water quality in the river is not heavily impaired at present so it has an assimilation capacity for pollutants; and c) more importantly, the river reach that will be most affected by reduced flow (between the dam and the tailrace) has no highly sensitive water uses such as drinking and bathing, although it does support sensitive aquatic organisms. Establishment of a sound monitoring plan is therefore suggested to ensure that the wastewater discharges comply with the appropriate legal standards. The actions in the event of violation of the stipulated standards will be determined by CEA, which is the legally responsible body.

Alternative 2- Relocation of Crysbro Broiler Farm outfall downstream of the proposed tailrace outlet

The project design has considered this option as a viable alternative and the option suggests conveying wastewater of this industry and locating its outfall downstream of the proposed tailrace outlet. This option, however may be costly and also require proper design and operation to ensure that the volume of wastewater is within the design capacity of the conveyance system.

Annexure

Annex 1

Terms of Reference (ToR)

TOR FOR WATER QUALITY IN THE MAHAWELI GANGA

Objective

Data presented in the EIA[1] report provided some evidence of water quality issues in the Mahaweli Ganga, including possible contamination with faecal bacteria from the outfall of the Crysbro Broiler Farm.

This is downstream of the dam in the 3 km reach that will be subjected to lower flows during scheme operation, so pollution impacts could be exacerbated by reduced dilution and dispersion. This survey will: a) investigate the present quality of water in the river upstream and downstream of the proposed dam site; b) determine the nature, extent and likely sources of any pollution; and c) predict the quality of water impounded in the Moragolla reservoir, and discharged downstream when the scheme is operating.

Scope of work

The Contractor shall collect duplicate water samples from the Mahaweli Ganga at 10 stations located at approximately 500m intervals, from 500m above the confluence between the Kothmale Oya and Mahaweli Ganga (one station at the confluence and one station 500 m upstream in both rivers) and 500m downstream of the confluence with the Atabage Oya. One station shall be located directly in the outflow from the Crysbro Broiler Plant.

Water samples shall be collected at midday, from the centre of the river at each station, during the low flow season in February/March 2013 and at the start of the high flow season at the end of May 2013. Samples shall be transported promptly to a Government-accredited laboratory, under controlled temperature conditions as prescribed by the laboratory. In the laboratory, samples shall be analysed for total suspended solids, BOD5, nitrate, phosphate, total coliforms and faecal coliforms. Temperature, dissolved oxygen and turbidity shall be measured on site, using accurately calibrated meters.

[1] Moragolla Hydropower Project, Feasibility Study. Final Report: Volume Environmental Impact Assessment (Central Engineering Consultancy Bureau, Sri Lanka and AI-Habshi Consultants Office, Kuwait).

Programme and Reporting
The Contractor shall submit a draft Interim Report on 31 March 2013 and a draft Final Report on 7 June 2013. Both reports will be reviewed by the Study Team and the Contractor shall amend the reports to address all comments and shall submit final reports within two weeks of receipt of comments.

The Interim Report shall present and discuss all data collected in the first survey and the Final Report shall present all data from both surveys and shall include the following:

- Map of the sampling stations, site photographs and appropriate tables and illustrations of key data

- Written descriptions of all sampling and analysis methods (full details) and quality control procedures operated by the laboratory

- A detailed discussion of the results, including but not necessarily limited to

  - Water quality in this part of the Mahaweli Ganga and local and seasonal variations;

  - Evidence of any pollution, comparing data with appropriate national and international standards; and likely pollution sources;

  - Likely water quality in the reservoir during and after impoundment, with reasons;

  - Likely water quality downstream during scheme operation (flow characteristics will be shown by a hydrological simulation study to be conducted in January 2013)

  - Suitable mitigation for any negative impacts of scheme operation on water quality

Tables showing all data should be provided in an appendix.

Annex 2

Study team

Study team

Key staff

Name	Designation
Ms S V Dias	Senior Scientist Water Quality Specialist
Mr IAVP Iddamalgoda	Senior Scientist
Ms S A M S Dissanayake	Senior Scientist
Mr HDS Premasiri	Senior Scientist
Mr Vimukthi Sumanasekara	Scientist
Ms H.T.J. Seneviratne	Scientist

Laboratory analysis team

Name	Designation
Ms P D C Pathiraja	Technical Assistant
Ms P H D Silva	Technical Assistant
Ms Thilangika Gunawardena	Project Assistant

Support staff

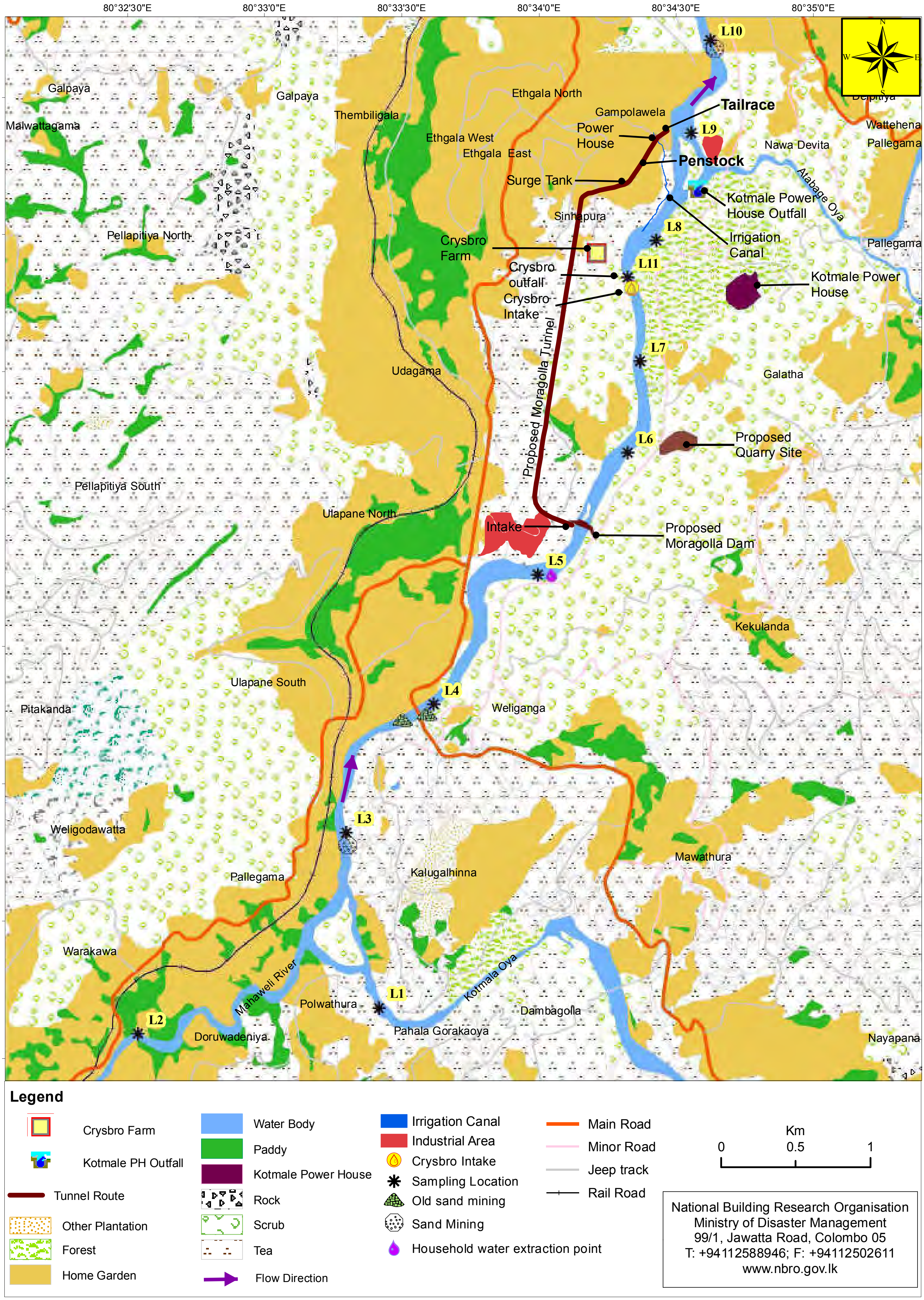
Name	Designation
Mr N Krishnamoorthi	Field Assistant
Mr Chamath Vithanage	Field Assistant
Mr WA Weerasinghe	Field Assistant
Mr A Premaratne	Field Assistant

Annex 3

Map of river water quality sampling locations

Water Quality Sampling Locations of Proposed Moragolla Hydropower Project Area

July, 2013



Annex 4

Photographs of pollution sources, river uses and river degradation

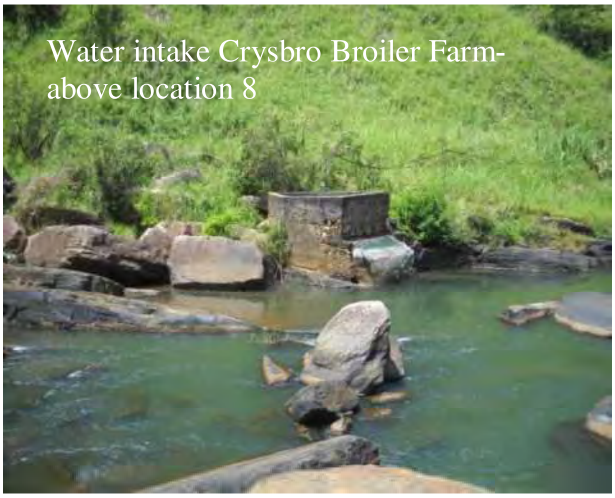
Pollution sources, River uses and river degradation

Crysbro Broiler farm wastewater outflow

Indicated in red arrows is the suspected wastewater outflow of the Crysbro Broiler farm. The milky white discharge is suspected to be the wastewater discharged by the industry. The wastewater appears to be discharged via two paths. In one the wastewater is brought along a closed pipeline along a steep slope driven to the river. The Pipeline is wrecked in the middle of its path draining wastewater along the bare slope. The other path discharges wastewater along an unlined canal dug along the steep slope- Photograph taken on 1st March 2013

Some river uses


Sand mining – Between Locations 6-7


Water intake Crysbro Broiler Farm- above location 8


Water intake irrigation canal- bellow location 7

River degradation

Accumulation of trash in rock pools - observed in locations 5.6.7.8

Annex 5

GPS reference, descriptions and photographs of sampling locations

GPS reference of sampling locations and descriptions

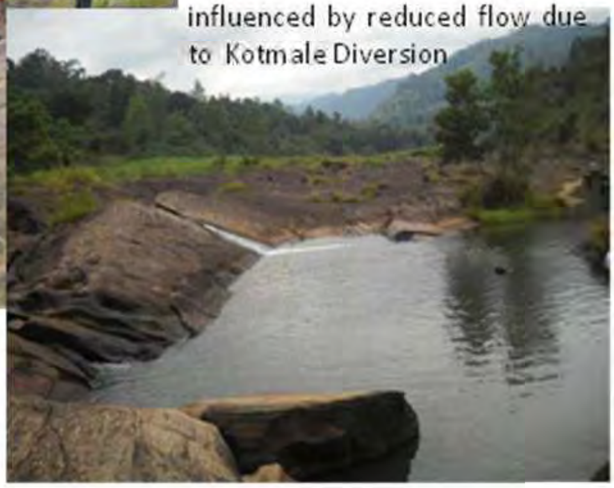
Sample location reference	GPS reference	Description of location
L1- Kothmale Oya	80^0 55' 65.84" 7^0 07' 78.92"	The sample location is at Kothmale Oya about 1km upstream from the confluence of the Mahaweli and the Kothmale Oya. The river section is relatively high gradient rocky terrain having exposed bed rock out crops. In this section water flows through a cascade of pools separated with short drops. In pools there is very little surface turbulence and at drops the flow is highly turbulent. In this section isolated water pools filled during high flow conditions were also present. These were cut-off from the main river stream due to reduced flow conditions. The water appeared colourless and clear. Aquatic organisms were observed on the water surface of pools. Both river banks were consisting of exposed bed rock out crops and disturbed riparian vegetation. At right hand side isolated plots of tea cultivations were observed in addition to trees and shrubs.
L2 - Mahaweli Ganga – closes to 13/6 culvert of the Ulapane – Nawalpitiya Road	80^0 54' 19.18" 7^0 07' 65.34"	Sample was collected over the "Sangili palama" (Hanging bridge) of Mahaweli Ganga near Pattunupitiya school of the sampling event of low flow season. However, the bridge was broken during sampling event of high flow season due to high rains and sample was taken by flinging a bucket to the mid water stream from the river bank. There were home gardens and isolated small tea plots present on the right hand side. On the Left bank, the riparian vegetation was dominated with a thick strip of Bamboo trees. Sand mining sites are located from 50m upstream from the sampling location. At the time of sampling there was no mining activity. The water is more turbid and muddy in colour and high in velocity during high flow season than low flow season.
L3 - downstream from the confluence of the Mahaweli River and Kothmale Oya	80^0 55' 46.70" 7^0 08' 85.13"	On the right hand side of the land of sampling location there was a Pinus plantation. River riparian vegetation is dominated with bamboo trees and tea lands are located along the buffer area. An old sand mining point 10m downstream from the location was observed. The water is more turbid and muddy in colour during high flow season than low flow season. Stream velocity is high owing to moderately high terrain gradient.
L4 - about 150 m downstream from the bridge at 1/1 Ulapane- Pussellawa Road	80^0 55' 99.02" 7^0 09' 63.11"	The sampling location is about 150m from the bridge towards downstream. There were rock boulders along the river. A small tributary discharges to river, just upstream to sample location at right hand side. Tea cultivations are observed at the right bank of the river. The Bridge was under construction. The water was more turbid and muddy and flow velocity is high during high flow season than low flow season.
L5-Mahaweli Ganga – at bathing point and sand mining point	80^0 56'62.02" 7^0 10' 41.82"	The sampling location is about 300m upstream from the proposed dam location. The sample location was accessed by a sand miner's ferry during low flow season however, in the sampling event of high flow season the ferry was not available due to high rains. The area is used for sand mining. No mining activity was observed during sampling. The water is more turbid and muddy in colour during high flow season than low flow season. The disturbed riparian vegetation consisted of shrubs and herbs; dominated with grasses. Ulapane Industrial zone was visible over the left bank of river. The trash material consist of plastic bottles, rubber, polyethylene bags were seen alone the rock cavities on either sides of the river which were carried away and deposited during high flow.

GPS reference of sampling locations and descriptions – contd...

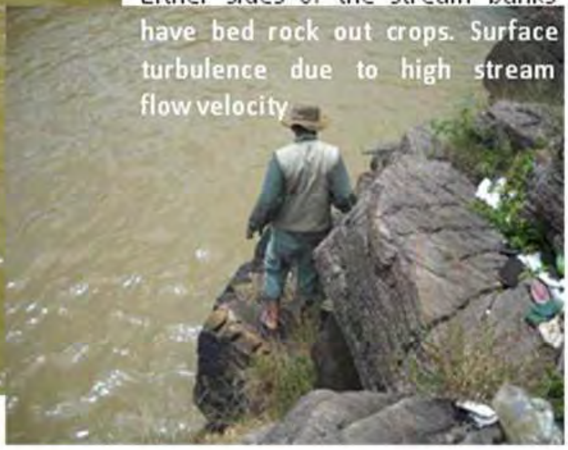
Sample location reference	GPS reference	Description of location
L6 - Mahaweli Ganga 250 m downstream from the proposed Dam	80^0 57' 20.14" $7^0$11' 13.83"	The sampling location is about 250 m downstream from the proposed dam. Water flows through terrain dominated with bed rock out crops which result formation of cascade of wide pools. Water drain into these pools through the exposed bed rock. The water flowing velocity is very low in the pool like river sections. The reservation land area along the both river banks consist forest riparian vegetation. The water was more turbid and muddy and flow velocity is high during high flow season than low flow season.
L7 - Mahaweli Ganga - sand mining site	80^0 57' 26.78" 7^0 11' 71.51"	The sampling location is about 1km from the proposed dam towards downstream. The river bottom substrate is excavated for sand mining but no mining activity at the collection of sample. The reservation land area along both river banks consists of forest riparian vegetation The water was more turbid and muddy and flow velocity is high during high flow season than low flow season.
L8 - Mahaweli Ganga - about 50 m downstream from the Crysbro effluent outlet	80^0 57" 34.89" 7^0 12' 44.09"	The terrain is dominated with large exposed bed rock out crops to form a cascade of short falls and pools. The stream flow is fast and highly turbulent at drops where sample was collected. Outlet of the Crysbro effluent plant was just upstream. Zero effluent flow was observed from wastewater outlet at the time of sampling in both seasons. The water was more turbid and muddy and flow velocity is high during high flow season than low flow season. There were forest vegetation on the right bank side and on the left hand side there were scrubland and pathana. Note: Refer annexure 6
L9 - Mahaweli Ganga- near the confluence of Mahaweli Ganga and Atabage Oya	80^0 57' 66.60" 7^0 13' 09.12"	The sampling location is about 50 m upstream from the confluence of Mahaweli Ganga (right arm stream) and Atabage Oya. The "Maga Neguma" Metal Crusher was located 10m upstream from the sampli point. Kothmale HPP tailrace outfall was located upstream to this location. There was no outflow during the sampling event of low flow season (March 2012). However, the tailrace released high flow of water with high turbulence and muddy colour during the sampling event of high flow season (May 2013). The stream bottom substrate consists of large to moderate size boulders. Left hand side of the riparian vegetation consist of shrubs and herbs, dominated with grasses. Right hand side is consisted of shrubs and stream bank dominated with Bamboo trees.
L10 - Mahaweli Ganga about 500 m from the confluence of Mahaweli Ganga and Kothmale tail race with Atabage Oya	80^0 57' 72.00" $7^0$13' 67.35"	The sampling location is about 500m downstream from the confluence of the Mahaweli Ganga and Atabage Oya. The area is used for sand mining but no mining activity during sampling. There was some aquatic flora in the water. The river width was about 20m at this location. Riparian vegetation consisted of shrubs and herbs, dominated with "mana". The water was highly turbid and muddy in colour and flow velocity is high during high flow season than low flow season.

River morphology and stream flow condition of the water quality sampling locations

Sample location 1- Kothmale Oya. A terrain with exposed bed rock out crops, sharp drops and rock pools. Water is flowing through a cascade of rock pools with short high gradient drops. High turbulence to flow at drops and smooth gentle flow in the rock pools with no surface turbulence. Terrains is greatly influenced by reduced flow due to Kotmale Diversion

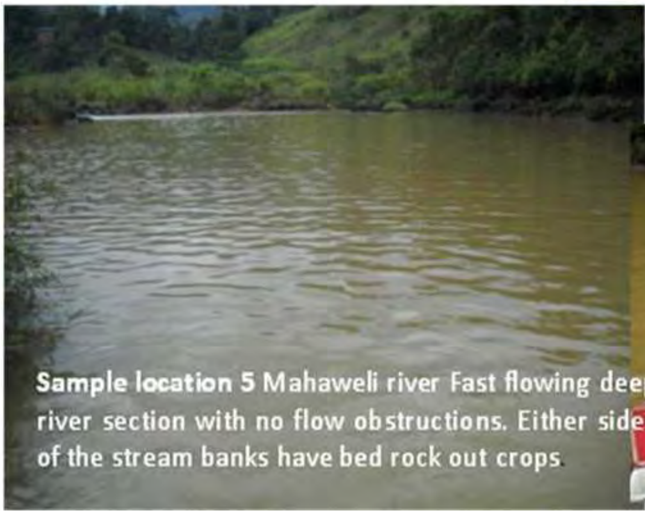


Sample location 2- Mahawei river draining Nawalapitiya area– Long straight low gradient river section without flow obstructions (Upstream). Stream flow is low and gentle with little or no turbulence. Floating aquatic plants. Deposits of sand ,gravel and pebbles along the river bank (down stream). River bottom substrate is excavated for sand.



Sample location 3- Mahaweli river after the confluence. Moderate flow velocity deep river section . Either sides of the stream banks have bed rock out crops. Surface turbulence due to high stream flow velocity

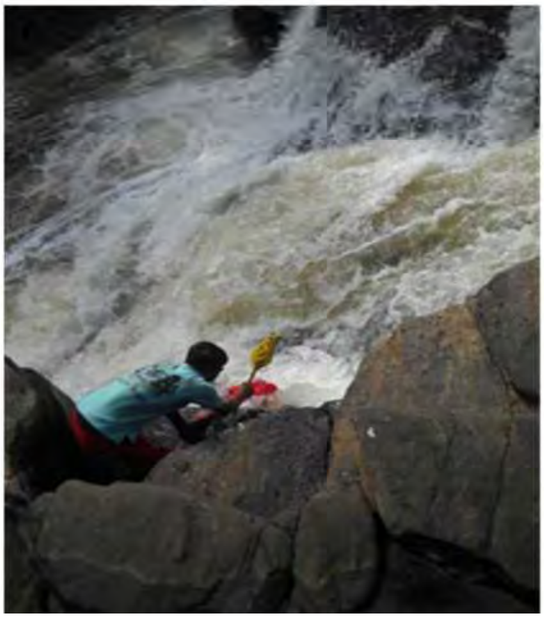
Sample location 4- Mahaweli river Low gradient shallow river section with some surface turbulence to stream flow. Either sides of the river banks and river bottom have bed rock out crops resulting obstruction to flow.



Sample location 5 Mahaweli river Fast flowing deep river section with no flow obstructions. Either sides of the stream banks have bed rock out crops.

Sample location 6 - Mahaweli river moderate gradient river section with obstruction to stream flow due to presence of bed rock out crops and embedded boulders resulting disturbance to smooth flow

Sample location 7 - Mahaweli river- Upstream Chrysbro wastewater outfall. Low gradient deep river section with no surface turbulence to stream flow. either sides of the river banks have bed rock out crops. Location has become deep due to sand mining.



Sample location 8 - Mahaweli river- Down stream Chrysbro wastewater outfall. High gradient rapid fall with bed rock outcrops and boulders. Swiftly flowing highly turbulent water flow section is characteristic with cascade of short falls and pools

Sample location 9 - Tail race out flow after the confluence of Atabage oya Low gradient shallow river section with some degree of surface turbulence to stream flow. either sides of the river banks have bed rock out crops and large boulders resulting obstruction to flow. No flow input from Kothmale power house tail race at the time of sampling.

Sample location 10 – Mahaweli River after confluence of the two river sections -Low gradient shallow river section little surface turbulence to stream flow. either sides of the river banks and river bottom have bed rock out crops and embedded boulders.

Photographs of sampling event – high flow season

Sample location 1 – Kotmale Oya

Sample location 2 - Mahawei River draining Nawalapitiya area

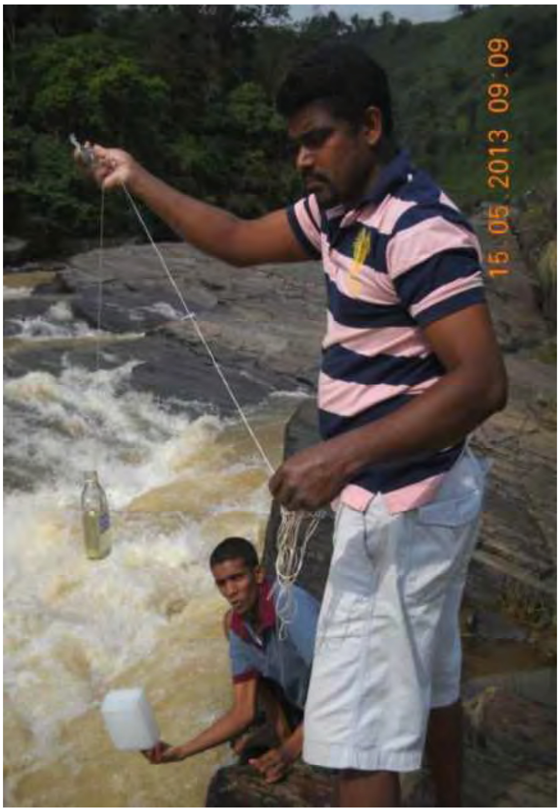
Sample location 3 - Mahaweli River after the confluence

Sample location 4 - downstream from the bridge Mahaweli River

Sample location 5 - Mahaweli River

Sample location 6 - Mahaweli River

Sample location 7 - Mahaweli River; upstream Crysbro wastewater outfall



Sample location 8 - Mahaweli River; downstream Crysbro wastewater outfall

Sample location 9 - Tail race out flow after the confluence of Atabage oya; The tailrace of the Kothmale power plant released high flow of water with high turbulence and muddy

Sample location 10 – Mahaweli River after confluence of the two river sections

It was observed that water was highly turbid and muddy color and flow velocity was high during the high flow season than the low flow season in all sample locations.

Annex 6

Analytical Methods and Quality Control procedures

1. Analytical Methods

Parameter	Method Reference	Description of the Method
pH	APHA 4500 H-B Electrometric method	pH and Temperature were measured using ***pH meter, brand ; pH 5+ pH/^{0}C of EUTECH Instrument Singapore origin.*** The meter was first calibrated using NIST pH 4.01 and pH 6.86 buffer solutions (NIST; National Institute of Standard Technology). The pH and Temperature of water samples were taken after calibration by immersing electrode and the probe
Temperature	APHA 2550 B Electrometric method	
Turbidity	APHA - 2130 B Nephelopmetric method	Turbidity was measured using Turbidity meter: ***TN-100/T-100 Portable Turbidity meter EUTECH instruments Singapore origin***. The meter follows the ISO 7027 standard. Turbidity meter was first calibrated using series of Environmental Protection Agency (EPA) approved standards (CAL 1:800, CAL 2:100, CAL 3: 20, CAL 4: 0.02). The 800 NTU vial was inserted into the sample well, aligning the mark on the vial with mark on the meter. Vial was pressed down until it snaps fully into the instrument and then covered using the light shield cap. Meter was switched "ON" and calibration function Calibration was repeated for CAL 2, CAL 3 & CAL 4 calibration standards. The vial was then rinsed and then filled with the sample water. The capped vial was then placed inside the sample well and aligned the vial's index mark with the meter's index mark. The meter was set "ON" and the reading appeared in the displa taken as the measurement.
Dissolved Oxygen	APHA-4500-O-C Azide modification	Water samples were collected in a 300 ml bottles having a ground-glass stopper and a flared mouth without entrapping air bubbles. Dissolved oxygen in the sample was fixed by adding 2 mL of $MnSO_4$ and 2 mL of alkali-iodize –azide reagents to the bottle at the site. Then the bottle was stoppered carefully to avoid air bubbles and mixed well by inverting the bottle a few times. These bottles were transported to the laboratory at 4 to 10 ^{0}C.. In the determination of DO, 2.0mL of conc. H_2SO_4 was added to the bottle and mixed well until dissolution of precipitate is completed. A 200 mL portion from this sample was titrated with 0.025M Na_2SO_4 solution to a pale yellow color. Then few drops of starch solution were added and titration was continued to first appearance of blue color. **Calculation** For titration of 200mL sample, 1mL 0.025N Na_2SO_4 = 1mg DO/L

Parameter	Method Reference	Description of the Method
Biochemical Oxygen Demand	APHAA 5210-B 5-Day BOD test	Water samples were collected in a 300 ml bottles having a ground-glass stopper and a flared mouth without entrapping air bubbles. To prevent entry of air in to bottles during incubation water was added to the flared mouth of the bottle and then capped with plastic cap. For each measurement two bottles were prepared in the above manner and transported to the laboratory at 4-10^{0}C. Of the two sets, the dissolved oxygen in one set was determined on the following day. This gives the Initial oxygen levels. The bottles in the other set were incubated at 20^{0}C for 5 days. After 5 days the DO was determined similar to first set. This gives remaining oxygen after five days Determination of BOD BOD mg/l = Initial dissolved oxygen level in the sample - Final dissolved oxygen level in the sample (Initial dissolved oxygen is the value measured as dissolved oxygen)
Nitrate	APHA 4500-NO2-B Photometry	10 mL of sample was taken to the sample vial and color was developed by crushing Nitrate test tablet supplied by the manufacturer. The developed color was then measured using Lovibond, Maxi Direct SN 10-1083 photometer made in Germany. The Method used is APHA 4500-NO2-B. The reading appeared on the meter was taken as the measured value
Ammonia	APHA-4500-NH_3 F	10 mL of sample was taken to a sample vial and color was developed using ammonia No.1 and No.2 tablets supplied by the manufacturer. The developed color was then measured using Lovibond Maxi Direct SN 10-1083 photometer made in Germany. The Method used is APHA-4500-NH_3 F. The reading appeared on the meter was taken as the measured value.
Total phosphorus	APHA 4500- P-D Stannous Chloride method	In the laboratory 100 mL of sample was digested with 1mL of H_2SO_4 acid and 0.4 g solid $(NH4)_2S_2O_8$ until a final volume of 10 mL was reached. The digested sample was then cooled, diluted to 30 mL with distilled water, and neutralized with NaOH. The sample was made up to 100 mL in a volumetric flask with distilled water. Then the color was developed by adding 4.0 mL Ammonium Molybdate reagent I ($NH_4Mo_7O_{24}.4H_2O$) and 0.5 mL stannous chloride reagent I ($SnCl_2.2H_2O$). After 10 minutes, colour was measured at 690 nm using UV visible spectrophotometer and compared with a calibration curve prepared using series of standard phosphate solution of KH_2PO_4 and the distilled water blank. In the analysis of dissolved Phosphated the digesion part was omitted. **Calculation** $\text{mg P/l} = \frac{\text{mg P (in approximately final volume)}}{\text{ml sample}} \times 1000$ The result phosphorus was expressed as P mg/L.

Parameter	Method Reference	Description of the Method
Total Suspended Solids	APHA 2540 D	Glass-fibre filter papers were used in the determination of suspended solids. First, the filter papers were washed with distilled water and dried in an oven at 103^{o}C to 105^{o}C for 1hour. Then the initial measurements were taken to 0.001g accuracy until constant weight is reached. The sample was then stirred with a magnetic stirrer at a speed to shear larger particles, if practical, to obtain a more uniform particle size. While stirring, a measured volume (100ml) was pipetted onto the pre weighed filter paper seated on glass-fibre filter. Vacuum suction was applied to filter the sample. The trapped suspended solids in the filter paper were dried in an oven at 103^{o}C to 105^{o}C for 1hour and cooled in desiccators to balance temperature and then weighed to 0.001g accuracy. This cycle of drying cooling, desiccating and weighing was repeated until a constant weight was obtained. The suspended solids content in the sample was then determined using following calculation. **Calculation** Mg Total Suspended Solids/L = $\frac{(A-B) \times 1000}{\text{Sample volume, mL}}$ Where: A = weight of filter + dried residue, mg B = weight of filter, mg
Faecal Coliforms and Total Coliforms	SLS 614: 1983 Part 2 Membrane filtration method	250 ml capacity sterilized glass bottles with attached twin thread were used for the collection of samples for analysis of Faecal and Total Coliforms. In the sampling, first the bottle was lowered to the water by unwinding the cord slowly. The bottle was immersed in the water completely, and once the bottle was judged to be sufficiently filled, the thread was rewound and bottle was brought up. Some water was discarded if the bottle was completely filled. In the laboratory, for the analysis of Faecal Coliforms, 100 ml of sample was filtered through a 0.45 µm grid marked membrane filter paper and the filter was placed in MFC agar and incubated at 44.5 ^{0}C for 24 hours. For the Total Coliforms, 100 mL of sample was filtered and filter was placed on M-Endo agar LES (Sigma origin) media and incubated at 36 ^{0}C for 24 hours. Colonies which showed a characteristic appearance of blue colour on the filter paper counted as Faecal Coliforms. No confirmation was done to Faecal Coliforms since MFC agar was used as the medium and it is specific for Faecal Coliforms (especially *E.coli*) as per SLS (1983). In detecting Total Coliform counts, colonies with metallic yellow sheen in M- Endo agar LES medium were sub cultured to phenol red lactose broth and all tubes showing acid and gas production were recorded as confirmed Total Coliforms after incubation of 36 ^{0}C for 48 hours. Confirmed Coliforms were expressed as Total Coliform counts per 100 ml. Confirmed Faecal Coliforms were expressed as Faecal Coliform counts per 100 ml.

2. Quality Control procedures

- The NBRO is registered in the Central Environmental Authority (CEA)- Laboratory as Consultant/ Specialist for Technical Guidance (Reg. No. 07/LM/Cons/10/2008).
  Copy of certificate - 2013 and a Letter indicating participation in Proficiency testing programs with CEA are given below. .

- Quality Control for the analysis of all the parameters was carried as per the procedures given in the Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WEF- 20th edition (APHA).

- All chemicals used in the analysis were of Analytical Grade (AR).

- The pH meter was calibrated before commencing the sample measurements using pH 4.01 and pH 6.86 buffer solutions (traceable to National Institute of Standards and Technology - NIST).

- Turbidity meter was calibrated using a series of Environmental Protection Agency (EPA) approved) calibration standards of 800 NTU, 200 NTU, 20 NTU and 2 NTU before commencing sample measurements.

- Dissolved Oxygen and BOD analysis - Glucose Glutamic acid (GGA) standard check solution was checked for reliability of the sample analysis. The GGA control is a standardized solution to determine the quality of the seed, where its recommended BOD_5 concentration is 198 mg/l ± 30.5 mg/l. The dilution water blank was used to confirm the quality of the dilution water that was used to dilute the samples. This is necessary because impurities in the dilution water may cause significant alterations in the results.

- In the Nitrates analysis, standard KNO_3 (strength was 1.00 mL= 100 µg NO_3^-) was prepared as per APHA and 0.1 mg/L solution as a known sample and deionized water was checked for an each set of sample analysis.

- In the Ammonia testing standard solution of NH_4Cl was used as the standard (1.00 mL =1.22 mg NH_3). For each set of sample analysis 0.01 mg NH_3/L solution as a known sample and deionized water as a blank were checked.

- For the Total Phosphates analysis, standard phosphate solution of KH_2PO_4 was used to prepare the calibration curve (The strength was 1.00 mL=50.0 g PO_4^{3-}P). In each set of analysis, 6 samples at a time; 3 water samples, 1 known standard sample, 1 spiked sample and a blank sample (deionized water) were digested and analyzed.

- In the Faecal Coliforms and Total Coliforms quality control procedures were carried out according to APHA.

This includes:

- Checking incubator temperatures:
    - Faecal Coliforms - 44.5^{0} C   Total Coliform - 37^{0}C
    - Performance of Autoclaves Sterilization using sterilization tapes - temperature 121^{0}C, pressure 15 lbs)

- Blank sample testing - Dilution water (KH_2PO_4 buffer) blanks were analyzed during the sample analysis. Three dilution blanks were filtered during the sample analysis for each set of analysis (beginning/ middle and at the end) and tested for Faecal and Total Coliforms.

- The Balance (electronic top loading balance AUW 120 D, Shimazdu, Japan) used for the preparation of reagents was calibrated from an accredited institution. (Calibration date - 15 08.2012 - Copy given below.

Certificate - NBRO registration in Central Environmental Laboratory as Consultant/ Specialist for Technical Guidance (Reg. No. 07/LM/Cons/10/2008)

ඔබේ යොමුව / உமது தொடர்பு / Your Ref

අපේ යොමුව / எமது தொடர்பு / Our Ref 19.08.2013

දිනය / திகதி / Date

මධ්‍යම පරිසර අධිකාරිය
மத்திய சுற்றாடல் அதிகாரசபை
Central Environmental Authority

"පරිසර පියස", 104, ඩෙන්සිල් කොබ්බෑකඩුව මාවත, බත්තරමුල්ල, ශ්‍රී ලංකාව.
"பரிசர பியச", 104, டென்சில் கொப்பேகடுவ மாவத்தை, பத்தரமுல்லை, ஸ்ரீ லங்கா.
"Parisara Piyasa", 104, Denzil Kobbekaduwa Mawatha, Battaramulla, Sri Lanka.
Web : www.cea.lk

To whome it may concern

This is to certify that the Environment Laboratory of the National Building Research Organization is a registered laboratory under CEA for environmental monitoring and analysis since the year 2008 up to date.

They have participated in proficiency testing programmes and will be taking part in the CEA PT programme, which is scheduled to be held in mid September 2013.

This letter is issued on request of Ms. S.V. Dias, Director (Environment Division), NBRO.

Yours faithfully,

Deputy Director General (EPC)
Envtl pollution Control Division
Central Environmental Authority

Chairman	Tel : 2872361, 2872348 Fax : 2872347	Director General	Tel : 2872359 Fax : 2872608	Gen. Office	Tel : 2872278, 2873447, 2877277-280, 2873448 Hot Line : 2888999	Media Unit : 2873449
Deputy Director Generals	HRD, Admin & Finance Division Tel : 2865296 Fax : 2872301	Envt. Pollution Control Division Tel : 2873453 Fax : 2872605	Envt. Mgt & Asses. Division Tel : 2872168 Fax : 2872296	Envt. Edu. & Awareness Division Tel : 2872297 Fax : 2872609		
Directors Tel Fax	2872607 (Admin) 2872301 (HRD), 2877290 (Finance) 2872601 (Admin), 2863094 (Finance)	2873352 (EPC), 2872606 (Lab) 2862335 (WM)	2872346 (NRM), 2876643 (EIA) 2867267 (R&D)	2867266 (EEA) Fax : 2872605	2872604 (Legal) (Western Province) Tel 2862031 Fax 2862294	

පරිසර හා පුනර්ජනනීය බලශක්ති අමාත්‍යාංශය | சுற்றாடல் மற்றும் புதுப்பிக்கத்தக்க சக்தி அமைச்சு | Ministry of Environment and Renewable Energy

Letter indicating participation in Proficiency testing programs with CEA

... **Continuation Sheet**

CALIBRATION CERTIFICATE
Issued by an Accredited
Calibration Laboratory

SWEDAC ACKREDITERING
1791
ISO/IEC 17025

Calibration Certificate

Certificate No. SS – 1208426

CUSTOMER National Building Research Organization No 99/1 Jawatta Road Colombo 05	**DESCRIPTION** Electronic Top Loading Balance (Dual range) Capacity (Max.) : 120 g / 42 g Resolution : 0 to 42 g: 0.01 mg 42 g to 120 g : 0.1 mg	**SERIAL No.** D 449911128 **IDENTIFICATION NO.** Not given

MANUFACTURER & MODEL NO. SHIMADZU, AUW 120 D	**RECEIVED CONDITION** Not applicable
REQUEST RECEIVED ON : 2012 June 19	**REFERENCE :** C 1205218/03

CALIBRATION DATE 2012 August 15	**LOCATION OF CALIBRATION** Laboratory National Building Research Organization	**TEST CONDITIONS** Temperature : 24± 2°C Relative humidity : 55 ± 10%

REFERENCE STANDARD

Set of weights of accuracy class E2 (Eqp. No. MA/004), traceable to Primary standard maintained at Korea Research Institute of Standards and Science, KRISS & Physikalisch Technische Bundesanstalt (PTB). (Our Ref: IML-344)

METHOD OF CALIBRATION

The balance was calibrated generally in accordance with the test method manual Ref. No MM/MA/01 – Calibration of Electronic Balance.

The balance scale was externally adjusted 50 g with weight of accuracy class E2 before the calibration.

Calibration certificate – Balance; AUW 120 D, Shimazdu, Japan

Annex 7

The river water quality (low flow season and high flow season)

Table 1 Water quality of river water **Date of sampling- 06th March 2013**

Category No.*	Location	Sample code	pH	Temperature ^{0}C	Turbidity NTU	Dissolved Oxygen mg/L	BOD_5 mg/L	Ammonia (as N) mg/L	Nitrate (as N) mg/L	Total Phosphorus (as P) mg/L	Total Suspended Solids (mg/L)	Faecal Coliforms (E.coli /100ml)	Total Coliforms (Coliform Organisms /100ml)
	L 1	D1-1	7.1	27.2	3.9	7.2	<1	0.00	0.328	0.120	2.4	100	400
		D1-2	7.0	27.2	4.1	7.2	<1	0.00	0.247	0.074	2.3	300	1600
	L 2	D2-1	7.1	25.4	20.4	6.9	<1	0.03	0.362	0.035	12.4	800	11200
		D2-3	7.1	25.1	20.9	6.9	<1	0.02	0.301	0.045	13.1	900	12200
	L 3	D3-1	7.4	26.3	34.6	7.2	<1	0.26	0.325	0.044	14.6	3100	14200
		D3-2	7.3	26.4	34.5	7.2	<1	0.19	0.433	0.036	15.8	4900	18000
	L 4	D4-1	7.4	26.5	38.6	7.0	<1	0.00	0.365	0.097	17.4	3100	18600
		D4-2	7.2	26.3	39.0	7.0	<1	0.04	0.662	0.012	18.1	2700	19000
	L 5	D5-1	7.3	26.0	34.0	7.1	<1	0.04	0.268	0.032	14.7	800	12000
		D5-2	7.3	26.0	33.9	7.3	<1	0.03	0.384	0.046	17.1	1000	16200
	L 6	D6-1	7.2	26.0	27.8	7.7	<1	0.00	0.355	0.029	14.3	124	11600
		D6-2	7.3	25.9	27.9	7.6	<1	0.00	0.373	0.021	14.5	400	21000
	L 7	D7-1	7.4	25.8	22.8	7.4	<1	0.00	0.407	0.079	12	100	18600
		D7-2	6.6	25.8	21.4	7.6	<1	0.01	0.407	0.080	11.1	200	19400
	L 8	D8-1	6.2	25.4	12.9	7.5	<1	0.00	0.369	0.020	7.8	600	5200
		D8-2	6.6	25.3	12.8	7.5	<1	0.06	0.377	0.019	8.1	530	9000
	L 9	D9-1	6.7	25.1	3.7	7.4	<1	0.00	0.421	0.088	2.6	500	8800
		D9-2	7.3	25.1	3.7	7.4	<1	0.06	0.120	0.124	2.8	580	9200
	L 10	D10-1	7.3	25.8	11.2	7.3	<1	0.00	0.397	0.012	6.9	1000	8000
		D10-2	7.3	25.9	10.8	7.2	<1	0.04	0.380	0.010	6.2	980	9600
2	Drinking water – Simple Treatment		6.0-8.5	-	5 (max)	6 (min)	3 (max)	-	5 (max)	0.23 (0.7 as PO_4) max	-	600 (max)	5000
3	Bathing		6.0-9.0	-	-	5 (min)	4 (max)	-	5 (max)	0.23 (0.7 as PO_4) max	-	50	1000
4	Fish & aquatic life		6.0-8.5	-	-	3 (min)	4 (max)	0.94 (max) (pH < 7.5)	5(max)	0.23 (0.7 as PO_4) max	-	-	20000
5	Drinking water – Conventional Treatment		6.0-9.0	-	-	4 (min)	5 (max)	-	5 (max)	0.23 (0.7 as PO_4) max	-	-	5000
6	Irrigation & Agriculture		6.0-8.5		-	3 (min)	5 (max)	-	5 (max)	0.23 (0.7 as PO_4) max	-	-	1000

*Ambient Water Quality – EA1P-DHV-2000

"<" denotes minimum detection level of the methodology employed.

	Non compliance with Category 2

Table 2 Water quality of river water **Date of sampling- 15th May 2013**

Category No.	Location	Sample code	pH	Temperature ^{0}C	Turbidity NTU	Dissolved Oxygen mg/L	BOD_5 mg/L	Ammonia (as N) mg/L	Nitrate (as N) mg/L	Total Phosphorus (as P) mg/L	Total Suspended Solids (mg/L)	Faecal Coliforms (E.coli /100ml)	Total Coliforms (Coliform Organisms /100ml)
	L 1	D1-1	6.6	21.8	13.5	8.3	<1	0.17	0.698	0.105	5.5	196	6000
		D1-2	6.6	21.9	15.4	8.1	1.3	0.11	0.908	0.063	4.1	120	5100
	L 2	D2-1	7.1	23.8	25.9	7.5	<1	0.37	0.632	0.040	31.1	1300	210000
		D2-3	7.1	23.6	25.7	7.4	<1	0.38	0.641	0.000	33.2	1100	200000
	L 3	D3-1	6.8	22.0	36.2	8.4	1.3	0.23	0.471	0.057	34.7	8000	110000
		D3-2	6.9	22.1	36.1	8.3	1.1	0.24	0.521	0.052	33.8	8100	100000
	L 4	D4-1	6.6	21.2	31.7	8.3	<1	0.17	0.433	0.085	34.7	3200	220000
		D4-2	6.4	20.9	32.1	8.1	<1	0.15	0.450	0.071	33.1	4800	200000
	L 5	D5-1	6.6	21.7	31.1	8.4	1.2	0.10	0.453	0.127	30.6	6000	140000
		D5-2	6.4	21.4	30.0	8.0	1.4	0.24	0.473	0.086	34.8	4000	80000
	L 6	D6-1	6.9	22.2	32.4	8.3	<1	0.09	0.493	0.128	29.5	1100	210000
		D6-2	6.5	21.5	29.9	8.2	<1	0.10	0.512	0.112	31.1	1300	280000
	L 7	D7-1	7.2	21.9	27.1	8.3	1	0.11	0.370	0.098	26.2	2000	140000
		D7-2	6.6	22.6	30.1	8.1	1	0.08	0.412	0.119	25.7	1000	90000
	L 8	D8-1	7.6	22.1	42.3	8.1	<1	0.33	0.532	0.110	36.9	3700	160000
		D8-2	7.1	21.0	40.1	8.0	<1	0.30	0.510	0.101	34.2	3000	120000
	L 9	D9-1	7.2	21.3	118	6.1	<1	0.19	0.185	0.160	55.4	300	110000
		D9-2	6.7	21.6	119	6.2	<1	0.13	0.636	0.116	61.6	400	100000
	L 10	D10-1	7.0	20.8	120	6.0	<1	0.31	0.730	0.161	63.3	600	170000
		D10-2	6.9	20.8	119	6.4	1	0.20	0.656	0.135	61.8	550	180000
2	Drinking water – Simple Treatment		6.0-8.5	-	5 (max)	6 (min)	3 (max)	-	5 (max)	0.23 (0.7 as PO_4) max	-	600 (max)	5000
3	Bathing		6.0-9.0	-	-	5 (min)	4 (max)	-	5 (max)	0.23 (0.7 as PO_4) max	-	50	1000
4	Fish & aquatic life		6.0-8.5	-	-	3 (min)	4 (max)	0.94 (max) (pH < 7.5)	5(max)	0.23 (0.7 as PO_4) max	-	-	20000
5	Drinking water – Conventional Treatment		6.0-9.0	-	-	4 (min)	5 (max)	-	5 (max)	0.23 (0.7 as PO_4) max	-	-	5000
6	Irrigation & Agriculture		6.0-8.5		-	3 (min)	5 (max)	-	5 (max)	0.23 (0.7 as PO_4) max	-	-	1000

*Ambient Water Quality – EA1P-DHV-2000

"<" denotes minimum detection level of the methodology employed.

Non compliance with Category 2

Annex 8

Analysis data of Crysbro Broiler Farm outlet

Quality of Crysbro Broiler Farm outfall

Location	Sample code	pH	Temperature ^{0}C	Turbidity NTU	Dissolved Oxygen mg/L	BOD_5 mg/L	Ammonia (as N) mg/L	Nitrate (as N) mg/L	Dissolved Phosporus (as P) mg/L	Total Suspended Solids (mg/L)	Faecal Coliforms (E.coli /100ml)	Total Coliforms (Coliform Organisms /100ml)
L 11	D11-1	6.7	27.2	160	1	800	8.5	0.502	3.60	70	268	24000
	D11-2	6.8	26.4	155	<1	780	8.3	0.410	3.50	80	280	22000
* Tolerance Limit Value		6.0 -8.5	<40	NM	NM	30	50	NM	5	50	40	NM

*Tolerance Limits for the Discharge of Industrial Waste in to Inland Surface Waters–National Environmental Act Gazette No.1534/18, 01.02.2008

NM – Not Mentioned

Non compliance with the standard

ADDITIONAL STUDIES ON NATURAL ENVIRONMENT FOR REVIEW OF FEASIBILITY STUDY AND PREPARATION OF DETAILED DESIGN AND BIDDING DOCUMENTS MORAGOLLA HYDROPOWER PROJECT, SRI LANKA

Final Report 2

Aquatic ecology in the Mahaweli Ganga

Prepared by
The National Building Research Organization

Prepared for
NIPPON KOEI Co Ltd - Moragolla Hydropower Project

July 2013

National Building Research Organization
Ministry of Disaster Management
99/1, Jawatte Road, Colombo 05, Sri Lanka

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Executive Summary

Introduction

The Ceylon Electricity Board (CEB), the institution responsible for electricity generation, transmission, distribution and retailing in Sri Lanka, plans to develop a new hydropower scheme in Moragolla, in Kandy District with a designed capacity of 30.0 MW. The proposed project envisages construction of a 35 m high dam across the Mahaweli Ganga at Weliganga. Nippon Koei Co. Ltd, Ltd., the consultant appointed by CEB to review the feasibility study and prepare designs and bidding documents for the Moragolla Hydropower Project, appointed the National Building Research Organization (NBRO) to conduct additional studies on the natural environment. This work is one of several studies conducted in order to update and upgrade the previous EIA study to comply with the ADB safeguard policy (Safeguard Policy Statement, ADB 2009).

In this study, surveys were conducted to provide a) an overview of the aquatic ecology downstream of the proposed dam, and b) a detailed account of the ecology at the project site. The objective was to determine the present status and importance of aquatic ecology, identify the likely impacts of constructing and operating the project, and propose suitable mitigation for any negative impacts.

Information and data collection

An overview of the aquatic ecology in Mahaweli River from the Moragolla project area to Polgolla weir 30 km downstream was prepared by referring to satellite images, published literature, conducting interviews and discussions with local people and experts, and this was followed by field visits and surveys in March and May 2013.

The detailed aquatic ecological assessment conducted in the Mahaweli River covered the area from upstream of the Kotmale Oya confluence to 500 m downstream of the Atabage Oya confluence. The survey involved investigation of 17 sites in the study area in March and May 2013 representing both low flow (dry) and high flow (wet) seasons. *In situ* studies on riparian vegetation, features of the river valley and river banks, presence of different habitats, river bed and substrate forms were done via the line-transect method and by referring to accepted international criteria for river habitat assessment. The macro/micro aquatic fauna and flora were studied qualitatively and quantitatively following standard ecological techniques. The fish were captured with cast nets, trammel nets and gill nets.

Overview of the aquatic ecology in Mahaweli River

The Mahaweli River at Moragolla is a diverse aquatic ecosystem, which flows through different valleys consisting of disturbed environments with only scattered natural habitats left. The river morphology is diverse and channel condition varies from rock pools, rapids, riffles to runners. River bed substrate is largely rocky in this area, but it is sandy to muddy further downstream in the Kalugamuwa-Getambe and Katugastota-Polgolla reaches. The Katugastota to Polgolla reach of the river has changed to a slow moving reservoir due to construction of a wire at Polgolla.

Biological diversity from Moragolla to Polgolla weir is generally high and this provides habitat to a recorded total of 49 fish species (14 endemics), 3 indigenous aquatic reptile species, 12 aquatic bird species and a semi-aquatic indigenous mammal. None of these are confined only to this river stretch.

There are 17 aquatic flowering plant species, of which 7 have been identified as rare and endemic, that are confined to Peradeniya-Getambe reach. Seven endemic dragonfly and damselfly species and one endemic crab also inhabit the overall study area.

At present, the river from Moragolla to Polgolla is subject to several uses including bathing, abstraction of drinking water, fishing, farming, sand mining and aesthetic uses but the environment is stressed due to colonization of noxious alien species, waste dumping, discharge of wastewater carrying pollutants, and soil erosion.

Existing aquatic ecology at Moragolla study area

The river bed in the immediate project area is entirely rocky with large boulders with rock pools, rapids, glides and cascades. The river valley varies in form from shallow to broad, with moderately to highly disturbed river banks. The river at the dam site and immediate downstream area has natural barriers that impair the passage of fish under average flow conditions. The river substrate consists of a mixture of cobble, gravel and pebble in different percentages. There is a good forest canopy (> 75% shading) at the proposed dam site and the adjacent downstream area. Other areas generally have disturbed riparian vegetation with some exotic alien plant species.

The zooplankton and phytoplankton distribution at the sites studied showed a seasonal variation in dry and wet months. Bio indicators of poor water quality such as invertebrates of many species were also recorded, suggesting the presence of water pollution. Here are 20 species of damselflies and dragonflies in the study area of which 7 are endemic to Sri Lanka. The fish species diversity is high, with 40 of the total of 91 fish species in Sri Lanka found here (including 14 endemics and six migratory species). In the river and associate habitats the survey recorded 3 aquatic reptiles, 7 aquatic bird species and a single species of aquatic mammal, none of which are endemic or confined only to the study area. Only four aquatic flowering plant species were recorded and these are also not endemic or threatened. The studies suggest that the aquatic fauna in the Moragolla area is under stress due to the impairment of water quality.

Potential impacts of the project

Soil and river bank erosion leading to siltation and depletion of water quality are the most likely impacts on aquatic fauna in the area during dam construction. In particular, rare fish species inhabiting rock pools in this area could be affected due to removal or alteration of their habitat size, depth and water quality. Drying of river-bed areas due to the diversion of the river, accumulation of garbage and vegetation removal during construction phase may also alter habitats of intact aquatic, semi-aquatic fauna and terrestrial animals. Further, effects on the behaviour and physiology of animals in the river due to blasting and vibration are significant impacts of concern.

When operating, the dam and the reservoir will cause changes in water level, altering the upstream river morphology and inundating the present river banks and adjacent areas. This will change aquatic habitat conditions. Obstruction of migratory movements and habitat fragmentation of aquatic organisms, especially fish, might lead to long-term decline in their populations in this river. Changes in downstream water quality are not expected to result in highly significant ecological impacts but, reduction of water level in the dry season may affect the downstream aquatic life and will hinder connectivity of deep rock pools while blocking in between fish passages. Thus, reconfiguration of the river is expected to cause changes in distribution patterns and population densities of fish and other organisms, but is unlikely to result in the loss of any species. Sediment build-up behind the dam may cause a decline in downstream habitat conditions, by reducing the amount of soft-sediment habitats and the oxygen content of water retained in the reservoir and flowing downstream. The likely risk of erosion, bank failures and undercuts leading to land degradation, land slippages and increased reservoir sedimentation from the steeply sloping new reservoir banks with little natural vegetation may also occur also expected during the operation stage.

Proposed mitigation measures

During construction work, adherence to basic soil conservation practices are proposed to minimize soil erosion and reduce the entry of sediment laden runoff into the river. Formulating and implementing a proper waste management plan covering all construction sites including accommodation camps, is recommended to minimize the entry of litter, organic matter and debris from vegetation clearance, fuel, oil or other toxic materials from accidental spills. Dynamite blasting should be avoided in areas in or close to the river and restricted only to necessary areas.

The proposed mandatory environmental flow of $1.5m^3/s$, should be released and channelized to supply enough water to deep rock pool areas continuously. The stream Thismada Ela, an additional source of perennial flow to the immediate downstream area of the dam, should not be blocked to maintain quality of the ecosystem. Translocation of the already stressed threatened endemic fish *Labeo fisheri* and other sensitive aquatic species that will be trapped in isolated pools below the dam to a suitable relief point is strongly recommended over much more costly fish ladder option. Regular monitoring of Crysbro Broiler Farm's effluent to ensure the enforcement of stipulated industrial discharge limits or relocation of the effluent outfall downstream of the proposed tailrace outlet are recommended to minimize the impacts on downstream aquatic ecology and water quality during the operational stage.

The dam and the reservoir across the river will act as an excellent sediment and debris trap that prevents downstream transportation of both. This, together with the proposed management efforts to maintain the effluent discharge of Crysbro Broiler Farm within stipulated pollutant discharge limits or its relocation downstream of proposed tailrace outfall will significantly benefit already stressed downstream water quality and aquatic ecology.

1. Introduction

The Ceylon Electricity Board (CEB) plans to develop a new 30.0 MW hydropower project at Moragolla in the Kandy District. The scheme involves construction of a 35 m high concrete gravity dam (with 5-gate spillway) across the Mahaweli Ganga at Weliganga, to create a 38.5 ha (1.98 MCM) reservoir with a Full Supply Level (FSL) at 548 masl. Water will be diverted through a 3.1 km underground tunnel, surge shaft and penstock on the left bank of the river, to a powerhouse and outfall located opposite the confluence with the Atabage Oya.

In this regard, CEB intend seeking international financial support for project implementation and potential funders include the Asian Development Bank (ADB). CEB has appointed Nippon Koei Co. Ltd in joint venture with Nippon Koei India Pvt Ltd to review the Feasibility Study and prepare detailed designs and bidding documents for the project. Review of the EIA indicated that further studies were needed in order to update and amend the document to comply with ADB safeguard policy (Safeguard Policy Statement, ADB 2009).

The Nippon Koei Co Ltd, Moragolla Hydropower Project appointed the National Building Research Organization (NBRO) to conduct additional studies on the natural environment and the studies covered the following:

1. Water quality in the Mahaweli Ganga
2. Aquatic ecology in the Mahaweli Ganga
3. Groundwater distribution and quality along the tunnel route
4. Updated land-use mapping

This report presents the results of the aquatic ecology survey in the Mahaweli Ganga and includes: present status of the aquatic ecology in the river upstream and downstream of the proposed dam site at Moragolla, the likely impacts on aquatic organisms during construction and operation phases and the proposed mitigation measures.

2. The scope of the study

According to the TOR (refer **Annex 1**) the aquatic study is required to be conducted as follows.

Overview of Mahaweli Ganga
An overview of the aquatic ecology of the Mahaweli Ganga in the 30 km stretch downstream of the project site was required to be prepared by consulting published information and other data from government agencies, consultancy reports and other sources, referring to aerial photographs and satellite imagery, visual observations on site and interviews with local people, and discussions with experts from Peradeniya University.

Aquatic ecology of the project site
For the detailed ecological study, aerial photographs and satellite images were to be referred to obtain a rough picture of the type and distribution of aquatic habitats of the river in the study area and refined further by site investigations including analyses of the type and distribution of river bed substrates and vegetation, supplemented by information obtained from local people, including sand miners.. Quantitative analyses were also required to describe the species present (flora and fauna) in each habitat type and the average numbers of individuals of the major species in the different habitats. This should cover the aquatic habitats (sampled by fish nets, traps, plankton nets etc) and river bed habitats (sampled by sediment grabs, quadrat sampling if

feasible and other suitable methods). Quantitative surveys were required to be conducted twice; during the low flow season in March 2013 and at the start of the high flow season at the end May 2013 to give an indication of seasonal variations.

3. Overview of aquatic ecology of the Mahaweli Ganga between the project site and Polgolla diversion weir

3.1 Methodologies adopted

Preparation of an overview of aquatic ecology of the Mahaweli River between Moragolla project site and Polgolla diversion weir, 30 km downstream, was done by referring to satellite image. (refer **Annex 2**) and the web site www. googleearth.com. The purpose of this was to get a rough picture of different types and distribution of aquatic habitats therein. All possible information and data pertaining to the aquatic ecology in this part of the river were gathered from the published and unpublished literatures, consultancy reports and etc. that are available at government and non-government agencies. For this study, a total of 31 sites (refer to the map in **Annex 3**) were selected based on the habitat type (presence of runner, riffle, pool, etc.), easy access and previous records of ecological significance (presence of rare, exotic or threatened taxa). Accordingly, two field visits were made in April 2013 and May 2013 to make visual observations at the selected sites. The field observations were supported by interviews with local people and discussions with experts in the field of aquatic ecology.

3.2 Overview of Aquatic Ecology

Mahaweli River, the largest river system in Sri Lanka, has a total of 24 sub-rivers that flow through different bio-climatic zones of the island (Arumugam, 1969). The Kotmale Oya, the main upstream tributary of the Mahaweli River is formed by the convergence of three main streams, namely Dambagastalawa Oya in the Ambewela hills, Agra Oya in Horton Plains, and the Nanu Oya in Piduruthalagala. Kotmale Oya has a large catchment area (1891 km^2) and it carries a substantial amount of water (mean annual runoff, 2,430 thousand acre feet)[1]. As such it has been dammed at two upstream locations to produce hydropower as well as to act as flood mitigation reservoirs, particularly in the Gamploa-Peradeniya reaches of the Mahaweli Ganga (Manchanayake and Madduma Bandara, 1999). Due to these diversion weirs, the Kotmala Oya is now having a pseudo lacustrine system (artificial reservoirs) in its upper reaches. At present it is considered as an altered and a disturbed river cascade system (Silva, 2013). The Kotmale Oya converges with Dik Oya, a tributary that flows through Hatton Dik Oya area near Ulapane to form the Mahaweli proper.

The Mahaweli River at Moragolla (the proposed project area) is a diverse flowing water habitat which flows through different valleys. The river has remarkable morphological diversity. Most of the natural vegetation in the river valley was removed many years ago to provide land for tea plantations and other types of farming, hence very little natural habitat is left at present. Consequently, this has resulted in negative effects on the river water quality mainly due to soil erosion. Traditional home gardens, tea plantations, and plantation sector colonies are prevalent in the valley and these represent highly disturbed environments.

The diverse aquatic habitats in this part of the river comprise steep, shady, cool, fast flowing perennial rock pools, rapids, riffles and runners. these are significant and they provide breeding,

[1] (http://www.mahawelicomplex.lk)

feeding and foraging grounds for the aquatic life therein, especially for cool water loving species such as Green Mountain Labeo (*Labeo fisheri*), Ceylon Stone-sucker (*Garra ceylonensis*), and Black Mahseer (*Tor khudree*) (Kortmulder *et al.* 1990; Shirantha, 2012). The presence of a series of rock pools ensures a constant flow of water in all seasons, providing habitat for species that inhabit deeper waters. Two small islands are also present in this part of the study area near the proposed powerhouse. These islands not only add aesthetic beauty to the area, but also provide shelter, nesting sites for waders, raptors and other wildlife in the surroundings.

Downstream of the project site, the river in the Gampola-Kalugamuwa reach (sites 17 to 21 of the map in **Annex 3**) is relatively wider and deeper in comparison to the project site. There are several small sand islands along this river reach and their length varies from 10 to 16 m. These islands support diverse habitats for the inhabitants in different water levels. Diverse river morphological features have resulted due to the presence of sand bars[2], passages, backwaters etc. and these are responsible for river flow modification. The habitats in this area are predominately occupied by native and non-native schooling fish species such as Cyprinds (Carp and Minnows) and Cichlids. At certain places the river width is about 25 m and has rocky substrate (site 21 in the map in **Annex 3**). This area also has rock pools and a number of small islets. These small islands provide habitats for terrestrial, semi-aquatic and aquatic animals which inhabit different water regimes. The water's edge on either side of the river bank contains shrub forest cover. Some places are predominantly occupied by invasive alien species: *Mimosa pigra* (Giant Mimosa), *Panicum maximum* (Guinea Grass) and *Wedelia trilobata* (Singapore Daisy) (Marambe, 2001a; Shirantha and Ranawaka, 2009). Several locations in this area are used for sand mining (refer Fig.11 in **Annex 4)**. This brings some negative impacts on the river morphology as in-stream mining lowers the stream bottom leading to bank erosion. Almost the entire river bank and valley areas are disturbed along this river stretch, which is densely populated and used for farming, along with various other activities. A Few locations in the river are still being used as bathing/washing sites by local communities; and there is some fishing for local consumption, but there is no commercial fishing activity.

The next downstream part of the Mahaweli River is the Kalugamuwa-Peradeniya reach (sites 21 to 25 of the map in **Annex 3**), which is mainly composed of runners with slow flowing water. The bed substrate in this area is sand to mud. The left bank of the Mahaweli River in this reach is open due to construction of Peredeniya-Katugastota Road. The open river bank is noticeable in the river stretch that runs around the Peradeniya Royal Botanic Garden. Closer to Hal-Oluwa-Warathenna (sites 26 to 27 of the map in **Annex 3**), the river channel narrows and the bed is entirely rocky, with few inhabitants because of the inhospitable bottom substrate and fast-flowing water. After this area the river is more ecologically important, with diverse habitats as the river becomes shallower and spreads over a large area, containing over 30 small islets (sites 28 and 29 of the map in **Annex 3**). This morphology has created suitable habitats for various types of endemic and non-endemic flora i.e. *Farmeria metzgerioides* and *Polypleurum elongatum* of the family Podostemaceae; *Cryptocoryne parva*, *C. walkeri*, *C. beckettii*, and *C. undulata* and *Lagenandra praetermissa* of the family Araceae (Yakandawala, 2012). These plants inhabit the submerged rocks at the water's edge (Environment Management Lanka (Pvt.) Ltd, 2006, Rehel S. 2011, Yakandawala 2012). The area is also a home for a total of 15 indigenous fish species including the endemic critically endangered *Labeo fisheri* (Green Mountain Labeo), the endemic vulnerable *Garra ceylonensis* (Ceylon Stone-sucker), and indigenous the near threatened *Tor khudree* (Black Mahseer) (Environment Management Lanka (Pvt) Ltd, 2006, Shirantha 2012). This part of the river is economically important as a tourist attraction and elephant bathing site. In addition to these, this particular Mahaweli River stretch

[2] Sand bar: a ridge of sand formed in a river or along a shore by the action of waves or currents, passage: a deep and relatively narrow body of water, backwater: a part of a river in which there is little or no current.

receives runoff water from urban and agricultural lands, which carry urban pollutants and agrochemicals into the river (Environment Management Lanka (Pvt) Ltd, 2006). This part of the river has been proposed for the Getambe mini hydropower project, which will be implemented in the near future.

The river in Katugastota reach (sites 30 and 31 of the map in **Annex 3**) shows some reservoir features due to river modification. About 1 km downward, the river is totally modified and has become a reservoir, with a very low flow rate due to Polgolla weir, constructed in 1976. This area is largely colonized by some exotic fish species such as *Oreochromis* spp. (Tilapia), *Cyprinus carpio* (Common Carp), *Cirrhinus mrigala* (Mrigal), *Labeo rohita* (Rohu) and *Catla catla* (Catla) introduced for aquaculture development of the country in the late 1950s (Pethiyagoda, 1991). There are some native fish species such as *Systomus spilurus* (Sri Lanka Olive Barb), *Ompok bimaculatus* (Butter Catfish), *Wallago attu* (Shark Catfish) and *Clarias brachysoma* (Walking Catfish), which are important as food fish. This artificial reservoir plays a vital role as an economically important water segment in the Central Province providing grounds for sand mining, eco-tourism, hydropower generation as well as for a capture-based inland fishery (De Silva and Wansapura, 1991).

One of the remarkable features of aquatic life in the Mahaweli River from the Moragolla project site to the Polgolla weir is its invertebrate diversity. Various taxa of macro invertebrates such as Ephemeropterans (mayflies), Odonates (dragonflies and damselflies), Crustaceans (crabs and shrimps), Coleopterans (beetles) and Dipterans (true flies) have been recorded from this part of the river (Environment Management Lanka (Pvt.) Ltd, 2006; Shirantha *et al*. 2010). However, little can be said about the invertebrate species present in this area, or their density and importance, as there have been no previous studies.

Of the vertebrate faunal groups, the river from Moragolla to Polgolla harbours a total of 49 freshwater fish species belonging to 18 families (Pethiyagoda, 1991; Shirantha and Amarasinghe, 2005) (see table 3 in **Annex 9).** Of these, the presence of the critically endangered *Labeo fisheri* (Green Mountain Labeo) is significant as it is only found in the middle catchment of the Mahaweli River (Pethiyagoda 1991; Senanayake, and Moyle 1982; Shirantha 2012). Other inhabitants of this area include the aquatic reptilian Water Monitor (*Varanus salvator*) and some aquatic bird species namely, the Indian Cormorant (*Phalacrocorax fuscicollis*), Little Cormorant (*P. niger*), Common Kingfisher (*Alcedo atthis*), White Breasted Water-hen (*Amaurornis phoenicurus*), Little Egret (*Egretta garzetta*), Cattle Egret (*Bubulcus ibis*), Pond Heron (*Ardeola grayii*), Intermediate Egret (*Mesophoyx intermedia*) and White-throated Kingfisher (*Halcyon smyrnensis*) (Environment Management Lanka (Pvt) Ltd, 2006). The Eurasian Otter (*Lutra lutra*) also shows a wide distribution in this area (De Silva, 1997), but there is no published record on any endemic faunal taxon that is confined only to this river stretch.

As mentioned above, the aquatic plant species diversity is high in the Mahaweli River from Moragolla to Polgolla weir. There are some rare endemic species belonging to the families *Podostemaceae* (*Farmeria metzgeniodes* and *Polypleurum elongatum*) and *Araceae* (C*ryptocoryne becketti, C. parva*, *C. undulata*, *C. walkeri* and *C. willisii)* that are restricted to this area (Wijesundara and Shantha Siri, 2004; Yakandawala, 2012). However, at present their existence is threatened due to development activities and rapid colonization of noxious aquatic species such as Water Hyacinth, Giant Mimosa and Giant Salvinia (Yakandawala, 2012).

The aquatic ecological integrity of this part of the river is degraded as a result of the many human activities in the area. The water pollution threat in the upper reach, particularly upstream of Gampola, mainly arises through soil erosion, use of agrochemicals and fertilizer and direct deposition of solid and liquid waste into the river (Amarathunga *et al*. 2010). This situation is severe between Gampola and Kandy due to increased inputs of urban waste; dilution by water is high however in this part of the river due to the presence of numerous perennial streams and high precipitation (annual average rainfall of 1450 mm source: http://www.gampolacity.com).

At present the low gradient Katugastota-Pollgolla River reach (sites 28 to 31 of the map in **Annex 3**) is heavily invaded by some alien species. Among them, the Orinoco Sailfin Catfish (*Pterygoplichthys multiradiatus*) has been identified as the biggest threat (Shirantha & Amarasinghe, 2005; Shirantha, 2009). Further, a rapid loosing of the natural balance in the ecosystem from heavy growth of some aquatic invasive plant species such as Water Hyacinth (*Eichhornia crassipes*) and Giant Salvinia (*Salvinia molesta*) has been reported as invade in the water's edge area and choke the river channels (Yakandawala, 2012).

During the monsoon the Moragolla project site to the Polgolla weir experiences a large influx of water and as a result the Katugastota area experiences flooding. There is therefore a clear need to utilize this renewable resource for the economic benefit of the country, and in a way that will reduce flooding and associated risk to human life, property and socio-economic development. Hydropower development is therefore, justified in this already heavily-exploited region however, combined with a proper river management plan, that will control and minimise the threats from pollution, promote land-use and use the water in this river reaches either for hydropower generation or other development projects which especially concerning its pollution trend and terrain stability.

4. Aquatic ecology of the project site

4.1 The study area considered for detailed ecological assessment

The assessment was initiated by referring to aerial photographs and satellite images of the study area in order to obtain a consensus of the different types and distribution of aquatic habitats. A total of 17 sites, covering approximately a 7 km river stretch was studied, from 500 m above the confluence with the Kotmale Oya to 500 m below the confluence with the Atabage Oya (refer to satellite image in **Annex 2** and the map in **Annex 3**).The site selection was based on the quality, the types of habitats present and accessibility. A detailed assessment of each site was done during three field visits, conducted from April 2013 to May 2013. Additional information on the sites, their inhabitants and importance was gathered by interviewing local villagers, and by referring to published data.

4.2 Methodologies adopted

An assessment of aquatic life in different habitats was done by employing the line transect method. At each of the 17 sites, a rope, clearly marked at 50 m intervals was strung along the river bank and across the river. At each 50 m point detailed observations were made on the main visual features of the substrate, and the presence of visible animals and plants. A special emphasis was given to study attached and submerged flora and riparian vegetation. Presence of any special (fish breeding and aggregation sites) and fragmented habitat (a place separated from a sand bar or isolated rock pools) was also noticed and studied. A non-mechanised boat was used to reach into deep, fast flowing distant areas. The other specific studies were conducted at each survey point as described below.

Plankton sampling and analysis

Plankton samples were collected from each sampling site using 50 µm mesh plankton net. Two samples were collected by lowering the net vertically into the water until the bottle at the end of the net is filled with water. Then pull until the net is extended and begin to tow. After about 5 minutes, the net was taken out and let it hang for a 1 to 2 minutes. Then all the plankton washed into the bottle by running freshwater from the outside of the net. One sample was collected in a plastic bottle and 3 to 5 drops of Lugol's solution[3] were added to preserve the samples for phytoplankton analysis in the laboratory. Another sample was preserved in 5% formalin for zooplankton analysis. In the laboratory, the plankton sample collected from each site was shaken well and 1 ml was transferred into a Sedgwick rafter cell (a counting cell) using a small dropper, Then the sample was covered with the glass cover without air bubbles. Later the plankton were examined under the mid power (10×10) of a light microscope and were identified using Needham and Needham (1962), Mendis and Fernando (1962) and Abewickrama (1979). The relative volume of each plankton in one transect along the Sedgwick rafter cell at 100x was measured following the method described in Vollenweider *et al.* (1974). Here, a cell of *Spirogyra* was selected as an arbitrary unit as it was the common phytoplankton in the samples collected.

Benthos sampling and analysis

On each sampling occasion, five benthic samples using a Peterson grab of 1250 cm^3 capacity (see Fig. 1 in **Annex 11**) were randomly collected at all sites, except the sites with rocky substrate. The sample was placed in a polythene bag and preserved immediately in 10 % formalin with Rose Bengal[4] and transported to laboratory for further analysis. In rocky sites, a 30 cm × 30 cm quadrat was placed. The animals found within the quadrat were collected into a container, identified *in situ* to the lowest possible taxonomic level using Mendis and Fernando (1962) and Needham and Needham (1962). Their number also recorded. The animals that needed further taxonomic confirmation were preserved in 5 % formalin and transported to the laboratory. This quadrat sampling procedure, however, could not be followed in higher water levels in May 2013.

In the laboratory, benthic samples collected from each of the sites were subjected to the wet sieving (sieving with water) method as described by Southwood (1966). The mesh sizes of sieves ranged from 2.00 mm to 250 µm. The collected benthic fauna were then placed in a white enamel tray and observed under a 1 × 10 magnifying lens. The benthos were identified to the lowest possible taxonomic level using Mendis and Fernando (1962) and Needham and Needham (1962) and their abundance was calculated as follows: Population density = number of individuals/sample volume.

Other aquatic macro fauna sampling and analysis

Various non-quantitative sampling methods, including visual observations and digital photographing were used to assess aquatic life in the river bed area, river banks, and peripheral areas. The aquatic macro fauna such as crabs, snails, damselfly and dragonfly larvae were captured with a hand net and a scoop net. The free-living nymphs and larvae of aquatic insects which live attached to river substrate (e.g. caddis flies) in the river were dislodged with a fine paint brush and subsequently collected into a white enamel tray. Some animals were picked up with fine-tipped forceps. They were then identified to the possible lowest taxa using Needham and Needham (1962) and Mendis and Fernando (1962). The animals that needed to have further

[3] Lugol's solution is a solution of 5% iodine dissolved in 10% potassium iodide. It acts as a preservative and stains the plant tissues.

[4]Rose Bengal is a vital stain that colours animal tissue pink and therefore it aids to recognize the animals in sediment samples

taxonomic confirmation were transferred into plastic bottles, preserved in 10% formalin and transported to the laboratory. In the laboratory, their taxonomic confirmation was done under the low power of a light microscope.

Fish sampling
At each sampling site, fish were caught using the cast nets of 1 cm (1.5 m height), 2.5 cm (2.5 m height) and 3.5 cm (3.5 m height) stretched mesh hauling 5 times at each site. The small hand nets, made up of the mosquito netting were used as drag nets or scoop nets grab (see Fig. 2 in **Annex 11**) to catch fish at the water's edges. A 15 m long trammel net with three layers of 3.0, 4.5, 6.0 cm netting and a 20 m long gill net of 3.5 cm stretched mesh were laid and kept 1 to 2 hours in large rock pools. The entangled fish were identified up to species level *in situ* using Pethiyagoda (1991). The Catch Per Unit Effort (CPUF) was calculated as follows:

CPUF = number of individuals caught/number of hauling

Assessing the occurrence of large animals
Survey work was supplemented by direct visual observations where possible, and by obtaining indirect evidence of the presence of certain animals, via bird calls, pugmarks (mammals), scat (carnivorous mammals), dung (herbivores), egg masses (amphibians), and discarded fur, seeds, flowers or fruit. In addition, local people were also interviewed regarding the presence of certain species and habitats, and sand miners were employed to collect additional samples of flora and fauna in locations with difficult access. The conservation status of each taxon was determined referring to The National Red List 2012 of Sri Lanka (MOE, 2012).

River habitat assessment
At present different river habitat assessment criteria have been developed by several countries to assess river habitat quality. Among them, River Habitat Audit Procedure (Anderson, 1993a) AUSRIVAS (Parsons *et al*., 2001) and Index of Stream Conditions (Ladson and White, 1999) are largely utilised in different countries (Ravena *et al*., 1998).These methods enable straightforward classification of rivers and streams based on their principal physical and biological features. They have been utilized successfully in many countries to assess river habitats (http://www.environment.gov.au). In Sri Lanka, the AUSRIVAS assessment criteria have been successfully utilized to assess site-specific river quality in the uppermost catchments of the Mahaweli River (Shirantha *et al*., 2010). The river habitat assessment criteria derived from River Habitat Audit Procedure (Anderson, 1993a), AUSRIVAS, Index of stream conditions (Ladson and White, 1999) and Stream Ecology and function (David Allen, 1998) were therefore used to assess the river habitat at each study site. Those criteria are given in **Annex 5.**

The river habitat assessment was done with the study conducted at each of the 17 survey locations and noted on pre-prepared recording sheets. Observations were made on each of the 22 assessment criteria by referring to the associated list of specified features. Decisions were made based on previous experience of using this assessment methodology in rivers similar to the Mahaweli Ganga. The decisions on percentage cover and other features were made by visual observations.

4.3 Aquatic ecology of the project site

4.3.1 River habitat variation

The results of the river habitat assessment at the study sites are given in **Annex 6**. According to the adapted assessment criteria, the river valley in this area varies widely, from "shallow" to "broad" and "gorge". The riparian vegetation cover along the river banks at the proposed dam site is relatively undisturbed, whereas in other areas, the disturbance to the river bank is "moderately undisturbed" to "highly disturbed". There is good shading of the river channel (> 75%) at the proposed dam site and the adjacent downstream area due to the presence of a forest reservation along the river on the right bank. The channel shading is however, in the range of 5-25% at most of the other sites where riparian vegetation is considerably disturbed with by certain invasive exotic alien plant species *viz.*, *Wedelia trilobata* (Singapore Daisy), *Mimosa pigra* (Giant mimosa) and *Panicum maximum* (Guinea Grass).

The river habitat analysis showed the presence of natural physical barriers for fish passage in the average water flow condition at the proposed dam site and in the immediate downstream area (between sites 11 to 15). The river in this part is almost entirely rocky with large boulders, and consists of pools, rapids, glides and cascades. However, in other areas, the conditions are generally "good" to "moderate" and favorable for fish passage. In addition to the above river morphological features, mid channel sand bars with vegetation cover are also found at many places. A prominent side-pointed sand bar is present 500 m downstream of the Atabage Oya confluence. The river substrate composition analysis shows that the bed substrate composition varies quite widely amongst the sites except at the proposed dam site, where it is 95% bed rock and in this part, the river flows through a gorge. At all other sites, the river bed substrate is basically a mixture of cobble, gravel and pebble in varying proportions.

4.3.2 Diversity and abundance of plankton

Tables 1 and **2** in **Annex 8** lists taxonomic groups of phytoplankton and zooplankton recorded at each study site. A total of 27 phytoplankton genera belonging to three families were recorded from these sites in the study area, of which diatoms (Family Chlorophyceae) and green algae (Family Bacillariophyceae) were common and their diversity was relatively high. However, this analysis was not sophisticated enough to reveal variations in phytoplankton species composition between the studied sites.

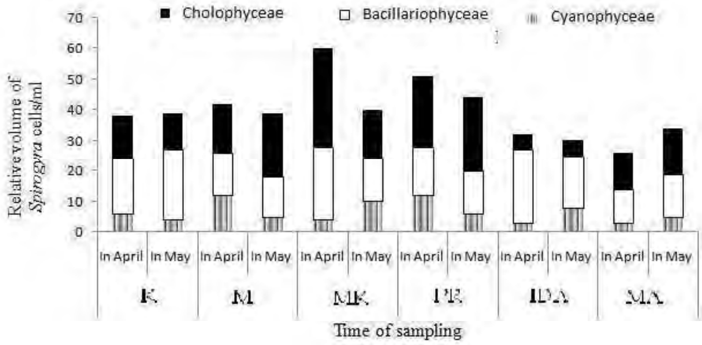

Fig. 1 Variation in relative volume (*Spirogyra* cells/ml) of different taxonomic groups of phytoplankton

Key: K; site1, 3-Kotmala Oya Before Confluence with Mahaweli River, M; site 2– Mahaweli river Before Confluence with Kotmale Oya, MK; site 4- Mahaweli River-Kotmale Oya Confluence of, PR; site 5, 6, 7, 8,9, 10- Proposed Reservoir Area, IDA; site 11, 12, 13, 14,15–Immediate Dam Area, MA; site 16, Mahaweli River-Atabage Oya confluence,

Fig. 1 shows the variation in relative volume (*Spirogyra* cells/ml) of different taxonomic groups of phytoplankton recorded at each study site: in April at the end of the dry season and in May at the beginning of the monsoon. The phytoplankton species composition is comparable to streams in Kelani and Kalu river basins in the country (Shirantha, 2004). In general there is a decline in the relative volume of phytoplankton during the month of heavy rain (in May 2013) compared to the dry month (in April 2013). This variation is common for flowing waters in the island which show seasonal variation in flow and water quality (Silva, 1996).

The zooplankton at each study site consists mainly of larval stages of aquatic insects, crustaceans, rotifers and protozoa. Most of the species in their larval form could not be identified to generic or species level, as the identification of larval stages of many aquatic insects and crustaceans in Sri Lanka is still at a neonate stage. **Fig. 2** shows the observed variation in the diversity and composition of zooplankton in the dry and wet months. The zooplankton show seasonal variation in their relative volumes in dry and wet months similar to the phytoplankton and this is common to other rivers in the country (Silva, 1996).

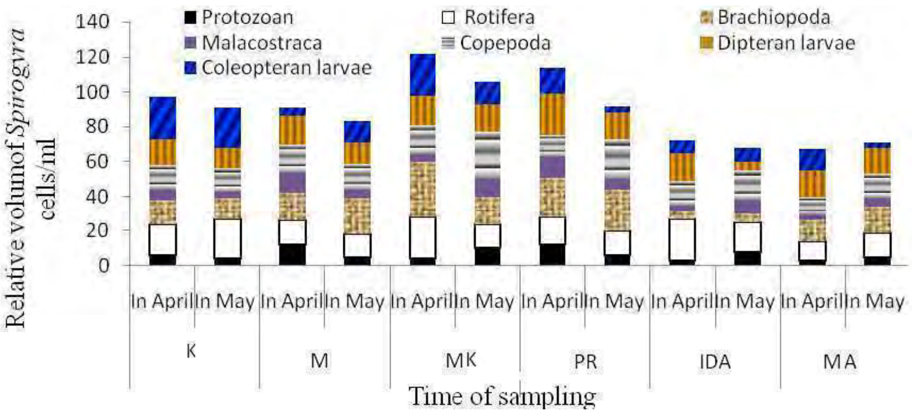

Fig. 2 Variation in the relative volume of different zooplankton taxa (*Spirogyra* cells/ml) at each study site (in April: low water level and in May: high water level)

Key: K; site1, 3-Kotmala Oya Before Confluence with Mahaweli River, M; site 2– Mahaweli river Before Confluence with Kotmale Oya, MK; site 4- Mahaweli River-Kotmale Oya Confluence of, PR; site 5, 6, 7, 8,9, 10- Proposed Reservoir Area, IDA; site 11, 12, 13, 14,15–Immediate Dam Area, MA; site 16, Mahaweli River-Atabage Oya confluence,

4.3.3 Diversity and abundance of the aquatic invertebrates

Tables 1 and 2 in **Annex 9** (see also photographs in Annex 10 - Figs 1-12) show the estimated population densities (individuals/cm^3) of all invertebrates recorded throughout the study area. This shows the presence of a variety of worms, molluscs, crustaceans and insects, with a similar taxonomic composition to those found elsewhere in upland areas of the Mahaweli River (Shirantha *et al.* 2009, 2010). Cladocerans and Copepods were the most numerous groups, and *Caridina* sp. is the most widespread species, being found at most stations, possibly because of its omnivorous habit. Most other species are quite low in abundance, which is likely to be a product of several factors, including the capture methods, the difficulty of sampling a fast-flowing river in May, and the limited coverage of particulate sediments in the study area.

Some of the species present have been suggested as being indicative of poor water quality, including the free-living turbellarian flatworms (Dudgeon, 1999) and the gastropod molluscs *Paludomus chilinoides*, *P. loricatus* and *Melanoides tuberculata* (Shirantha *et al.*, 2009); so water quality could have a limiting effect on invertebrate density, especially during the first survey period, at the end of the dry season. In contrast, Table 2 of **Annex 9** shows that there was quite a good diversity of dragonflies and damselflies, comprising 20 species, of which 7 are endemic to Sri Lanka, and two are Near Threatened according to MOE 2012 i.e. *Indothemis carnati*ca and *Paragomphus henryi*.

4.3.4 Diversity and abundance of aquatic plants

The list of aquatic plants and their occurrence in each study site are given in **Table 1** in **Annex 7.** The study reveals that the aquatic plant diversity is very low at the project site compared to the Mahaweli River at the Getambe area where there are some rare, endemic and non-endemic aquatic plant species such as *Cryptocoryne parva*, *C. walkeri*, *C. beckettii*, *C. undulata* and *Lagenandra praetermissa* (Yakandawala, 2012). None of these species were found in the project area, possibly because of the rapid flow of the river and the presence of rocky substrate, which does not support the growth of such submerged plants. The only similar species recorded was *Lagenandra ovata* (Malayan Sword), which is present in a small patch at the proposed reservoir area. Some other very rare plant species i.e. *Farmeria metzgerioides* and *Polypleurum elongatum* of the family Podostemaceae, were recorded in the submerged rocky substrate at Getambe but were absent from the project site. In contrast, certain common exotic and indigenous submerged aquatic plant species such as *Hydrilla verticillata* (Hydrilla), *Vallisneria spiralis* (Mini Twister) and *Blyxa aubertii* (Roundfruit Blyxa) were found at the water's edge at all the sites studied. There was also a dense growth of *Potamogeton pectinatus* (Sago Pondweed) in the Kotmale Oya and at the Atabage Oya confluence.

4.3.5 Diversity and abundance of fish fauna

Table 3 in **Annex 9** gives the list of fish species recorded in the project area. This shows that the fish diversity in the study area is relatively high. The survey recorded a total of 40 fish species out of 91 species in Sri Lanka (MOE, 2012). These species belong to 17 families, representing 14 endemics, 21 indigenous and 5 exotics. Of these, eight species are nationally threatened according to the current Red Data List of Sri Lanka (MOE, 2012). They include, *Channa ara* (Giant Snakehead), *Labeo fisheri* (Green Mountain Labeo), *Channa orientalis* (Smooth-breasted Snakehead), *Garra ceylonensis* (Ceylon Stone-sucker), *Pethia melanomaculata* (Fire fin barb), *Pethia reval* (Red fin barb), *Pethia nigrofasciata* (Black ruby barb) and *Wallago attu* (Shark catfish). Further, there are six migratory fish; *Anguilla bicolor* (Level fined eel) and *A. nebulosa* (Long finned eel), *Labeo fisheri* (Green Mountain labeo), *Tor khudree* (Black Mahseer), *Garra ceylonensis* (Ceylon Stone Sucker) and *Wallago attu* (Shark catfish), which swim upstream to spawn in the breeding season (Silva & Davies, 1986). Figure 3 shows the abundance of some endemic fish in the project area calculated as Catch Per Unit Effort (CPUE). The figure 3 shows that *Dawkinsia singhala* was the most abundant endemic fish species (5.75 CPUE) in the project area whereas the others were all relatively low in density (<1.5 CPUE). The CPUF of *Belontia signata* and *Clarias brachysoma* was very low <0.01 and therefore, not included in the figure 3.

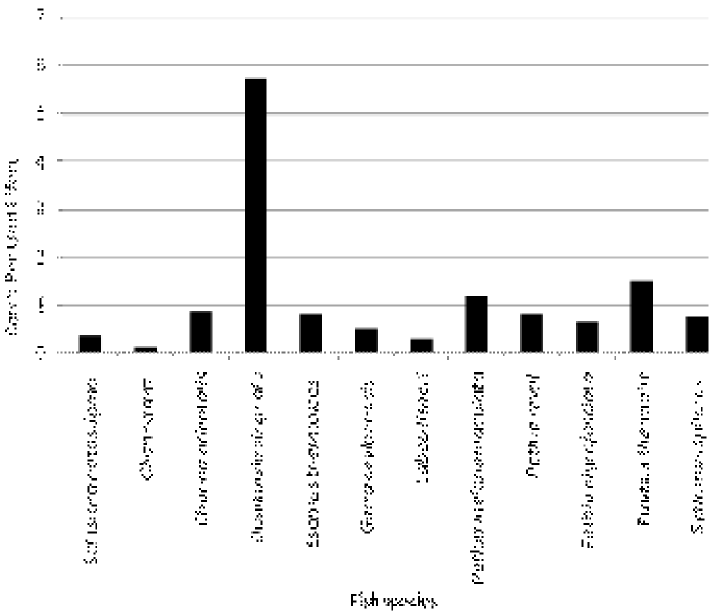

Fig. 3 Variation in abundance (CPUE: Catch Per Unit Effort) of the endemic fish species recorded in the study area

4.3.6. Diversity and abundance of other vertebrates

The aquatic/semi aquatic birds, reptiles and mammals that were recorded at the Moragolla project area are given in Table 4, 5 and 6 in **Annex 9** respectively. Three species of aquatic reptiles, seven species of aquatic birds, one aquatic mammal species and two species of terrestrial mammals that hunt their prey mainly in rivers and associated habitats. Of these species, the Eurasian otter (*Lutra lutra*) and the fishing cat (*Prionailurus viverrinus*) are of particular interest as they both feed mainly on fish, crustaceans and frogs, and are classified as Near Threatened and Endangered respectively according to the IUCN Red List of Threatened Species 2012[5]. It should be noted however that none of the species listed in Tables 4, 5 and 6 are confined only to the Moragolla project area.

5. Potential impacts

5.1 Impacts on aquatic ecology during construction

5.1.1 Soil erosion and siltation in the river

Intensified soil erosion is expected in areas where land clearing, excavation, drilling and laying of foundations take place for the proposed dam, underground tunnel, surge shaft, penstock and powerhouse, as well as the areas for other activities such as development of access roads and other facilities for the project. All these involve operation of heavy machinery and other equipment that will disturb the surface soil cover on land alongside the riverine areas, and many of the construction activities also require removal of surface soil. The dam construction will lead to soil cover removal on either side of the river bank, whereas the powerhouse, underground tunnel, surge shaft and penstock construction will lead to removal of soil on the left bank only.

[5] www.environmentmin.gov.lk/b

During construction the drilling of the bed rock and the uprooting of large woody trees and others vegetation will be inevitable. These and other activities during the construction phase of the project will cause disturbance to soil cover in the riparian area that will lead to soil erosion during rainfall and entry of silt-laden water into the river. This could be severe in the rainy season as the bank of the entire river stretch concerned is already disturbed, having little natural vegetation cover. Excessive soil erosion is therefore already a very common environmental degradation issue in this area, and the anticipated additional disturbances caused by the construction process may also cause earth slippages if surfaces from which vegetation has been cleared are exposed to heavy rain. This may be more severe in the steep areas of silt or muddy substrate, and may be more of a risk on the left bank, where there are abandoned tea plantations, an industrial area and home gardens that are susceptible to heavy surface runoff. Removal of riparian vegetation along the river bank will also reduce the stability of the banks, and increase insolation and raise the temperature of the water, especially during the low flow season.

Bedrock and boulders may have to be removed for the dam foundations and other structures, and this may exacerbate soil erosion in these areas. The anticipated soil erosion will deliver sediments into the river channel, which may cause detrimental effects on in-stream habitats and inhabitants.

Soil erosion usually causes high siltation in the river, producing highly turbid water from the increased amount of suspended loads. In these circumstances, gills of fish and invertebrates could become clogged, impairing respiration, and if the condition becomes severe, the more sensitive life forms, including larvae of fish and other aquatic animals could die (Kerr, 1995). Motile animals may move to avoid highly turbid waters so distribution patterns could change, and if light penetration is impeded, photosynthesis by macroscopic plants and phytoplankton would be reduced, leading to reduced overall productivity of the ecosystem. Increasing the sediment input in the river could therefore have a variety of impacts in the project area and downstream, depending on the extent and duration of any siltation issue. It should be borne in mind however that little soil disturbance is anticipated on the right bank, where there is less construction activity and a relatively good riverine forest cover, and that these anticipated impacts will occur mainly in the construction phase.

5.1.2 River bank erosion

Construction work in the river channel will be required in order to build the dam and the tailrace outfall, and the river will be diverted temporarily in the area of the dam to enable safe access for the riverbed construction. There will be changes therefore in flow patterns in the river, which could cause erosion of the river banks, and this could be exacerbated by any damage caused by heavy machinery operating alongside river banks in these and other locations. There is a direct and indirect interconnection between the substrate and the biota in river banks as the substrate provides a surface to cling to or burrow in, shelter from the current, materials for construction of cases and tubes, and refuge from predators. Thus if banks were allowed to erode significantly, any inhabiting plants, together with fauna such as crabs, molluscs, some aquatic insects (mayflies, caddis flies, etc), and annelid worms would be dislodged. The natural morphology of the river in the project area however provides quite stable bedrock (see **Annex 4**) and banks that are naturally protected by rock boulders, so it may not be necessary to have specific mitigation measures for these impacts. Particularly in the tailrace construction area the river consists of mainly riffles where the water flow rate is rather high, and any changes in flow patterns will be dissipated by the presence of the small islands and good woody plant cover and rock boulders, described in **Section 4** above. This will minimize erosion of the river bank as they act as a barrier to break up the energy of the flow.

5.1.3 Water quality depletion in the river

There are several ways in which the water quality in the river could be reduced during construction. The principal risks include: direct contamination by cement and other construction waste, or by spillage of fuel and other materials into the water; indirect contamination due to spillage of these materials onto soil, which washes into the river; and increased inputs of silt (as described above), which then settle out in quiet waters, causing siltation and sedimentation. Any impacts resulting from these factors would be greatest at and immediately downstream of the construction sites, after which any pollutants will gradually be diluted by water from inflowing rivers downstream.

5.1.4 Impacts on aquatic fauna and flora in the river

Impacts on fish

The immediate project area (from site 6 to 16) is home to a total of 32 native species fish, out of which 11 are endemic (refer **Table 3** in **Annex 9**). Of the endemics, the presence of *Labeo fisheri,* locally known as "Kalu Gadeya", a critically endangered species (MOE, (2012), is of particular interest as it is only found in the middle catchments of the Mahaweli river system (Pethiyagoda, 1991; Shirantha, 2012). During the present survey it was recorded at Ethgala "Hath-wala" (7°07´.453N and 80°34´.476E); site 15 (**Fig.7** in **Annex 4**) and site 16 where the river provides a series of large, cool, dark rock pools (>10 m depth) of ever-present water, approximately 1.5 km downstream of the proposed dam site. *L. fisheri* is a species that shows reproductive migration, moving upstream to spawning sites to breed (Senanayake and Moyle, 1982; Silva and Davies, 1986, Silva, 1993; Shirantha 2012). If it is present in this area there is then a risk that this very rare species could be affected by dam construction, if rock pools in this area dry out or become severely reduced in size, depth and water quality, or removed by rock blasting and excavation of the dam foundations. It will be important therefore, that adequate care is taken to adopt the mitigation measures described below (see **Section 6**) and not to exceed the approved limits for rock blasting.

Notwithstanding the above, it is not considered that the presence of the endemic and endangered Green Mountain Labeo in the project area is a major conservation issue or a severe environmental problem. The proposed mitigating measures given elsewhere in this report will almost certainly minimize the anticipated impacts, so CEB along with their consultants and contractors should ensure that these actions are implemented carefully and in full. It should also be stressed that this species is currently recorded at more than 10 other locations within the Mahaweli river system (Shirantha, 2012). Recent studies and surveys have shown that the fish fauna of this part of Sri Lanka is quite secure in some fast flowing waters in reserved and legally protected areas of the sub-catchments of Loggal Oya, Beli-ul Oya, Badulu Oya, Wasgamuwa Oya, Nicola Oya, Heen Ganga, Theligamuwa Oya and Kalu Ganga (Shirantha, 2012).

Project construction could also adversely affect breeding and feeding grounds of some other endemic fish species, such as *Garra ceylonensis, Belontia signata, Channa orientalis* and *Schistura notostigma* as they lay eggs or build their nests at the water's edge. However this is unlikely to be of major significance, as they are common endemic fish species and there are enough nesting sites in both upstream and downstream areas for them. Furthermore they will probably adapt to the river morphological changes and seek alternative places to survive and breed within a very short period of time.

The presence of some other threatened endemic fish species in the project area, such as *Pethia nigrofasciata* and *Pethia reval* is a result of translocation practices that took place in the late

1980s as a conservation strategy (Wickremanayake, 1990). At present these fish species are well established in the Gamploa, Nawalapitiya and Ginigathena area (Wickremanayake, 1990, Pethiyogoda 1991, Shirantha, 2004). The construction process is therefore unlikely to cause severe population declines in these species within the Mahaweli river catchments.

The largest Cyprinid in Sri Lanka, *Tor khudree* (Black Mahseer) was found in this part of the river particularly around the river convergence with the Atabage Oya. This species is unlikely to be significantly affected although the river channel will be temporarily diverted during the construction period, as the water from the Atabage Oya will facilitate them to move into a more secure area in the downstream.

There could be some effect on the fish fauna from the changes in water quality as stated above (pollution from spillage of oil, cement and other materials; and increased turbidity and sedimentation) and the species most at risk are the small Cyprinid fishes such as *Rasbora dandia, Devario malabaricus* and *Dawkinsia singhala*. If there are substantial and prolonged changes in water quality, the more delicate younger stages of these and other species may die, and adults could also succumb, or alter their distribution to avoid the worst affected areas.

Impacts on other aquatic vertebrates

The other vertebrate fauna recorded in the immediate project area includes three mammals that are of conservation importance according to the National Red List of Sri Lanka 2012 (MOE, 2012): the Eurasian otter *Lutra lutra* is categorised as vulnerable; the rusty spotted cat *Prionailurus rubiginosus* is endangered; and the fishing cat *Prionailurus viverrinus* is endangered. Most of the other aquatic vertebrates recorded are relatively common in aquatic habitats throughout the country. It should also be noted that none of the endemic or endangered mammalian, reptilian or aquatic bird species are confined only to this part of the Mahaweli river system.

During the construction period the feeding grounds of some of the rare and important species (including *L. lutra, P. rubiginosus, P. viverrinus, Varanus salvator* (Water monitor) and *Haliaeetus leucogaster* (White-bellied sea eagle)) could be altered and disturbed by ground clearance, construction work and other activities. This is unlikely to be a major impact however, as these are all highly mobile animals that can move into alternative areas to find their prey, in both aquatic and terrestrial environments.

Impacts on aquatic/semi aquatic flora

As shown by the description in **Section 3** and **4** above, very few endemic or rare aquatic flora have been found in this reach of the river. The project area is generally characterised by fast flowing water and with a predominance of rocky substrates. As such this part of the river is not a conducive habitat for extensive growth of rooting, submerged or floating aquatic plants. A few plants of *Lagenandra ovata* (Malayan Sword) were recorded at the water's edge, but they are already disturbed due to prevailing river bank erosion. It is not expected therefore that the project will have significant impacts on macroscopic aquatic plants.

Impacts on aquatic invertebrates

Various insects and other macroscopic invertebrates, including aquatic bivalves and gastropods were recorded from the project area during the surveys (see Table 1 in **Annex 9**), and most were relatively common and none are threatened or endangered, or confined only to the Moragolla project area. As mentioned above, there have been no detailed studies on the presence, distribution, conservation and taxonomic status of most of the aquatic invertebrates in Sri Lanka, so it is very difficult to make definitive statements on the potential impacts of the project on these organisms or their likely significance. It can be said however that invertebrates will be susceptible to some of the construction activities as they tend to be aggregated in water-edge areas. They could therefore be removed by excavation in these areas for construction of the dam and tailrace outfall, crushed by any vehicles or machinery that is operated in or outside such areas, or washed away if there is any bank erosion. They might also be affected by any pollutants that are spilled in the water (especially toxins like vehicle oil), and increase of sediment content could clog their respiratory surfaces, impeding oxygen uptake and causing metabolic stress. Most probably less mobile animals such as aquatic worms, shellfish and bivalves will be most affected by any such impacts as others can move into less disturbed areas as they are very sensitive to even slight changes in their environments. Some of the dragonfly and damselfly species are endemic to the island but none of them are restricted only to this part of the river. All taxa shown in **Annex 9** Tables 1 and 2 are very common in all riverine habitats in the wet zone of Sri Lanka. Impacts on invertebrates are therefore unlikely to be of major significance.

5.1.5 Impacts on associated terrestrial fauna and flora in riparian area

According to the project design very little of the riparian area will be cleared of vegetation for the construction work. Some woody trees and shrubs will be removed, but the total cleared area will be less than 2 ha. This vegetation supports some terrestrial fauna, especially underground dwellers such as mongoose and shrews, and small numbers may be killed during this process, or they may move to other areas, including the riparian shrub cover along the right river bank where there is a forest reservation agro gardens. None of the animals found in the areas of riparian vegetation are rare or endangered, and most will move into other similar areas nearby once vegetation removal begins; so these will not be major impacts and no special mitigation is required. Keeping vegetation removal to the minimum is however necessary as it helps conserve these species *in situ*. During the construction period the migratory paths of some carnivorous animals such as wild cats and otters may be blocked or disturbed temporarily, but this will also not be a major impact as these are highly mobile animals that will avoid the construction site anyway, and will utilise undisturbed areas in the vicinity or elsewhere.

Some plant cover at the water's edge may also be damaged or destroyed during site clearance, and due to movement of machinery and other heavy equipment. Most of these species are alien invasive e.g. *Wedelia trilobata* (Singapore Daisy) and *Panicum maximum* (Guinea grass), so they are of no special floral value. They play an important role however, in controlling soil erosion and providing shelter for the animals that live at the water's edge (adult dragonflies and damselflies, crabs, etc.). This is therefore another reason for keeping the damage and loss of bank-side and in-river vegetation to the minimum possible.

5.1.6 Impact due to recruitment of labour force for construction activities

The project contractors will employ some people from outside the project area in their workforce and this may require provision of an accommodation camp, closer to the dam site. This could be a source of water pollution that could affect aquatic ecology, for example if raw sewage from the camp was discharged into the river, causing reductions in oxygen under low flow conditions as the waste decomposes. Solid waste could also be a problem if it is discarded into the river, as it could damage habitats and cause the death or injury of aquatic mammals, fish or invertebrates from contact with or ingestion of the waste. This will need to be avoided by proper waste management procedures at the accommodation camp, as described below.

There is also the risk that workers may capture fish for consumption, especially as the project area supports some large food fish species that are of high consumer preference including the

Black Mahseer, Green Mountain labeo, Common carp, Shark catfish and some other large Cyprinds such as Olive barb and Long-snouted barb. During periods of low flow in the construction period these fish will tend to congregate in the large rock pools that are common around the dam site and downstream near the tailrace outfall. These pools will be accessible because of the low water levels and workers may attempt to kill the fish by the use of dynamite or poisons. This is quite a common occurrence in river diversion projects and it causes detrimental effects on the fish populations as these agents indiscriminately kill all stages, including young individuals, and also other aquatic animals in the vicinity. It will be very important that prompt actions are taken to avoid this.

5.1.7 Removal of riparian vegetation and loss of shade

For the road construction, machinery movement and excavation of on-land foundations for the dam and powerhouse some trees, grass cover and non-woody plants will have to be cut and removed. This may lead to more debris and leaf/woody material entering the river, which could cause sudden changes in river water quality from eutrophication if this material accumulates in low flow areas and decomposes. It could also promote microbial activity and create new micro habitats, and could clog water channels, etc. These impacts could affect aquatic life by impeding migration or limiting feeding and breeding areas, or if reductions in water quality impede respiration and cause metabolic stress. Proper measures should therefore be taken to minimize these impacts.

Vegetation removal, especially trees, will cause loss of shade, and where this occurs close to the river, the increased action of the sun on the water could lead to temporary increases in water temperature, especially during the low flow season. Tree and shrub removal will also lead to increased soil erosion during rainfall, and will also reduce the nesting, foraging and feeding grounds for the aquatic and semi-aquatic fauna as well as for the terrestrial animals. These will be relatively small-scale impacts as removal of vegetation will not affect large areas, and the project site anyway does not contain very much natural habitat. Nevertheless, as explained above, vegetation removal should be minimised as much as possible, as the impacts could be more serious if combined with other impacts, e.g. reduction in water quality and loss or disturbance of aquatic habitats.

5.1.8 Construction in the river bed

The project will involve significant construction in the river bed, to build the dam and the tailrace outfall. The river will be diverted to allow most of this work to be done, so some river-bed areas in the vicinity will dry out and their inhabiting plants and animals will die. This will affect relatively small areas in which none of the aquatic plants or invertebrates are known to be rare, so no special mitigation measures will be needed to protect these organisms. Some of the rare and locally important food fish however might become trapped in rock pools, so to avoid those impacts, a small scale capture and relocation programme should be conducted.

If any construction is conducted directly in the river in these and other areas, the associated disturbance of the river bed could increase the sediment load in the river, and contribute to increases in turbidity and downstream siltation from other sources, and associated impacts on fish and other fauna and flora as described above. Measures will therefore be required to minimise any such disturbance, and in particular to avoid the spillage of potentially toxic materials into the river, e.g. oil and cement.

5.1.9 Other construction hazards

In relation to the various other construction activities, the key concern regarding impacts on the aquatic ecology is the effect of blasting and vibration. There may be some blasting in the river itself to break up and remove bedrock at the dam site, and there is likely to be other detonations on either side of the river bank, and along the underground tunnel. Depending on the frequency of blasting, its location and the severity and penetration of the related shockwaves, there could be effects on the behaviour and physiology of animals in the river. Fish and other motile animals may move away from areas where there are vibration impacts, but these will not be permanent changes and any displaced individuals may return once the disturbance is over. There could however be more permanent impacts on organisms inhabiting pools in the riverbed during the dry season, as severe vibration from blasting nearby could cause stress and even death. The programme of capture and relocation mentioned above should therefore also encompass rock-pools in the vicinity of any proposed blasting.

5.1.10 Waste disposal and accumulation in the river and riparian area

The river is already subject to an unsightly and unnecessary accumulation of garbage of anthropogenic origin as described above and shown in Fig. 6 in Annex 4, and this can affect aquatic habitats and inhabitants as described in Section 5.1.6 above. This pollution load and its ecological impacts could be increased significantly through used snack wrappers, bottles, etc. discarded by construction workers, and there could also be inputs of organic waste, from defecation/urination, discarded food and cut vegetation. These will add some more organic and inorganic pollutants to the river of the project area. Since this is an existing threat, the impacts would be amplified by the construction work. This can be minimized if proper mitigating actions are taken, including a proper waste disposal program that is implemented with the local government.

5.2 Impacts of dam, reservoir and hydropower scheme operation on aquatic ecology

5.2.1 Impacts of dam creation

Changes in river morphology

The dam will both streamline and distribute the river flows, as in the rainy season water will flow over the crest through the discharge gates, and through the headrace tunnel 3.1 km downstream. The deflection of water through the tunnel and over the sloping crest of the dam will reduce the flow turbulence, and as the river section here is rocky and deep, with large pools and riffles, there should be few impacts on downstream river morphology, as the rocky terrain is not easily susceptible to such changes.

The dam will also divide the river into two and instead of the steep and fast flowing rhithron upstream and the sluggish and flat potamon downstream, there will be a new and larger inundated area upstream and reduced flow downstream in the dry season (January, February and March). This will lead to sudden changes in river morphology upstream, due to the changes in water levels. The relatively narrow river channel will be converted into a wider and deeper man-made lake, and the water surface will be higher and exposed to new and potentially unstable bank areas, with muddy to sandy substrate. It is expected therefore that bank erosion may occur in the proposed reservoir area from the increased surface turbulence in the rainy season. This will require mitigation measures to avoid excessive silt and turbidity in the water, and resulting reduced storage capacity.

Changes in water flow and quality

The presence of the dam and the usage of water for power generation will alter both the downstream water flow in the river and its physical, chemical and biological characteristics. The aquatic environment will therefore change, both upstream and downstream of the dam.

The Moragolla reservoir will operate as a “run-of-river” scheme, where the relatively small reservoir acts as a regulating pond, not a storage basin. During the wet season (May - November) there will be sufficient water to generate power almost constantly, and the excess water will flow from the reservoir through the spillway gates. This will maintain an almost normal rate of downstream flow in the river. Water will be retained by the dam for only a short time (<1 day) so major changes in water quality during this period are unlikely, apart from possibly small reductions in sediment content as the reduced flow speeds in the reservoir will allow some suspended particles to settle onto the bed.

During the dry season (December - April) the Moragolla scheme will be operated primarily to satisfy peak electricity demand, so power will be generated between 6-9 pm each day. For the rest of the time power will be generated when there is sufficient water in the reservoir, which is expected to be for a few hours on most days. Water will therefore be retained in the reservoir for longer periods during the dry season, so water quality could fluctuate. The main changes in quality of the impounded water are expected to be: a) increased temperature from the action of the sun on the surface of the reservoir b) decreased oxygen, especially in the lower water levels, from microbial breakdown of dead and decaying plants and animals and organic debris entering from on land and c) decreased sediment content as particles settle on the reservoir bed. Water flowing downstream at this time will therefore be warmer and slightly lower in oxygen content than normal, and somewhat less turbid. These differences will gradually be reduced by inflows from other rivers downstream, including the “Thismada Ela” a perennial stream that enters the Mahaweli River immediately below the dam. Downstream flow will also be augmented by a continuous release of $1.5m^3/s$ from the dam, which is the “environmental flow”, intended to maintain the downstream aquatic ecosystem.

Increase in upstream water levels

The proposed dam is 35 m high and it will create a 38.5 ha, 1.98 MCM reservoir with a full supply level at 548 msl. This will inundate the present upstream river bank and parts of the adjacent on-land riparian areas. This in turn will change habitat conditions in these areas and a different set of dynamics will begin impacting the species that traditionally grow, nest, feed, or spawn in these areas until a new equilibrium emerges. Since the dam site valley is a gorge (see Annex 6) the presence of the dam is unlikely to cause floods in its immediate vicinity, but there will be a significant increase in water level upstream in the area that covers the study sites 5, 6, 7, 8, 9 and 10 (refer Annex 3) as the river valleys here vary at different sites from a broad and asymmetrical floodplain to a shallow valley. The proposed dam will therefore inundate a significant area and it will affect a longer section of the upstream profile. The potential ecological impacts of these changes both upstream and downstream are discussed below.

Impacts on aquatic fauna and flora

The dam will block the movement patterns of migratory aquatic organisms, especially fish. This part of the Mahaweli River supports at least six migratory fish species, all of which were recorded during this survey, namely, *Anguilla bicolor* (Level finned eel) and *A. nebulosa* (Long finned eel), *Labeo fisheri* (Green Mountain labeo), *Tor khudree* (Black mahseer), *Garra ceylonensis* (Ceylon Stone-sucker) and *Wallago attu* (Shark catfish). All these species move upstream cooler waters or downstream (i.e. Eels) to spawn particularly with the onset of the monsoon rain (Senanayake and Moyle 1982; Silva and Davies 1986; Silva 1993; Shirantha

2012). The dam will therefore block their movement as well as the subsequent downstream passage of juvenile fish to the waters where they will spend their adult lives. During the breeding season, adults of some of these species will migrate upstream as far as the dam, and on reaching the barrier may try to pass through it, or remain in the vicinity. This may cause stress and injury, and the individuals may become disoriented, and may die because of contact with the walls of the dam, or deflection screens. They will also congregate in a relatively small area below the dam or around the tailrace outfall, where their exposure to predators will be increased. In such circumstances the breeding success of these and other species is likely to be greatly reduced, which might then lead to long-term decline of the populations in this river. This is of particular concern in the case of the rarer species, in particular the endemic critically endangered *Labeo fisheri.*

The survey results presented in Annex 9 show that at least eight endemic fish species i.e. *Garra ceylonensis*, *Labeo fisheri*, *Pethia nigrofasciata*, *Pethia reval*, *Channa orientalis*, *Dawkinsia singhala*, *Belontia signata* and *Schistura notostigma* are found around the dam site and the habitats of these species will become fragmented due to the construction of the dam. There is therefore a possibility of dilution of the gene pool, which could reduce the biological fitness and survival ability of these populations over the longer term. This impact can be minimized if species translocation will be implemented during the construction period as proposed in Section 6.

The changes in the quality of water flowing downstream (described above), are not expected to result in significant ecological impacts, because they will only occur during the relatively short dry season, and will not extend far downstream because of dilution by other river inputs. The reductions in downstream water flow will be more significant however, especially in the dry season, as this could reduce the connectivity and passage of fish between the deep rock pools in this area during this time. This may lead to their population decline due to alteration of their reproductive cycle, which is largely dependent on river hydrology and food availability. This negative impact can be minimised with some additional mitigation measures given in the Section 6.

The reduction in water level will also affect aquatic flora in the river, as plants in areas that dry out will die from desiccation in the dry season. This will inevitably reduce the coverage and richness of habitats in the downstream area, but these will not be severe impacts, because as explained above the reductions in flow will mainly affect the area between the dam and the tailrace outfall, where there is a predominance of rocky substrates. There are also no known rare or endangered plant species in the area.

Adequacy of the proposed environmental flow

During the dry season (December - April) there is expected to be sufficient water in the reservoir to allow power generation during the peak demand period, and for a few additional hours each day. There is unlikely to be an excess of water discharged through the spillway gates, so for much of this time the only water released from the dam will be the environmental flow of 1.5 m^3/sec. This will be discharged continuously, and it will be augmented by inflows from other rivers and streams, in particular the “Thismada-Ela” immediately downstream of the dam. However these streams will also be under low flow conditions at this time, and as the e-flow is around 42% of the average annual minimum natural flow, it is inevitable that areas of the river bed between the dam and the tailrace will dry out. As a result, plants in these areas will die, along with any animals that are unable to move into areas of flowing or standing water. Fish and other animals that do survive will be subjected to reduced water quality in the remaining pools.

The environmental flow will therefore not be sufficient to maintain the aquatic ecology unaltered in the area between the dam and the tailrace. However the evidence from this study does not justify increasing the environmental flow in order to protect the ecology of this area. This is because:

(a) The area affected by significant reductions in flow will be mainly limited to the 3 km length between the dam and the tailrace, in which this study has found no rare, endangered or otherwise ecologically significant habitats, aquatic plants or invertebrate animals.

(b) Impacts on the rare and endangered fish and aquatic and terrestrial mammals that inhabit this area will be reduced by a series of mitigation measures outlined in Section 6 below, which are expected to ensure the conservation of these species, and may even lead to the growth of their overall populations.

(c) The energy generated will be reduced with the increase of the environmental flow, which will result in an increase of fossil fuelled energy generation.

5.2.2 Impacts resulting from the reservoir

Impacts on fish and other aquatic fauna

The future changes in river morphology and habitats particularly marked in the area of the reservoir where the retained water will inundate extensive areas of land flanking the main channel. This will increase living space for the aquatic flora and fauna, and the release of plant nutrients from newly-submersed soil may produce a surge of primary productivity from growth of phytoplankton and macroscopic plants, followed by an expansion in biomass of certain animal communities. The individual species that prefer lacustrine water bodies, would be expected to adapt quickly to these conditions e.g. fish species like *Oreochromis mossambicus* and *Cyprinus carpio* and aquatic plant species like *Potamogeton pectinatus.* Their adaptations are not only morphological but also behavioural. This could lead to the development of a good fishery, particularly culture-based, in the near future. Some species however may move upstream to avoid conditions that are unfavourable for their breeding or feeding. These species may move upstream, out of the inundated area. The reconfiguration of this running water body into a pseudo lacustrine one is therefore expected to cause changes in the populations of fish and other animals and plants, as different species will react differently to the new conditions. Those that prefer deeper and slow-moving water are expected to thrive in the reservoir, and those that prefer faster moving water, and are intolerant of lower levels of oxygen may move into the upstream area. These readjustments will alter the distribution patterns and population densities, but are not expected to cause any species to die out, so no special mitigation measures are proposed.

Impacts due to sediment accumulation

River water typically contains suspended particles of organic and inorganic materials, eroded from the land or riverbed upstream. These particles tend to settle out where current speeds are low, forming areas of fine sediment on the riverbed. In reservoirs these particles accumulate on the bed behind the dam because the dam itself is a physical barrier. The upstream area at the Moragolla site is surrounded by steeply sloping land containing plantations and home gardens, so there will be man-made as well as natural erosion of lands adjacent to the reservoir, especially during the rainy season. This will probably lead to sediment build-up behind the dam. Once sediments collect, the aquatic ecosystem may be affected in three main ways: downstream habitat conditions may decline because these sediments no longer provide important organic and inorganic nutrients; the amount of soft-sediment habitat may also decline as there is less sediment flowing down the river to replace substrates that are eroded away during the high-flow season; and finally, the nutrient loading may deplete the supply of oxygen in the reservoir due to the increase of sediment-dwelling animals, and from microbial breakdown of dead organisms and waste products that accumulate on the reservoir bed. River gravel is transported downstream under high-flow conditions, so this may also be trapped behind the dam in the same way as finer sediments, so areas of gravel habitat downstream may also decline.

Periodic release of sediments entrapped by reservoirs can have significant impacts on aquatic organisms, as those living in the sediment will be washed downstream and probably killed, and those living downstream will be exposed to highly turbid water, which may clog their gills and hamper respiration and smother and kill animals and plants living on the river bed. The level of impact however, depends greatly on the type of sediment and intended management practice. The Moragolla dam does not include valves or any other mechanism to permit the regular flushing of silt. It may take 30 years or more for the sediment in the reservoir to reach the spillway crest level which is 8 m below the minimum operation level of the reservoir. The sediment further accumulated will then be removed by mechanical dredging at the low flow season or sediment sluicing through the spillway gate at the high flow season. It will be important to manage this process carefully to reduce adverse impacts from sudden increases in the downstream sediment load.

The heavy upland soil degradation including erosion at present transport substantial sediment load in the river this if get accumulated behind the dam, the reservoir may fill its storage earlier than expected. It would be prudent therefore to take additional action to prevent the entry of sediments into the reservoir and the river upstream, through improved land management. This could include: planting a reserve area around the reservoir with species that are known to bind and conserve the surface soil; improving land drainage in this area; incorporating silt traps or other filters to capture sediment before water drains into the reservoir; plus possibly implementing some form of wider study and improvement of land management in the overall Mahaweli Ganga catchment.

Impacts on debris movement

During the survey it was observed that in some areas potholes at the margins of the river, which are habitat for certain fish and other macro fauna, are filled with materials of anthropogenic origin, including plastic bottles, polythene and other non-degradable and degradable organic waste. These materials enter the river from its upland catchments during high flow conditions, and can be a threat to sensitive species, from ingestion of or contact with inert or toxic material, and from damage to their habitats. Construction of the dam and reservoir will greatly reduce downstream movement of these materials, and in this respect, the hydropower project should be beneficial for downstream ecology, provided that these materials are managed in an environmentally sound manner by CEB.

Bank erosion

As explained above, almost the entire natural river bank in the immediate project area comprises primarily rocky material, so river bank erosion is not expected to be a significant additional source for the entry of silt into the reservoir. However, as noted above, once the reservoir is impounded, the upstream water level will rise well above the natural water channel and the edges of the new water body will be in contact with land that is presently cultivated (home gardens or tea plantations) or abandoned (unworked plantations). There is little natural vegetation in this area, so there is a risk of erosion from the new reservoir bank areas. This is compounded by the fact that many of these areas are steeply sloping, and the likely operation of the power plant, whereby water levels in the reservoir will fluctuate regularly, during drawdown and subsequent refilling. This could cause bank failures, erosion, and undercuts leading to land degradation, land slippages and increased reservoir sedimentation. This impact may not be as severe as in certain other reservoirs because at Moragolla it is proposed to have an optimum drawdown of only 6 m. These impacts will therefore be mitigated by land management at the reservoir margins, and other proposed mitigating measures that will be discussed in **Section 6.**

Reduced dilution of pollutants

The River water quality study has shown evidence of water pollution from the Crysbro Broiler Farm (poultry industry), which discharges wastewater from the left bank approximately 2 km below the proposed dam site. The water quality analysis and the field observations suggest discharge of inadequately treated wastewater (see Report 1: Water quality in the Mahaweli Ganga - upstream and downstream of the proposed dam at Moragolla). The reduced flow during operation of the Moragolla scheme may reduce the dilution and dispersion of this effluent, which contains high levels of Biochemical Oxygen Demand, Suspended Solids and animal oils and fats. These pollutants will decompose in the water, reducing levels of Dissolved Oxygen, which may hinder the respiration of sensitive fish and other aquatic organisms. Mitigation measures to minimize these impacts will therefore be needed.

6. Proposed mitigation measures

6.1 Mitigation measures to minimise impacts during construction

This section summarises the potential impacts on aquatic ecology during project construction; and mitigation measures are proposed below for those impacts considered likely to be significant.

Table 6.1 Summary of possible impacts during construction

Project action	**Possible negative impacts**	**Remarks**
Soil erosion after vegetation clearance and use of machinery	Increased silt in the river, which may clog the gills of fish and invertebrates causing changes in distribution or even death and reducing plant photosynthesis	Significant Mitigation measures should be taken
River bank erosion	Inhabiting plants and associated fauna may become dislodged and washed away	Unlikely to be significant Temporary Mitigation measures are not proposed as explained in **5.1.2**
Water pollution from spills of oil, cement and other toxins (into the water or onto land)	Toxins may kill plants and animals or affect respiration, metabolism, breeding, etc.	Significant Temporary Some mitigation measures should be taken
River diversion causes an increase in the riverbed area that dries out in the dry season	Reductions in populations of *L. fisheri* and other fish species	Significant Permanent Some mitigation measures should be taken
Damage and disturbance of the riverine area by construction activity	Altered and disturbed feeding grounds and habitats of some important terrestrial species; damage and dislodgement of aquatic and semi-aquatic flora and invertebrates	Less significant Temporary Mitigation measures are not proposed as explained in **5.1.4**
Sewage, solid waste and other pollution may enter the river from the worker accommodation camp and construction sites	Reductions in oxygen and metabolic stress to any inhabitants if organic or inorganic waste accumulates in quiet waters in the dry season Inert waste could also damage habitats	Significant Temporary Some mitigation measures should be taken

	and injure or kill animals and plants if it enters the river	
Increased fishing pressure on rare or popular food fish species	Fish species when isolated in pools in the dry season become more susceptible to predation and capture by fishing. These and other species could also be damaged significantly by the use of dynamite or poison	Significant Temporary Some mitigation measures should be taken
Increased inputs of organic matter and debris into the river during vegetation clearance	May injure animals from direct contact or cause stress from oxygen reductions caused by decomposition	Significant Temporary Some mitigation measures should be taken
Disturbance of the river bed due to construction	Adding to the sediment load in the river	Significant Temporary Some mitigation measures should be taken
Bed rock blasting	Changes in the distribution of fish and other motile animals and may even cause the death of inhabitants of rock pools	Significant Temporary Some mitigation measures should be taken

6.1.1 Minimize soil erosion after vegetation clearance and use of machinery, and damage to river banks

The most basic and simplest mitigation measure that can minimize the potential negative impacts of soil erosion is to conduct as much construction work as possible in the relatively dry period between January and March. The ground soil erosion should be further minimized by paving or grass turfing of the cut slopes, and terracing any cut hill slopes.

It is expected that the Project Approving Agency (Mahaweli Authority of Sri Lanka) will require CEB to prepare a soil conservation action plan for the project area as one of the conditions attached in granting the necessary construction permits; so this should be adhered very carefully by all contractors involved in the construction work.

The damage caused due to excavation of soil for the footings and to lay the foundations of the dam and other structures is unavoidable. Any other damage to river banks and slopes should be rehabilitated concurrently, by replacing boulders and reinstating any damaged vegetation and areas of soft sediment on the river bed, which are relatively scarce habitats in the project area. To reduce the amount of silt-laden runoff entering the river, excavated soil from the dam foundations should be transported for disposal as soon as possible and any soil that is stockpiled at the site should be compacted and protected using rip-rap or rubble pitching to prevent the soil being blown or washed into the river.

The slope cuts and filled embankments should also be protected by adopting appropriate methods of covering, such as gabion protection, coir matting, rubble mounds, vegetation planting and turfing with grass. The best and most effective method should be decided by the site staff depending on the specific site conditions. In any areas of severe erosion an appropriate soil textile should be laid on the surface to prevent further depletion.

An area becomes prone to erosion when vegetation is removed prior to topsoil stripping during initial site clearance. Every care should therefore be taken not to excavate or uproot trees or other vegetation beyond the specified footprint of the works.

Some topsoil will be stockpiled on site for use to rehabilitate the same area or any other area that has been disturbed. Soil stockpiles should be located in cleared areas away from drainage paths, and protected from rainfall to avoid runoff as noted above.

All possible care should be taken not to directly discharge heavy flows from pumps and runoff diversions to natural gullies and drainage paths that are susceptible to erosion. The outlets of all pipes that discharge water from dewatering sites, flow diversions, etc. at each construction location should be placed away from erodible areas and provided with appropriate provisions to avoid erosion by dissipating energy and flow velocities. This can be done by instillation of 'cut off drains' i.e. drainage ditches dug specifically to drain water and control water runoff speed.

The runoff from areas outside construction sites should be diverted away from the site by constructing perimeter drains, diversion banks and other measures prior to starting work at the site.

Use of heavy machinery on steep slopes should be strictly restricted to only that which is absolutely necessary and should be closely monitored. The machinery operation should be done by skilled operators, and before commencement of the work they should be trained in the risks of excessive soil erosion and avoidance measures.

Apart from the above measures the negative impact of soil erosion that will affect river quality should be further minimized via properly erected silt traps in appropriate places to arrest the sediment flux that carries into the river.

6.1.2 Minimize water pollution from spills of oil, cement and other toxins into the water or onto land

Wherever possible, all construction plant, material stockpiles, vehicle parks, labour camps etc., should not be located alongside the river banks to prevent soil erosion and other pollution of the river. Before beginning work, all site workers and staff should be made aware of measures of water conservation and waste minimization in order to stop the entry of mud-laden sediments and other pollutants into the river.

The storage of fuel, oil or other toxic materials on site should be prohibited, ensuring they are stored offsite at premises with appropriate pollution control procedures, including oil separators on drains; and vehicle refuelling and maintenance on site should be prohibited except in an emergency situation.

6.1.3 Conservation of fish fauna

The anticipated impacts on the rare endemic fish species including *Labeo fisheri* in the project area can be minimized by translocation. *L. fisheri* and other species that become trapped in isolated pools below the dam when the river is diverted may be captured and translocated to a suitable relief point. Several such relief points with favourable conditions are present in the Mahaweli river catchment, in both upstream and downstream areas, with undisturbed rock pools, which could be ideal for these species to live no harm (e.g. main tributaries of Mahaweli River: Loggal Oya, Heen ganga, Kalu ganga, Nicola Oya, Hasalaka Oya, Wasgomu Oya, Dunuwila Oya and Badulu Oya). If this is done it should be commenced with a pilot project since there is no such action that has been taken previously for a large habitat-specific fish species in Sri Lanka.

6.1.4 Minimize impacts from river diversion

The Ceylon Electricity Board should take all necessary actions to ensure that the mandatory environmental flow is provided continuously, for 24 hours a day. As mentioned in **Section 5** discharge of the "Thismada-Ela" will supplement this environmental flow to sustain a reduced aquatic ecology in the 3 km between the dam and the tailrace outfall, so this stream must be kept flowing and free of obstruction or pollution throughout the construction period.

6.1.5 Prevent discharge of sewage and other pollution into the river from construction sites and the accommodation camp

The contractor should provide adequate toilets for workers at the accommodation camp and at all construction sites and should ensure that all waste is treated to Sri Lankan legal standards and that no effluent is discharged to the river.

6.1.6 Minimize the increased fishing pressure on rare or popular food fish species, isolated in pools

Illegal fishing in the project area should be avoided by incorporating preventative action in site security procedures. The main contractor should be tasked with informing their appointed security contractors that no fishing is to be allowed in the designated project area by any persons (including the workforce), and requiring the security contractors to take appropriate preventative action, via security patrols, etc.

6.1.7 Minimize increased inputs of organic matter and debris into the river during vegetation clearance, causing injury and stress to animals from oxygen reductions

All cut vegetation and other debris produced during site clearance should be taken to a licenced site for disposal immediately after the removal or cutting. This licenced site should be located away from the river to ensure no seepage of decomposition products.

6.1.8 Minimize harmful effect of bedrock blasting on river inhabitants

The construction constructor should take action to keep the amount of dynamite blasting to the minimum necessary, and avoiding blasting in areas that are in or close to the river channel as far as possible. The contractors should strictly adhere to the standards on vibration for blasting activities established by Central Environmental Authority.

6.1.9 Minimize water pollution from defecation/urination or solid waste discarded by workers

The main contractors should set up and implement a waste management plan covering all construction sites and accommodation camps. The plan should prohibit littering, ensure provision of adequate litter bins and waste receptacles, and ensure that solid waste is taken for disposal at a licenced site twice a week.

6.2 Mitigation measures to minimize impacts during project operation

Table 6.2 summarises potential impacts of the Moragolla project during operation of the dam, powerhouse and reservoir and Section 6.2.1 below describes the proposed mitigation to address all significant impacts.

Table 6.2 Summary of potential impacts during operation

Project activity	Potential negative impacts	Remarks
Presence of the dam	Change in river type and morphology upstream of the dam, where the fast-flowing river is converted into a slow-moving man-made reservoir, and animal populations change their distribution patterns accordingly.	Unavoidable; but not of major significance Permanent No mitigation proposed as explained in Section 5.2.2 (a).
	Blocked movement of migratory fish (*L. fisheri, T. khudree, G. ceylonensis, W. attu* and *Anguilla* spp.) resulting in a) increased predation when adults congregate downstream of the dam; and b) reduced spawning success, leading to long-term population decline.	Significant Permanent Some mitigation measures should be taken
	Fragmentation of populations of eight endemic fish species found at the dam site, leading to reduced genetic vigour.	Significant Permanent Mitigation measures should be taken
Operation of the reservoir	Reduced quality of water flowing downstream in the dry season (warmer, lower turbidity and lower dissolved oxygen).	No significant ecological impacts Seasonal No mitigation necessary
	Gradual build-up of sediment behind the dam; and periodic removal by dredging.	Significant Mitigation measures should be taken
	Reservoir banks erosion from wave action at the water's edge in the regular drawdown area.	Less significant Mitigation measures should be taken
	Erosion of land in the proposed reservoir area in the rainy season leading to excessive silt and turbidity in the water, and reduced storage capacity in the reservoir	Significant Mitigation measures should be taken
Usage of water for power generation	Reduced river flow in the wet season in the 3 km length between the dam and tailrace outfall	Significant Seasonal Increase in environmental flow not justified as explained in Section 5.2.1
	Reduced dilution of pollutants in the broiler farm wastewater discharge	Significant Seasonal Some mitigation measures should be taken

6.2.1 Mitigation measures

Soil conservation and erosion control

Soil erosion is a pervading problem throughout this catchment and elsewhere in Sri Lanka, which reduces the quality of agricultural land and river water, and affects aquatic ecology in a number of ways as explained above. As noted in Section 5.2.2 it could also affect the Moragolla scheme by reducing the quality of water in the reservoir, and filling the dead storage capacity more quickly than the currently estimated 30 year period. Various actions described in Section 6.1 will be taken to reduce soil erosion during the construction period to ensure that the project does not exacerbate this problem during site clearance, excavation and other activities. It will be important that good practice is also extended into the period when the completed scheme is operating, in order to provide more lasting improvements in water quality and aquatic ecology in the project area and downstream.

CEB should therefore ensure that the Soil Conservation Action Plan (see Section 6.1.1) also includes measures to be adopted in the operational phase, and that these are implemented in the areas around the reservoir and at the project sites downstream that are owned by CEB. This could include:

a) Structural measures: terracing; flood interception and diversion works; gully head protection; bank protection structures; silt traps; etc.
b) Vegetative measures: reforestation of the reservoir buffer and other areas; planting soil-retaining shrubs and grasses; etc.

Under Sri Lankan law the on-land area at the edge of the reservoir is demarcated as a buffer zone, in which construction, farming and other usage of the land for purposes not related to the reservoir or power generation is prohibited. Soil conservation is improved if this area is designated as a green belt, and planted with species that are known to promote soil conservation in steep valleys. This should therefore be done in the buffer zone for the Moragolla reservoir. In addition to this the entire area should be declared as a protected area under the control of Ceylon Electricity Board.

Mitigation of impacts due to sediment management activities

The Moragolla dam does not have a facility for the flushing of retained sediment. It may take more than 30 years for the sediment in the reservoir to reach the spillway crest level which is 8m below the minimum operation level of the power generation. It is anticipated that at the end of this time the sediment may be removed by mechanical dredging in the dry season or sediment sluicing through the spillway gates in the rainy period. The removal of sediment by hydraulic dredging and downstream pumping would cause sudden very large increases in the suspended sediment content of the river water, which could have very deleterious impacts on ecology by smothering and killing bottom-dwelling species and impairing the respiration of fish and other organisms, which could also lead to death. Properly-managed on-land disposal of the silt, or using it in agriculture if feasible, would be better options in terms of protecting aquatic ecology, so these should be investigated during the planning of any silt-removal operation. If these are not feasible, then the downstream release of silt should be done gradually over a long period, to avoid sudden large-scale increases of suspended sediment; and this should be done in the rainy season to ensure maximum dilution and dispersal of the material.

Minimize impacts on aquatic ecology

A mandatory environmental flow $1.5m^3/s$ should be released from the dam at all times with the aim of maintaining the sustainability of the aquatic ecosystem downstream. This E-flow should be channelized to supply enough water to deep rock pool areas. At the same time care should be taken not to dam or block the water flow that comes through Thismada Ela, as this will provide an additional perennial flow to the area immediately below the dam and therefore assist in maintaining the ecosystem. However, it was noted during the field surveys that this water is currently pumped for some local usages, so it would be beneficial if CEB could investigate whether it would be possible to provide water from the reservoir for these purposes, to allow the full flow of this stream to flow into the river.

In reservoir projects, the anticipated impacts due to prevention of spawning migrations is often minimized by including in the dam an appropriate fish ladder or similar structure. In the case of the Moragolla project it must be borne in mind however, that good populations of all the migratory fish species are well established elsewhere within the same river catchments, and this reduces the significance of these impacts. For example the Knuckles forest range in the Mahaweli River catchments that come under Forest Department of Sri Lanka harbours viable populations of *Garra ceylonensis*, *Labeo fisheri*, *Systomus spilurus*, *Dawkinsia singhala*, *Belontia signata* and *Schistura notostigma* (Pethiyagoda 1991; Shirantha 2012*)*.This area gives enough protection for the above endemic fish species. As such, construction of a fish ladder at this dam site is not considered to be compulsory.

The sensitive aquatic species in the proposed project area are already stressed due to excess sediment and debris in the water, water pollution from upper catchment anthropogenic activities, waste disposal and fishing pressure, and hence translocation of these important species to one of the secure sites mentioned in **Section 5.1.4** or another suitable location.

A limited capture, relocation and release programme was suggested in Section 5.1.8 as a means of ensuring survival of fish trapped in rock pools when the river is diverted to enable construction of the dam. As a less costly alternative to provision of a fish pass, consideration could be given to extending the capture and release programme over the long-term to incorporate fish that are migrating upstream to breed. Adults could be captured at the toe of the dam and released above the reservoir, from where they would be able to continue their migration, at least to the next upstream barrier, which is the Kotmale dam, about 6 km upstream from the Moragolla reservoir tail.

Minimize reduced dilution of pollutants discharged from the broiler farm

The issue of pollution from the Crysbro poultry factory is discussed in detail in the final report of the water quality study. Two mitigation measures are proposed: monitoring to ensure enforcement of stipulated discharge limits for Crysbro Broiler Farm wastewater; and relocation of Crysbro Broiler Farm outfall downstream of the proposed tailrace outlet to ensure effective dilution of the effluent once river flow is interrupted by the Moragolla scheme. At present, potential impacts on downstream water quality and ecology could be high due this wastewater discharge. Implementation of the above mitigation measures therefore will have a very significant positive impact on both river water quality and aquatic ecology.

Annexure

Annex 1

Terms of Reference (ToR)

TOR FOR AQUATIC ECOLOGY IN THE MAHAWELI GANGA

Objective

The EIA study described the ecology of the river, but descriptions consisted largely of lists of species and there was little discussion of the different types of habitats present in the river, their local distribution, the importance of the habitats and species, and how they may be affected by construction and operation of the dam, reservoir and power generation facility. Aquatic ecology is one of the environmental issues that can be most affected by hydropower schemes, so these issues need to be investigated in more detail.

Scope of work

The Contractor shall use a combination of methods to prepare. a) an overview of the aquatic ecology of the Mahaweli Ganga between the project site and Polgolla Diversion Weir, 30 km downstream; and b) a detailed account of the aquatic ecology of the Mahaweli Ganga in the immediate project area, from 500m above the confluence with the Kothmale oya (in both rivers) to 500m below the confluence with the Atabage Oya. The Contractor shall draw conclusions regarding the importance of the aquatic ecology in both areas (with reasons) and the likely impacts of constructing and operating the project.

a) Overview of Mahaweli Ganga

The Contractor shall obtain an overview of the aquatic ecology of the Mahaweli Ganga in the 30 km stretch downstream of the project site, by consulting published information and other data from government agencies, consultancy reports and other sources. This should be supplemented by reference to aerial photographs and satellite imagery (see b below), visual observations on site, interviews with local people, and discussions with experts from Peradeniya University.

b) Aquatic ecology of the project site

For the detailed ecological study, the Contractor shall first consult aerial photographs and satellite imagery to obtain a rough picture of the type and distribution of aquatic habitats in the river in the project area. This will be refined by site investigations, including analyses of the type and distribution of river bed substrates and vegetation, supplemented by information obtained from local people, including sand miners.

Quantative analyses will then be conducted to describe the species present (flora and fauna) in each habitat type and average numbers of individuals of the major species in the different habitats. This will cover the aquatic habitats (sampled by fish nets, traps, plankton nets, etc) and river bed habitats (sampled by sediment grabs, quadrat sampling if feasible and other suitable methods). Quantitative surveys will be conducted twice; during low flows in February 2013 and at the start of the high flow season at the end of May 2013, to give an indication of seasonal variations.

Programme and Reporting

The Contractor shall submit a draft Interim Report on 31st March 2013 and a draft Final Report on 7 June 2013. Both reports will be reviewed by the Study Team and the

Contractor shall amend the reports to address all comments and shall submit final reports within two weeks of receipt of comments.

The Interim Report shall present and discuss all data collected up to that time and the Final Report shall present all data and shall include the following:

A map of the survey area showing sampling stations; site photographs, aerial photographs and satellite imagery; and appropriate tables and illustrations of key data, including a map showing the distribution of habitats and species in area b;

Written descriptions of all sampling, analysis and species identification methods;

A detailed discussion of the results, including but not necessarily limited to:

i) The aquatic ecology of the Mahaweli Ganga (area a) and its importance (with reasons);
ii) Potential impacts of operation of the completed hydropower scheme on aquatic ecology in area a (flow characteristics will be shown by a hydrological simulation study to be conducted in January 2013).
iii) The aquatic ecology of the immediate project area (area b) including the distribution and importance (with reasons) of the main habitats and species and seasonal variations.
iv) The manner in which the habitats and species are likely to be affected by construction and operation of the dam, reservoir and hydropower scheme (operational conditions shown by the January 2013 hydrological simulation);
v) Suitable mitigation for any negative impacts of construction and operation of the project on aquatic ecology in areas a and b;

Discussions shall refer to published literature where relevant and the importance of species, habitats and overall ecology shall be assessed on the basis of conservation status, abundance elsewhere in Sri Lanka, the local economy and other relevant criteria.

Discussions should describe existing conditions, then potential impacts of construction and proposed mitigation, and then potential impacts of scheme operation and proposed mitigation;

Tables showing all data should be provided in an appendix.

Annex 2

Satellite image of the proposed Morogolla Hydropower project


Ecological Map of
Moragolla Hydro Power Project
N
W
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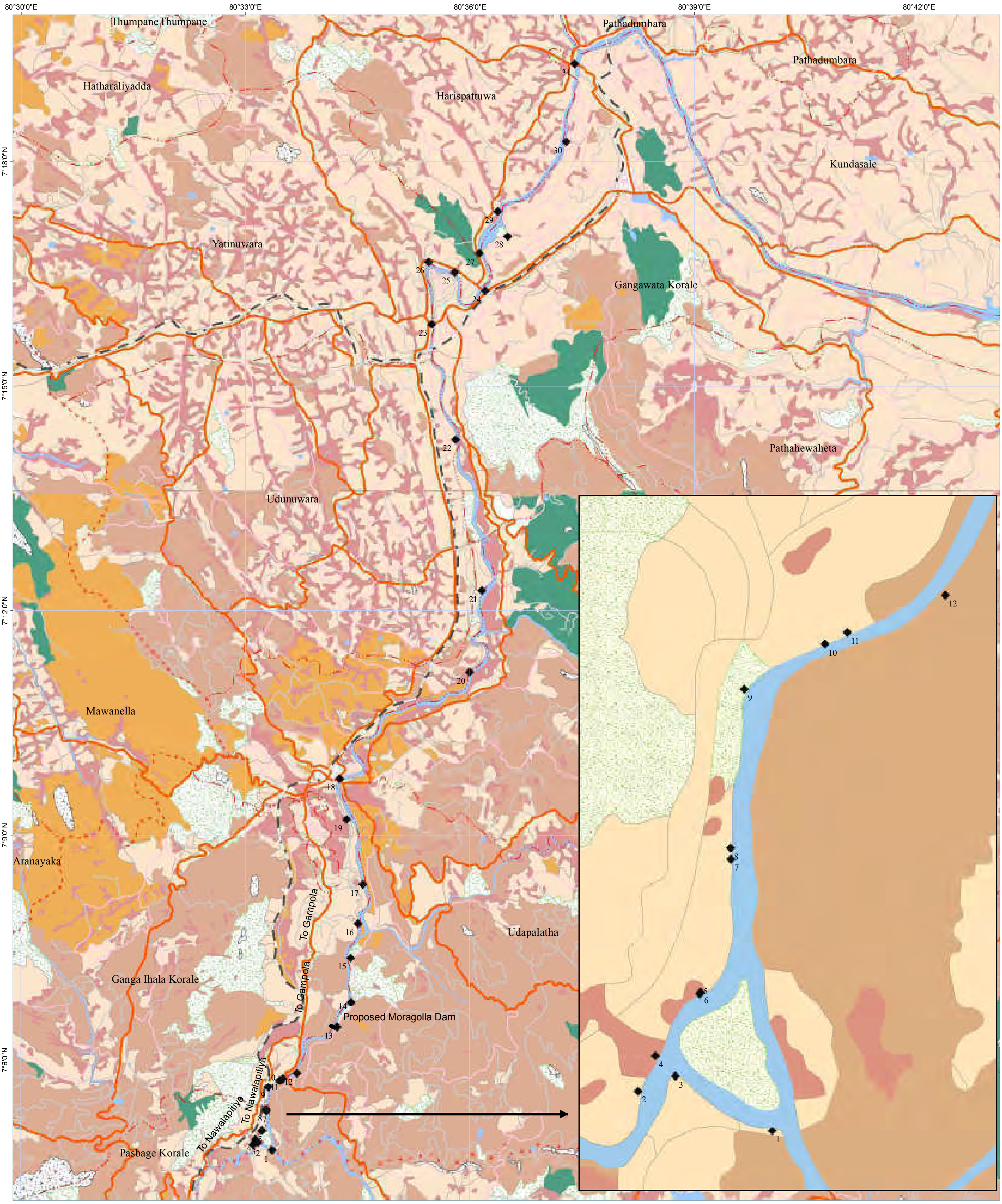
0.5
1
2 km
Source: GeoEye Sattelite Image- March 2013

Annex 3

Map - Aquatic ecological survey sites of Moragolla Hydro Power Project

Aquatic Ecological Survey Sites of Moragolla Hydropower Project

March, 2013



Legend

Aquatic Ecology Sampling Site	Minor Road	Coconut	Rubber
Province Boundary	Jeep track	Forest	Rock
District Boundary	Rail Road	Homesteads	Water Body
D.S. Div. Boundary		Marshy Lands	Scrub
Main Road		Paddy	Tea

Name of the Sample Sites

1. Polwathura
2. Pallegama
3. Piliwela
4. Confluence
5. Mahaweli Tea Plantation
6. Balli Bridge
7. Forest Site 1
8. Forest Site 2
9. Forest Site 3
10. Bridge
11. Industrial Estate
12. Weliganga
13. Dam Site
14. Downstream, Dam Site
15. Ethgala
16. Camp Site
17. Sand mining Site
18. Gampola Town
19. Maligapura
20. Geli Oya
21. Kalugamuwa
22. Ganethenne
23. Peradeniya Bridge
24. Suspending Bridge
25 . Gannoruwa
26. Botanical Garden
27. Warathenna 1
28. Warathenna 2
29. Hal-Oluwa Suspending Bridge
30. Gohagoda

Km

0 1 2 4

National Building Research Organisation
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Annex 4

Photographs of habitats

Fig.1: Disturbed rocky terrain, 500m upstream the Kothmale Oya (Site 1)

Fig. 2: Existing shallow rock pools, good breeding grounds for aquatic fauna (Site1)

Fig.3: Eroded river bank in Pellegama area (Site 2)

Fig. 4: The confluence of Kothmale Oya (Site 4)

Fig. 5: Intrusion of water during the rainy season on to the river banks - Bailey bridge

Fig. 6: Accumulation of garbage washed down from upstream (Site 7)

Fig.7:Typical habitat of *Labeo fisheri* (Site 8)

Fig. 8: Rock pool with small riffle (Site 9)

Fig. 9: Small islets in the river (Site 14)

Fig.10: River narrowing and forest area

Fig. 11: Sand mining site (Site 17)

Fig. 12: Flowing water between Kalugamuwa and Peradeniya (Site 21)

Fig.13: Rocky river – Gatembe/ Warathenna (Site 28)

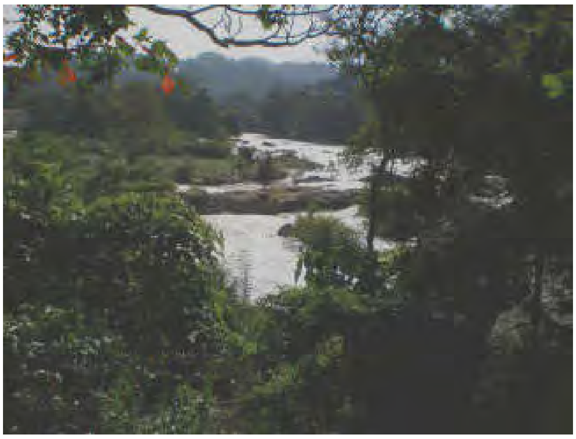


Fig.14:Rocky river – Gohagoda (Site 30)

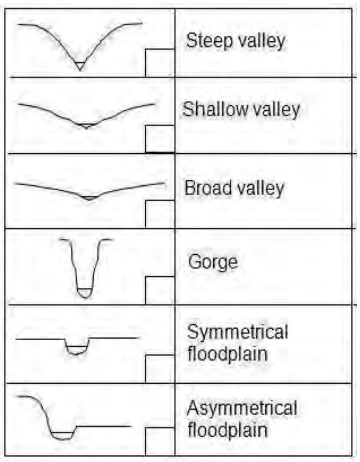
Annex 5

River habitat assessment criteria

River Habitat Assessment Criteria

River Habitat Assessment Criteria adapted from River Habitat Audit Procedure (Anderson 1993a), AUSRIVAS (Australian River Assessment standards) Parsons *et al.* (2001), the Index of stream conditions (Ladson & White, 1999) and (David Allan, 1998).

1. Valley shape



2. Floodplain features

NO
Sampling site has no distinct floodplain

Oxbows / billabongs
Body of water occupying a former river meander, isolated by a shift in the stream channel

Remnant channels
Formed during a previous hydrological regime. May be in-filled with sediment

Flood channels
A channel that distributes water onto the floodplain and off the floodplain during floods

Scroll systems
Short, crescentic strips or patches formed along the inner bank of a stream meander

Splays
Small alluvial fan formed where an overloaded stream breaks through a levee and deposits material on the floodplain

Floodplain scours
Scour holes formed by the concentrated clearing and digging action of flowing water

No floodplain features present
Floodplain present at the sampling site but does not contain any of the above features

3. Riparian zone composition

Assess for entire sampling site

	% Cover
Trees (>10m in height)	____________
Trees (<10m in height)	____________
Shrubs	____________
Grasses / ferns / sedges	____________

4. Shading of channel

<5%
5 -25%
25-50%
50-75%
>75%

5. Extent of trailing bank vegetation

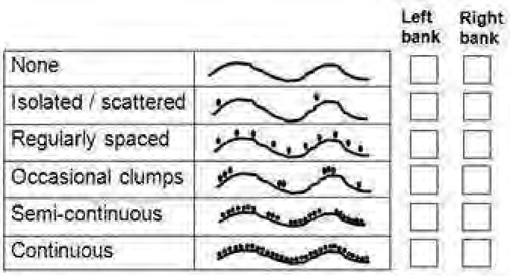
Nil
Slight
moderate
Extensive

6. Native and exotic riparian vegetation

Native %
Exotic %

7. Longitudinal extent of riparian vegetation

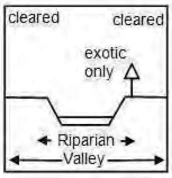
Choose one category for each bank. Do not include ground layer except where site is in native grassland.



8. Overall vegetation disturbance rating

Sites with valley vegetation cleared on BOTH sides, but with riparian vegetation in good condition should be scored in the high disturbance category. Words within the drawings summaries the detailed text about the state of the riparian and valley vegetation for each category.

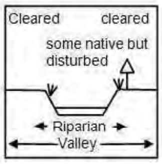
Extreme disturbance



Riparian vegetation – absent or severely reduced. Vegetation is extremely disturbed (ie. dominated by exotic species with native species rare or completely absent)

Valley vegetation – agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines etc.)

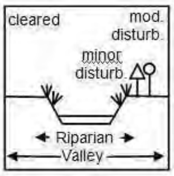
Very high disturbance



Riparian vegetation – some native vegetation present, but it is severely modified BOTH sides by grazing or the intrusion of exotic species. Native species severely reduced in number and cover.

Valley vegetation – agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines etc.)

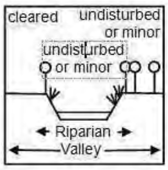
High disturbance



Riparian vegetation – moderately disturbed by stock or through the intrusion of exotic species, although some native species remain

Valley vegetation – agriculture and/or cleared land ONE side, native vegetation on the other side clearly disturbed or with a high percentage of introduced species present

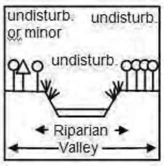
Moderate disturbance



Riparian vegetation – native vegetation on BO sides with canopy intact or with native species widespread and common in the riparian zone. T intrusion of exotic species is minor and of mode impact

Valley vegetation – agriculture and/or cleared l on ONE side, native vegetation on the other in reasonably undisturbed state

Low disturbance



Riparian vegetation – native vegetation present on BOTH sides of the river and in relatively good condition with few exotic species present. Any disturbance present is relatively minor.

Valley vegetation – native vegetation present on BOTH sides of the river, with a virtually intact canopy and few exotic species

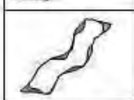
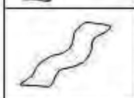
Very low disturbance

Riparian vegetation – native vegetation present on BOTH sides of the river and in an undisturbed state. Exotic species are absent or rare. Representative of natural vegetation in excellent condition

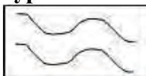
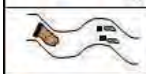
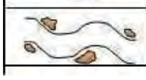
Valley vegetation – native vegetation present on BOTH sides of the river with an intact canopy. Exotic species are absent or rare. Representative of natural vegetation in excellent condition

9. Physical barriers to local fish passage

each flow condition

		Base flow	Low flow	High flow
	No passage	☐	☐	☐
	Very restricted passage	☐	☐	☐
	Moderately restricted passage	☐	☐	☐
	Partly restricted passage	☐	☐	☐
	Good passage	☐	☐	☐
	Unrestricted passage	☐	☐	☐

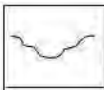
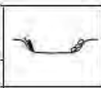
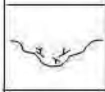
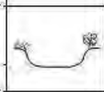
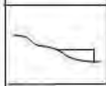
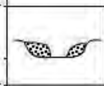
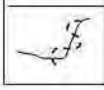
10. Type of bars

	Bars absent
	Side/point bars VEGETATED
	Side/point bars UNVEGETATED
	Mid-channel bars VEGETATED
	Mid-channel bars UNVEGETATED
	Bars around obstructions
	Braided channel
	Unfiled channel
	High flow deposits

11. Dominant particle size on bars

Boulder >256 mm	Cobble 64-256 mm	Pebble 32-64 mm	Gravel 4-16 mm	Sand 0.126-1 mm	Silt/clay < 0.063 mm

12. Channel modifications

	No modifications		Reinforced
	Disengaged		Re-vegetated
	Dams and diversions		In-filled
	Re-sectioned		Berms or embankments
	Straightened	Signs of work still visible	Recently channelized
	Realigned	Works old and re-vegetated	Channelized in the past

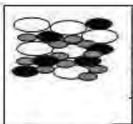
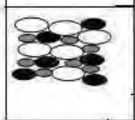
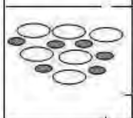
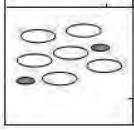
13. Extent of bed-form features

Total % composition for all features must equal 100%

Height >1m Gradient >60°	Waterfall 	Gradient 1-3° Small currents Surface unbroken and smooth	Glide 
Step Height <1m Gradient 5-60° Strong currents	Cascade 	Gradient 1-3° Small but distinct & uniform current Surface unbroken	Run 
Gradient 3-5° Strong currents Rocks break surface	Rapid 	Area where stream widens or deepens and current declines	Pool 
Gradient 1-3° Moderate currents Surface unbroken but unsmooth	Riffle 	A reasonable sized (>20% of channel width) cut-off section away from the channel	Backwater 

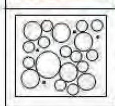
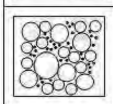
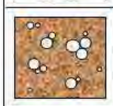
14. Bed compaction

Choose one category only

	Tightly packed, armoured Array of sediment sizes, overlapping, tightly packed and very hard to dislodge
	Packed, un-armoured Array of sediment sizes, overlapping, tightly packed but can be dislodged with moderate effort
	Moderate compaction Array of sediment sizes, little overlapping, some packing but can be dislodged with moderate effort
	Low compaction (1) Limited range of sediment sizes, little overlapping, some packing and structure but can be dislodged very easily
	Low compaction (2) Loose array of fine sediments, no overlapping, no packing and structure and can be dislodged very easily

15. Sediment matrix

Choose one category only

	Bedrock
	Open framework 0-5% fine sediment, high availability of interstitial spaces
	Matrix filled contact framework 5-32% fine sediment, moderate availability of interstitial spaces
	Framework dilated 32-60% fine sediment, low availability of interstitial spaces
	Matrix dominated >60% fine sediment, interstitial spaces virtually absent

16. Sediment angularity

Choose one category only
Assess cobble, pebble and gravel fractions only

	Very angular
	Angular
	Sub-angular
	Rounded
	Well rounded
	Cobble, pebble and gravel fractions not present

17. River substrate composition

Bedrock	______
Boulder (>256mm)	______
Cobble (64-256mm)	______
Pebble (16-64mm)	______
Gravel (2-16mm)	______
Sand (0.06-2mm)	______
Fines (silt and clay <0.06mm)	______

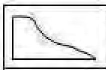
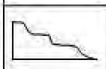
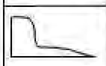
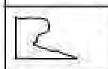
$\}$ Total 100%

18. Bed stability rating

Severe erosion	Moderate erosion	Bed stable	Moderate deposition	Severe deposition
Streambed scoured of fine sediments. Signs of channel deepening. Bare, severely eroded banks. Erosion heads. Steep streambed caused by erosion.	Little fine sediment present. Signs of channel deepening. Eroded banks. Streambed deep and narrow. Steep streambed comprised of unconsolidated (loosely arranged and unpacked) material	A range of sediment sizes present in the streambed. Channel is in a 'relatively natural' state (not deepened or infilled). Bed and bar sediments are roughly the same size. Banks stable. Streambed comprised of consolidated (tightly arranged and packed) material.	Moderate build-up of fine sediments at obstructions and bars. Streambed flat and uniform. Channel wide and shallow.	Extensive build up of fine sediments to form a flat bed. Channel blocked, but wide and shallow. Bars large and covering most of the bed or banks. Streambed comprised of unconsolidated (loosely arranged and unpacked) material.

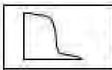
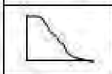
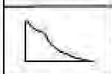
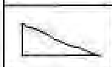
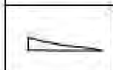
19. Bank shape

Choose one category for each bank

		Left bank	Right bank
	Concave	☐	☐
	Convex	☐	☐
	Stepped	☐	☐
	Wide lower bench	☐	☐
	Undercut	☐	☐

20. Bank slope

Choose one category for each bank

		Left bank	Right bank
	Vertical 80 - 90°	☐	☐
	Steep 60 - 80°	☐	☐
	Moderate 30 - 60°	☐	☐
	Low 10 - 30°	☐	☐
	Flat <10°	☐	☐

21. Bank material Assess % composition for each

	Left bank	Right bank
Bedrock	_____	_____
Boulder (>256mm)	_____	_____
Cobble (64-256mm)	_____	_____
Pebble (16-64mm)	_____	_____
Gravel (2-16mm)	_____	_____
Sand (0.06-2mm)	_____	_____
Fines (silt and clay, <0.06mm)	_____	_____

Total 100% each

22. Macrophyte cover in bank

Overall % cover of native macrophyte

Overall % cover of exotic macrophyte

Annex 6

River habitat assessment Results of each study site - Mahaweli River

River habitat assessment of each study site- Mahaweli River

River habitat assessment of the each study site at Mahaweli River (K; site1, 3-Kotmala Oya Before Confluence with Mahaweli River, M; site 2– Mahaweli river Before Confluence with Kotmale Oya, MK; site 4-Mahaweli River-Kotmale Oya Confluence of, PR; site 5, 6, 7, 8,9, 10- Proposed Reservoir Area, IDA; site 11, 12, 13, 14,15–Immediate Dam Area, MA; site 16, Mahaweli River-Atabage Oya confluence and MP; site 17–Mahawli Proper 500 m downstream after Atabage Oya confluence)

Criteria	**Location**						
	K **Site 1 & 3**	**M** **Site 2**	**MK** **Site 4**	**PR** **Site 5, 6, 7, 8, 9, 10**	**IDA** **Site 11, 12, 13, 14, 15,**	**MA** **Site 16**	**MP** **Site 17**
1. Valley shape	Shallow	broad	broad	Varies as a broad, asymmetrical floodplain and shallow	gorge	shallow	Shallow
2. Floodplain features	Remnant channels	Remnant channels	Remnant channels	Splays	Floodplain scours	Floodplain scours	Flood channels
3. Riparian zone composition	Trees > 10m 25% Tress < 10m 40% Shrubs 10% Grass/ferns/sedges 25%	Trees > 10m 20% Tress < 10m 25% Shrubs 15% Grass/ferns/sedges 40%	Trees > 10m 25% Tress < 10m 35% Shrubs 30% Grass/ferns/sedges 10%	Trees > 10m 45% Tress < 10m 30% Shrubs 10% Grass/ferns/sedges 15%	Trees > 10m 45% Tress < 10m 20% Shrubs 30% Grass/ferns/sedges 5%	Trees > 10m 30% Tress < 10m 40% Shrubs 20% Grass/ferns/sedges 10%	Trees > 10m 25% Tress < 10m 40% Shrubs 20% Grass/ferns/sedges 15%
4. Shading of channel	5 -25%	5 -25%	5 -25%	50-75%	>75%	5 -25%	5 -25%
5. Extent of trailing bank vegetation	Slight	Slight	Slight	moderate	moderate	Slight	Slight
6. Native and exotic riparian vegetation	Native 55% Exotic 45%	Native 60% Exotic 40%	Native 65% Exotic 35%	Native 95% Exotic 5%	Native 60% Exotic 40%	Native 75% Exotic 25%	Native 65% Exotic 35%
7. Longitudinal extent of riparian vegetation	Occasional clumps L Isolated/scattered R	Semi continuous L Isolated/scattered R	Semi continuous L Occasional clumps R	Semi continuous L Semi-continuous R	Occasional clumps L Semi-continuous R	Semi continuous L Semi continuous R	Occasional clumps L Isolated/scattered R
8. Overall vegetation disturbance rating	High disturbance	High disturbance	High disturbance	Moderate disturbance	Low disturbance	Moderate disturbance	High disturbance
9. Physical barriers to local fish passage	B Moderately restricted L Partly restricted H Good	B Moderately restricted L Partly restricted H Good	B Partly restricted L Good H Good	B Very restricted L Moderately restricted H Moderately restricted	B Very restricted L Very restricted H Moderately restricted	B Good L Partly restricted H Good	B Good L Partly restricted H Unrestricted
10.Type of bars	Mid channel bar vegetated	Mid channel bar vegetated	Side/pointed bar vegetated	Mid channel bar vegetated	Side/pointed bar vegetated	Mid channel bar un-vegetated	Side/pointed bar vegetated

11. Dominant particle size on bars	Boulder and Silt/clay	Cobble and Silt/clay	Cobble and Gravel	Boulder, Pebble Cobble	Boulder	Boulder and Cobble	Boulder and Cobble
12. Channel modifications	Re-sectioned	Re-sectioned	Re-sectioned	Re-sectioned	Re-sectioned	Dam and diversion (Dunhida irrigation canal)	Dam and diversion (Polgolla)
13. Extent of bed-form features	Pool 85 % Backwaters 15%	Glide 90% Backwaters 10%	Riffle 65% Run 25% Backwaters 10%	Rapid 30% Glide 40% Run 20% Pool 10%	Waterfall 5% Cascade 20% Rapid 20% Riffle 15% Pool 40%	Riffle 30 % Glide 30% Run 30% Pool 10%	Glide 60% Run 40%
14. Bed compaction	Tightly packed armoured	Low compaction 2	Moderate compaction	Tightly packed armoured	Tightly packed armoured	Moderate compaction	Moderate compaction
15. Sediment matrix	Framework dilated	Framework dilated	Framework dilated	Framework dilated	Bed rock	Open framework	Open framework
16. Sediment angularity	Well rounded	Well rounded	Well rounded	Well rounded	Well rounded	Well rounded	Well rounded
17. River substrate composition	Bed rock 60% Boulder 20% Cobble 5% Pebble 3% Gravel 4% Sand 3% Fines 5%	Bed rock 5% Boulder 15% Cobble 30% Pebble 20% Gravel 10% Sand 5% Fines 15%	Bed rock 10% Boulder 8% Cobble 50% Pebble 12% Gravel 5% Sand 10% Fines 5%	Bed rock 35% Boulder 18% Cobble 10% Pebble 20% Gravel 5% Sand 12%	Bed rock 95% Boulder 5%	Bed rock 15% Boulder 25% Cobble 35% Sand 15% Fines 05%	Bed rock 5% Boulder 10% Cobble 25% Pebble 5% Gravel 10% Sand 45%
18. Bed stability rating	Moderate erosion	Moderate erosion	Moderate erosion	Moderate erosion	Bed stable	Moderate erosion	Moderate erosion
19. Bank shape	Concave	Concave	Concave	Stepped	Wide low bench	Concave	Concave
20. Bank slope	Flat	Flat	Low	Moderate	Steep	Flat	Low
21. Bank material Assess % composition for each	Bed rock 10% Boulder 5% Cobble 5% Pebble 5% Gravel 5% Sand 20% Fines 50%	Bed rock 10% Boulder 40% Cobble 10% Pebble 5% Gravel 5% Sand 10% Fines 20%	Bed rock 15% Boulder 5% Cobble 15% Pebble 5% Gravel 25% Sand 25% Fines 10%	Bed rock 20% Boulder 20% Cobble 15% Pebble 10% Gravel 10% Sand 15% Fines 10%	Bed rock 80% Boulder 10% Sand 5% Fine 5%	Bed rock 20% Boulder 10% Gravel 50% Sand 15% Fines 5%	Bed rock 5% Pebble 35% Gravel 10% Sand 30% Fines 20%
22. Macrophyte cover in bank	Native 60% Exotic 40%	Native 40% Exotic 60%	Native 30% Exotic 70%	Native 20% Exotic 80%	Native 10% Exotic 90%	Native 15% Exotic 85%	Native 5% Exotic 95%

Annex 7

Aquatic plants in the study sites in Mahaweli River

Table 1: list of the aquatic plants in the study sites in Mahaweli River

(Status; IN: Indigenous, E: Endemic and EX: Exotic, NCS - National Conservation Status: GCS – Global Conservation Status, LC – Least Concern, NT- Near Threatened, VU – Vulnerable, EN – Endangered, CR – Critically Endangered, DD – Data Deficient, LR/cd – Low Risk/conservation dependent, K; site1, 3-Kotmala Oya Before Confluence with Mahaweli River, M; site 2– Mahaweli river Before Confluence with Kotmale Oya, MK; site 4- Mahaweli River-Kotmale Oya Confluence of, PR; site 5, 6, 7, 8,9, 10- Proposed Reservoir Area, IDA; site 11, 12, 13, 14,15–Immediate Dam Area, MA; site 16, Mahaweli River-Atabage Oya confluence and MPD–Mahaweli River at 30 km stretch downstream to Polgolla weir)

Species				Red list 2012		Location						
Scientific name	Common English name	Local name	Status	NCS	GCS	K	M	MK	PR	IDA	MA	MPD
Family Aponogetonaceae												
Aponogeton crispus	Wavy-edged Aponogeton	Kekatiya	IN	VU	LC							+
Family Alismataceae												
Limnophyton obtusifolium	Blunt Arrowhead		IN	LC	LC				+			+
Family Araceae												
Cryptocoryne becketti	Water trumpet	Athi-Udiyan	E	VU								+
Cryptocoryne parva	Micro Crypt	Athi-Udiyan	E	EN								+
Cryptocoryne undulata	Crypt	Athi-Udiyan	E	CR								+
Cryptocoryne walkeri	Crypt walker	Athi-Udiyan	E	CR								+
Cryptocoryne willisii	Crypt	Athi-Udiyan	E	CR								+
Lagenandra ovata	Malayan Sword	Kethala	IN	LC	LC	+	+	+	+			+
Family Hydrocharitaceae												
Hydrilla verticillata	Hydrilla	Diya Sarupa	IN	LC	LC	+	+	+	+		+	+
Vallisneria spiralis	Mini Twister		EX			+	+	+			+	+
Blyxa aubertii	Roundfruit Blyxa	Diya Hawariya	IN	LC		+	+	+			+	+
Family Typhaceae												
Typha angustifolia	Great Reedmace		EX						+			
Family Potamogetonaceae												
Potamogeton pectinatus	Sago Pondweed		IN	LC		+					+	+
Family Podostemaceae												
Farmeria metzgeriodes			E	VU								+
Polypleurum elongatum			E	VU								+
Zeylanidium subulatum			IN	EN								+
Zeylanidium olivaceum			IN	EN								+
Family Lemnaceae												**+**
Lemna minor.	Duck weed		EX			+	+	+			+	+
FamilyPontederiaceae												
Eichhornia crassipes	Water hyacinth	Japan Jabara	EX									+

Annex 8

Taxonomic groups of plankton in the study sites in Mahaweli River

Table 1 list of the phytoplankton taxa in the study sites in Mahaweli River

(K; site1, 3-Kotmala Oya Before Confluence with Mahaweli River, M; site 2– Mahaweli river Before Confluence with Kotmale Oya, MK; site 4- Mahaweli River-Kotmale Oya Confluence of, PR; site 5, 6, 7, 8,9, 10- Proposed Reservoir Area, IDA; site 11, 12, 13, 14,15–Immediate Dam Area, MA; site 16, Mahaweli River-Atabage Oya confluence)

Taxa	Location					
	K	M	MK	PR	IDA	MA
Cyanophyceae						
Lyngbya		+				
Rivularia	+					
Scytonema			+	+	+	
Bacillariophyceae						
Achnanthes	+					
Asterionella	+	+				+
Coscinodiscus	+			+	+	
Cymbella		+			+	+
Navicula	+	+	+	+	+	+
Diatoma		+	+	+	+	+
Pinnularia	+	+	+	+	+	+
Stauroneis	+		+	+	+	+
Surirella	+	+		+		
Chlorophyceae						
Bulbochaete			+			
Chaetophora				+	+	
Chaetophora			+			
Closmarium	+	+				+
Costerium	+	+	+	+	+	+
Desmidium	+	+	+	+	+	+
Euastrum	+					
Micrasterias	+					+
Microspora	+		+	+		
Netrium		+		+		+
Oedogonium		+				
Pediastrum	+	+	+	+	+	+
Sorastrum	+	+	+	+		+
Spirogyra	+	+	+	+	+	+
Zygnema	+	+	+	+	+	

Table 2 list of the zooplankton taxa in the study sites in Mahaweli River

(K; site1, 3-Kotmala Oya Before Confluence with Mahaweli River, M; site 2– Mahaweli river Before Confluence with Kotmale Oya, MK; site 4- Mahaweli River-Kotmale Oya Confluence of, PR; site 5, 6, 7, 8,9, 10- Proposed Reservoir Area, IDA; site 11, 12, 13, 14,15–Immediate Dam Area, MA; site 16, Mahaweli River-Atabage Oya confluence)

Taxa	**Location**					
	K	**M**	**MK**	**PR**	**IDA**	**MA**
Phylum Protozoa						
Acanthocytis	+		+	+	+	+
Actinosphaerium			+	+	+	+
Paramecium	+	+				
Phylum Rotifera						
Conochilus						
Kellioittia	+		+	+	+	
Lecane			+	+	+	
Rotaria	+	+	+	+	+	
Phylum Arthropoda						
Class Crustacea						
Brachiopoda	+	+	+	+	+	+
Malacostraca	+	+	+	+	+	+
Copepoda	+	+	+	+	+	+
Class Insecta						
Dipteran larvae	+	+	+	+	+	+
Coleopteran larvae	+	+	+	+	+	+

Annex 9

Taxonomic groups of fauna in the study sites in Mahaweli River

Different taxonomic groups of fauna in the study sites in Mahaweli River

Table 1: list of different taxonomic groups of invertebrate fauna and their estimated abundance (number of individuals/cm^3) in the study sites in Mahaweli River

(K; site1, 3-Kotmala Oya Before Confluence with Mahaweli River, MBCK; site 2– Mahaweli river Before Confluence with Kotmale Oya, MK; site 4- Mahaweli River-Kotmale Oya Confluence of, PR; site 5, 6, 7, 8,9, 10- Proposed Reservoir Area, IDA; site 11, 12, 13, 14,15–Immediate Dam Area, MA; site 16, Mahaweli River-Atabage Oya confluence)

Taxonomic group	Common English name	Location/site					
		K	M	MK	PR	IDA	MA
Phylum Platyhelminthes	Flatworms						
Turbellaria		0.20				0.11	0.05
Phylum Nematoda	Roundworms						
Anguina tritici		0.10	-	-	-	-	0.01
Phylum Annelida	Earthworms and leeches						
Class Oligochaeta	Aquatic earthworms						
Family Aeolosomatidae							
Aeolosoma ternarium		0.75	0.17	-	0.05	-	-
Family Naididae							
Dero sp.		0.37	-		-	-	0.06
Class Hirudinea							
Placobdella emydae		0.03	-	0.24	-	0.13	0.34
Phylum Mollusca							
Class Gastropoda	Snails and Mussels						
Family Thiaridae							
Paludomus chilinoides		0.31	0.10	0.38	0.21	0.03	0.04
P. loricatus							0.08
Melanoides tuberculata		0.08	0.72	0.09	1.02	-	0.03
Family Paludestrinidae							
Bithynia sp.		-	-	0.91	-	-	-
Family Pilidae							
Pila globosa		0.04	-	0.03	-	-	-
Family Lymnaeidae							
Lymnaea sp.		0.05	-	-	-	0.01	-
Family Panorbiddae							
Indoplanorbis sp.		0.01	0.81	-	-	-	-
Family Unionidae							
Lamellidens sp.		0.06	-	-	-	-	-
Class Crustacea							
Sub class Cladocera							
Diaphanosoma sp.		-	17	-	-	-	51

Leptodora kindtii		27	-	-	11	-	--
Sub-class Copepoda							
Diaptomus sp.		12	14	19	-	-	-
Cyclops sp.		13	-	-	15	13	-
Order Decapoda							
Caridina sp.		0.51	0.90	0.94	0.34	1.86	1.43
Macrobrachium rosenbergii		0.27	0.31	-	-	-	-
Perbrinckia sp.		0.45	0.31	0.41	-	0.57	-
Class Insecta							
Family Nepidae	Water Scorpions						
Laccotrephes grossus		0.02	0.13	-	0.20	-	-
Family Ranatridae	Water stick Insects						
Ranatra filiformis							
Family Belostomatidae	Giant Water Bug						
Lethocerus sp.		0.02	-	-	-	-	-
Family Naucoridae	Creeping Water bug						
Naucoris scutellaris		-	.020	-	-	0.59	-
Family Helotrephidae	Backswimmers						
Tiphortephes indicus		-	-	0.23	0.71	-	-
Family Notonectidae							
Anisops barbata		0.03	-	-	-	-	1.02
Family Corixidae	Water Boatmen						
Micronecta sp.		-	-	0.07	-	0.04	-
Family Gerridae	Water Striders						
Gerris adelaids		0.40	1.38	-	0.87	-	-
Order Coleoptera	Beetles						
Family Dytiscidae	Diving beetles						
Copelatus sp.		0.02	-	-	-	0.17	-
Hydraticus facificus		0.21	-	0.03	0.21	-	-
Cybister confusus		0.67	0.23	0.05	0.35	-	-
Family Gyrinidae	Whirligig Beetles						
Gyrinus convexiusculus		-	-	-	1.2	-	0.17
Dipteran larvae	True mosquitoes	0.82	0.21	0.08	-	-	-

Table 2 list of the dragonflies and damselflies fauna in the study sites in Mahaweli River

(Status; IN: Indigenous, E: Endemic and EX: Exotic, NCS - National Conservation Status: GCS – Global Conservation Status, LC – Least Concern, NT- Near Threatened, VU – Vulnerable, EN – Endangered, CR – Critically Endangered, DD – Data Deficient, LR/cd – Low Risk/conservation depend, K; site1, 3-Kotmala Oya Before Confluence with Mahaweli River, M; site 2– Mahaweli river Before Confluence with Kotmale Oya, MK; site 4- Mahaweli River-Kotmale Oya Confluence of, PR; site 5, 6, 7, 8,9, 10- Proposed Reservoir Area, IDA; site 11, 12, 13, 14,15–Immediate Dam Area, MA; site 16, Mahaweli River-Atabage Oya confluence and MPD–Mahaweli River at 30 km stretch downstream to Polgolla weir)

Species			Redlist 2012		Location						
Scientific name	**Common English name**	**Status**	**NCS**	**GCS**	**K**	**M**	**MK**	**PR**	**IDA**	**MA**	**MPD**
Family Calopterygidae											
Neurobasis chinensis	Oriental Green wing	IN	VU	LC	+	+	+	+	+	+	+
Vestalis apicalis	Black-tipped Flashwing	E	VU	LC	+	+	+	+	+	+	+
Family Chlorocyphidae											
Libellago adami	Sri Lanka Adam's Gem	E	VU		+	+	+	+		+	+
Libellago finalis	Sri Lanka Ultima Gem	E	VU				+	+	+	+	
Libellago greeni	Sri Lanka Green's Gem	E	EN				+	+			
Family Euphaeidae											
Euphaea splendens	Sri Lanka Shining Gossamer wing	E	NT		+	+	+	+	+	+	+
Family Lestidae											
Indolestes gracilis	Mountain Reedling	E	VU	LC	+	+	+	+	+	+	+
Family Coenagrionidae											
Agriocnemis pygmaea	Wandering Wisp	IN	LC	LC	+	+	+	+		+	+
Ischnura aurora	Dawn Blue tail	IN	NT	LC	+	+	+	+		+	+
Ischnura senegalensis	Common Blue tail	IN	LG		+	+	+	+	+	+	+
Family Libellulidae											
Crocothemis servilia	Oriental Scarlet	IN	LC	LC	+	+	+				+
Indothemis carnatica	Light Tipped Demon	IN	NT	LC			+				+
Neurothemis tullia	Pied Paraso	IN	LC	LC	+	+	+	+	+	+	+
Orthetrum pruinosum	Pink Skimmer	IN	NT	LC	+	+	+	+			+
Orthetrum Sabina	Green Skimmer	IN	LC	LC	+	+	+	+			+
Orthetrum triangulare	Triangle Skimmer	IN	EN	LC	+	+	+				
Sympetrum fonscolombii	Red-Veined Darter	IN	EN	LC			+	+			
Trithemis aurora	Crimson Dropwing	IN	LC	LC		+	+	+		+	+
Trithemis festiva	Indigo Dropwing	IN	LC	LC	+	+	+				+
Family Gomphidae											
Paragomphus henryi	Sri Lanka Brook Hooktail	E	EN	NT				+		+	

Table 3 list of the fish species in the study sites in Mahaweli River

(Status; IN: Indigenous, E: Endemic and EX: Exotic, NCS - National Conservation Status: GCS – Global Conservation Status, LC – Least Concern, NT- Near Threatened, VU – Vulnerable, EN – Endangered, CR – Critically Endangered, DD – Data Deficient, LR/cd – Low Risk/conservation depend, K; site1, 3-Kotmala Oya Before Confluence with Mahaweli River, M; site 2– Mahaweli river Before Confluence with Kotmale Oya, MK; site 4- Mahaweli River-Kotmale Oya Confluence of, PR; site 5, 6, 7, 8,9, 10- Proposed Reservoir Area, IDA; site 11, 12, 13, 14,15–Immediate Dam Area, MA; site 16, Mahaweli River-Atabage Oya confluence, MPD–Mahaweli River at 30 km stretch downstream to Polgolla weir)

	Species			Redlist 2012		Location						
Scientific name	**Common English name**	**Local Name**	**Status**	**NCS**	**GCS**	**K**	**M**	**MK**	**PR**	**IDA**	**MA**	**MPD**
Family Anabantidae												
Anabas testudineus	Climbing perch	Kawaiya	IN	LC	DD	+	+	+			+	+
Family Anguillidae												
Anguilla bicolor	Level finned eel	Kalu Anda	IN	LC	LC	+	+	+	+		+	+
Anguilla nebulosa	Long finned eel	Polmal Anda	IN	LC	LC	+	+	+	+		+	+
Family Aplocheilidae												
Aplocheilus parvus	Dwarf panchax	Udda	IN	LC		+	+	+				+
Family Bagridae												
Mystus seengi	Yellow catfish	Path Ankutta	IN	LC		+	+	+			+	+
Mystus vittatus	Striped dwarf catfish	Iri Ankutta	IN	LC		+	+	+			+	+
Family Balitoridae												
Schistura notostigma	Banded mountain loach	Kandu Ehirawa	E	NT		+	+	+	+	+	+	+
Family Belontiidae												
Belontia signata	Comb-tail	Thal Kossa	E	NT	LR/cd	+	+	+	+		+	+
Family Channidae												
Channa ara	Giant snakehead	Gan Ara	E	EN			+	+	+			+
Channa gachua	Brown snakehead	Paradel Kanaya	IN	LC		+	+	+				+
Channa orientalis	Smooth-breasted snakehead	Kola Kanaya	E	VU		+	+	+	+		+	+
Channa punctata	Spotted snakehead	Mada Kanaya	IN	LC		+	+	+			+	+
Channa striata	Murrel	Loola	IN	LC		+	+	+			+	+
Family Cichlidae												
Etroplus maculatus	Orange chromide	Kaha Koraliya	IN	LC								+
Etroplus suratensis	Pearl spot	Mal Koraliya	IN	LC								+
Oreochromis mossambicus	Mozambique tilapia	Japan Koraliya	EX			+	+	+				+
Oreochromis niloticus	Nile tilapia	Nile-Tilapia	EX			+	+	+				+
Family Clariidae												
Clarias brachysoma	Walking catfish	Magura	E	NT		+	+	+				+
Clarias batrachus	Marble catfish	-	EX									+
Family Cobitidae												
Lepidocephalichthys thermalis	Common spiny loach	Ehirawa	IN	LC		+	+	+	+	+	+	+
Family Cyprinidae												
Amblypharyngodon melettinus	Silver carplet	Wevu Salaya	IN	LC								+
Catla catla	Catla	Catla	EX									+
Cirrhinus mrigala	Mrigal	Mirigala	EX									+
Cyprinus carpio	Common carp	Rata pethiya	EX			+	+		+	+		+

Dawkinsia singhala	Sri Lanka filamented barb	Dan Kola Pethiya	E	LC		+	+	+	+	+	+	+
Devario malabaricus	Giant danio	Dan Kola Salaya	IN	LC		+	+	+	+	+	+	+
Esomus thermoicos	Flying barb	Reul Dandiya	E	LC		+	+	+				+
Garra ceylonensis	Ceylon stone-sucker	Gal pandiya	E	VU		+	+	+	+	+	+	+
Labeo fisheri	Mountain/Green labeo	Gadeya	E	CR	EN					+	+	+
										(site 15)	(site 16)	
Labeo rohita	Rohu	Rohu	EX									+
Pethia melanomaculata	Fire fin barb	Thith Pathiya	E	VU			+	+				+
Pethia reval	Red fin barb	Rathu viral pethia	E	VU					+	+		
Pethia nigrofasciata	Black ruby barb	Bulat hapaya	E	VU					+			
Puntius bimaculatus	Redside barb	Ipilli Kadaya	IN	LC		+	+	+	+			+
Puntius dorsalis	Long snouted barb	Katu Kuriya	IN	LC		+	+	+	+	+	+	+
Puntius thermalis	Swamp barb	Kota Pethiya	E	LC		+	+	+	+			+
Puntius vittatus	Silver barb	Podi Pethiya	IN	LC								+
Rasbora dandia	Striped rasbora	Iri Dandiya	IN	LC		+	+	+	+	+	+	+
Systomus spilurus	Sri Lanka olive barb	Mas Pethiya	E	DD		+	+	+	+		+	+
Tor khudree	Mahseer	Leylla	IN	NT			+	+	+	+	+	+
Family Gobiidae												
Awaous melanocephalus	Scribbled goby	Bali Weligouwa	IN	LC		+	+				+	+
Glossogobius giuris	Bar eyed goby	Maha Weligouwa	IN	LC		+	+	+	+		+	+
Family Heteropneustidae												
Heteropneustes fossilis	Stinging catfish	Hunga	IN	LC		+	+	+				+
Family Loricaridae												
Pterygoplichthys multiradiatus	Sail fin catfish	Tanki Sudda	EX									+
Family Mastacembelidae												
Mastacembelus armatus	Marbled spiny eel	Gan Theliya	IN	LC		+	+	+	+	+	+	+
Family Osphronemidae												
Osphronemus goramy	Giant gourami	Teppiliya	EX				+				+	+
Family Poeciliidae												
Poecilia reticulata	Guppy	Guppi	EX			+	+	+	+		+	+
Family Siluridae												
Ompok bimaculatus	Butter catfish	Wala Poththa	IN	LC		+	+	+	+	+	+	+
Wallago attu	Shark catfish	Walaya	IN	EN	NT	+			+			+

Table 4 list of the aquatic/semi-aquatic reptiles in the study sites in Mahaweli River

(Status; IN: Indigenous, E: Endemic and EX: Exotic, NCS - National Conservation Status: GCS – Global Conservation Status, LC – Least Concern, NT- Near Threatened, VU – Vulnerable, EN – Endangered, CR – Critically Endangered, DD – Data Deficient, LR/cd – Low Risk/conservation depend, K; site1, 3-Kotmala Oya Before Confluence with Mahaweli River, M; site 2– Mahaweli river Before Confluence with Kotmale Oya, MK; site 4- Mahaweli River-Kotmale Oya Confluence of, PR; site 5, 6, 7, 8,9, 10- Proposed Reservoir Area, IDA; site 11, 12, 13, 14,15–Immediate Dam Area, MA; site 16, Mahaweli River-Atabage Oya confluence and MPD–Mahaweli River at 30 km stretch downstream to Polgolla weir)

	Species			Redlist 2012				Location				
Scientific name	Common English name	Local name	Status	NCS	GCS	K	M	MK	PR	IDA	MA	MPD
Family Trionychidae												
Lissemys ceylonensis	Flap-shell turtle	Kiri Ibba	E	EN	LC		+	+				+
Family Vaqranidae												
Varanus salvator	Water monitor	Kabaragoya	IN	LC	LC	+	+	+	+		+	+
Family Natricidae												
Xenochrophis asperiimus	Checkered Keelback	Diya Polonga	E	LC	LC	+	+	+	+	+	+	+
						+	+	+	+	+	+	+

Table 5 list of the aquatic and associate avifauna in the study sites in Mahaweli River

(Status; IN: Indigenous, E: Endemic and EX: Exotic, NCS - National Conservation Status: GCS – Global Conservation Status, LC – Least Concern, NT- Near Threatened, VU – Vulnerable, EN – Endangered, CR – Critically Endangered, DD – Data Deficient, LR/cd – Low Risk/conservation depend, K; site1, 3-Kotmala Oya Before Confluence with Mahaweli River, M; site 2– Mahaweli river Before Confluence with Kotmale Oya, MK; site 4- Mahaweli River-Kotmale Oya Confluence of, PR; site 5, 6, 7, 8,9, 10- Proposed Reservoir Area, IDA; site 11, 12, 13, 14,15–Immediate Dam Area, MA; site 16, Mahaweli River-Atabage Oya confluence and MPD–Mahaweli River at 30 km stretch downstream to Polgolla weir)

	Species			Redlist 2012				Location				
Scientific name	Common English name	Local name	Status	NCS	GCS	K	M	MK	PR	IDA	MA	MPD
Family Alcedinidae												
Alcedo atthis	Common Kingfisher	Mal Pilihuduwa	IN	LC	LC						+	+
Ceryle rudis	Pied Kingfisher	Gomara Pilihiduwa	IN	LC	LC						+	
Halcyon smyrnensis	White Throated kingfisher	Gela sudu Pilihuduwa	IN	LC	LC	+	+	+	+	+	+	+
Halcyon capensis	Stork-Billed kingfisher	Mana Hota Pilihuduwa	IN	LC	LC							+
Family Phalacrocoracidae												
Phalacrocorax niger	Little Cormorant	Punci Diyakawa	IN	LC	LC	+	+	+	+	+	+	+
Family Ardeidae												
Bubulcus ibis	Cattle Egret	Gawa-Koka	IN	LC	LC	+	+	+			+	+
Ardeola grayii	Indian Pond Heron	Kana Koka	IN	LC	LC						+	+
FamilyAccipitridae												
Spilornis cheela	Crested Serpent-eagle	Silu Sarappakussa	IN	LC	LC	+	+	+	+	+	+	+
Pernis ptilorhyncus	OrientelHoney-buzzard	Silu-Bambarakussa	IN	NT	LC	+	+	+	+	+	+	
Ictinaetus malayaensis	Black Eagle	Kalukussa	IN	NT	LC	+	+	+	+	+	+	
Haliastur indus	Brahminy Kite	Banumu Piyakussa	IN	LC	LC	+	+	+	+	+	+	
Haliaeetus leucogaster	White-bellied Sea Eagle	Kusa-Eli Mudukussa	IN	LC	LC					+	+	+

Table 6 list of the aquatic and associate Mammalian fauna in the study sites in Mahaweli River

(Status; IN: Indigenous, E: Endemic and EX: Exotic, NCS - National Conservation Status: GCS – Global Conservation Status, LC – Least Concern, NT- Near Threatened, VU – Vulnerable, EN – Endangered, CR – Critically Endangered, DD – Data Deficient, LR/cd – Low Risk/conservation depend, K; site1, 3-Kotmala Oya Before Confluence with Mahaweli River, MK; site 2– Mahaweli river Before Confluence with Kotmale Oya, MK; site 4- Mahaweli River-Kotmale Oya Confluence of, PR; site 5, 6, 7, 8,9, 10- Proposed Reservoir Area, IDA; site 11, 12, 13, 14,15–Immediate Dam Area, MA; site 16, Mahaweli River-Atabage Oya confluence nce and MPD–Mahaweli River at 30 km stretch downstream to Polgolla weir)

	Species			Redlist 2012		Location						
Scientific name	**Common English name**	**Local name**	**Status**	**NCS**	**GCS**	**K**	**M**	**MK**	**PR**	**IDA**	**MA**	**MPD**
Family Felidae												
Prionailurus rubiginosus	Rusty Spotted Cat	Kala Diviya	IN	EN	VU	+	+	+	+	+	+	+
Prionailurus viverrinus	Fishing Cat	Handun Diviya	IN	EN	VU	+	+	+	+	+	+	+
Family Mustelidae												
Lutra lutra	Eurasian Otter	Diya balla	IN	VU	NT	+	+	+	+	+	+	+

Annex 10

Photographs of some fauna and flora at the project site

Annexure 10

Photographic images of aquatic fauna and flora

Invertebrate fauna

Fig.1: *Neurothemis tullia*

Fig.2: *Orthetrum pruinosum*

Fig.3: *Vestalis apicalis*

Fig.4: *Orthetrum triangulare*

Fig.5: *Trithemis aurora*

Fig.7: *Laccotrephes* sp.

Fig.8: *Gerris adelaids*

Fig.9:*Anisops barbarata*

Fig.10: *Naucoris scutellaris*

Fig.11: *Paludomus chilinoides*

Fig.12: *Perbrinckia* sp.

Vertebrate fauna


Fig.13: *Euphlyctis cyanophyctis*


Fig.14: *Dawkinsia singhala*


Fig.15: *Garra ceylonensis*


Fig.16: *Belontia signata*


Fig.17: *Tor khudree*

Fig.18: *Labeo fisheri*

Indirect Signs of Mammals

Fig.19: Scat of an otter

Flora

Fig.20: *Vallisneria spiralis*

Fig.21*: Potamogeton pectinatus*

Fig.22: Potamogeton pectinatus

Annex 11

Photographs of a Peterson grab and a hand net

Photographs of a Peterson grab and a hand net

Fig. 1 Peterson grab

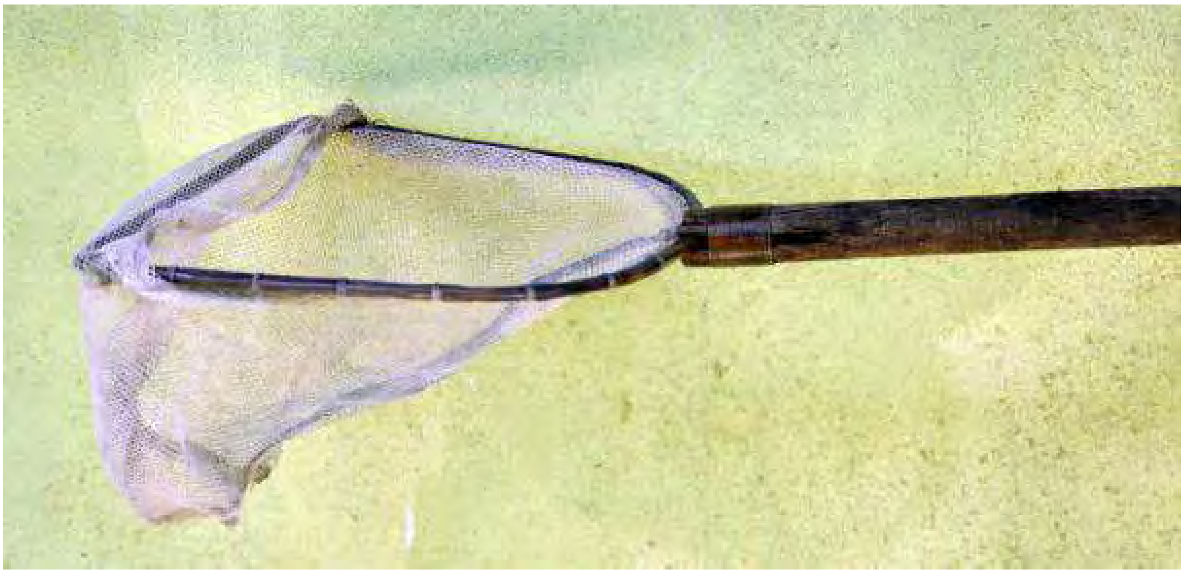


Fig. 2 a small net used to catch fish at the water's edges

Annex 12

References

References

Abeywickrama, B.A. (1979).The genera of the freshwater algae of Sri Lanka. The National Science Council of Sri Lanka, Colombo.

Amarathunga, A.A.D, K.A.W.S. Weerasekara, R. R. A. R. Shirantha, N. Suresh Kumara and S.A.M. Azmy (2010). Nutrient loading in Nanu Oya, Dabagastalawa Oya and Agra Oya in Mahaweli upper catchment of Sri Lanka. In: *The proceeding of 3rd International Symposium on New Horizons in Humanities & Sciences towards Sustainable Development*, Sambaragamuwa University of Sri Lanka, 26-28 August, Belihul Oya, Sri Lanka, 137p.

Anderson, J. R. (1993a). *State of the Rivers Project - Report 1: Development and Validation of the Methodology*, AquaEco Services, Lismore.

Arumugam, S. (1969). *Water Resources of Ceylon*; *utilization and development.* Water Resources Board, Colombo, 246pp.

David Allan, J. (1998). Stream Ecology: *The Structure and Function of Running Waters*, Chapman & Hall, 388pp.

De Silva, K.H.G. and D.M. Wansapura (1991). Distribution of fish species in the Mahaweli River system in Kandy district. Paper presented at the national workshop on stream ecology and reservoirs production of the Mahaweli basin, a modified ecosystem. 22-23 March, Institute of Fundamental Studies, Kandy, Sri Lanka.

De Silva, P. K. (1997). Seasonal variation of the food and feeding habits of the Eurasian otter *Lutra lutra* (Carnivora: Mustelidae) in Sri Lanka, *Journal of South Asian Natural History*, **2**: 205-216.

Dudgeon, D. (1999), Tropical Asian Streams: *Zoobenthos, Ecology and Conservation.* Hong Kong University Press.

Environmental & Management Lanka (Pvt) Limited (2006).). Environmental Impact Assessment report, Getambe mini hydro power project on Mahaweli Ganga, Colombo, Sri Lanka.

Kerr, S.J. 1995. *Silt, turbidity and suspended sediments in the aquatic environment: an annotated bibliography and literature review.* Ontario Ministry of Natural Resources, Southern Region Science & Technology Transfer Unit Technical Report TR-008. 277pp.

Kortmulder, K., K. G. Padmannadhan and S.S. De Silva (1990). Patterns of distribution and endemism in some Cyprinid fishes as determined by geomorphology of South-west Sri Lanka and South Kerala (India). *Ichthyological Exploration of Freshwaters* **2**: 97-112.

Ladson, A. R., and White, L. J. (1999). *An Index of Stream Condition: Reference Manual.* Department of Natural Resources and Environment, Melbourne.

Manchanayake, P. and C.M. Madduma Bandara (1999). *Water Resources of Sri Lanka.* National Science Foundation, Colombo.

Marambe, B. (2001a). Alien invasive plants in the central province of Sri Lanka. *Sri Lanka Biodiversity Review* **1**:21-30.

Mendis, A.S. & C.H. Fernando (1962). A guide to the freshwater fauna of Ceylon, Fisheries Research Station, Ceylon.

MOE, (2012). The National Red List 2012 of Sri Lanka; *Conservation Status of the Fauna and Flora,* Ministry of Environment, Colombo.

Moyle, P.B. and F.R. Senanayake, (1984). Resource partitioning among the fishes of rainforests stream in Sri Lanka. Journal o Zoology, London. **203**: 195-223.

Needham, J.G. & P.R. Needham (1962). A guide to the freshwater biology. 5th edition, Holden-Day Inc. San Francisco.

Parsons, M., Thoms, M., Norris, R. (2001). *AUSRIVAS Physical Assessment Protocol*. Cooperative Research Centre for Freshwater Ecology, University of Canberra.

Pethiyagoda, R. (1991). Freshwater fishes of Sri Lanka. The Wildlife Heritage Trust of Sri Lanka, Sri Lanka. 362pp.

Ravena, P.J., N.T.H. Holmes, F.H. Dawson and M. Everard (1998). Quality assessment using River Habitat Survey data, *Aquatic Conservation* in *Marine Freshwater Ecosystems*. **8**: 477–499.

Rehel, S. 2011. *Farmeria metzgerioides*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 13 July 2013.

Senanayake, F.R and P.B. Moyle (1982). Conservation of freshwater fishes of Sri Lanka. *Biological Conservation*, **22**: 181-185.

Shirantha R. R. A. R. and U. S. Amarasinghe (2005). Alien ichthyofauna and aquatic biodiversity in torrential riverine habitats of Sri Lanka. In: *Proceeding of the International Conference on Tropical Humid Ecosystems: Challenges, Changes and Opportunities, (MAB) Committee, National Science Foundation Sri Lanka*, 4-9 December, Kandy, Sri Lanka. 51p.

Shirantha, R. R. A. R. (2004). *Some aspects of biology and population dynamics of selected endemic fish species inhabiting two river basins in Sri Lanka*. Unpublished M. Phil. Thesis, Department of Zoology, University of Kelaniya, Sri Lanka, 241 pp.

Shirantha, R. R. A. R. (2009). Ecology, biology and socio-economic features of *Pterygoplichthyes multiradiatus* (Osteichthyes; Loricarridae) in the Mahaweli middle catchment of Sri Lanka. In: *The proceeding of National Symposium on Invasive Alien Species*, Biodiversity Secretariat, Ministry of Environment and Natural Resources, Agricultural Education Unit (AEU), of University of

Peradeniya and Institute of Biology (Sri Lanka), 21-22 May 2009, Browns Beach Hotel, Negombo, Sri Lanka, 14p.

Shirantha, R. R. A. R., A. A. D. Amarathunga and K. A. W. S. Weerasekara (2009). Assessment of ecological integrity through a study on invertebrate communities in Kotmale uppermost catchment of Sri Lanka In: *The proceeding of First National Symposium on Natural Resources Management NRM 2009*, Department of Natural Resources, Sambaragamuwa University of Sri Lanka, 29-30 August 2009, Belihul Oya, Sri Lanka, Abstract 56p.

Shirantha, R. R. A. R., and N. K. Ranawaka (2009). Life history and feeding bahaviour of a natural enemy of *Mimosa pigra* in Sri Lanka. In: *The proceeding of National Symposium on Invasive Alien Species*, Biodiversity Secretariat, Ministry of Environment and Natural Resources, Agricultural Education Unit (AEU), of University of Peradeniya and Institute of Biology (Sri Lanka), 21-22 May 2009, Browns Beach Hotel, Negombo, Sri Lanka, 5p.

Shirantha, R.R.A.R. (2012). Socio-ecological dimension on *Labeo fisheri* (Family: Cyrinidae) in Mahaweli middle catchments of Sri Lanka; an endemic fish species of enigmatic population decline. Paper presented at *The OMICS group International Symposium on Biodiversity and Energy Development,* HITEC City, 14-15 September, Hyderabad, India.

Shirantha, R.R.A.R., A. A. D. Amarathunga and K. A. W. S. Weerasekara, (2010). Existing challenge to succeed a sustainable built aqua-environment in misty green valleys in the hill country of Sri Lanka; a case study. *In: Proceeding of the International Conference on Sustainable Built Environment (ICSBE-2010)*, (M.R.T. Jayasinghe, P.A. Mendis and R. Dissanayala eds.) Vol:**2** Pp. 344-354, 13th -14th December, Kandy, Sri Lanka.

Silva, E.I.L and R.W. Davies (1986). Movement of some indigenous riverine fish in Sri Lanka. *Hydrobiologia***, 137** : 263-270.

Silva, E.I.L. (1993). Discontinusm of the Mahaweli River and it impacts on the distribution and diversity of indigenous riverine fish fauna. In: *Proceeding of the international and inter disciplinary symposium "Ecology and Landscape Management Sri Lanka*", (W. Erdelin, C. Preu, N . Ishvaram and C. M. Madduma Bandara (eds.) Pp. 397-414. Sri Lanka.

Silva, E.I.L. (1996). Water quality of Sri Lanka; a review on twelve water bodies. Institute of Fundamental Studies, Kandy.

Silva, E.I.L. (2013). "*Our Common Feature Conservation and Management of Aquatic Resources*", Key note address of the 19th Annual session of Sri Lanka Association for Fisheries and Aquatic Resources (SLAFA), Colombo, Sri Lanka. 16th May 2013.

Southwood, T.R.E. (1966). *Ecological Methods*, Butler & Tanner Ltd. London.

Vollenweider, R.A., M. Munawar and P. Stadelmann (1974). A comparative Review of Phytoplankton and Primary Production in the Laurentian Great Lakes. *Journal of the Fisheries Research Board of Canada*, **31**(5): 739-762.

Wickremanayake, E.D. (1990). Conservation of endemic rain forest fishes of Sri Lanka; Results of translocation experiment. *Conservation Biology*, **4** (1): 32-37.

Wijesundara, D.S.A. & J.G. Shantha Siri (2004). Some Selected aquatic ornamental plants of Sri Lanka. National Science Foundation, Colombo. 95p.

Yakandawala, D. (2012). Present status of fresh water aquatic flora in Sri Lanka. *In: The National Red List 2012 of Sri Lanka: Conservation Status of Fauna and Flora.* Weerakoon, D.K. & S. Wijesundara Eds., Ministry of Environment, Colombo, Sri Lanka.186-196pp.

Electronic references
http://www.environment.gov.au/water/publications/environmental/rivers/nrhp/protocol1/pubs/protocol-1.pdf (accessed on 12 July 2013).

http://www.mahawelicomplex.lk/kotdam.htm (accessed on 28 June 2013).

http://www.google.earth.org (accessed on 28 March 2013).

ADDITIONAL STUDIES ON NATURAL ENVIRONMENT FOR REVIEW OF FEASIBILITY STUDY AND PREPARATION OF DETAILED DESIGN AND BIDDING DOCUMENTS MORAGOLLA HYDROPOWER PROJECT SRI LANKA

Final Report 3

GROUNDWATER DISTRIBUTION AND QUALITY ALONG THE PROPOSED TUNNEL ROUTE OF THE MORAGOLLA HYDROPOWER PROJECT

Prepared by
The National Building Research Organization

Prepared for
NIPPON KOEI Co Ltd - Moragolla Hydropower Project

July 2013

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Executive Summary

Introduction

The Ceylon Electricity Board (CEB), the institution responsible for electricity generation, transmission, distribution and retailing in Sri Lanka, plans to develop a new hydropower station in Moragolla, Kandy with a designed capacity of 30.0 MW. The proposed project involves construction of a 35 m high dam across the Mahaweli Ganga at Weliganga and a 3.1 km tunnel, surge shaft and penstock on the left bank of the river, plus a powerhouse and tailrace.

Nippon Koei Co. Ltd., the consultant appointed by CEB to review the feasibility study and prepare designs and bidding documents for the Moragolla Hydropower Project, appointed the National Building Research Organization (NBRO) to conduct additional studies on the natural environment. This is one of several studies conducted in order to update and upgrade the previous EIA study to comply with the ADB safeguard policy (Safeguard Policy Statement, ADB 2009).

The study investigated the distribution and quality of the groundwater located between the proposed dam site and the tailrace outfall, in the left bank of the Mahaweli Ganga, between the river and the Ulapane to Gampola Road. Subsurface strata, aquifer characteristics and the main directions of groundwater flow of the study area, likely impacts of construction of the tunnel and suitable mitigation measures for any negative impacts of tunnel construction on groundwater were also examined.

Description of the study area

The study area lies in the middle peneplain of Sri Lanka having heavily dissected ridges and valleys with steep rocky slopes, through which the river Mahaweli flows in the North-East direction with incised bends and meanders. The proposed tunnel intake and outfall structures are located on the isolated N-S oriented ridge of the left bank of the River. Geologically, the study area is in the western part of the Highland Complex consisting of high grade meta-sediments and granulitic orthogneisses and the proposed tunnel route is underlain by garnet sillimanite biotite gneiss with quartzite bands but due to the low dip angle the proposed tunnel will not be driven through the quartzite**.**

Monitoring groundwater level and the quality

All existing wells and springs in the study area were geo-referenced and plotted accurately on 1:10,000 scale map using ArcGIS software. A representative sample of 20 wells was selected to determine the present depth, water column height in the wells and quality of groundwater. A Dip Meter was used to measure the depth to groundwater level. Groundwater samples were collected in March and May to examine seasonal variations, and analysed for physicochemical and bacteriological parameters.

Groundwater distribution, aquifer characteristics and recharge potential of the study area

The topography and geology of the study area and ground survey observations suggest the occurrence of continuous and considerable water accumulations, but the conditions are unfavourable due to presence of shallow hard bedrock and relatively thin overburden. The porous and weathered overburden may however favour few isolated and discontinuous small shallow aquifers. Recharge potential of groundwater is very poor since the percolation of rain water into deep aquifers is hindered by the tight joints in the bedrock.

Seasonal variation of ground water quality and suitability for drinking
The difference in variation of water quality between two seasons appears to be marginal with respect to many determinands and generally reflect conditions similar to rural residential setting. The Faecal and Total Coliform counts in several wells although do not comply with Sri Lanka Standard (SLS) for potable water in both seasons, their relatively low numbers suggest that this water would be suitable for drinking after boiling.

Anticipated impacts
Since the tunnel will be drilled through the solid bedrock, no loss of water from wells situated in shallow aquifers is anticipated during construction. Seepage into the tunnel could take place in areas where fracture intensity of bedrock is high. However the tunnel is located within the intact bedrock so seepage into the excavated area is unlikely and therefore no significant impact on the surrounding groundwater bodies is expected. Tunnel construction is unlikely to have any direct impact on groundwater quality, because there should be no major contact between the tunnelling activities and the surface aquifers. Ingression of contaminants such as waste oil, sanitary waste and organic matter into groundwater may result if the waste generated from construction and other project activities is not properly managed.

Mitigation measures
The following are recommended as mitigation measures during the construction phase: regular monitoring of groundwater level during tunnel construction, and provision of an alternative water supply for affected communities if reductions in well water level occur; formulation of an environmental management plan to minimize potential deterioration of groundwater quality due to seepage of waste oils and fuel, and human waste from insanitary practices.

1. Introduction

The Ceylon Electricity Board (CEB) plans to develop a new 30.0 MW hydropower project at Moragolla in Kandy District. The scheme involves construction of a 35 m high concrete gravity dam (with a 5 -gate spillway) across the Mahaweli Ganga at Weliganga, to create a 38.5 ha, 1.98 MCM reservoir with a Full Supply Level (FSL) at 548 masl. Water will be diverted through a 3.1 km underground tunnel, surge shaft and penstock on the left bank of the river, to a powerhouse and outfall located opposite the confluence with the Atabage Oya.

In this regard, CEB intend seeking international financial support for project implementation and potential funders include the Asian Development Bank (ADB). CEB has appointed Nippon Koei Co. Ltd in joint venture with Nippon Koei India Pvt. Ltd to review the feasibility study and prepare detailed designs and bidding documents for the project. Review of the EIA indicated that further studies were needed in order to update and amend the document to comply with ADB safeguard policy (Safeguard Policy Statement, ADB 2009).

The Nippon Koei Co, Ltd, Moragolla Hydropower Project appointed the National Building Research Organization (NBRO) to conduct additional studies the on natural environment as described in Terms of Reference (ToR) shown in **Annex 1**. These studies covered the following:

- Water quality in the Mahaweli Ganga
- Aquatic ecology in the Mahaweli Ganga
- Groundwater distribution and quality along the proposed tunnel route
- Updated land-use mapping

The aspects covered by this report are outlined as follows:

- Description of geology and hydrogeology of the survey area
- Distribution of groundwater extraction sources, groundwater level and quality along the proposed tunnel route of the Moragolla Hydropower Project
- A detailed map showing all wells in the survey area
- Photographs of sampling locations
- Sampling and analysis methods
- Quality Control procedures operated by the laboratory
- Discussion of the likely impacts of construction of the headrace tunnel
- Proposed mitigation for any likely negative impacts

2. Scope of the study

According to the ToR (**Annex 1**) the survey required following:

Mapping well locations
Locate and map all wells in the survey area, which is the left bank of the Mahaweli Ganga, between the proposed dam site and the tailrace outfall, between the river and the Ulapane to Gampola Road. Well locations shall be obtained from information provided by the Mahaweli Authority and Irrigation Department, if available, and by interviews with property owners and occupiers on site. All well locations to be geo-referenced via GPS receivers and plotted accurately on the map.

Monitoring groundwater quality
A sample of 20 wells to be selected at locations covering the whole survey area and with permission from the owners, for the measurement of present depth and water quality[1].

Samples are to be transported to a government-accredited laboratory under controlled temperature conditions prescribed by the laboratory. In the laboratory samples are to be analysed for: Conductivity, Total Suspended Solids, BOD_5, Nitrate, Phosphate, Total Coliforms, Faecal Coliforms and likely pesticides[2]. This survey shall be conducted twice; during February, 2013 and at the end of May, 2013, to give an indication of seasonal variations.

Examine the geology and hydrogeology
The geology and hydrogeology of the survey area are required to be studied using available data and prepare a description of the subsurface strata and aquifer characteristics and the main directions of groundwater flow.

[1] The requirement of duplicate samples mentioned in the ToR of Bid invitation document was later amended as to collect and analyze 1 sample from each location at the meeting held on 15.02.2013 between NBRO and Nippon Koei Pvt Ltd
[2] Agreed to exclude pesticide analysis at the meeting held on 15.02.2013 between NBRO and Nippon Koei Pvt Ltd

3. Description of the study area

3.1 General

The study area, which is located between Ethgala Junction and Ulapane Industrial Park, can be reached through Gampola – Nawalapitiya (A 113) Road. This area is situated within Grama Niladhari Divisions of Ulapane, Thembiligala and Ethgala of Ganga Ihala Divisional Secretary Division.

3.2 Topography

Morphologically, the area belongs to the middle peneplain [3] of Sri Lanka. The general topography consists of ridges and valleys with steep slopes. The ridges are heavily dissected by 1st and 2nd order streams. The streams flow in a dendritical pattern and join the Mahaweli River, which flows in North-East direction. In the study area, the River Mahaweli flows in a steep-sided valley with incised bends and meanders. The maximum relief of the study area is about 230 m. The local topography consists of the northerly flowing River Mahaweli with steep rocky embankments and meanders with an island close to the proposed tailrace outlet. The slope steepness of the river bank varies from 35º to 50º. The slope angle of the land area varies between 30º and 70º and the steepness is high along the Gampola – Nawalapitiya main road. The river shows typical youthful stage characteristics with steep 'V' shaped valleys, potholes and rapids. A few cross-cutting shallow valleys, which are oriented along the NW-SE direction, are situated on the slope. These valleys are the surface expressions of regional lineaments and they are located at much higher elevation in relation to the river bed level (data extracted from the 1:10,000 scale ABMP map; sheet number 61/13, published by the Survey Department of Sri Lanka).

The proposed tunnel intake and outfall structures are located on the isolated ridge of the left bank of Mahaweli River. The orientation of the ridge is North to South. The highest elevation of the ridge is 700 m. The elevations at the intake area (river level) and the power house area are 520 m and 470 m respectively.

[3] All technical terms are explained in the glossary in Annex 3

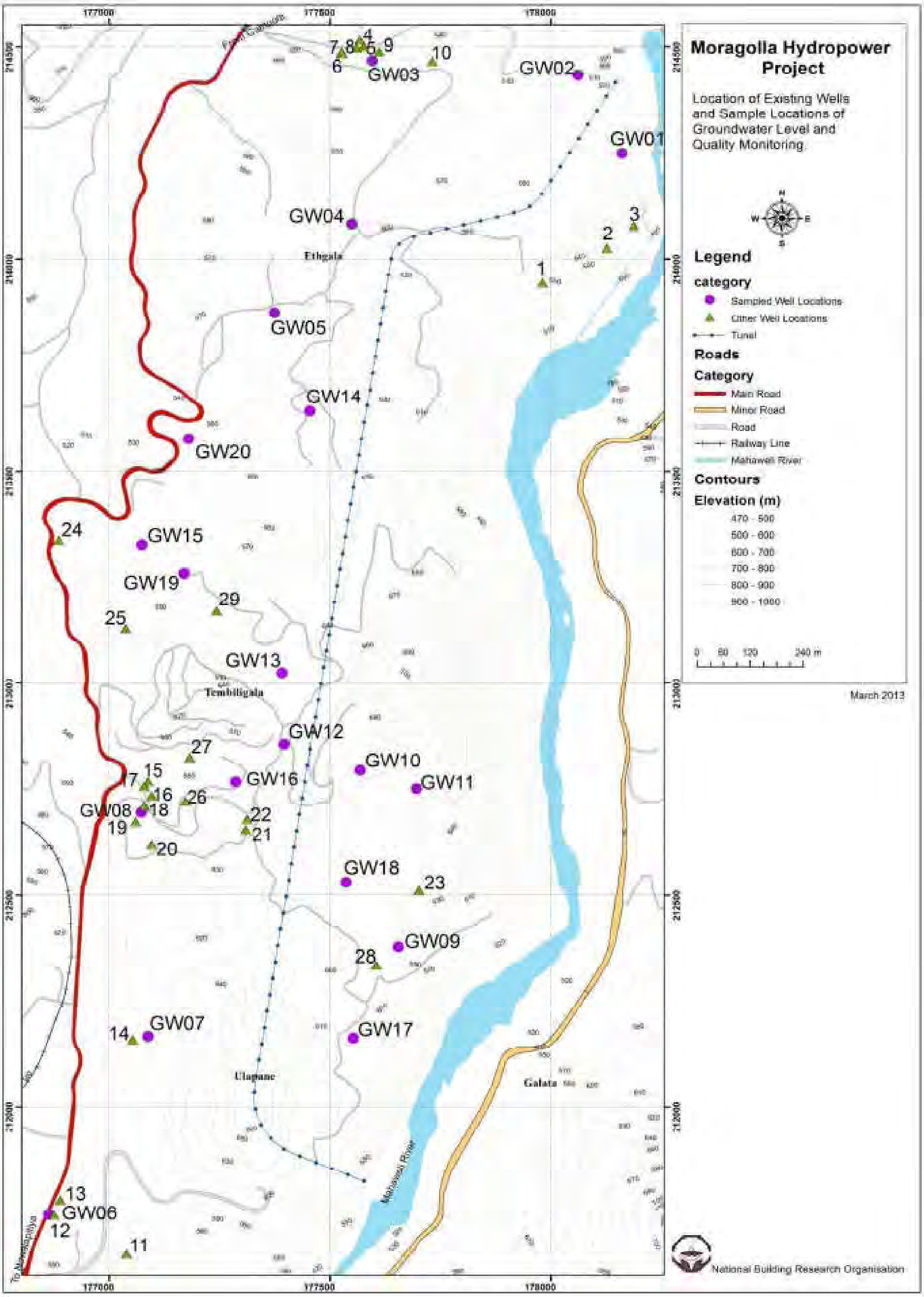


Fig. 1 Map of the study area

3.3 Geology

More than nine tenths of Sri Lankan basement is underlain by Late Proterozoic age high-grade gneissic rocks. This is sub-divided into major crustal units namely Highland Complex (HC), Wanni Complex (WC), Vjayan Complex (VC) and Kadugannawa Complex[4] (Fig. 2). The project area is in the western part of the Highland Complex; very close to the boundary between Highland and Kadugannawa complexes. The Highland Complex, which is comprised of the oldest rocks of the island, consists of high grade meta-sediments and granulitic orthogneisses. According to the geology map of the area; 1:100,000 Sheet No.14[5], the proposed tunnel route is underlain by garnet sillimanite biotite gneiss, with some bands of quartzite (refer **Annex 2**). However, the tunnel will not be driven through the quartzite due to the low dip angle. The rock strata show NE strike and dipping in the NW direction. The NW trending Kotmale Shear Zone crosses the project area at the middle of the proposed tunnel route. The left bank is identified as a scarp slope.

According to borehole log data[6], the country rock in this area is garnet biotite gneiss with prominent foliation plain with an attitude of N25ºE/27ºNW. The tunnel will be located in this rock, which represents the north limb of an antiform structure. The rock is dissected by two almost vertical joint sets, striking N80ºE and N30ºE. Many rock wedges created by the above joints appear and may have a strong capacity to be moved on the foliation plain along the right river bank as rock slides. This setting is therefore unfavourable from the rock slope stability point of view. In the left bank, the country rock dips into the left bank and is favourable for sliding failures. However, toppling may be possible, as the rock is dissected by discontinuities and the steepness of the slope, along the left river bank. Nevertheless, the above mentioned condition is not expected along the proposed tunnel route, as the joint intensity is poor and joints are tight in the fresh rock, through which the tunnel will be driven. The surface layers of the study area consist of mainly, residual gravelly clay soil with some sporadic distribution of colluvial materials. The thickness of overburden varies from place to place. This variation is related to underlying bedrock condition[4]. The glossary terms is given in **Annex 3.**

[4] Kroner, A., Cooray, P. G. and Vitanage. P. W., (l99l), Lithotectonic subdivision of the Precambrian basement in Sri Lanka. The Crystalline Crust of Sri Lanka. Part I. Summary of Research of the German-Sri Lankan Consortium. Geological Survey Department, Sri Lanka, Professional Paper 5: pp. 5-21.

[5] Geology map of the area is extracted from the 1:100,000 scale, Sheet No.14, published by Geological Survey & Mines Bureau (GSMB)

[6] For bore hole data, please refer the Feasibility study report on Moragolla Hydropower Project (Final report-Volume 4-Geology-February 2010), prepared by Central Engineering Consultancy Bureau/Al Habshi Consultants Office

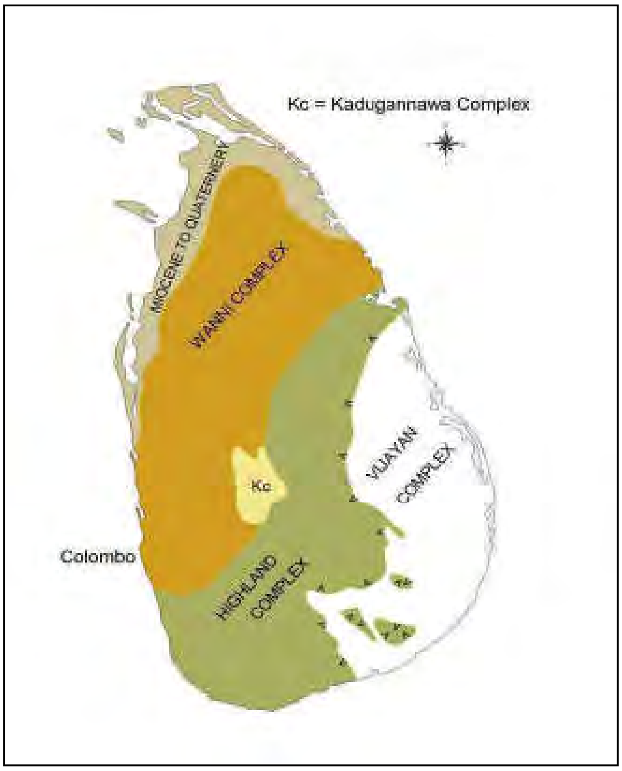


Fig. 2 Main litho-tectonic subdivisions of Sri Lanka

4. Mapping locations of wells in the study area

A team of Geologists of Landslide Research and Risk Management Division (LRRMD) of NBRO accomplished the task during the period from 05.03.2013 to 13.03.2013. All existing wells/springs within the study area were identified by an in-depth ground survey as updated data were not available in the Mahaweli Authority or in the Irrigation Department. The coordinates of identified groundwater wells/springs were then recorded using 1m accuracy GPS instrument[7]. A geo referenced map in the scale of 1:10,000 was prepared in ArcGIS software and then GPS coordinates of all wells/springs in the study area were plotted. The locations of the wells chosen for monitoring of water levels and groundwater quality were demarcated separately on the map plotted. Refer **Annex 4**; Map - Location of existing wells and sampled locations for groundwater level and quality monitoring, and **Annex 5** gives location description of all wells in the survey area.

[7] GPS instrument: make-Trimble, model-Geo XT 2005 series

5. Monitoring ground water levels and quality

The initial survey revealed that in this area the people use groundwater from two different sources: from dug wells and from springs. Shallow pits have been excavated to tap the spring water at the foot of slope cuts. The majority of the population uses dug wells and only a few residents use springs with excavated shallow pits.

The depth to groundwater level from the ground surface and present water quality of the selected wells/springs were then determined as follows. A total of twenty (20) wells were selected by obtaining permission from the owners to represent the ground water quality in the study area. Selection of wells was based on their construction type (protected or not), accessibility for sampling and existence for future reference. Accordingly, wells sealed with concrete slabs and those abandoned were not considered. More monitoring wells were selected above or in the vicinity of the proposed route of the underground tunnel since the groundwater regime can be disturbed specially during the construction of the tunnel.

The groundwater survey team (refer **Annex 6**) visited the site on 13th March 2013 to take measurements of ground water level and for the collection of water samples for water quality monitoring. The same was repeated on 21st May 2013 after showers.

The device called "Dip Meter" (Water Level Indicator –model BFK 200, Made in Italy (Fig. 3)) was used to measure the depth of groundwater level. Using this device the measurements were taken in a day. The Dip Meter consists of a long wire cord marked in metres with cm and mm divisions and a sensor connected to the rear end of the cord. During the measurement, the sensor was slowly dipped into the well and a "beep" sound was heard when the sensor touches the water surface. At this point the reading on the wire cord at the ground surface level was recorded as the depth to the groundwater level. **Annex 7** gives the location descriptions, water level and height of the water column of wells sampled during the survey.

Fig. 3 : Front view and side view of Dip meter

6. Sample collection, preservation and transportation for water quality testing

As instructed by the ToR, the samples were analysed for Conductivity, Total Suspended Solids, BOD_5, Nitrate, Phosphates, Total Coliforms, and Faecal Coliforms. In addition, Dissolved Oxygen (DO), Ammonia and Total Iron were also measured as low water levels in wells could lower redox conditions leading to: leaching of Iron, high levels of Ammonia and occurrence of low DO.

Sample collection, preservation, transportation and analysis for physicochemical parameters were carried out as per the international standards [8]. The bacteriological analysis (Faecal Coliforms, Total Coliforms) were done according to the Specification for potable water [9]. Accordingly, water samples were collected using specially wrapped sterilized sample bottles (Fig. 4). The bacteriology sample collection bottle is a narrow mouth bottle to which a sterile nylon cord is tied. The sample was collected by dipping the bottle up to the required water level by unwinding a nylon cord. Once the bottle was judged to be filled the thread was rewound to bring the bottle up. After collection, one third of the water in the bottle was discarded to leave sufficient air for microorganisms for their respiration. The groundwater samples for other parameters were collected from wells using a Depth Sampler: Lamotte water sampler – code 1060 (Fig. 5). The purpose of using this device is to collect representative samples from the mid water column. The sampler was lowered to a desired depth and immersed in the water completely, once the bottle was sufficiently filled, the cord was rewound and sampler was brought up. Water sample was transferred to a clean plastic beaker and pH, temperature, Conductivity and DO were measured on-site. Bottles having a ground-glass stopper and flared mouth were filled with water samples for the determination of Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD), and bottles with samples for Dissolved Oxygen were fixed at site by adding $MnSO_4$ and alkali-iodize – azide reagents. The water samples collected for water quality parameters except for DO, BOD and bacteriological analysis were transferred securely into pre- cleaned screw-top plastic containers, All samples were labelled with location No, date and specific parameter to be analysed. Carefully packed samples in separate cooler boxes with ice were then transported to the NBRO laboratory, Colombo on the same day. A temperature of 4 -10^0 C was maintained during transportation. In the laboratory, the samples were stored at 4^0 C until analysis was performed. The analysis was commenced on the following day of sample collection and continued up to10 days.

[8] Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 20th Edition, 1998
[9] Specification for potable water SLS 614,1983, Bacteriological requirements (Part 2)

Fig. 4 - Sterilized sample bottle used for the collection of water samples for bacteriological analysis

Fig. 5 – Depth sampler used for the collection of groundwater samples from wells

7. Analysis of groundwater distribution, aquifer characteristics and recharge potential of the study area

The above analysis of the topography and geology of the study area, and observations made during the survey work suggest that in general, favourable conditions do not exist in the study area for the occurrence of continuous and considerable water accumulations. This is due to following factors:

- Presence of shallow hard bedrock in the majority of the area
- Presence of discontinuous shallow overburden with restricted extent
- Steep topographical nature of slopes of the area

Nevertheless, the existence of localized porous weathered overburden with gravelly and sandy nature at some places can create favourable conditions for a few isolated and discontinuous small shallow aquifers in the overburden. In addition, the presence of small low valleys and depressions also facilitate water accumulation on the ridges. Because of this, several springs can be observed in depressions at valley bottoms, discharging groundwater from their shallow aquifers. These springs prove the existence of bed rock at a shallow level, though it is not exposed in any of these valley bottoms. The presence of shallow solid bedrock forces groundwater to discharge at the surface as springs, restricting downward percolation. The inspected dug wells and springs are located within the above described setting within small discontinuous aquifers.

The recharge potential of groundwater in the study area is significantly poor. Percolation of water into deep aquifers is hindered, or occurs at a low rate through the existing tight joints in the bedrock. Further, the presence of relatively thin overburden and steep slopes in the project area significantly restrict the accumulation of groundwater. Recharge of these shallow isolated aquifers is therefore accomplished only by precipitation.

8. Seasonal variations of groundwater in the study area

8.1 Groundwater level

Fig. 6 shows the water level of each of the 20 surveyed wells in March 2013 (dry season) and May 2013 (beginning of the wet season). The data shows that, as expected, water levels were generally higher in the wet season, although the seasonal differences were not large (maximum around 3 m) and in around half of the sampled wells there was little seasonal variation. This survey was conducted in March and May and it covered the first inter monsoon period (March to April) and the beginning of the Southwest monsoon period (May to September). The study area receives relatively high precipitation, which is the only source for groundwater recharge in the area; and recharge mainly occurs during the longer Southwest monsoon (May to September) and in the second inter monsoon period (October to November). It is likely therefore that greater seasonal variation would have been apparent if the second period of sampling was conducted later in the year, during or after the main recharging period, when groundwater levels are generally greatly enhanced.

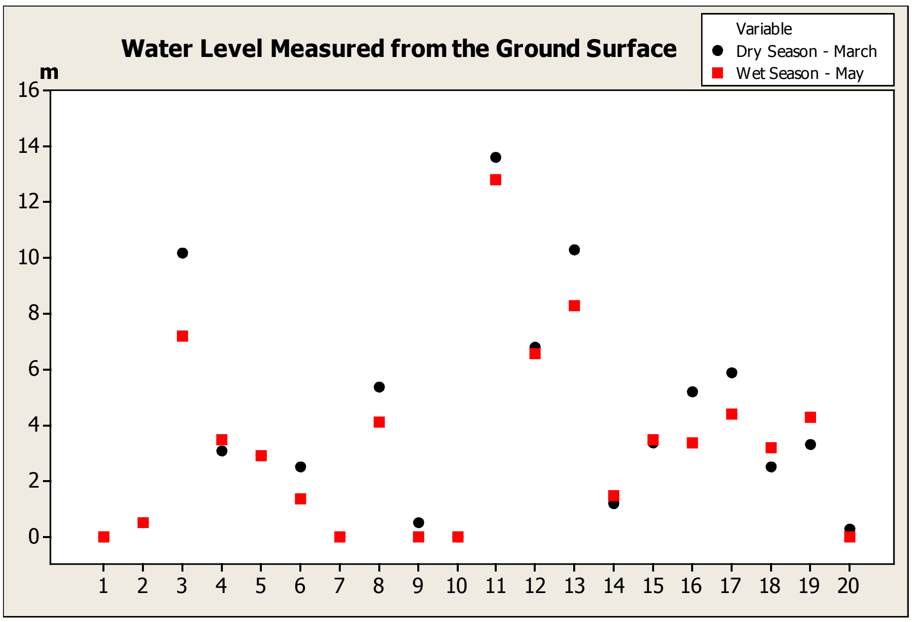


Fig. 6 - Water level measured in wells in March and May in 2013
(Level shown as m from the ground surface)

8.2 Groundwater quality

Seasonal variation in groundwater quality

The **Annex 9** contains the analysis of groundwater quality of the wells sampled during March and May 2013, and Fig.7 shows the variation in Conductivity, Total Suspended Solids, Ammonia, Phosphates, and bacteriological quality (Faecal and Total Coliforms) of the 20 wells in the two seasons. Conductivity in wet season was slightly low in most of the wells in comparison to dry season due to dilution of dissolved constituents in percolating rain water. In contrast, notably high conductivity values were reported in Well No. 6 and 9, but just two sets of samples are inadequate to explain the reason for this. Total Suspended Solids in all wells except Well No. 15 show no or little variation between two seasons. The values of Ammonia, Phosphates, Faecal and Total Coliform show mixed variation between two seasons in which some wells show low values for above determinands in the dry season in comparison to wet season while others show the opposite.

Suitability of water for different uses

SLS 614, 1983 is the national standard for potable water, including physical and chemical requirements (part 1) and bacteriological requirements (part 2). Accordingly, the levels of the tested parameters were compared with the limits given in this standard, because water in some wells is consumed directly for drinking.

The results of these comparisons are shown in **Annex 9**. The results indicate that the well water quality conforms to the SLS requirements with respect to Conductivity, Nitrates, Total Phosphates and Iron levels in both seasons. There are however some discrepancies with respect to the other parameters. Among the 20 wells tested, 4 wells in the dry season and 11 wells in the wet season do not conform to the prescribed Ammonia level. This is likely to be caused by seepage of runoff water contaminated with nitrogenous pollutants from diffused sources (animal urine and faces) in to groundwater during rains. The pH levels are slightly lower than the standard in some wells, but the values reflect natural variations in Carbon Dioxide dissolution, and have no health risk or aesthetic effect. The results also show that there are several wells where Faecal and Total Coliform counts do not comply with the standard in both wet and dry seasons, although the values are quite low and are generally within the range of what would be expected in groundwater in a rural setting. Other parameters, such as BOD and Total Iron are similarly low in most wells and also represent typical background conditions. These results suggest that groundwater in the study area should not be consumed raw because of the faecal coliform content, but would be suitable for drinking after simple treatment by boiling.

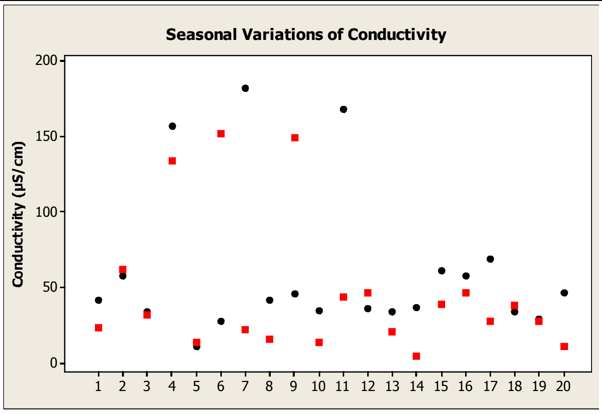


Fig 7.1 Seasonal Variations of Conductivity

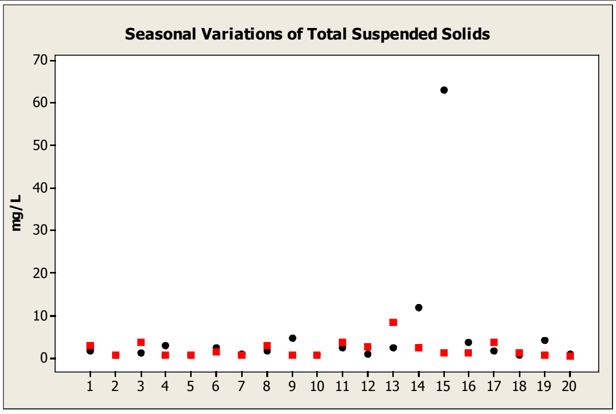


Fig 7.2 Seasonal Variations of Total Suspended Solids

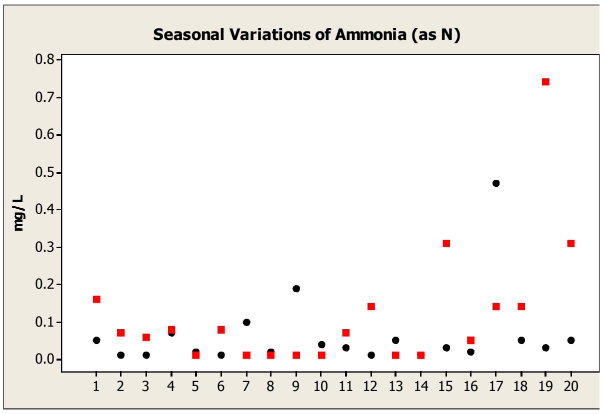


Fig 7.3 Seasonal Variations of Ammonia

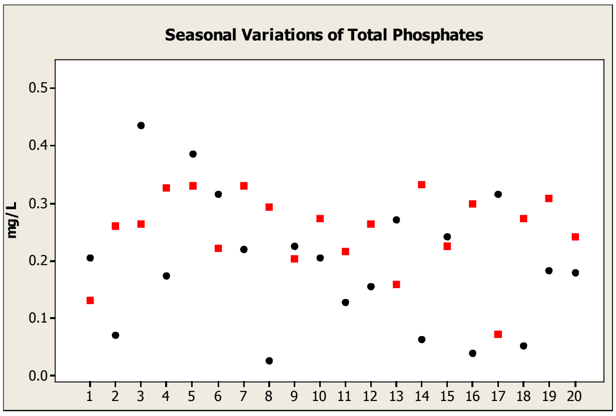


Fig 7.4 Seasonal Variations of Total Phosphates

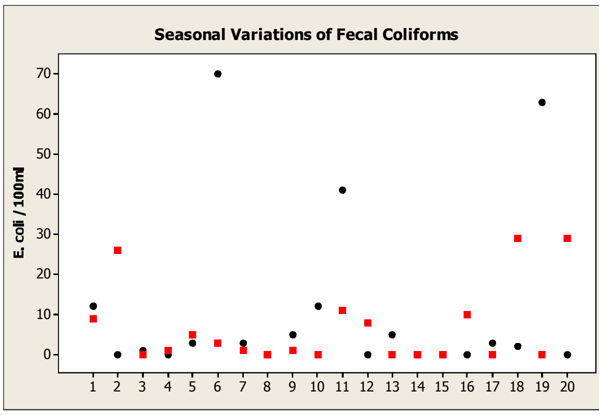


Fig 7.5 Seasonal Variations of Faecal Coliforms

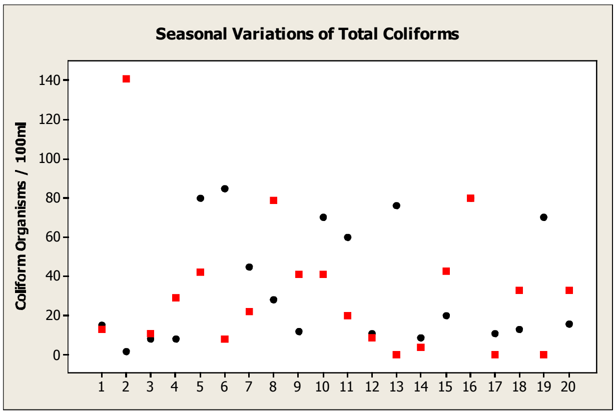


Fig 7.6 Seasonal Variations of Total Coliforms

Fig. 7 Seasonal variations in groundwater quality in 20 wells in the study area
(1-20 depicts the sampling locations GW1 – GW20.
Dry season data are shown in black and wet season data are shown in red)

9. Anticipated impacts

9.1 Groundwater level

Borehole log data[6] revealed that the natural groundwater level in the shallow discontinuous isolated aquifers located along the tunnel route is always above the proposed tunnel elevation and the full supply level of the reservoir. Since the tunnel will be driven through the intact bedrock, no loss of water from wells situated in shallow aquifers is anticipated during construction. However, seepage could take place into the tunnel during construction in areas where fracture intensity is high in the basement rock.

According to the drilling data, depths to the sound bedrock from the surface along three differently oriented sections of the tunnel route are: 10 m, 20 m and 25 m (at the surge chamber), and 10 m (at the outfall) respectively. The proposed tunnel route runs almost 50 m vertically below the crest line of the ridge on the left bank along most of the route. The tunnel is therefore located well below the bedrock, so there is very unlikely to be major seepage into the excavated area, and therefore the expected impact on the surrounding shallow isolated groundwater bodies will be insignificant.

9.2 Groundwater quality

The wells in the study area exploit percolating rainwater from discontinuous and relatively shallow aquifers near the surface and as explained above, the tunnel will be located below the layers of bedrock. Tunnel construction is therefore unlikely to have any direct impact on groundwater quality, because there should be no major contact between the tunnelling activities and the surface aquifers.

Nevertheless materials used or produced during the construction process (such as fuel oil, sanitary waste, and other organic matter) could enter and pollute groundwater if disposed of under poor waste management practices.

10 Mitigation measures

10.1 Mitigation of impacts of reduction in well water yield

As local communities depend almost entirely on groundwater for their potable supplies, it is recommended that water levels of existing dug wells are monitored during the tunnel construction period so that alternative water could be provided by tanker if any changes were to happen.

10.2 Mitigation of ground water quality impacts

Measures should be included in the project Environmental Management Plan to ensure that the aquifers and wells here and elsewhere in the project area are protected from potential sources of pollution, including disposal of construction waste, storage and usage of chemicals (including fuel, oils and waste oil) and waste from insanitary practices by workers.

Annexure

Annex 1

Terms of Reference

ToR FOR GROUNDWATER DISTRIBUTION AND QUALITY ALONG THE TUNNEL ROUTE

Objective

The EIA study suggested that groundwater levels could be lowered during construction of the tunnel, but provided no data on the distribution and quality of groundwater or the numbers of wells likely to be affected. These factors therefore need to be investigated to allow a more informed assessment of these impacts.

Scope of work

The Contractor shall first determine the location of all wells in the survey area, which is the left bank of the Mahaweli Ganga, between the proposed dam site and the tailrace outfall, between the river and the Ulapane to Gampola road. Well locations shall be obtained from information provided by the Ministry of Mahaweli and Irrigation if available, and by interviews with property owners and occupiers on site. All locations shall be geo-referenced via GPS receivers and plotted accurately on maps.

A sample of 20 wells should then be selected at locations covering the whole survey area and with permission from the owners the Contractor shall determine the present depth of water and will take samples for subsequent examination of water quality. Samples shall be transported promptly to Government accredited laboratory, under controlled temperature conditions as prescribed by the laboratory. In the laboratory, samples shall be analysed for; conductivity, total suspended solids, BOD5, nitrate, phosphate, total coliforms, faecal coliforms and likely pesticides. This survey shall be conducted twice; during February 2013 and at the end of May 2013, to give an indication of seasonal variations.

The Contractor shall examine the geology and hydrogeology of the survey area using available data and shall prepare a description of the subsurface strata and aquifer characteristics and the main directions of groundwater flow.

Programme and Reporting

The Contractor shall submit a draft Interim Report on 31 March 2013 and a draft Final Report on 7 June 2013. Both reports will be reviewed by the Study Team and the Contractor shall amend the reports to address all comments and shall submit final report within two weeks of receipt of comments.

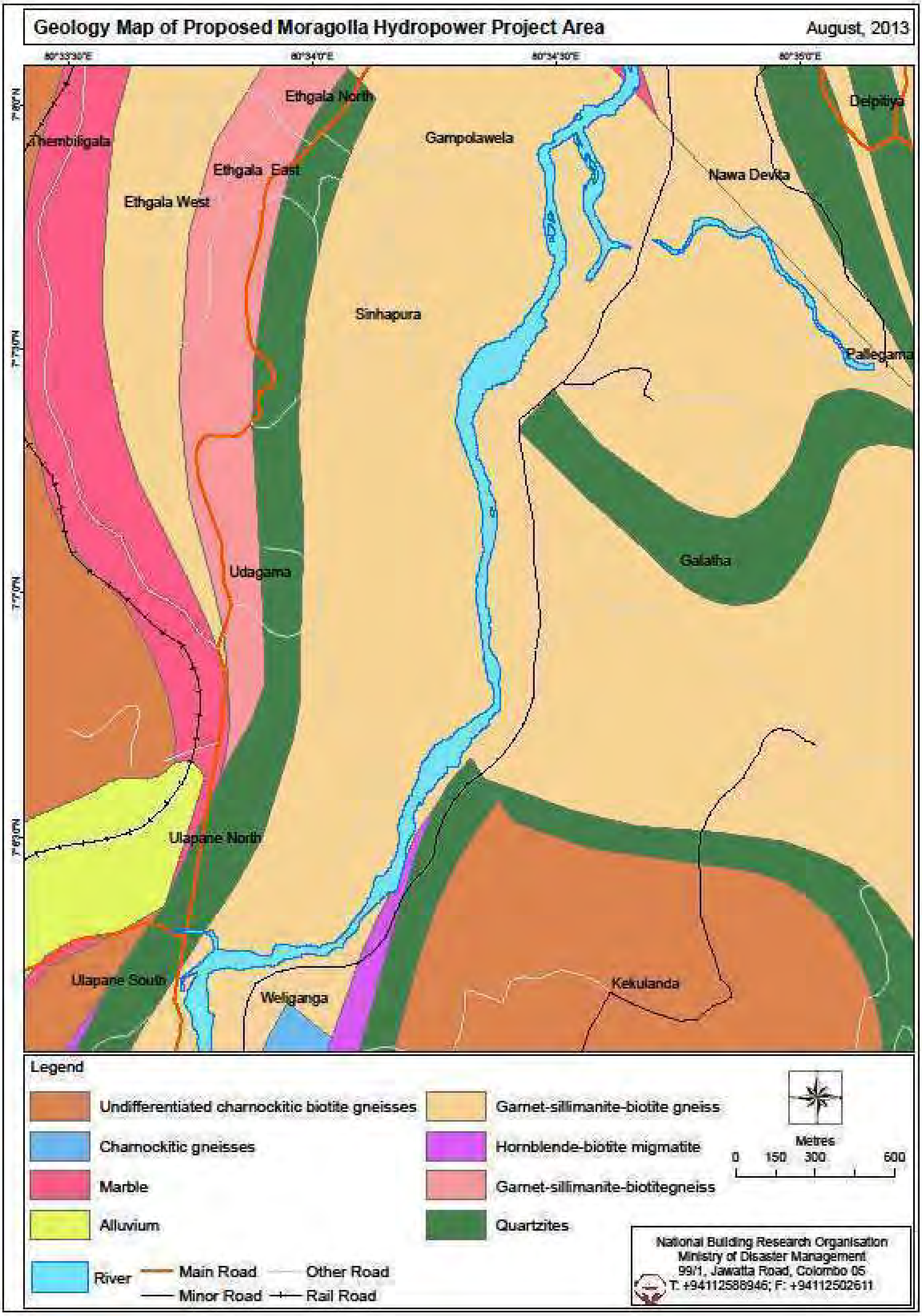
The Interim Report shall present and discuss all data collected in the first survey and the Final Report shall present all data from both surveys and shall include the following:

- A detailed and accurate map showing all wells in the survey area, plus site photographs and appropriate tables and illustrations of key data;
- Written descriptions of all survey and analysis methods (full details), quality control procedures operated by the laboratory, and all other methods of data collection and analysis;
- A detailed discussion of the results, including but not necessarily limited to:

  - A description of the geology and hydrology of the survey area, including the distribution and flow in aquifers, recharge characteristics, water depths and quality, and local and seasonal variations;
  - The likely impact of construction of the 3.1 km long, 4.5 m diameter tunnel, at an elevation of 528.25 msl (intake) and 510m as (outfall);
  - Suitable mitigation for any negative impacts of tunnel construction on groundwater;
  - Discussions of impacts shall explain the reasons for all conclusions and impacts shall be quantified to the extent possible.
  - Tables showing all data should be provided in an appendix.

Annex 2

Geology map of proposed Moragolla Hydropower project area



Geology map of Moragolla Hydropower project

Annex 3

Glossary of terms

Glossary

ABMP
Agricultural Base Mapping Project

Antiform
The descriptive term for any fold that is convex up

Basement
The thick foundation of ancient and oldest metamorphic rock that forms the crust of continents

Crust
Outermost solid shell of Earth planet, or of any other planet or moon.

Crustal
Made of the crust

Country rock
The geological term meaning the rock native in a certain area. The term is used to denote the usual strata of a region

Colluvial material
Mixture of soil and rock that has moved downhill to the bottom of the slope without the help of running water

Clay
A natural material with plastic properties, composed of particles of very fine, hydrous aluminium or magnesium silicate minerals

Dendritic drainage pattern

A drainage pattern in which the streams branch randomly in all directions and at almost any angle, resembling in plan the branching habit of certain trees. It is produced where a consequent stream receives several tributaries which in turn are fed by smaller tributaries.

Dike (Dyke)
A type of sheet intrusion referring to any geologic body that cuts discordantly across

Fault
Discrete planar rock fracture, which shows evidence of a displacement. A fault is a discrete surface

Fold
Stack of originally flat and planar surfaces, such as sedimentary strata, are bent or curved as a result of plastic (i.e. permanent) deformation.

Foliation plain
Surfaces of parallel alignment of textural and structural features of a rock

Garnet sillimanite biotite gneiss
Metamorphic rock composed chiefly of garnet, sillimanite and biotite minerals

Granulitic
The term implies the granulite facies rocks. The granulite facies is determined by lower temperature boundary of 700 +/- 50 °C and pressure range 5–15 kb

Gravel
Loose detrital material, composed chiefly of small rounded pebbles mixed with sand and clay

High-grade gneissic rock
Metamorphic rocks formed at temperatures greater than 320^0C

Lineament
A linear feature in a landscape, which is an expression of an underlying geological structure such as a fault. Typically a lineament will comprise a fault-aligned valley, a series of fault or fold-aligned hills, a straight coastline or indeed a combination of these features. Fracture zones, shear zones and igneous intrusions such as dykes can also give rise to lineaments. Lineaments are often apparent in geological or topographic maps and can appear obvious on aerial or satellite photographs.

Metamorphic rocks
Rocks formed by the solid state re-crystallization of pre-existing rocks due to changes in heat and/or pressure and/or introduction of fluids i.e. without melting.

Meta-sediments
Sediment or sedimentary rock that shows evidence of having been subjected to metamorphism. The overall composition of a meta-sediment can be used to identify the original sedimentary rock, even where they have been subject to high-grade metamorphism and intense deformation

Metamorphism
Solid state re-crystallization of pre-existing rocks due to changes in heat and/or pressure and/or introduction of fluids i.e. without melting

Orthogneisses
Metamorphic rocks formed by the metamorphism of igneous rocks

Overburden
The material that lies above the rock

Peneplain
A nearly flat surface of country produced by long period of subaerial erosion; almost a plain

Proterozoic age
The era of geologic time, 2.5 billion to 570 million years ago, during which sea plants and animals

Quartz
SiO_2, crystalline silica or oxide of silicon

Quartzite
Metamorphosed sandstone consisting of an interlocking mosaic of quartz crystals

Residual gravelly clay
In-situ clay soil formed by weathering of the parent rock rich in gravel

Scarp slope
The face of a ridge, facing in an opposite direction to the dip of the rock strata

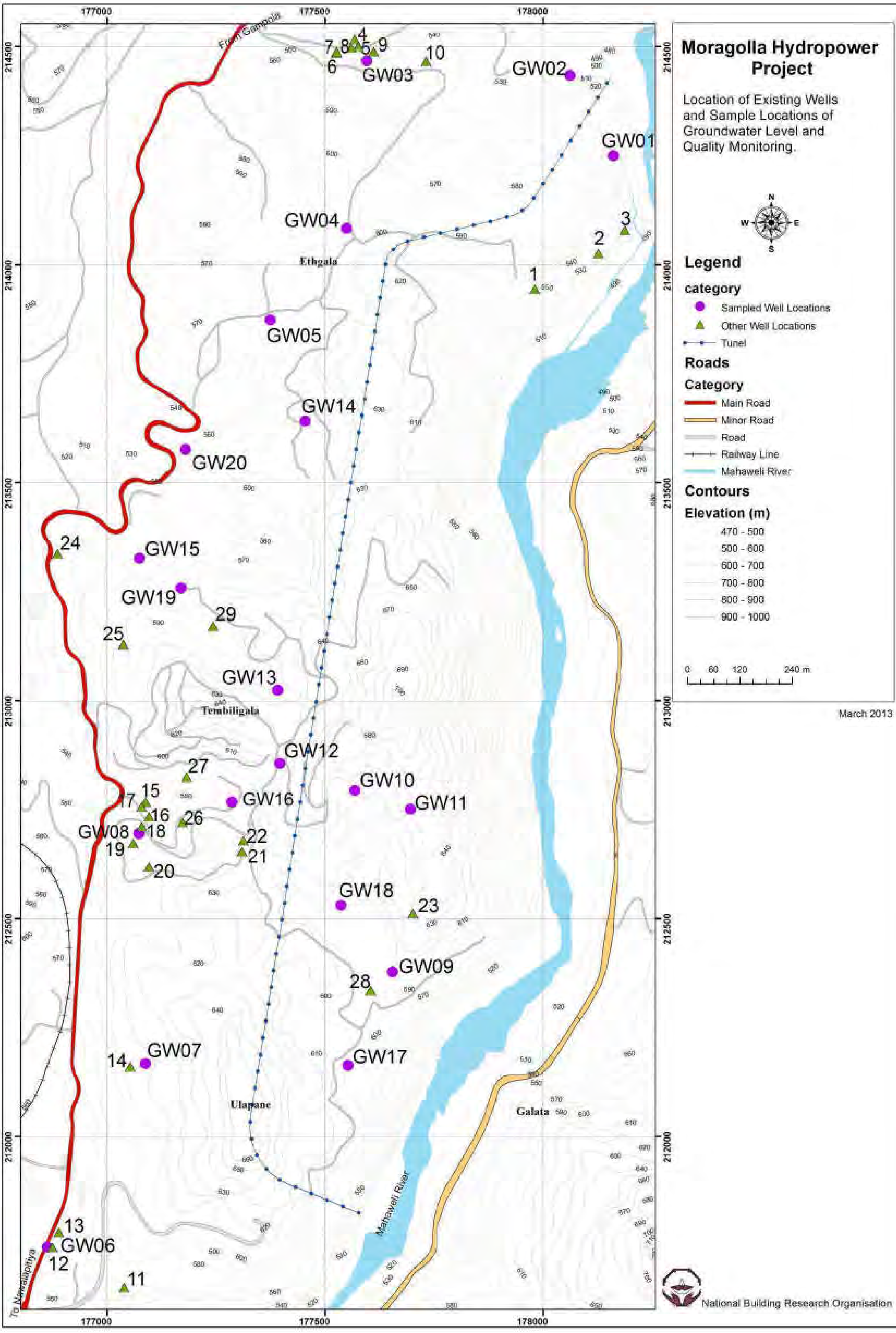
Shear Zone
A tabular to sheet like, planar or curviplanar zone composed of rocks that are more highly strained than rocks adjacent to the zone.

Stream order
Numbering begins at the top of a catchment with headwater ('new') flow paths being assigned the number 1(**first order**). Where two flow paths of first order join, the section downstream of the junction is referred to as a **second order** stream. Where two second order streams join, the waterway downstream of the junction is referred to as a **third order** stream, and so on. Where a lower order stream (e.g. first order) joins a higher order stream (e.g. third order), the area downstream of the junction will retain the higher number (i.e. it will remain a third order stream).

Strike
Bearing of the foliation plain of a rock

Annex 4

Map-Location of existing wells and sample locations for groundwater level and quality monitoring



Moragolla Hydropower Project
Location of Existing Wells and Sample Locations of Groundwater Level and Quality Monitoring.
Legend
category
Sampled Well Locations
Other Well Locations
Tunel
Roads
Category
Main Road
Minor Road
Road
Railway Line
Mahaweli River
Contours
Elevation (m)
470 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1000
0 60 120 240 m
March 2013
National Building Research Organisation
GW01
GW02
GW03
GW04
GW05
GW06
GW07
GW08
GW09
GW10
GW11
GW12
GW13
GW14
GW15
GW16
GW17
GW18
GW19
GW20
Ethgala
Tembiligala
Ulapane
Galata
Mahaweli River
From Gampola
To Nawalapitiya
177000
177500
178000
212000
212500
213000
213500
214000
214500

Annex 5

Location description of all wells in the study area

Location description of all wells in the survey area

DW – Dug Well

Locations of well used for water level and quality monitoring

Well No.	Date Observed	Name & Address of Owner	Type of Source	Depth to GWL/m	Elevation of GWL/m	Northing/m	Easting/m	Elevation/m
GW-01	5.3.2013	H.M. Francis, 863/1, Dunhinda road, Ethgala watta, Gampola	Spring	0	528	214250	178161	528
GW-02	5.3.2013	Jayawardhena, Dunhinda road, Ethgala watta, Gampola	DW	0.5	508.5	214434	178062	509
GW-03	7.3.2013	Susantha Ileperuma, Bungalow road, Ethgala, Gampola	DW	10.2	544.8	214467	177596	555
GW-04	7.3.2013	Bandara Nissanka, 852, Bungalow road, Ethgala, Gampola	DW	3.1	590.9	214083	177550	594
GW-05	7.3.2013	B.S.M. Senarath Bandara, 851A, Bungalow road, Ethgala, Gampola	DW	2.9	574.1	213873	177375	577
GW-06	8.3.2013	K.M.Karunasena, 250, Gampola road, Ulapane	DW	2.5	543.5	211746	176864	546
GW-07	8.3.2013	Youth Council Premises, Gampola road, Ulapane	Spring	0	508	212167	177089	508
GW-08	9.3.2013	P. Marimuttu, 15, Thembiligala watta, Ulapane	DW	5.4	576.6	212695	177074	582
GW-09	10.3.2013	Common use, Mahawila watta, Ulapane	DW	0.5	600.5	212378	177655	601
GW-10	10.3.2013	Common use, SAARC village	Spring	0	545	212794	177569	545
GW-11	10.3.2013	Baby Nona, No 12, Denmark Colony, Ulapane	DW	13.6	539.4	212751	177696	553
GW-12	9.3.2013	Abesinghe, No. B5/A, Sri Dharan Pura, Ulapane	DW	6.8	516.2	212856	177397	523

Location description of all wells in the survey area – contd....

DW- Dug Well

Well No.	Date Observed	Name & Address of Owner	Type of Source	Depth to GWL/m	Elevation of GWL/m	Northing/m	Easting/m	Elevation/m
Locations of well used for water level and quality monitoring								
GW-13	11.3.2013	W.C Nimalsiri, 326, Handabima Ihala, Udagama, Ulapane	DW	10.3	502.7	213024	177392	513
GW-14	7.3.2013	Common use	DW	1.2	579.8	213641	177455	581
GW-15	11.3.2013	R.G.Leelawathie, 21, Handabima, Ulapane	DW	3.4	546.6	213326	177075	550
GW-16	12.3.2013	DGM Thiranjeewa, 61, Sarc Village, Ulapane	DW	5.2	582.8	212767	177287	588
GW-17	10.3.2013	Sunil, 321B, Mahawila watta, Ulapane	DW	5.9	584.1	212163	177553	590
GW-18	10.3.2013	C. Pandithathilaka, B7, Mahawila watta, Ulapane	DW	2.5	499.5	212530	177537	502
GW-19	11.3.2013	R.D.G. Wijeratne, 35/6, Handabima Ihala, Udagama, Ulapane	DW	3.3	566.7	213258	177170	570
GW-20	12.3.2013	Ruwan Jayawickrama, 900/1/2, Ethgala watta, Nawalapitiya road, Gampola	DW	0.3	544.7	213576	177181	545

Location description of all wells in the survey area- contd......

Locations of other existing wells of the project area

Well No.	Date Observed	Name & Address of Owner	Type of Source	Depth to GWL/m	Elevation of GWL/m	Northing/m	Easting/m	Elevation/m
01	5.3.2013	Mrs. De Silva, Dunhinda road, Ethgala watta, Gampola	Spring	0	551	213943	177981	551
02	5.3.2013	Ariyadasa, Dunhinda road, Ethgala watta, Gampola	Spring	0	530	214025	178127	530
03	5.3.2013	Dias, Dunhinda road, Ethgala watta, Gampola	Spring	0	523	214078	178187	523
04	7.3.2013	Hemachandra, Bungalow road, Ethgala, Gampola	DW	6.2	531.8	214516	177568	538
05	7.3.2013	Hettiarachchi, 859, Bungalow road, Ethgala, Gampola	DW	1.9	544.1	214501	177577	546
06	7.3.2013	N.P. Wickramasinghe, 851/2, Bungalow road, Ethgala, Gampola	DW	9.3	536.7	214484	177527	546
07	7.3.2013	W.E.C. Fernando, 836/2, Bungalow road, Ethgala, Gampola	DW	7.2	541.8	214487	177527	549
08	7.3.2013	W.A. Fernando, 836/3, Bungalow road, Ethgala, Gampola	DW	5.3	541.7	214497	177560	547
09	7.3.2013	W.M.T.B. Karunatilaka, 13Bungalow road, Ethgala, Gampola	DW	1.5	545	214488	177612	546.5
10	7.3.2013	Jayaruwan, Hapuarachchi, 831/1, Bungalow road, Ethgala, Gampola	DW	15.2	542.4	214466	177732	557.6
11	8.3.2013	Upali Wijetunga, 10, Gampola road, Ulapane	Spring	0	555.5	211653	177040	555.5
12	8.3.2013	G.W. Ariyadasa, 44, Gampola road, Ulapane	DW	2.3	547.7	211745	176876	550
13	8.3.2013	Mrs. Basheer, 60, Gampola road, Ulapane	Spring	0	550	211780	176890	550

Locations of other existing wells of the project area								DW – Dug well
	Date Observed	Name & Address of Owner	Type of Source	Depth to GWL/m	Elevation of GWL/m	Northing/m	Easting/m	Elevation/m
14	8.3.2013	K.M.C. Ulapane, 158, Gampola road, Ulapane	Spring	0	502.8	212159	177054	502.8
15	9.3.2013	K.A.R.L. Dharmaratne, 2, SARC Village, Ulapane	DW	Not able to measure	-	212767	177089	570
16	9.3.2013	Common Use, SARC Village, Ulapane	Spring	0	576	212733	177097	576
17	9.3.2013	R. Bogahawatta, 8, Subasiri, SAARC Village, Ulapane	TW	Not able to measure	-	212756	177080	574
18	9.3.2013	Karupan Rama, 18, 26Thembiligala watta, Ul27apane	DW	8.8	571.2	212710	177080	580
19	9.3.2013	Ruwan Chamara, 14, Thembiligala watta, Ulapane	DW	5.7	580.3	212672	177061	586
20	10.3.2013	Commom Use, SARC Village, Ulapane	DW	8.8	518.2	212618	177097	527
21	10.3.2013	D.U.Keerthisinghe, 56, Mahawilawatta, Ulapane	TW	Not able to measure	-	212653	177310	516.5
22	10.3.2013	M.S.S.Mohomad, 38, SARC Village, Ulapane	TW	6.1	506.9	212678	177313	513
23	10.3.2013	Subash Nirishan, 10, Denmark Colony, Ulapane	DW	2.2	527.8	212511	177702	530
24	11.3.2013	H.G.H.Samaranayaka, 21/2A, Handabima, Thembiligala, Ulapane	DW	3.1	541.9	213336	176887	545
25	11.3.2013	Common Use, Handabima, Thembiligala, Ulapane	Spring	0	585	213128	177038	585
26	12.3.2013	Gamini Bandara, 54, Mahawila watta, SARV Village, Ulapane	DW	5.7	574.3	212720	177174	580
27	12.3.2013	R.S.S.Chandrasekara, 107, Mahawila watta, Ulapane	DW	1.9	575.6	212824	177183	577.5
28	10.3.2013	Piyal Pushpakumara, 103B, Denmark North, Ulapane	DW	0.5	553.5	212334	177605	554
29	11.3.2013	W. Arthur Paul, 14/1, Handabima Ihala, Udagama, Ulapane	DW	7.8	581.2	213170	177244	58

Annex 6

Study team

Study team

Key staff

Name	Designation
Ms S V Dias	Senior Scientist / Water Quality Specialist
Mr Mahesh Somaratne	Senior Geologist
Mr NIC Peiris	Senior Geologist
Mr IAVP Iddamalgoda	Senior Scientist
Ms S A M S Dissanayake	Senior Scientist
Mr HDS Premasiri	Senior Scientist
Mr Vimukthi Sumanasekara	Scientist
Ms H.T.J. Seneviratne	Scientist

Laboratory analysis team

Name	Designation
Ms P D C Pathiraja	Technical Assistant
Ms P H D Silva	Technical Assistant
Ms Thilangika Gunawardena	Project Assistant

Support staff

Name	Designation
Mr N Krishnamoorthi	Field Assistant
Mr Chamath Vithanage	Field Assistant
Mr WA Weerasinghe	Field Assistant
Mr A Premaratne	Field Assistant

Annex 7

Location description, water level and the height of the water column of the wells sampled during the survey

Table 1 - Location description, water level and the height of the water column of the wells and springs sampled during the survey

Location reference				Water level measured from Ground (m)		Height of the water colomn in the wells (m)[10]	
Sample reference	GPS reference	Name and Address of owner	Source	March	May	March	May
GW 1	214250N 178161E	HM.Francis, 63/1, Dunhida road, Ethgala Watta, Gampola	Spring	0	0	0.5	0.5
GW 2	214434N 178062E	Jayawardhena, Dunhinda road, Ethgala watta, Gampola	DW	0.5	0.5	0.5	0.5
GW 3	214467N 177596E	Susantha Illeperuma, Bungalow road, Ethgala,Gampola	DW	10.2	7.2	1.5	4.5
GW 4	214083N 177550E	Bandara Nishsanka, 852,Bungalow road, Ethgala,Gampola	DW	3.1	3.5	3	2.6
GW 5	213873N 177375E	BSM Senarath Bandara 851 A,Bungalow road, Ethgala, Gampola	DW	2.9	2.9	1.2	1.2
GW 6	211746N 176864E	KM Karunasena, 250, Gampola road, Ulapane	DW	2.5	1.4	1.2	2.7
GW 7	212167N 177089E	Youth council Premises, Gampola road, Ulapane	Spring	0	0	2.5	2.5
GW 8	212695N 177074E	P.Marimuttu,15, Thembiligala watta, Ulapane	DW	5.4	4.1	0.5	1.8
GW 9	212378N 177655E	Common Use, Mahawila Waththa,Ulapane	DW	0.5	0	1.2	1.7
GW 10	212794N 177569E	Common Use, SAARC Village	Spring	0	0	0.5	0.5

DW- Dug well

[10] Height of the water column in wells

Table 1 - Location description, water level and the height of the water column of the wells samples during the survey –continued

Location reference				Water level measured from Ground(m)		Height of the water colomn in the wells (m)[10]	
Sample reference	GPS reference	Name and Address of owner	Source	March	May	March	May
GW 11	212751N 177696E	BD.Babinona, No 12, Denmarc Colony, Ulapane	DW	13.6	12.8	1	1.8
GW 12	212856N 177397E	Abesinghe, No.B5/A, Sri Dharanpura, Ulapane	DW	6.8	6.6	1.2	1.4
GW 13	213024N 177392E	WC.Nimalsiri,326, Handabima Ihala,Udagama, Ulapane	DW	10.3	8.3	1.5	3.5
GW 14	213641N 177455E	Common use	DW	1.2	1.5	1.5	1.2
GW 15	213326N 177075E	RG Leelawathie, 21, Handabima, Ulapane	DW	3.4	3.5	1.5	1.4
GW 16	212767N 177287E	DGM Thiranjeewa, 61, Sarc Villege, Ulapane	DW	5.2	3.4	1.5	3.3
GW 17	212163N 177553E	Sunil,312B, Mahawila watta, Ulapane	DW	5.9	4.4	0.7	2.2
GW 18	212530N 177537E	C Pandithathilake, B7, Mahawila watta, Ulapane	DW	2.5	3.2	2.2	1.5
GW 19	213258N 177170E	RDG Wijerathna, 35/6,Handabima Ihala,Udagama, Ulapane	DW	3.3	4.3	1.2	0.2
GW 20	213576N 177181E	Ruwan Jayawickrama, 900/1/2,Etgalawatta, Nawalapitiya road, Gampola	DW	0.3	0	1.5	1.8

DW- Dug well

Annex 8

Methods of analysis and quality control procedures

Method of Analysis

Parameter	Method Reference	Description of the Method
pH	APHA 4500 H-B Electrometric method	pH and Temperature were measured using ***pH meter, brand ; pH 5+ pH/^{0}C of EUTECH Instrument Singapore origin.*** The meter was first calibrated using NIST pH 4.01 and pH 6.86 buffer solutions (NIST; National Institute of Standard Technology). The pH and Temperature of water samples were taken after calibration by immersing electrode and the probe.
Temperature	APHA 2550 B Electrometric method	
Conductivity	APHA - 2510 B Electrometric method	Conductivity was measured using potable multi parameter instrument; ***HORIBA U-50 Multiparameter; Water Quality Checker Japan origin.*** The meter was first calibrated using standard of 0.005mol/L KCl solution (conductivity =0.718mS/cm) to match with the measuring conductivity range. Initially zero point calibration was conducted. The sensor probes were then washed 2 or 3 times in deionized water and all moisture was removed. Calibration of the instrument-The "Cond" mode was selected in the parameter selection screen. Then the number of calibration points was set and, "Cond" value was set into 0.000 mS/cm. After the "Measurement value" has been stabilized the calibration was started by pressing ENTER key. Taking measurements- The transparent calibration cup was washed 2 to 3 times with deionized water and filled to the reference line with 0.718mS/cm standard solution. The sensor probe was submerged in the transparent calibration cup. The "Cond" value was set to 0.718 mS/cm and the calibration was started. After the calibration was completed the calibration cup was washed again with deionized water and filled with sample. Then the measurement was taken after "Measurement value" was stabilized.
Dissolved Oxygen	APHA-4500-O-C Azide modification	Water samples were collected in a 300 ml bottles having a ground-glass stopper and a flared mouth without entrapping air bubbles. Dissolved oxygen in the sample was fixed by adding 2 mL of $MnSO_4$ and 2 mL of alkali-iodize –azide reagents to the bottle at the site. Then the bottle was stoppered carefully to avoid air bubbles and mixed well by inverting the bottle a few times. These bottles were transported to the laboratory at 4 to 10 ^{0}C. In the determination of DO, 2.0mL of conc. H_2SO_4 was added to the bottle and mixed well until dissolution of precipitate is complete. A 200 mL portion from this sample was titrated with 0.025M Na_2SO_4 solution to a pale yellow color. Then few drops of starch solution were added and titration was continued to first appearance of blue color. **Calculation** For titration of 200mL sample, 1mL 0.025N Na_2SO_4 = 1mg DO/L

Parameter	Method Reference	Description of the Method
Biochemical Oxygen Demand	APHAA 5210-B 5-Day BOD test	Water samples were collected in a 300 ml bottles having a ground-glass stopper and a flared mouth without entrapping air bubbles. To prevent entry of air in to bottles during incubation water was added to the flared mouth of the bottle and then capped with plastic cap. For each measurement two bottles were prepared in the above manner and transported to the laboratory at 4-10^{0}C. Of the two sets, the dissolved oxygen in one set was determined on the following day. This gives the Initial oxygen levels. The bottles in the other set were incubated at 20^{0}C for 5 days. After 5 days the DO was determined similar to first set. This gives remaining oxygen after five days Determination of BOD BOD mg/l = Initial dissolved oxygen level in the sample - Final dissolved oxygen level in the sample (Initial dissolved oxygen is the value measured as dissolved oxygen)
Nitrate	APHA 4500-NO2-B Photometry	10 mL of sample was taken to the sample vial and color was developed by crushing Nitrate test tablet supplied by the manufacturer. The developed color was then measured using Lovibond, Maxi Direct SN 10-1083 photometer made in Germany. The Method used is APHA 4500-NO2-B. The reading appeared on the meter was taken as the measured value
Ammonia	APHA-4500-NH_3 F	10 mL of sample was taken to a sample vial and color was developed using ammonia No.1 and No.2 tablets supplied by the manufacturer. The developed color was then measured using Lovibond Maxi Direct SN 10-1083 photometer made in Germany. The Method used is APHA-4500-NH_3 F. The reading appeared on the meter was taken as the measured value.
Total Iron	Photometric method	A disk type Lovibond comparator was used in the determination. First, two comparator cells were rinsed twice with deionized water and then deionized water and the sample were filled to each of the cells separately. For both cells Iron Low Range tablets supplied by the manufacturer were added, crushed and dissolved completely and allowed to develop color. Then the two cells were placed in the comparator. The color disc prepared with different color intensities was rotated while holding the comparator, facing good natural light until the colour of the sample marches with that of the sample. The iron level was expressed as mg/l. The value for concentration of the color standard in mg/l was taken as Total iron concentration of the test sample.

Parameter	Method Reference	Description of the Method
Total Phosphates	APHA 4500- P-D Stannous chloride method	In the laboratory 100 mL of sample was digested with 1mL of H_2SO_4 acid and 0.4 g solid $(NH4)_2S_2O_8$ until a final volume of 10 mL was reached. The digested sample was then cooled, diluted to 30 mL with distilled water, and neutralized with NaOH. The sample was made up to 100 mL in a volumetric flask with distilled water. Then the color was developed by adding 4.0 mL Ammonium Molybdate reagent I ($NH_4Mo_7O_{24}.4H_2O$) and 0.5 mL stannous chloride reagent I ($SnCl_2.2H_2O$). After 10 minutes, colour was measured at 690 nm using UV visible spectrophotometer and compared with a calibration curve prepared using series of standard phosphate solution of KH_2PO_4 and the distilled water blank. **Calculation** $$\text{mg P/l} = \frac{\text{mg P (in approximately final volume)}}{\text{ml sample}} \times 1000$$ The result phosphorus was expressed as PO4 mg/L.
Total Suspended Solids	APHA 2540 D	Glass-fibre filter paper was used in the determination of Suspended solids. First, the filter papers were washed with distilled water and dried in an oven at $103^{o}C$ to $105^{o}C$ for 1hour . Then the initial measurements were taken to 0.001g accuracy until constant weight is reached. The sample was then stirred with a magnetic stirrer at a speed to shear larger particles, if practical, to obtain a more uniform particle size. While stirring, a measured volume (100ml) was pipetted onto the pre weighed filter paper seated on glass-fiber filter. Vacuum suction was applied to filter the sample. The trapped suspended solids in the filter paper were dryed in an oven at $103^{o}C$ to $105^{o}C$ for 1hour and cooled in a desiccator to balance temperature and then weighed to 0.001g accuracy. This cycle of drying cooling, desiccating and weighing was repeated until a constant weight was obtained. The suspended solids content in the sample was then determined using following calculation **Calculation** $$\text{mg total suspended solids/L} = \frac{(A-B) \times 1000}{\text{Sample volume, mL}}$$ Where:

		A=weight of filter + dried residue, mg, and B= weight of filter, mg.
Parameter	**Method Reference**	**Description of the Method**
Faecal Coliforms and Total Coliforms	SLS 614: 1983 Part 2 Membrane filtration method	250 ml capacity sterilized glass bottles with attached twin thread were used for the collection of samples for analysis of Faecal and Total Coliforms. In the sampling, first the bottle was lowered to the water by unwinding the cord slowly. The bottle was immersed in the water completely, and once the bottle was judged to be sufficiently filled, the thread was rewound and bottle was brought up. Some water was discarded if the bottle was completely filled. In the laboratory, for the analysis of Faecal Coliforms, 100 ml of sample was filtered through a 0.45 µm grid marked membrane filter paper and the filter was placed in MFC agar and incubated at 44.5 ^{0}C for 24 hours. For the Total Coliforms, 100 mL of sample was filtered and filter was placed on M-Endo agar LES (Sigma origin) media and incubated at 36 ^{0}C for 24 hours. Colonies which showed a characteristic appearance of blue colour on the filter paper counted as Faecal Coliforms. No confirmation was done to Faecal Coliforms since MFC agar was used as the medium and it is specific for Faecal Coliforms (especially *E.coli*) as per SLS (1983). In detecting Total Coliform counts, colonies with metallic yellow sheen in M- Endo agar LES medium were sub cultured to phenol red lactose broth and all tubes showing acid and gas production were recorded as confirmed Total Coliforms after incubation of 36 ^{0}C for 48 hours. Confirmed Coliforms were expressed as Total Coliform counts per 100 ml Confirmed Faecal Coliforms were expressed as - Faecal Coliform counts per 100 ml.

Quality Control procedures

- The NBRO is registered in the Central Environmental Authority (CEA)- Laboratory as Consultant/ Specialist for Technical Guidance (Reg. No. 07/LM/Cons/10/2008). Copy of certificate - 2013 and a Letter indicating participation in Proficiency testing programs with CEA are given below.
- Quality control for the analysis of all the parameters was carried as per the procedures given in the Standard methods for the Examination of water and wastewater, APHA, AWWA, WEF- 20th edition (APHA).
- The pH meter was calibrated before commencing the sample measurements using pH 4.01 and pH 6.86 buffer solutions (traceable to National Institute of Standards and Technology-NIST).
- The conductivity meter ***HORIBA U-50 Multiparameter; Water Quality Checker Japan origin.*** The meter was calibrated using prepared standard of 0.005mol/L KCl solution (conductivity = 0.718 mS/cm) to match with the measuring conductivity range.
- Dissolved Oxygen and BOD analysis -Glucose Glutamic acid (GGA) standard check solution was checked for reliability of the sample analysis. The GGA control is a standardized solution to determine the quality of the seed, where its recommended BOD_5 concentration is 198 mg/l ± 30.5 mg/l. The dilution water blank was used to confirm the quality of the dilution water that was used to dilute the samples. This is necessary because impurities in the dilution water may cause significant alterations in the results.
- In the Nitrates analysis, standard KNO_3 (strength was 1.00 mL= 100 µg NO_3^-) was prepared as per APHA and 0.1 mg/L solution as a known sample and deionized water was checked for an each set of sample analysis.
- In the ammonia testing standard solution of NH_4Cl was used as the standard (1.00 mL =1.22 mg NH_3). For each set of sample analysis 0.01 mg NH_3/L solution as a known sample and deionized water as a blank were checked.
- For the total phosphates analysis, standard phosphate solution of KH_2PO_4 was used to prepare the calibration curve (The strength was 1.00 mL=50.0 g PO_4^{3-}P). In each set of analysis, 6 samples at a time; 3 water samples, 1 known standard sample, 1 spiked sample and a blank sample (deionized water) were digested and analyzed.

- In the Faecal coliforms and Total coliforms quality control procedures were carried out according to APHA.
- This includes;
- Checking incubator temperatures,
    - Faecal coliforms -44.5^0 C Total coliform - 37^{0}C)
    - Performance of Autoclaves Sterilization using sterilization tapes - temperature 121^{0}C, pressure 15 lbs)
- Blank sample testing- Dilution water (KH_2PO_4 buffer) blanks were analyzed during the sample analysis. Three dilution blanks were filtered during the sample analysis for each set of analysis (beginning/ middle and at the end) and tested for faecal and total coliforms.
- All chemicals used in the analysis were of Analytical Grade (AR).
- The Balance (electronic top loading balance AUW 120 D, Shimazdu, Japan) used for the preparation of reagents was calibrated from an accredited institution. (Calibration date- 15 08.2012- Copy given below.


Central Environmental Authority

Consultant / Specialist for Technical Guidance

This is to certify that

National Building Research Organzation of

99/1, Jawatta Road, Colombo-05

Registered as a Consulting Agency for Technical Guidance on Pollution Control Activities for the year 2013

Reg. No: 07/LM/ Cons/ 01/ 2008

Validity Period:
From: 01.01.2013 to: 31.12.2013

Deputy Director General
Environmental Pollution Control

Director General
Central Environmental Authority

Certificate - NBRO registration in Central Environmental Laboratory as Consultant/ Specialist for Technical Guidance (Reg. No. 07/LM/Cons/10/2008)

ඔබේ යොමුව
உமது தொடர்பு
Your Ref.

අපේ යොමුව
எமது தொடர்பு
Our Ref. 19.08.2013

දිනය
திகதி
Date

මධ්‍යම පරිසර අධිකාරිය
மத்திய சுற்றாடல் அதிகாரசபை
Central Environmental Authority

"පරිසර පියස", 104, ඩෙන්සිල් කොබ්බෑකඩුව මාවත, බත්තරමුල්ල, ශ්‍රී ලංකාව.
"பரிசர பியச", 104, டென்சில் கொப்பேகடுவ மாவத்தை, பத்தரமுல்லை, ஸ்ரீ லங்கா.
"Parisara Piyasa", 104, Denzil Kobbekaduwa Mawatha, Battaramulla, Sri Lanka.
Web : www.cea.lk

To whome it may concern

This is to certify that the Environment Laboratory of the National Building Research Organization is a registered laboratory under CEA for environmental monitoring and analysis since the year 2008 up to date.

They have participated in proficiency testing programmes and will be taking part in the CEA PT programme, which is scheduled to be held in mid September 2013.

This letter is issued on request of Ms. S.V. Dias, Director (Environment Division), NBRO.

Yours faithfully,

Deputy Director General (EPC)
Envtl pollution Control Division
Central Environmental Authority

Chairman	Tel : 2872361, 2872348 Fax : 2872347	Director General	Tel : 2872359 Fax : 2872608	Gen. Office	Tel : 2872278, 2873447, 7877277-280, 2873449 Hot Line : 2888999	Media Unit : 2873446	
Deputy Director Generals	HRD, Admin & Finance Division Tel : 2865296 Fax : 2872301	Envt. Pollution Control Division Tel : 2873453 Fax : 2872605	Envt. Mgt & Asses. Division Tel : 2872388 Fax : 2872296	Envt. Edu. & Awarness Division Tel : 2872297 Fax : 2872609			
Directors Tel Fax	2872607 (Admin) 2872301 (HRD), 7877290 (Finance) 2872601 (Admin), 2863984 (Finance)	2873452 (EPC), 2872606 (Lab) 2882335 (WM)	2872346 (NRM), 2876643 (EIA) 2867263 (R&D)	2867266 (EEA) Fax : 2872609	2872604 (Legal) (Western Province) Tel: 286285I Fax: 286529I		

පරිසර හා පුනර්ජනනීය බලශක්ති අමාත්‍යාංශය | சுற்றாடல் மற்றும் புதுப்பிக்கத்தக்க சக்தி அமைச்சு | Ministry of Environment and Renewable Energy

Letter indicating participation in Proficiency testing programs with CEA

... **Continuation Sheet**

CALIBRATION CERTIFICATE
Issued by an Accredited
Calibration Laboratory

SWEDAC ACKREDITERING
1791
ISO/IEC 17025

Calibration Certificate

Certificate No. SS – 1208426

CUSTOMER	**DESCRIPTION**	**SERIAL No.**
National Building Research Organization No 99/1 Jawatta Road Colombo 05	Electronic Top Loading Balance (Dual range) Capacity (Max.) : 120 g / 42 g Resolution : 0 to 42 g: 0.01 mg 42 g to 120 g : 0.1 mg	D 449911128 **IDENTIFICATION NO.** Not given

MANUFACTURER & MODEL NO.	**RECEIVED CONDITION**
SHIMADZU, AUW 120 D	Not applicable
REQUEST RECEIVED ON :	**REFERENCE :**
2012 June 19	C 1205218/03

CALIBRATION DATE	**LOCATION OF CALIBRATION**	**TEST CONDITIONS**
2012 August 15	Laboratory National Building Research Organization	Temperature : 24 ± 2^0C Relative humidity : $55 \pm 10\%$

REFERENCE STANDARD
Set of weights of accuracy class E2 (Eqp. No. MA/004), traceable to Primary standard maintained at Korea Research Institute of Standards and Science, KRISS & Physikalisch Technische Bundesanstalt (PTB). (Our Ref: IML-344)

METHOD OF CALIBRATION
The balance was calibrated generally in accordance with the test method manual Ref. No MM/MA/01 – Calibration of Electronic Balance.

The balance scale was externally adjusted 50 g with weight of accuracy class E2 before the calibration.

Calibration certificate – Balance; AUW 120 D, Shimazdu, Japan

Annex 9

Groundwater quality of the wells monitored during March and May

Table 1- Groundwater quality of the wells monitored on 13th March 2013

Sample Reference	pH	Temperature (^{0} C)	Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	BOD at 20 ^{0} C BOD_5, mg/L	Ammonia (as N mg/L)	Nitrate (as N) mg/L	Total Iron (as Fe mg/L)	Total phosphates (as PO_4^{3-} , mg/L)	Total Suspended Solids mg/L	Fecal Coliforms (E.coli /100ml)	Total Coliforms (Coliform Organisms /100ml)
GW 1	7.4	24.6	42	6.9	< 1	0.05	0.29	0.1	0.205	1.6	12	15
GW 2	7.7	23.2	58	5.6	< 1	<0.02	0.04	<0.1	0.070	<1	0	2
GW 3	7.2	24.1	34	4.4	< 1	<0.02	0.19	0.1	0.435	1.2	1	8
GW 4	8.3	23.2	157	5.2	1.8	0.07	2.12	<0.1	0.174	3.0	0	8
GW 5	6.2	23.7	11	4.3	< 1	0.02	0.06	0.2	0.386	<1	3	80
GW 6	6.0	24.0	28	2.4	1.4	<0.02	0.22	0.2	0.315	2.4	70	85
GW 7	6.4	23.5	182	2.7	1.3	0.1	1.84	<0.1	0.220	1.0	3	45
GW 8	6.1	23.7	42	2.4	< 1	0.02	0.07	0.1	0.027	1.7	0	28
GW 9	6.0	23.1	46	3.9	1.8	0.19	0.99	0.1	0.226	4.8	5	12
GW 10	6.2	24.6	35	5.6	< 1	0.04	0.05	0.1	0.205	<1	12	70
**Desirable Level	7.0-8.5	-	750	-	-	-	-	0.3	-	-	0	10*
**Max permissible Level	6.5-9.0	-	3500	-	-	0.06	10	1	2	-	-	

**** For individual or small community water supplies*** ***indicates non compliances with the National Standard for potable water***

"<" indicates minimum detection level of methodology employed

** Specification for potable water Part 1- Physical and Chemical requirements, Part 2- Bacteriological requirements, SLS 614, 1983

Table 1- Groundwater quality of the wells monitored on 13th March 2013 –contd.....

Sample Reference	pH	Temperature ^{0} C	Conductivity µS/cm	Dissolved Oxygen (mg/L)	BOD at 20 ^{0} C BOD_5 mg/L	Ammonia (as N, mg/L)	Nitrate (as N, mg/L)	Total Iron (as Fe, mg/L)	Total phosphates (as PO_4^{3-} , mg/L)	Total Suspended Solids mg/L	Fecal Coliforms (E.coli /100ml)	Total Coliforms /00ml
GW 11	6.5	24.3	168	2.1	1.97	0.03	<0.01	0.3	0.128	2.5	41	60
GW 12	5.8	24.3	36	5.4	< 1	<0.02	0.06	0	0.156	1	0	11
GW 13	6.2	24.3	34	5.2	1.17	0.05	0.03	0.1	0.272	2.5	5	76
GW 14	6.1	24.2	37	3.9	1.24	0.01	0.02	0.1	0.064	12	0	9
GW 15	6.2	24.2	61	4.3	1.37	0.03	1.33	0.1	0.242	63	0	20
GW 16	6.1	23.5	58	6.3	1.12	0.02	0.72	0	0.039	3.8	0	80
GW 17	6.5	23.1	69	1.5	1.04	0.47	0.04	0.1	0.315	1.8	3	11
GW 18	6.1	23.3	34	3.9	1.45	0.05	0.54	0.1	0.052	<1	2	13
GW 19	6.6	23.3	29	6.5	< 1	0.03	0.53	0.1	0.183	4.3	63	70
GW 20	6.3	24.2	47	5.4	1.23	0.05	0.66	0.1	0.180	1	0	16
**Desirable Level	7.0-8.5	-	750	-	-	-	-	0.3	-	-	0	10*
**Max permissible Level	6.5-9.0	-	3500	-	-	0.06	10	1	2	-	-	

**** For individual or small community water supplies*** **-** ***indicates non compliances with the National Standard for potable water***

"<" indicates minimum detection level of methodology employed

**Specification for potable water Part 1- Physical and Chemical requirements, Part 2- Bacteriological requirements, SLS 614, 1983

Table 2- Groundwater quality of the wells monitored on 21st May 2013

Sample Reference	pH	Temperature ^{0}C	Conductivity µS/cm	Dissolved Oxygen (mg/L)	BOD at 20 ^{0}C BOD_5 mg/L	Ammonia (as N, mg/L)	Nitrate (as N, mg/L)	Total Iron (as Fe, mg/L)	Total phosphates (as PO_4^{3-} , mg/L)	Total Suspended Solids mg/L	Fecal Coliforms (E.coli /100ml)	Total Coliforms /100ml
GW 1	6.5	24.1	24	6.9	<1	0.16	0.10	0.3	0.132	2.9	9	13
GW 2	5.7	23.8	62	4.3	<1	0.07	0.02	0.1	0.261	<1	26	141
GW 3	7.0	25.1	32	3.9	<1	0.06	0.13	0.1	0.264	3.7	0	11
GW 4	5.9	23.1	134	5.9	<1	0.08	2.08	0.1	0.327	<1	1	29
GW 5	6.9	22.8	14	4.6	<1	<0.02	0.01	0.1	0.33	<1	5	42
GW 6	5.6	23.4	152	1.8	<1	0.08	2.15	0.1	0.222	1.5	3	8
GW 7	6.5	23.9	22	3.2	<1	<0.02	0.17	0.1	0.33	<1	1	22
GW 8	6.0	25.6	16	3.7	<1	<0.02	1.26	0.1	0.294	3.0	0	79
GW 9	6.9	23.4	149	4.7	<1	<0.02	0.35	0.1	0.204	<1	1	41
GW 10	6.4	24.7	14	5.6	<1	<0.02	0.12	0.1	0.273	<1	0	41
**Desirable Level	7.0-8.5	-	750	-	-	-	-	0.3	-	-	0	10*
**Max permissible Level	6.5-9.0	-	3500	-	-	0.06	10	1	2	-	-	

** For individual or small community water supplies - indicates non compliances with the National Standard for potable water*

“<” indicates minimum detection level of methodology employed

**Specification for potable water Part 1- Physical and Chemical requirements, Part 2- Bacteriological requirements, SLS 614, 1983

Table 2- Groundwater quality of the wells monitored on 21st May 2013, contd.................

Sample Reference	pH	Temperature ^{0}C	Conductivity µS/cm	Dissolved Oxygen (mg/L)	BOD at 20 ^{0}C BOD_5 mg/L	Ammonia (as N, mg/L)	Nitrate (as N, mg/L)	Total Iron (as Fe, mg/L)	Total phosphates (as PO_4^{3-} , mg/L)	Total Suspended Solids mg/L	Fecal Coliforms (E.coli /100ml)	Total Coliforms /00ml
GW 11	5.8	23.2	44	4.6	<1	0.07	0.19	0.3	0.216	3.8	11	20
GW 12	5.2	23.2	47	4.1	<1	0.14	1.28	0.1	0.264	2.7	8	9
GW 13	6.3	23.0	21	6.0	<1	<0.02	0.03	0.1	0.159	8.4	0	0
GW 14	6.2	23.4	5	4.1	<1	<0.02	0.92	0.1	0.333	2.4	0	4
GW 15	6.4	25.1	39	1.8	<1	0.31	1.05	0.1	0.225	1.3	0	43
GW 16	6.4	24.1	47	5.1	<1	0.05	0.07	0.1	0.3	1.3	10	80
GW 17	6.5	23.1	28	5.1	<1	0.14	0.04	0.1	0.072	3.6	0	0
GW 18	6.5	23.5	38	3.2	<1	0.14	0.08	0.1	0.273	1.3	14	19
GW 19	6.3	22.8	28	3.8	<1	0.74	0.08	0.1	0.309	<1	0	0
GW 20	6.4	23.9	11	4.7	<1	0.31	0.10	0.1	0.243	0.49	29	33
Desirable Level	7.0-8.5	-	750	-	-	-	-	0.3	-	-	0	10*
Max permissible Level	6.5-9.0	-	3500	-	-	0.06	10	1	2	-	-	

** For individual or small community water supplies* - ***indicates non compliances with the National Standard for potable water***

‘<” denotes minimum detection level of the methodology employed

**Specification for potable water Part 1- Physical and Chemical requirements, Part 2- Bacteriological requirements, SLS 614, 1983

Annex 10

Photographs of sampled wells

Photographs of sampled wells

GW 1- spring

GW 2- Dug well

GW 3- Dug well

GW 4- Dug well

Photographs of sampled wells

GW 6- Dug well

GW 8-Dug well

GW 9-Dug well

GW 10- Spring

Photographs of sampled wells

GW 11-Dug well

GW 13- Dug well

GW 14-Dug well

GW 16-Dug well

ADDITIONAL STUDIES ON NATURAL ENVIRONMENT FOR REVIEW OF FEASIBILITY STUDY AND PREPARATION OF DETAILED DESIGN AND BIDDING DOCUMENTS
MORAGOLLA HYDROPOWER PROJECT, SRI LANKA

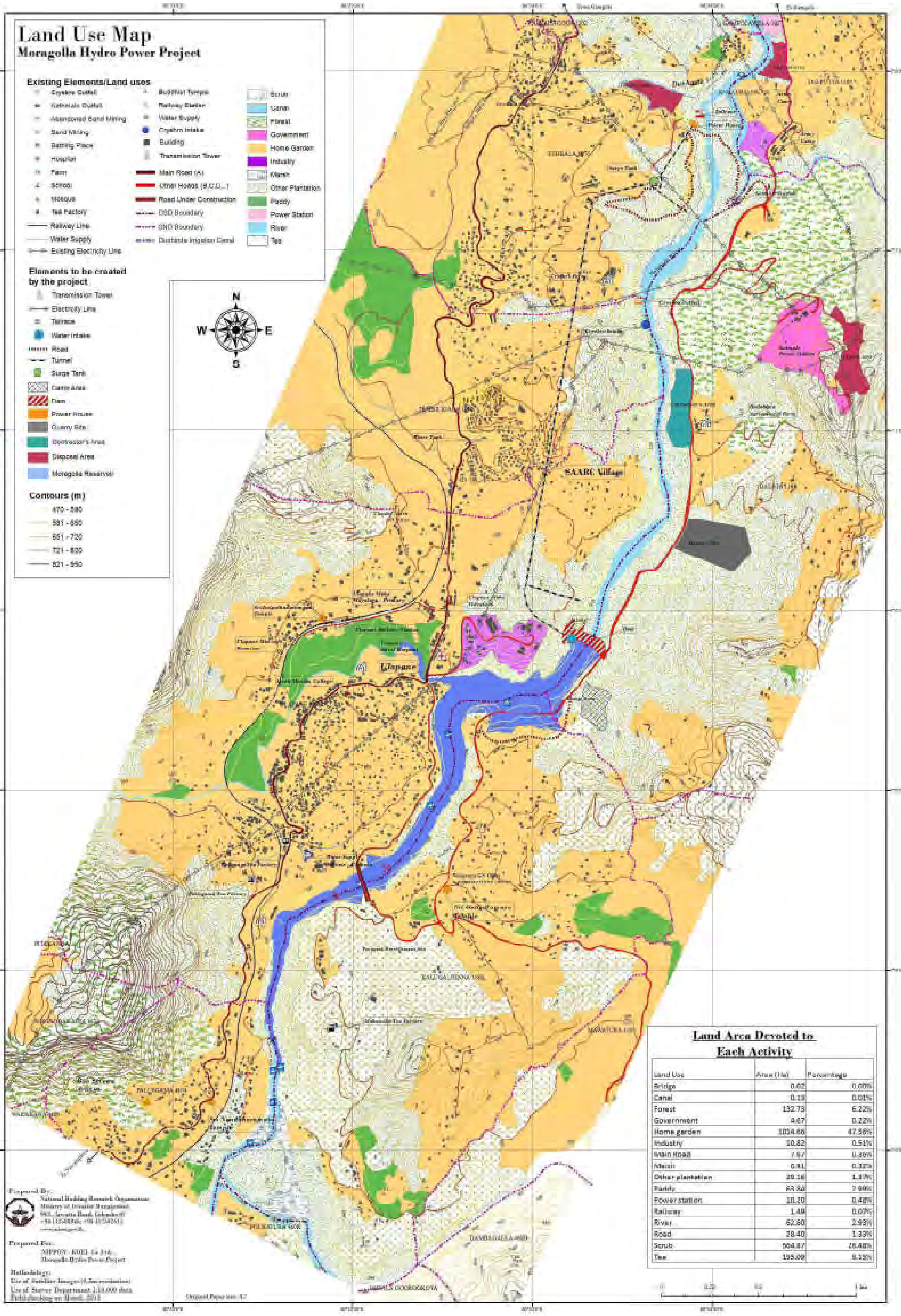
Updated Land use Map

Prepared by
The National Building Research Organization

Prepared for
NIPPON KOEI Co Ltd - Moragolla Hydropower Project

July 2013

National Building Research Organization
Ministry of Disaster Management
99/1, Jawatte Road, Colombo 05, Sri Lanka



Land Area Devoted to Each Activity

Land Use	Area (Ha)	Percentage
Bridge	0.02	0.00%
Canal	0.13	0.01%
Forest	132.73	6.22%
Government	4.67	0.22%
Home garden	1014.66	47.58%
Industry	10.82	0.51%
Main Road	7.67	0.36%
Marsh	6.91	0.32%
Other plantation	29.16	1.37%
Paddy	63.84	2.99%
Power station	10.20	0.48%
Railway	1.49	0.07%
River	62.60	2.93%
Road	28.40	1.33%
Scrub	564.87	26.48%
Tea	195.09	9.15%

Moragolla Hydropower Project

Study of the Rationale and Suitability of the Proposed Environmental Flow






November 2013

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1. **Introduction**

The Moragolla Hydropower Project is designed to harness the hydropower potential of the water flow of Mahaweli Ganga near Ulapane to generate 30 MW of power. Average annual energy generation is estimated as 97.6GWh. The project consists of a reservoir formed by constructing a dam across the Mahaweli Ganga to divert water via a conveyance system (underground tunnel and penstock) to the powerhouse located on the left bank of the Mahaweli Ganga approximately 1 km east of Ethgala Town. The water conveyance system is designed to transfer a maximum flow of $50m^3/s$ to the power house. After passing through the turbines the water will be discharged back into the Mahaweli Ganga. River flow will therefore be reduced in the 3km stretch between the dam and the tailrace outfall, and farther downstream in the dry season, when little water will overflow the dam and there will only be sufficient water in the reservoir to allow power generation for a few hours per day.

As development of hydropower projects involves altering the natural flow regime of the surface water system, it is necessary to assess the impact of the changed flow regime on the river bed and river bank ecology and also on water uses, so that measures can be incorporated into the project to avoid or reduce any negative impacts to the extent possible. Although older hydropower systems were constructed and many still operate on the basis that all the available water can be retained for power generation purposes, it is now generally recognized that there should be at least some downstream flow in the river at all times, to reduce ecological and other impacts. This is generally referred to as "environmental flow", from the diversion dam, and is intended to ensure that the biological life in the affected stretch is maintained and the human livelihoods and well-being that depend on these ecosystems are sustained. Globally there is a variety of terminology that is used interchangeably[1][2], and they include:

- In-stream flow requirement
- Environmental water requirements
- Ecological reserve
- Ecological flows
- Environmental flows
- Reserved flow
- Environmental allocation
- Ecological flow requirement

In early discussions between the Project Proponent (Ceylon Electricity Board - CEB) and the Project Approving Agency (Mahaweli Authority of Sri Lanka - MASL), MASL proposed an E-flow of

[1] Nigel Rossouw, , Dams and environmental flows managing releases for livelihood security and ecosystem protection: Overview of the literature and practical lessons from the Berg River Dam. (2009) (http://www.cdri.org.kh/shdmekong/11.Berg_Dams%20and%20Environmental.pdf

[2] Pradeep Kumar, Umesh Chandra Chaube and Surendra Kumar Mishra, Environmental Flows for Hydropower Projects – A Case Study, *International Conference on Small Hydropower - Hydro Sri Lanka, 22-24 October 2007*

4 m^3/s. However CEB advised that a rate in excess of 1.5 m^3/s would render the project financially non-viable, so this was agreed as the proposed E-flow.

The Environmental Impact Assessment (EIA) report[3] of the project, suggests that an E-flow of 1.5 m^3/s is sufficient for present uses by the Dunhinda Irrigation Canal (0.28 m^3/s) and the Crysbro Broiler Plant (0.01 m^3/s) and to maintain flora, fauna and biodiversity in the 3 km stretch of river between the dam and the tailrace outfall, which is the area in which flows will be reduced most significantly. There was however no clear explanation of the reasons for this conclusion regarding ecology and biodiversity, and no consideration of potential impacts farther downstream. Hence as part of the FS review, the consultants examined the appropriateness of the proposed environmental flow and the results are presented in this report.

2. Approach

This analysis draws on a variety of sources of information as follows:

a) Information in consultancy reports and other available documents detailing the flow regimes and environmental flows adopted in other large hydropower schemes in Sri Lanka and elsewhere in South Asia;

b) Information from the design-team hydrologists on the proposed downstream flow regime for this project during operation, and the existing flow regime in the river, showing in each case the seasonal variations;

c) Information from additional aquatic ecology studies[4] carried out during March – July, 2013 on the distribution, extent and importance of the aquatic habitats in the 3 km of river downstream of the proposed dam site and in a 30 km downstream length, which also may receive reduced flows during non-operation hours of the power plant.

d) Published information on the topic of environmental flows, their methods of calculation, and the degree of success in maintaining biodiversity under altered flow regimes.

e) Information obtained from the EIA consultant (Central Engineering Consultancy Bureau) and the client (CEB) regarding the background and rationale for the present proposal of 1.5 m^3/s (which is 41% of the seasonal minimum natural flow (Q_{95}) in the Mahaweli Ganga – EIA report Table 3.6 (d)).

---

[3] Ceylon Electricity Board (November 2012): Moragolla Hydropower Project, Feasibility Study, Final Report: Volume 3-Environmental Impact Assessment (Central Engineering Consultancy Bureau, Sri Lanka and Al-Habshi Consultants Office, Kuwait).

[4] Additional studies on natural environment carried out for review of feasibility study and preparation of detailed design and bidding documents: Report No 2; Aquatic ecology in the Mahaweli Ganga, Prepared by the National Building Research Organization, July 2013

3. Results

While in principle the concept of environmental flows is now generally accepted uniformly, the methodologies for establishing the levels of environmental flows vary considerably amongst experts, environmental agencies or countries. In Sri Lanka, there is no specific legislation, ruling or instruction from relevant statutory bodies or regulatory agencies to establish a specific framework or methodology for determining environmental flow. Consequently, in development of hydropower projects, where the level of environmental flows has to be established, consultants rely mainly on existing precedents or use their own experience and understanding to propose such flow requirements

3.1. Historical Precedents

Flow regimes and environmental flows adopted in large hydropower projects in Sri Lanka and some other South Asian countries are presented in the table below.

Table 1: Comparison of e-flow adopted in large Hydropower Projects

Project Name	River	Capacity MW	Min. dry season flow m^3/s	e-flow m^3/s	e-flow as % of natural min flow	Funding	Reference
Sri Lanka							
Kotmale HPP[5]	Kotmale Oya	201	3.1	None	-	Gov. of Sweden	TAMS report (1980)[6] and various other sources. (USAID[7] funded for EIA of Accelerated Mahaweli Development Programme
Polgolla Barrage (Ukuwela Power Station[8])	Mahaweli Ganga	40	NA[9]	None	-		
Victoria Dam	MahaweliGanga	210	NA	None	-	British Gov. Grant	
RandenigalaDam	Mahaweli Ganga	126	1.9	None	-	Gov. Of Germany	
Rantambe Dam	Mahaweli Ganga	50	NA	None	-	Gov. Of Germany	
Kukula Ganga HPP (KGHPP)	Kukula Ganga	70	6	0.3	5	JBIC	EIA report of KGHPP
Upper Kotmale HPP (UKHP)	KothmalaOya	150	4	0.6	15	JBIC	EIA report of UKHP
Broadlands HPP (BHPP)	Kelani Ganga	40	12.1	0.2	2.5	JBIC for EIA report, Chinese Government for implementation	EIA report of BHPP
Moragolla HPP (MHPP) (this project)	Mahaweli Ganga	30	3.6	1.5	41.5	ADB	EIA report of MHPP

[6] TAMS report (1980) – Environmental Assessment of Accelerated Mahaweli Development Programme – October 1980- prepared by TAMS (Tippetts-Abbett-Mccarthy-Stratton)of New York
[7] USAID - United States Agency for International Development
[8] After trans basin diversion to Sudu Ganga
[9] Not Available

Project Name	River	Capacity MW	Min. dry season flow m^3/s	e-flow m^3/s	e-flow as % of natural min flow	Funding	Reference
Pakistan							
Patrind HPP	Konhar	147	24	2	8.3	Korean Investment	EIA report[10]
Shagharthong HPP	KachuraLangma	26	2.1	0.276	13	ADB	IEE report [11]
Nepal							
Tanahu (Upper Seti) HPP	Seti	127	23	2.4	10.5	ADB	EIA addendum 2012
Kali Gandaki "A" HPP	Kali GandakiRiver	144	40	4	10	ADB	[12]
Laos							
Nam-Ngiep 1 HPP	Nam Ngiep	272	26	5.5	21	ADB	EIA Report (Jan 2012)[13]
India							
Tidong HEPP	Tidong Khad	100	2.03	0.678	24.5	ADB[14]	EIA report[15]
Nathpa-Jhakri HEPP	Satluj River	1500	80 (Q^{16}_{95})	7	8.75	World Bank[17]	[18]

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[10] Environmental Impact Assessment: Part 2; Patrind Hydropower Project; Prepared by Star Hydropower Limited for the Asian Development Bank; April 2011; (ADB Project Number: 44914); http://www.adb.org/sites/default/files/projdocs/2011/44914-01-pak-eia-02.pdf

[11] http://www.adb.org/sites/default/files/projdocs/2012/34339-043-nep-iee-01.pdf

[12] http://www.adb.org/documents/performance-evaluation-report-kali-gandaki-hydroelectric-project

[13] Draft Environmental Impact Assessment Report; Nam Ngiep 1 hydropower project , Prepared by The Kansai Electric Power Company, Inc., EGAT International Company, Ltd., and Lao Holding State Enterprise for the Asian Development Bank, January 2012, http://www.adb.org/sites/default/files/projdocs/2012/41924-lao-eia-draft.pdf

[14] http://www.hydroworld.com/articles/2013/05/india-s-100-mw-tidong-hydroelectric-project-gets-adb-backing.html and http://www.aecen.org/sites/default/files/india_eia_report_tidonghydroelectricpower_2012.pdf

[15] EIA report of 100 MW Tidong hydroelectric power project, India Prepared by AECOM India Private Limited for NSL Renewable Power Private Limited, March 2013, (ADB Project Number: 46919), http://www.adb.org/sites/default/files/projdocs/2013/46919-014-ind-eia-final.pdf

[16] Q_{95}, Flow which is equaled or exceeded for 95% of the time

[17] http://www.worldbank.org/projects/P009869/nathpa-jhakri-power-project?lang=en

[18] P Kumar, U Chaube and S K Mistra (2007), Environmental Flow for Hydropower Projects – A case study; International conference on small hydropower – Hydro Sri Lanka, 22-24 October 2007

3.2 Methods used in e-flow assessment (EFA)

More than 200 methods for estimating environmental flows have been developed globally[19][20]. Techniques differ widely in accuracy and required input information, and at present there is no single universally-accepted approach. Discussions on these techniques are found in many published sources[21,22]. Different EFA methods are used for different purposes – from general water resources planning to management of dam releases to maintain the ecological and social needs.

These methods are based on various approaches such as:[23][24][25]

a) Hydrological or statistical values;

b) Physiographic principles;

c) Formulas based on velocity and depth of water; and

d) Methods based on multi-objective planning, taking into consideration ecological parameters.

a) Methods Based on Hydrological or Statistical Values

Within these methods, a first subgroup of techniques refers to the average flow rate (MQ) of the river at a given cross section and calculates the E-flow as a percentage. These methods give values of between 5 and 60 % of the MQ, the latter being location where the fishery was of high economic importance. A second subgroup refers to the minimum mean flow (MNQ) in the river and utilizes values of between 33 to 100 % of MNQ. A third subgroup of methods refers to the prefixed values on the Flow Duration Curve (FDC), which shows the daily flow rate of the river against frequency of occurrence. In this group there are a wide variety of values: from a reserved flow equal to 20% of Q_{300} (flow rate exceeding 300 days of duration) to complex interpolating formulae.

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[19] Tharme, R. E. (2003), A global perspective on environmental flow assessment: emerging trends in the development and application of environmental flow methodologies for rivers. River Res. Applic., 19: 397–441. doi: 10.1002/rra.736

[20] Environmental Impact Assessment: Part 2; Patrind Hydropower Project; Prepared by Star Hydropower Limited for the Asian Development Bank; April 2011; (ADB Project Number: 44914); http://www.adb.org/sites/default/files/projdocs/2011/44914-01-pak-eia-02.pdf

[21] http://www.newater.uni-osnabrueck.de/caiwa/data/papers%20session/H2/ForslundAnnaCAIWAFINAL.pdf

[22] Tharme, R. E. 2003. A global perspective on environmental flow assessment: emerging trends in the development and application of environmental flow methodologies for rivers. River Research and Applications 19:397-441.Vol 19 Issue 5-6

[23] European Small Hydropower Association, ESHA 2004, http://dev02.semaforce.eu/fileadmin/esha_files/documents/publications/GUIDES/GUIDE_SHP/ UIDE_SHP_EN.pdf

[24] Environmental Integration of Small Hydropower Plants, ESHA – Europhian Small Hydropower Association (ESHA), Rue d'Arton, 63-65, 1040 Brussels, Belgium

[25] Reference: EIA report : part 2 – Patrind Hydropower Project and IEE report for Thak Nullah Hydropower Plant

The results obtained from these methods may not precise but they can be obtained in a short time and this method is normally considered acceptable for use in the planning stage of a water-related projects. The mostly widely used approach is the Tennant (or modified Tennant) method (see below).

b) Methods Based on Physiographic Principles

These methods basically refer to a prefixed specific flow rate expressed as $l/s/km^2$ of catchment area. Values can vary from 1.6 to 9 or more $l/s/km^2$. The latter applies to rivers having excellent abundance of fish . These methods are easily applicable presuming there is good basic data. However no hydraulic parameters are considered and neither the effect of tributaries nor the length of the diversion reach is taken into account.

c) Formulae Based on Velocity and Depth of Water

In this group of methods there is also a wide range of variation. For example one study [26] suggests that water velocity in the case of reserved flow may not fall below a prefixed threshold value of 0.3-0.5 m/s and the minimum depth of water must be greater than a prefixed value of 10 cm. Another suggests 1.2 – 2.4 m/s and 12 - 24 cm water depth; and so on.

The great advantage of these formulae is that the shape of the river bed profile is included in the calculation and there is no need for hydrological data. Nevertheless diversion length and tributaries are again not considered.

e) Methods Based on Multi-Objective Planning Taking into Consideration Ecological Parameters.

These methods are generally very complex in their application and require considerable expertise to be used successfully. They require site-specific flow observations and take into account hydrological, hydraulic, ecological, and meteorological data, embracing both ecological and economic parameters. Methods are expensive in data collection and mathematical computing, and are suitable only for particular types of rivers. Their transferability is doubtful[27].

[26] http://dev02.semaforce.eu/fileadmin/esha_files/documents/publications/publications/reserved_flow_-methods_of_Calculation.pdf

[27] Environmental Integration of Small Hydropower Plants, ESHA – European Small Hydropower Association. Rue d'Arlon, 63-65, 1040 Brussels

3.3 Application of Environmental Flow Assessment formulae for Moragolla HPP

The following two methods were used to ascertain the E-flow requirement of MHPP as they are widely used in ADB funded projects[28].

1. Formula developed for Minimum Flow for Ecological Requirements by the Agriculture and Environmental Research Institute, Antony, France (2006) CEMAGREF[29].The formula is: **$Q=[(0.651Q_{mm}+2)/100]Q_{am}$**. Where, Q_{mm} = mean minimum monthly flow and Q_{am} = annual mean discharge of the river at the dam site. Q = Environmental flow.

Table 2 shows the monthly average natural flow throughout the year at the Moragolla site, estibated based on 42 years of data**[30]**. This shows that the average minimum monthly flow (Q_{mm})is 6.8 m^3/s and the average monthly flow (Q_{am})is 22.4 m^3/s. If these figures are incorporated into the CEMAGREF formula, the required flow for ecological requirements is calculated as 1.44 m^3/s.

Table2: Monthly Average (Estimated) Discharge at Moragolla Dam Site (m^3/s)

Month	Monthly Average Discharge (m^3/s)
January	10.1
February	**6.8**
March	7.0
April	11.1
May	20.0
June	33.9
July	34.9
August	26.5
September	30.6
October	34.0
November	35.3
December	18.1
Total discharge	268.3
Average	**22.4**
10% of Average	2.24

[28] Such as ThakNullah HPP, Shagharthong HPP- Pakistan, Patrind Hydropower Project - Pakistan
[29]CEMAGREF is a French public scientific research institute in agricultural and environmental engineering with a scientific and technological vocation under the responsibility of the ministries for agriculture and research.
[30] Revised Feasibility Study Report, Moragolla Hydropower Project, Volume 2 Appendix - 2

2. Tennant flow method [31]

   In 1976 Donald L Tennant introduced a method for determining in stream flow (or e-flow) requirements for fish, known as the 'Montana method', or more commonly the Tennant method. From research on 58 cross sections from 11 streams in Montana, Nebraska, and Wyoming (USA), Tennant concluded that 10% of the average annual flow (AAF) is the minimum requirement for short term fish survival, 30% of AAF provides fair survival conditions, and 60% of AAF provides excellent to outstanding habitat. These quantities have been widely employed internationally, regardless of physical and hydrological setting, due to the simplicity of using only the average annual hydrograph.

The Tennant method is also based on the assumption that flows that are satisfactory for the needs of fish and other aquatic biota will also be sufficient for maintaining the recreational and aesthetic qualities of the system.

Application of the Tennant method to the Moragolla project would suggest that an E-flow of 2.24 m^3/s (see Table 2) would be needed to ensure the short-term survival of fish, and that 6.72 m^3/s (30% of AAF) would provide fair survival conditions. This needs to be qualified however by an evaluation of the ecology of the affected river reach, to determine the level of protection that is appropriate according to the quality of the ecological resource, given that an increase in E-flow produces a corresponding reduction of generation capacity. For the Moragolla project an up-to-date ecological evaluation is available, from aquatic ecology surveys conducted as a part of this study (see below).

3.4 Ecological Sensitivity of the study area

The EIA study for the project conducted surveys of fish and other fauna and flora in the river between the proposed sites of the dam and tailrace outfall in 2009, and found ten species of fish, of which five were endemic to Sri Lanka, and two were reported as threatened and one as vulnerable, according to national conservation criteria. A much more comprehensive ecological evaluation was conducted during the present study[32], which focused on the immediate project

[31] Tennant, D. L., 1976. In stream flow regimens for fish, wildlife, recreation and related environmental resources. Fisheries1(4):6-10.

[32] NBRO (2013): Additional Studies on Natural Environment for Review of Feasibility Study and Preparation of Detailed Design and Bidding Documents Moragolla Hydropower Project, Sri Lanka. Final Report 2: Aquatic ecology in the Mahaweli Ganga. National Building Research Organisation, July 2013, 81pp.

area, but also investigated the ecology of the river up to 30 km downstream, some of which will also be affected by reduced river flows.

The 2013 surveys found 49 fish species in the 30 km length (14 endemics), plus 3 indigenous aquatic reptiles, 12 aquatic bird species and one semi-aquatic indigenous mammal. There were also 17 aquatic flowering plant species (7 rare and endemic), 20 dragonfly/damselfly species (7 endemic), and one endemic crab. In the area between the dam and tailrace there were 40 species of fish (including two that are endangered and two near-threatened, according to the IUCN Red Data List[33]), 3 aquatic reptile species, 7 aquatic birds and the semi-aquatic mammal.

This is clearly an area with a quite diverse fish fauna; and because of the rarity and international importance of some of the species, the project will implement a specific conservation program to mitigate potential impacts on these and other species. This will involve habitat management in the upper Mahaweli catchment to protect and enhance the fish populations as an offset measure, along with translocation to mitigate additional construction-related impacts.

The other ecological features of the area are not especially sensitive, as the river and adjacent on-land areas are already greatly affected by the activities of man, in particular farming and power generation. None of the species and habitats recorded in the surveys are restricted only to this river; and the habitats in the immediate project area are relatively barren, comprising rock and boulders and with relatively few aquatic plants (four species).Impacts on fish will be mitigated by the habitat management and translocation program, which will be planned and conducted in cooperation with IUCN[34]. In the light of this and the limited sensitivity of the remainder of the ecological resource, this is not considered to be an area that requires additional protection by a relatively high rate of E-flow. The lower rate as calculated by the Tennant method or other formulae would therefore seem to be the most appropriate in this case.

3.5 Impact on downstream hydrology and water levels in the Mahaweli Ganga due to power plant operations.

Figure 1 shows the monthly variability in water release from the dam (environmental flow and spill releases), indicating the minimum expected in the lean season (when accumulating storage

[33]http://www.iucnredlist.org/

[34]IUCN (2013): Moragolla Hydropower Project. Additional studies in the natural environment: Expert report on mitigating the impacts of the Moragolla Hydropower Project on fish. International Union for Conservation of Nature, Sri Lanka Country Office, August 2013, 59 pp (Draft).

in the reservoir is required) at 1.5 m^3/s in February-March, and maximum discharge of about 9 m^3/s in the early monsoon (June-July). This combined flow, as well as that of a few other small tributaries between the dam site and the tailrace, will constitute the new discharge regime in the 3 km between the dam and the tailrace.

Figure 1: Monthly Water Release from the Dam (environmental flow and spill releases).

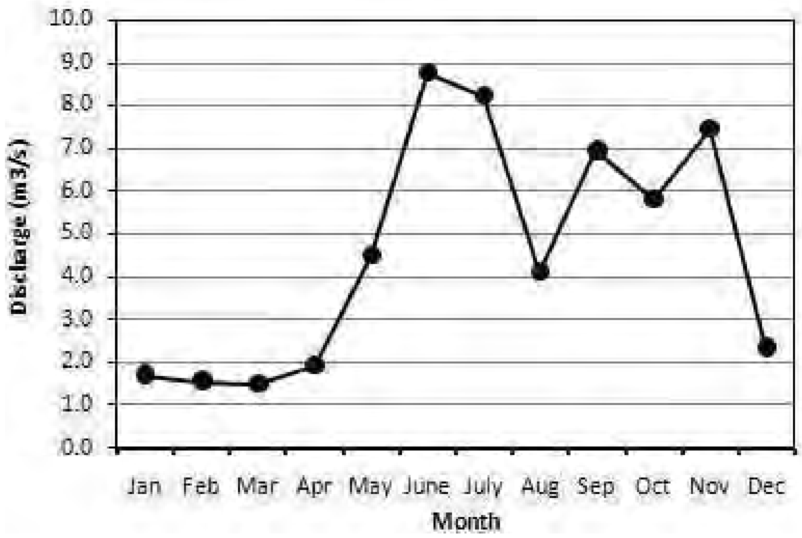
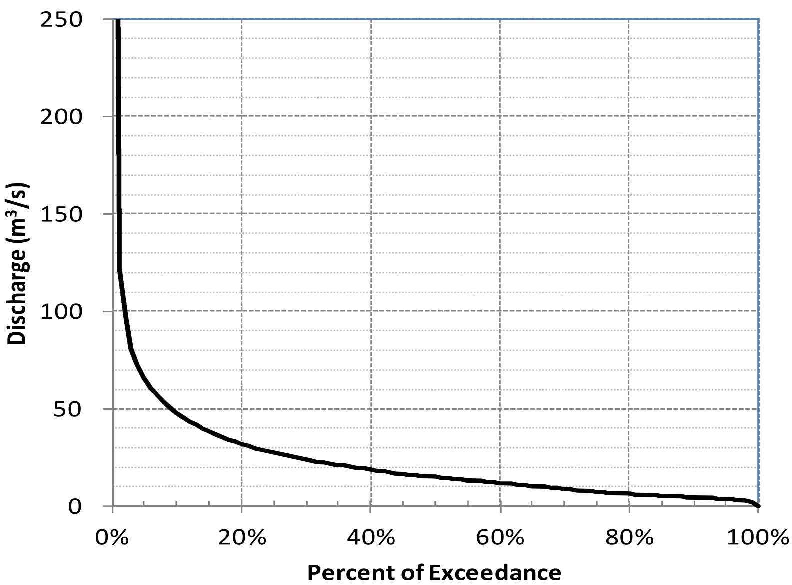


Figure 2: Flow Duration Curve



The combined effects of the Moragolla tailrace discharge, the environmental flow and spill releases, and also the Kotmale tailrace discharge will create variability in both the discharge rates and the water levels in the downstream section of the Mahaweli Ganga. However, this is not so different from the current annual variability, which indicates a one order-of-magnitude natural variability in discharge rates between dry and wet years, from 4 to about 66 m^3/s (see Figure 2 and Table 3). The combined effects of the Moragolla project and residual flow in the Mahaweli Ganga (from the Atabage Oya and the Kotmale tailrace) on discharge rates and water levels in the immediate downstream section of the Mahaweli Ganga are shown in Figures 3-6, and discussed subsequently.

Table 3: Percentage exceedance of Mahaweli Ganga discharge (95% of the time, the discharge in the river exceeds 3.6 m^3/s).

Percent of Exceedance	Discharge (m^3/s)
95%	3.60
90%	4.46
85%	5.34
80%	6.28
75%	7.33
70%	8.99
65%	10.43
60%	11.91
55%	13.31
50%	14.80
45%	16.49
40%	18.76
35%	21.12
30%	23.74
25%	27.19
20%	31.99
15%	38.47
10%	47.97
5%	66.07

Figure 3: Combined effect of the Moragolla and Kotmale tailrace discharges in the immediate downstream section of the Mahaweli Ganga.

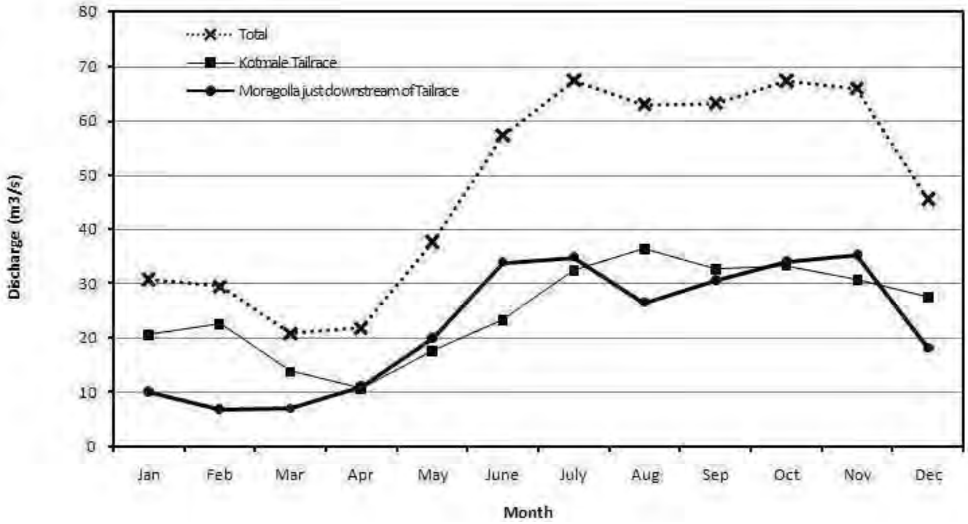
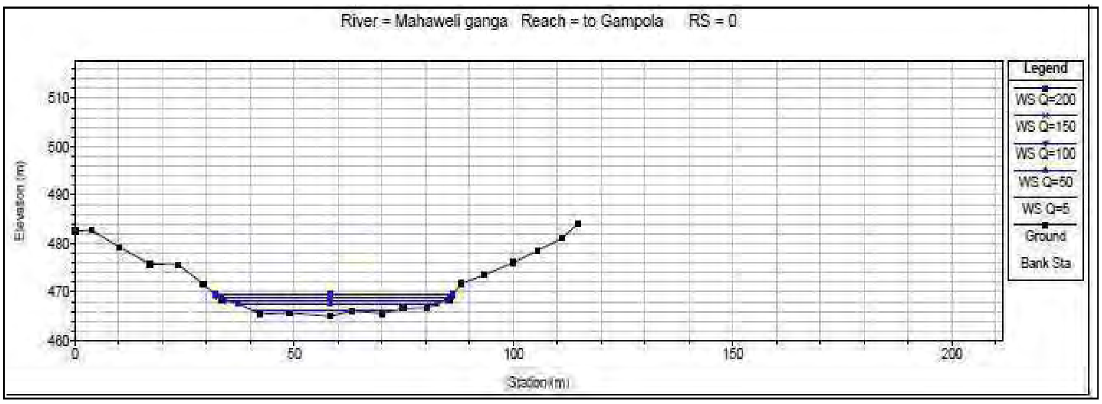
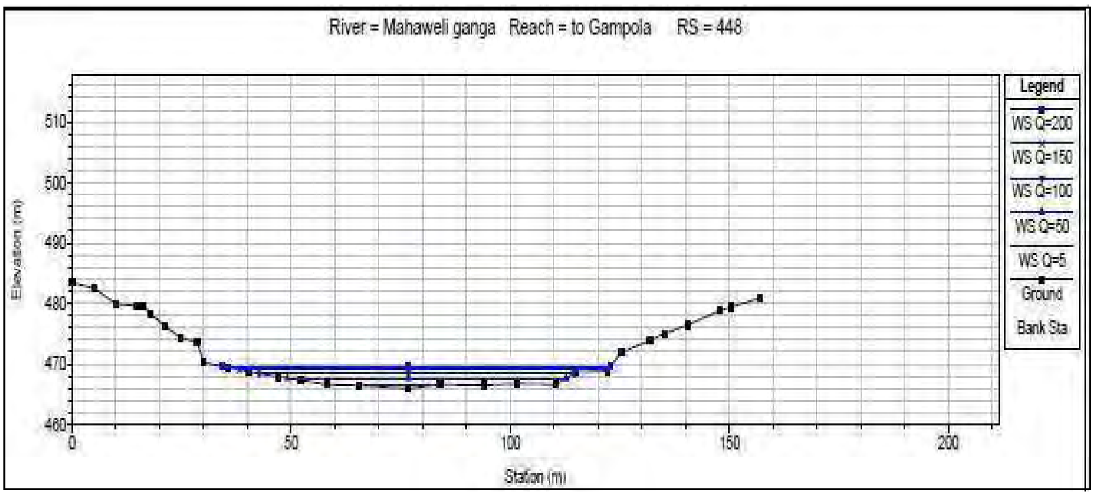


Figure 4: Cross-section of the river under different discharge regimes of the Moragolla project.

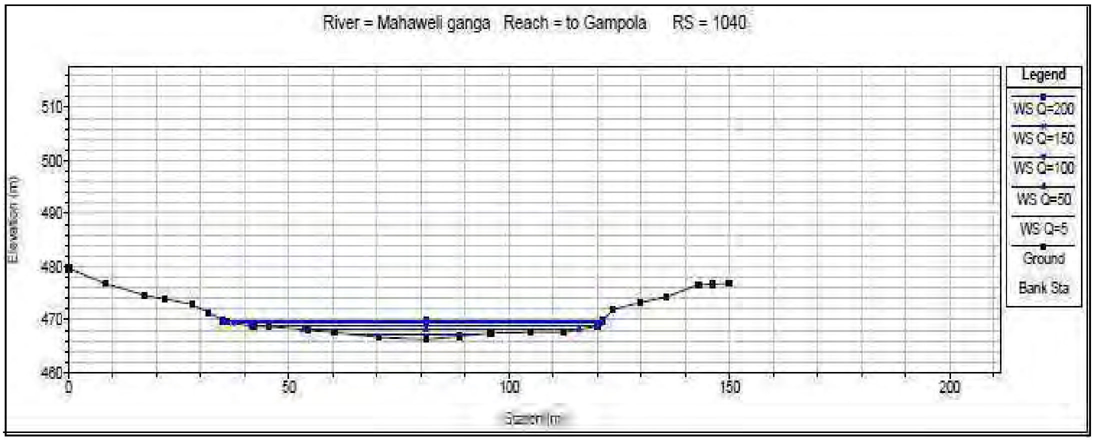
4(a): 3710m downstream from tailrace of MHPP (At Gampola Bridge)



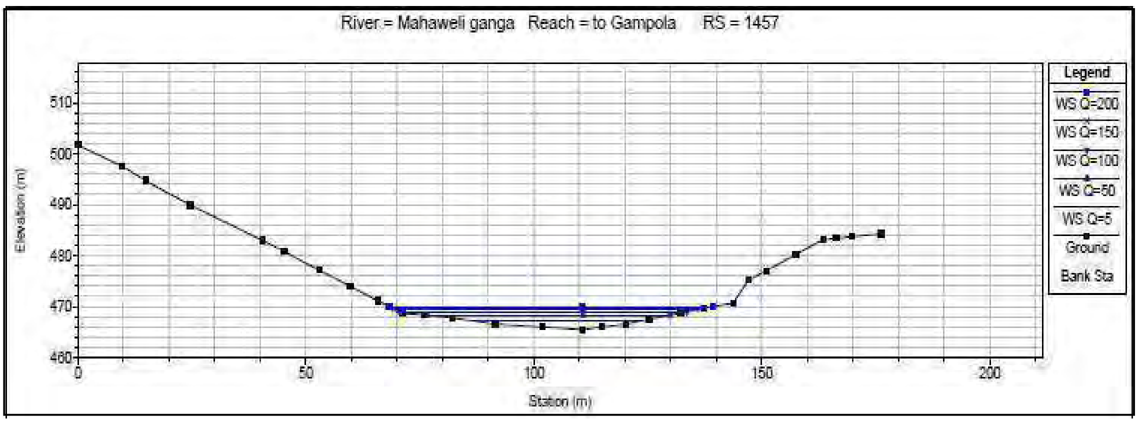
4(b): 3260m downstream from tailrace of MHPP



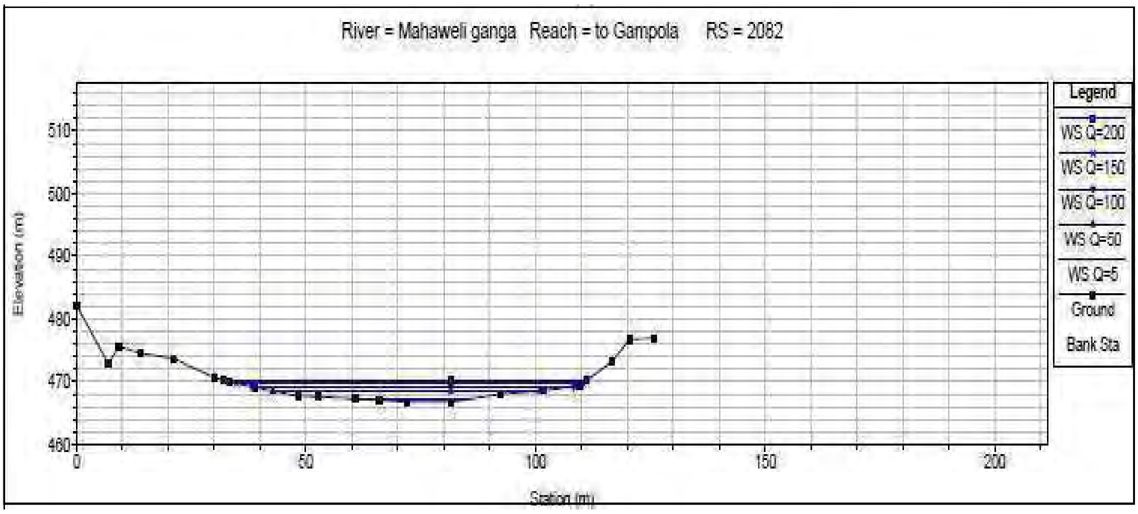
4(c): 2660m downstream from tailrace of MHPP



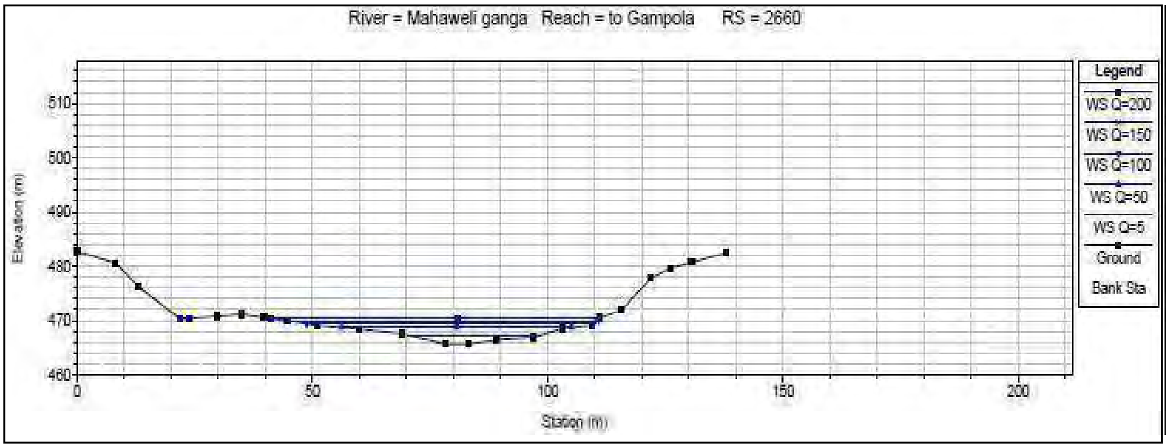
4d): 2250m downstream from tailrace of MHPP



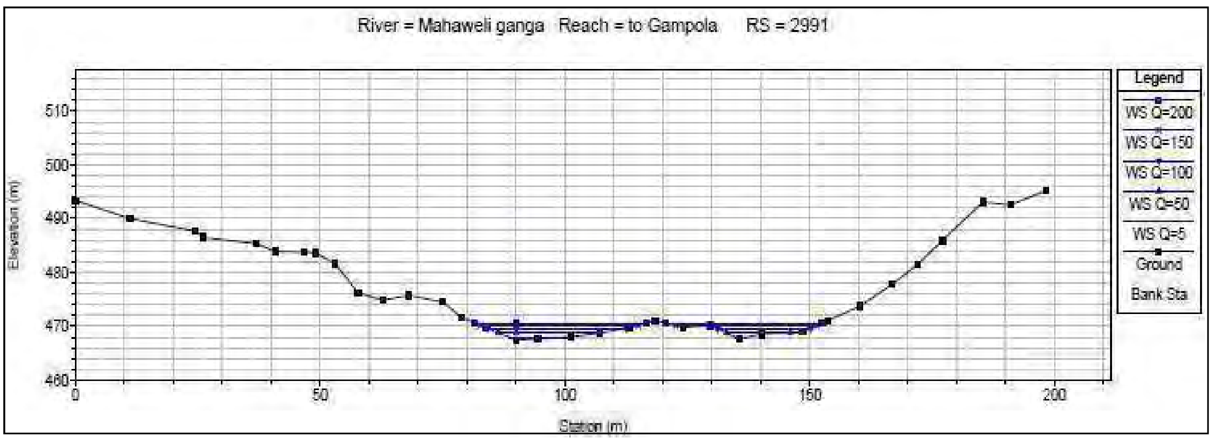
4(e): 1620m downstream from tailrace of MHPP



4(f): 1050m downstream from tailrace of MHPP



4(g): 720m downstream from tailrace of MHPP



4(h): 200m downstream from tailrace of MHPP

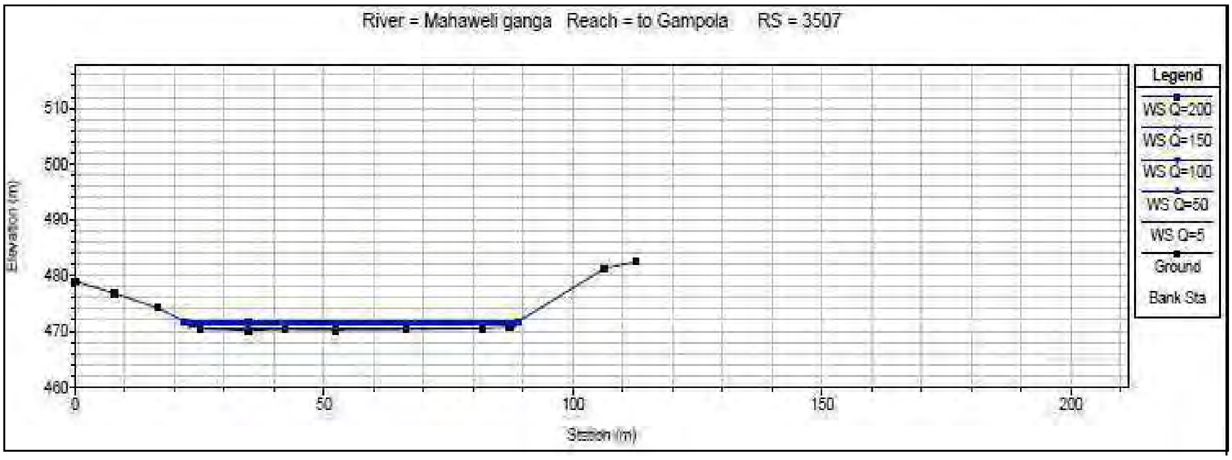


Figure 5: Variability of water levels in the downstream section of the Mahaweli Ganga under various discharge regimes of the Moragolla project.

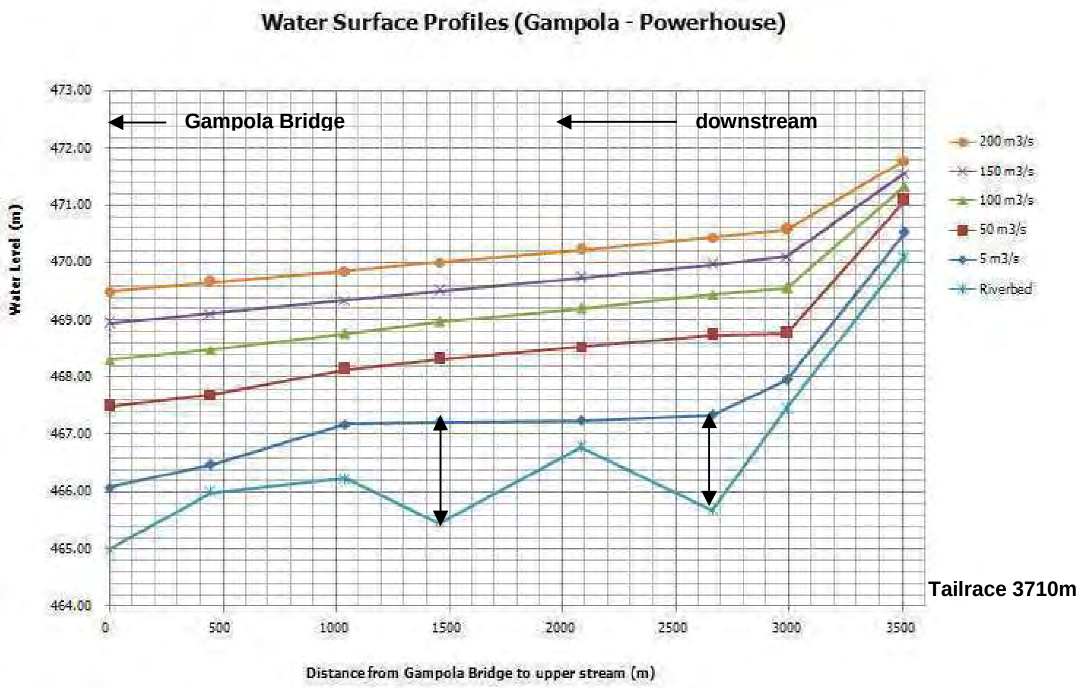
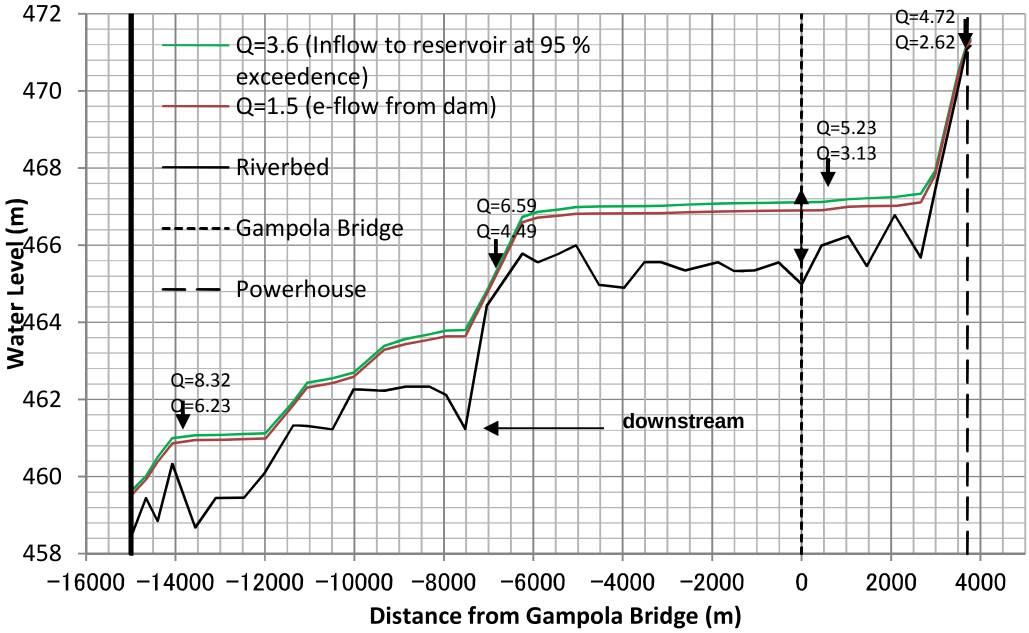


Figure 6: Comparison of environmental flow and existing minimum flow in the Mahaweli Ganga in terms of downstream water levels.



The minimum environmental flow of 1.5 m3/s, in terms of impact on water levels in the immediate downstream section of the Mahaweli Ganga, does not differ significantly from the previous low flow conditions (the 95% exceedance discharge of 3.6 m^3/s; see Figure 6). Ignoring contributions of water flow from the Kotmale and the Atabage Oya (and other downstream tributaries), the data indicate that low flow water levels in the Mahaweli Ganga can be maintained between 0.5 and 1.5 m depth (it would still be deeper in the pools, wherever they are located). Obviously, the lowest discharge rates and the shallowest water will occur in the area between the dam and the Molgolla tailrace.

The combined effect of the Molgolla and Kotmale tailrace discharges produces a minimum of about 20 m^3/s in the immediate downstream section of the Mahaweli Ganga and a maximum of about 70 m^3/s (monthly averages). Throughout the downstream section of the Mahaweli Ganga, the most frequent combined discharge (about 50 m^3/s, in eight months of the year) maintains water levels of at least 1 to 3 meters above the river bed. Even a variability of 3-4 times this discharge rate (up to 200 m^3/s) adds only 1.5-2 m to the water level, which reflects the wider cross-section of the river in the downstream stretch (see Figure 4 (a) to (h)).

4. Discussion

Table 1 shows that there are no E-flow releases from older hydropower schemes in Sri Lanka (and elsewhere), including several located on the Mahaweli Ganga. However most of the more recent schemes do include some provision for continuous downstream releases, and Table 1 shows that for the larger dams in Sri Lanka and elsewhere in Asia, E-flow ranges from 2.5% to 25% of the minimum dry season rate. The proposed release of 1.5 m^3/s from the Moragolla scheme (41% of the minimum dry season flow) therefore compares favourably with other schemes and is the highest of the sixteen examples given.

Of the very many methods that have been used elsewhere to calculate the appropriate level of E-flow, two of the more common approaches were used to examine the validity of the proposed Moragolla rate. According to the CEMAGREF Formula, a flow of 1.44 m^3/s would be required to maintain the ecology of the downstream area; and based on the Tennant method the required release to allow the short-term survival of fish is 2.24 m^3/s. Ecological studies conducted for this project suggest that the area that will be most affected by changes in river flow is not especially sensitive, and providing impacts on the fish fauna are mitigated (which will be done as outlined above) then there is no justification for adopting a relatively high rate of E-flow (such as provided by the Tennant 30% calculation for example).

If the Moragolla project was not realized, CEB would have to forgo 97.6 GWh of renewable energy annually, which is sufficient to supply over 100,000[35] households of average consumption. In the absence of a project of this nature, the forgone amount of energy will have to be fulfilled by other generation methods which would probably involve thermal power options, which not only absorb foreign currency but also cause greater environmental impacts than hydropower. Both thermal alternatives of oil fired and coal fired generation would result in long-term emissions of Carbon Dioxide(CO_2), Oxides of Nitrogen (NO_x), Oxides of Sulphur (SO_x) and particulate matter.

5. Conclusion and Recommendations

The e-flow proposed for the Moragolla HPP is significantly greater than the e-flow releases of other hydropower plants in Sri Lanka and many other Asian countries, when expressed as a

[35] Total consumers in domestic sector = 4,391,445 (Statistical Digest 2012 published by CEB)
Total annual energy consumption by the domestic sector = 3,522GWh (Statistical Digest 2012 published by CEB)
Annual per-capita energy consumption = 3,522,000,000/4.391,445 kWh = 802.5kWh
Number of households (Consumers) which could be supplied with energy using 97.6GWh = 97,600,000/802=121,697

percentage of the minimum dry season flow. E-flow calculated using two widely applied methods suggests that the flow required to sustain minimal ecological resources is between 1.44 and 2.24 m^3/s, which confirms the broad acceptability of the proposed rate of 1.5 m^3/s. Ecological studies for this project provided no justification for adopting a higher rate on ecological grounds, especially as impacts on fish will be mitigated by other action recommended by IUCN.

The environmental flow of 1.5 m^3/s is widely quoted in the EIA report of the MHPP, which assesses the impacts of the changes in river flow in detail. This EIA report was opened for public comments in April 2013 and no comments were received. Environmental approval for the Project was granted by the Project Approving Agency (MASL) on 13 August 2013, subject to several terms and conditions, including release of 1.5m^3/s as environmental flow through an unregulated opening to maintain the ecology and to fulfil the requirements of the downstream users.

The proposed E-flow of 1.5 m^3/s has therefore been subject to a great deal of scrutiny, both expert and public, and no objections have been raised. It has also been subject to considerable investigation, during the original Feasibility Study, and in the present FS Review and Detailed Design study, and no case for changing the E-flow has been made. The additional investigation presented in this report examines further evidence, including widely used E-flow calculation methods and current ecological studies in the project area, and also finds no case for amending the proposed rate. The conclusion is therefore that the proposed E-flow of 1.5 m^3/s is acceptable and is in-line with the limited ecological sensitivity of the project area, providing the impacts on fish are mitigated by the habitat management and translocation measures recommended by IUCN.

Moragolla Hydropower Project

The Stakeholder Consultation and Disclosure Process

Nippon Koei Co. Ltd

November 2013

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Annex 1 (B): Newspaper advertisement, which appeared in *Thinakaran* on April 01, 2013

Annex 1 (C): Newspaper advertisement, which appeared in *Daily News* on April 01, 2013

Annex 2 (a): Minutes of the Stakeholder Meeting held on January 24, 2013

Annex 2 (b): List of Participants of the First Stakeholder Consultation Meeting held on January 24, 2013

Annex 2 (c): Power Point Presentation of Project Manager at the first stakeholder consultation meeting

Annex 2 (d): Participants of the First Stakeholder Consultation Meeting held on January 24, 2013

Annex 3 (a): Minutes of the Second Stakeholder Meeting held on November 18, 2013

Annex 3 (b): List of Participants of the second stakeholder consultation meeting held on November 18, 2013

Annex 2 (c): Power Point Presentation of Project Manager at the first stakeholder consultation meeting held on November 18, 2013

Annex 3 (d): Power Point Presentation of the National Environmental Specialist at the second stakeholder consultation meeting held on November 18, 2013

Annex 2 (e): Participants of the First Stakeholder Consultation Meeting held on November 18, 2013

1. CONSULTATION AND DISCLOSURE DURING EIA STUDY

The following informal consultations with project Affected Persons (APs), interested groups and civil society were held during the early stages of the EIA preparation as determined by the Project Proponent (CEB) and the Feasibility Study (FS) consultant (CECB)[1].

1.1 Consultation meetings and awareness programmes conducted by CEB and CECB

Event	Views/ Comments / Discussion	Response given / Action taken by CEB
Awareness programme for stakeholder government agencies. June 04, 2009: Kotmale Holiday Resort. No of participants: 30 (attendance list Annex 1)	The only information available on this meeting is the attendance list.	
Awareness programme for the Farmer Organisations of "Dunhinda Ela" irrigation scheme May 08, 2012: Maligapurana Temple, Gampola. No of participants: 27 (attendance list Annex 2	1. The lands cultivated under this irrigation scheme belong to the "Dalada Maligawa" - Temple of Tooth, Kandy. The farmers inherited the lands, which they have cultivated for generations; and they pay tax bi-annually to the Temple of Tooth for their hereditary land.	
	2. The National Water Supply and Drainage Board blocked the "Raja Ela" irrigation canal and diverted the water for their water supply scheme, but no water is released downstream for farmers' requirements. It is expected that a similar thing will not happen to the farmers of "Dunhinda Ela" and that CEB will act responsibly in this regard.	

[1]Central Engineering Consultancy Bureau – consultant who carried out the feasibility studies including EIA during 2009-20012.

Event	Views/ Comments / Discussion	Response given / Action taken by CEB
	3. When will this project be commissioned?	It will take 2 years for the detailed designs and another 4 years for construction. An EIA report is being prepared by CEB and it will be opened for public comments soon. Once the EIA approval is received, the lending agencies will release the required funds for the project.
	4. Water is leaking through the irrigation canal. It is expected that CEB will repair those leaks.	CEB agreed to do the required repairs to the irrigation canal and maintain the section which traverses through CEB premises.
	5. It is requested to have another meeting with the members of three farmer organisations, relevant Divisional Secretaries, Grama Niladaries of the area, tax officer of the Temple of the Tooth and officials of the Irrigation Department (ID).	Agreed
Awareness programme organised for the members of Community-Based Organisations. October 18, 2012: Auditorium of Ganga IhalaKorale Divisional Secretariat Office No of participants: 26 (attendance list and minutes of the meeting Annex 3)	1. A brief introduction about the project, its benefits to the people of the area, national importance and present position and future plans was given by the CEB Project Manager (Detailed Design), MHPP. 2. Potential environmental impacts of the project and the mitigation measures proposed to minimise such impacts were explained by the Head of Environmental Division of CEB. The water requirement for agriculture and human consumption and proposed solutions to minimise any impacts were also explained.	
	3. What is the guarantee that MHPP will not cause similar problem to that created by NWS&DB for the farmers of the 'Raja Ela" irrigation scheme?	Action has already been taken to sign an agreement between CEB and ID.

Event	Views/ Comments / Discussion	Response given / Action taken by CEB
	a.A substantial quantity of water entering into "Dunhinda Ela" is wasted due to the dilapidated condition of the canal. Can CEB repair the entire length of the irrigation canal?	The canal section which traverses through CEB premises will be repaired and maintained by CEB. Repairs of the rest of the canal will be attended to after having a discussion with ID.
	b. Priority should be given to repairs of the canal when project construction activities commence.	Repair work will be carried out along with the infrastructure development works.
	c. Uninterrupted water supply to "Dunhinda Ela" should be guaranteed during the construction period of the project.	Agreed
	4 Crysbro Farm discharges its effluent to Mahaweli Ganga without proper treatment. It contaminates the waters of "Dunhinda Ela" too.	The effluent discharge point will be extended up to the tailrace of the power house. It will be designed to allow the authorities to collect samples for analysis and check the effluent quality.
	5. Gampolawela paddy field belongings to the Temple of the Tooth - "Dalada Maligawa" and the farmers pay taxes for the land cultivated by them. Even if they are unable to cultivate, taxes need to be paid to "Dalada Maligawa". It is requested that CEB inform the Tax Officer about the project and possible problems the farmers will face during construction of the project.	Already this matter was discussed with the Tax Officer and the Revenue Collecting Company. A discussion is planned to be held with "Diyawadana Nilame" (incharge of the Temple of the Tooth) and the Board of Management.
	6. The reservoir area is used by the people for bathing. Water requirement for bathing is crucial during drought. What action is proposed to facilitate bathing places? Is there any suitable land for the resettlement of affected people?	Safe bathing places will be constructed by the project. A five acre plot of land within "MahawilaWatta" near SARC Village is identified for the resettlement of affected people.
	7. In order to solve the problem created by NWS&DM by extracting water from "Raja Ela", is it possible to release water for the NWS&DB scheme through Moragolla reservoir.	CEB agreed to discuss this matter with the relevant parties.

Event	Views/ Comments / Discussion	Response given / Action taken by CEB
	8.Land requirement for road widening shall be informed to the public in advance. The Right of Way should be marked on the ground.	Agree to take action after having a discussion with DS.
	9.What is the action taken by the project to minimise the inundation of arable land.	To minimise this impact the reservoir level has been lowered by 2 metres. (Originally it was at 550m and now it is reduced to 548m)
	10.It is requested to give priority to the members of the farmer organisations when recruiting workers for the project.	This request can be accommodated very easily.
Consultative meeting with the Management of Farm's Pride (Pvt) Ltd.,Crysbro Processing Plant August 21, 2012: Factory premises No of participants: 5 (minutes of the meeting Annex 4)	The purpose of the meeting was to discuss the issues in relation to relocating the waste water discharge outlet of Crysbro Farm to a suitable place. The following information was provided by the Crysbro representatives: 1. Effluent is kept for 24hrs in settling tanks before release to the outlet. 2. There are no solid particles, as the effluent is passed through several filters. 3. About 30,000 litres/day of effluent is released to Mahaweli Ganga during night time. 4. The diameter of the effluent discharge pipe is 6" and it is of 1000 grade PVC. 5. There will be a reduction of the river flow at the effluent discharge location due to MHPP.	It is necessary to direct the effluent to a place where there is sufficient flow. The cost of relocation of the effluent pipeline to a suitable place will be borne by CEB. The proposed design of the new outfall will be forwarded to Crysbro Farm.

Event	Views/ Comments / Discussion	Response given / Action taken by CEB
Consultative meeting with the Management of Farm's Pride (Pvt) Ltd., Crysbro Processing Plant September 21, 2012: Office of Farm's Pride (Pvt) Ltd. at Jayamalapura No of participants : 6 (minutes of the meeting attached Annex 5)	1. The management of Farm's Pride Pvt. Ltd. explained that the main reason for setting up Crysbro processing plant at Ethgala is easy access to Mahaweli River water which is pure enough and sufficiently available for the requirements of Crysbro processing plant even during severe droughts.	CEB is bound to release 1.5m^3/s as e-flow to maintain the ecology of the river stretch between the dam and the outfall of the powerhouse and for the requirements of the downstream water uses. CEB will also carry out necessary modifications to the existing water intake of Farm's Pride Pvt. Ltd. so that the required quantity of water would be properly diverted to the intake throughout the year.
	2. Whether the proposed tunnel will be routed under the processing plant?	The tunnel is so designed to avoid traversing beneath the Industrial zone and the Crysbro Processing Plant. The tunnel will be constructed about 60m below the ground surface in this area.
	3. Will there be any climatic changes due to the reservoir and will there be a possibility of formation of algae in the reservoir?	The proposed reservoir is not a storage type reservoir like Victoria, Randenigala and Kotmale power stations and hence such impact due to the proposed reservoir would be negligible. Unless reservoir water is mixed with biological substances produced by anthropogenic activities the possibility of formation of algae in the reservoir water would be negligible.
	4. Farm's Pride Pvt. Ltd. consented to the CEB proposal to relocate the wastewater outlet as proposed in letter No PM/MOGL/DD-EIA dated September 28, 2012 addressed to the Chairman, Farm's Pride Pvt. Ltd. on relocation of waste water outlet. Maintenance of the waste water discharge line would be a Farm's Pride Pvt. Ltd. responsibility.	

Event	Views/ Comments / Discussion	Response given / Action taken by CEB
	5. Farm's Pride Pvt. Ltd. requested an official letter from CEB assuring them that the river water will be available for the processing plant in all circumstances if they are allowed to pump water from the present location. They also queried the availability of water during extreme droughts.	Release of e-flow is clearly mentioned in the EIA report, which will be opened for public comments by the MASL in the near future. Copies will be available for public inspection at the Divisional Secretariats of Ganga Ihala Korale and Uda Palatha. CEB will examine the possibility of issuing such a letter after discussion with management. The present water requirement as previously indicated by the industry ie.,400,000/day (through their letter dated June 15, 2009) could easily be met by the proposed release and even if the Crysbro facility increase their production to three shifts per day, the maximum quantity needed would be $0.016m^3/s$, which is still within the $0.02m^3/s$ allocation.
	6. Farm's Pride Pvt. Ltd. would prefer to relocate the river water intake point to the down streamside of the outfall of the proposed powerhouse. The whole modifications of the newly proposed intake and pipe work will be carried out by Farm's Pride Pvt. Ltd. What they expect from CEB is only the funds allocated for the modification of the intake structure as mentioned in the letter No PM/MOGL/DD-EIA dated September 28, 2012 from CEB. The balance investment requirement for this modification and pumping arrangement, including maintenance costs, will be borne by Farm's Pride Pvt. Ltd. They opined that this would be a win-win solution for this issue and they will not be a stake holder (or affected party) of this hydropower project if this proposal is implemented.	The detailed designs of the modifications required to the existing water intake of Farm's Pride Pvt. Ltd. are already included in the detailed designs of the project. The cost estimates for this modification can be obtained from the design consultants and that is the maximum amount that can be paid as compensation by CEB if this proposal is implemented instead of modifying the existing water intake. This is also possible only if the management of CEB agree to transfer the estimated cost to Farm's Pride Pvt. Ltd. This will be discussed further with CEB management and Farm's Pride Pvt. Ltd. will be notified of the outcome in due course.

1.2 Communication with stakeholder government agencies

Reference	Summary of main relevant comments	Remarks
Letter ADGM/P&P/MHP/127/2010; March 22,2010;from Additional General Manager(Policy & Planning), NWS&DB to DGM (Tr& Gen PI), CEB	NWS&DB grants approval for MHPP subject to the conditions of the Memorandum of Understanding signed between NWS&DB and CEB	In response to CEB letter PM/MOGL/FS of February 25, 2010
Letter PM/MOGL EIA; February 24, 2010 from CEB to NWS&DB	Agreed conditions: 1. A bottom outlet (draw off arrangement), which could be used to release water at critical situations, shall be incorporated into the structural arrangement of the dam. 2. Water supply shall be treated as a similar priority to electricity supply. Hence NWS&DB's right to obtain water for present or future water supply schemes from up/down stream or both is assured. 3. Subsequent structural modifications that shall increase the water storage capacity upstream will not be implemented without prior agreement with the NWS&DB. 4. Proper structural drawings to a suitable scale will be furnished to NWS&DB to visualise the cross sections of the structures to be constructed across the river before construction commences. 5. All step-up transformers will be provided with a contingency arrangement built-in at site to direct all coolant oils, chemicals etc., to a sufficiently protected water collection pit so that it could be removed from site for safe disposal elsewhere. 6. All body metal components in contact with high velocity raw water flow will not contain metals that are identified and given in Sri Lankan Standards as hazardous heavy metals (eg. Pb, Zn, Cr, Cd, Ni) 7. All used lubricants / bearing fluids will be collected in a sufficiently protected container for safe storage and removal from the site. 8. All mechanical seals and respective standards shall not be affected to bacteriological and chemical parameter of water quality of the discharge of the proposed hydropower project. 9. Periodical chemical testing of raw water before and after the generator facility shall be carried out by CEB as directed by the	

Reference	Summary of main relevant comments	Remarks
	NWS&DB, which would be required to maintain safe quality of raw water to be used in the treatment process and quality of treated water.	
Letter HW/KOT G/22; March 04. 2010;from Engineer in Charge, Kothmale, MASL to CECB EIA Team Leader	1.The existing quarry has only a IML-C category licence, and hence only a very small quantity of rubble can be extracted. If CEB intend to adopt large scale blasting, an EIA is essential. Transport of material across the existing Kotmale dam is not allowed. **2.**As far as the water supply for Farmers Pride Pvt. Ltd. is concerned, they are allowed to extract only up to 50,000 gallons of raw water from Kotmala Oya by MASL.	In response to letter CB/WR/WMR/P-05; February 18, 2010.
Letter RDA/ES/BD (XVIV);October 06, 2009;from Director, Engineering Services, RDA to CEB Additional GM (Water Resources)	Some sections of the piers and abutment foundations of the bridge over Mahaweli Ganga on Ulapane-Mawathura Road are placed on weathered rock layers. Hence, there would be a possibility to erode the soil overburden in foundation areas. It was therefore decided to protect the ground surface around the abutments and piers under the submerged area with rubble paving using cement-sand mortar. CEB shall bear the cost of this additional work.	
Letter Env/526(Kan ii) Moragolla; October 04, 2009;from Director General, Irrigation Department (ID) to Director General CEA	Conditions of consent letter dated April 04, 2009 is relaxed and the new conditions are: 1. A full EIA shall be carried out by CEB for the proposed project. **2.** No impact shall be caused to the command area of "Raja Ela" irrigation scheme. High Flood Level (HFL) of the reservoir shall be below the anicut and the irrigation scheme. **3.** The water requirement for Dunhinda anicut, which is located below the proposed reservoir, shall not be reduced. The power generation intake shall be designed in order to allow release of a minimum of 10 cusecs to the irrigation canal. A Memorandum of Understanding shall be signed between ID and CEB. If CEB decide to transfer the hydropower scheme to a third party, the ownership of the plant and the reservoir shall be transferred to CEB. **4.** If water shortage is experienced during the dry season, priority shall be given to providing sufficient water for the Dunhinda irrigation	Refer to letters CB/WR/WRM/P-11;March 02, 2009 and April 04, 2009 from CECB and Reply letter from ID dated August 10, 2009

Reference	Summary of main relevant comments	Remarks
	scheme. **5.** Water for the environmental requirements shall also be released in addition to the water needed for irrigation purposes.	
Letter No.fla$àã$11$P.ú.jHdmD;s September 22, 2009 from Regional Officer, Forest Dept. to Additional General Manager (Water Resources) of CECB.	No forest reserve or forest plantations are involved in the proposed MHPP and hence we have no objection regarding the implementation of MHPP.	
Letter of 11.08.2009 from Director/ Geology, GSMB to Additional General Manager (Water Resources) of CECB.	It appears that the proposed quarry site has been operated to supply rock material to construct the Kotmale dam. If quarrying activities at the same site are commenced it would adversely affect the surrounding area because soil creeping and earth subsidence have been reported since impoundment of Kotmale reservoir. It is therefore suggested to identify a suitable alternative quarry site to obtain rock material for Moragolla Hydropower Project.	In response to letter of June 29, 2009 from Additional General Manager (Water Resources) of CECB.
Letter .bflda$m%df,a2/1/2009/1 ; June 25, 2009;from Divisional Secretary, Ganga IhalaKorale; to	Current development programmes in Ulapane area are as follows: 1. Raja Ela Development 2. Mahawelawatta Land and Housing Project 3. Ethgala New Town Development 4. Ulapane Industrial Zone **5.** Kandy South Water Supply Scheme	
Letter No .bflda$m%df,a2/1/1/2009/1 August 07, 2009 from Divisional Secretary, Ganga Ihala Korale to Additional General Manager (Water Resources) of CECB.	Provides details of the above development programmes.	
Letter RDA/ES/H/CP; August 03, 2009 from Director/Highway Designs, RDA, to Additional General Manager (Water Resources) of CECB.	Comment of RDA to letter No. CB/WR/WRM/P-11 dated July 14, 2009 of Additional General Manager (Water Resources) of CECB	
Letter No.m%df,a$aWm/1/5/11/27; July 27, 2009from Divisional Secretary, Udapalatha, Gampola to Additional	There are no development programmes in the project area. However, the development programmes implemented in surrounding areas are as follows:	

Reference	Summary of main relevant comments	Remarks
General Manager (Water Resources) of CECB.	1. Pilawala- KalugalhinnaMawathuraPilawalaRoad 2. Mawathura –MawathuraNew Colony Road 3. Weliganga – KanapathyWattaRoad via the cemetery 4. Kekulandala – NayapanaWattaRoad via GalathaSchool 5. Mawathura – Remaining parts of MihinduMawatha 6. Water tank near Mawathura – MawathuraWelawattaGalmula	
Letter ED/TS/MH/MORA/14;June 18, 2009;from Director General, MASL To Additional General Manager (Water Resources) of CECB.	The ToR issued for the EIA study by the MASL covers all the required details to incorporate in the environmental study.	In response to letter CB/WR/WRM/p-11 of April 07, 2009
Letter No.m%df,a$aWm/1/5/11/27 ;June 19, 2009;from Divisional Secretary, Udapalatha, Gampola, to Additional General Manager (Water Resources) of CECB.	Proposed the following mitigation measures: 1. Provide alternative lands for the people who are living in theproposed reservoir area as the lands are either privately owned or colony lands. 2. Provide alternative lands for the people impacted due to the construction of proposed alternative roads. 3. Alternative roads shall be constructed without causing any environmental problems. **4.** Sufficient water to sustain the river system shall be released to the river stretch between the dam and the power house.	Reference letters dated February 20, 2009 and May 13, 2009
Letter 17/CP/N/UDA/1;July 11, 2009;from Deputy Director General (P1) – Zone II, UDA, to Additional General Manager (Water Resources) of CECB.	The proposed project site does not fall within the area declared under the Urban Development Authority Act.	
Letter No. .bflda$m%df,a2/1/2009/1; March 20,2009;from Divisional Secretary, Ganga Ihala Korale, to Additional General Manager (Water Resources) of CECB.	As the tunnel of the proposed project traverses beneath the Ulapane Industrial Zone, it is proposed by the DS to have a discussion with the industrialists of the zone regarding their concerns and come to an amicable solution.	
Letter LE 1479;September 29, 2009;from Director, Environment Management, Board of Investment (BOI) of Sri Lanka, to Additional	The BOI has granted an approval for M/S Farm's Pride (Pvt) Ltd to establish a Broiler Processing Plant at Davidson Estate Ethgala, Gampola after obtaining approval from the Committee for determining the sitting of High and Medium polluting industries outside the Export Processing	

Reference	Summary of main relevant comments	Remarks
General Manager (Water Resources) of CECB.	Zone (EPZ) and industrial estates. The initial water requirement was 450, 000 litres/day and now approximately 600,000 litres/day of waste water is said to be discharged into Mahaweli River after treatment to comply with the legal standard for industrial wastewater discharged into inland surface waters. Farm's Pride (Pvt) Ltd had requested an approval for their first expansion on July 04, 2009; however our records reveal that the above approval has been withdrawn on April 08, 2009. Contact M/S Farm's Pride (Pvt) Ltd to obtain information about future expansion as the required information is currently not available with BOI.	
Letter 109/12/01/71;July 30, 2009;from Regional Director, Regional Industry Service Centre – Central Province, to Additional General Manager (Water Resources) of CECB.	1. Proposed industries to be established with the industrial zone are as follows: • Diva Plastic Ltd – Polythene and Plastic • Fermtech Co. – Wooden frames • Jayalanka Furniture – MDF and steel furniture • Tharindu Products – Fruit drinks 2. No waste water discharge from the industrial zone. Solid waste is collected and disposed of through Ganga Ihala Korake Pradeshiya Sabah. 3. The only rain water is discharged into storm water drainage system. 4. An IEE report for Ulapane Industrial Zone is being prepared. It is authorised by MASL to discharge industrial waste water which conforms to MASL norms, within 60m from the river bank.	
Letter of July 15, 2009 from Chairman, Farm's Pride (Pvt.) Ltd. to Additional General Manager (Water Resources) of CECB.	We require 400,000 litres of water per day at present and we may need max of 1,000,000 litres per day for expansion of production in the future. The water used for the production facility is discharged to the river after treatment as per CEA specification.	
Letter RDA/ESD/CEB; January 13, 2012;rom Director General, RDA, to CEB	Grant consent for MHPP subject to several conditions. (Motor Traffic (dimensions and gross vehicle weights) Regulation, 2004 is attached.)	In response to letter PM/MOGL/EIA of December 29, 2011 from DGM (Tr and Gen. PI)

Reference	Summary of main relevant comments	Remarks
Letter DS/UP/MHP/17; November 30, 2011;from Divisional Secretary, Udapalatha, Gampola to CEB	Grant consent for MHPP subject to the following conditions: • Proper resettlement of affected persons • Develop and implement a forestry programme. • Minimise the public nuisance caused due to dust, noise and vibration. • Minimise soil erosion, water pollution and air pollution.	In response to letter PM/MOGL/EIA dated October 10, 2011.
Letter .bflda$m%df,a/6/1/;October 25, 2011;from Divisional Secretary, Ganga IhalaKorale, to CEB	Propos e several mitigatory measures to minimise the potential social and environmental impacts: • Proper compensation shall be paid for the loss of land and property. • Any damage caused to Dunhinda Ela irrigation scheme shall be rehabilitated • Any impact on Ulapane Industrial zone shall be rectified.	In response to letter from CEB dated October 10, 2011.
tpÞvæ$fld;a$amS$22; August 03, 2011;from Engineer In charge of , Kothmale Project, MASL, to CEB	Considering that the proposed MHPP is an important national project, and as there is no other suitable land in the vicinity, we herewith grant approval for the proposed land to be used as a spoil disposal area subject to the following conditions: • Since the land is sloping towards the river, proper protection shall be taken in order to prevent damage to the river bank and minimise soil erosion. • The trees planted by MASL and other natural trees shall be protected and the river bank shall be protected by planting suitable tree species. • Runoff water shall be directed through a sediment trap and the resultant water shall meet the national standards. • Water quality test results shall be submitted periodically to MASL • A detailed plan shall be submitted to MASL taking into consideration of the above recommendations.	
Letter MC/KOT/RP/MHP; April 26, 2011;from Chief Engineer, Kotmale Power Project, CEB, to Deputy General Manger (Tr. and Gen. Pl.), CEB	The identified lands in four blocks (total area ~5ha) can be used for the disposal of spoil material.	

Reference	Summary of main relevant comments	Remarks
Letter No.fla$wdr®tia$bvi$fudrf.d,a, c,jÞ¥,Þ n,d.drh;June 02, 2011;from Resident Project Manager, Victoria /Kotmale Project, MASL, to ...	Request CEB to prepare a survey plan of the proposed land for spoil disposal in order to obtain the consent of the physical planning committee of MASL and submit the same for the approval of Director General of MASL	In response to letters PM/MOGL/EIA dated March 23, 2011 and April 25, 2011.
Letter DGM/RSC-C/SP/08/01;February 14, 2011;from Deputy General Manager, Regional Support Centre, Central, NWS&DB[2], to CEB	As requested, the locations of NWS&DB water intake points in Gampola water supply scheme are provided.	In response to letter PM/MOGL/EIA dated December 16, 2010
Letter CPC/GIPS/01/07/fudrf.d,a, jÞ¥,s;November 04, 2010;from Chairman, Ganga IhalaKorale PradeshiyaSabha (PS) – Kurunduwatte Bazaar, to CEB	Inform CEB that the approval of PS is already granted through their letter No. CPC/GI/PS/07/fudrf.d,a, jÞ¥,s dated August 08, 2006 and they (PS) will send the revised approval letter based on a discussion held on October 07, 2010 at MASL.	In response to letter PM/MOGL/FS dated October 27, 2010

[2]NWS&DB = National Water Supply and Drainage Board

1.3 Disclosure – opening the draft final EIA report for public review and comments

The EIA report prepared by the EIA consultants (Central Engineering Consultancy Bureau and Al-Habshi Consultants Office, Kuwait) based on the Terms of Reference (ToR) issued by the Project Approving Agency (PAA), Mahaweli Authority of Sri Lanka, was opened for public comments on April 01, 2013 for a period of 30 working days, as required by NEA. The EIA report was made available in the following locations in Sinhala, Tamil and English languages for the inspection by the public:

- Divisional Secretariat Office, Udapalatha
- Divisional Secretariat Office, Ganga IhalaKorale
- Engineer-In-Charge Office, Head Works Administration, Operation and Maintenance Division, MASL, Riverside, Mawathura
- Library, Central Environmental Authority, 104, Denzil Kobbekaduwa Mawatha, Battaramulla
- Pradeshiya Sabha Office, Udapalatha
- Pradeshiya Sabha Office, Ganga Ihala Korale
- Central Environmental Authority, Regional Office, Dam Site, Polgolla
- Library, 6th Floor, MASL, 500, T B Jaya Mawatha, Colombo 10

Newspaper advertisements were published by the PAA, in *Dinamina* (Sinhala),*Thinakaran* (Tamil) and *Daily News* (English) on April 01, 2013 inviting the general public to submit their comments (if any) in writing on the project to the Director General of MASL. Scanned copies of the advertisements are attached in Annex 1(A), 1(B) and 1(C). The thirty day public commenting period ended on May 15, 2013. No comments were received from the affected parties, the general public, or any stakeholder agencies.

2. CONTACTS BY EIA TEAM DURING SOCIO-ECONOMIC SURVEY CARRIED OUT IN 2009

2.1 Meetings and Focus Group discussions with representatives of key stakeholder organisations.

Event	Views/ Comments / Discussion	Response given / Action taken
Divisional Secretaries of Udapalatha and Grama Niladaries of the area.	• The development interventions should be well guided by EIA report. • Project required land needs to be acquired from the private owners. According to the GN (Weliganga Division) required land can be acquired with compensation. • Many of these land plots hold annual permits issued by MASL.	EIA report will be prepared, opened for public comments and approval obtained from the Project Approving Agency. A Resettlement Plan (RP) is being prepared. All compensation matters will be discussed therein.
Divisional Secretary of Ganga Ihala Korale.	• The proposed project may not create serious negative impacts on the settlements in the division because the proposed tunnel is an underground construction and also other project interventions will be carried out in non-residential lands. However, project development activities should be implemented in accordance with the recommendations in the EIA Report.	Noted
National Water Supply & Drainage Board (NWS&DB): with Mr S P Rathnayake, Officer in charge and Mr A N B Heenkenda, Technical Assistant	• There are no domestic water supply projects located downstream of the proposed dam which will have impacts due to the proposed project.	Noted
Road Development Authority: Embilmeegama, Pilimatalawa Office: with Mr Dharmadasa, Executive Engineer	• If the proposed road diversion is established to replace the section of existing road that will be inundated due to the proposed reservoir, there will not be a problem for the users of the existing road located on the right side of Mahaweli River at the project location.	Noted
Department of Agrarian Services: at Ganga Ihala Korele office: with Mr Kamal Priyantha, Divisional Officer	• Generating power is a national need. Similarly agriculture in Gampola-Raja Ela irrigation scheme is also important and therefore, the irrigation canal (Known as DunhindaEla) located downstream of proposed dam should be provided with adequate water to deliver to the Gampola-Raja Ela Irrigation scheme.	The water requirement of the DunhindaEla has been assessed. Water release devises are incorporated into the project designs.

2.2 Group discussions with communities likely to be affected by the project.

Event	Views/ Comments / Discussion	Response given / Action taken
Discussion with sand miners likely to be affected.	▪ We have been involved in sand mining in the river at different locations for a long period of time. ▪ The labourers working in our sand mining sites are from local communities and are unemployed. We do not hire the same labourers regularly but those who work for us are from the local communities. ▪ We would like to propose that the project developer considers offering employment in construction sites to our labourers when they lose their work in our mining sites. ▪ We would also like to propose that Divisional Secretaries recommend issuing new permits to us in other feasible locations in the upstream and other downstream locations to start new sites for sand mining. ▪ Most of us are small scale sand miners involved in sand mining with the assistance of the local communities and therefore we insist that the authorities consider us as persons who will experience negative impacts due to the proposed project.	Employment for the labourers who will lose their jobs could easily be provided at construction sites once the project construction activities are commenced. In addition, a compensation programme will be provided through the resettlement planning process.
Focus group discussions with community members affected due to proposed reservoir	▪ Many of us were the people who were evacuated from Kotmale area due to Kotmale power project[3] and resettled in these present locations. Once again we are going to face the same fate. We do not mind losing current residences if we are given suitable alternative places and other assistance to re-establish our settlements. ▪ Some of the persons in the area will not have to move from their residences but portions of their land will be inundated due to the reservoir.	

[3] Located about 10km upstream of MPPP site. Construction work commenced in February 1979and commercial power generation began in June 1985.

Event	Views/ Comments / Discussion	Response given / Action taken
	▪ We have been told by some officers that only a section of our lands will be affected but we need to have the remaining portions of the land protected from landslides and other vulnerabilities due to the reservoir. Even though some of our houses will not be negatively affected, we do not like to take the risk of living in a hilly land upstream of the reservoir due to possible landslides. ▪ We must be properly compensated for our affected property (land). ▪ All potentially vulnerable houses must be evacuated from the area upstream of the reservoir although the houses will not be inundated.	
Focus group discussions with community members affected due to access roads (Ethgala to Powerhouse and other access roads).	▪ If the roads to the proposed project site are widened there will be some negative impacts on the lands in our home gardens. In most cases small sections of the lands will have to be acquired and also structures such as boundary walls, fences and gates will have to be removed. ▪ There will be disturbances to the local road users during the construction phase of the roads. However, in some cases the local communities have alternative access to reach their residences. ▪ We see/perceive expansion of local roads as benefits to the local communities from the project. ▪ We were told that the CEB will introduce certain conditions for the road development contractors to manage the construction sites in such a way so as to minimize the possible disturbances to the local communities.	Proper and fair compensation mechanism will be provided through the resettlement planning process for those who will lose their land or property. All public nuisances and inconveniences will be minimised through the implementation of the Environmental Management Plan (EMP).
Discussion with the stakeholders on potential impacts on Ulapane Industrial Estate	▪ Industries have not yet been established in a major portion of the land allocated for Ulapane Industrial Estate.	

Event	Views/ Comments / Discussion	Response given / Action taken
	▪ Water scarcity is a significant problem in the area since the ground water table is very deep in this hilly area. There are also no surface water sources to tap easily. ▪ The project will not require any land from the industrial estate. ▪ The only negative impact perceived is potential disturbance to the limited ground water due to construction activities during underground tunnelling works of the project. ▪ The impact will have to be carefully mitigated by the CEB who should introduce alternative measures to solve the problems during construction phase. This will have to be an obligation of the CEB as the project developer.	
Group discussions with people who use the river for bathing and washing purposes.	▪ We have been using these river locations for bathing and washing for a long period of time. These locations are important to us from many aspects. These locations can be accessed free of cost with no payments involved and the water in these locations is good for bathing and washing. ▪ The locations we use are the only places that can be reached with no serious access difficulties. ▪ Most of other locations of the river within the project area cannot be reached due to its steep river bed posing serious access difficulties. ▪ Only three locations upstream and one location downstream of the proposed dam are used for bathing. What we request is for CEB to establish alternative locations for bathing and washing and construct concrete steps to create safer access to these bathing spots.	Alternative locations for bathing will be established by the project.

3. CONSULTATION AND DISCLOSURE DURING PREPARATION OF THE ENVIRONMENTAL ADDENDUM

3.1 First multi stakeholder consultation meeting

On January 24, 2013 a formal consultation meeting was held at the Sri Gangarama Temple at Weliganga to create awareness about the Moragolla Hydropower Project and to stimulate discussion on the environmental and social impacts of the project among the local people and other relevant stakeholders. A total of 117 stakeholders attended the meeting. The meeting was commenced with religious observance performed by Ven. Kotikawatte Vipassi Thera. After the welcome address, opening remarks and keynote address by the CEB engineers, the Project Manager (PM) of the Moragolla Hydropower Project gave a comprehensive account on the project using a PowerPoint presentation. (A copy of the presentation is attached: annex 2(c)). He specially mentioned that the project has been planned in such a manner that it will not pose any threat to the environment. He also stated that the Project will bring about enormous benefits to the nation. Speaking on the entitlements of the affected people, the PM said that every effort will be made to safeguard these. In preparation of the Resettlement Plan (RP), the views and observations of the affected people and other stakeholders will be entertained as appropriate, he added.

During the subsequent discussion session the stakeholders raised several questions to obtain clarifications from the project team. Their opinion on the anticipated impacts and possible mitigation measures were also discussed.

Questions and issues raised by the participants and the clarifications made are as follows:

Question/Issue	Response Given
Would there be a 100 metre security zone on either side of the river coming within the proposed reservoir	The river reservation of the Mahaweli River differs from place to place depending on certain factors
It is learnt that the location of the proposed dam has now been changed and it would be located 50 metres downstream. With this change will the height of the Dam be raised	There is a possibility of moving the Dam by nearly 100 metres further downstream. Therefore height of the Dam may be changed by a few feet. However full supply level (FSL) will not be changed and hence there will be no significant change in the inundation area.
What is the method of resettlement of affected households and payment of compensation in respect of acquired properties?	Provision of alternative buildings in lieu of affected houses and business establishments is being considered. Payment of compensation in respect of land and other structures will be made to bona fide claimants. An entitlement package will be introduced shortly.

At present I am running a business. If that is affected what action would be taken restore the loss.	After a census survey and establishment of the ownership, either an alternative place will be provided or compensation will be paid depending on the circumstances.
If the Project is going to take some action against discharge of harmful effluents to the river by the Crysbro poultry farm	This issue is not directly relevant to the Project. However, the Project will discuss this matter with the management of the poultry farm and suitable action will be initiated.
In allocating alternative houses in lieu of those are to be affected, are there any arrangements to provide alternative lands in similar extents in lieu of those to be acquired along with the houses	There is no firm decision as yet whether to provide alternative lands in lieu of those are to be affected. However, action will be initiated to secure the rights of the affected people to the maximum. Development of an Entitlement Policy is underway.
Whether the same type of alternative houses will be provided to all affected households, in lieu of those affected.	Basis for the provision of alternative houses will be the floor areas of the affected houses. Therefore sizes of the alternative houses will depend on the floor areas of the existing houses.
Whether the alternative lands will be provided in lieu of the tea lands to be affected.	Development of an Entitlement Policy is underway. In developing the Entitlement Policy this request will also be taken into consideration.
Due to the construction work of the Moragolla Project I will stand to lose my land. What action would be taken by the Project to restore the loss.	All affected assets other than those that will be replaced by the Project, will be adequately and suitably compensated.
Whether future meetings of this nature could be held on week end days.	Some of the stakeholders such as public officers may not be willing to attend meetings on week end days due to different reasons. However, in future, attempts will be made to hold the meetings on week end days.
Due to the implementation of the Moragolla Hydropower Project the sand miners along the Mahaweli River, within the project area, will stand to lose their livelihood. What action will be taken by the Project to restore their livelihood.	Project has already collected information on the sand miners to be affected within the project area. The Project will implement an income restoration/enhancement programme covering all genuine sand mining people.

The minutes of the meeting, the list of participants and the photographs of the event are attached in Annex 2 (a), 2(b) and 2(d) respectively.

3.2 Second multi stakeholder consultation meeting

The second stakeholder consultation meeting was held on November 18, 2013 at the Sri Gangarama Temple at Weliganga to appraise the affected people and other concern parties about the additional studies carried out on natural environment during the Feasibility Study Review and Detail Design Preparation (FSR &DD) stage of the Moragolla Hydropower Project (MHPP) and to introduce the Entitlement Matrix to the affected people. A total of 128 stakeholders attended the meeting. The meeting was commenced with religious observance performed by Ven. Kotikawatte Vipassi Thera. After the welcome address, by the CEB engineers, the Project Manager (PM) of the Moragolla Hydropower Project presented the design changes incorporated into the MHPP during FSR process(PowerPoint presentation is attached as Annex 3(c)). Subsequently, the National Environmental Specialist of the FSR and DD team gave a comprehensive account on potential Environment Impacts of the project, proposed measures to mitigate of minimise such impacts and the Environmental Impact Assessment procedure followed by the Ceylon Electricity Board during 2009-2012. He further mentioned that the EIA report of the project was opened for public comments in April 2013 for a period of one month and approval obtained from the Project Approving Agency (ie., Mahaweli Authority of Sri Lanka – MASL). Since CEB intend to obtain financial assistance from Asian Development Bank (ADB) for the implementation of the project, a gap analysis based on the environmental safeguard requirements of ADB followed by the following additional studies were carried out during December 2012 – May 2013 to bridge the gaps;
Water quality in the Mahaweli Ganga - upstream and downstream of the proposed dam at Moragolla;
Aquatic ecology in the Mahaweli Ganga;
Groundwater distribution and quality along the proposed tunnel route of the Project;
Land-use map of the area in the vicinity of the proposed Project;
Survey of the Rationale and Suitability of the Proposed Environmental Flow;
The Stakeholder Consultation and Disclosure Process;
Institutional Arrangements for Project Implementation;
Survey of river water quality in the Moragolla project area in the monsoon season;
Survey of the New Project Sites proposed during FSR process;
Report on river users downstream of the proposed Moragolla Dam;
Mitigating the Impacts of the Moragolla Hydropower Project on Fish;
Habitat Creation and Management to enhance Terrestrial Biodiversity;
Afforestation and Watershed Management Plan;
(A copy of the presentation is attached: annex 3(d).

During the subsequent discussion session the stakeholders raised several questions to obtain clarifications from the project team. Their opinion on the anticipated impacts and possible mitigation measures were also discussed.

The minutes of the meeting, the list of participants and the photographs of the event are attached in Annex 3(a), 3(b) and 3(e) respectively.

Questions raised and suggestions given by the participants and the clarifications made by the project team are as follows:

Question / Suggestion	Response Given
Can the Dunhinda Ela be rehabilitated by the project as it is in a dilapidated condition?	Yes, it is taken a decision to rehabilitate 400m of the canal from the intake point.
All employment opportunities shall be provided to the people of the area.	Priority will be given to the affected people and the people of the area depending on their qualifications and capabilities.
The land which will be given to affected people shall be equal or better quality and the land shall be properly developed before handing over to the recipients.	Once the financial arrangements of the project are finalised, the resettlement land will be purchased and handover to the APs.
Who will be affected in Weliganga area?	The 10 households identified in the Weliganga area to be relocated are as follows: M A N Sarath Kumara, L R M karunawathi, M A Aberatne, M G Pushpa Gunatunga, P G R R Parakramage, M G gnnaappu, P G K P Parakramage A N M Naazik, Y G Thilakaratne and N G Prematunga
Have the lands which will be inundated are gazetted	Not yet, it will be done after the project finances are finalised
Can we opt for compensation in cash.	Yes, it is possible. But, it will be more beneficial to the affected people accept the land and the house instead of cash compensation as it can take longer period to finalise the legal procedures under land acquisition laws of the country and it is necessary to prove proper ownership to obtain proper compensation. However, the legal ownership will not be considered according to the compensation payment policy of the project.
Who will be affected in Ulapane area?	The 5 households identified in the Ulapane area to be relocated are as follows: S Krishnamoorthi, T L Ranjith Liyanage, M L Danials, W M Indika weerasinghe and R M Sumanadasa
Who will be affected in Ehgala area?	Two households identified in the Ethgala area to be relocated are as follows: H M Fransis and K N S Chandakanthi,

3.3 Third multi stakeholder consultation meeting

It is proposed to have a malty stakeholder consultation meeting immediately after the Environmental Addendum and the Environmental Management Plan are prepared. The reports in Sinhala, Tamil and English languages will be disclosed to the participants. The salient features of the environmental mitigation and management plans along with monitoring mechanisms will be explained to the local people and other relevant stakeholders and a discussion on the environmental and social impacts and proposed mitigation measures will be simulated

3.4 Public disclosure

Environmental Addendum and the Environmental Management Plan will be posted on websites of ADB and CEB. They will be made available in Sinhala, Tamil and English languages for the inspection by the public at the same locations where the EIA report was made available for public inspection in April 2013 (see section 1.3 above).

Newspaper advertisements will be published, in *Dinamina* (Sinhala),*Thinakaran* (Tamil) and *Daily News* (English) papers inviting the general public to submit their comments (if any) in writing on the Environmental Addendum and the EMP to the Project Manager of MHPP of CEB.

4. Future Consultation and Disclosure

CEB will continue to consult with relevant stakeholders throughout the life cycle of the Project i.e. pre-construction (from now until construction contract is offered), construction and operation phases of the Project. It will also report ongoing consultations as part of its regular reporting requirements to ADB. In addition, monthly environmental monitoring reports will be posted on the websites of ADB and CEB for the information of wider stakeholders.

Consultation during construction will be more focussed on information on safety, community development programs, environmental monitoring, employment issues, and health awareness which will include:

- Maintain regular communications with all stakeholders, including the media
- Provide local residents with regular information on the progress of work and related implications
- Provide local residents with information on employment and training opportunities
- Maintain awareness of health and safety issues specially through the local work force
- Maintain constructive relationships between local residents and project representatives by continuing regular information meetings and informal interactions
- Identify and respond to new stakeholder issues and concerns by reviewing the complaints file and listening to stakeholders
- Ensure complaints are addressed according to the established process, and that project affected persons are educated on appropriate grievance redress procedures
- Monitor implementation and effectiveness of community development initiatives, and other social investment programs
- Ensure gender sensitive and culturally appropriate processes are used in communication and interactions

ANNEXTURES

Annex 1 (A): Newspaper advertisement, which appeared in *Dinamina* on April 01, 2013

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ජාතික පාරිසරික පනතේ 23 ආ ආ වගන්තියේ දෙවන උප ලේඛනය යටතේ දැනුම් දීමයි

මහවැලි ගඟෙහි ඉදිකිරීමට යෝජිත මොරගොල්ල ජල විදුලි බල ව්‍යාපෘතිය (මෙ. වො. 26.5) පාරිසරික බලපෑම් ඇගයීම් වාර්තාව

1988 අංක 56 සහ 2000 අංක 53 දරන පනත මගින් සංශෝධිත 1980 අංක 47 දරන ජාතික පාරිසරික පනතේ අංක 23 ආ ආ (1) වගන්තිය යටතේ පනවා ඇති නියම වලට අනුකූලව ලංකා විදුලි බල මණ්ඩලය විසින් ඉදිරිපත් කර ඇති මහනුවර දිස්ත්‍රික්කයේ. උඩපලාත හා ගඟ ඉහළ කෝරලේ ප්‍රදේශයේ මහවැලි ගඟෙහි ඉදිකිරීමට යෝජිත මොරගොල්ල ජල විදුලි බල ව්‍යාපෘතිය (මෙ. වො. 26.5) පිළිබඳ පාරිසරික බලපෑම් ඇගයීම් වාර්තාව මෙම දැන්වීම පළවන දින සිට දින 30 ක කාල සීමාවක් තුළ පෙ.ව. 8.30 සිට ප.ව. 4.00 දක්වා මහජනතාවගේ පරීක්ෂාව සඳහා පහත සඳහන් ස්ථාන වල තබනු ලැබේ. (සති අන්ත හා රජයේ නිවාඩු දිනවල හැර)

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  මූලික වැඩ පාලන හා නඩත්තු අංශය
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  රිවර් සයිඩ්, මාවතුර
* මධ්‍යම පරිසර අධිකාරියේ
  ප්‍රාදේශීය කාර්යාලය,
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  පොල්ගොල්ල.

මෙම දැන්වීමේ දිනයේ සිට වැඩ කරන දින 30 ක කාල සීමාවක් ඇතුළත ඉහත ව්‍යාපෘතිය පිළිබ මහජනතාවගේ අදහස් හා යෝජනා ඇතොත් ඒවා ලිඛිතව ශ්‍රී ලංකා මහවැලි අධිකාරියේ අධ්‍යක්ෂ ජනරාල් වෙත ඉදිරිපත් කළ යුතුවේ.

අධ්‍යක්ෂ ජනරාල්,
ශ්‍රී ලංකා මහවැලි අධිකාරිය,
අංක 500, ටී. බී. ජායා මාවත,
කොළඹ - 10

Annex 1 (B): Newspaper advertisement, which appeared in *Thinakaran* on April 01, 2013

இலங்கை மஹாவலி அதிகார சபை

தேசிய சுற்றாடல் சட்டத்தின் 23 BB பிரிவின் 2ஆம் உப பிரிவின் கீழான அறிவித்தல்

மஹாவலி கங்கையில் உத்தேசிக்கப்பட்ட மொரகொல்ல நீர்மின்சார செயற்திட்டம் (26.5MW)

சுற்றாடல் தாக்கம் தொடர்பான மதிப்பீட்டு அறிக்கை

இவ்விளம்பரத் திகதியிலிருந்து வாரஇறுதிகள் மற்றும் அரசாங்க விடுமுறைகள் நீங்கலாக, 30, நாட்களுக்கு மு.ப. 8.30 மணிக்கும் பி.ப. 4 மணிக்கு மிடையில் பின்வரும் இடங்களில், 1988ஆம் ஆண்டின் 56ஆம் இலக்கம் மற்றும் 2000ஆம் ஆண்டின் 53ஆம் இலக்க சட்டங்களினால் திருத்தம் செய்யப்பட்ட 1980ஆம் ஆண்டின் 47ஆம் இலக்க தேசிய சுற்றாடல் சட்டத்தின் 23 BB(1) ஆம் பிரிவின் கீழ் இலங்கை மின்சார சபையினால் சமர்ப்பிக்கப்பட்ட மஹாவலி கங்கையின் கண்டி மாவட்டத்திலுள்ள உடப லாத்த மற்றும் கங்க இஹல கோறளை ஆகிய இடங்களில் உத்தேசிக்கப்பட்ட 26.5 MW மொரகொல்ல நீர்மின்சார செயற்திட்ட சுற்றாடல் தாக்கம் தொடர்பான மதிப்பீட்டு அறிக்கை, பொது மக்களின் பார்வைக்காக வைக்கப்படும்.

பிரதேச செயலக அலுவலகம்
உடபலாத்த

பிரதேச சபை அலுவலகம்
உடபலாத்த

பிரதேச செயலக அலுவலகம்
கங்க இஹல கோறளை

பிரதேச சபை அலுவலகம்
கங்க இஹல கோறளை

பொறுப்பான பொறியியலாளரின் அலுவலகம்
பிரதான வேலைகளின் நிருவாகம்.
செயற்பாடு மற்றும்
பராமரிப்புப் பிரிவு
இலங்கை மஹாவலி அதிகார சபை
ஆற்றுப் பிரதேசம்
மாவதுற

மத்திய சுற்றாடல் அதிகார சபை
பிராந்திய அலுவலகம்,
அணைக்கட்டுப் பிரதேசம்
போல்கொல்ல.

நூலகம்
மத்திய சுற்றாடல் அதிகார சபை
104, டென்சில் கொப்பேகடுவ மாவத்தை,
பத்தரமுல்ல

நூலகம் - 6ஆம் மாடி
இலங்கை மஹாவலி அதிகாரசபை
500 T.B. ஜாயா மாவத்தை
கொழும்பு 10.

எந்தவொரு பொது நபரும் இவ்விளம்பரத் திகதியிலிருந்து 30 வேலை நாட்களில் மேற்குறிப்பிட்ட செயற்திட்டம், தொடர்பாக அவர்களின் கருத்துரைகளை எழுத்து மூலம் இலங்கை மஹாவலி அதிகார சபையின் பணிப்பாளருக்கு சமர்ப்பிக்கலாம்.

பணிப்பாளர் நாயகம்
இலங்கை மஹாவலி அதிகார சபை
500, T.B. ஜாயா மாவத்தை
கொழும்பு 10.

Annex 1 (C): Newspaper advertisement, which appeared in *Daily News* on April 01, 2013

ADVERTISEMENTS

MAHAWELI AUTHORITY OF SRI LANKA

NOTIFICATION UNDER SECTION 23 BB SUB SECTION (2) OF THE NATIONAL ENVIRONMENTAL ACT

Proposed Moragolla Hydropower Project on Mahaweli Ganga (26.5 MW)

ENVIRONMENT IMPACT ASSESSMENT REPORT

The Environmental Impact Assessment (EIA) Report of the Moragolla Hydropower Project proposed at Mahweli Ganga at Udapalatha and Ganga Ihala Korale in Kandy District (26.5 MW) submitted by Ceylon Electricity Board, under Section 23 BB (1) of the National Environmental Act No. 47 of 1980 as amended by Act Nos. 56 of 1988 and No. 53 of 2000, will be available for inspection by the public at the following locations between 8.30 am and 4.00 pm for a period of 30 days (except on weekends & Public Holidays) from the date of this advertisement.

* Divisional Secretariat Office
  Udapalatha.
* Divisional Secretariat Office
  Ganga Ihala Korale.
* Engineer-In-Charge Office
  Head Works Administration,
  Operation & Maintenance Div.
  Mahaweli Authority of Sri Lanka
  Riverside, Mawathura.
* Library
  Central Environmental Authority
  104, Denzil Kobbekaduwa Mawatha
  Battaramulla.
* Pradeshiya Sabha Office
  Udapalatha.
* Pradeshiya Sabha Office
  Ganga Ihala Korale.
* Central Environmental
  Authority
  Regional Office, Dam Site,
  Polgolla.
* Library - 6th Floor
  Mahaweli Authority of Sri Lanka
  500, T.B. Jayah Mawatha
  Colombo 10.

Any member of the public may within 30 working days from the date of this advertisement submit their comments in writing on the above Project to the Director General, Mahaweli Authority of Sri Lanka.

Director General,
Mahaweli Authority of Sri Lanka,
500, T.B. Jayah Mawatha,
Colombo 10.

Annex 2 (a): Minutes of the Stakeholder Meeting held on January 24, 2013

Venue	: Sri Gangarama Temple at Weliganga
Date	: January 24, 2013
Time	: 2.00 PM
Participants	: 117 (List attached – annex 2-b)
Objective	: to create awareness about Moragolla Hydropower Project amongst the affected people and the other relevant stakeholders.

The meeting was presided over by Ven. Kotikawatte VipassiThera, Chief Incumbent of the Sri Gangarama Temple at Weliganga.

Proceedings of the meeting were conducted by Mr.S.Serasinghe, National Resettlement Specialist for the Feasibility Review and Detailed Design Study Consultant Nippon Koei Co. Ltd.

Proceedings of the meeting commenced with religious observances performed by Ven. Kotikawatte VipassiThera.

A welcome address was delivered by Ms.Hemali Samaradiwakara, Project Engineer of the Moragolla Hydropower Project.

Mrs. Kamani Jayasekera, Deupty General Manager of the Ceylon Electricity Board (CEB) delivered the Keynote Address. In her speech she made a brief but informative description about the proposed Moragolla Hydropower Project. She highlighted the importance of hydropower generation being the least cost per unit of generation and a more environmental friendly mode of power generation. She further said that the proposed project will be funded by the Asian Development Bank (ADB) and assisted by the Nipon Koei Company Ltd, by providing consultancy services. She added that the Project, once commissioned, will add 27 Megawatts to National Grid. Finally, she solicited the cooperation of the affected people and other stakeholders for successful completion of the Project.

Mr. R.K.B. Gunaratne, the CEB Project Manager of the Moragolla Hydropower Project made a PowerPoint presentation (see Annex 2-c) covering all the components of the Project. He elaborated on each of the following components.

- Details about the Proposed Dam and its inundation area
- Switch Yard
- Surge Chamber
- Under Ground Tunnel
- Transmission Line
- Access Roads

He specifically mentioned that the project has been planned in such a manner that it will not pose any threat to the environment. He also, stated that the Project will bring about enormous benefits to the nation. Speaking on the entitlements of the affected people, Mr. Gunaratne said that every effort will be made to safeguard these entitlements. In preparation of the Resettlement Action Plan (RAP), the views and observations of the affected people and other stakeholders will be entertained as appropriate, he added.

Mr. S. Serasinghe who spoke next elaborated on the importance of power for the economic development of the country, particularly, advantages of development of hydropower due to its low cost of generation and environmental considerations. Speaking on resettlement planning of the Moragolla Hydropower Project he reiterated that affected people will not be in a disadvantageous position due to the Project. The Project is already in the process of developing an attractive entitlement package for affected people, he added. He further said that unstinted support of all the stakeholders, particularly, affected people, would be imperative to achieve the desired results of the Project.

The next item on the agenda was the discussion session.

Questions and issues raised by the participants and the clarifications made were as follows.

Stakeholder	Question or Issue raised	Response by : Reply
Ms. L.M. DingiriMenike	Would there be a 100 metre security zone on either side of the river coming within the proposed reservoir	A representative from the Mahaweli Authority of Sri Lanka (MASL):The river reservation of the Mahaweli River differs from place to place depending on certain factors
Mr.KelumAmarasiri	1. It is learnt that the location of the proposed dam has now been changed and it would be located 50 metres downstream. With this change will the height of the Dam be raised 2. What is the method of resettlement of affected households and payment of compensation in respect of acquired properties?	Mr. R.K.B. Gunaratne, Project Manager, Moragolla Hydropower Project: There is a possibility of moving the Dam by nearly 100 metres further downstream. Therefore the height of the Dam may be changed by a few feet. However Full Supply Level (FSL) will not be changed and hence there will be no significant change in the inundation area. Mr. S. Serasinghe, Resettlement Specialist, Nippon Koei Study Team: Provision of alternative buildings in lieu of affected houses and business establishments is being considered. Payment of compensation in respect of land and other structures will be made to bona fide claimants. An entitlement package will be introduced shortly.
Mr.Asela Suran Pathirana	At present I am running a business. If that is affected what action would be taken restore the loss.	Mr.Gunaratne, Project Manager : After a census survey and establishment of the ownership, either an alternative place will be provided or compensation will be paid depending on the circumstances.

Mr. K. D. Wimalaratne	Is the Project going to take some action against discharge of harmful effluents to the river by the Crysbro poultry farm	Mr.Gunaratne, Project Manager: This issue is not directly relevant to the Project. However, the Project will discuss this matter with the management of the poultry farm and suitable action will be initiated.
Mr. Y.G. Thilakaratne	In allocating alternative houses in lieu of those that are to be affected, are there any arrangements to provide alternative lands in similar extents in lieu of those to be acquired along with the houses	Mr.Serasinghe, Resettlement Specialist : There is no firm decision as yet whether to provide alternative lands in lieu of those are to be affected. However, action will be initiated to secure the rights of the affected people to the maximum. Development of an Entitlement Policy is underway.
Mr.KelumAmarasiri	Will the same type of alternative houses be provided to all affected households, in lieu of those affected.	Mr. S. Serasinghe : The basis for the provision of alternative houses will be the floor areas of the affected houses. Therefore sizes of the alternative houses will depend on the floor areas of the existing houses.
Mr. S.G. Premathunga	Willalternative lands be provided in lieu of the tea lands to be affected.	Mr.Gunaratne : Development of an Entitlement Policy is underway. In developing the Entitlement Policy this request will also be taken into consideration.
Ms. Soma Samaraweera	Due to the construction work of the Moragolla Project I will stand to lose my land. What action would be taken by the Project to restore the loss.	Mr.Gunaratne : All affected assets other than those that will be replaced by the Project, will be adequately and suitably compensated.
Mr. M.G. Thilakaratne	Could future meetings of this nature be held on weekend days.	Mr.Gunaratne : Some of the stakeholders such as public officers may not be willing to attend meetings on week end days due to different reasons. However, in future, attempts will be made to hold the meetings on weekend days.
Mr. A.P.A. Jayaweera	Due to the implementation of the Moragolla Hydropower Project the sand miners along the Mahaweli River, within the project area, will stand to lose their livelihood. What action will be taken by the Project to restore their livelihood.	Mr.Serasinghe : The project has already collected information on the sand miners to be affected within the project area. The Project will implement an income restoration/enhancement programme covering all genuine sand mining people.

After the discussion session Mr.Samitha Midigaspe, Chief Engineer of the Planning Division of the CEB made a few observations on the involvement of the Planning Division in the power generation projects of the CEB. He said that the Planning Division has been involved in designing many power generation projects such as the recently commissioned Upper Kotmale Hydropower Project. He further said that in the implementation of these projects the CEB has been highly concerned about the rights and entitlements of the affected people. Similarly, in the implementation of the Moragolla Hydropower Project too, a favourable Entitlement Policy will be introduced, he added.

At this stage Mr.Serasinghe opined that it would be necessary to form a Housing Committee of the affected households,to function as a forum for exchange of views and opinions between the affected households and the officials of the project. He further opined that the committee can consist of eleven (11) members, which could include the positions of a President, a Secretary, a Treasurer and eight (08) committee members. He also suggested that Ven. Kotikawatte Vipassi Thera, Chief Incumbent of the Sri Gangarama Temple be requested to be the patron of the Committee. Accordingly, a Housing Committee was elected from among the affected households. A list of the Committee Members is attached.

Mr. B.M.N. Balasooriya, Divisional Secretary, Udapalatha addressing the meeting said that his unstinted support will be extended in the implementation of the Project and securing the rights and entitlements of the affected people. He explained how he had managed to settle disputes over the land acquisition for the road projects implemented by the Road Development Authority (RDA). In the implementation of Moragolla Hydropower Project too, all problems and issues can be solved by dialogue and mutual understanding, he said.

Mr. D.G. Gunasena, Chairman, Udapalatha Pradeshiya Sabha who addressed the meeting next said that the policy of Mahinda Chinthana of **"electricity for all'** could be achieved by implementing projects of this nature. He affirmed his fullest cooperation for the Moragolla project.

Ven. Kotikawatte Vipassi Thera delivered the exhortation. In his exhortation he said that the Moragolla Hydropower Project is a project of national importance. Therefore, blessings and support for this project should be extended by all concerned parties. Particularly he requested the cooperation of the affected people for the project. At the same time the project in reciprocation bears the responsibility of securing and safeguarding the rights and the livelihood of affected people.

Mr.Chandana Abeyratne, Electrical Superintendent attached to the Moragolla Hydropower Project delivered the vote of thanks speech. Proceedings of the meeting concluded at 5.30 pm.

Annex 2 (b): List of Participants of the First Stakeholder Consultation Meeting held on January 24, 2013

Moragolla Hydropower Project - Ceylon Electricity Board

Stake Holder Meeting No:0.. (2013/01/24)

Officers from Government / Non Government Institutes

	Name	Designation & Institutes / Company	Telephone No:	E-Mail Address	Signature
01	Mrs. AMSPK Senevirathne	Senior environmental officer CEA – Kandy	081-294884	ceacpo@gmail.lk	
02	T.D.G. [illegible]	[illegible]	071-9872491	–	
03	A.H.A. Dissanayake	Divisional Environmental officer CEA – Kandy	081-2494884	–	
04	[illegible]	[illegible]	0724651624	–	
05	KAS [illegible]	[illegible]	0779877300		
06	U.B. [illegible]	[illegible]	0776091190	–	
07	A.D. [illegible]	[illegible]	0779313247		
08	CGS Gunasekara	Chief Engineer Kotmale Power Station CEB	0775076587	cekot@ceb.lk	
09	T.A.K Jayasekera	DGM(Tr. & Gen NL), CEB			
10	Upul Goonasekera	Deputy Team Leader / NK Moragolla Project	0777-253388		

	Name	Designation & Institutes / Company	Telephone No:	E-Mail Address	Signature
11	D. Sirisinghe	Consultant, N/K	0777 253395		
12	KNSM Kandaligama	PM (Moragolla P&)	0714240482	pmmhpp@ceb.lk	
13	S.H. MIDIGASPE	CE(GDS) / CEB		cegds@ceb.lk	
14	Kelum Niranjana	Civil Eng / Env. unit - CEB	011 2320012		
15	B.K. Nawarathna	Civil Eng / HAOM of MASL Kotmale project		bnawarathna@gmail.com	
16	M.A.C Rajasinghe	DEO / central environmental Authority.	0716585600		
17	B.M.N. Balasooriya	Divisional Secretary - Udapalatha	0773227130		
18	K. Vipassi Thero	GANGARAMAYA WALIGANGA. MAHATHUR	071/6611508.		
19	K. Abeysoorige	NWSDB SEA	0812388086		
20	[illegible]	[illegible]	0724606920		

	Name	Designation & Institutes / Company	Telephone No:	E-Mail Address	Signature
21	S. Dilruk Dissanayake	E/O - Udapalatha P/S	0718103811	dilrukdissanayake@yahoo.com	
22	P.M.C.A.K. Alagoda	CEB. (ES - Maragolla)			
23	H.W. [illegible]	EE, CEB			
24	K.M.N.B. Herath	ministry of industria	081-2205619		
25					
26					
27					
28					
29					
30					

දැනුවත් කිරීමේ රැස්... 2013/01/24 (වැලිගඟ ප්‍රජාශාලාව)-මොරගොල්ල ජලවිදුලි ව්‍යාපෘතිය-ලංකා විදුලි බල මණ්ඩලය

ව්‍යාපෘති කලාපය තුළ වැලි ගොඩ දැමීමේ නියුතු මහතුන්ගේ ලේඛනය

	නම	ලිපිනය	ග්‍රා: නි: වසම	දුරකථන අංකය	අත්සන
01	S.D.G. [illegible]	5A, [illegible]	[illegible]	0770317555	
02	S.D.N.S. [illegible]	[illegible]	[illegible]	0772580855	
03	R.M.H. [illegible]	[illegible]	[illegible]	0813 830 802 [illegible]	
04	S.D.D. [illegible]	221/8 [illegible]	[illegible]	0724330897	
05	D.M.A.U. [illegible]	[illegible]	[illegible]	0776785606	
06	HA. අමරසිංහ	අංක 40 [illegible]	[illegible]	0770520 656	අමරසිංහ
07	[illegible]	181/21 [illegible]	[illegible]	0777617881	

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දැනුවත් කිරීමේ රැස්වීම 2013/01/24 (වැලිගඩ ප්‍රජාශාලාව)-මොරගොල්ල ජලවිදුලි ව්‍යාපෘතිය-ලංකා විදුලි බල මණ්ඩලය 3

ව්‍යාපෘති කලාපය තුල වැලි ගොඩ දැමීමේ නියුතු මහතුන්ගේ ලේඛනය

	නම	ලිපිනය	ග්‍රා: නි: වසම	දුරකථන අංකය	අත්සන
08	ආර්. එම් [illegible]	129, මොරගොල්ල ගම්පොළ	[illegible]	0777568062	
09	S.G. පුෂ්පා	36 [illegible]	[illegible]	0773125148	
10	J A D සමරසිංහ	නො: 25/A [illegible], ගම්පොළ	[illegible] ~~[illegible]~~ (මොරගොල්ල)	077-3425743 081-2353204	
11	[illegible]	නො 149 [illegible]	[illegible]	0723231 ~~[illegible]~~ 0812350439	
12	A [illegible]	123 [illegible]	([illegible]) [illegible]	0723704615	
13	R P [illegible]	128 [illegible]	[illegible]	0776051910	
14	R.M. රත්නායක (P.D.M. [illegible])	18/3 [illegible] [illegible] - ගම්පොළ	වැලිගඩ	0723704314 0779067034 0715921788	

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දැනුවත් කිරීමේ රැස්වීම 2013/01/24 (වැලිගහ ප්‍රජාශාලාව)-මොරගොල්ල ජලවිදුලි ව්‍යාපෘතිය-ලංකා විදුලි බල මණ්ඩලය
ගොවිසංවිධාන නියෝජිත මහතුන්ගේ ලේඛනය

	නම	තනතුර සහ ගොවිසනවිධාන, ලිපිනය	දුරකථන අංකය	අත්සන
01	[illegible]	ප්‍රධාන සභාපති [illegible]	0815682481	[illegible]
02	[illegible]	[illegible]	[illegible]	[illegible]
03	[illegible]	[illegible]	-	[illegible]
04	[illegible]	සභාපති [illegible]	0776925396	[illegible]
05				
06				
07				

දැනුවත් කිරීමේ රැස්වීම 2013/01/24 (වැලිගඟ ප්‍රජාශාලාව)-මොරගොල්ල ජලවිදුලි ව්‍යාපෘතිය-ලංකා විදුලි බල මණ්ඩලය

ව්‍යාපෘති කලාපය තුල පදිංචිකරුවන්ගේ ලේඛනය

	නම	ලිපිනය හා දුරකථන අංකය	ග්‍රා: නි: වසම	අත්සන
01	R. A. විජේසිංහ	588/1A. මාවෙල පාර උලපනේ 081-3752373	උලපනේ උතුර	R. [illegible]
02	ආර්. එම්. රත්නායක	0726018695 මාවෙල පාර උලපනේ	2 උලපනේ	[illegible]
03	එල්. එම්. සිරිවර්ධන	081-2356188 නො: 588/1, මාවෙල පාර, උලපනේ	උතුර	සිරිවර්ධන
04	R.A. සෝමරත්න	නො 688/මාවෙල පාර උලපනේ	උතුර	සෝමරත්න
05	ඒ. එම්. ප්‍රනාන්දු	863/1, ප්‍රනාන්දු පාර - ඇත්ගාල වත්ත ගම්පොල	ඇත්ගාල පිංගලුව	[illegible]
06	කේ. සිරියලත් ලිනාවතී	අංක 15 - වැලිගල - කොතලේ	වැලිගල.	ලීලාවතී
07	එච්. ඒ. ආරියරත්න	අංක 17 - වැලිගල - බාබලේ	වැලිගල 071678 1726	ආරියරත්න.
08	ඩබ්. එම්. අනුර විජේසිංහ	615/2 ස්වාල වත්ත ගම උලපනේ	උලපනේ	W.M.A. විජේසිංහ
09	එම්. ජී. ගුණසේකර	8.40/3 ඇත්ගාල වත්ත	උතුර සිංගල පුර	ගුණසේකර

	නම	ලිපිනය හා දුරකථන අංකය	ග්‍රා: නි: වසම	අත්සන
08	ඩී. පී. ආර්. ආර්. පරාක්‍රම.	නො: 03/04 - වැලිගම - මාවනැල්ල. 054-56815	වැලිගම.	[illegible]
09	ඩී. පී. ප්‍රේමලතා .	11 B " " 0815716284.	"	[illegible]
10	ඩී. පී. [illegible]	11 C " "	"	
11	[illegible]	06, වැලිගම, මාවනැල්ල 0815682551	වැලිගම	[illegible]
12	[illegible]	5/1 වැලිගම, මාවනැල්ල, 0726583550	වැලිගම	[illegible]
13	H.G සෝමා [illegible]	මාවෙල පාර, උළපනේ	වැලිගම	[illegible]
14	R.A [illegible]	689 මාවෙල පාර උළපනේ	උළපනේ දකුණ ~~මාවෙල පාර~~	[illegible]
15	R.A. චන්ද්‍රිකා රත්නසිංහ	689/1, මාවෙල පාර, උළපනේ	උළපනේ දකුණ	චන්ද්‍රිකා
16	A.B. V. S. රන්ජිත් කුමාර	108 A, මාවෙල පාර, උළපනේ	උළපනේ දකුණ	[illegible]

	නම	ලිපිනය හා දුරකථන අංකය	ග්‍රා: නි: වසම	අත්සන
17	ගම්පොළවෙල - වැව ගොවිසංවිධානය සභාපති යූ.ජී. සෝමරත්න	නො.38. රත්නලුගම, ගම්පොළවෙල, ගම්පොල	ගම්පොළවෙල	[illegible]
18	එස්. පී. ජී. නිමල් සුජීව	0815613253 දෝලුව වත්ත, ගාමෙල පාර, උලපනේ.	උලපනේ දකුණ	Nimal
19	W.A. අජිත් කුමාර	0726502697 මාවෙල පාර උලපනේ	උලපනේ දකුණ	[illegible]
20	M.S. ප්‍රියංකා කුමාරි	මාවෙලපාර උලපනේ.	උලපනේ දකුණ	ප්‍රියංකා
21	පතිබා උම්මා	මාවෙලපාර උලපනේ.	උලපනේ දකුණ	පතිමා.
22	සිත්ති උම්මා	මාවෙලපාර උලපනේ	උලපනේ දකුණ	සිත්ති උම්මා
23	W.A. ජයරත්න	මාවෙලපාර උලපනේ	උලපනේ දකුණ.	[illegible]
24	සුමනා දිසා.	මාවෙලපාර උලපනේ.	උලපනේ දකුණ.	[illegible]
25	K.A.D.R.J. චන්ද්‍රසේන	මාවෙල පාර, උලපනේ	උලපනේ දකුණ	[illegible]

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	නම	ලිපිනය හා දුරකථන අංකය	ග්‍රා: නි: වසම	අත්සන
26	M.ආ. කරුණාරත්න	107 මාවෙල පාර උලපනේ 0814492626	උලපනේ දකුණ	
27	එච්.එම්. [illegible]	18/1 නාරිගම මාවත [illegible]	නාරිගම	
28	[illegible] ([illegible])	මාවෙල පාර [illegible] 0729422529	[illegible]	
29	[illegible]	අංක 48 [illegible]	නාරිගම	
30	එච්.ජී. නයනා නිර්මලා	2/107 මාවෙල පාර උලපනේ ([illegible]) 081-4992684	[illegible]	
31	M.R.O. [illegible]	මාවෙල පාර, උලපනේ.	උලපනේ	
32	S.G. [illegible]	615/4/B මාවෙල පාර උලපනේ	උලපනේ	
33	[illegible] ලියනගේ	මාවෙල පාර උලපනේ	උලපනේ	
34	එච්. [illegible]	1/107 මාවෙල පාර 081-2354471 උලපනේ	උලපනේ දකුණ	

0726436500

	නම	ලිපිනය හා දුරකථන අංකය	ග්‍රා: නි: වසම	අත්සන
35	M.G. රත්නසිංහ	අංක 401, වැලිගල, මාවතුර 0718383381	වැලිගල.	
36	A.R.M. [illegible]	0778884453 අංක 04. වැලිගල මාවතුර.	"	[illegible]
37	[illegible] තිලකරත්න.	201/1 වැලිගල, මාවතුර	වැලිගල	
38	A.A. රවුෆ් -	123, බෝගොල්ල ජනපදය 0779060587	උලපනේ	
39	[illegible]	අංක 8/6 වැලිගල. මාවතුර 0770613300	වැලිගල	
40	Y.G. [illegible]	5, වැලිගල මාවතුර 0776042845	වැලිගල	
41	W.A. සමරවීර	නො 113 මාස්වෙල/පාර උලපනේ	වැලිගල ~~උලපනේ~~ ~~උලපනේ~~	[illegible]
42	D.G.S. වසන්ත කුමාර	NO: 679/21 වාවෙල පාර දේවාලවත්ත - උලපනේ	උලපනේ දකුණ	
43	මල්කා පද්මිණි	නො 01 වැලිගල මාවතුර	වැලිගල	පද්මිණි.

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	නම	ලිපිනය හා දුරකථන අංකය	ග්‍රා: නි: වසම	අත්සන
44	W.M. ඉන්දිකා චිත්‍රසිරි විරසිංහ	615/2 . නාවෙලපාර, උලපනේ.	උලපනේ දකුණ.	ඉන්දිකා.
45	W.M. දිමුතු විරසිංහ	615/13 මාවෙල පාර උලපනේ	උලපනේ දකුණ	D. විරසිංහ
46	P.M. මාලනී [illegible]	615/2 මාවෙල පාර, උලපනේ	උලපනේ දකුණ	මාලනී.
47	M.G. කමලාවතී	මාවෙල පාර, උලපනේ ගෙදර : 49	උලපනේ දකුණ	කමලාවතී
48	P. MILTON	DANMARK ULAPANE	උලපනේ දකුණ	P. MILTON
49	S. [illegible]	[illegible]	[illegible]	[illegible]
50	G. Kumaravelu	DANMARK Ulapane	උලපනේ දකුණ	Kumaravelu.
51	K.P. හේරත් කුමාරගේ	[illegible], වැලිගල, [illegible]	වැලිගල 1158	K.P. [illegible]
52	SELVARATNAM	DANMARK ULAPANE	ULAPANE	SELVARATNAM

9

	නම	ලිපිනය හා දුරකථන අංකය	ග්‍රා: නි: වසම	අත්සන
53	පී.ඒ.සී.එම්.ජේ. විජේතුංග	ගො/12 ½ වැලිගල මාවත	වැලිගල	
54	S E M බණ්ඩා	ගො/12 වැලිගල මාවත	වැලිගල	
55	D.J. නිශාන්ත	ගො/04 වැලිගල මාවත	වැලිගල	
56	G.G. [illegible]	ගො/11-A වැලිගල. මාවත.	වැලිගල.	
57	ආර්. කේ. සෝමාවති	0783355057 අංක 841 මාවලම්විට පාර - තුන්දොළ	සිරාපුර	R.D. [illegible]
58	ආ. කේ. සෝමලතා	අංක 841/1 මාවලම්විට පාර, තුන්දොළ 0783355058	සිරාපුර	
59	Malik lawerence Daniels	075-5491509 kelehanda mahawela Rd ulapane	ulapane South	
60	Kshiwan kishnamurthi	077-9876248 mahawela Rd ulapane	ulapane South	
61	A. [illegible]	123 මවල පාර උලපනේ	උලපනේ දකුණ	

දැනුවත් කිරීමේ රැස්වීම 2013/01/24 (වැලිගහ පුස්තකාලය)-මොරගොල්ල ජලවිදුලි ව්‍යාපෘතිය-ලංකා විදුලි බල මණ්ඩලය

~~ව්‍යාපෘති කලාපය තුළ වැලි ගොඩ දැමීමේ නියුතු මහතුන්ගේ ලේඛනය~~

	නම	ලිපිනය	ග්‍රා: නි: වසම	දුරකථන අංකය	අත්සන
22	එච්. ගංගා කුමාරි	112 ද. මාවෙලවර, උලපනේ	උලපනේ [illegible]	0775528523	
23	[illegible]	[illegible] 29 [illegible] උලපනේ, 121 මාවෙලවර උලපනේ	[illegible]	07237043[illegible]	
24	A.F.M. Nazik (Abesekara)	No 10 Mawathura waligaga	udapalatha	0773050092 0774030660	
25	[illegible] (වැලිගහ)	[illegible] වර උලපනේ [illegible]	2: [illegible]	0776051910	
26	K.P. [illegible] කුමාර්	නො. 59 වැලිගහ [illegible]	වැලිගහ	072-5569140	
27	M.W.K. [illegible]	නො. 72 වැලිගහ [illegible]	වැලිගහ	0711217551	
28	[illegible]	නො. 128 [illegible] පාර උලපනේ	උලපනේ	0723704142	

01. එම්.ජී. දයාවන්ස [illegible] [illegible] [illegible]	අංක. 71. [illegible] අංක (17 [illegible]) [illegible] අංක. 11 C	[illegible] [illegible] [illegible]	0815732807 0817903644	[illegible] ([illegible]) [illegible]

Annex 2 (c): Power Point Presentation of Project Manager at the first stakeholder consultation meeting

මොරගොල්ල ජලවිදුලි ව්‍යාපෘතිය

ලංකා විදුලිබල මණ්ඩලය

වැලිගල ප්‍රජා ශාලාව

24/01/2013

යෝජිත ජලවිදුලි ව්‍යාපෘති

මොරගොල්ල	27 මෙ.වො.
බ්‍රෝඩ්ලන්ඩ්ස්	35 මෙ.වො.
ගිං ගඟ	49 මෙ.වො.
උමා ඔය	120 මෙ.වො.

සාකච්ඡාවලට අදහස් කරන ප්‍රධාන කරුණු

- මොරගොල්ල ව්‍යාපෘතිය ගැන කෙටි හැඳින්වීමක්
- ව්‍යාපෘතියේ ප්‍රධාන අංග
- ව්‍යාපෘතියේ ඉදිරි වැඩ පිළිවෙළ
- පාරිසරික බලපෑම් අධ්‍යයන ක්‍රියාවලිය
- ව්‍යාපෘතිය අමට ප්‍රදේශයට ව්‍යාපෘති අංග නිසා සිදුවන බලපෑම්
- නිමාව

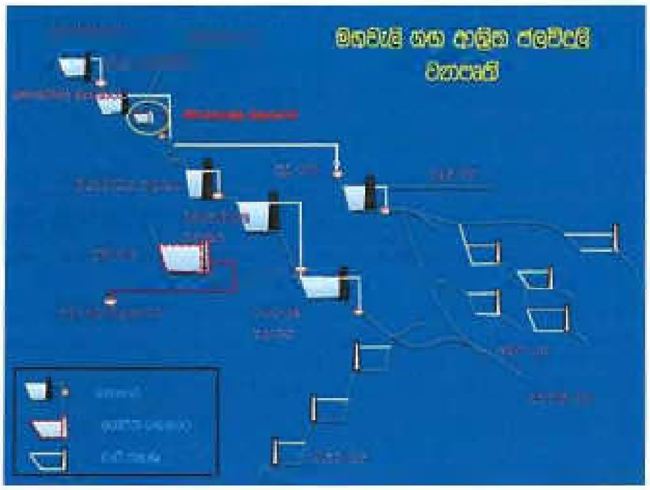
ඒ අනුව මොරගොල්ල යෝජිත ජලවිදුලි ව්‍යාපෘතියේ ශක්‍යතා අධ්‍යයන කටයුතු ගරු මහින්දානන්ද අලුත්ගමගේ හිටපු විදුලිබල නියෝජ්‍ය ඇමතිතුමාගේ කාලයේදී (2009 ජනවාරි) ආරම්භ කරන ලදී

2004 වර්ෂයේ මහින්ද චින්තන ප්‍රතිපත්ති ප්‍රකාශයෙන් ද ප්‍රධාන සංවර්ධන ව්‍යාපෘතියක් ලෙස මොරගොල්ල ජලවිදුලි බල ව්‍යාපෘතිය හඳුනාගෙන ඇත.

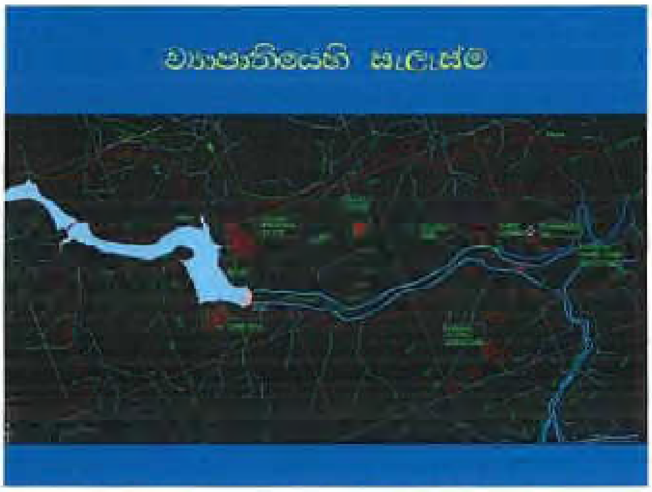
ව්‍යාපෘතියෙහි පිහිටීම

මධ්‍යම පළාත

මහනුවර දිස්ත්‍රික්කය


මහවැලි ගඟ ආශ්‍රිත ජලවිදුලි ව්‍යාපෘති


ව්‍යාපෘතියේ ප්‍රධාන අංග


ව්‍යාපෘතියෙහි සැලැස්ම


යෝජිත ප්‍රධාන වේල්ල ඉදිවන ප්‍රදේශය


ව්‍යාපෘතියේ ප්‍රධාන අංග


යෝජිත ප්‍රධාන වේල්ල ඉදිවන ප්‍රදේශය අහසේ සිට දිස්වන අයුරු

ව්‍යාපෘතියේ ඉදිරි වැඩ පිළිවෙල

ගඟ දෙපස ජලයෙන් පිරී යන කොටස්

පාරිසරික බලපෑම් අධ්‍යයන ක්‍රියාවලිය

- (CECB)

ගඟ දෙපස ජලයෙන් පිරී යන කොටස්

පාරිසරික බලපෑම් අධ්‍යයන ක්‍රියාවලිය

ව්‍යාපෘතිය ආශ්‍රිත ප්‍රදේශයට ව්‍යාපෘති අංග නිසා සිදුවන බලපෑම්

ව්‍යාපෘතිය මගින් ඇතිවන පාරිසරික බලපෑම

- නැවත පදිංචි කරවීම
  - ජලාශය පිරවීම නිසා
  - බලාගාරය සහ අධිපීඩන නල මාර්ග ඉදිකිරීම නිසා
  - අලුතින් ඉදිවන පාරවල් නිසා
  - අනිකුත් හේතූන් නිසා (අවදානම් සහගත බව)

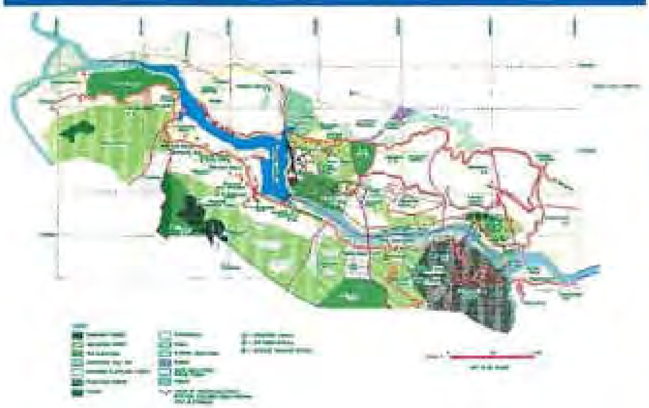
ව්‍යාපෘති අංග

ව්‍යාපෘති අංග	ග්‍රාම නිලධාරී කොට්ඨාශය	ගම
වේල්ල	උලපනේ උතුර සහ වැලිගංගා	උලපනේ සහ වැලිගංගා
ජලාශය	වැලිගංගා, කරගල්ඩෙනිය, උලපනේ උතුර සහ දකුණ	වැලිගංගා, කරගල්ඩෙනිය සහ උලපනේ
ජල ගිලීම් දොරටුව, උමග, කැපුම් ළිඳ, Penstock	උලපනේ උතුර, සිංහපුර, කම්මලදෙනිය, උඩකඩ	උලපනේ, වෙරැල්ලපිටිය, සිංහපුර සහ කම්මලදෙනිය
බලාගාරය සහ පාර, වතුර, ආගාරය, සිටුවුම ගැබ	කම්මලදෙනිය	අටබාගෙ
කැපුම් ළිඳ පාර	උලපනේ දකුණ	වෙරැල්ලපිටිය
සම්ප්‍රේෂණ රැහැන්	කම්මලදෙනිය	අටබාගෙ

නැවත පදිංචි කරවීමට යෝජිත පවුල් සංඛ්‍යාව

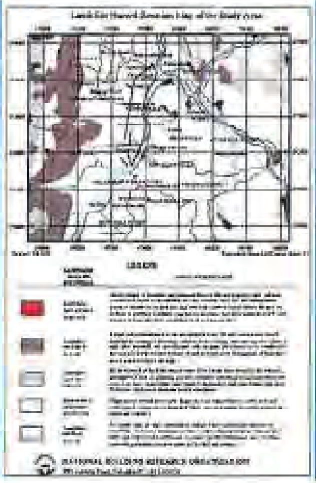
ව්‍යාපෘති අංග	නිවාස ගණන	ඉඩම් පමණක්
ජලාශය	04	02
ජලාශය, සංරක්ෂිත කලාපය, නිවාස	37	05
බලාගාරය සහ පාර, වතුර, ආගාරය, සිටුවුම ගැබ, කැපුම් ළිඳ, Penstock	02	03
එකතුව	[illegible]	10

ජනාවාස සිතියම



ව්‍යාපෘතිය මගින් ඇතිවන පාරිසරික බලපෑම...

- වේල්ල සහ පිටවුම් ඇළ අතර ජලය අඩුවීම නිසා
  - පරිසර පද්ධතියට සිදුවන බලපෑම
  - එතිහිද ඇළ වටිමාර්ග ව්‍යාපෘතියට ජලය නොලැබී යාමේ අවධානම
  - ෆාබ්ස් ප්‍රයිව් කර්මාන්තය සඳහා වන බලපෑම
- උලපනේ කර්මාන්තපුරයට සිදුවන බලපෑම
- ජලාශයට යටවන නාන තැන්
- නාය යෑම්, පාංශු ඛාදනය



අපේක්ෂිත පාරිසරික හා සමාජයීය බලපෑම් අවම කිරීම සඳහා යෝජිත ක්‍රමෝපායයන්...

- [illegible] (1.5 m³/s)
  - [illegible] (1.23 m³/s)
  - [illegible] (0.28 m³/s) [illegible]
  - [illegible] (0.01 m³/s)

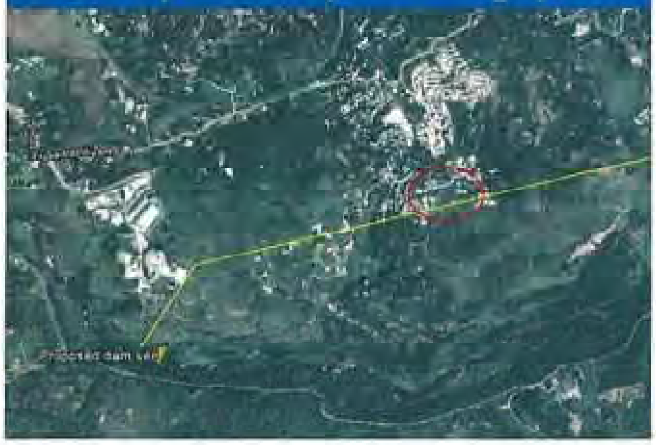
අපේක්ෂිත පාරිසරික හා සමාජයීය බලපෑම් අවම කිරීම සඳහා යෝජිත ක්‍රමෝපායන්

- අවම පරිසර හානියකින් ව්‍යාපෘතියේ සියළුම අංග සැලසුම් කිරීම
- නැවත පදිංචි කරවීම
  - [illegible] 19 [illegible]
  - [illegible]
  - [illegible]
  - [illegible]

අපේක්ෂිත පාරිසරික හා සමාජයීය බලපෑම් අවම කිරීම සඳහා යෝජිත ක්‍රමෝපායයන්...

- උළපනෙ කර්මාන්තපුරයට සිදුවන බලපෑම්
  - [illegible]
  - [illegible]
  - [illegible]

නැවත පදිංචි කිරීම සඳහා යෝජිත ප්‍රදේශය



ලංකා විදුලිබල මණ්ඩලය මගින් උන්හිඳ ඇළ ව්‍යාපෘතියට වන බාධ

- උන්හිඳ වාරිමාර්ග ඇළ සඳහා සම්පූර්ණ ජල අවශ්‍යතාවය (0.28 m³/s) ලබා දීම
  - [illegible]
  - [illegible]
  - [illegible]
  - [illegible]

ව්‍යාපෘතිය නිසා බලාපොරොත්තුවන සමාජමය සංවර්ධනය

- ව්‍යාපෘති කලාපය තුල
  - ප්‍රදේශයේ මාවත් ඇතුළු මූලික පහසුකම් වැඩි දියුණුවීම
  - කෘෂිකර්මාන්තය හා හිලව අවශ්‍ය ජලය අඛණ්ඩව සැපයීමට දායක වීම (ස්ථාවර ජල මුදා හැරීම)
  - සෘජු හා වක්‍ර රැකියා උත්පාදනය (ඉදිකිරීම් අදියර තුල)
  - ජලාශය නිසා භූගත ජල ස්තරය පෝෂණය වීම
- රට තුල
  - නිවාස ඒකක 120,000 ප්‍රමාණයකට විදුලිබලය නිපදවීම
  - රටේ ආර්ථිකයට දායක වීම
  - පරිසරය ආරක්ෂා වීම
  - නව කර්මාන්ත බිහි වීම හා නව රැකියා අවස්ථා

ඔබගේ අදහස් හා යෝජනා යොමුකල යුත්තේ

නියෝජ්‍ය සාමාන්‍යාධිකාරී
(සම්ප්‍රේෂණ හා ජනක සැලසුම්)
5 වන මහල
තැ.පෙ. 540
ලංකා විදුලිබල මණ්ඩලය
කොළඹ 02

011 2324842

Annex 2(d): Participants of the Stakeholder Consultation Meeting held on January 24, 2013

Annex 3 (a): Minutes of the Second Stakeholder Meeting held on November 18, 2013

2013/11/18 දින කොත්මලේ, වැලිගඟ, ශ්‍රී ගංගාරාම ධර්මශාලාවේදී පවත්වන ලදයෝජිත මොරගොල්ල ජලවිදුලි ව්‍යාපෘයේ බලපෑමට ලක්වන්නන්ගේ දෙවන රැස්වීමේ වැඩකටයුතු සහ සාකච්ජාකරන ලද කරුණු.

- ❖ න්‍යායපත්‍රයට අනුකූලව නිපෝන් කොයි ආයතනයේ එස්.සේරසිංහ මහතා විසින් සභාවේ වැඩකටයුතු මෙහෙයවන කරන ලදී.

- ❖ වැලිගඟ ශ්‍රී ගංගාරාම විහාරාධිපති කොටිකාවත්ත විපස්සි නාහිමියන් විසින් පැමිණිසිටි සියලුදෙනා පංචශීලයේ පිහිටවීම සිදුකරන ලදී.

- ❖ පිළිගැනමේ කථාව ලංකා විදුලිබල මණ්ඩලයේ විදුලි ඉංජිනේරු හේමාලි අමරදිවාකර මහත්මිය විසින් සිදුකරන ලදී.

- ❖ ලංකා විදුලිබල මණ්ඩලයේ මොරගොල්ල ව්‍යාපෘති කළමනාකරු ආර්.කේ.ඩී.ගුණරත්න මහතා විසින් ව්‍යාපෘතියේවත්මන් තත්වය පිළිබඳවවිස්තර කරන ලදී.

- ❖ නිපෝන් කොයි ආයතනයේ ඩබ්ලිව්.ජේ.ඩී.බී.විජේසූරිය මහතා විසින් ව්‍යාපෘති ප්‍රදේශයේ වර්ථමාන පාරිසරික තත්වය සහ ව්‍යාපෘතිය නිසා ඇතිවිය හැකි පාරිසරික බලපෑම් පිළිබඳ පැහැදිලි කරන ලදී. විශේෂයෙන් පරිසරයට සිදුවන හාණි අවම කරගනිමින් ව්‍යාපෘතිය ඉදිරියට කරගෙන යාහැකි ආකාර විස්තර කරන ලදී. මහවැලි ගඟ ආශ්‍රිතව වෙසෙන ජලජ ජීවීන්ට වන බලපෑම් සහ ඔවුන් සංරක්ෂණය කිරීම සඳහා යෝජිත උපායමාර්ග ද පැහැදිලි කරන ලදී. ජාතික පාරිසරික පනතේ විධිවිධාන යටතේ සකස් කරන ලද පාරිසරික බලපෑම් ඇගයීමේ වාර්ථාව (EIAR)සහ මෙම ව්‍යාපෘතියට මූල්‍යමය ආධාර ලබාදෙන ආසියානු සංවර්ධන බැංකුවේ (ADB)අවශ්‍යතා පිළිබඳවදපැහැදිළි කරන ලදී.

- ❖ අනතුරුව වැලිගඟ ශ්‍රී ගංගාරාම විහාරාධිපති කොටිකාවත්ත විපස්සි හිමින් විසින් අනුශාසනාවක් පවත්වමින් කියා සිටියේ,

    - ➢ මීට ප්‍රථම පවත්වන ලද රැස්වීමේදී ඉදිපත් කළ සැලැස්මට වඩා මෙවර ඉදිරිපත් කල සැලැස්ම සතුටුදායක බවත් සැමටම සාධාරණය ඉටුවී ඇති බවත්
    - ➢ රැකියා අවස්ථා ලබාදීමේදී ව්‍යාපෘති ප්‍රදේශයේ අයට ප්‍රමුඛතාවය ලබාදීම සුදුසු බවද උන් වහන්සේ ප්‍රකාශ කර සිටියහ.

- ❖ ඉනිපසු අදහස් දැක්වූ නිපෝන් කොයි ආයතනයේ එස්.සේරසිංහ මහතා විසින්බලපෑමට ලක්වන පවුල් ප්‍රතිස්ථානය කිරීම සම්බන්ධ විස්තර ඉදිරිපත් කළේය.

- ❖ මීලගට එළඹියේ විවෘත සාකච්ජා අවස්ථාවයි.

ඉඩම්,නිවාස ලාභීන්ගේ සහ ගඟ ආශ්‍රිතව ව්‍යාපාර කරන අයගේ ප්‍රශ්න,ගැටළු සහ යෝජනා සාකච්ඡා කිරීම.

ඉඩම්,නිවාස ලාභීන්ගේ සහ ගඟ ආශ්‍රිතව ව්‍යාපාර කරන අයගේ ප්‍රශ්න,ගැටළු සහ යෝජනා.		පිළිතුරු	
ප්‍රශ්නය සහ යෝජනාව ඉදිරිපත් කළ අයගේ නම	ප්‍රශ්නය සහ යෝජනා	පිළිතුරු ලබාදුන් මහතාගේ නම	පිළිතුර
කේ.ඩී.විමලරත්න (ගොවි සංවිධාන සාමාජික-ගම්පලවෙල).	01.ඇත්ගාල දුන්හිඳ ඇල දැනට කැඩී බිඳී ගොස් ඇති හෙයින් එය ප්‍රතිසංස්කරණය කරදෙනවාද යනවග	01.ආර්.කේ.ඩී.ගුණරත්න මහතා (ව්‍යාපෘති කළමනාකරු-CEB)	01.දුන්හිඳ ඇල විශාල වශයෙන් හානියට පත්වීඇති බවත් පසුගිය සතියේ වාරිමාර්ග සහ ගොවි සංවිධාන සමඟ එය නිරීක්ෂණය කරන ලද අතරඑය ප්‍රතිසංස්කරණය කිරීම අනිවාර්යයෙනම සිදුකරන බවත් ගුනරත්න මහතා පැවසීය. ඇල පටන්ගන්නා ස්ථානයේ සිට මීටර 400 ක් දක්වා දුර ප්‍රමාණයක් අළුත්වැඩියා කර දීමටත් ඉතිරි කොටසේ ජලය ලබාගන්නා ස්ථාන සකස්කරදීමට කටයුතු කරන බවත් ඒ මහතා තව දුරටත් කියා සිටියේය.
	02.විමලරත්න මහතා තව දුරටත් යෝජනා කර සිටියේ ව්‍යාපෘතියේ රැකියා ලබාදීමේදී ප්‍රදේශයේ සිටින රැකියා අපේක්ෂකයින්ට ප්‍රමුඛත්වය ලබාදිය යුතුය යන්නයි.	02. ආර්.කේ.ඩී.ගුණරත්න මහතා (ව්‍යාපෘති කළමනාකරු-CEB)	02.රැකියා ලබාදීමේදී හැකි පමණ ව්‍යාපෘති ප්‍රදේශයේම ජීවත්වනජනතාවට අවස්ථාව ලබාදීමට අදහස්කර තිබෙන බවත් එසේ සිදුකරන්නේ සුදුසුකම් සැලකිල්ලට ගැනීමෙන් බවත් ගුනරත්න මහතා කියා සිටියේය.

එම්.ජී.තිලකරත්න මහතා	මෙම ව්‍යාපෘතිය ඉදිරියට කරගෙන යාමට කිසිම ඉඩම් ලාභියෙක් විරුද්දත්වයක් ප්‍රකාශ වී නැති බවත්,එම නියා ලබාදෙන ඉඩම් හොඳ ඉඩම් වියයුතු බවත් එසේම මෙමඉඩම් සංවර්ධනය කර ඉක්මනින් ලබාදීමට කටයුතු කළයුතු බවත් තිලකරත්න මහතා කියා සිටියේය.	ආර්.කේ.ඩී.ගුණරත්න මහතා (ව්‍යාපෘති කළමනාකරු-CEB)	ව්‍යාපෘතිය සඳහා ඉඩම් අත්කරගත හැක්කේ අමාත්‍ය මණ්ඩලය විසින් ව්‍යාපෘතිය සඳහා අනුමැතිය ලබාදීමෙන් අනතුරුව බවත් ඊට පෙර ව්‍යාපෘතිය සඳහා අවශ්‍ය අරමුල් ලබාදීම පිළිබඳව ආසියානු සංවර්ධන බැංකුවේ එකගත්වය ලබාගතයුතු බවත් ව්‍යාපෘති කළමනාකාර මහතා කියා සිටියේය. එසේම අනුමැතිය ලබාගැනීමෙන් අනතුරුව අදාල අයට ඉක්මනින් ඉඩම් ලබාදීමට කටයුතු කරන බවත් ඒ මහතා කියා සිටියෙය.
අනෝජා ප්‍රියදර්ශනී මහත්මිය.	වැළිගග ප්‍රදේශයේ ඉවත්වන නිවාස ප්‍රමාණය සහ ඒවායේ අයිතකරුවන්ගේ නම් ප්‍රකාශයට පත්කරන ලෙසත් ඉල්ලාසිටින ලදී.	ආර්.කේ.ඩී.ගුණරත්න මහතා (ව්‍යාපෘති කළමනාකරු-CEB)	හඳුනාගෙන ඇති නිවාස 10 ක් බව ප්‍රකාශ කළ ව්‍යාපෘති කළමණාකාර තුමා පහත සඳහන් පරිදි ඔවුන්ගේ නම් ප්‍රකාශයට පත් කරන ලදී. 01.එම්.ඒ.එන්.සරත් කුමාර. 02.එල්.ආර්.එම්.කරුනාවතී. 03.එම්.ඒ.අබේරත්න. 04.එම්.ජී.පුෂ්පා ගුණතුංග. 05.ජී.ජී.ආර්.ආර්.පරාක්‍රමගේ. 06.එම්.ජී.දොනප්පු. 07.ජී.ජී.කේ.පී.පරාක්‍රමගේ. 08.ඒ.එන්.එම්.නාසික්. 09.වයි.ජී.තිලකරත්න. 10.එන්.ජී.ප්‍රේමතුංග. අනෙකුත් නිවාස වලට හානියක් සිදුනොවන බවත් තවද ජලයෙන් යටවන ප්‍රදේශය දැනට නිවැරදිව අදාල ස්ථාන වල ලකුණුකර ඇතිබවත් කියා සිටියේය. එමෙන්ම යටවන මාර්ගය වෙනුවට ඉදිකරන මාර්ගය වෙනුවෙන් යම් ඉඩම් ප්‍රමානයක් හානියට ලක්විය හැකියි බවත්බලපෑමට ලක්වන ඉඩම් අක්කරයට නොවැඩිනම් හා පර්චස් 40 ට වැඩිනම් අදාල ප්‍රමාණය අනුව විකල්ප ඉඩම් ලබාදෙන බවත් එම ගුණයට අයත් නොවන ඉඩම් වෙනුවෙන් වන්දි මුදල් ලබාදීමට

			කටයුතු කරන බවත් ව්‍යාපෘති කළමණාකාර මහතා කියා සිටියේය
සිලක් අබේසේකර මහතා	01.ව්‍යාපෘතියට යටවන ඉඩම් දැනට ගැසට් කර තිබේද යනවග විමසා සිටියේය.	01. ආර්.කේ.ඩී.ගුණරත්න මහතා (ව්‍යාපෘති කළමනාකරු-CEB)	01.ව්‍යාපෘතියට යටවන ඉඩම් පිළිබඳව තවමත් ගැසට්කර නොමැති බවත් එම කටයුතු මූල්‍ය ආධාර ලැබීමෙන් පසු සිදුකරනු ලබන බවත් ව්‍යාපෘති කළමණාකාරතුමා කියා සිටියේය.
	02.මෙම ව්‍යාපෘතිය ආරම්භ කිරීමට තව අවුරුදු 02 ක් පමණ ගතවිය හැකි බවත් එතෙක් තමන්ගේ ඉඩම්වල ව්‍යාපාරයක් කරගෙන යාමට නොහැකි බවත් අබේසේකර මහතා කියා සිටියේය.එම අවුරුදු 02 ක කාලයේ අපට මෙම ඉඩම්වලින් ලැබීමට තිබෙන ආදායම් නොලැබීම අසාධාරණ බවත් එතුමා ප්‍රකාශ කළේය.	02. ආර්.කේ.ඩී.ගුණරත්න මහතා (ව්‍යාපෘති කළමනාකරු-CEB)	02.මෙම කරුණ පිළිබඳව නොබෝ දිනකින් පැවැත්වෙන නිවාස කමිටු රැස්වීමේදී සවිස්තරාත්මකව සාකච්ඡා කළහැකි බව ව්‍යාපෘති කළමනාකාර මහතා කියා සිටියේය.
	03.යටවන ඉඩම් සඳහා විකල්ප ඉඩම් ලබාදීමේදී පෙර ඉඩමේ පැවති පහසුකම් නොතිබුනහොත් සිදුවන්නේ අසාධාරණයක් බැවින්, එහෙයින් ඉඩමට ඉඩමක් නොව අහිමිවන ඉඩමට වන්දියක් ලබාදීම සුදුසු බවත් ඔහු වැඩිදුරටත් කියා සිටියේය.	03.එස්.පේරසිංහ මහතා (නිපෝන්කොයි ආයතනය)	03.බලපෑමට ලක්වන ජනතාවගේ හිමිකම් පිළිබඳව පැහැදිලි කරමින් කතාකළ පේරසිංහ මහතා කියා සිටියේ බලපෑමට ලක්වන නිවාස දැනට තිබෙන ස්ථානට ආසන්නයේ ප්‍රතිස්ථාපනය කිරීමට සැලසුම්කර ඇති බවයි. තව දුරටත් අදහස් දැක් වූ ඒ මහතා කියා සිටියේ බලපෑමට ලක්වන ඉඩම් වෙනුවට විකල්ප ඉඩම් දීමේ ප්‍රතිපත්තියක් අනුගමනය කරන ලද්දේ බලපෑමට ලක්වන ජනතාවගේ යහපත සඳහා බවත් ඉඩම් වලට වන්දි ගෙවීමේදී මෙම ඉඩම් සඳහා නීතිමය හිමිකම් තහවුරු කළයුතු බවත් ය. විකල්ප ඉඩම් ලබාදීමේදී බලපෑමට ලක්වන ඉඩම් සඳහා නිත්‍යානුකූල අයිතිය පිළිබඳ

			තැකීමක් නොකරන බැවින් සීමා දිනිය වනවිට එම ඉඩම් පරිහරණය කළ බවට තහවුරු කරගැනීම පමණක් සිදුකරනු ලබන බවත් ඔහු කියා සිටියේය.
එච්.එම්.කේ.බන්ඩාර මහතා (ග්‍රාමනිළධාරී-අමුණුපුර)	දැනට වැලි ගොඩ දමන අය සඳහා අහිමිවන විකල්ප වැලි ගොඩදමන ස්ථාන ලබාදෙන බවට ව්‍යාපෘතිය මගින් පොරොන්දු වී ඇති බැවින් එසේ විකල්ප වැලි ගොඩදමන ස්ථාන ලබාදෙන්නේ කෙසේද යනවග විමසා සිටියහ.	එස්.සේරසිංහ මහතා (නිපෝන්කොයි ආයතනය)	මෙයට පිළිතුරු දෙමින් කතාකළ සේරසිංහ මහතා කියා සිටියේ බලපෑමට ලක්වන වැලි ගොඩදමන අය සඳහා විකල්ප ස්ථාන නොව විකල්පආදායම් මාර්ග හඳුන්වාදෙනු ලබන බවය.
ඉන්දික මහතා	උලපනේ ප්‍රදේශයේ ඉවත්වන නිවාස ප්‍රමාණය සහ ඒ ඉවත් වන අයගේ නම් දැනගැනීමට සළස්වන ඉල්ලා සිටියේය.	ආර්.කේ.ඩී.ගුණරත්න මහතා (ව්‍යාපෘති කළමනාකරු-CEB)	හඳුනාගෙන ඇති නිවාස 05 ක බවත් එම නිවාස හිමිකරුවන්ගේ නම් පහත සඳහන් පරිදි වන බවත් ගුනරත්න මහතා කියා සිටින ලදී. 01.එස්.ක්‍රිෂ්ණමූර්ති. 02.ටී.එල්.රන්ජිත් ලියනගේ. 03.එම්.එල්.ඩැනියල්ස්. 04.ඩබ්ලිව්.එම්.ඉන්දික වීරසිංහ. 05ආර්.එම්.සුමනදාස.
රවින්ද්‍ර සමරසිංහ මහතා	01.ඇත්ගාල ප්‍රදේශයේ ඉවත්වන නිවාස ප්‍රමාණය සහ ඒ ඉවත් වන අයගේ නම් දැනගැනීමට සළස්වන මෙන් ඉල්ලා සිටියේය.	01.ආර්.කේ.ඩී.ගුණරත්න මහතා (ව්‍යාපෘති කළමනාකරු-CEB)	01.හඳුනාගෙන ඇති නිවාස 02ක් බැවින් ඒවායේ හිමිකරුවන්, 01.එච්.එම්.ෆැන්සිස් 02.කේ.එන්.එස්.චන්ද්‍රකාන්ති. යන අය බවත් ගුනරත්න මහතා කියා සිටියේය. තවද දැනට කර තිබෙන සමීක්ෂණ අනුව ෆැන්සිස් මහතාගේ නිවාසය පමණක් බලපෑමට ලක්වන බව සොයාගෙන තිබෙන බවත් බොහෝවිට චන්ද්‍රකාන්ති මහත්මියගේ නිවාසය අහිමි නොවීමට ඉඩ ඇති බවත් ඔහු කියා සිටියේය.

	02. බලපෑමට ලක්වන නිවාස සඳහා විකල්ප නිවාස ලබාදීම වෙනුවට වන්දි මුදල් ලබාගත හැකිද යන්න විමසා සිටියේය.	02.එස්.සේරසිංහ මහතා (නිපෝන්කොයි ආයතනය)	02.බලපෑමට ලක්වන නිවාස සඳහා වන්දි මුදල් ගෙවනු ලබන්නේ ඉඩම් අත්කරගැනීමේපනතේ විධිවිධාන අනුව අදාල ප්‍රාදේශීය ලේකම් විසින් බවත් එසේ වන්දි ලැබීමට නම් එම නිවාස දේපල සඳහා නීත්‍යානුකූල අයිතිය තහවුරු කළයුතු බවත් සේරසිංහ මහතා කියා සිටියේය. විකල්ප නිවාස ලබාදීමේදී නීත්‍යානුකූල අයිතිය සැළකිල්ලට නොගන්නා බැවින් සීමා දිනය වන විට බලපෑමට ලක්වන නිවාස වල පදිංචිව සිටීම පමණක් ප්‍රමාණවත් වන බවත් ඒ මහතා තවදුරටත් කියා සිටියේය.
	03.දැනට තිබෙන සැලැස්ම අනුව මෙම ව්‍යාපෘතියේ,බලාගාර ප්‍රදේශය ඉදිවන විට ඒ අදාල පස් සහ ගල් ගොඩ කිරීමට බලාපොරොත්තුවෙන් සිටින්නේ තමාගේ ඉඩමෙ බැවින් එහිදී එකවරම ඉඩම සම්පූර්ණයෙන් පිරවුවහොත් තමාගේ හරිතාගාර ව්‍යාපාරය කරගෙන යා නොහැකියි බවත් ඊට හේතුව එවා සම්පූර්ණයෙන්ම කඩා දැමියයුතු වීම බැවින් ඒ නිසා එයට පිළියමක් වශයෙන් මෙය කොටස් දෙකකට පිරවිය හැකිද යන්න ගැන විමසා සිටියේය.	03.ආර්.කේ.ඩී.ගුණරත්න මහතා (ව්‍යාපෘති කළමනාකරු-CEB)	03.මෙමෙ ඉඩම් කොටස ව්‍යාපෘතියේ ඉදිරි වැඩකටයුතු වෙනුවෙන් ලබාදීම ගැන සමරසිංහ මහතාට ස්තුති කළ ගුනරත්න මහතා කියා සිටියේ යෝජනා කරන ලද ආකාරයට කටයුතුකළ හැකි බවත්ය.

- ❖ සාකච්ජා වාරයෙන් අනතුරුව කතාකළඋඩ පළාත ප්‍රාදේශීය ලේකම්තුමා කියා සිටියේ රට තුල සිදුකරගෙන යන සංවරධන කටයුතු සඳහා සියළු දෙනාගේ සහයෝගය අවශ්‍ය බවත් ව්‍යාපෘතිය සඳහා ඉඩම් අත්කරගැනීම ඇතුළු ප්‍රතිස්ථාපන කටයුතු සඳහා තමාගේ හා තම කරය මණ්ඩලයේ සහයෝගය ලැබෙන බවත් ඔහු කියා සිටියේය
- ❖ ඉන්පසු අදහස් දැක්වූ ගඟ ඉහල කෝරලේප්‍රාදේශීය ලේකම්තුමා කියා සිටියේරටේ සංවර්ධන කටයුතු සඳහා බලශක්තිය අත්‍යාවශ්‍ය වන බවත් මෙවැනි ව්‍යාපෘති සඳහා සියයට සියයක් සහයෝගය ලැබියයුතු බවත් ඔහු කියා සිටියේය.
- ❖ ලංකා විදුලිබල මණ්ඩලයේ,මොරගොල්ල ව්‍යාපෘතියේ, සිවිල් ඉංජිනේරු අශාන්දිසානායක මහතා විසින් ස්තුති කථාව කිරීම.
- ❖ පස්වරු 5.30 ටසභාවේ වැඩ කටයුතු අවසන් විය.

Annex 3 (b): List of Participants of the second stakeholder consultation meeting held on November 18, 2013

Moragolla Hydropower Project - Ceylon Electricity Board
Second Stake Holder Meeting (2013/11/18)
Attendance List - Officers From Government & Other Institutes / Organizations

3

No.	Name	Designation & Intitute	Telephone No	E - Mail Address	Signature
8	K. M. Geetha Malkanthi	Colonization officer, Divisional secretariat Ganga Ihala Korale.	0812352604.	geethabugma@yahoo.com.	
9	Mallika . M. Abeykoon	Grama Niladhari, Singhapura 1076	0779216679		
10	B. K. Hawarathna	Civil Engineer. Mahaweli Authority kotmale project	0776301143	HAOMkotmale@yahoo.com	
11	A. H. A. Dissanayake	Divisional Envi officer, CEA, Polgolla (Gangaihala Division)	077-9783539	—	
12	A. D. Heleruma.	Govijanaseva	0779313207	—	
13	Sanan Perera	OSEL Shee (PVT) LTD	0722220355		
14	H. M. K [illegible]	[illegible]	0718009265		

Moragolla Hydropower Project - Ceylon Electricity Board

Second Stake Holder Meeting (2013/11/18)

Attendance List - Officers From Government & Other Institutes / Organizations

3

No.	Name	Designation & Intitute	Telephone No	E - Mail Address	Signature
15	D.M. [illegible]	ග්‍රාම නිලධාරි 1167 [illegible]	0725388797		[signature]
16	M M S [illegible]	[illegible]	0778197278		[signature]
17	PS 45134 [illegible]	[illegible]	07765135		[signature]
18	[illegible]	ග්‍රාම නිලධාරි / [illegible]	0724655624		[signature]
19	I.D. Bandara	Land officer udapalatha Div. Sec. office	0718357484		[signature]
20	D.B. Rathnayake	R.M.A.S. Divisional Secretarial Udapalatha	0776992211		[signature]
21	U.B. [illegible]	[illegible], 1072-[illegible]	0776091196		[signature]

3

Moragolla Hydropower Project - Ceylon Electricity Board

Second Stake Holder Meeting (2013/11/18)

Attendance List - Officers From Government & Other Institutes / Organizations

3

No.	Name	Designation & Intitute	Telephone No	E - Mail Address	Signature
22	T. D. [illegible]	[illegible]	071-9872491	—	
23	K A S [illegible]	[illegible]	077 9877300		
24	J. M. D. K. [illegible]	[illegible]			
25	S. Baditotuwa	Human Resource & Institutional Development officer MASL - Kotmale	0772429374		
26	T. A. D. W. Dayananda	Divisional Secretary Div. Sec. - Ganga Ihala Korale	071 4400317		
27	B. M. P. G. P. R. Bandara.	Divisional Secretary (Acting) Udapalatha -	0719003096	pobandara@gmail.com	
28	T. N. Amman	Sri Lanka Administrative Officer	0713307056	amountn@gmail.com	

4

Moragolla Hydropower Project - Ceylon Electricity Board
Second Stake Holder Meeting (2013/11/18)
Attendance List - Officers From Government & Other Institutes / Organizations

No.	Name	Designation & Intitute	Telephone No	E - Mail Address	Signature
29	A.H. Dissanayake	Civil Eng. CEB - MOGL .	0718418014	hansike039@yahoo.com.	Ashen
30	PIM e.a.k. Abeyarathna	" " "	0718014022	pimcak@gmail.com	
31.	H.W. Amaradiwakara	EE , CEB	.	eemdd@ceb.lk.	
32	U.S Goonasekera	Deputy TEAM LEADER NIPPON KOEI	0777-252388	upulg77@yahoo.co.uk	
33	R.C.B Gunaratne	CEB, PM .	071-4530922	pmmdd@ceb.lk.	
34	S. Samarasinghe	N/K , Sociologist	0777 215391		
35	W.A.D.D. Wijesooriya.	N/K National Environment Specialist.	0777253397	wijesooriya.wadd@gmail.com	

Govt. officials

Attendance - Stake holder meeting

2013 - 11 - 18

Name නම	Designation & Institute තනතුර	Address ලිපිනය	Contact Number දුරකතන අංකය	Signature අත්සන
36. S. [illegible]	[illegible]	[illegible]	0812353218	[signature]
37 G. L. C. [illegible]	[illegible]	[illegible]	081-2352222	[signature]
38. [illegible]	[illegible]	[illegible]	0716611508	[signature]

මොරගොල්ල ජල විදුලි ව්‍යාපෘතිය ලංකා විදුලි බල මණ්ඩලය

දැනුවත් කිරීමේ දෙවන රැස්වීම 2013/11/18 (වැලිගඟ ගංගාරාම විහාරස්ථානය)

ව්‍යාපෘති කලාපය තුල පදිංචිකරුවන්ගේ නාම ලේඛණය

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අංකය	නම	ලිපිනය	ග්‍රා.නි.වසම	දුරකථන අංකය	අත්සන
01	[illegible]	අංක 205 [illegible], ගම්පොල	[illegible]	0813812578	S. [illegible]
02	පී.ජී.කේ.පී. [illegible]	අංක [illegible] වැලිගඟ, මාවතුර	වැලිගඟ	0814870100	[illegible]
03	ඩබ්.ආර්.ජී. [illegible]	උලපනේ, [illegible]	උලපනේ	—	[illegible]
04.	ඩබ්.එම්.ජී. [illegible]	අංක, 30/2 වැලිගඟ, මාවතුර.	වැලිගඟ	077-4812951	[illegible]
05.	P.G. [illegible]	අංක 30/5 වැලිගඟ, මාවතුර.	වැලිගඟ.	054-4904213	[illegible]
06.	W.G. ජයවර්ධන.	අංක, 29 වැලිගඟ මාවතුර.	වැලිගඟ.	081-2353916	[illegible]
07.	M.G. [illegible]	අංක, 1/5 වැලිගඟ මාවතුර	වැලිගඟ.	072-6583550	[illegible]

මොරගොල්ල ජල විදුලි ව්‍යාපෘතිය ලංකා විදුලි බල මණ්ඩලය

දැනුවත් කිරීමේ දෙවන රැස්වීම 2013/11/18 (වැලිගග ගංගාරාම විහාරස්ථානය)

ව්‍යාපෘති කලාපය තුල පදිංචිකරුවන්ගේ නාම ලේඛණය

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අංකය	නම	ලිපිනය	ග්‍රා.නි.වසම	දුරකථන අංකය	අත්සන
08	ආර්. ආර්. ජයසුන්දර	නො: 3/4 වැලිගග කාවතුර	වැලිගග	0545681597	[illegible]
09.	ජී.ජී. රත්නප්‍රිය ප්‍රියන්ත කුමාර ද සිල්වා	11-A, වැලිගග, කාවතුර	1188 - වැලිගග	077-6686203	[illegible]
10.	ජී.ජී. ප්‍රේමලතා	11-B, වැලිගග, කාවතුර	1188 - වැලිගග	081-5716284	[illegible]
11	එච්.ජී. තිලකරත්න	26/11 වැලිගග, කාවතුර	1188 වැලිගග	0812353788	[illegible]
12	[illegible]	17/1 [illegible]	1188 - [illegible]	0817903644 ~~071[illegible]~~	[illegible]
13	D.G.S. බණ්ඩාර [illegible]	679/21 [illegible] උඩපලාත	උඩපලාත [illegible]	0718288821	[illegible]
14.	L.R.M. [illegible]	නො: 04 වැලිගග කාවතුර	වැලිගග	0813753713	[illegible]

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මොරගොල්ල ජල විදුලි ව්‍යාපෘතිය ලංකා විදුලි බල මණ්ඩලය

දැනුවත් කිරීමේ දෙවන රැස්වීම 2013/11/18 (වැලිගඟ ගංගාරාම විහාරස්ථානය)

ව්‍යාපෘති කලාපය තුල පදිංචිකරුවන්ගේ නාම ලේඛණය

අංකය	නම	ලිපිනය	ග්‍රා.නි.වසම	දුරකථන අංකය	අත්සන
15	W.A. සමරවීර	නො 113, මාස්වෙල/වාර උලපනේ	උලපනේ දකුණ		
16	[illegible]	83/2 [illegible]	[illegible]	081 2788831 0724163208	
17	M.A.S.M. මාවලගම	අංක 01 වැලිගල මාවත	වැලිගල	0752708274	
18	[illegible]	[illegible]	වැලිගල 1188	0729310853	
19	W.M.I.W. විරසිංහ	65/2 මාවෙලවාර උලපනේ	උලපනේ දකුණ	077-6224243	
20	D.M. [illegible]	[illegible]	[illegible]	[illegible]	
21	[illegible]	උලපනේ දකුණ	උලපනේ උතුර	0778587218	

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මොරගොල්ල ජල විදුලි ව්‍යාපෘතිය ලංකා විදුලි බල මණ්ඩලය
දැනුවත් කිරීමේ දෙවන රැස්වීම 2013/11/18 (වැලිගඟ ගංගාරාම විහාරස්ථානය)
ව්‍යාපෘති කලාපය තුළ පදිංචිකරුවන්ගේ නාම ලේඛණය

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අංකය	නම	ලිපිනය	ග්‍රා.නි.වසම	දුරකථන අංකය	අත්සන
22	ධර්මවර්ධන	දුංක 113 B මාවෙල පා/උඩපනේ	උ. දකුණ		[illegible]
23	[illegible]	[illegible]	දකුණ		[illegible]
24	M.G. කුමාරමනී	මාවෙල්පාර උඩපනේ	උ. දකු.		[illegible]
25	K.G. කරුණාරත්න	107, මාවෙලාර උඩපනේ	උ. දකු.		[illegible]
26	K.G. කරුණාරත්න	වැලිගල, උඩපනේ	වැලිගල		[illegible]
27	සෝමා සමරවීර	113 මාවෙලපාර උඩපනේ	උ. දකුණ		[illegible]
28	m.m.m. නජීම්	123 මාවෙල පාර උඩපනේ	උ. දකුණ	08123537[illegible] 0778346768	[illegible]

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<u>මොරගොල්ල ජල විදුලි ව්‍යාපෘතිය ලංකා විදුලි බල මණ්ඩලය</u>

<u>දැනුවත් කිරීමේ දෙවන රැස්වීම 2013/11/18 (වැලිගඟ ගංගාරාම විහාරස්ථානය)</u>

<u>ව්‍යාපෘති කලාපය තුල පදිංචිකරුවන්ගේ නාම ලේඛණය</u>

අංකය	නම	ලිපිනය	ග්‍රා.නි.වසම	දුරකථන අංකය	අත්සන
29	A R M HASSAN	[illegible]			[signature]
30	A. Raufh.	123/D, Mawela Road UP.		0779060587	[signature]

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මොරගොල්ල ජල විදුලි ව්‍යාපෘතිය ලංකා විදුලි බල මණ්ඩලය

දැනුවත් කිරීමේ දෙවන රැස්වීම 2013/11/18 (වැලිගගා ගංගාරාම විහාරස්ථානය)

ගොවි සංවිධාන නියෝජිතයන්ගේ නාම ලේඛණය

අංකය	නම	ලිපිනය	ග්‍රා.නි.වසම	දුරකථන අංකය	අත්සන
1	[illegible]	18/2 [illegible]	[illegible] 1188		[illegible]
2	[illegible]	[illegible]	[illegible]	077-9097207	[illegible]
3	[illegible]	73 [illegible]	[illegible]	0776921396	[illegible]
4	[illegible]	[illegible]	[illegible]	0815611808	[illegible]

මොරගොල්ල ජල විදුලි ව්‍යාපෘතිය ලංකා විදුලි බල මණ්ඩලය

දැනුවත් කිරීමේ දෙවන රැස්වීම 2013/11/18 (වැලිගල ගංගාරාම විහාරස්ථානය)

ව්‍යාපෘති කලාපය තුල පදිංචිකරුවන්ගේ නාම ලේඛණය

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අංකය	නම	ලිපිනය	ග්‍රා.නි.වසම	දුරකථන අංකය	අත්සන
1	එම්. ජී. පුංචිබණ්ඩා	පුන්හිඳ පාර, ඇත්ගොඩ ගම්පොල	සිංහපුර	0813813715	
2	ජේ. ඩී. විමලරත්න	73 කෙළඹගේ ගම්පොල	ගම්පොලවෙල	0776925396	
3.	එම්. ජී. සෝමාවතී.	05, වැලිගල, මාවතුර	වැලිගල.	071 8067878	
4.	බාලසිංහ ආරච්චිගේ	අංක 17 වැලිගල, මාවතුර	වැලිගල	0776781726	
5	එම්. ජී. සෝමදාස	අංක 31 වැලිගල මාවතුර	〃	081 2353797	
6.	කේ. ජී. ප්‍රියන්ත	〃 〃 〃 〃	〃	〃	
7.	කේ. ජී. උදයරත්න	〃 〃 〃	〃	081 2353880	උදයරත්න.

මොරගොල්ල ජල විදුලි ව්‍යාපෘතිය ලංකා විදුලි බල මණ්ඩලය

දැනුවත් කිරීමේ දෙවන රැස්වීම 2013/11/18 (වැලිගඟ ගංගාරාම විහාරස්ථානය)

ව්‍යාපෘති කලාපය තුල පදිංචිකරුවන්ගේ නාම ලේඛණය

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අංකය	නම	ලිපිනය	ග්‍රා.නි.වසම	දුරකථන අංකය	අත්සන
8	[illegible]	වැලිගඟ [illegible]	වැලිගඟ	[illegible]	[illegible]
9	එච්.ජී. ප්‍රේමතිලක	NO-06, වැලිගල, බටහිර	වැලිගල	081-5682586	[illegible]
10	[illegible]	[illegible]	〃 〃		[illegible]
11	ඩී.ජී.එස්. විපුල බණ්ඩාර	"කුසුම්", රාවණාතොට. විහාරමහාදේවි	රාවණාතොට බටහිර	051 3501112	[illegible]
12	එම්.ජී. රන්මැණිකා.	නො: 40/1 වැලිගඟ පාර	වැලිගඟ.	0718383381	[illegible]
13	R.M. කුමාරිහාමි	[illegible] උලපනේ	උලපනේ	077-1941340	[illegible]
14	ඊ.ජී. චන්ද්‍රා කුමාරිහාමි	26, වැලිගඟ, [illegible]	වැලිගඟ.	0815680290	[illegible]

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මොරගොල්ල ජල විදුලි ව්‍යාපෘතිය ලංකා විදුලි බල මණ්ඩලය

දැනුවත් කිරීමේ දෙවන රැස්වීම 2013/11/18 (වැලිගඟ ගංගාරාම විහාරස්ථානය)

ව්‍යාපෘති කලාපය තුල පදිංචිකරුවන්ගේ නාම ලේඛනය

අංකය	නම	ලිපිනය	ග්‍රා.නි.වසම	දුරකථන අංකය	අත්සන
15	එස්.ජී. ධම්සිරි	100, වැලිගඟ, මාවතුර, ගම්පොල.	වැලිගඟ	0815682094	[illegible]
16	B.M. තිලකසිරි බණ්ඩාරනායක	මාවෙල පාර උලපනේ.	ගඟහිහල	081-4997435	[illegible]
17	ගමගේ සුජිත් කුමාර පෙරේරා	10, වැලිගඟ, මාවතුර	වැලිගඟ	072-1822259	[illegible]
18	L.R. [illegible]	[illegible] පාර, [illegible], ගම්පොල	ගම්පොල [illegible]	077 0981461	[illegible]
19	R.A විජේසිංහ	නො: 1/588 මාවෙල පාර උලපනේ	ගඟහිහල		[illegible]
20	R.A. [illegible]	නො: 688/6, මාවෙල පාර උලපනේ	ගඟ හිහල	0523528112	[illegible]
21	S. Jayakumar	No 688/6 Mawela Road Ulapane	Ganga Hihala	0523528112	[illegible]

මොරගොල්ල ජල විදුලි ව්‍යාපෘතිය ලංකා විදුලි බල මණ්ඩලය

දැනුවත් කිරීමේ දෙවන රැස්වීම 2013/11/18 (වැලිගඟ ගංගාරාම විහාරස්ථානය)

ව්‍යාපෘති කලාපය තුල පදිංචිකරුවන්ගේ නාම ලේඛණය

අංකය	නම	ලිපිනය	ග්‍රා.නි.වසම	දුරකථන අංකය	අත්සන
22	W A [illegible] කුමාර	108 A මාවෙල පාර උලපනේ	උලපනේ දකුණ		[illegible]
23	[illegible]	679/17 මාවෙල පාර උලපනේ			PARA[illegible]
24	[illegible]	107/ මාවෙල පාර උලපනේ	උලපනේ දකුණ		[illegible]
25	A - [illegible]	123, මාවෙල පාර, උලපනේ	උලපනේ දකුණ		FAREED N.
26	A A [illegible]	123, මාවෙල පාර, උලපනේ	උ/ දකුණ.	0779632837	[illegible]
27	P.G. [illegible]	11/C වැලිගහ මාවත	වැලිගහ		[illegible]
28	A.B. [illegible] රංජිත් කුමාර	108/A, මාවෙල පාර, උලපනේ	උ/ දකුණ		[illegible]

මොරගොල්ල ජල විදුලි ව්‍යාපෘතිය ලංකා විදුලි බල මණ්ඩලය
දැනුවත් කිරීමේ දෙවන රැස්වීම 2013/11/18 (වැලිගඟ ගංගාරාම විහාරස්ථානය)
ව්‍යාපෘති කලාපය තුල පදිංචිකරුවන්ගේ නාම ලේඛණය

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අංකය	නම	ලිපිනය	ග්‍රා.නි.වසම	දුරකථන අංකය	අත්සන
29.	M.L. [illegible]	43, [illegible], [illegible]	[illegible]		[illegible]
30	M. L Daniels.	Kelehanda mahawela Rd ulapane	Ulapane south	075-5491509	[illegible]
31	[illegible]	114 මාවෙල පාර [illegible]	[illegible]	0771360660	[illegible]
32	[illegible]	මාවෙල පාර [illegible] - [illegible]	[illegible]	072-4049289	[illegible]
33	[illegible]	112-3 [illegible]	[illegible]	0726720123	[illegible]
34	A. F. M NAZIK	30/3 NAWALAPITIYA ROAD. GAMPOLA	ULAPANE.	077-3050092	[illegible]
35	W.M. [illegible]	මාවෙල පාර [illegible]	[illegible]	0724812405	W.M. [illegible]

මොරගොල්ල ජල විදුලි ව්‍යාපෘතිය ලංකා විදුලි බල මණ්ඩලය

දැනුවත් කිරීමේ දෙවන රැස්වීම 2013/11/18 (වැලිගඟ ගංගාරාම විහාරස්ථානය)

ව්‍යාපෘති කලාපය තුළ පදිංචිකරුවන්ගේ නාම ලේඛණය

අංකය	නම	ලිපිනය	ග්‍රා.නි.වසම	දුරකථන අංකය	අත්සන
36.	[illegible]	[illegible]	[illegible]	[illegible]	
37.	T.L. රංජනී [illegible]	මාවෙල පාර [illegible]	[illegible]	075-6257636	[illegible]
38.	H. සන්ධ්‍යා කුමාරි	නො: 47. වැලිගඟ [illegible]	වැලිගඟ.	0	Sandana.
39.	B.G. [illegible]	[illegible]	[illegible]		[illegible]
40.	K.P තරංග [illegible]	අංක 49 වැලිගඟ	වැලිගඟ		[illegible]
41.	M.S. Preema	අංක 74/9 [illegible]	වැලිගඟ		[illegible]

මොරගොලුව් ජල විදුලි ව්‍යාපෘතිය ලංකා විදුලි බල මණ්ඩලය
දැනුවත් කිරීමේ දෙවන රැස්වීම 2013/11/18 (වැලිගඟ ගංගාරාම විහාරස්ථානය)
වැලි ගොඩ දැමීමේ නියුතු අයගේ නාම ලේඛණය

අංකය	නම	ලිපිනය	ග්‍රා.නි.වසම	දුරකථන අංකය	අත්සන
01	SAD [illegible]	නො: 85/A [illegible], [illegible]	[illegible]	0773425743	[illegible]
02	[illegible]	නො: 149, [illegible], [illegible]	[illegible]	0774743978	[illegible]
3	H A [illegible]	නො 40 [illegible] [illegible]	[illegible]	0770520656	[illegible]
04	[illegible]	නො 14/1 A [illegible] [illegible]	[illegible]	0770568083	[illegible]
05	[illegible]	36. [illegible] [illegible] [illegible]	[illegible]	0779067034 0723704514	[illegible]
06	R P [illegible]	126 [illegible], [illegible]	[illegible]	0776051910	[illegible]
07	A.M.A.U. [illegible]	44 [illegible]	[illegible]	0776725606	[illegible]

මොරගොලල් ජල විදුලි ව්‍යාපෘතිය ලංකා විදුලි බල මණ්ඩලය

දැනුවත් කිරිමේ දෙවන රැස්වීම 2013/11/18 (වැලිගඟ ගංගාරාම විහාරස්ථානය)

වැලි ගොඩ දැමීමේ නියුතු අයගේ නාම ලේඛණය

අංකය	නම	ලිපිනය	ග්‍රා.නි.වසම	දුරකථන අංකය	අත්සන
08	S.D.J. පුනාන්දු	22/8 කුඹි පහල කොටස ගස්ගොඩ	[illegible]	0724330897	
09	නිහාල් සිසිර කුමාර	4/1 කුඹි පහල කොටස ගස්ගොඩ	නවදෙව්ට	0772580855	
10	B.D සිරිසේන	18/2 [illegible] ගස්ගොඩ	[illegible]	0777617881 ~~[illegible]~~	
11	[illegible]	[illegible]	නවදෙව්ට	0913830802	
12	D M ජයසේකර	නවදෙව්ට [illegible]	නවදෙව්ට	0775882756 ~~[illegible]~~	
13	S.B [illegible]	නවදෙව්ට ගල්මල	නවදෙව්ට	59	
14.	S.D.G. [illegible]	5/A, [illegible]	[illegible]	0720317555	

මොරගොලල් ජල විදුලි ව්‍යාපෘතිය ලංකා විදුලි බල මණ්ඩලය

දැනුවත් කිරිමේ දෙවන රැස්වීම 2013/11/18 (වැලිගඟ ගංඝාරාම විහාරස්ථානය)

වැලි ගොඩ දැමීමේ නියුතු අයගේ නාම ලේඛණය

අංකය	නම	ලිපිනය	ග්‍රා.නි.වසම	දුරකථන අංකය	අත්සන
15	ආර්.එම්. ජයරත්න	35 [illegible] ගම්පොල	අඹුළුපුර	0777558067	[illegible]

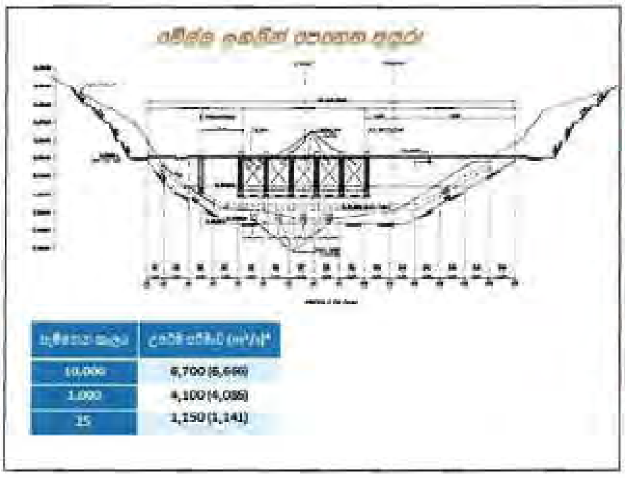
3

Moragolla Hydropower Project - Ceylon Electricity Board
Second Stake Holder Meeting (2013/11/18)
Attendance List - Officers From Government & Other Institutes / Organizations

No.	Name	Designation & Intitute	Telephone No	E - Mail Address	Signature
01	[illegible]	[illegible]	0777640218	-	
02	Seetma Bandara	Plant Engineer	0773865486	ppl2@crysbro.net	
03	[illegible] Herath	D/O ministry of Industrial & [illegible]	078-[illegible]	asokaban@-[illegible]	
04	Major A G U J Dharmasena	Army Camp, 2SLRC Gampola	0773141969 0812420744		
05	A M S P K Seneviratne	Senior Environmental Officer CEA - Polgolla	081-2494884		
06	G. W. Nimalsiri	Ad- RFO Nawalapitiya.	0542223054,		
07	G W N R Wadugr	CEB - Nawalapitiya.	0715313872	Aist	

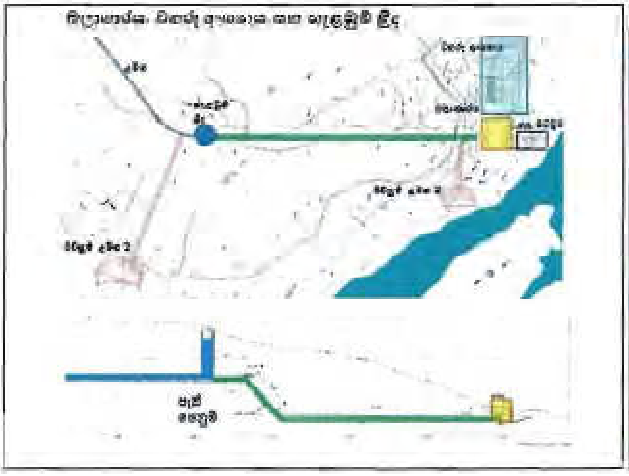
1

Annex 3 (c): Power Point Presentation of the Project Manager (MHPP) at the second stakeholder consultation meeting held on November 18, 2013


10,000 6,700 (6,690)
1,000 4,100 (4,085)
25 1,150 (1,141)

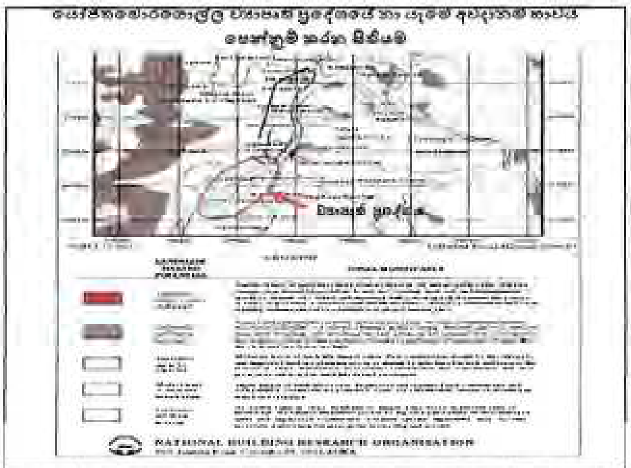

උපරිම ජල මට්ටමේදී ජලාශයේ පැතිරීම


ප්‍රධාන උමං මග
දිග මී 2765
විෂ්කම්භය මී 4.7
පොළොව මට්ටම සිට ඇති දුර මී 50




සම්ප්‍රේෂණ මාර්ගය

යෝජිත විදුලි බලාගාරයට හා සැලසුම් ...



පාරිසරික බලපෑම් අවම කිරීමට ව්‍යාපෘතියෙන් කරන ලද සැලසුම්

1) ව්‍යාපෘති අංග සැලසුම් කිරීම මගින්

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

2) පාරිසරික හා අනෙකුත් අවශ්‍යතා සඳහා ජලාශයෙන් අඛණ්ඩව තත්පරයට ඝ.මී. 1.5 ක් මුදා හැරීම

[illegible]

දුන්හිඳ ඇල ව්‍යාපෘතියට ලැබෙන වාසි

ව්‍යාපෘතිය මගින් සිදුවන ආර්ථික සාමාජීය සංවර්ධනය

ව්‍යාපෘති ප්‍රදේශය

1. ජන ජීවිතයට අවශ්‍ය මූලික පහසුකම් සංවර්ධනය වීම
2. ගඟෙහි පහල ප්‍රදේශයට වාරි ජලය හා බීමට අවශ්‍ය ජලය අවශ්‍යවිට සැපයීමේ හැකියාව තහවුරු කිරීම
3. සෘජු හා වක්‍ර රැකියා ජනනය වීම
4. භූගත ජල ස්තර පවිමින් වීම

මුළු රටටම

1. නිවාස ඒකක 150,000 කට පමණ විදුලිය සැපයීමට අවශ්‍ය විදුලිය ජනනය කිරීම
2. ජාතික ආර්ථිකයට සරිමින් ලෙස දායක වීම
3. පරිසරයට හිතකාමී විදුලි ජනනය කිරීමක් වීම
4. අලුතින් කර්මාන්ත හා එමගින් නව රැකියා බිහිවීම

ස්තුතියි

Annex 3 (d): Power Point Presentation of the National Environmental Specialist at the second stakeholder consultation meeting held on November 18, 2013

Moragolla Hydropower Project

Stakeholder Meeting

Natural Environment

ව්‍යාපෘතියේ ස්වාභාවික පරිසරය

November 15, 2013

Venue

History of Environmental Initiatives of the Project (Contd....)

- **EIA report reviewed by a Technical Evaluation Committee (TEC) appointed by MASL**
- Environmental approval for the implementation of the Project was granted by MASL in August 13. (Subject to certain conditions and proper implementation of mitigation measures proposed in EIA report)

ව්‍යාපෘතිය සඳහා පාරිසරික අනුමැතිය 2013 අගෝස්තු මස්දී ජාතික පරිසර පනතට අනුව මහවැලි අධිකාරිය මගින් ලබාදෙන ලදී

History of Environmental Initiatives of the Project

- Environmental Impact Assessment (EIA) carried out (as part of the Feasibility Studies) during 2009 and 2012 based on a ToR issued by the Project Approving Agency (ie.,Mahaweli Authority of Sri Lanka) under the National Environmental Act
- EIA report opened for public comments in all three languages (Sinhala, Tamil and English) in April 2013

The EIA was opened for public comments in April. 2013

- CEB appointed Nippon Koei Co. Ltd of Japan to review the Feasibility Study report and prepare detailed designs of the project.
- Financial assistance for the project is expected from Asian Development Bank (ADB)
- In order to fulfil the requirements of ADB environmental and social safeguard requirements, additional studies were carried out in 2012-2013

සිදුකරනලද අමතර අධ්‍යයන කටයුතු

1 (Water Quality)
2 (Aquatic Ecology)
3 (Ground Water)
4 (Land Use Map)

5 Public consultation and disclosure
6 Environmental flow analysis
7 Institutional assessment including grievance redress mechanism (GRM)

Anticipated Environmental Impacts during construction

- Excavation of Soil – Erosion and muck (excavated Material) disposal
- Rock Blasting - Noise and Vibration
- Surface Water- Pollution and Depletion
- Ground Water – Pollution and Depletion
- Bio diversity – Impact on Fauna and Flora
- Air Pollution - Dust and other physical disturbances
- Noise and Vibration
- Increased Traffic

ව්‍යාපෘතියේ කටයුතු මගින් සිදුවන විශේෂ පාරිසරික බලපෑම් අවමකිරීම සඳහා සිදුකල අමතර අධ්‍යයන

Studies carried out to plan and design mitigation measures.

8 – mitigating the impacts of the Moragolla HPP on fish
9 – habitat creation and management to enhance terrestrial biodiversity
10 afforestation and watershed management plan
11
12
13

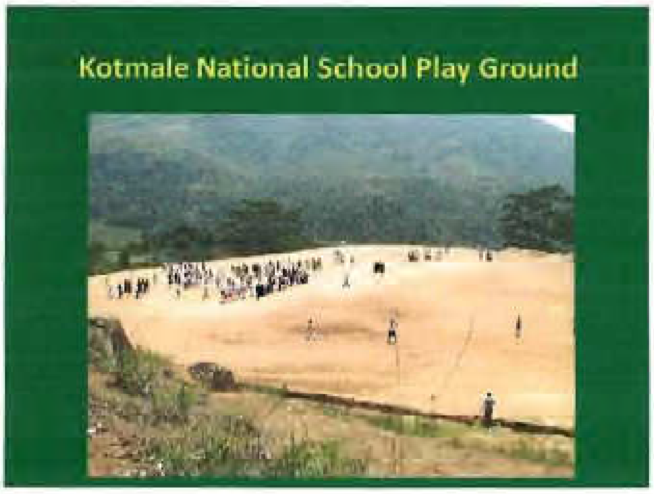
Excavation of Soil – Erosion and muck (excavated Material) disposal

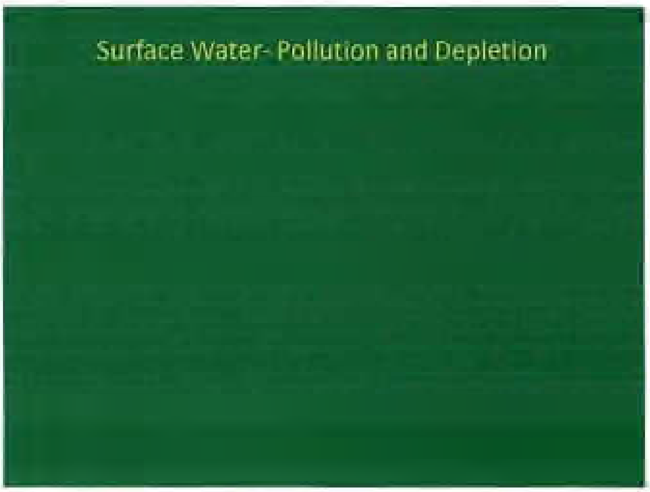
- Most aggregate requirement for construction will be obtained from the tunnel excavation materials
- Tunnel muck and excavated soil will be used for back filling and slope stabilization.
- All debris and residual spoil material including left earth will be disposed only at designated locations (Spoil Banks).

Metal Quarry

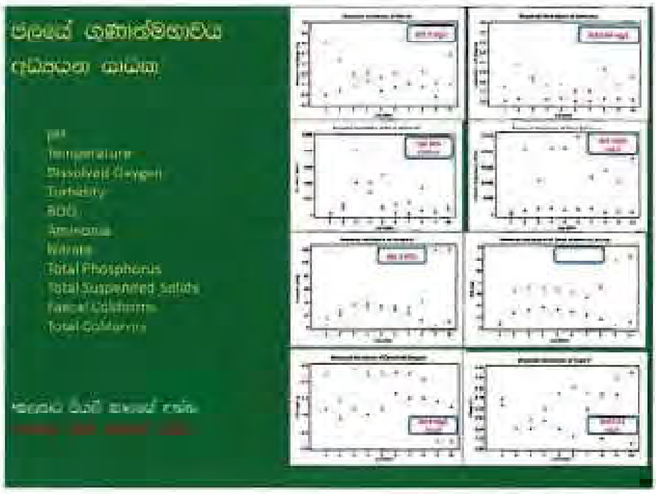

UKHP Experience


Domestic Solid Waste Management

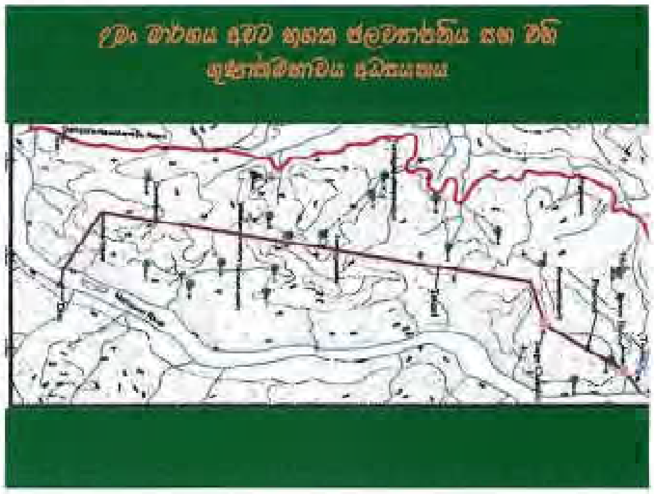

Kotmale National School Play Ground

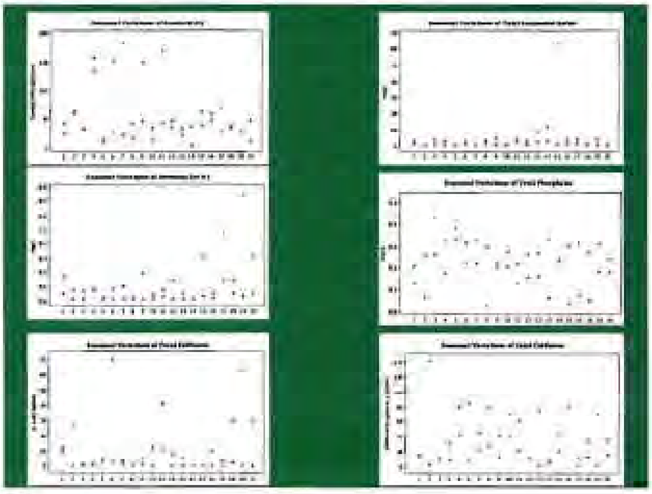

Surface Water- Pollution and Depletion


Progressive Rehabilit

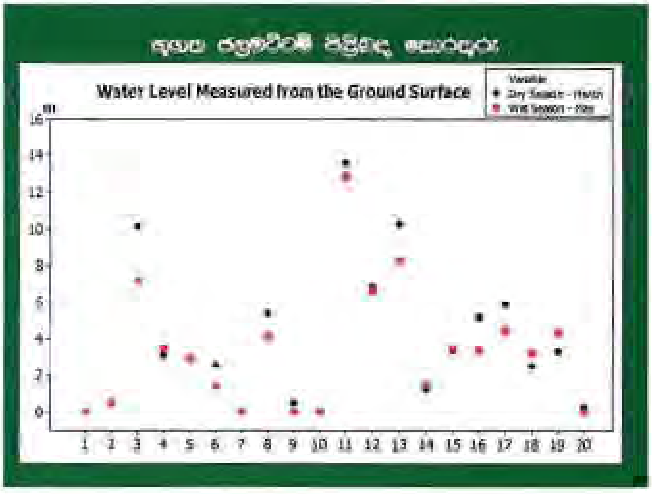

ජලයේ ගුණාත්මකභාවය
pH
Temperature
Dissolved Oxygen
Turbidity
BOD
Ammonia
Nitrate
Total Phosphorus
Total Suspended Solids
Faecal Coliforms
Total Coliforms


Sedimentation Pond – UKHP






Ground Water – Pollution and Depletion


Water Level Measured from the Ground Surface
Variable
m
16
14
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Air Pollution - Dust and other physical disturbances

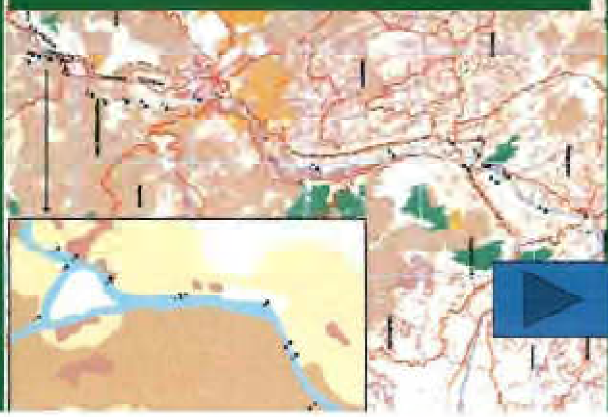
Bio diversity – Impact on Fauna and Flora

- මහවැලි නදියේ ජලජ පරිසර අධ්‍යයනය (Aquatic Ecology)
  - මත්ස්‍යයන්ට සිදුවන හානි අවම කිරීම - mitigating the impacts of the Moragolla HPP on fish

ව්‍යාපෘතිය ක්‍රියාත්මක වීමේදී ඇතිවිය හැකි පාරිසරික බලපෑම්

- ජලාශ පූර්ණ මට්ටමේ දී වන වගා- ලඳුකැළෑ- ගෙවතු ජලාශයට යටවීම (30.5 ha), (no unique, critical, or limited habitats for wildlife)
- වේල්ල මගින් මත්ස්‍යය සංචරණයට බාධාවීම
- වේල්ල හා බලාගාර ජලනිට්ටවුම අතර ජලප්‍රවාහ අඩුවීම :Reduced flow (about 1.5 m^3/s which is the e-flow) below dam to confluence with Atabage Oya (3 km)
- ගඟේ තුදකලා ජල වලවල් ඇතිවීම isolation of pools

මහවැලි නදියේ ජලජ පරිසර අධ්‍යයනය



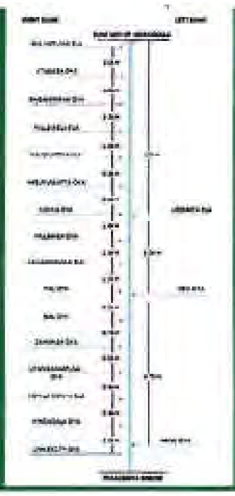
ජලාශයෙන් යටවන ප්‍රදේශය

- Fish encountered throughout project area;
- only one is endemic, limited distribution, and threatened (Green or Mountain Labeo: *Labeo fisheri*); everything else has wider distribution in Sri Lanka.
- *Labeo fisheri* is not presently found above confluence of Atabage Oya and Mahaweli Ganga; it is not a long-range migrator.

(to be rehabilitated/ replanted after construction)

(to be re-vegetated accordingly);
no incursion into unique, critical, or limited habitats.

MAJOR DOWNSTREAM TRIBUTRIES of MAHAWELI RIVER



habitat creation and management to enhance terrestrial biodiversity

– afforestation and watershed management plan

Proposed Mitigation for *Labeo fisheri*...

- Avoid / control blasting at Moragolla tailrace area.
- "Catch-and-haul" as each fish is encountered (or pre-empt; do an echo-sounder fish survey of whole river section, before construction and possibly catch some to move to other areas).
- Technical study of nearby alternative locations for placing *Labeo fisheri* (but, do not move all to new locations, in case this stresses the Mahaweli Ganga population).
- Undertake a "pool connection" analysis from dam site to tailrace; establish connections between pools that will maintain water exchange during lean season minimum environmental flow (allow fish to move between dam and tailrace at all times).
- Fish pass not warranted (*Labeo* not encountered upstream at the moment, and their possible use of a fish pass unknown).

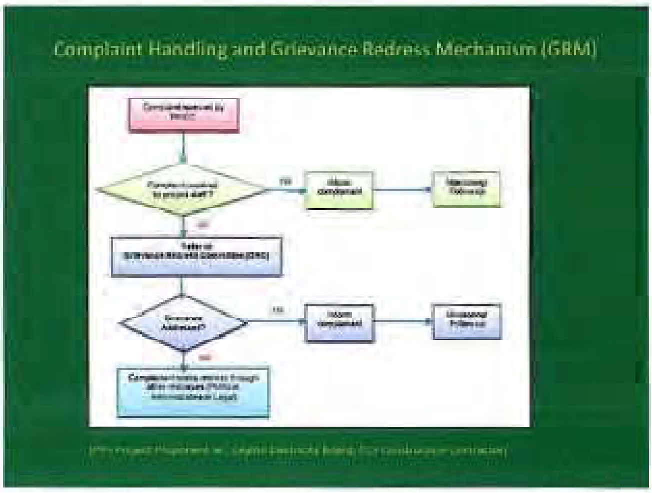
The Moragolla and Kotmale tailraces will ensure high discharge rates and suitable habitat in Mahaweli into the river section that currently supports most of the *Labeo fisheri* population (downstream of project site)

Mitigation

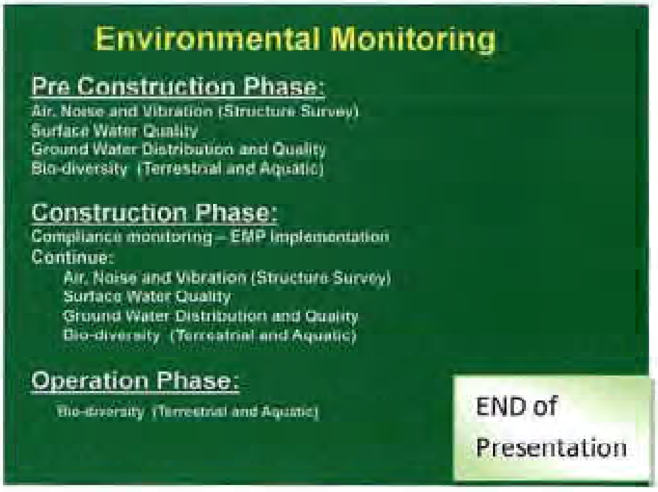
- No unique, critical, or endangered vegetation will be impacted; mostly scrub and secondary forest that will be cleared; nevertheless, accurate tree counts and then replacement in the reservoir buffer (more than 2:1, in 100-meter strip) and other selected areas (focus on habitat enhancement for 5 selected wildlife species: 3 mammals; 2 butterflies).
- These species are not under threat at the project site (they occur elsewhere in Sri Lanka); but they can be helped, as they have national conservation status.
- Will maintain a "find-and-move" program for "moveable" species before and during land clearing.


ජල පෝෂක ප්‍රදේශ කළමනාකරණය


Plant
Nursery,
UKHP


Complaint Handling and Grievance Redress Mechanism (GRM)


Planted
Trees,
UKHP


Environmental Monitoring
Pre Construction Phase:
Air, Noise and Vibration (Structure Survey)
Surface Water Quality
Ground Water Distribution and Quality
Bio-diversity (Terrestrial and Aquatic)
Construction Phase:
Compliance monitoring – EMP implementation
Continue:
Air, Noise and Vibration (Structure Survey)
Surface Water Quality
Ground Water Distribution and Quality
Bio-diversity (Terrestrial and Aquatic)
Operation Phase:
Bio-diversity (Terrestrial and Aquatic)
END of
Presentation

Annex 3(e): Participants of the Stakeholder Consultation Meeting held on November 18, 2013

Moragolla Hydropower Project

Institutional Arrangements for Project Implementation

Nippon Koei Co Ltd

November 2013

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1. Legislative and Administrative Framework

1.1 Central Environmental Authority

The Central Environmental Authority, established under the National Environmental Act (NEA) No 47 of 1980, is the Government's main environmental regulatory agency and is primarily responsible for enforcing the National Environment Act and formulating and implementing other environmental policies. The NEA has been amended twice to make improvements and to respond to the needs of the time:

1. National Environmental (Amended) Act No 56 of 1988; and
2. National Environmental (Amended) Act No 53 of 2000.

There are two main regulatory provisions in the NEA through which impacts on the environment from the process of development are assessed, mitigated and managed. These are:

1. The Environmental Impact Assessment (EIA) procedure for major development projects. Regulations pertaining to this process are published in Government Gazette Extraordinary No.772/72 dated 24 June 1993 and in several subsequent amendments.

2. The Environmental Protection License (EPL) procedure for the control of pollution. Regulations pertaining to this process are published in Government Gazette Extraordinary No. 1533/16 dated 25 January 2008.

1.1.1 Environmental Impact Assessment

The broader legal framework for the EIA process in Sri Lanka was laid down by the amendments made to the NEA in 1988. The provision relating to EIA is contained in Part IV C of the NEA and provides for the submission of two types of report: an Initial Environmental Examination (IEE) report or an Environmental Impact Assessment (EIA) report. These are required in respect of "prescribed projects" included in the EIA regulations[1]. Prescribed projects in the Power Generation Sector include "construction of hydroelectric power stations exceeding 50 MW" and "installation of overhead transmission lines of length exceeding 10 km and voltage above 50 KV". Furthermore, any project or undertaking irrespective of its magnitude, if located partly or wholly within an Environmental Sensitive Area[2], will become a prescribed project requiring approval under the EIA regulations.

The EIA process is implemented through designated Project Approving Agencies (PAAs), listed in Government Gazette (Extra Ordinary) No. 859/14 dated 13 February 1995. The PAAs are line

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[1] published in Government Gazette Extraordinary No.772/72 dated 24 June 1993 and in several subsequent amendments
[2] such as "60 meters from a bank of a public stream having a width of 25 metres or more at any point of its course"

ministries and agencies, and are responsible for administration of the EIA process under the NEA, which includes but is not limited to the following:

- Subject all prescribed projects to IEE/EIA requirements;
- Ensure and guide a proper scoping process for IEEs/EIAs;
- Draft Terms of Reference (ToR) for IEEs/EIAs;
- Establish, conduct and participate in Technical Evaluation and reviews during and after IEE/EIA report preparation;
- Ensure public notification of the availability of the EIA report for public review;
- Evaluate the comments received from the public and other agencies;
- Establish appropriate mitigation measures and ensure that they are incorporated in the approval conditions;
- Ensure implementation of the conditions through effective monitoring;
- Obtain concurrence of the CEA prior to taking a decision on approval of the EIA report.

As the Moragolla Hydropower Project is located in an area under the jurisdiction of Mahaweli Authority of Sri Lanka (MASL - see below) the MASL was designated by CEA as the appropriate PAA for this project.

In order to obtain environmental approval for a proposed project, the project proponent (PP) should submit either an Initial Environmental Examination (IEE) report or an Environmental Impact Assessment (EIA) report as required by the PAA. EIAs are required for projects considered likely to have significant impacts, determined by considering the context and intensity of the potential impacts.

<u>The EIA Procedure</u>

In the event that an EIA is required, the PAA in consultation with CEA is responsible for subjecting the preliminary information submitted by the project proponent to environmental scoping, in order to set the ToR for the EIA within 30 days from the date of acknowledging receipt of the preliminary information. The ToR is prepared by a Scoping Committee comprising experts in the relevant field, appointed by the PAA. In developing the ToR, the EIA regulations provide for the PAA to consider the views of state agencies and the public.

Upon submission of the EIA report by the project proponent, the PAA is required to determine whether the issues referred to in the ToR have been addressed and to notify the proponent of any inadequacies within 14 days. If inadequacies are identified, the proponent is required to make the necessary amendments and resubmit the report. Once accepted, the EIA is forwarded to the CEA by the PAA, and notice is placed in a national newspaper published daily in Sinhala, Tamil and English, inviting the public to make written comments to the PAA within 30 days from the date of first appearance of the notice.

According to the legislation, public consultation is mandatory only at this stage of the EIA process, although informal consultation with NGOs, interested groups and civil society may also occur earlier, depending on the type of project and the degree of public interest. The notification specifies the times and places at which the EIA report will be available to the public. As a minimum the report would be available at the CEA, PAA and in appropriate government agencies in the project area. The environmental regulations have provisions for public hearings at the discretion of the PAA, although this is not mandatory. The PAA is required to forward all comments, either written or raised during any public hearing, to the project proponent for review and response within 6 days of completion of the public comment period. The proponent is required to respond to all such comments in writing to the PAA.

The Technical Evaluation Committee (TEC) appointed by the PAA then evaluates the EIA and requires the project proponent to respond to any queries. The TEC also evaluates the adequacy of the project proponent's response to any comments raised during the public comment period. Upon completion of the evaluation, the PAA with the concurrence of the CEA either grants approval for the implementation of the proposed project subject to specified conditions, or refuses approval, giving reasons for doing so. This decision must be made within 30 days of the receipt of responses from the project proponent. The PAA is required to specify a period within which the approved project should be completed. If the proponent is unable to complete the project within the specified period, written permission for an extension has to be obtained from the PAA, 30 days prior to the expiration date.

The IEE Procedure

Upon review of the preliminary information provided by the project proponent (PP), if the PAA determines that the project would have no long-term adverse environmental impacts, an Initial Environmental Examination (IEE) may be considered adequate. Under such circumstances, the proponent is required to submit a detailed IEE report for review and approval by the PAA, identifying potential environmental and social issues and the complexity of possible remedial actions. Upon reviewing the IEE, if the TEC identifies any substantial environmental issues that may arise as a result of the project, the proponent will be required to undertake a detailed EIA. The IEE review process is similar to the EIA review process, except for the level of detail and analysis involved, which is proportionate to the anticipated environmental and social impacts. The IEE is not required by law to be opened to the public for comments and does not go through the public consultation process.

An Environmental Impact assessment Report (EIAR) for the Moragolla HP Project was prepared by the Ceylon Electricity Board (CEB) during the Feasibility Study period (2009-2012) and approval obtained from MASL in 2013. If the Construction Contractor intends to carry out any "Prescribed Project" that is not assessed in the current EIA report[3], he is responsible for obtaining environmental approval from the appropriate PAA after going through the prevailing EIA process. The activities most likely to be classified as prescribed projects are expected to be:

- Inland deep mining and mineral extraction;
- Inland surface mining[4]; and
- Mechanized mining and quarrying operations of aggregate, marble, limestone, silica, quartz, and decorative stone within 1 kilometre of any residential or commercial areas.

1.1.2 Environmental Protection License

The Environmental Protection License (EPL) is a regulatory tool introduced under the provisions of the National Environmental (Amended) Act No 56 of 1988 to prevent or minimize the release of pollutants from industrial activities.

Regulations in Government Gazette Extraordinary No 1533/16 classify industrial activities according to their pollution potential. List A comprises 80 potentially high polluting industries; List B covers 33 medium polluting industries; and List C comprises 25 low polluting industries.

EPLs for List A and B industries are issued by the relevant Provincial / District offices of the CEA, while EPLs for List C industries are issued by the relevant local authority(Municipal Councils, Urban Councils or Pradeshiya Sabha: see Section 1.4). The EPL for List A industries is valid for one year while those for List B and C industries are valid for three years. For List A and B industries the project proponent must submit a duly filled application (obtained from CEA headquarters, provincial and district offices or downloaded from the CEA website) for each prescribed activity to the CEA provincial or district office, who will evaluate the application and decide upon issuing an EPL and the appropriate inspection fee. The proponent must then pay the prescribed fee to CEA headquarters or provincial/district office and submit the receipt to the relevant provincial or district office. A team of

[3]Ceylon Electricity Board (November 2012): Moragolla Hydropower Project, Feasibility Study, Final Report: Volume 3- Environmental Impact Assessment (Central Engineering Consultancy Bureau, Sri Lanka and Al-Habshi Consultants Office, Kuwait).

[4] "mining" means excavating in, on, or below the surface for the purpose of evaluating and obtaining any minerals (ref. Mines and Minerals Act No 33 of 1992); this legislation therefore applies also to quarrying to obtain construction materials.

officers will then carry out an inspection and submit a report based on the site visit and the information provided. If the issue of EPL is recommended, the proponent can obtain the EPL upon payment of the license fee.

For List C industries the procedure is the same, except the Local Authority will appoint a Technical Evaluation Committee (TEC) that makes the final decision regarding the issue of EPL based on the field assessment report and information furnished by the industrialist/proponent.

The EPL can be renewed by submitting a renewal application three months prior to the date of expiry to the relevant authority, which will conduct a field inspection and determine whether the EPL should be renewed.

There are several activities associated with construction of the Moragolla Hydropower Project that come under the provisions of this regulation and the Contractor is responsible for obtaining the Environmental Protection License (EPL) in each case. The prescribed activities are: bulk petroleum liquid or liquefied petroleum gas storage or filling facilities; asphalt processing plants; concrete batching plants; mechanized mining activities; granite crushing (metal crushing) plants; incinerators; wastewater treatment plants; solid waste dumping yards; and toxic or hazardous waste treatment or disposal facilities.

1.2 Mahaweli Authority of Sri Lanka

The MASL was established in 1979 with the purpose of implementing the accelerated Mahaweli Ganga Development Scheme (MGDS). The Mahaweli Authority Act of 1979 empowered the MASL to use and develop the water resources of Mahaweli Ganga or any other neighbouring river basins for purposes of irrigation, hydropower generation, land settlement, etc. The MGDS involves integrated development and management of the land and water resources of Mahaweli and allied river basins. Its objectives are to develop, operate and maintain irrigation systems to expand farmland, increase agricultural production, increase hydropower generation, provide land to the farmer community, encourage employment generation and enterprise development, and conserve the environment, particularly in the watershed areas.

According to the Mahaweli Authority Act, the functions of the MASL in relation to, any Special Area[5]shall be to:

a) Plan and implement the MGDS including the construction and operation of reservoirs, irrigation distribution systems and installations for the generation and supply of electrical energy. Provided

[5]Any area declared by the Minister by Order published in the Gazette, which can be developed with the water resources of Mahaweli Ganga or any other major river to be a Special Area, in relation to which the MASL may exercise, perform and discharge all or any of its powers, duties and functions.

however, that the function relating to the distribution of electrical energy may be discharged by any authority competent to do so under any other written law.

c) Foster and secure the full and integrated development of any Special Area;

d) Optimize agricultural productivity and employment potential and generate and secure economic and agricultural development within any Special Area;

e) Conserve and maintain the physical environment within any Special Area;

f) Further the general welfare and cultural progress of the community within any Special Area and administer the affairs of such Area;

g) Promote and secure the participation of private capital, both internal and external, in the economic and agricultural development of any Special Area; and

h) Promote and secure the co-operation of government departments, state institutions, local authorities, public corporations and other persons, whether private or public, in the planning and implementation of the MGDS and in the development of any Special Area.

Regulations for the control of reservoirs, natural and artificial waterways, and other water bodies and their environs are published in the Government Gazette Notification 431 dated 26 December 1980. According to these regulations no person shall engage in any development activity within any area coming under the purview of MASL without a proper approval obtained from the Authority.

The Forestry and Environmental Management (F&EM) Division of MASL, headed by a Director who is responsible to the Executive Director (Technical Services and River Basin Management), handles the environmental interventions of the Authority. The major activities carried out by the F&EM Division are: soil and water conservation; environmental education; conservation farming; biodiversity conservation; Geographical Information Systems (GIS) and remote sensing based mapping and database preparation; land use planning; sediment and river flow monitoring; water quality monitoring; and aquatic weed management in Mahaweli water bodies.

MASL also functions as a project approving agency (PAA) under the NEA in order to oversee the EIA process and grant environmental approval for prescribed projects in the Mahaweli Ganga watershed, such as the Moragolla Hydropower Project.

In addition to the above two key organizations and related legislative provisions, several other establishments will also be involved in evaluating and approving environmental and social safeguard measures of projects of this nature, as explained below.

1.3 Geological Surveys and Mines Bureau (GS&MB)

The GS&MB, established under the Mines and Minerals Act No. 33 of 1992,is responsible for licensing mining and exploitation for minerals. Mining licenses are issued only to qualified individuals and companies registered to do business in Sri Lanka. Mining is not permitted in Archaeological Reserves and within a specified distance of scheduled monuments. New mining licenses are subject to the EIA process, if the type and extent of mining is listed under the EIA regulations[6]. Additionally, the GS&MB has the power to stipulate conditions including the taking of financial deposits and insurance for the protection of environment. Regulations made by the GS&MB under the Act cover a variety of environmental stipulations, criteria and conditions for licensing and operating mines. The Act also deals with the disposal of mine wastes and the health, safety and welfare of miners. Reclamation of mines is a major problem in Sri Lanka and because of this, current practice requires the mining enterprise to make a deposit to cover the costs of reinstatement of mines. Mining rights on public and private land are subject to licensing by the GS&MB and all minerals wherever situated belonging to the State.

1.4 Local Authorities

Local authorities (LA) consist of Municipal Councils, Urban Councils and Pradeshiya Sabhas and constitute the third level of governance after the central government and provincial councils. Environmental management is a de-centralised responsibility, so the LAs are expected to play a major role in protecting the environment. Activities related to environmental management in the LA are generally coordinated by an Environmental Officer (EO), who receives all complaints from thepublic concerning environmental issues. This may lead to investigation of complaints and recommendations to responsible authorities for further action.

Industries carrying out activities of low polluting nature must obtain an Environmental Protection License (EPL) from the LA where the activity will be undertaken. As explained above, the LAs are empowered to issue EPLs for 25types of low polluting activities listed in part C of the prescribed activities. Most construction activities for this project will be large enough to require an EPL from the CEA, but it is possible that certain other activities may only require licensing by the LA.

1.5 Prevention of Mosquito Breeding Act[7]

The Construction Contractors will be required by their contracts to comply with all national legislation that is in any way relevant to the activities they are conducting. This includes labour laws, health and safety legislation and many other legal provisions. In relation to the natural environment,

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[6]Published in Government Gazette Notification No. 772/22 dated 24 June 1993.
[7]http://srilankalaw.lk/revised-statutes/volume-vi/954.html

there is one piece of legislation that covers an issue of critical importance for Sri Lanka, to which the contractor should pay particular attention: the Prevention of Mosquito Breeding Act (11 April 11 2007).

This Act was passed for the purpose of preventing and eradicating all mosquito-borne diseases. Under this Act, it is the duty of every owner or occupier of any premises to cause: (a) open tins, bottles, boxes, coconut shells, split coconuts, tires or any other article or receptacle found in or within such premises, capable of holding water to be removed, destroyed or otherwise effectively disposed; (b) any well found in the premises and its surroundings to be maintained and kept in good repair so as to make it mosquito-proof and thereby prevent the breeding of mosquitoes; (c) any artificial pond or pool found in such premises to be emptied at least once in every week; (d) any casual collection of water within the premises that is conducive to mosquito breeding, to be regularly drained; (e) shrubs, undergrowth and all other types of vegetation, other than those grown for the purpose of food or those that are ornamental, found within or outside any building or structure within the premises used as a dwelling place, which has become a breeding place for mosquitoes, to be removed; (f) the removal and destruction of water plants that have the botanical name *Pistia stratiotes* and commonly known as “Diya Parandal”, “Kondepasei”, “Telpassy”, “Barawa Pasi”, “Nanayaviraddi” or water lettuce, and of any other water plant or plants, found within the premises, which may facilitate the breeding of mosquitoes.

2 Project Implementation

2.1 Project Organisation

2.1.1 Executing and Implementing Agencies

The Ministry of Power and Energy (MoP&E) is the Executing Agency of this project. The Ceylon Electricity Board (CEB), which is one of the four agencies[8] comes under the purview of MoP&E, is the Implementing Agency or the Project Proponent. In order to ensure smooth functioning of the project, a Project Management Office (PMO), headed by a Project Director (PD) will be established by CEB. The PD will report directly to the Additional General Manager (Projects) –AGM (P) of CEB. The overall organization of the project is illustrated in Fig 1.

[8] Other three agencies are: Lanka Electricity Company (Pvt) Limited, LTL Holdings (Pvt) Ltd. and Lanka Coal Company (pvt) Ltd

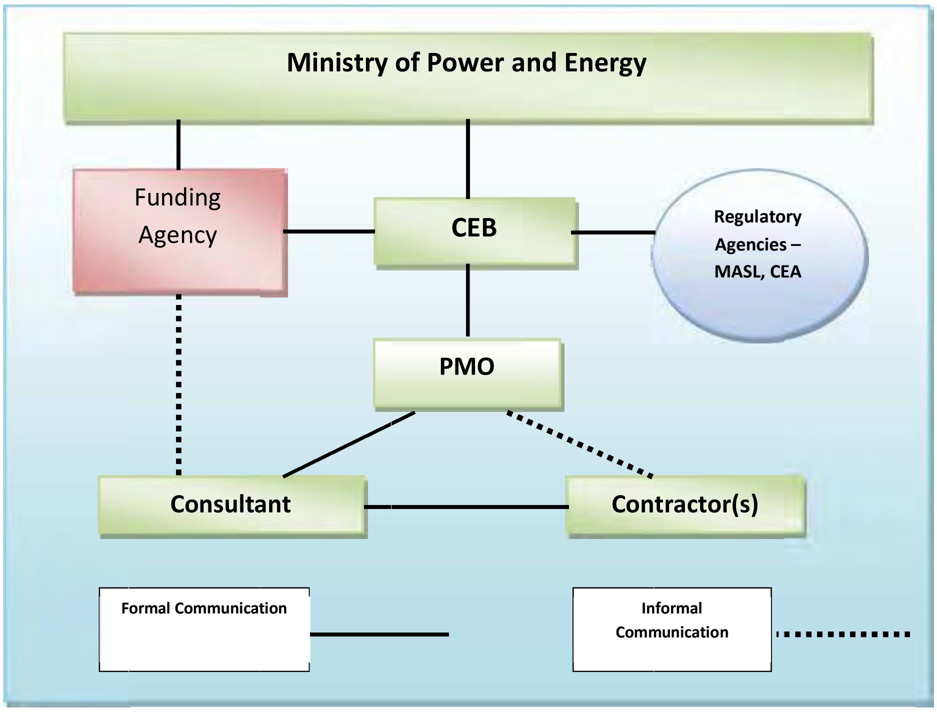

Fig 1: Overall Organisation of the Project

A Project Steering Committee (PSC) will be established by MoP&E immediately after the financial arrangements for project implementation are finalised.

The proposed composition of the PSC and their statutory responsibilities that may impinge on the project are as follows:

1.	Secretary, Ministry of Power & Energy	Chair Person
2.	Representative from the Ministry of Defence and Urban Development	Planning approval for infrastructure development facilities
3.	Representative from the Ministry of Lands and Land Development	Publish the relevant Gazette Notifications pertaining to land acquisition.
4.	Commissioner General of Lands or a representative	Prepare relevant documents for land acquisition
5.	Representative from the Mahaweli Authority of Sri Lanka (MASL)	Designated Project Approving Agency under the National Environmental Act. Responsible for compliance monitoring with conditions of the environmental approval
6.	Representative from the Department of External Resources	Loan disbursement

7.	Representative from the Central Environment Authority	Monitoring the environmental impacts of the project.
8.	Representative from the Survey General's Department	Carry out legal survey for land acquisition
9.	Representative from the National Water Supply and Drainage Board (NWS&DB)	Provide water supply for resettlement sites and other facilities
10.	Survey General (SD)	Legal survey of land and prepare Advance Tracing (AT) and Preliminary Plan (PP)
11.	Valuation Department (VD)	Valuation of the lands and prepare Valuation Reports (VR)
12.	Divisional Secretary, Udapalatha	Responsible for the following activities of the Land acquisition process: - Decide the legal owners of the land to be acquired. -Request the SD to survey the land and prepare AT and PP. -Request the VD to submit the VR. -Pay the compensation in respect of acquired lands and property.
13.	Divisional Secretary, Ganga Ihala Korale	

The PSC will act as the apex decision-making body for the project. The PSC will meet once every two months to review the progress of project activities, provide policy guidelines, resolve issues that may impede the progress of project implementation, and advice on remedial action. The PSC will provide a forum for deliberation of important aspects of the project among its members and facilitate inter-agency coordination.

2.1.2 Project team arrangement for implementation of the project EMP

The responsibility of implementing the project lies with the Project Proponent CEB who will appoint Contractor(s) to construct the various elements of the project once the financial arrangements are finalized, and a Consulting Engineer to supervise construction.

The PMO will co-ordinate the pre-construction, construction and commissioning of the project. An Environmental Management Office (EMO), which will form part of the PMO, will also be established. This will be staffed with an Environmental Specialist (Physical and Natural), Environmental Specialist

(Social) and supporting staff as shown in Figure 2. International Environmental and Social Specialists supported by qualified local specialists will also be appointed by the Supervision Consultant.

The contractor(s) are legally required to implement those elements of the project Environmental Management Plan that are allocated to them in the EMP document; and they will be required to report on this and any other environmental issues to the EMO at monthly intervals or more frequently if necessary. All main contractors will be required to appoint Environmental Officers, who will be the primary point of contact for all environmental issues in relation to construction activities.

The internal arrangement of the PMO is illustrated in Figure 2.

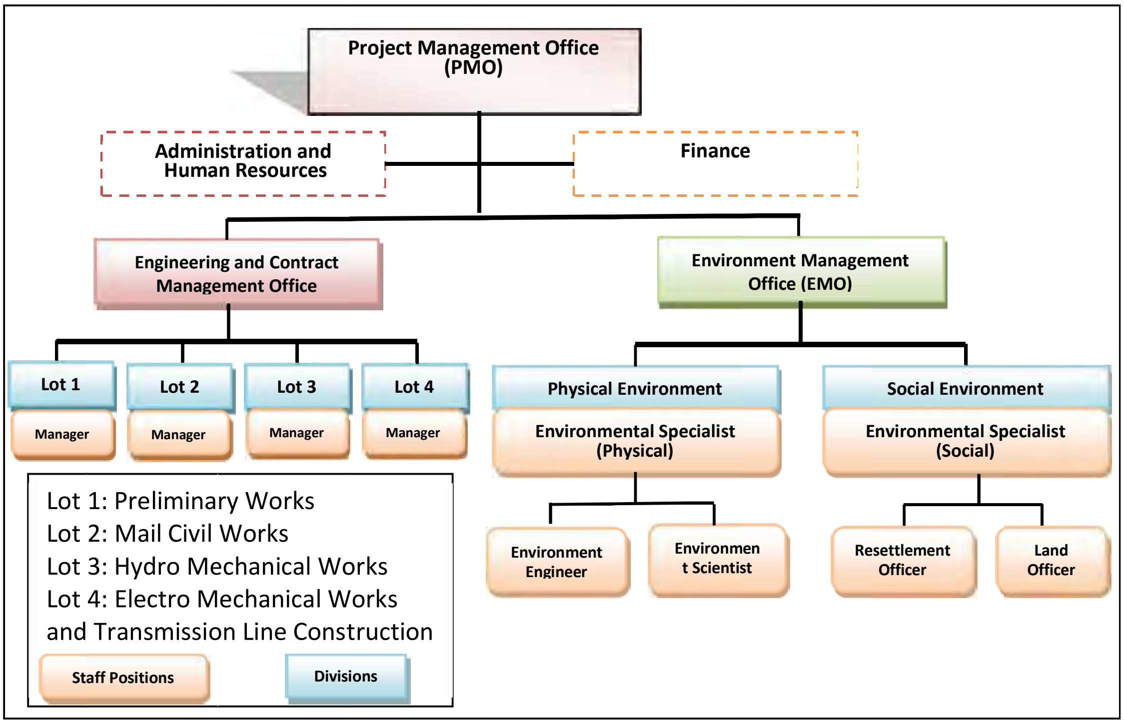

Fig. 2: Proposed structure of the Project Management Office

2.2 Responsibilities of the main organisations

The successful construction and operation of the MHPP will depend on many factors, which include the successful implementation of the various monitoring and mitigation measures set out in the EIA report and the EMP. To achieve this it is imperative that all the participants and organisations having a designated role in project execution and implementation act in a responsible manner and implement their duties professionally and diligently, as set out in the EMP. The main participants and their responsibilities are summarised below:

Agency	Project related responsibilities
Ministry of Power and Energy (MoP&E)	Executing Agency (EA) - Apex decision making body. Responsible for administration of loan / grant finance on behalf of the Government and Progress monitoring through establishment of a Project Steering Committee (PSC). Resolving issues that impede the progress of project implementation, through inter-agency coordination.
Ceylon Electricity Board (CEB)	Project Implementing Agency or the Project Proponent (PP).
Project Management Office (PMO)	Day-to-day project management and coordination: financial management; project administration; technical oversight (engineering and environmental); review and approval of the work of the Design Consultant. Also responsible for ensuring the project adheres to national law and the policy of the lender, including social and environmental safeguards.
Design Consultants (DC)	Detailed design of all elements of the project infrastructure; project planning and programme; calculation of project budgets; preparation of tender documents; inclusion of environmental mitigation measures in design, tender documents and budgets as specified in project EMP.
Supervision Consultants (SC)	Supervision of the work of the Contractors to ensure that all infrastructure is built as designed. Environmental Supervision to ensure that all mitigation is provided as specified in the project EMP (by Contractors, Design Consultants and other bodies).
Construction Contractor(S) (CC)	Construction of specific elements of the infrastructure according to designs, drawings and tender documents; provision of mitigation and monitoring impacts of construction activities as specified in the project EMP.
Mahaweli Authority of Sri Lanka (MASL)	Functions as the Project Approving Agency (PAA) under the National Environmental Act. Responsible for administering the EIA process, including scoping, preparing ToR, public disclosure, review of EIA report, decision-making and compliance monitoring which would involve compliance with conditions and the effectiveness of the mitigatory measures.
Central Environmental Authority (CEA)	Oversees the EIA implementation by the PAA, Monitor the quality of the environmental to ascertain the long term effects (if any). Issuing of EPL for prescribed activities.

3 Institutional Assessment

The outcome of the discussions had with the Deputy Director General (Environmental Management and Assessment) and the Director (EIA) of the Central Environmental Authority, Director (Forestry and Environmental Management) of Mahaweli Authority of Sri Lanka, Project Manager of Moragolla Hydropower Project Feasibility Study Review and Environmental Officer of Ceylon Electricity Board were used in this institutional assessment study.

3.1 Central Environmental Authority

3.1.1 EIA Unit

The EIA Unit, headed by the Director (EIA), functions under the Environmental Management and Assessment Division of CEA and is responsible for: administration of the EIA process; co-ordination between Project Approving Agencies (PAA's); preparation of manuals and guidelines on EIA; and maintenance of a database on EIA. Currently there are three Deputy Directors (DD), six Assistant Directors (AD), eight Senior Environmental Officers (SEO) and three Environmental Officers (EO) attached to the EIA Unit. All of them are graduates having at least a Second Class Honours Degree in environment related subjects such as Biological Science, Physical Science, Engineering, Geography, Agriculture or Built Environment, with post graduate qualifications in environment management related specialties; and in general the senior positions are occupied by those staff with the most experience.

Since its introduction in 1994, the CEA has gathered considerable experience and expertise in managing (over 800 EIAs and IEEs) the EIA process in Sri Lanka and has benefited from numerous capacity building and training projects supported by various donor agencies (NAREPP/IRG project funded by the World Bank, ISEA project funded by ADB and Netherlands funded capacity building project ect.,). However, it is understood that, although the CEA has achieved fairly high standards in implementing EIA procedures and also gained quite a lot of experience in monitoring of post-implementation impacts during the last decade (Upper Kotmale Hydropower Project financed by JICA, Southern Transport Development Project financed by ADB/JICA and Outer Circular Highway Project and Colombo-Katunayake Expressway financed by the Government of China), this is still a weak area that needs to be strengthened (according to the D(EIA) of CEA).

3.1.2 Environmental Pollution Control (EPC) Unit

The EPC Unit of CEA is responsible for management of the Environmental Protection License (EPL) scheme through: development of pollution control guidelines; review and upgrading the existing discharge and emission standards; and introduction of new mechanisms such as the load base license scheme. This division is headed by the Director (EPC), who reports to the Deputy Director General (EPC). Currently there is one Deputy Director (DD), four Assistant Directors (AD), eight Senior Environmental Officers (SEO) and four Environmental Officers (EO) attached to this Unit. As in the EIA unit, all of the professional staff are science graduates, with post graduate qualifications in environment management related specialties. Issuing of EPL is now delegated to the Regional offices of CEA and Local Authorities (see below).

3.1.3 Regional Offices of CEA

The CEA operates Provincial and District offices that handle most of the compliance and enforcement functions at grass-roots level. These offices often function as the focal points for EIA[9]and EPL matters in their area of jurisdiction and issue EPL for prescribed activities.

The MHPP area comes under the jurisdiction of the Central Provincial office of CEA. This is headed by the Regional Director (Central Province), with two DDs, four ADs, eight SEOs and forty EOs. Qualifications and experience for each level are equivalent to those for the CEA as described above.

3.2 Mahaweli Authority of Sri Lanka

As explained above, the CEA designates the MASL as the Project Approving Agency (PAA) for the environmental approval process for proposed prescribed projects that are in the areas of MASL jurisdiction. The Forestry and Environmental Management (F&EM) Division of MASL functions as the "environment cell" to implement the requirements of the NEA. This division is headed by a Director who is qualified to MSc level in the field of Natural Resources Management, with more than 20 years of experience in relevant government departments. He is supported by four Deputy Directors, thirteen Environmental Officers, three Water Quality Officers and several support staff. All staff are qualified science graduates and most of them possess at least a MSc degree in environmental science or a related field, with periods of experience that are generally commensurate with their level of seniority (for example 5 or more years for EO grade).

3.3 Ceylon Electricity Board

In general, responsibility for implementing the Environmental Management and Monitoring Plan (EMMP) of MHPP lies with CEB as the project proponent. In practice this will be delegated to the Project Director and staff of the PMO, once it is established. The existing Environment Unit of CEB, which functions under DGM Transmission Design and Environment, will have the responsibility of

[9]Administration of IEE process for the projects and undertakings for which CEA functions as PAA are now totally delegated to Provincial offices. This involves all elements of the process, including scoping, issuing of ToR, review of report and decision-making.

monitoring the implementation of the EMMP and coordinating the monitoring activities with the Project Approving Agency, MASL and CEA.

The Environment Unit of CEB is the focal point for most of the environmental activities of CEB. Their main responsibilities include:

- Implementation of the complete environmental approval process for all the transmission projects of CEB, including preparation of EIA/IEE reports and obtaining the Environmental Approval.
- Coordination of the complete environmental approval process for the generation projects of CEB, including Public Consultations/ Public Hearings, and obtaining the Environmental Approval.
- Implementation of the Environmental and Social Assessment Process under the relevant Environmental/ Social guidelines of the respective funding agencies for all CEB projects.
- Monitoring the implementation of Environmental Management/Monitoring Plans for the ongoing projects of CEB.

Currently the staff of Environment Unit of CEB consists of three officers, namely Environmental Officer (Head of Environment Unit), Civil Engineer and one Electrical Superintendent. This does not provide sufficient staff numbers or technical specialisation to deal with the amount or range of activities for which the unit is responsible and the time targets set for most of the environmental approvals (which currently includes preparation of IEE reports for four (4)[10] transmission line projects funded by ADB for which environmental approval is needed by the end of 3013, five (5)[11] environmental studies for JICA funded transmission line projects to be completed in early 2014 and two (2)[12] feasibility studies funded by JICA).

Considering the large number of activities involved in the Environmental Management and Monitoring Plan of MHPP it would be very difficult for the Environment Unit to handle the coordination / monitoring of the implementation of the EMMP without additional resources. It is recommended therefore the Environment Unit of CEB shall be strengthen after carrying out a detailed assessment of the workload and the staff requirement.

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[10] Anuradhapura-Vaunia-Mannar (220kV, 127km); Polpitiya-Pannipitiya (220kV, 70km); Thulhiriya-Kegalle (132kV, 22km); Mannar-Nedukudu (132kv, 32km)

[11] Veyangoda-Kirindiwela-Padukka (220kV, 41km); Polpitiya –habarana (123kV, 131km); Polpitiya-Kotmale (220kv, 27km); Veyangoda-Thulhiriya (132kV, 26km); Kirindiwela-Koggala (132kV, 12km)

[12] Feasibility study on Energy Diversification Enhancement of Sri Lanka and Peaking Power Generation Options of Sri Lanka

4 Institutional Strengthening

4.1 CEA, MASL and CEB

During research conducted for this institutional study, the current Director (EIA) of CEA expressed the view that most of the Environmental Management Plans received by CEA are not up to the expected quality. The Director also stated that the staff members of the EIA unit are not properly exposed to the EMP process and therefore do not have the knowledge or experience necessary to guide project proponents and consultants on preparation of good EMPs. To address this deficiency and raise the capacity of others who are in key positions in relation to the review/approval, implementation and supervision of the EMMP for the MHPP, it is proposed to have a training workshop on EMP for relevant members of CEA, PP and PAA. The content would be as follows:

Subject : "Environmental Management and Monitoring Plans".

Target Group: Staff members of EIA unit of CEA, F&EM Division of MASL and Environment Unit of CEB who are involved in activities related to MHPP.

No of Participants: 20

Duration: 3 days (Including one day of practical work on EMP preparation)

Principal Resources Person: International Environment Specialist of Design/Supervision Consultant

Venue: Kotmale Holiday Resort

Purpose/Objectives of the training workshop:

- Expose participants to the purposes, principles and methods of EMP;
- Improve the level of appreciation and understanding of EMP implementation;
- Provide participants with the capacity and confidence to support the design and implementation of EMP;
- Enable participants to conduct training programmes for other organisations and thus allow for improved environmental performance within such organisations; and
- Inform the participants about the Moragolla HPP and its likely environmental impacts and mitigation, to assist them in fulfilling their roles in the project.

4.2 CEB

According to the Head of the Environment Unit of CEB, the training received by the staff of his Unit, in the work areas they are currently engaged in (especially in the field of Environmental Impact

Assessment of generation projects) is rather inadequate, compared to most of the other branches of CEB. For example, the Civil Engineer in the Environment Unit has never participated in a training programme focused on EIA process of projects.

Hence, it is proposed that the staff of the Environment Unit be provided with suitable training in order to improve the quality and accuracy of their outputs to the organisation (CEB) and particularly to the project (MHPP) in the area of environment protection and management.

4.3 PMO, Supervision Consultants and Construction Contractors

The PMO will be led by a director, appointed from the existing CEB senior staff, and he will be supported by a variety of technical and administrative positions as shown in Fig 2 above. Some of the technical staff will be existing CEB employees and others will be consultants, both domestic and international, employed on a contract basis, for the duration of the project, or for shorter fixed terms. The requirements of these positions will be decided in advance and specified in the job descriptions and advertisements. It is likely that all senior technical positions will require a higher degree and several years of relevant experience in similar positions. Senior staff in the Environment Management Office will require higher degrees in environmental management or other relevant specialism, plus previous work experience in preparing and implementing Environmental Management Plans, conducting environmental monitoring surveys, and/or other relevant activities.

The Terms of Reference for the Supervision Consultants will specify the requirements for all key positions, and this will include a Senior Environmental Specialist, plus two or more Environmental Specialists, who together will be responsible for supervising the work of the contractors to ensure they all provide the mitigation that is assigned to them in the project EMMP. Similarly the major Construction Contractors will each be required to provide a Senior Environmental Manager, who will be responsible for the Contractor's environmental performance, and in particular implementing the EMMP requirements. It is likely that the senior environmental specialists of both the Supervision Consultant and the Construction Contractors will also require a higher degree in a relevant subject plus several years of experience of similar work activities, preferably involving hydropower projects.

If these requirements are properly adhered to and staff of the required calibre are appointed, then all should have sufficient expertise and previous experience to be able to adequately fulfil their duties on this project without further extensive training or capacity building exercises. It would however still be advisable for CEB to provide a brief induction programme for all those involved in environmental matters in relation to the MHPP to ensure they are all fully informed of the specific requirements of the MHPP and their individual and collective responsibilities.

The training and induction course should include but not be limited to:

- Overview of Environmental Legislation in Sri Lanka;
- Relevant environmental Standards and Guidelines (water, air, noise etc.);
- National Involuntary Resettlement Policy (NIRP) principles;
- CEB's environmental policy;
- Requirements of the ADB Safeguard Policy Statement (2009);
- An introduction to the Environmental Management and Monitoring Plan of MHPP;
- Environmental responsibilities of all project staff;
- Site- and project-specific requirements such as the afforestation programme, watershed management plan, habitat creation and biodiversity conservation plan, etc;
- Dissemination of extra information as required during the course of the construction works.

5 Complaint Handling and Grievance Redress Mechanism

5.1 Grievance Redress Mechanism

Construction activities of hydropower projects, especially where Involuntary Resettlement is involved, might give rise to grievances among Affected Persons (APs), however much the potential sources of conflict have been addressed in Environmental Management Plans and Resettlement Plans and Policies. Grievances may be related to social issues such as eligibility criteria and entitlements, location of resettlement sites, quality of services at those sites, allocation of houses, livelihoods and social and cultural issues, etc. Grievances may also be related to environmental issues such as dust generated due to clearing and grubbing works, vibration and damages to structures, noise, traffic congestion, decrease in water level and water pollution in private and public wells due to blasting and tunnelling, damage to tea plantations and agricultural lands, etc.

Social grievances occur mostly at the time of implementation of the Resettlement Action Plan; and complaints on environmental issues and public nuisances generally occur during the construction period. Both types of grievances are different in nature. However, it is imperative to have a mechanism in place to examine each and find solutions in a transparent manner, to demonstrate to the people that their grievances are examined carefully. A Grievance Redress Mechanism (GRM) is essential for smooth implementation of the project. The main objective of establishing a GRM is to resolve problems in an efficient, timely and cost-effective manner in a cordial environment with the participation of all stakeholders including affected parties.

It is preferable to resolve the grievances and disputes at the community level and as and when they occur. Donor agencies are inevitably highly concerned about the grievance redress and dispute resolution mechanisms in the implementation of development projects. The GRM should be able to provide benefits to both the project and affected parties by setting up the following objectives:

- Provide a forum for redressing grievance and disputes at the lowest feasible level;
- To create effective communication between the project and affected parties;
- To build up productive relationships among the stakeholders including affected parties;
- Provide access to allow affected parties to negotiate and influence the decisions and policies of the project which might adversely affect them;
- Mitigate or prevent adverse impacts of the project on the environment and produce appropriate corrective or preventive action;
- To harmonize both project and affected parties' activities.

5.2 Complaints Management

All complaints regarding social and environmental issues are usually received either orally or in writing by the Project Proponent (PP) or the Construction Contractor (CC). A key part of the GRM is the requirement for the PP /CC to maintain a registry of complaints received at the respective project site offices. A sample complains registry is given in Annex 1.

All complainants shall be treated respectfully, politely and with sensitivity. Every possible effort should be made by the PP or the CC to resolve the issues referred to in the complaint within their purview. However, there may be certain problems that are more complex and cannot be solved through project-level mechanisms. Such grievances will be referred to the Grievance Redress Committee (GRC, see below). The proposed complaint handling and Grievance Redress Mechanism for the Moragolla project is illustrated in Figure 3.

5.3 Grievance Redress Committee (GRC)

The Moragolla Hydropower Project, in keeping with the ADB and national safeguard policies, will set up a Grievance Redress Committee (GRC), which will function as an independent body to find solutions to grievances and disputes among the affected and concerned parties.

The appointment of the GRC will be notified to the general public by publication of a notice in national newspapers in three languages ie., Sinhala, Tamil and English. The local community will also be informed about the grievance handling procedures of the project through Grama Niladharis[13]of the area and displaying notices at important public places within the Divisional Secretariat Divisions of Udapalatha and Ganga Ihala Korale.

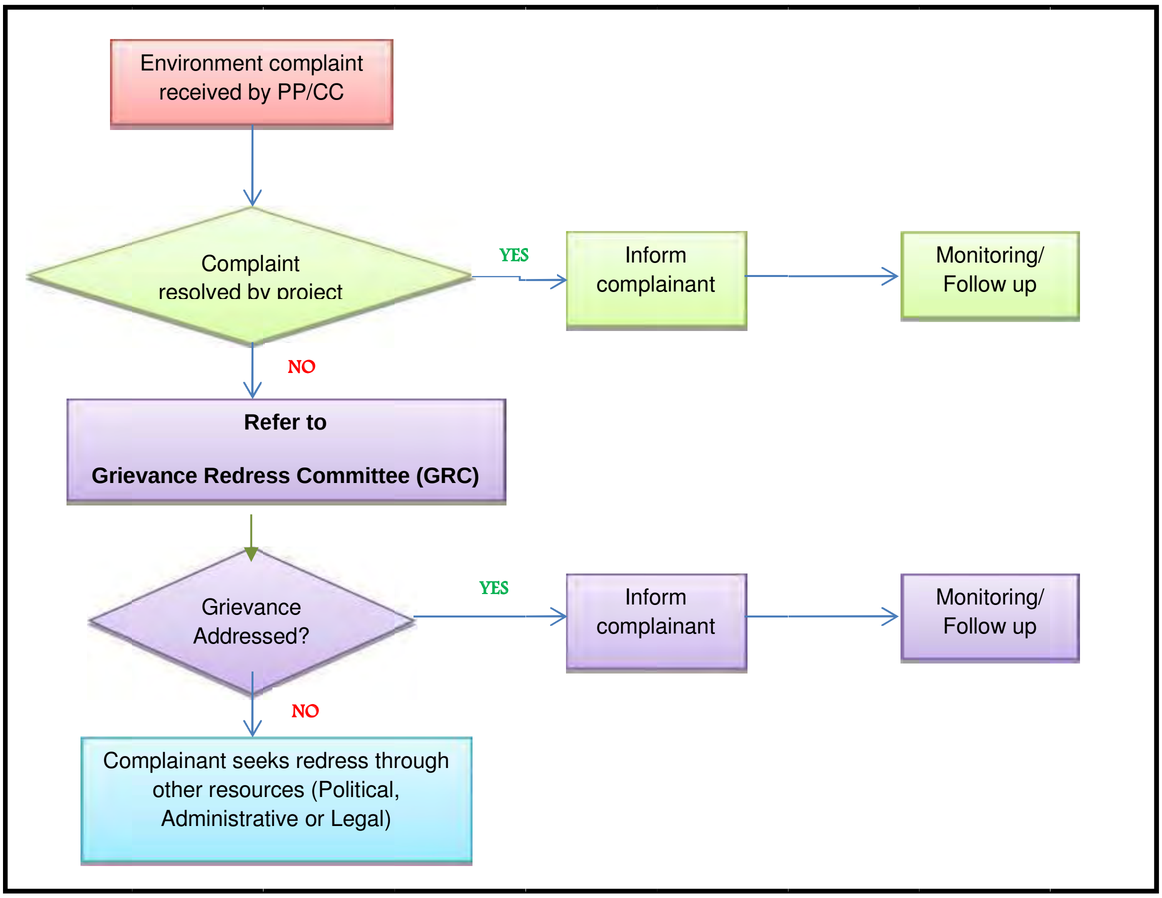

Fig. 3 : Complaint handling and Grievance Redress Mechanism

(PP= Project Proponent (Ceylon Electricity Board); CC= Construction Contractor)

[13]GramaNiladhari (Village leader) is a Sri Lankan public official appointed by the central government to carryout administrative duties in a GramaNiladhari division, which is a subunit of a divisional secretariat. The duties of a GramaNiladhari include the reporting of issuing of permits, gathering statistics, maintaining the voter registry and keeping the peace by settlement of personal disputes. They are responsible for keeping track of any criminal activity in their area and issuing character certificates on behalf of residents when requested.

5.4 Institutional Arrangements for GRM

The Additional District Secretary of the Kandy District will function as the Chairperson of the GRC. Members to represent the Affected Persons (AP) at the GRC will be appointed from among respected persons[14]in the area on the recommendations of the Divisional Secretaries of Udapalatha and Ganga Ihal Korale. Other members of the GRC shall be the Project Director (PD) of the PMO, a senior representative of the Design and Supervision Consultant and representative(s) of the Contractor(s). An officer nominated by the Project Director of the MHPP will serve as the Secretary to the GRC. An honorarium will be paid to the members of the GRC; the required funds for operation of the GRC will be borne by CEB.

A suitable place and other facilities to conduct the meetings of the GRC will be provided by MHPP. However, GRC meetings can also be held at any other suitable location for the convenience of the affected parties (eg. in case of ill health or any other valid reasons).

The GRC is expected to meet at least once a month, although more meetings may be held depending on the number of complaints received. The GRC may make field visits where necessary and these will be facilitated by MHPP.

5.5 Terms of Reference (ToR) of GRC

The GRM will be established by CEB during the pre-construction stage, so that the GRC and grievance redress procedures are in place and functioning before land acquisition, resettlement and project construction activities begin. The following is a draft ToR for the GRC, which CEB will consider and incorporate or amend as necessary:

- The GRC will examine any kind of dispute or grievance arising out of implementation of the Resettlement Plan (RP) and Environmental Management and Monitoring Plan (EMMP) and resolve such disputes and grievances in a transparent manner.
- GRC will not deal with matters that are pending in a court of law.
- The GRC will not have any jurisdiction over the amount of compensation determined by the Chief Government Valuer.
- The decision of the GRC is deemed final, although a dissatisfied complainant may seek redress through the Sri Lankan legal system if they so wish.
- Only authorized members will be allowed to participate in the GRC meetings (including the relevant Affected Persons and their representatives).

[14]Such as Senior Citizens; Priest of the Temple, Church or Kovil; Headmaster of school etc.,

- A decision on a particular dispute/grievance will be made unanimously or on a majority vote basis.
- The disputes and grievances will be resolved on the first day of the hearing or within 2 – 4 weeks of the first hearing where the issues may be more complicated and more information is required to arrive at a decision.
- A Hearing of certain disputes or grievances may be postponed and a new date be fixed if more evidence is required to make decisions.
- The decision of the GRC will be intimated to the Project Director and the aggrieved party in writing within a week from the meeting.
- The following general conditions should also apply: Persons who make appeals to the GRC shall attend the meetings of the GRC in person. In a case where the appellant is unable to attend the meeting on the appointed date due to sickness or other unavoidable circumstances, he/she can nominate a close relative or other representative in writing.
- No legal professionals are allowed to represent an appellant.
- Appellants may request an alternative date to attend at a particular meeting of the GRC if they are physically unfit to attend the meeting or due to other unavoidable circumstances.

Annex 1: Sample Complaints Registry

COMPLAINTS REGISTRY

Moragolla Hydropower Project

Reference No.	Date of receipt	Complainant Details	Nature of Complaint	Action Taken	Date Action Taken	Person Responsible	Inspection of completed action

SURVEY OF RIVER WATER QUALITY IN THE MORAGOLLA PROJECT AREA IN THE MONSOON SEASON FOR REVIEW OF FEASIBILITY STUDY AND PREPARATION OF DETAILED DESIGN AND BIDDING DOCUMENTS MORAGOLLA HYDROPOWER PROJECT, SRI LANKA

Final Report

Prepared by
National Building Research Organization

Prepared for
NIPPON KOEI Co Ltd - Moragolla Hydropower Project

September 2013

National Building Research Organization
Ministry of Disaster Management
99/1, Jawatte Road, Colombo 05, Sri Lanka

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Executive Summary

Introduction

The Ceylon Electricity Board (CEB) plans to develop a new 30.0 MW hydropower project at Moragolla in Kandy District. The project components are: 35 m high concrete gravity dam (with a 5-gate spillway) across the Mahaweli Ganga at Weliganga , 38.5 ha (1.98 MCM) reservoir with a Full Supply Level (FSL) at 548 m, a 3.1 km underground tunnel, surge shaft and penstock on the left bank of the river, and the powerhouse and the tail race outfall opposite the confluence with the Atabage Oya.

Nippon Koei Co. Ltd., the consultant appointed by CEB for the project assigned the National Building Research Organization (NBRO) to conduct an additional survey of river water quality in the project area in the monsoon season with the intension of investigating the differences in water quality between stations and between dry and wet seasons and to determine the reasons for all significant changes.

Monitoring river water quality

Water samples were collected from the Mahaweli Ganga at four stations numbered as L1 (Kotamale Oya), L2 Mahaweli Ganga (near Pattunupitiya school), L5 (about 300 m upstream from the proposed dam location) and L9 (downstream from the confluence of Mahaweli Ganga and Atabage Oya). The pH, Temperature, Dissolved Oxygen and Turbidity, Biochemical Oxygen Demand (BOD_5), Ammonia, Nitrate, Total Phosphorus , Total Suspended Solids, Faecal Coliforms and Total Coliforms were analyzed, and water quality status in monsoon, seasonal variations and compatibility with proposed national standards; "Ambient Water Quality – EA1P-DHV-2000" are reported.

Results and discussion

The water quality in stations L1 and L9 shows a closer resemblance to each other because; these two locations receive discharge water from Kothmale reservoir as environmental flow and tailrace discharge, respectively. Also, water draining from Nawalapitiya area influences the quality at L2 & L5.

Comparison of results with proposed water quality standards recommended for specific uses suggests that water in this part of the Mahaweli Ganga is not suitable for drinking, bathing or irrigation, in any of the seasons especially because of its high turbidity and bacterial content (Total coliforms).

Conclusion

The concentrations of most of the analysed parameters in the Mahaweli Ganga at tested locations are quite high in the wet season in comparison to dry. This evidence pollution from run-off containing fertilizers (Nitrogen and Phosphorus), sediment from erosion and other anthropogenic matter (Faecal coliforms) suggesting that water in this part of the Mahaweli Ganga is not suitable for drinking (after simple or conventional treatment), bathing or irrigation, in any of the seasons when compared with the proposed Ambient Water Quality standards.

The damming will create a permanent barrier against the natural flow discharge. However, the water will retain behind the dam only for a shorter period because this power project is a run on river type hydropower. Similarly, downstream water quality impacts are also considered to be low in the monsoon season because in addition to environmental flow, intermittent spills may also contribute to the river flow of the section between dam and the tailrace outfall enabling adequate dilution to pollutants.

1. Introduction

The Ceylon Electricity Board (CEB) plans to develop a new 30.0 MW hydropower project at Moragolla in Kandy District. The scheme involves construction of a 35 m high concrete gravity dam (with a 5-gate spillway) across the Mahaweli Ganga at Weliganga, to create a 38.5 ha (1.98 MCM) reservoir with a Full Supply Level (FSL) at 548 msl. The water from the reservoir will be diverted through a 3.1 km underground tunnel, surge shaft and penstock on the left bank of the river, to a powerhouse and outfall located opposite the confluence with the Atabage Oya.

A Feasibility Study (FS) was conducted in 2009, and this included an Environmental Impact Assessment (EIA) which is expected to be approved by the Mahaweli Authority of Sri Lanka (MASL). In 2012, CEB appointed Nippon Koei Co., Ltd (NK) to review the FS, prepare detailed designs and tender documents for project construction and to upgrade the EIA to comply with the Safe Guard Policy of the Asian Development Bank, the principal funding agency (Safeguard Policy Statement, ADB, Manila, 2009).

To upgrade the EIA, additional surveys were conducted in certain key fields in 2013, to supplement existing baseline conditions and to update the assessment of environmental impacts.

In addition to above studies, a survey of river water quality in the Mahaweli River at proposed Moragolla Hydropower Project area has been proposed in the monsoon season (September). The Nippon Koei Co. Ltd, Moragolla Hydropower Project appointed National Building Research Organisation (NBRO) to conduct this survey. This report presents the river water quality in the Mahaweli River at the Proposed Project area in the monsoon season (September).

This report presents the study conducted for river water quality as described in the Terms of Reference (ToR), shown in **Annex 1,** and includes following aspects:

- Differences in water quality between stations during the Monsoon season
- Differences between dry and wet seasons, and reasons for all significant changes
- Differences in Dry (March), with the first onset of rains (May) and Monsoon (September) surveys

2. Rationale

A survey of water quality in the Mahaweli Ganga was conducted by the National Building Research Organisation (NBRO) in March and May 2013. The period includes dry season and the end of the period. The river water quality data collected in this period does not reflect the condition in the monsoon season.

The objective of this additional survey is therefore to investigate water quality in the river during the monsoon and examine the seasonal differences by comparing results with the earlier surveys.

3. Approach

The ToR required colleting duplicate water samples from the Mahaweli Ganga at four stations numbered as L1, L2, L5 and L9 same stations as the previous survey [1] (refer location map, Fig.1) and water should be analyzed for total of ten water quality parameters, namely, pH, Temperature, Turbidity, Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD_5), Ammonia, Nitrate, Total Phosphorus (TP), Total Coliforms (TC) and Faecal Coliforms (FC). The Dissolved Oxygen content was also analysed in this survey because this determinand is a main parameter in previous surveys; March and May.

3.1 Sample collection, transportation and preservation

Samples were collected on 17.09.2013 during Monsoon period between 09.00 am and 11.45 am by the NBRO staff (**Annex 2**). Description of sampling locations and GPS references are given in **Annex 3**. Photographs taken during sampling are given in Fig.2.

Sample collection, preservation, transportation and analysis for physicochemical parameters were carried out according to the Standard Methods[2]. The bacteriology (Faecal Coliforms and Total Coliforms) sampling and analysis were done according to the Specification for Potable Water[3]. Different devices were used in sampling depending on the method requirement. Accordingly, samples for general water quality parameters were collected by flinging a clean plastic bucket, tied to a rope, to the flowing water stream. Bottles having a ground-glass stopper and flared mouth were used for the collection of water samples for the determination of Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) whilst pre sterilized bottles were used for the collection of samples for bacteriological analysis. Duplicate water samples were collected from each location within 10 minutes from the collection of first sample. Accordingly, the sampling program covered collection of 8 samples from 04 locations.

The water samples collected for water quality parameters except for DO, BOD and bacteriological analysis were transferred securely into clean plastic screw-top containers, and those collected for Dissolved Oxygen were fixed at site by adding $MnSO_4$ and alkali-iodize - azide reagents. All samples were labelled with location No, date and specific parameter to be analysed. Carefully packed samples in separate cooler boxes with ice were then transported to the NBRO laboratory, Colombo on the same day. A temperature of 4 -10^0 C was maintained during transportation. In the laboratory, the samples were stored at 4^0 C until analysis was performed.

3.2. Analysis of samples for water quality parameters

The pH, Temperature and Turbidity were measured at site using calibrated meters. The analysis was commenced on the following day of the sampling event and continued for 05 days.
Annex 4 presents the methodology followed in sampling and analysis.
Fig.3 shows the photographs taken during the sample analysis in the laboratory.

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[1] Final Report: Water quality in the Mahaweli Ganga- upstream and downstream of the proposed dam at Moragolla (NBRO, 2013)
[2] Standard Methods for the Examination of Water and Wastewater, American Public Health Association, AWWA, WEF, 20th Edition, 1998.
[3] Specification for potable water, Bacteriological requirement, Sri Lanka Standards, 614:1983, Part 2

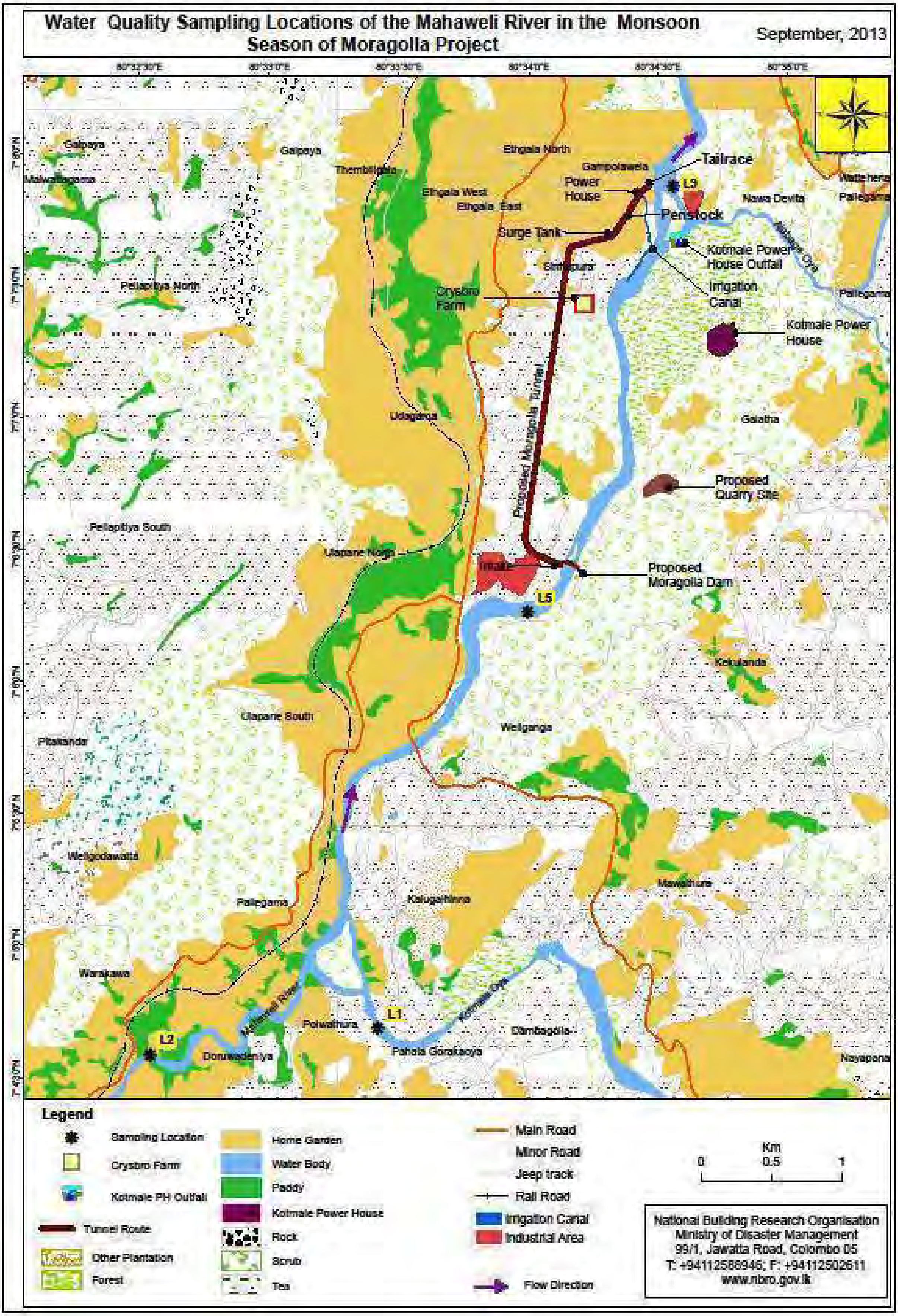

Fig 1. Map of survey area and sampling locations

	
Sampling Location L1- Kothmale Oya	Sampling Location- L2 Mahaweli Ganaga near Pattunupitiya school
	
Sampling Location L5- Mahaweli river 300m upstream from the proposed dam location	Sampling Location L9- Mahaweli Ganga after the confluence of Atabage Oya

Fig.2 Photographs taken during sampling

Fig.3. Photographs taken during laboratory analysis

4. Results and Discussion

The **Table 1 and Annex 5** presents the results of river water quality analysis and the data are shown graphically in **Fig.4**.

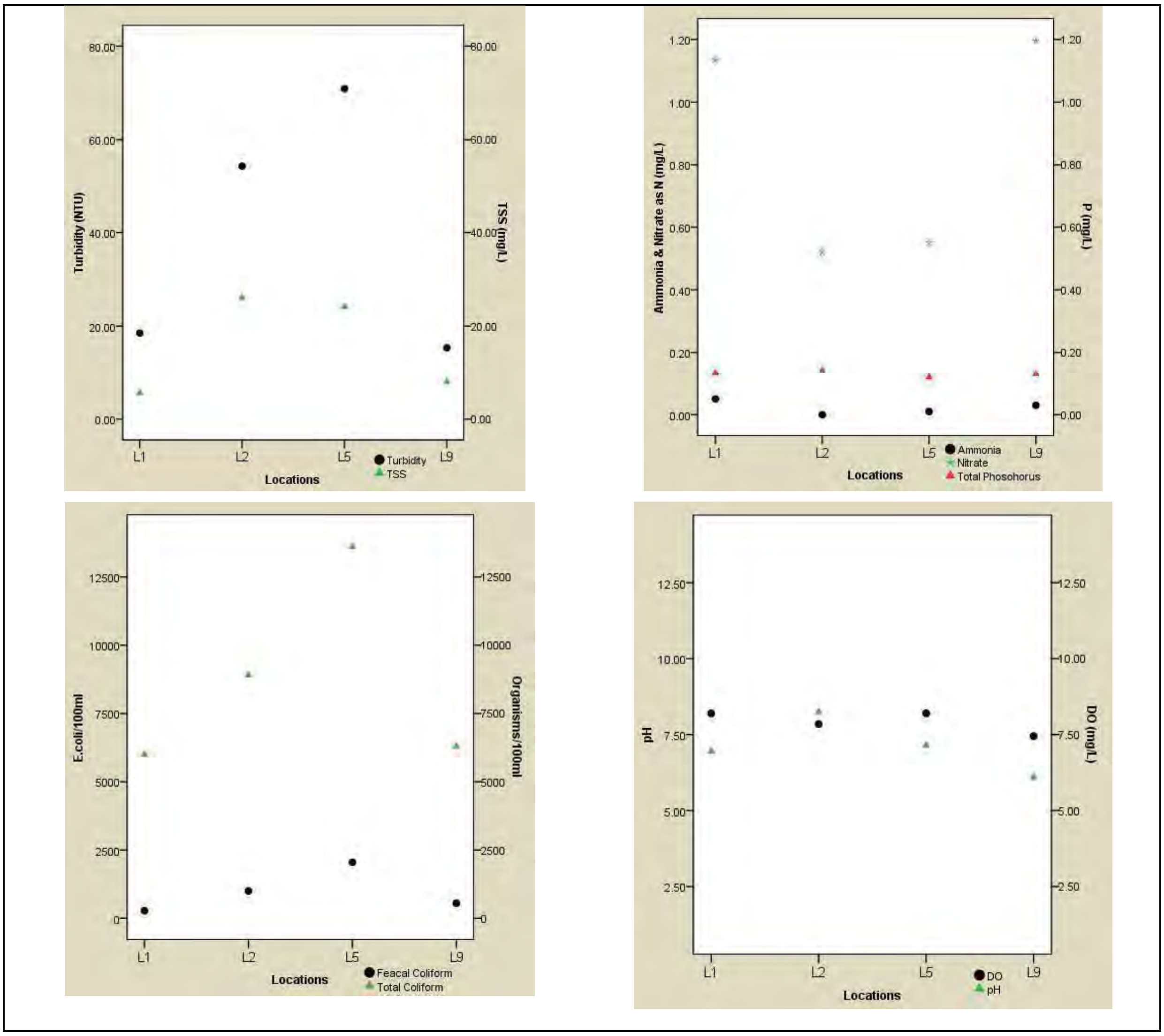

Fig 4. Variations in water quality between stations
(Values are the average of two duplicate samples)

Table 1. Results of water quality in Dry (March), First onset of rains (May) and Monsoon (September) surveys

Category No.	Location	pH	Temperature ^{0}C	Turbidity NTU	DO mg/L	BOD_5 mg/L	Ammonia (as N) mg/L	Nitrate (as N) mg/L	TP (as P) mg/L	TSS (mg/L)	FC E.coli/100ml)	TC (Coliform Organisms/ 100ml)
	Monsoon (September) Survey											
	L1	6.95	20.8	18.5	8.2	1.0	0.05	1.134	0.134	5.5	274	6000
	L2	8.25	20.5	54.3	7.8	1.4	0	0.521	0.142	26.1	1000	8900
	L5	7.15	20.3	70.9	8.2	<1	0.01	0.55	0.120	24.1	2050	13600
	L9	6.10	19.3	15.3	7.5	1.2	0.03	1.195	0.131	8.0	550	6300
	Dry (March) Survey											
	L1	7.05	27.2	4.0	14.4	<1	0	0.2875	0.097	2.4	200	1000
	L2	7.10	25.3	20.6	6.9	<1	0.03	0.33	0.040	12.7	850	11700
	L5	7.30	26.0	33.9	7.2	<1	0.04	0.326	0.039	15.9	900	14100
	L9	7.0	25.1	3.7	7.4	<1	0.03	0.27	0.106	2.7	540	9000
	First onset of rains (May) Survey											
	L1	6.6	21.8	14.4	8.2	1	0.14	0.803	0.084	4.8	158	5550
	L2	7.1	23.7	25.8	7.4	<1	0.37	0.6365	0.020	32.2	1200	205000
	L5	6.5	21.5	30.5	8.2	1.3	0.17	0.463	0.106	32.7	5000	110000
	L9	6.95	21.5	118.5	6.1	<1	0.16	0.4105	0.138	58.5	350	105000
	Ambient Water Quality – EA1P-DHV-2000											
2- Drinking water – Simple Treatment		6.0-8.5	-	5 (max)	6 (min)	3 (max)	-	5 (max)	0.23 (0.7 as PO_4) max	-	600 (max)	5000
3-Bathing		6.0-9.0	-	-	5 (min)	4 (max)	-	5 (max)	0.23(0.7 as PO_4) max	-	50	1000
4-Fish &Aquatic life		6.0-8.5	-	-	3 (min)	4 (max)	0.94 (max) (pH < 7.5)	5(max)	0.23(0.7 as PO_4) max	-	-	20000
5-Drinking water – Conventional Treatment		6.0-9.0	-	-	4 (min)	5 (max)	-	5 (max)	0.23 (0.7 as PO_4) max	-	-	5000
6- Irrigation & Agriculture		6.0-8.5		-	3 (min)	5 (max)	-	5 (max)	0.23(0.7 as PO_4) max	-	-	1000

Non compliance with Category 2 *Values are the average of 2 duplicate samples*

4.1 Differences in water quality between stations during the Monsoon season

The pH, Temperature, DO, BOD, TP and Ammonia at 4 stations do not show noticeable differences among each other in the season. However, differences are observed in turbidity, TSS and Nitrates. The measured turbidity values are very high at L2 & L5; Avg. 70.9 NTU and 54.35 NTU respectively, and much low values at L1 and L9 (Avg. 18.5 and 15.35 NTU). Values for TSS also showed a similar pattern in which measured TSS at L2 and L5 are as high as 26.05 and 24.1 mg/l , but that is low at L1 & L9 (5.05 and 8.05 mg/l respectively).

The Nitrates show an opposite distribution where the average nitrate levels at L1 and L9 are as high as 1.13 mg/l and 1.19 mg/l, but the levels are low at L2 and L5, 0.52 mg/l and 0.55 mg/l respectively. In this survey, one set of data was collected to represent seasons. Actual cause for increased nitrates at L1 and L9 cannot be explained with this.

However, it appears that the water quality in Kotmale has played a significant role in the water quality of L1 and L9. During the monsoon season reservoir undergo turnover and mixing and as a result bottom nutrients may come to upper layers where nitrogenous compounds decompose resulting conversion to Nitrates (NO_3; the ultimate stable form of N). Therefore, there is a possibility that nitrogen levels could be high in the environmental flow and tailrace discharge of Kotamale reservoir.

The measured values of faecal indicator bacteria at L1 and L9 are almost closer to each other and similarly at L2 and L5.

These results indicate that the water quality in stations L1 and L9 shows closer resemblance to each other. The reason for this could be the influence of Kothmale reservoir on the river water quality, because; these two locations receive discharge water from Kothmale reservoir as environmental flow and tailrace discharge, respectively. At the time of sampling, flow in L9 may presumably be dominated by the Kotmale tailrace discharge; but flow data are required to conclude this.

Similarly, the levels of determinands at stations L2 and L5 resemble each other especially in TSS, Nitrates, TP, and faecal coliform content. The water quality at two stations (L2 and L5) is dominated by water draining from Nawalapitiya area.

4.2 Suitability of water for different uses

The proposed Standard; "Ambient Water Quality – EA1P-DHV-2000" was used to indicate suitability water in the river reach for different uses. The proposed standard specifies seven user categories:

- Category 1 - Nature conservation
- Category 2 - Drinking water with simple treatment
- Category 3 - Bathing
- Category 4 - Fish and aquatic life
- Category 5 - Drinking water with conventional treatment
- Category 6 - Irrigation and agriculture
- Category 7 - Minimum Quality

These comparisons suggest that pH, DO, BOD, Nitrate and Total Phosphorus levels at 4 locations meets requirements for all six uses (Categories 2-7), and in addition, faecal coliform levels at L1 and L9 conform with Category 2 water use (drinking water after simple treatment) But, other parameters, turbidity and total coliforms, exceed the Category 2 limit.

Also, the results show that during the monsoon season, water at all locations do not satisfy the quality requirement for Category 3 (bathing) or use in irrigation (Category 6) because the faecal and total coliform counts exceed the limits. Further, at all locations, the water is not suitable for drinking after conventional treatment (Category 5) because values for total coliforms exceeded the respective limit.

The damming will create a permanent barrier against the natural flow discharge. However, the water will retain behind the dam only for a shorter period because this power project is a run on river type hydropower. Nevertheless, sediment may enter and accumulate behind the dam during the wet season as a result of rain triggered soil erosion, but the quantities may not be significant because of shorter retention time in the rainy season. Therefore, in this season, the possible occurrence of reservoir eutrophication is unlikely. Similarly, downstream water quality impacts are also considered to be low in the monsoon season because in addition to environmental flow, intermittent spills may also contribute to the river flow of the section between dam and the tailrace outfall enabling adequate dilution to pollutants.

4.3. Differences between dry and wet season

A graphical presentation of the water quality in dry (March) and wet season (September) is presented in the Fig. 5.

This figure shows that at most stations the concentration of most of the analysed parameters are high in the wet season, in comparison dry season. Accordingly, the values of Dissolved oxygen are generally higher under high flow conditions because of increased atmospheric exchange caused by high surface turbulence. The suspended solids, plant nutrients (nitrate and phosphate) and other contaminants such as ammonia and faecal bacteria are also high in the wet season, most likely because of runoff of erosion prone land contaminated with fertilizers and other matter of anthropogenic origin.

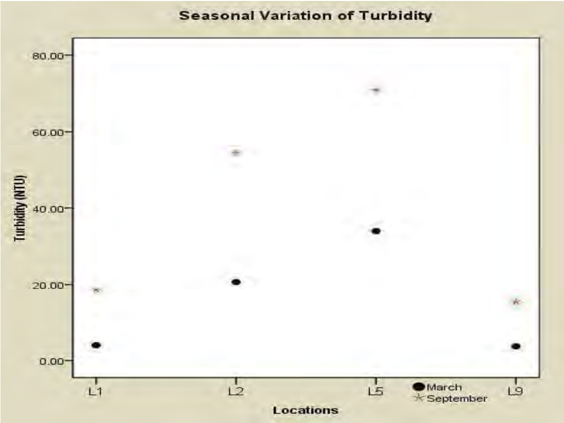

Fig 5.1 Variations of Turbidity

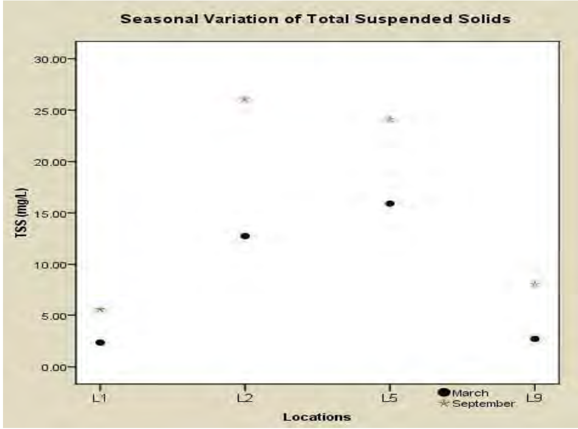

Fig 5.2 Variations of Total Suspended Solids

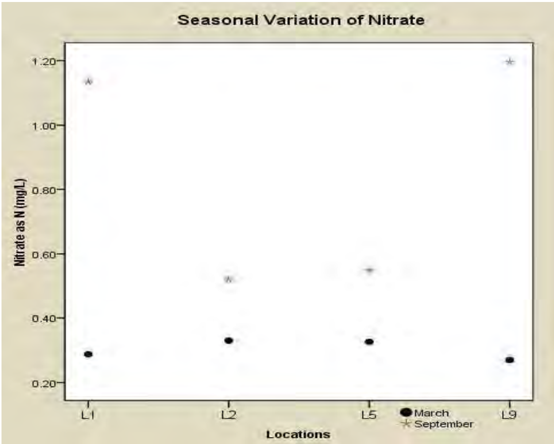

Fig 5.3 Variations of Nitrate

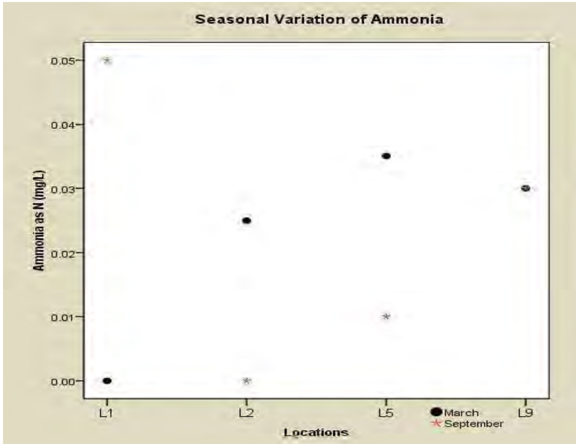

Fig 5.4 Variations of Ammonia

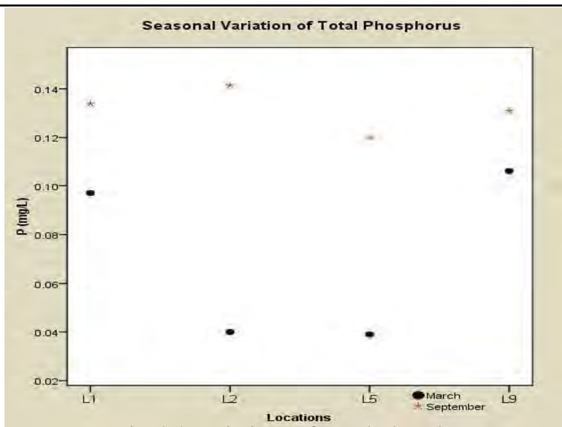

Fig 5.5 Variations of Total Phosphorus

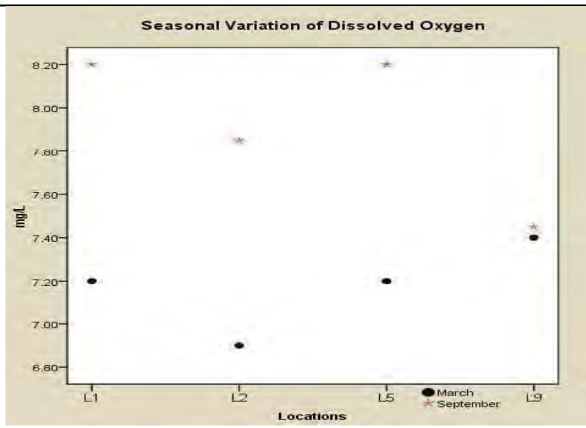

Fig 5.6 Variations of Dissolved Oxygen Oxygen

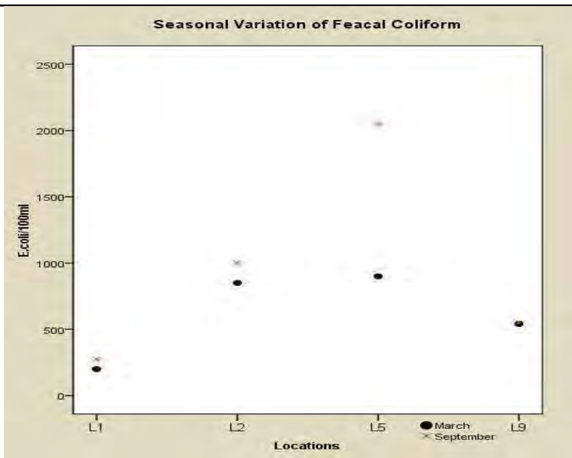

Fig. 5.7 Variations of Feacal Coliforms

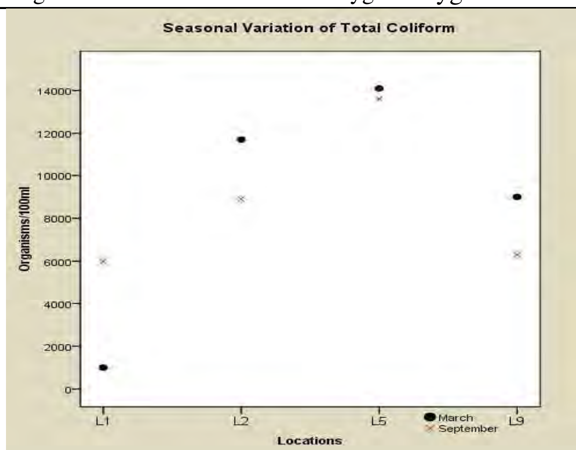

Fig 5.8 Variations of Total Coliforms

Fig 5 Variations in water quality (Dry and wet seasons) Values are the average of two duplicate samples

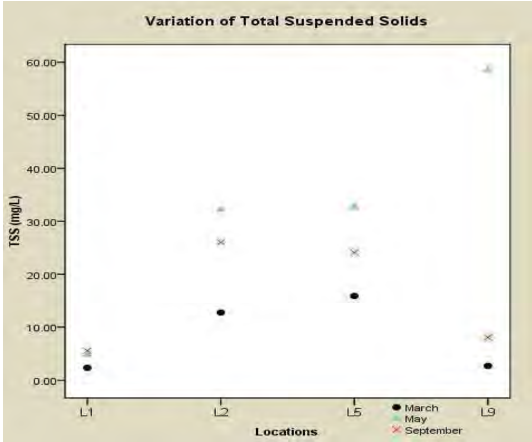

Fig 6.1 Variations of Total Suspended Solids

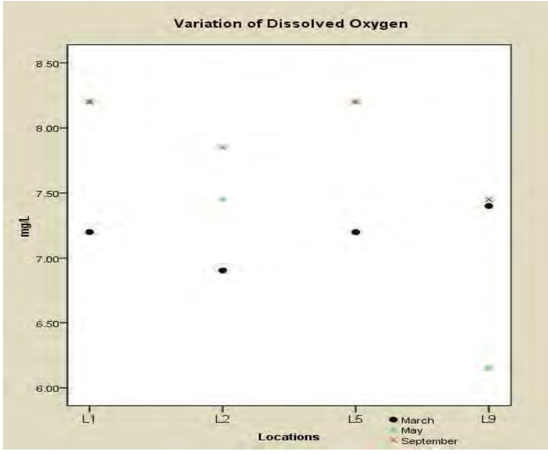

Fig 6.2 Variations of Turbidity

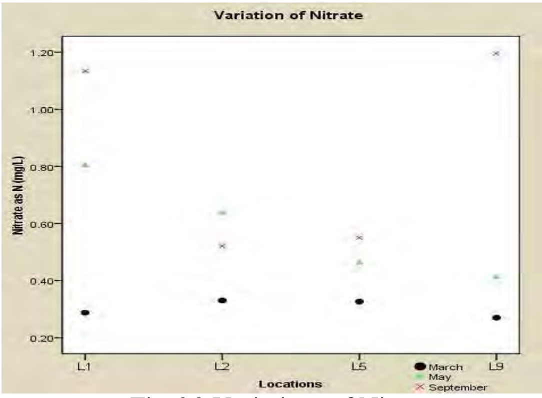

Fig 6.3 Variations of Nitrate

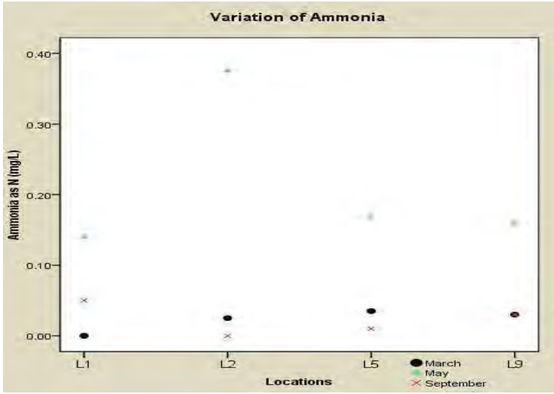

Fig 6.4 Variations of Ammonia

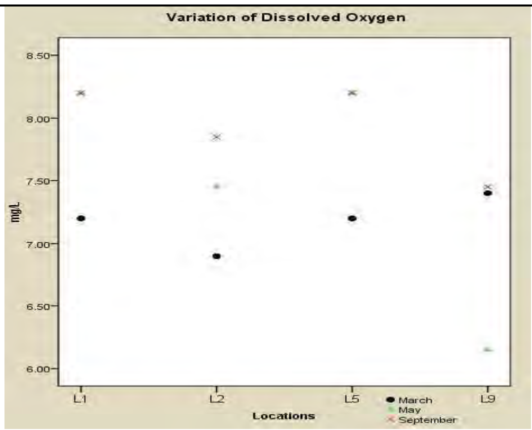

Fig 6.5Variations of Dissolved Oxygen

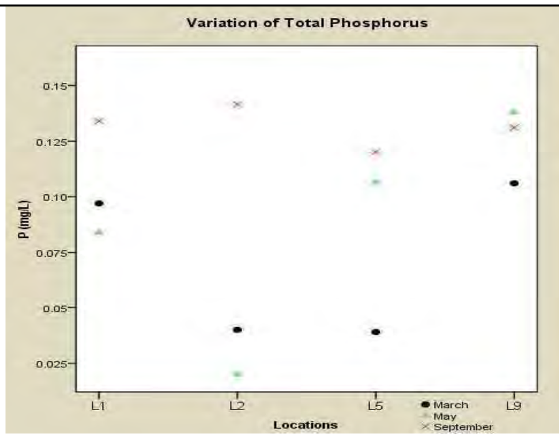

Fig 6.6 Variations of Total Phosphorus

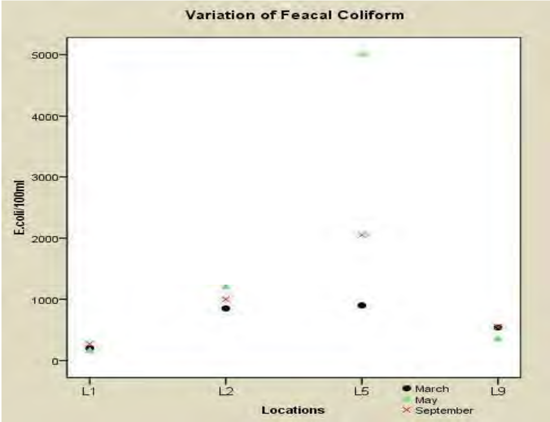

Fig 6.7 Variation of Feacal Coliforms

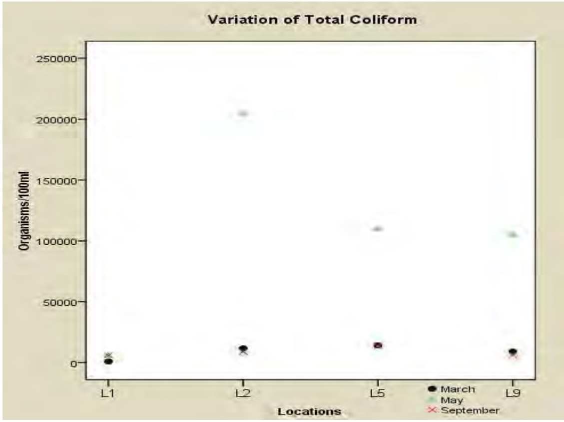

Fig 6.8 Variation of Total Coliforms

4.4 Differences in Dry (March), with the first onset of rains (May) and Monsoon (September) surveys

The results of water quality in the Mahaweli Ganga at stations L1, L2 L5 and L9 in all three surveys; March, May and September are tabulated in Table 1. and are graphically presented in Fig. 6. These graphs and the discussion in Sections 4.1-4.3 show that there is a temporal and seasonal variation in river water quality.

The concentration of water quality determinads appear to be influenced by the increased runoff of the first onset of rainfall (May) and with the monsoon rains (September). The higher suspended load in the initial onset of rains is seen in the river water quality in May, but the levels tend to lower due to dilution during monsoon period (September). This pattern is shown in the results of ammonia at all four stations and the bacterial counts; Total coliforms at stations L2, L5 and L9. The Total coliform bacteria inhabit in natural environment, mostly associated with soils and plant debris. In the event of first onset of rainfall in May, runoff draining the land enters into the river and soil inhabiting TC may also be carried with the rains resulting very high numbers at the survey in May. Higher values of TC have been reported at L2 and L5 (water draining from Nawalapitiya area) and L9 (draining from Atabage Oya catchment). But at L1, the value is lower because Kotamala reservoir acts as a buffer and under decay results lower TC values in the environmental flow discharge.

TSS values at all locations except L1 show increase with the onset of rains and decrease in the monsoon season. Turbidity values increase at stations; L1, L2, L9 in May with the onset of rains, however, the value decrease only in L9 with first onset of rains and increase further at stations L1 and L2 with the monsoon rains. The station L5 shows different pattern in turbidity level with rains.

Nitrogen and Phosphorus levels are considered, the values of Nitrates tend to increase with the onset of rains at all locations. This is due to run-off contaminated with fertilizers of Nitrogen origin. But only at the location L2 decrease during monsoon while at other locations are in the increasing trend.

The levels of phosphorus are considered, stations L5 and L9 show increase with the rains however, L1 and L2 show different results.

Comparison of results with proposed water quality standards recommended for specific uses suggests that water in this part of the Mahaweli Ganga is not suitable for drinking (after simple or conventional treatment), bathing or irrigation, in any of the seasons especially because of its high turbidity and bacterial content (Total coliforms).

Fig 6. Variation in water quality (March, May and September surveys)
Values are the average of two duplicate samples

5. Conclusion

In conclusion, it can be stated that at all stations the concentration of most of the analysed parameters are quite high in the wet season, in comparison to dry. This evidence pollution from run-off containing fertilizers (Nitrogen and Phosphorus), sediment from erosion and other anthropogenic matter (Faecal coliforms). This may be due to land use pattern in the Mahaweli catchment which dominated with tea cultivations, agriculture among the other.

The damming will create a permanent barrier against the natural flow discharge. However, the water will retain behind the dam only for a shorter period because this power project is a run on river type hydropower. In this season, the possible occurrence of reservoir eutrophication is unlikely. Similarly, downstream water quality impacts are also considered to be low in the monsoon season because in addition to environmental flow, intermittent spills may also contribute to the river flow of the section between dam and the tailrace outfall enabling adequate dilution to pollutants.

Annexure

Annex 1

Terms of Reference (ToR)

TERMS OF REFERENCE FOR ADDITIONAL STUDIES IN THE NATURAL ENVIRONMENT

MORAGOLLA HYDROPOWER PROJECT
REVIEW OF FEASIBILITY STUDY AND PREPARATION OF DETAILED DESIGN & BIDDING DOCUMENTS
SURVEY OF RIVER WATER QUALITY IN THE MORAGOLLA PROJECT AREA IN THE MONSOON SEASON

1. BACKGROUND

The Ceylon Electricity Board (CEB) plans to develop a new 30.0 MW hydropower project at Moragolla in Kandy District. The scheme involves construction of a 35 m high concrete gravity dam (with a 5 gate spillway) across the Mahaweli Ganga at Weliganga, to create a 38.5 ha, 1.98 MCM reservoir with a full supply level (FSL) at 548 m asl. Water will be diverted through a 3km underground tunnel, surge shaft and penstock on the left bank of the river, to a powerhouse and outfall located opposite the confluence with the Atabage Oya

A feasibility study (FS) for the project was conducted in 2009, and this included an Environmental Impact Assessment (EIA)[I] which is expected to be approved by the Mahaweli Authority of Sri Lanka (MASL) in the near future. In 2012 CEB appointed Nippon Koei Co., Ltd (NK) to review the FS and prepare detailed designs and tender documents for project construction; and to upgrade the EIA to comply with the Safeguard Policy[II] of the Asian Development Bank, the principal funding agency.
To upgrade the EIA, surveys were conducted in certain key fields in 2013, to supplement existing baseline data and update the assessment of impacts. Some further study is now needed, so that mitigation measures can be properly planned and designed.

2. RATIONALE

A survey of water quality in the Mahaweli Ganga in the vicinity of the project area was conducted by the National Building Research Organisation (NBRO) in May-July 2013. The aim of this work was to: a) investigate the present quality of water in the river; b) determine the nature, extent and likely sources of any pollution; and c) predict the quality of water impounded in the Moragolla reservoir, and discharged downstream when the scheme is operating.
The period in which the study was conducted only allowed sampling in March and May 2013, so the data did not properly examine conditions in the monsoon season. An additional small-scale survey is therefore required in order to correct this anomaly. The objective of this survey is to investigate water quality in the river during the monsoon and examine seasonal differences by comparison with the results of the earlier surveys, and discuss the reasons for any significant water quality changes.

3. SCOPE OF WORK

1. This work will be conducted by a nationally – recognised environmental consultancy company, with 10 years or more of professional experience in environmental survey, analysis, data interpretation and report preparation, including extensive experience of water quality surveys in rivers.
2. The field surveys will be planned and led by a senior water quality expert with at least 10 years of practical experience in planning and interpretation of river water quality surveys and data analysis.

[I] Ceylon Electricity Board (2012): *Moragolla Hydropower Project, Feasibility Study.* Final Report: Volume 3 Environmental Impact Assessment (Central Engineering Consultancy Bureau

[II] Asian Development Bank (2009) Safeguard Policy Statement. ADB, Manila, 90pp. (http://www.adb.org/site/safeguards/policy-statement).

3 The contractor shall collect duplicate water samples from the Mahaweli Ganga at four stations only. Stations are numbered L1, L2, L5 and L9 and the locations are shown on Fig 1 (Page 3) of the NBRO water quality report

4 Water samples shall be collected in August 2013, and all samples shall be collected on the same day, between 08.00 and 13.00 hours. Samples should be collected in rapidly flowing water, as far from the bank as feasible, and the same collection technique shall be used at each station.

5 Samples shall be transported promptly to a suitable Government-accredited laboratory, under controlled temperature conditions that are appropriate for the tests to be conducted. All analyses shall be performed on the same day as sample collection, or at the latest on the following day.

6 Laboratory analyses must be performed by a laboratory that is fully accredited by the Government to perform the analyses specified in this study and a copy of the relevant accreditation certificates shall be included in the report appendix.

7 Temperature, turbidity and pH should be measured on site using suitable, accurately calibrated meters. In the laboratory the duplicate water samples shall be analysed for total suspended solids, BOD_5, nitrate, ammonia, total phosphorus, total coliforms and faecal coliforms using standard analytical procedures.

8 The results of the analyses shall be presented and discussed in a report, which shall be set out as shown in Box 1 below. The text should be divided into each of the main sections indicated (Executive Summary, Introduction, etc) and each section should be further subdivided as necessary. The text in each section should cover at least the topics shown in the annotations, plus any other topics necessary to provide an informed discussion of the issues.

9 The report should be written in the style of an academic paper and should be concise and informative and written in grammatically correct, good quality English.

10 The report will be read by professional persons who are not experts in water quality, so any technical terms must be explained in footnotes or a glossary.

4 PROGRAMME

The works shall be commenced immediately after signing the Contract Agreement. The draft report shall be submitted to NK within one month from the date of signing the Contract Agreement: 3 hard copies and 1 soft copy (in a single MS Word file). NK will review the report and provide their comments, which the expert shall address in full within two weeks of receipt. The expert shall then submit the final version of the report: 3 hard copies and 1 soft copy (in a single MS Word file).

Box 1 : Lay out and content of Report on Water Quality of the Mahaweli River in the Moragolla Project area during the monsoon season

The project; reasons for this study; aims and objectives

EXECUTIVE SUMMARY	Concise summary of the report, key findings and recommendations
INTRODUCTION	The project; reasons for this study; aims and objectives
APPROACH	How this work was done. Full written descriptions of: sample collection; sample storage and transportation; field analyses; laboratory analyses. With a map of the sampling stations and photographs of work being conducted on site and in the laboratory.
RESULTS & DISCUSSON	A detailed discussion of the results, in particular examining; a) differences between stations during this survey; and b) differences between dry and wet seasons (shown by comparisons with the data collected by the previous survey).Reasons for all significant differences should be discussed, and wet season water quality should be assessed by reference to appropriate standards. Data should be presented in tables and graphical from, in the same way as the previous survey, and the data from all three survey periods should be shown on the same graphs to assist in the discussion.
CONCLUSION	Overall conclusions regarding: water quality in the project area during the monsoon season; the main differences from the dry season, and the reasons for those differences.
APPENDICES	TOR; tables of data collected by this survey; details of all analytical methods and laboratory quality control procedures; certificates showing that the laboratory is accredited by the government for performing the analyses involved in this study

Annex 2

Study team

Study team

Key staff

Name	Designation
Ms S V Dias	Senior Scientist Water Quality Specialist
Ms S A M S Dissanayake	Senior Scientist
Mr Vimukthi Sumanasekara	Scientist
Ms H.T.J. Seneviratne	Scientist

Laboratory analysis team

Name	Designation
Ms P D C Pathiraja	Technical Assistant
Ms P H D Silva	Technical Assistant

Support staff

Name	Designation
Mr N Krishnamoorthi	Field Assistant
Mr A Premaratne	Field Assistant
Mr Chamath Vithanage	Laboratory Attendant

Annex 3

GPS reference of sampling locations and descriptions

GPS reference of sampling locations and descriptions

Sample location reference	GPS reference	Description of location
L1- Kothmale Oya	80^0 55’ 65.84” 7^0 07’ 78.92”	The sample location is at Kothmale Oya about 1km upstream from the confluence of the Mahaweli and the Kothmale Oya. The river section is relatively high gradient rocky terrain having exposed bed rock out crops. In this section water flows through a cascade of pools separated with short drops. In pools there was very little surface turbulence and at drops the flow was highly turbulent. In this section isolated water pools filled during high flow conditions were also present. These were cut-off from the main river stream due to reduced flow conditions. The water appeared colourless and clear. Aquatic organisms were observed on the water surface of pools. Both river banks were consisting of exposed bed rock out crops and disturbed riparian vegetation. At right hand side isolated plots of tea cultivations were observed in addition to trees and shrubs. There were rains during sampling.
L2 - Mahaweli Ganga – closes to 13/6 culvert of the Ulapane – Nawalpitiya Road	80^0 54’ 19.18” 7^0 07’ 65.34”	Sample was collected from the Mahaweli Ganga near Pattunupitiya school. There were home gardens and isolated small tea plots present on the right hand side. On the Left bank, the riparian vegetation was dominated with a thick strip of Bamboo trees. Sand mining sites were located from 50 m upstream from the sampling location. The water was more turbid and muddy in colour and high in velocity. There were rains during sampling.
L5-Mahaweli Ganga – at bathing point and sand mining point	80^0 56’62.02” 7^0 10’ 41.82”	The sampling location is about 300m upstream from the proposed dam location. The area is used for sand mining. Sand mining activities were observed during sampling. The water was turbid and muddy in colour. The disturbed riparian vegetation consisted of shrubs and herbs; dominated with grasses. Ulapane Industrial zone was visible over the left bank of river. There were rains during sampling.
L9 - Mahaweli Ganga- near the confluence of Mahaweli Ganga and Atabage Oya	80^0 57’ 66.60” 7^0 13’ 09.12”	The sampling location is about 50 m downstream from the confluence of Mahaweli Ganga (right arm stream) and Atabage Oya. The “Maga Neguma” Metal Crusher is located about 10 m upstream from the sampling point. Kothmale HPP tailrace outfall is located upstream to this location. During the sampling event it was observed the tailrace released high flow of water with high turbulence and muddy colour. The stream bottom substrate consists of large to moderate size boulders. Left hand side of the riparian vegetation consist of shrubs and herbs, dominated with grasses. Right hand side is consisted of shrubs and stream bank dominated with Bamboo trees.

Annex 4

Analytical Methods and Quality Control procedures

1. Analytical Methods

Parameter	Method Reference	Description of the Method
pH	APHA 4500 H-B Electrometric method	pH and Temperature were measured using ***pH meter, brand ; pH 5+ pH/^{0}C of EUTECH Instrument Singapore origin.*** The meter was first calibrated using NIST pH 4.01 and pH 6.86 buffer solutions (NIST; National Institute of Standard Technology). The pH and Temperature of water samples were taken after calibration by immersing electrode and the probe
Temperature	APHA 2550 B Electrometric method	
Turbidity	APHA - 2130 B Nephelopmetric method	Turbidity was measured using Turbidity meter: ***TN-100/T-100 Portable Turbidity meter EUTECH instruments Singapore origin***. The meter follows the ISO 7027 standard. Turbidity meter was first calibrated using series of Environmental Protection Agency (EPA) approved standards (CAL 1:800, CAL 2:100, CAL 3: 20, CAL 4: 0.02). The 800 NTU vial was inserted into the sample well, aligning the mark on the vial with mark on the meter. Vial was pressed down until it snaps fully into the instrument and then covered using the light shield cap. Meter was switched "ON" and calibration function Calibration was repeated for CAL 2, CAL 3 & CAL 4 calibration standards. The vial was then rinsed and then filled with the sample water. The capped vial was then placed inside the sample well and aligned the vial's index mark with the meter's index mark. The meter was set "ON" and the reading appeared in the display was taken as the measurement.
Dissolved Oxygen	APHA-4500-O-C Azide modification	Water samples were collected in a 300 ml bottles having a ground-glass stopper and a flared mouth without entrapping air bubbles. Dissolved oxygen in the sample was fixed by adding 2 mL of $MnSO_4$ and 2 mL of alkali-iodize –azide reagents to the bottle at the site. Then the bottle was stoppered carefully to avoid air bubbles and mixed well by inverting the bottle a few times. These bottles were transported to the laboratory at 4 to 10 ^{0}C. In the determination of DO, 2.0mL of conc. H_2SO_4 was added to the bottle and mixed well until dissolution of precipitate is completed. A 200 mL portion from this sample was titrated with 0.025M Na_2SO_4 solution to a pale yellow color. Then few drops of starch solution were added and titration was continued to first appearance of blue color. **Calculation** For titration of 200mL sample, 1mL 0.025N Na_2SO_4 = 1mg DO/L

Parameter	Method Reference	Description of the Method
Biochemical Oxygen Demand	APHAA 5210-B 5-Day BOD test	Water samples were collected in a 300 ml bottles having a ground-glass stopper and a flared mouth without entrapping air bubbles. To prevent entry of air in to bottles during incubation water was added to the flared mouth of the bottle and then capped with plastic cap. For each measurement two bottles were prepared in the above manner and transported to the laboratory at 4-10^{0}C. Of the two sets, the dissolved oxygen in one set was determined on the following day. This gives the Initial oxygen levels. The bottles in the other set were incubated at 20^{0}C for 5 days. After 5 days the DO was determined similar to first set. This gives remaining oxygen after five days Determination of BOD BOD mg/l = Initial dissolved oxygen level in the sample - Final dissolved oxygen level in the sample (Initial dissolved oxygen is the value measured as dissolved oxygen)
Nitrate	APHA 4500-NO2-B Photometry	10 mL of sample was taken to the sample vial and color was developed by crushing Nitrate test tablet supplied by the manufacturer. The developed color was then measured using Lovibond, Maxi Direct SN 10-1083 photometer made in Germany. The Method used is APHA 4500-NO2-B. The reading appeared on the meter was taken as the measured value
Ammonia	APHA-4500-NH_3 F	10 mL of sample was taken to a sample vial and color was developed using ammonia No.1 and No.2 tablets supplied by the manufacturer. The developed color was then measured using Lovibond Maxi Direct SN 10-1083 photometer made in Germany. The Method used is APHA-4500-NH_3 F. The reading appeared on the meter was taken as the measured value.
Total phosphorus	APHA 4500- P-D Stannous Chloride method	In the laboratory 100 mL of sample was digested with 1mL of H_2SO_4 acid and 0.4 g solid $(NH4)_2S_2O_8$ until a final volume of 10 mL was reached. The digested sample was then cooled, diluted to 30 mL with distilled water, and neutralized with NaOH. The sample was made up to 100 mL in a volumetric flask with distilled water. Then the color was developed by adding 4.0 mL Ammonium Molybdate reagent I $(NH_4Mo_7O_{24}.4H_2O)$ and 0.5 mL stannous chloride reagent I $(SnCl_2.2H_2O)$. After 10 minutes, colour was measured at 690 nm using UV visible spectrophotometer and compared with a calibration curve prepared using series of standard phosphate solution of KH_2PO_4 and the distilled water blank. In the analysis of dissolved Phosphated the digesion part was omitted. **Calculation** $\text{mg P/l}=\frac{\text{mg P (in approximately final volume)}}{\text{ml sample}}\times 1000$ The result phosphorus was expressed as P mg/L.

Parameter	Method Reference	Description of the Method
Total Suspended Solids	APHA 2540 D	Glass-fibre filter papers were used in the determination of suspended solids. First, the filter papers were washed with distilled water and dried in an oven at 103^{o}C to 105^{o}C for 1hour. Then the initial measurements were taken to 0.001g accuracy until constant weight is reached. The sample was then stirred with a magnetic stirrer at a speed to shear larger particles, if practical, to obtain a more uniform particle size. While stirring, a measured volume (100ml) was pipetted onto the pre weighed filter paper seated on glass-fibre filter. Vacuum suction was applied to filter the sample. The trapped suspended solids in the filter paper were dried in an oven at 103^{o}C to 105^{o}C for 1hour and cooled in desiccators to balance temperature and then weighed to 0.001g accuracy. This cycle of drying cooling, desiccating and weighing was repeated until a constant weight was obtained. The suspended solids content in the sample was then determined using following calculation. **Calculation** $$\text{Mg Total Suspended Solids/L} = \frac{(A-B) \times 1000}{\text{Sample volume, mL}}$$ Where: A = weight of filter + dried residue, mg B = weight of filter, mg
Faecal Coliforms and Total Coliforms	SLS 614: 1983 Part 2 Membrane filtration method	250 ml capacity sterilized glass bottles with attached twin thread were used for the collection of samples for analysis of Faecal and Total Coliforms. In the sampling, first the bottle was lowered to the water by unwinding the cord slowly. The bottle was immersed in the water completely, and once the bottle was judged to be sufficiently filled, the thread was rewound and bottle was brought up. Some water was discarded if the bottle was completely filled. In the laboratory, for the analysis of Faecal Coliforms, 100 ml of sample was filtered through a 0.45 µm grid marked membrane filter paper and the filter was placed in MFC agar and incubated at 44.5 ^{0}C for 24 hours. For the Total Coliforms, 100 mL of sample was filtered and filter was placed on M-Endo agar LES (Sigma origin) media and incubated at 36 ^{0}C for 24 hours. Colonies which showed a characteristic appearance of blue colour on the filter paper counted as Faecal Coliforms. No confirmation was done to Faecal Coliforms since MFC agar was used as the medium and it is specific for Faecal Coliforms (especially *E.coli*) as per SLS (1983). In detecting Total Coliform counts, colonies with metallic yellow sheen in M- Endo agar LES medium were sub cultured to phenol red lactose broth and all tubes showing acid and gas production were recorded as confirmed Total Coliforms after incubation of 36 ^{0}C for 48 hours. Confirmed Coliforms were expressed as Total Coliform counts per 100 ml. Confirmed Faecal Coliforms were expressed as Faecal Coliform counts per 100 ml.

2. Quality Control procedures

- The NBRO is registered in the Central Environmental Authority (CEA)- Laboratory as Consultant/ Specialist for Technical Guidance (Reg. No. 07/LM/Cons/10/2008).
  Copy of certificate - 2013 and a Letter indicating participation in Proficiency testing programs with CEA are given below. .

- Quality Control for the analysis of all the parameters was carried as per the procedures given in the Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WEF- 20^{th} edition (APHA).

- All chemicals used in the analysis were of Analytical Grade (AR).

- The pH meter was calibrated before commencing the sample measurements using pH 4.01 and pH 6.86 buffer solutions (traceable to National Institute of Standards and Technology - NIST).

- Turbidity meter was calibrated using a series of Environmental Protection Agency (EPA) approved) calibration standards of 800 NTU, 200 NTU, 20 NTU and 2 NTU before commencing sample measurements.

- Dissolved Oxygen and BOD analysis - Glucose Glutamic acid (GGA) standard check solution was checked for reliability of the sample analysis. The GGA control is a standardized solution to determine the quality of the seed, where its recommended BOD_5 concentration is 198 mg/l ± 30.5 mg/l. The dilution water blank was used to confirm the quality of the dilution water that was used to dilute the samples. This is necessary because impurities in the dilution water may cause significant alterations in the results.

- In the Nitrates analysis, standard KNO_3 (strength was 1.00 mL= 100 µg NO_3^-) was prepared as per APHA and 0.1 mg/L solution as a known sample and deionized water was checked for an each set of sample analysis.

- In the Ammonia testing standard solution of NH_4Cl was used as the standard (1.00 mL =1.22 mg NH_3). For each set of sample analysis 0.01 mg NH_3/L solution as a known sample and deionized water as a blank were checked.

- For the Total Phosphates analysis, standard phosphate solution of KH_2PO_4 was used to prepare the calibration curve (The strength was 1.00 mL=50.0 g PO_4^{3-}P). In each set of analysis, 6 samples at a time; 3 water samples, 1 known standard sample, 1 spiked sample and a blank sample (deionized water) were digested and analyzed.

- In the Faecal Coliforms and Total Coliforms quality control procedures were carried out according to APHA.

This includes:

- Checking incubator temperatures:
    - Faecal Coliforms - 44.5^0 C   Total Coliform - 37^0C
    - Performance of Autoclaves Sterilization using sterilization tapes - temperature 121^0C, pressure 15 lbs)
- Blank sample testing - Dilution water (KH_2PO_4 buffer) blanks were analyzed during the sample analysis. Three dilution blanks were filtered during the sample analysis for each set of analysis (beginning/ middle and at the end) and tested for Faecal and Total Coliforms.

- The Balance (electronic top loading balance AUW 120 D, Shimazdu, Japan) used for the preparation of reagents was calibrated from an accredited institution. (Calibration date - 15 08.2012 - Copy given below.


Central Environmental Authority

Consultant / Specialist for Technical Guidance

This is to certify that

National Building Research Organization .... of

99/1, Jawatta Road, Colombo 05 ....

Registered as a Consulting Agency for Technical Guidance on Pollution Control Activities for the year 2013

Reg. No: 07/LM/Cons/10/2008

Deputy Director General
Environmental Pollution Control

Validity Period:
From: 01.01.2013 to: 31.12.2013

Director General
Central Environmental Authority

Certificate - NBRO registration in Central Environmental Laboratory as Consultant/ Specialist for Technical Guidance (Reg. No. 07/LM/Cons/10/2008)

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உமது தொடர்பு
Your Ref

අපේ යොමුව
எமது தொடர்பு
Our Ref

දිනය
திகதி
Date 19.08.2013

මධ්‍යම පරිසර අධිකාරිය
மத்திய சுற்றாடல் அதிகாரசபை
Central Environmental Authority

"පරිසර පියස", 104, ඩෙන්සිල් කොබ්බෑකඩුව මාවත, බත්තරමුල්ල, ශ්‍රී ලංකාව.
"பரிசர பியச", 104, டென்சில் கொப்பேகடுவ மாவத்தை, பத்தரமுல்லை, ஸ்ரீ லங்கா.
"Parisara Piyasa", 104, Denzil Kobbekaduwa Mawatha, Battaramulla, Sri Lanka.
Web : www.cea.lk

To whome it may concern

This is to certify that the Environment Laboratory of the National Building Research Organization is a registered laboratory under CEA for environmental monitoring and analysis since the year 2008 up to date.

They have participated in proficiency testing programmes and will be taking part in the CEA PT programme, which is scheduled to be held in mid September 2013.

This letter is issued on request of Ms. S.V. Dias, Director (Environment Division), NBRO.

Yours faithfully,

Deputy Director General (EPC)
Envtl pollution Control Division
Central Environmental Authority

Chairman	Tel : 2872361, 2872348 Fax : 2872347	Director General	Tel : 2872359 Fax : 2872608	Gen. Office	Tel : 2872278, 2873447, 7877277-280, 2873448 Hot Line : 2888999	Media Unit : 2873449
Deputy Director Generals	HRD, Admin & Finance Division Tel : 2863296 Fax : 2872301	Envt. Pollution Control Division Tel : 2873451 Fax : 2872605	Envt. Mgt & Asses. Division Tel : 2872318 Fax : 2872296	Envt. Edu. & Awarness Division Tel : 2872297 Fax : 2872609		
Directors Tel Fax	2872607 (Admin) 2872301 (HRD), 7877290 (Finance) 2872601 (Admin), 2863984 (Finance)	2873452 (EPC), 2872606 (Lab) 2882335 (WM)	2872346 (NRM), 2876643 (EIA) 2867263 (R&D)	2867266 (EEA) Fax : 2872609	2872604 (Legal) (Western Province) Tel: 2862831 Fax: 2865293	

Letter indicating participation in Proficiency testing programs with CEA

... **Continuation Sheet**

CALIBRATION CERTIFICATE
Issued by an Accredited
Calibration Laboratory

SWEDAC ACKREDITERING
1791
ISO/IEC 17025

Calibration Certificate

Certificate No. SS – 1208426

CUSTOMER National Building Research Organization No 99/1 Jawatta Road Colombo 05	**DESCRIPTION** Electronic Top Loading Balance (Dual range) Capacity (Max.) : 120 g / 42 g Resolution : 0 to 42 g: 0.01 mg 42 g to 120 g : 0.1 mg	**SERIAL No.** D 449911128 **IDENTIFICATION NO.** Not given

MANUFACTURER & MODEL NO. SHIMADZU, AUW 120 D	**RECEIVED CONDITION** Not applicable
REQUEST RECEIVED ON : 2012 June 19	**REFERENCE :** C 1205218/03

CALIBRATION DATE 2012 August 15	**LOCATION OF CALIBRATION** Laboratory National Building Research Organization	**TEST CONDITIONS** Temperature : 24 ± 2^0C Relative humidity : $55 \pm 10\%$

REFERENCE STANDARD
Set of weights of accuracy class E2 (Eqp. No. MA/004), traceable to Primary standard maintained at Korea Research Institute of Standards and Science. KRISS & Physikalisch Technische Bundesanstalt (PTB). (Our Ref: IML-344)

METHOD OF CALIBRATION
The balance was calibrated generally in accordance with the test method manual Ref. No MM/MA/01 – Calibration of Electronic Balance.

The balance scale was externally adjusted 50 g with weight of accuracy class E2 before the calibration.

Calibration certificate – Balance; AUW 120 D, Shimazdu, Japan

Annex 5

The river water quality

Water quality of river water

Date of sampling 17th September 2013

Category No.*	Location	Sample code	pH	Temperature ^{0}C	Turbidity NTU	Dissolved Oxygen mg/L	BOD_5 mg/L	Ammonia (as N) mg/L	Nitrate (as N) mg/L	Total Phosphorus (as P) mg/L	Total Suspended Solids (mg/L)	Faecal Coliforms (E.coli /100ml)	Total Coliforms (Coliform Organisms /100ml)
Ambient Water	L 1	D1-1	7.1	20.9	16.3	8.3	1.0	0.04	1.151	0.159	4.2	300	5600
		D1-2	6.8	20.7	20.7	8.1	1.0	0.06	1.118	0.109	6.9	248	6400
	L 2	D2-1	8.2	20.7	53.3	7.8	1.4	0.00	0.514	0.146	27.2	900	8800
		D2-2	8.3	20.3	55.4	7.9	1.5	0.00	0.529	0.137	24.9	1100	9000
	L 5	D5-1	7.4	20.6	78.6	8.2	<1	0.00	0.541	0.120	25.2	2100	13600
		D5-2	6.9	20.1	63.2	8.2	<1	0.01	0.550	0.120	23.0	2000	13600
	L 9	D9-1	6.1	19.4	15.5	7.4	1.4	0.04	1.120	0.119	8.2	400	6600
		D9-2	6.1	19.2	15.2	7.5	1.0	0.02	1.179	0.143	7.9	700	6000
2	Drinking water – Simple Treatment		6.0-8.5	-	5 (max)	6 (min)	3 (max)	-	5 (max)	0.23 (0.7 as PO_4) max	-	600 (max)	5000
3	Bathing		6.0-9.0	-	-	5 (min)	4 (max)	-	5 (max)	0.23 (0.7 as PO_4) max	-	50	1000
4	Fish & aquatic life		6.0-8.5	-	-	3 (min)	4 (max)	0.94 (max) (pH < 7.5)	5(max)	0.23 (0.7 as PO_4) max	-	-	20000
5	Drinking water – Conventional Treatment		6.0-9.0	-	-	4 (min)	5 (max)	-	5 (max)	0.23 (0.7 as PO_4) max	-	-	5000
6	Irrigation & Agriculture		6.0-8.5		-	3 (min)	5 (max)	-	5 (max)	0.23 (0.7 as PO_4) max	-	-	1000

E
A1P-DHV-2000

"<" denotes minimum detection level of the methodology employed.

Non compliance with Category 2

TECHNICAL REPORT FOR ADDITIONAL STUDIES OF THE NATURAL ENVIRONMENT SURVEY OF THE NEW PROJECT SITES MORAGOLLA HYDROPOWER PROJECT

NIPPON KOEI
Moragolla Hydropower Project

CEYLON ELECTRICITY BOARD
Sri Lanka

by

Centre for Environmental Studies (CES)
University of Peradeniya

October 2013

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EXECUTIVE SUMMARY

This report contains the physical, biotic and social status of the locations where the quarry, construction offices and spoil bank are located and possible impacts due to the construction and operation of activities in these sites.

The study found that the project does not lead to resettlement (only temporary evacuation of three houses), or the loss of any sensitive ecological resources. All three sites have been used and disturbed by human activity in the past.

Those who were affected did not oppose the project but expect reasonable compensation. The project needs to negotiate with the affected people regarding compensation.

The study found that several negative and positive impacts arising from the construction activities of the three sites.

Environmental Component	Positive or Negative	Impact
Physical	Negative	Soil Erosion
	Negative	Surface Water Pollution
	Negative	Air Pollution and Noise pollution and vibration
	Negative	Noise and Vibration due to Drilling and Blasting
Biological		No significant impacts except removal of some trees
Social	Positive	Increased employment to the local people who will be hired to work at the three sites
	Negative	Temporary evacuation of three houses near the quarry site
	Negative	Potential structural damages to the three buildings near the quarry site
	Negative	Loss of the Green houses at the spoil dump site and thus an income source to one family
	Positive	Reclamation of land to be economically more valuable at the spoil dump site upon completion of work
	Negative	Threat to the safety of the road users and the users of the access road

However all these impacts can be mitigated as can be seen from the table below.

Impact	Mitigation
Soil Erosion	Divert the stream running through the quarry to one of the adjacent stream Construction of appropriate drainage systems at all sites.
Surface Water and soil Pollution	Divert the stream running through the quarry to one of the adjacent stream Appropriate measures to be taken to avoid pollution of the ground due to spilling of oil and other liquid wastes etc. Construction of sedimentation/ settling ponds and discharge water to Mahaweli River
Air Pollution and Noise pollution	Use of efficient vehicles Controlled blasting Wetting using sprinklers to avoid dispersion of dust
Noise and Vibration due to Drilling and Blasting	Controlled blasting, Blasting to be limited to definite time gap, Avoid blasting during night time,
Removal of some trees	Initially unavoidable but reforestation and after reclaiming the quarry site. Maintain 50 m riverine buffer zone undisturbed
Increased employment to the local people who will be hired to work at	No mitigation needed
Temporary evacuation of three houses near the quarry site	Compensation during the temporary evacuation.
Potential structural damages to the three buildings near the quarry site	Temporary evacuation, Compensation or repair damages upon completion of the quarry operation (Crack survey to be carried out before commencing quarry operation)
Loss of the Green houses at the spoil dump site and thus an income source to one family	Compensation and assisting in rebuilding after completion of the reclamation.
Reclamation of land to be economically more valuable at the spoil dump site upon completion of work	No mitigation needed
Threat to the safety of the road users and the users of the access road	Controlled blasting, Sufficient warning to be issued to the traffic and the Users of the access road, Use piles of debris or excavated rock as a shield to minimize fly rock

If the above stated mitigation are complied with, the severity of the impacts can be avoided and or minimized.

1. INTRODUCTION

1.1 Background of the Project

The Ceylon Electricity Board (CEB) plans to develop a new 30.8 MW hydropower project at Moragolla in Kandy District. The scheme involves construction of a 35 m high concrete gravity dam (with a 5-gate spillway) across the Mahaweli Ganga at Weli Ganga, to create a 38.5 ha, 1.98 MCM reservoir with a Full Supply Level (FSL) at 548 masl. Water will be diverted through a 3 km underground tunnel, surge shaft and penstock on the left bank of the river, to a powerhouse and outfall located opposite the confluence with the Atabage Oya.

A Feasibility Study for the project was conducted in 2009, and this included an Environmental Impact Assessment (EIA), which is expected to be approved by the Mahaweli Authority of Sri Lanka (MASL) in the near future. In 2012 CEB appointed Nippon Koei Co., Ltd. (NK) to review the Feasibility Study (FS) and prepare detailed designs and tender documents for project construction and to upgrade the EIA to comply with the Safeguard Policy of the Asian Development Bank, the principal funding agency.

To upgrade the EIA, surveys were conducted in certain key fields in 2013, to supplement existing baseline data and update the assessment of impacts. Some further study was needed to ensure properly planned and designed mitigation measures.

1.2 Rationale

The Technical Report describes the main physical, biological and social features of areas that will be directly affected by the project, assesses the impacts of activities to be conducted at each site, and proposes mitigation for negative impacts. This additional study includes three areas that were identified and under consideration as key project components namely;

a) spoil dumping site for disposal of tunnel muck and other excavated spoil,

b) quarry site,

c) contractor’s office and camp site.

These three sites have been identified during the FS review (by Nippon Koei Co., Ltd.) and the study of physical, biotic and social impacts of these sites and associated activities needed to be assessed.

1.3 Scope of Work

This work was conducted by the Centre for Environmental Studies (CES) of the University of Peradeniya, a nationally-recognised environmental consultancy arm of the University of Peradeniya. It has over 25 years of professional experience in environmental survey, analysis, data interpretation and report preparation, including extensive experience of assessing the physical, biological and social features of terrestrial sites.

The field survey work was led by three senior experts namely

a. Dr. Jagath Gunatilake, Department of Geology (Team Leader and Geologist)

b. Prof. Kithsiri Ranawana, Department of Zoology (Ecologist)

c. Prof. Shantha Hennayake, Department of Geography (Social Scientist)

All of the three have over 20 years of research and consultancy experience in Sri Lanka in: a) field geology/topographic studies; b) terrestrial ecology (flora and fauna); and c) rural social studies. The senior experts and research assistants had several visits to each of the three sites and conducted sufficient qualitative site observations and investigations. The investigations included the following aspects:

Physical: topography, drainage, geology, distance from Mahaweli Ganga and inflowing streams.

Biological: flora, fauna, habitats and their importance, type and number of trees.

Social: location and proximity of any houses, commercial or industrial buildings, other infrastructure, or locations or features of community importance at or near the site or alongside likely access routes.

The results of the surveys are presented in this report based on the format specified in the TOR (see the Attachment 1 for the TOR issued by the project)

2. APPROACH AND METHODOLOGY

Based on the potential impacts on a) physical features of locations of these sites including existing topography, drainage, geology, b) ecological features including existing fauna and flora, restricted areas etc. and c) social environment including existing settlements and the livelihood of the people, access roads, areas with religious concerns etc., 200m buffer zone is identified for the quarry site and 100 m buffer zones were selected as the impact areas of dumping site and campsite/office areas. Considering the impacts that may create due to quarry operations including site clearing, removing top soil and weathered rock, drilling, blasting, loading and hauling of rock as construction material for the dam and appurtenant structures, 200 m buffer zone was identified as the impact area for quarry site. However, identifying the potential impacts due to proposed access roads and the other construction sites are not included in the scope of this study.

Table 1-2 Methodology adopted in the study and report preparation

Item	Data Type	Data collection methods	Data analysis and Impact identification	Mitigation measures	Monitoring plan
Physical	topography, drainage, geology, distance from Mahaweli Ganga and inflowing streams	Secondary sources of GSMB Geological maps (1:100,000), NBRO Landslide Hazard Maps, and field observations, Other maps related to the project: 1:10,000- Sheet No.6113, Survey Plans; Satellite images (Google earth) In addition, GPS was devised to collect data on land use etc.	The data obtained from different sources and in different formats were integrated using GIS & RS technology. Maps, overlays, buffer generation, digital elevation model generation, preparation of slope maps were carried out by using GIS, Impact area was demarcated with the aid of geo-visualization method in GIS. Also significant impacts have been discussed in detail.	Based on consultant s' experiences working in similar projects, mitigation measures have been given for each significant negative impacts	Environmental monitoring plan has been given on the internationally accepted format. This includes mitigation measures, relevant place or time, criteria, responsible institutions and personals who should carry out them.
Biology:	flora, fauna, habitats and their importance, type and number of trees	Field investigations			
Social:	location and proximity of any houses, commercial or industrial buildings, other infrastructure, or locations or features of community importance at or near the site or alongside likely access routes	Through maps, Key informant interviews, focus group discussion and direct observations, Land use maps, Satellite images (Google earth) etc. were used to collect data			

2.1 Methodology of Impact Assessment for Physical Environment

There will certainly be drastic changes in the physical landscape and as a whole, physical environment within the project area in all three sites. Considering the potential impacts on the topography, existing surface and sub surface drainage in particular to the nearby Mahaweli Ganga, 200 m buffer zone was identified as the potential impact zone for the proposed quarry site. One hundred meter buffer zone surrounding the proposed camp/office site was identified as the potential impact zones for the physical features due to site clearing, construction and operation. Considering the site clearing, transportation of waste rock and soil, tunnel muck etc., 100 m buffer zone is identified as the potential impact zone for dumping site.

2.1.1 Topography

Topography of each of the three sites were studied including the desk study using the available large scale contour maps (survey maps provided by the client), topographic maps (1:10,000) as well as satellite images and aerial photographs. Aerial photographs were being used to study whether there are any significant structural features of lineaments or faults particularly within the quarry site.

Field investigations were carried out to identify the topographic features of the three sites under investigation. Topography and the general elevations at the spoil dumping site and the future scenarios during and after completion of the spoil dumping operation were assessed by comparing and analysing the information from contour maps, satellite images, survey maps and the field observations.

2.1.2 Drainage

Existing drainage ways within the sites and the demarcated impact areas were studied using the available maps, satellite images and aerial photographs combined with field investigations. All likely impacts on drainage systems at each site and also the nearby river banks are identified and necessary mitigation measures were proposed. GIS maps were generated using the available AutoCad drawings and the field observations made.

2.1.3 Geology and Slope Stability

All existing data on surface and sub-surface geology including bore hole data, rock samples and rock thin section studies etc. were used to identify any adverse conditions and impacts that may encounter during the operation of the quarry site, dumping site and camp site. In addition, field studies were carried out to compare the actual conditions at site. However, since the contractor's method statements were not being available, general operating conditions at similar projects were taken into consideration.

Slope stability conditions also were evaluated considering the future operations of the quarry site, camp/office site and spoil bank area. However, since the method statement of the quarry operation was not available, the slope stability conditions within the quarry site could not be evaluated. Diagrams indicating 3-D view of the quarry site and the surrounding area, dump site and the camp site etc. were generated using GIS and Remote Sensing. Landslide Hazard maps compiled by the National Building Research Organization was used to describe the potential of landslides within and the surrounding area. Necessary mitigation measures are suggested to minimize the potential impacts including the slope instability.

Data Analysis and interpretation were carried out for all available sites using the data obtained by GIS and remote sensing techniques as well as the field information collected during the field studies and the available bore hole data. Geological maps and profiles were compiled for quarry site and slope stability conditions were assessed and evaluated based on the actual field conditions during operations. Slope stability of the Contractor's area and spoil bank areas were also studied considering the progressive excavation and filling work proposed. Geological profiles/maps, photographs, etc. are being included in this report to illustrate the potential impacts on the physical environment and the proposed mitigation measures.

Several rock samples were obtained and analysed for the mineralogical composition. Thin sections made could confirm the type of rock and the mineralogy as well as strength properties of the rocks.

2.2 Methodology of Impact Assessment for Biological Environment

Direct sampling methods using transect surveys were adopted to identify the fauna and Flora to be affected due the project development.

Ecological study (Fauna and flora) has been carried out for three sites selected for different project activities. These include sites selected for quarrying, construction of workers camp and spoil disposal. The site selected for quarrying is derelict grassland dominated by the grass species *Panicum maximum.* Site allocated for the construction of workers camp is a broad strip of vegetation bordering the Mahaweli river below the Gampola – Kotmale road between 4- 5 km posts. Spoil dumping site mainly consists of Kandyan forest gardens.

Wherever possible, attempts have been made to compare the results obtained from the survey with the information presented in the Environmental Impact Assessment Report of the Moragolla Hydropower Project (CECB, 2012)

2.2.1 Sampling Terrestrial Habitats

Fauna and flora of impact areas was mainly studied through the field work. Villagers were also interviewed to get some additional information on certain faunal groups.

2.2.2 Vegetation Survey

The vegetation in three sites was studied using sampling plots representing all habitats types. Stratified Random Sampling method was used to locate the sampling points in the project area. Presence of different tree / plant species in the project area was recorded. Lists of plants giving their conservation status (such as endangered, threatened etc.), and ecological status (such as endemic, exotic, invasive etc.) was compiled for the three sites. Trees >20cm dbh was identified and counted. Accordingly number of trees to be removed in three sites was estimated. If there are any rare or endangered plant species within the study areas, methods for relocation of these species is proposed.

2.2.3 Faunal Sampling

Sampling method for each group is different. Looking at the time frame of the study, rapid sampling methods were used to evaluate the richness of key species in each faunal group.

i. Invertebrates

Two groups of invertebrates, namely, butterflies and land molluscs was selected for sampling. Butterflies in the sites were sampled using fixed survey routes within a single habitat type. A fixed survey route was of 100m in length. All the species encountered during the transect survey was identified.

ii. Vertebrates

Amphibians and Reptiles

Amphibians and Reptiles in the sites were sampled using a combination of three methods: visual encounter surveys along transect lines, quadrate searches, and specialized searches in select habitats known to be important to particular species.

Birds

Line transect method was used to count and gather data on birds. An experienced observer walk along the entire length of transect (500 m) identifying and counting birds seen within 20m distance to both sides of the transect. Transects spots were systematically positioned to represent each and every habitat type in the project area.

Mammals

Mammals were sampled using the line-transect method. The length of transect was determined suitable to the site specific characteristics. While walking along transect, direct observation of individual species as well as signs indicating their presence (dung piles, tracks, browse, etc.) was be recorded. Interviews were conducted with the villagers in the area to get an idea of the species inhabiting the area.

Species lists were prepared indicating their conservation and ecological status

2.3 Methodology of Social Impact Assessment

The Social Impact Area considered for the study is two folds.

1. The direct impact area consisting of the foot print of the three project sites and 100 meter buffer zone. However, for the quarry site this is extended to 200 m.
2. Indirect Impact area covering the Grama Niladari Divisions within which the project sites are located.

The social study and the assessment took into account the following variables.

1. Current pattern
2. Dwellings within the foot print and the impact area
3. Culturally significant places within foot print the impact area
4. Land that will be affected
5. Houses and other buildings that will be affected
6. Income sources and levels that will be affected
7. Accessibility that will be affected
8. Nature of compensation expected

The data collection techniques adopted include the following

1. Observation and collecting photographic evidence
2. Detailed discussions with the households in the impact area to collect the following information

Data Analysis was based on the following.

1. Total area that will be affected, the ownership and value
2. Value of structures that will be affected
3. Income losses
4. Social impacts and inconveniences due to increased traffic and noise

Mitigation measures will be proposed for the identified following major impacts

1. Loss of land
2. Loss of structures
3. Loss of income sources

3. SITE DESCRIPTIONS

A detailed description of each site is provided individually, dealing in each case with. Physical Features, Ecology and Social Environment. Each section is dealt with the aspects specified in the TOR and any others that are considered relevant to this study. All important or sensitive features were identified and the reasons for their importance were explained. Discussions are illustrated with maps, Figures (including photographs) and Tables for each site and key features.

The entire study area is belongs to the narrow strip of the Kandy District of the Central Province of Sri Lanka in between Kegalle District and Nuwera Eliya Districts. The site is adequately accessible through main road from Gamopola to Nuwera Eliya and then through secondary road running towards Ulapane (Map Nos. 3.1 & 3.2). The quarry site and the contractor's office/camp area are located in Galatha GND in Uda Palatha DSD and the disposal site is located in Gampola Wela GND in Ganga Ihala Korale DSD (Map No. 3.3).

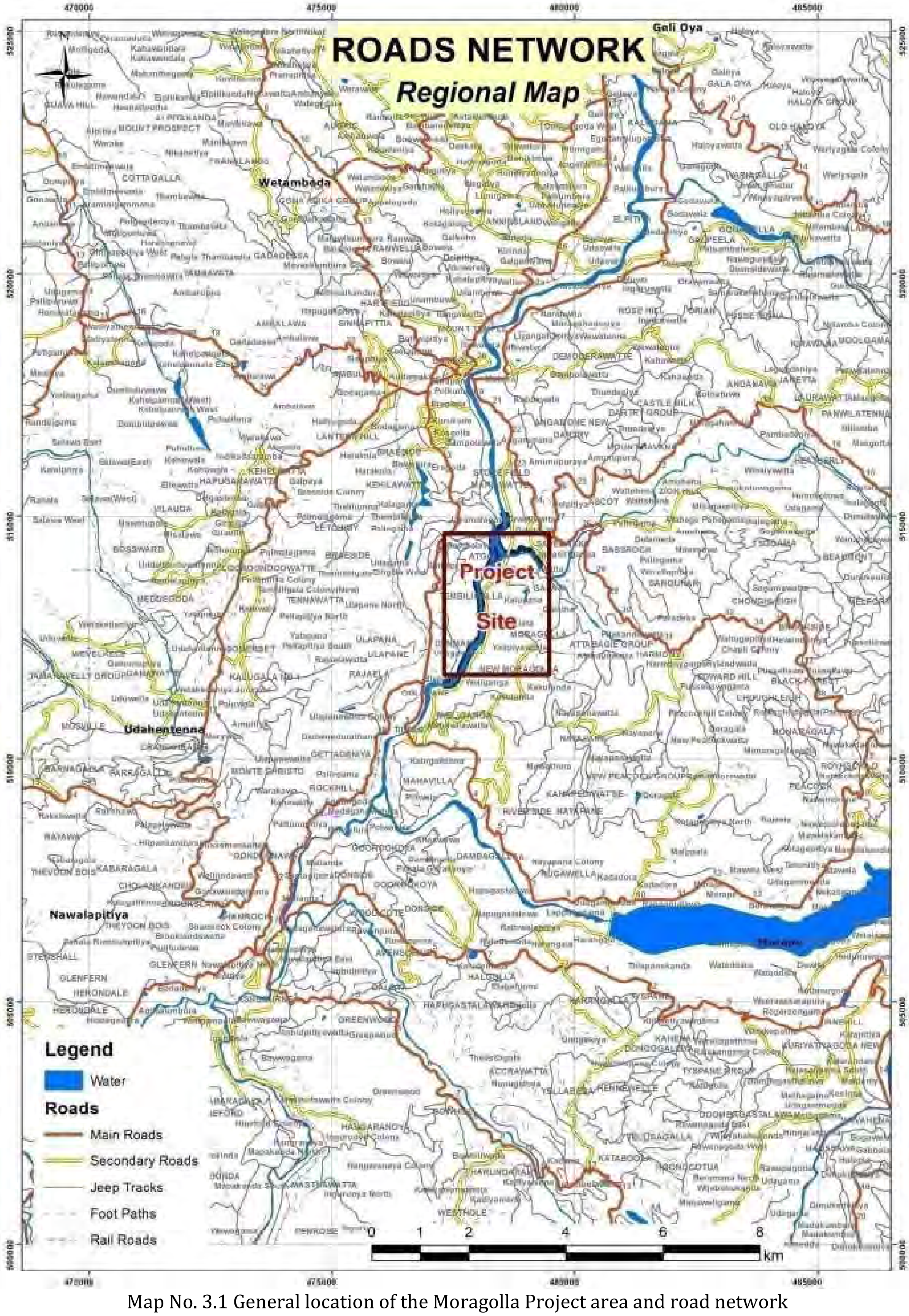
3.1. Proposed Quarry Site

3.1.1 Physical Environment

3.1.1.1 Landuse

General landuse of the area is illustrated as forest in Map No. 3.4 which is based on available 1:10,000 topographical maps prepared in 1987 by the Survey Department of Sri Lanka and subsequent field verification carried out by them in 1989.The topographic map (1:10,000) shows that the proposed quarry site is within forest area but field observations revealed that the forest are has been cleared for developing as residential areas as well as small scale agriculture.

The land area has undergone a lot of developmental changes during the recent past and therefore some areas indicated as forest in the vicinity have been cleared and developed for residential purposes, small scale agriculture and housing schemes etc. The existing landuse observed during the current study is illustrated in the satellite image (Map Nos. 3.5, 3.6 and Figure 3.1)



Map No. 3.1 General location of the Moragolla Project area and road network
Source; 1 : 50,000 ABMP Maps, Survey Department, Sri Lanka

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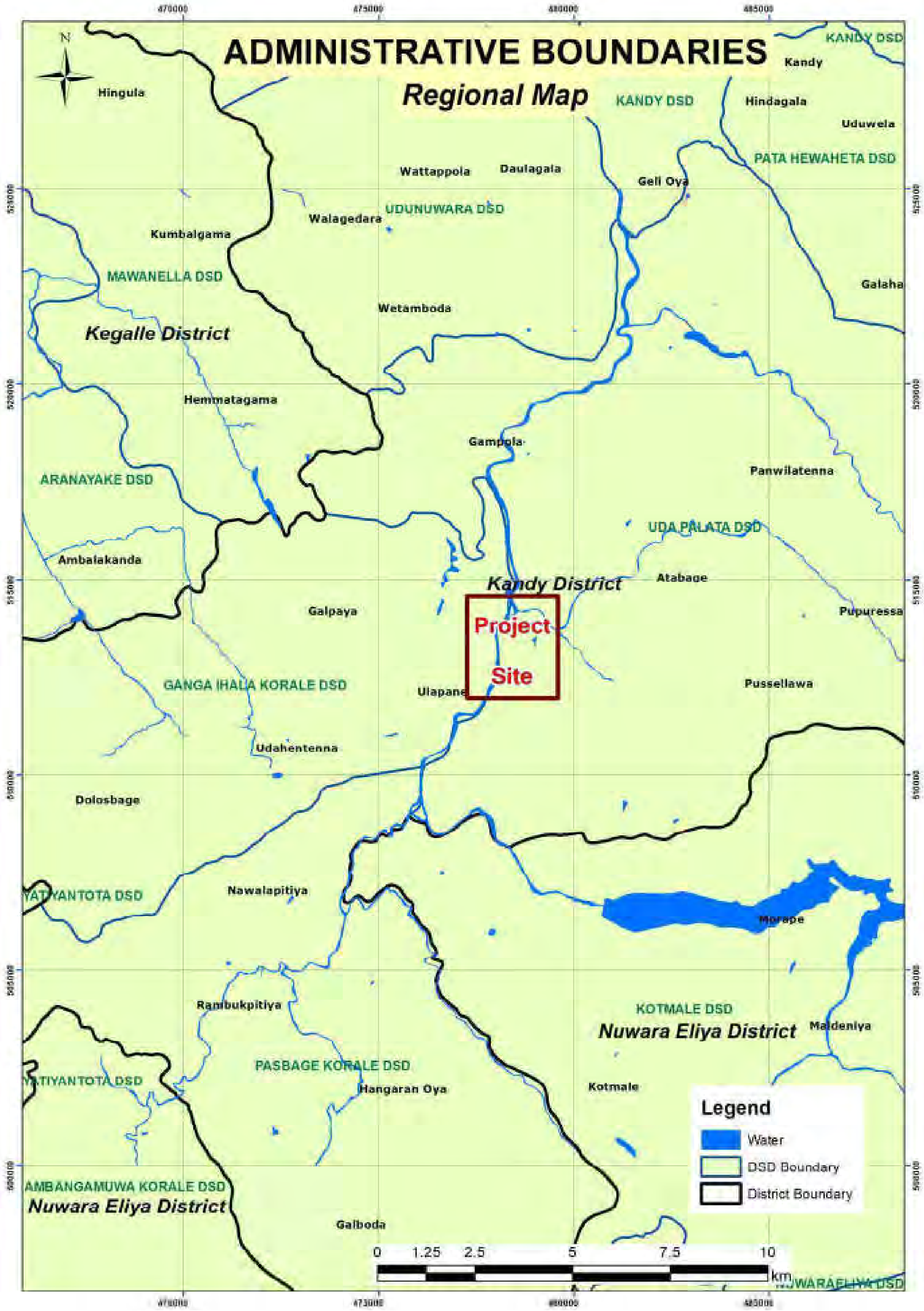
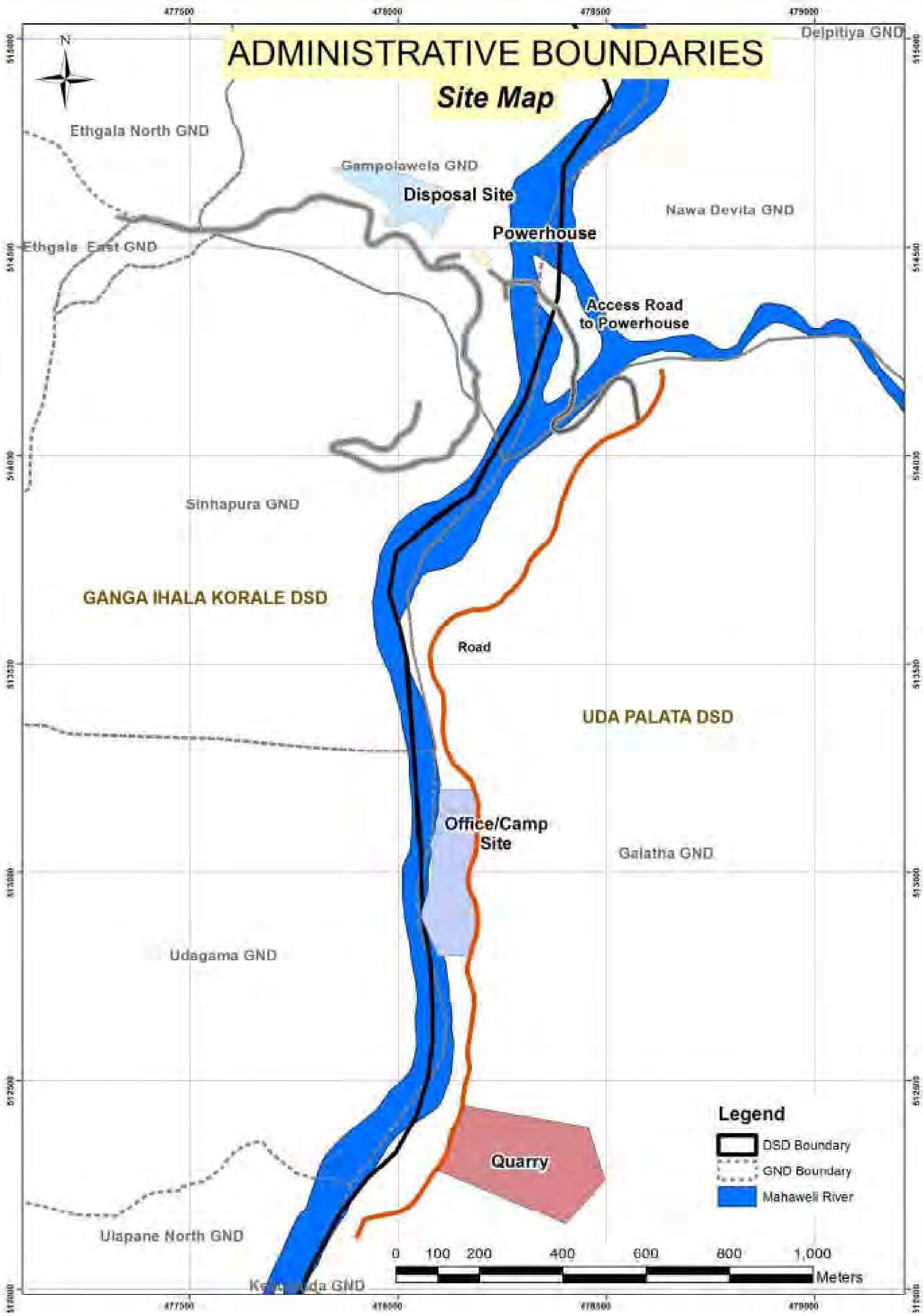
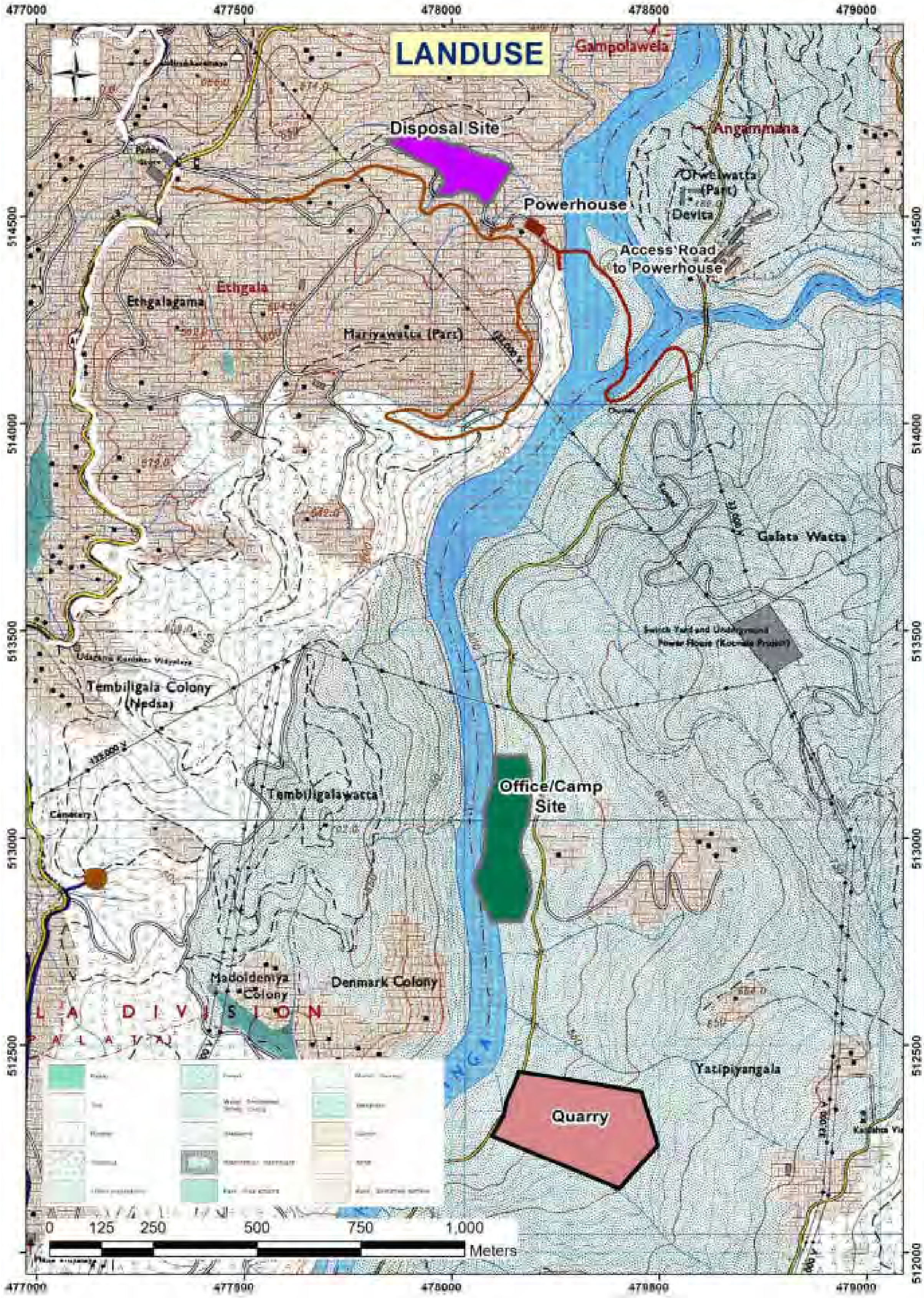


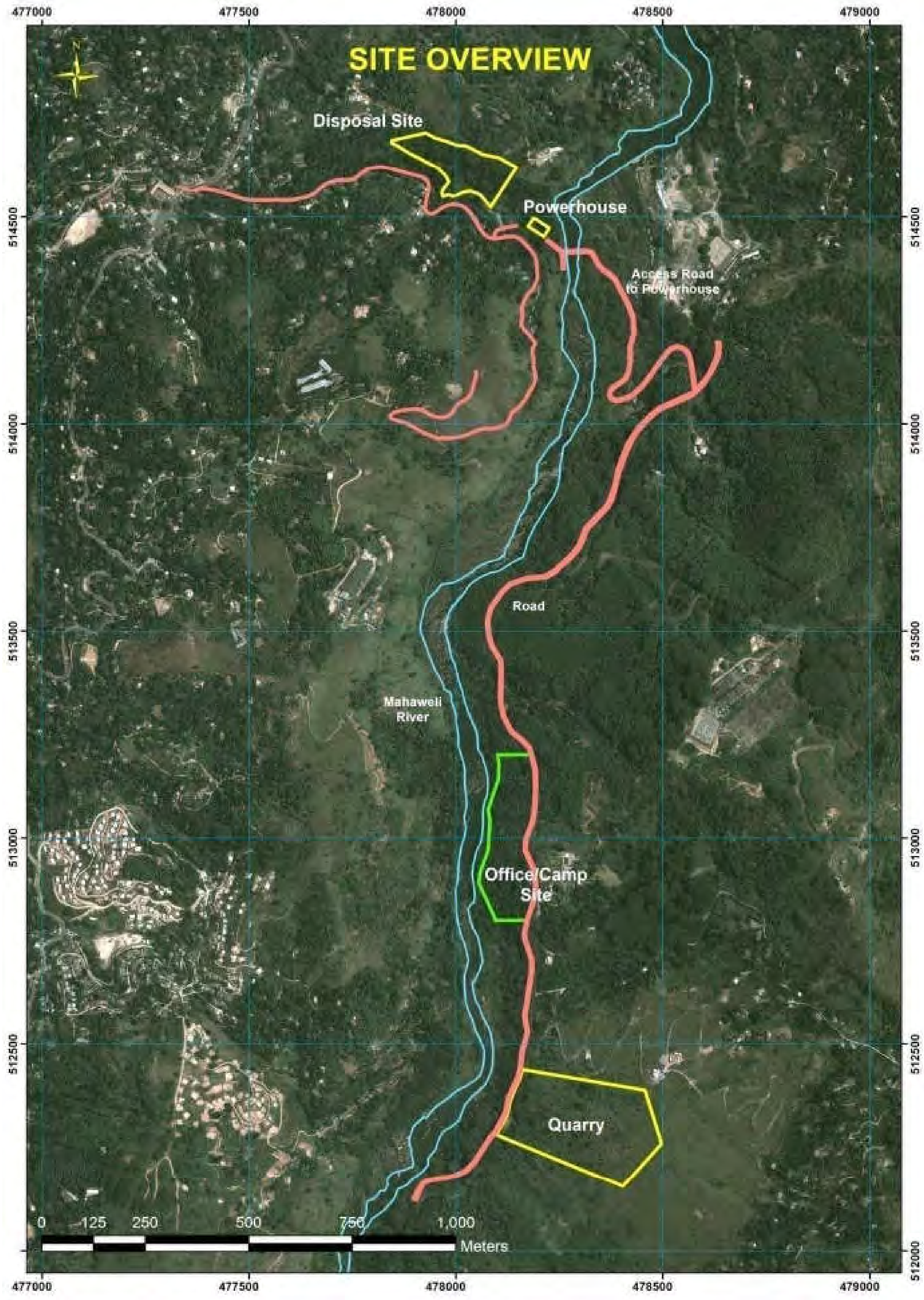
Map No. 3.2 Administrative Boundaries of the project area and the surrounding (Districts and DSD)
Source; 1 : 50,000 ABMP maps, Survey Department, Sri Lanka



Map No. 3.3 Administrative Boundaries of the project area (GN and DSD)
Source; 1: 10,000 ABMP maps, Survey Department, Sri Lanka



Map No. 3.4 Landuse map of the project area - Moragolla Hydropower Project
Source; 1: 10,000 ABMP maps, Survey Department, Sri Lanka



Map No. 3.5 Satellite Image of the project area and the surrounding
Source; Google Earth

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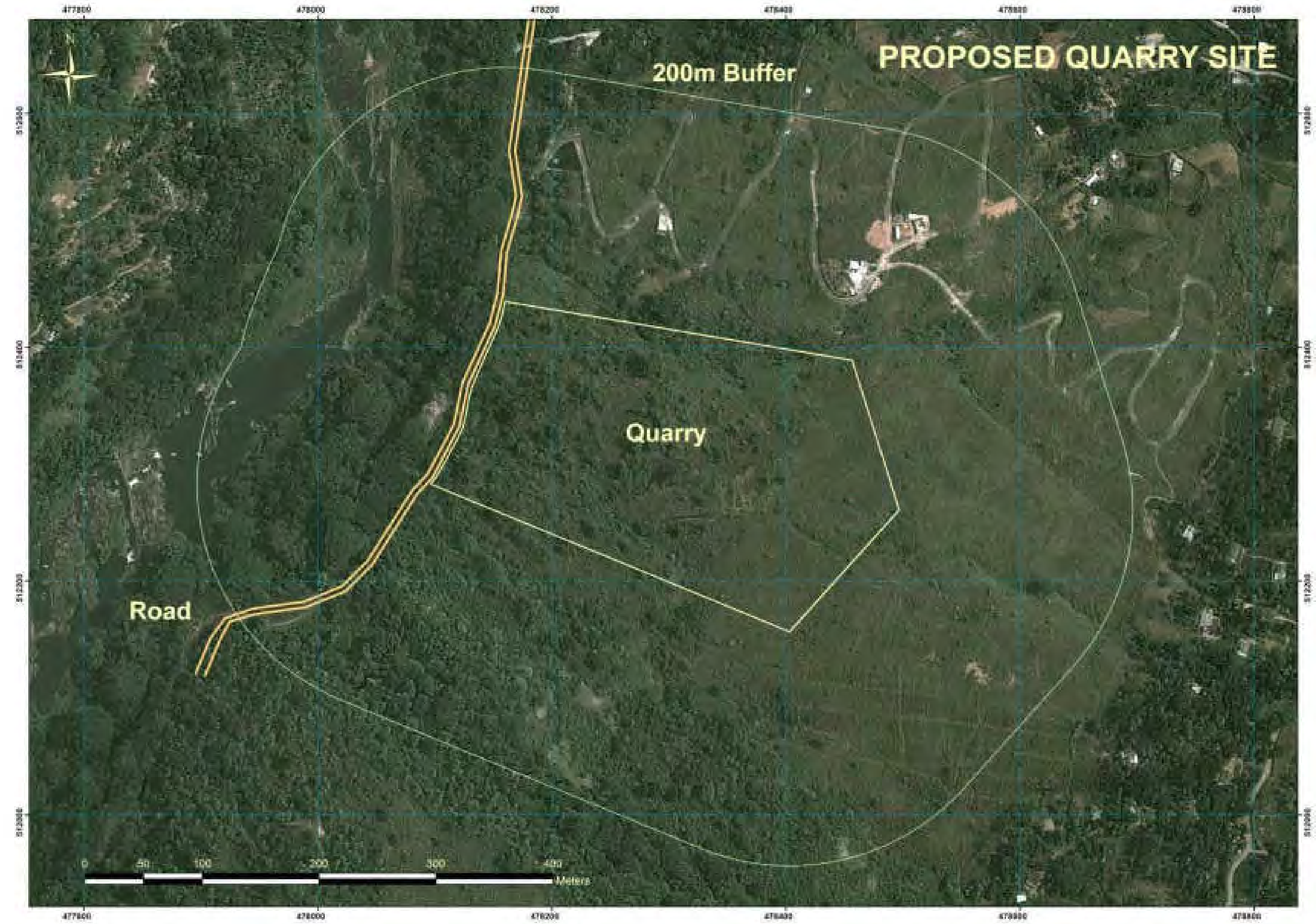
Figure 3.1 three-Dimensional views of the Quarry site and contractor's Office, Camp area; 200 m buffer zone is demarcated as the impact area of quarry operation.

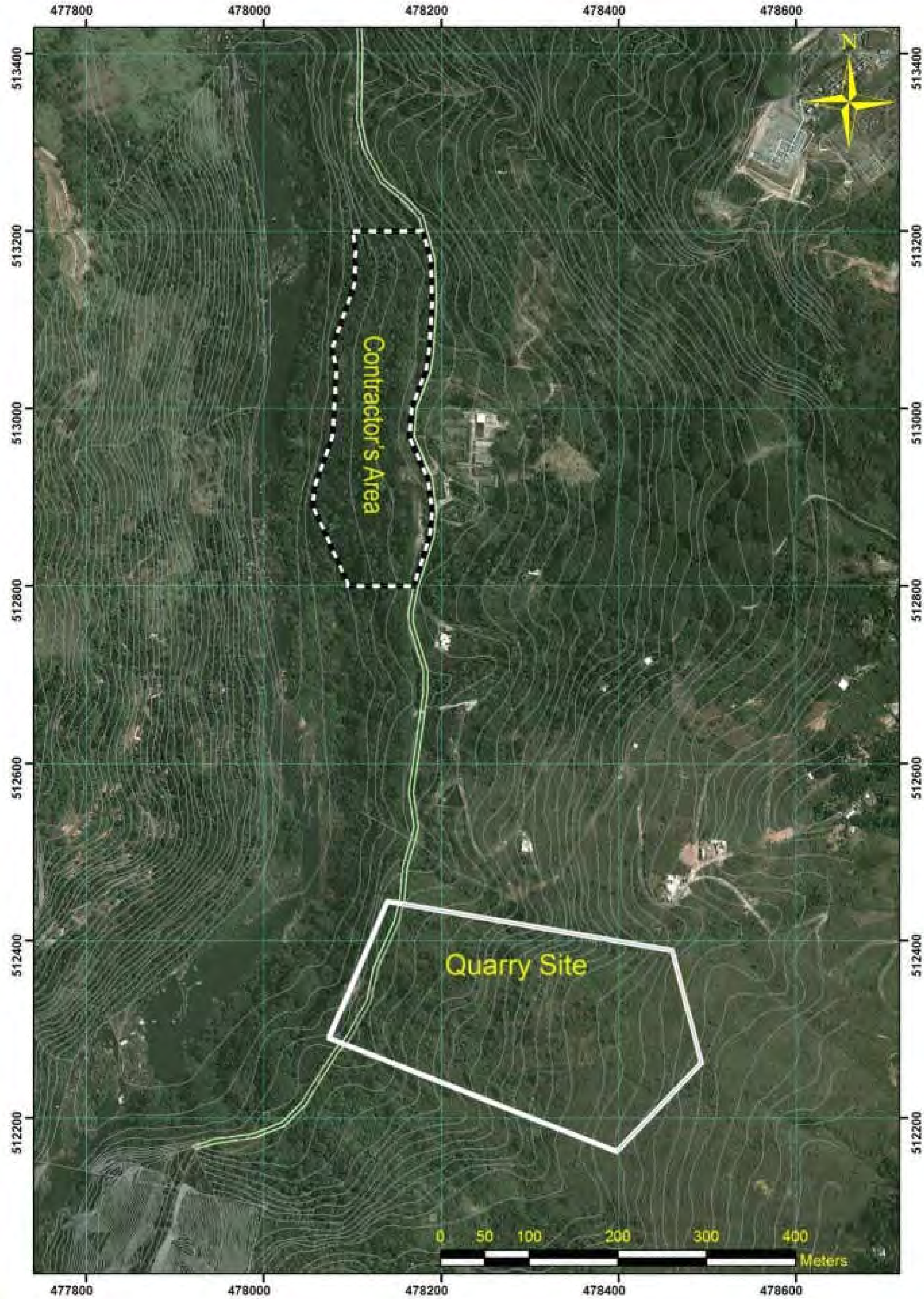
3.1.1.2 Topography and Drainage

The proposed quarry site is located within the Mahaweli drainage basin and belongs to wet climatic zone. Mahaweli River flows towards northeast direction and bend towards North near the proposed quarry site. The area consist of rugged topography(Figure 3.2) with an elevation ranging from 500m above mean sea level to about 700m within the narrow strip of Kandy District in between Kegalle and Nuwara Eliya Districts (Map Nos. 3.2 & 3.3). Satellite image (Map No. 3.7) and contour map (Map No. 3.8) indicate the general topography at the Quarry Site.

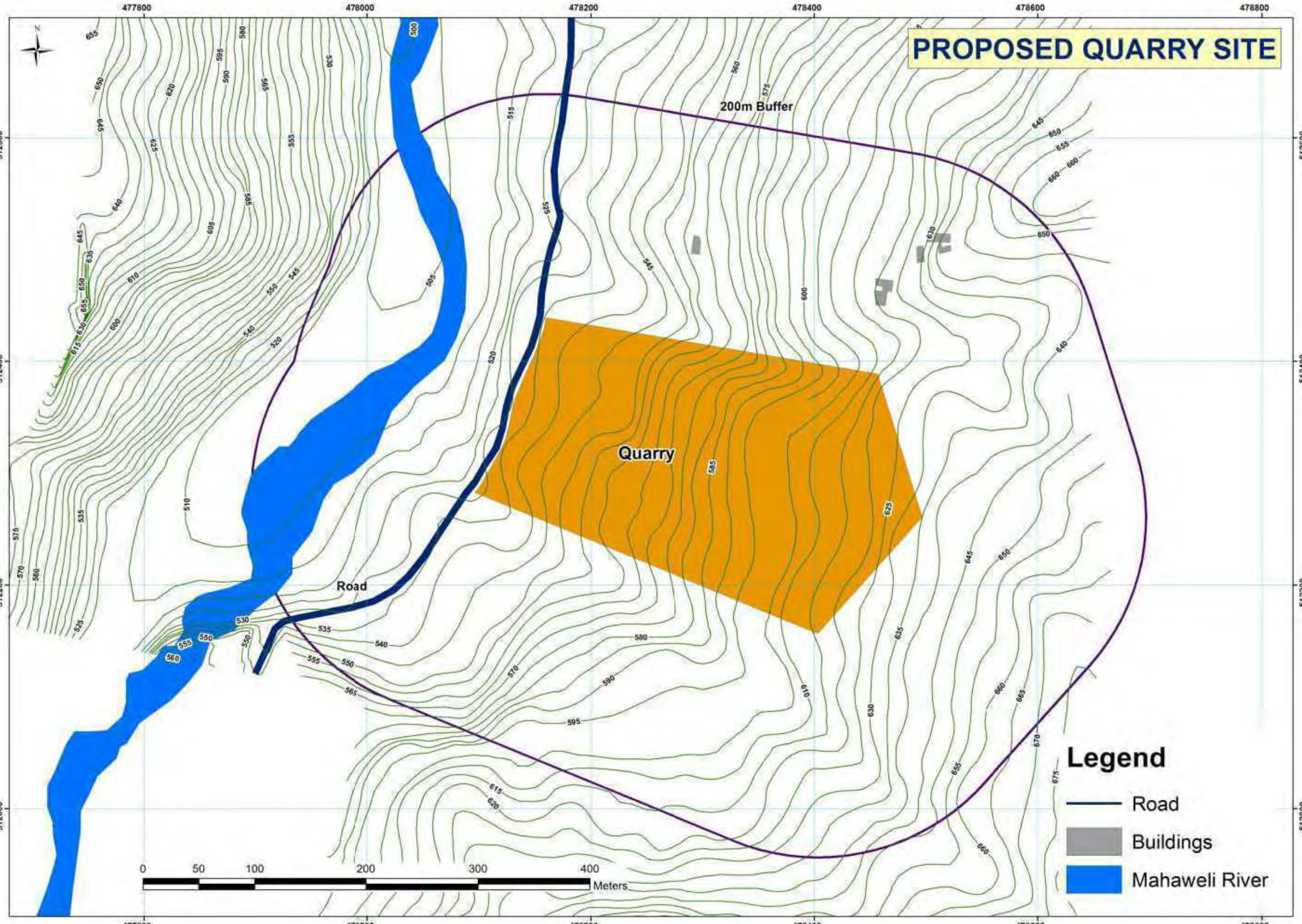
The elevation rises from the right bank of Mahaweli River towards Southeast direction beyond the upper boundary of the quarry site up to about 800 m. Map No. 3.7 shows the distribution of contours superimposed on a satellite image of the area. Gentle slope towards the west, follow the dip slope of the underlying basement rock. However, at certain locations, slope consists of colluviums of variable thickness. As per the slope map for the site (Map No. 3.9), it shows that slope of the entire area surrounding the proposed quarry site ranges from 10-30 degrees which can be categorized as gentle slope.



Map No. 3.6 Satellite Image of the proposed quarry site; 200 m buffer zone and the buildings/houses which are to be affected
Source; Google Earth images, Survey Maps – Moragolla HEP



Map No. 3.7 Satellite Image of the quarry site, contractor's office/camp area and the surrounding
Sources; Google earth, Survey Maps – Moragolla HEP



Map 3.8 Contour map of the proposed quarry site; 200 m buffer zone and the buildings/houses which are to be affected
Source; Google Earth images, Survey Maps – Moragolla HEP

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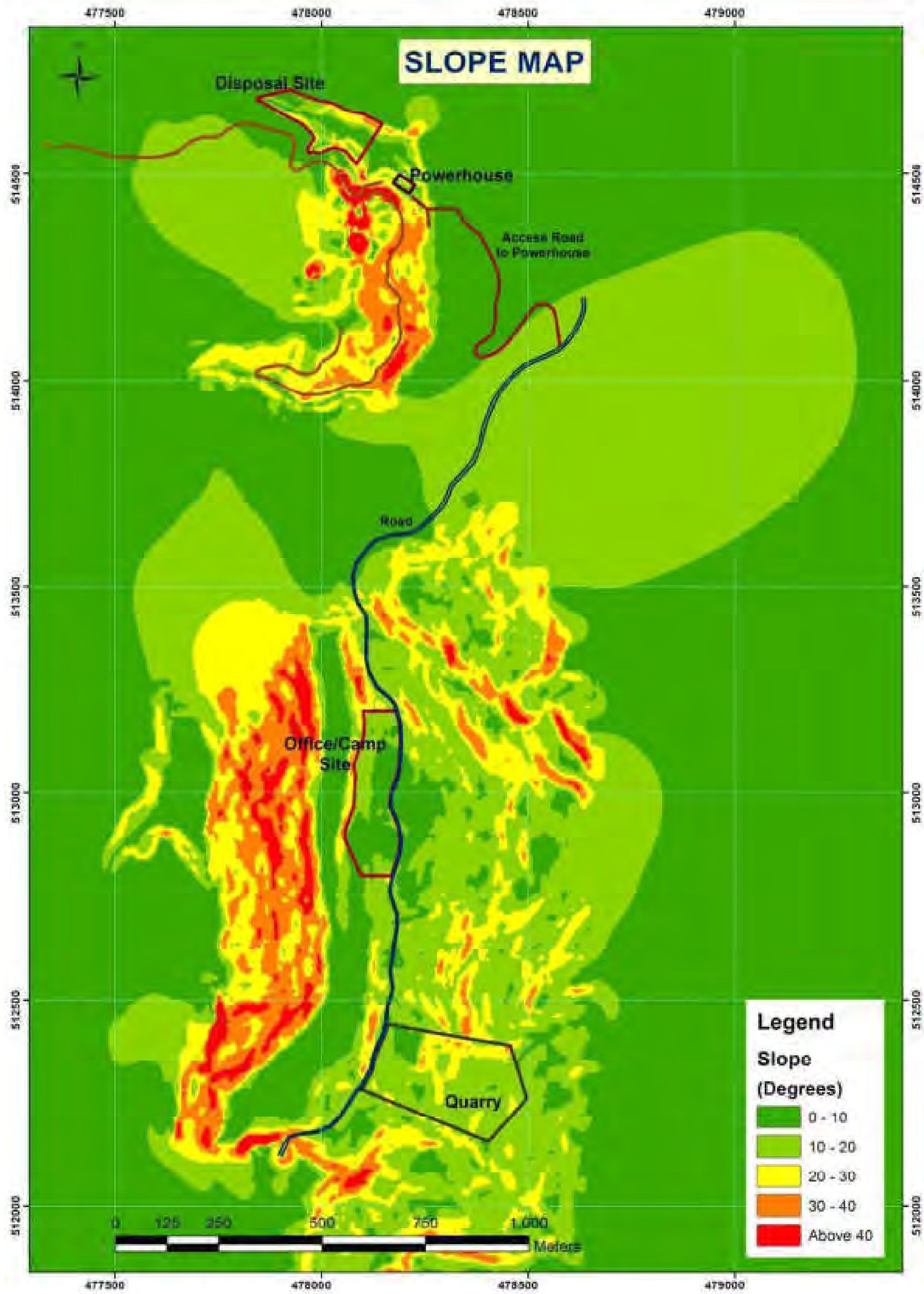

Map No. 3.9 Slope Map of the project area - Generated using 1:10,000 scale elevation data
Source; Survey Department, Sri Lanka

Some sections of the slopes adjacent to the stream valleys and right bank of Mahaweli River below the main road are as steep as 40 degrees and other regions have gentle slope. Left bank of the Mahaweli River consists of steep slope on bed rock.

Figure 3.2 Left; Rugged topography at the upper reaches of the quarry site; Right; relatively thick weathered overburden exists at the upper reaches of the quarry site.

Figure 3.3Gentle slope of the valley and the stream traces follow the foliation of the charnockitic gneiss bed rock.

The western boundary of the proposed quarry site is the secondary road on the right bank of Mahaweli River where Northern and Southern boundaries are marked by small parallel tributaries fed by the upper reaches of the Mahaweli Right bank (Map No. 3.6and 3.8 and Figure 3.4). As seen in Figure 3.4, the third stream is running right across quarry site along the small valley in the middle of the proposed quarry site. Approximately 100 m distance is there from the secondary road being the Western boundary and the Mahaweli River. In case this site is selected as the quarry, it is anticipated that all these three streams are to be adversely affected unless proper mitigation measures are undertaken. The stream running across the quarry will have to be diverted from the upper reaches beyond the Eastern boundary of the proposed quarry site. However, facilitating appropriate drainage system within the quarry site including a settling pond (for sedimentation of quarry dust and soils to be washed along the slope during quarry operations) will be an essential requirement. In addition to that, the paths of existing two streams on either side should be kept intact. However, protecting the lower reaches of the streams by burying Hume pipes of appropriate diameter can also be considered as suitable mitigation measures.

Appropriate measures to be taken to remove colluviums overlaying the bed rock to avoid eroding them towards the Mahaweli River during the quarry operations. Since the thickness of overburden at the upper reaches at the Eastern most end, opening up of the quarry towards the upper reaches should be limited. Overburden material removed should be dumped at appropriate spoil banks without piling them in the vicinity of the quarry site in operation.

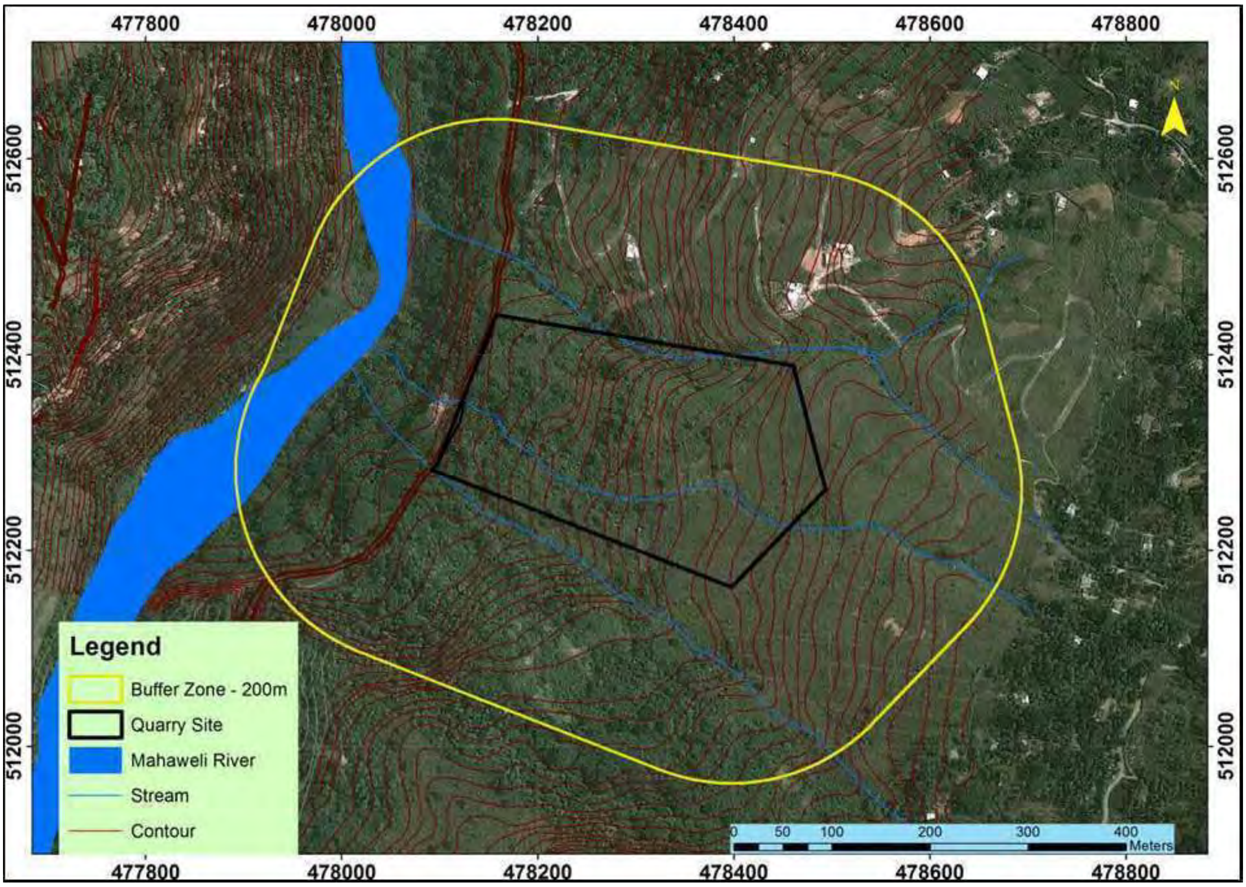

Figure3.4 Satellite image showing the topography of the quarry site where three streams run parallel to each other on Northern and Southern boundary and right across the proposed quarry site

3.1.1.3 Geology and Structure of the Quarry Site;

Geologically, the area lies within the Highland Complex and composed of high grade metamorphic rocks namely charnockitic gneiss (Figure 3.5).Although the geological map by the Geological Survey & Mines Bureau indicate that the entire area consists of garnet sillimanite biotite gneiss (Map No. 3.10), field investigations indicated that predominantly charnockitic gneiss exist at the site. The stream valleys and Mahaweli main river valley are comprised with fresh charnockitic gneiss basement rock (Figures3.3, 3.5 and 3.6) with occasionally thin bands of garnatiferous biotite gneiss. The garnatiferrous biotite gneiss bands are either too thin to be mapped or too difficult to be distinguished at 1: 5,000 scale and hence entire area was mapped as one unit of charnockitic gneiss (Figure 3.5). However, the 5-8m thick garnatiferrous biotite gneiss bands have been identified in drill core logs (attachment 1) as well as rock thin sections

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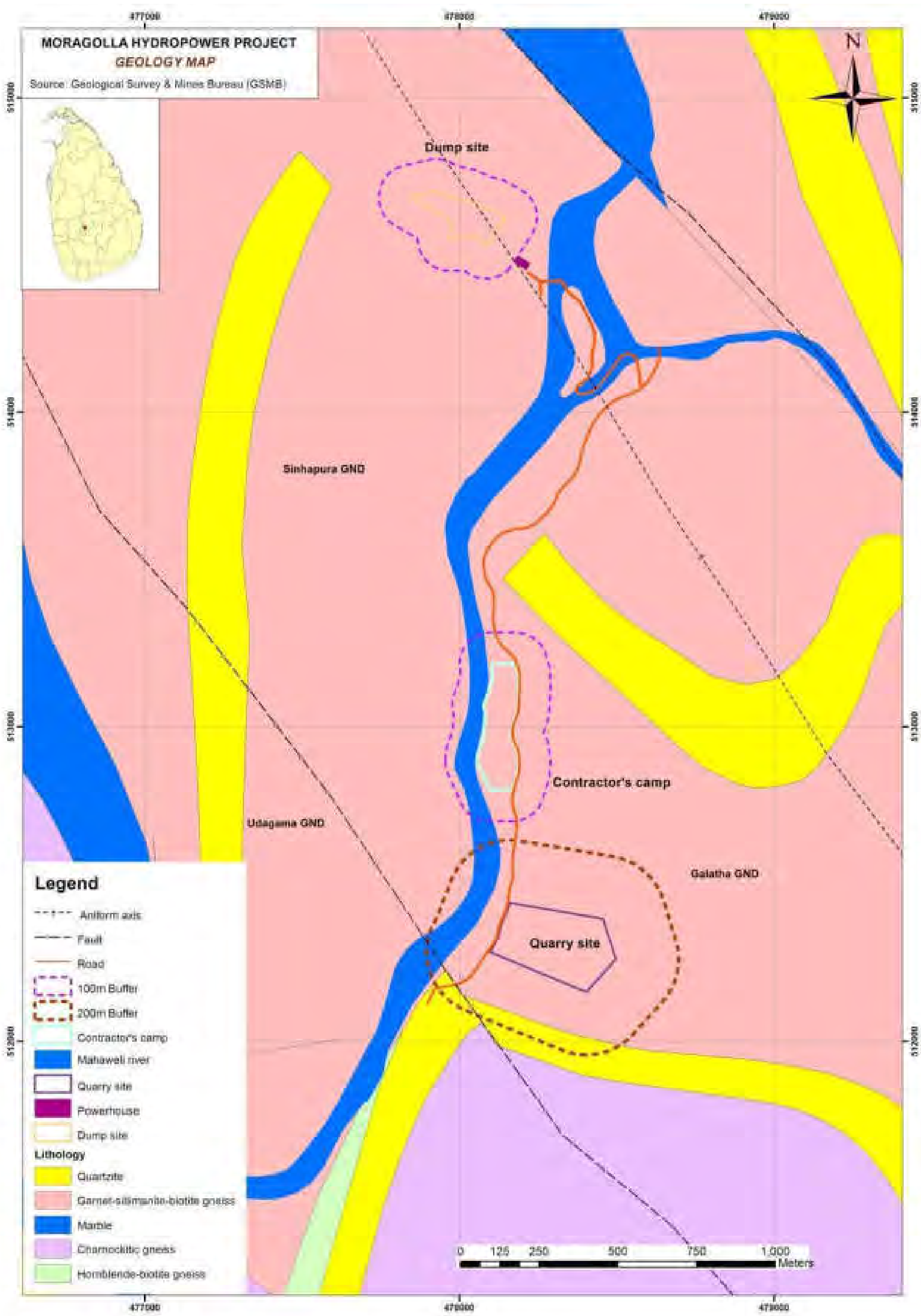


Map No. 3.10 Geological map of the project area and the surrounding
Source; 1:10,000 scale Geological maps compiled by the GSMB

studied. A thin Quartzite band was observed at Southwest -Southeast boundary away from the quarry site within the 200m buffer zone identified as the impact area.

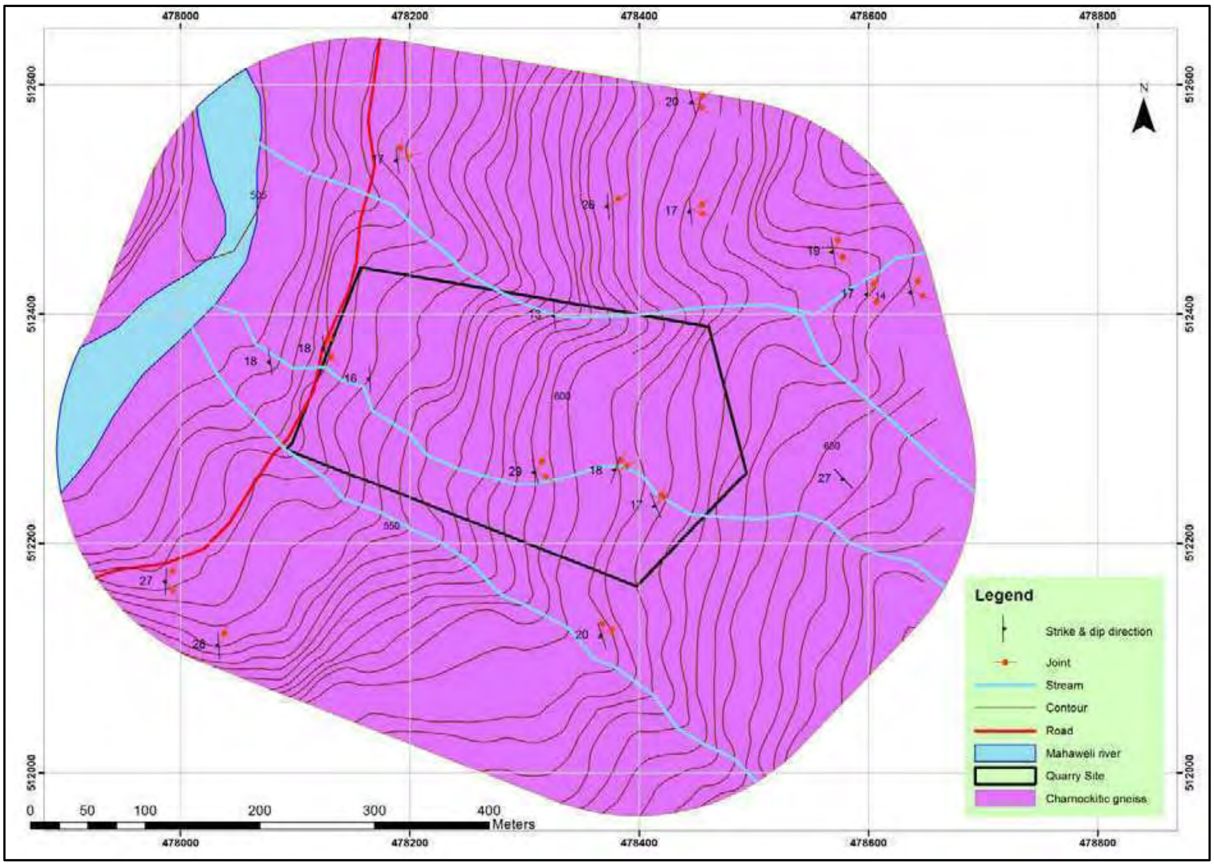


Figure 3.5 Surface Geological map compiled using the field observations in and around the proposed quarry site

Figure 3.6 Stream flowing across the proposed quarry site

The bed rock terrain is dissected by the two prominent conjugate joint systems (Figure 3.8) as major structural features in the area. These are ubiquitous in the project area. There are several different joint sets in the area with the major ones being vertical and trending N 250-300 E and N 550-600 W (Figure3.8). These tend to intersect and create blocks of charnockitic gneiss varying in size from fractions of meter to several meters. Several open fractures exist and they are widened by weathering and erosion to create fissures and gullies.

The strike of the foliation in this charnockitic rock varies from N 42^0 W to N 18^0 E and dip direction varies from Southwest to Northwest direction. The bedrock of the proposed quarry site dips between 13 and 29 degrees mainly towards Mahaweli River. The irregular dip variations occur due to the physical and chemical weathering of the foliation plane and weathering along joints. Charnockitic gneiss rock is exposed mostly along the valley slopes and along the stream traces (Figures 3.6 and 3.7).

Figure 3.7 Large bedrock exposures in the proposed quarry site

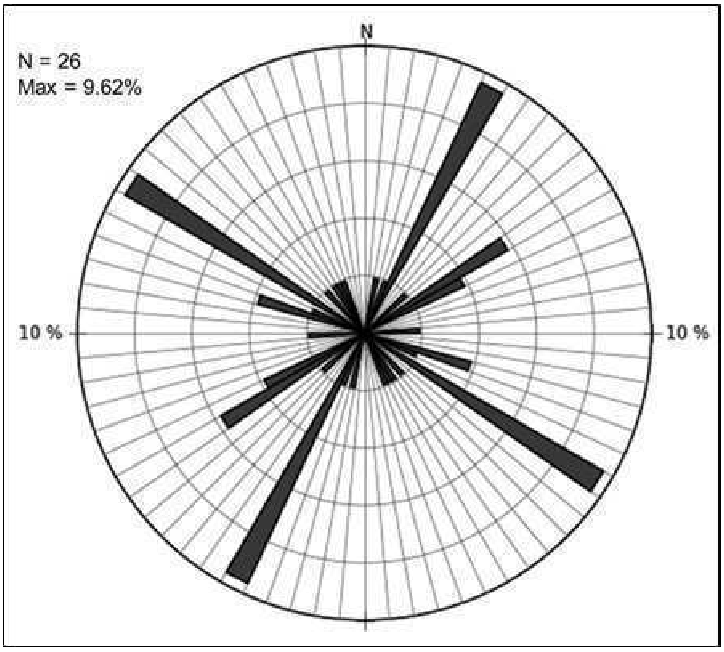


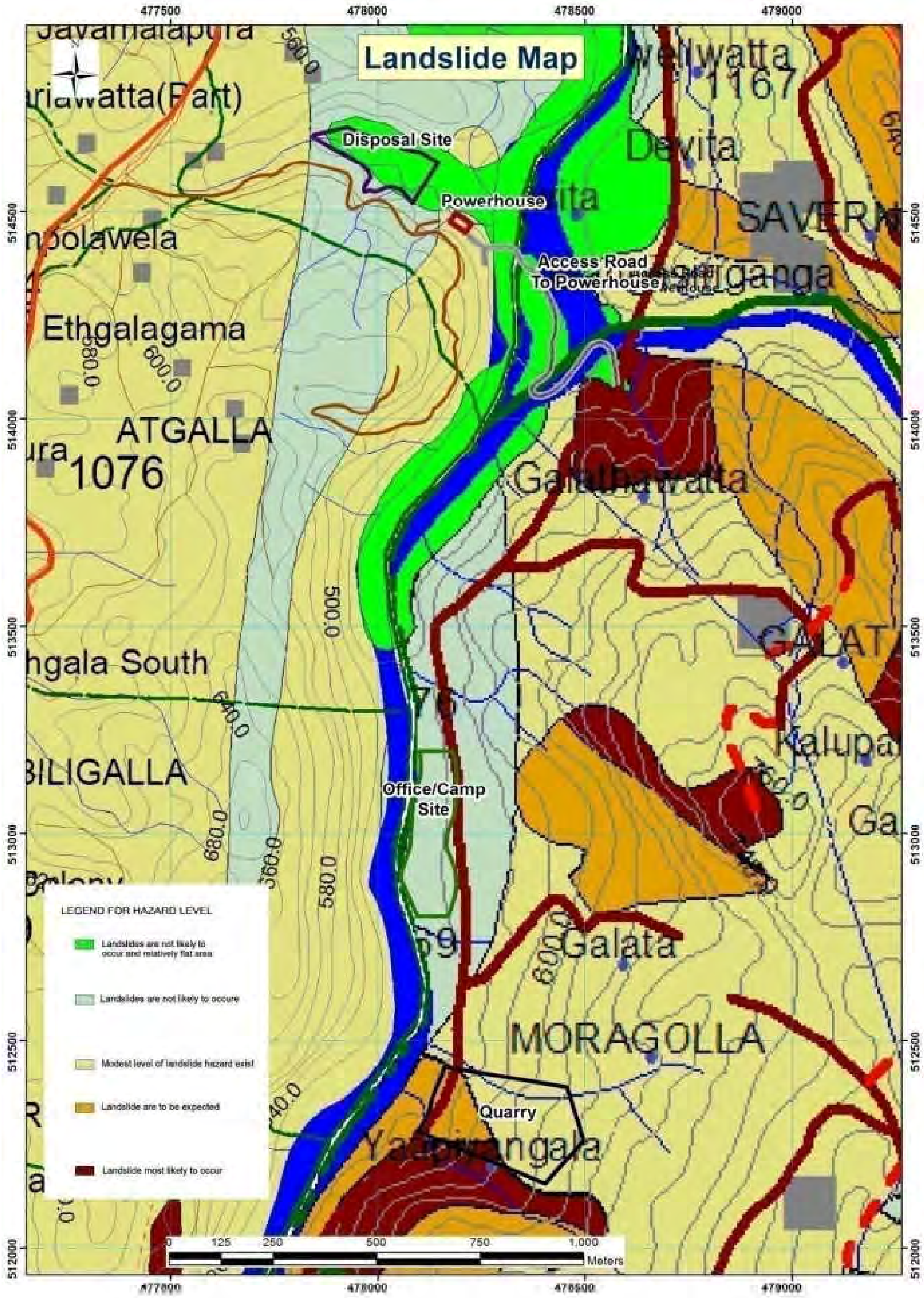
Figure 3.8 Rose diagram showing two conjugate joint sets in the study area

The most dominant subsurface soil type in the quarry site is colluviums with boulders ranging from 0.25 m to about 5m sizes and the thickness of the soil cover varies about 0.5 m to 8 m (Figures 3.9and 3.10).

Figure 3.9 Colluviums at the lower reaches of the quarry site

Figure 3.10 Large boulders on the quarry site indicate the existence of colluviums

Except for the South western boundary of the proposed quarry site and few sections along the southern most streams, other areas are being categorised by NBRO landslide hazard map as modest level landslide hazard areas (Map 3.11).



Map No. 3.11 Landslide Hazard Map of the project area
Source; Landslide hazard maps - NBRO, Sri Lanka

3.1.2 Biological Environment

3.1.2.1 Site description

This site consists of a grassland dominated vegetation type with few scattered trees, shrubs and herbs. The soil layer in the site is very thin and hence does not support a growth of large trees forming a close canopy. *Dcranopterislinearis* (kekilla) forms the dominant ground cover of the site while patches of *Panicum maximum* (Mana) and *Cymbopogonnardus* (Pangirimana) are found in patches (Figure 3.11).

Figure 3.11 *Dcranopterislinearis* (kekilla), *Panicum maximum* (Mana) and *Cymbopogonnardus* (Pangirimana) dominant ground cover in the quarry site.

Few tree species such as *Symplocuscochinchinensis* (Bombu*), Tremnaorientalis* (Gadumba), *Acacia mangium*, *Macrangapeltata*, *Alstoniamacrophylla* (Hawerinnuga) are found near the road side and bordering the stream. Few herb species such as *Eupatorium inufifolium*, *E. Odoratum*were also found in the stream bank (Figure 3.12).

Figure 3.12 Tree cover near the stream bank of the quarry site

3.1.2.2 Current Status of Fauna and Flora

3.1.2.2.1 Fauna

Area selected for the quarry site is a species poor habitat. Only 41 species of animals in 25 families have been recorded from this site. Fauna recorded include tow endemics, and one threatened species (Table 3.1).

Table 3.1. Summary of the fauna recorded from the quarry site

Animal group	Families	No. of Species		Conservation status* of the species recorded			
		Total	Endemics	CR	EN	VU	NT
Invertebrates							
Dragonflies	3	10	1	-	-	-	-
Butterflies	5	13	1	1	-	-	-
Vertebrates							
Amphibians	2	2	1	-	-	-	-
Reptiles	5	6	-	-	-	-	-
Birds	4	4	-	-	-	-	-
Mammals	6	6	-	-	-	-	-
Total	25	41	2	1	4	5	8

*Conservation status follows National Redlist 2012

CR- Critically endangered
EN-Endangered
} Threatened

VU-Vulnerable

NT – Near Threatened

Complete list of endemic and threatened fauna is given in Appendix II and the detailed list of fauna recorded is given in the Appendix III.

3.1.2.2.2 Flora

A total of 72 plant species (Table 3.2) including three endemics (Table 3.3) have been recorded in the sampling area. Majority of the species recorded are shrub and herbs.

Table 3.2. Summary of the flora recorded from the quarry site

Sites	Family	Species	Life form categories					
			Tree	Small tree	Shrub	Herb	Liana	Grass
Quarry site	42	72	26	8	10	19	5	4

Most of the plants recorded are characteristic species of disturbed sites. The plant species recorded in all three sites is given in the Appendix V.

Table 3.3 Ecological status of the flora recorded from the quarry site

	Family	Species			Ecological Status		
			Native	Endemic	Cultivated	Introduced	Ornamental
Quarry site	42	72	64	3	-	5	-

Endemicity of plants is very poor (only three endemics recorded) and no threatened plants were found in the site sampled.

3.1.3 Social Environment

The site is located in Galatha GND in Udapalatha DSD in Kandy District (see Map 3.3). Table 3.4 provides basic information of the two GN Divisions where the components of the project are located.

Table 3.4

Social Variable		**Gampola Wela - 1077** (According to 2012 data)	**Galatha -1185** (According to 2011 data)
Total Population		2469	3456
Total Families		668	662
House Holder (Families)	F	129	14
	M	539	648
Population	Female	1283	1676
	Male	1186	1780
	Total	2469	3456
Religious Composition of the population	Buddhist	1945	2040
	Hinduism	20	1377
	Islam	40	0
	Roman Catholic	464	39
	Other	0	0
Ethnic Composition of the population	Sinhala	1942	2043
	Sri Lankan Tamil	48	16
	Indian Tamil	0	1389
	Sri Lankan Muslims	476	0
	Burger	0	8

The current landuse in the area demarcated is characterized primarily by grassland (see Map 3.4) and remains in a state of abandonment. Occasionally stray neat cattle are seen grazing in the grassland. There are no houses or any other structures within the foot print of the quarry site. There are no culturally or religiously significant places within the footprint or within the 200 m buffer zone. There are no access roads through the site.

a


b


Figure 3.13 “a” and “b” Two Houses located within the buffer zone of the Quarry site

However, the land adjacent to the site on the south side has been auctioned for residential purposes a few years ago and three houses has been constructed as holiday homes (See Figure 3.13). The access to these roads runs along the southern perimeter of the site (See Map 3.7 and Figure 3.4).

3.1.4 Issues and Impacts

3.1.4.1 Physical Environment

The impacts identified due to quarry operation and mitigation measures proposed;

Soil Erosion

Soil erosion along the slope of the quarry site is anticipated during clearing the site and removal of the overburden. This may aggravate by the existing perennial stream which is running through the quarry site.

Leaving a stable slope cut at the boundary of the quarry site and diverting the stream to one of the adjacent streams on either sides of the quarry will help to mitigate the problem. Construction of appropriate drainage system and facilitating ponding areas for sedimentation is required.

Surface Water and Soil Pollution

Soil and surface water along the streams may get polluted due to oil spills, cleaning and washing of loaders, dump trucks or other machineries operating at the quarry site.

As a large fleet of heavy vehicles are to be deployed for quarry operation and haulage of rock material and spoil material, appropriate measures to be taken to avoid pollution of the ground due to spilling of oil and other liquid wastes etc. Special areas to be maintained for maintenance of such vehicles or machineries, cleaning and washing purposes. Construction of sediment settling ponds would be required to avoid the pollution of the surface water sources.

Turbidity of the water in the stream running through the middle of the quarry site will get increased by mixing with quarry dust and the spoil material.

The stream running through the quarry to be diverted to one of the adjacent stream and maintain the quarry without water flowing through it. However, water drained through the quarry site should be diverted through a sedimentation/ settling ponds before discharging water to Mahaweli River

Air Pollution and Noise pollution

Air pollution and noise pollution are anticipated during quarry operation.

Use of efficient vehicles for drilling, loading and hauling operations, controlled blasting, wetting using sprinklers to avoid dispersion of dust etc. would be appropriate as mitigation measures.

Noise and Vibration due to Drilling and Blasting

Encouraging the contractor to limit drilling and blasting to day time, Controlled blasting, and using noise barriers such as piles of spoil material or sand bags etc., would be appropriate. However, frequent monitoring of the buildings for the occurrence of cracks or widening of the existing cracks to be carried out. Duration of blasting and drilling operations must be clearly stated in the contractor's method statement and strict vigilance to be maintained to assure the safety and freedom of the people living in the area.

Potential structural damages to the three buildings near the quarry site within the 200m buffer zone

As indicated in Map No. 3.6, the three houses are under direct threat of the structural damages from the quarry operations.

Occupants are to be temporarily evacuated and compensation be paid for the duration. Compensation or repair damages upon completion of the quarry operation (Crack survey to be carried out before commencing quarry operation to avoid future disputes). Upon completion of the project, proper damage assessment to be done for the buildings and either compensation be paid or necessary repairs be done up to the satisfaction of the owners.

Fly rock during blasting

Threat to the safety of the road users and the users of the access road leading to the village in the upper reaches are under threat due to fly rock during blasting.

Controlled blasting is to be encouraged. Appropriate and sufficient warning to be issued (alarm signals) to the traffic and the pedestrians of the Secondary road and access road to upper reaches above the quarry site.

Sand bags, piles of debris or excavated rock or any other form of barriers can be used as a shield to minimize fly rock problem. Controlled blasting to be encouraged and appropriate and sufficient warning to be issued to the traffic on the secondary road as well as the users of the access road. Appropriate measures to be taken to ensure the safety of the users of the access road or to provide an alternative access road for them away from the hazardous area.

3.1.4.2 Biological Environment

Removal of trees

A total of 71 trees belonging to 11 species will have to be removed from the site (Table 3.5).

Table 3.5. Trees to be removed from quarry site

Family	Species	Common name	No. of trees
Fabaceae	*Acacia mangium*	Accasia	36
Fabaceae	*Albizialebbeck*	Albezia	10
Anacardiaceae	*Spndiasmombin*	Ambalanga	1
Moraceae	*Ficusreligiosa*	Bo	1
Euphorbiaceae	*Homalanthuspopulifolius*	Ginikanda	1
Lecythidaceae	*Careyaarborea*	Kahata	7
Euphorbiaceae	*Macarangapeltata*	Kenda	2
Euphorbiaceae	*Brideliaretusa*	Ketakala	1
Fabaceae	*Delonixregia*	Mi Mara	10
Moraceae	*Ficusbenghalensis*	Nuga	1
Apocynaceae	*Alstoniascholaris*	Rukattana	1
		Total	**71**

All these species are not considered as high quality timber species. Species such as *Acacia mangium, Albizia lebbeck* , *Macaranga peltata* are low grade timber species which are mainly used for making temporary structures in construction facilities.

3.1.4.3 Social Environment

Although no houses are located inside the land demarcated for the quarry site, the three houses located in the 200 meter buffer zone need special attention as the high explosives and blasts could damage these houses both aesthetically and structurally. The owners of the houses were not available at the time of field visits to get their comments.

It is suggested, subject to further discussions and negotiations that the following steps are adopted as mitigation measures.

1. Conduct a comprehensive crack survey prior to the commencement of blasting.
2. Value the house.

3. Request the occupants to leave the houses for the duration of operation of the quarry.
4. Through negotiations with the house owners, pay a monthly allowance commensurate with the going rate for a guest houses.
5. Upon closure of the quarry, to repeat the crack survey to assess any damages caused by blasting.
6. Offer to compensate for the damages or the contractors rebuild the houses free of charge for the owners.
7. If the damage is too severe, acquire the land and compensate the owners.

The large scale blasting could have impacts on the traffic along Gampola-Kotmale road bordering the site. Thus sufficient precautions should be taken to stop the traffic sufficiently away from the site during blasting times.

3.2 Proposed Site for Contractor's Office and Camp Area

3.2.1 Physical Environment

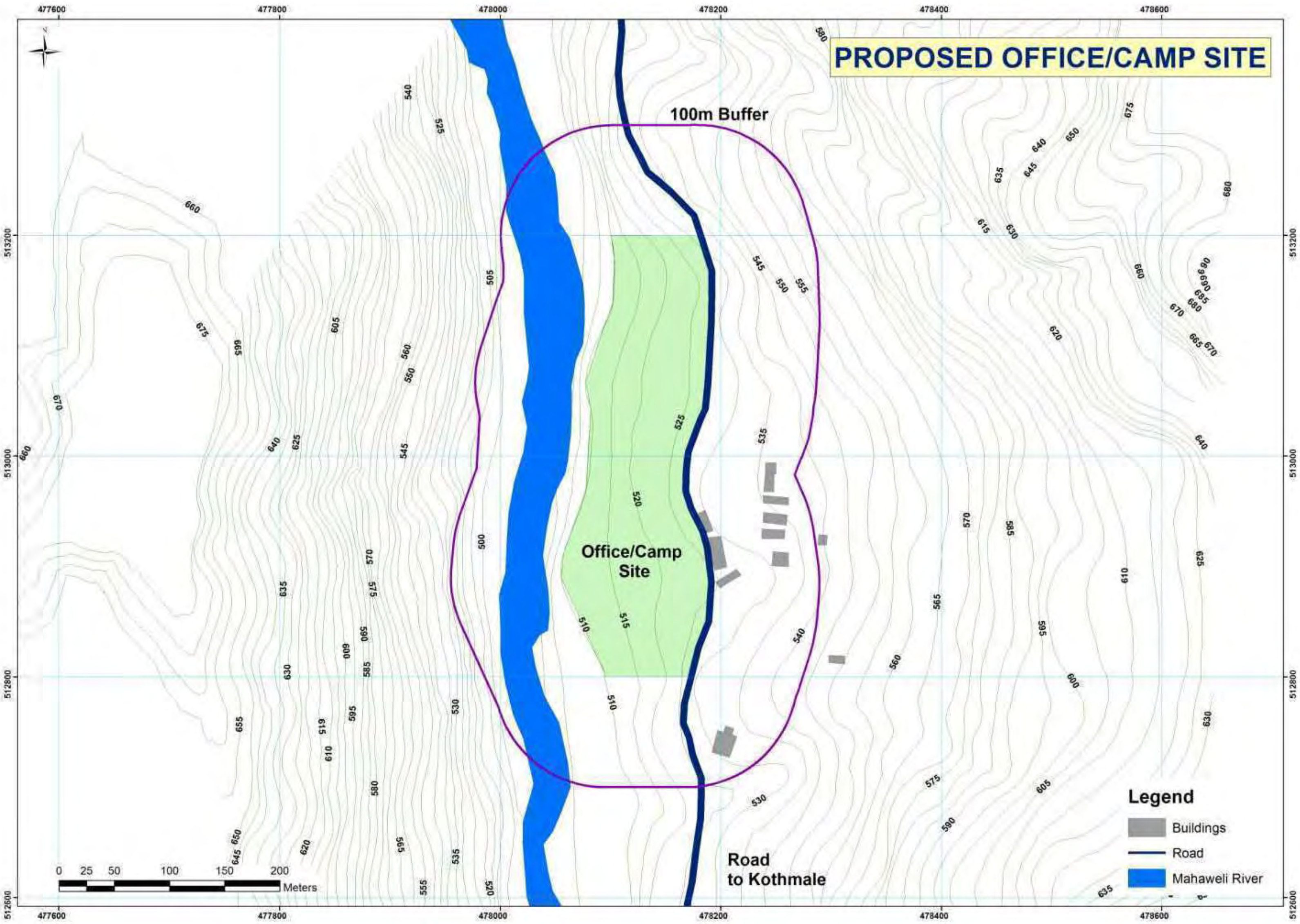
3.2.1.1 Landuse

General landuse of the area is illustrated as forest in Map No. 3.4 which is based on available 1:10,000 topographical maps prepared in 1987 by the Survey Department of Sri Lanka and subsequent field verification carried out by them in 1989. The field observations revealed that part of the forest area has been cleared for developing as religious location as well as small scale agriculture (Farm land). The existing landuse observed during the current study is illustrated in the satellite image (Map Nos. 3.7, 3.12 and 3.13) and Figure 3.14.

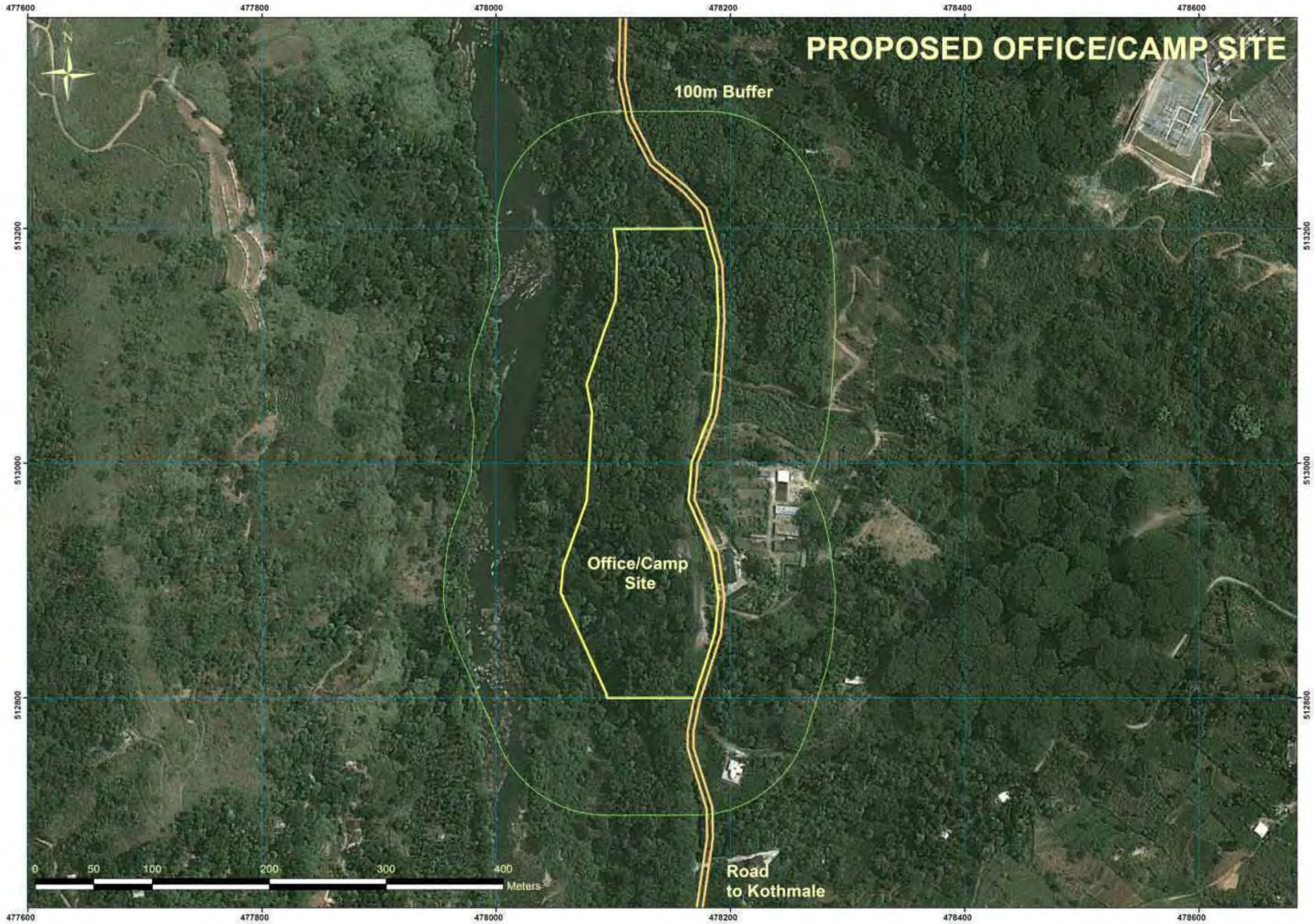
3.2.1.2 Topography and Drainage

The proposed Office and camp site for Contractor is located within the immediate vicinity of the right bank of Mahaweli River at the upstream of the proposed quarry site (Figure 3.14). The designated area is generally having a flat topography (Map Nos. 3.7, 3.12 and 3.13) where elevation ranges from 510-525m above MSL except for the very steep river bank adjacent to the area. Slope map (Map No. 3.9) shows that the general gradient of the land is 0 – 10 Degrees. This area is former cultivated area and presently it is fully covered with thick vegetation. There are several small streams flowing across the camp site and join with the Mahaweli River.

This land area is formerly used for cultivation and presently fully covered with thick riverine vegetation. There are several small streams flowing across the proposed camp site and join with the Mahaweli River. Total area covered by this facility is about 0.04 km^2 (Map Nos. 3.12, 3.13 and Figure 3.15). A 50 m distance is to be maintained as the Reservation for Mahaweli River and, the riverine vegetation in the immediate vicinity of the river should not be disturbed (Map No. 3.13).



Map No. 3.12 Contour map of the proposed site for Contractor's Office/Camp area Source; Survey Maps – Moragolla HEP



Map 3.13 Satellite Image of the proposed site for Contractor's Office/Camp site; 100 m buffer zone and the buildings/houses which are to be affected
Source; Google Earth Images, Survey Maps – Moragolla HEP

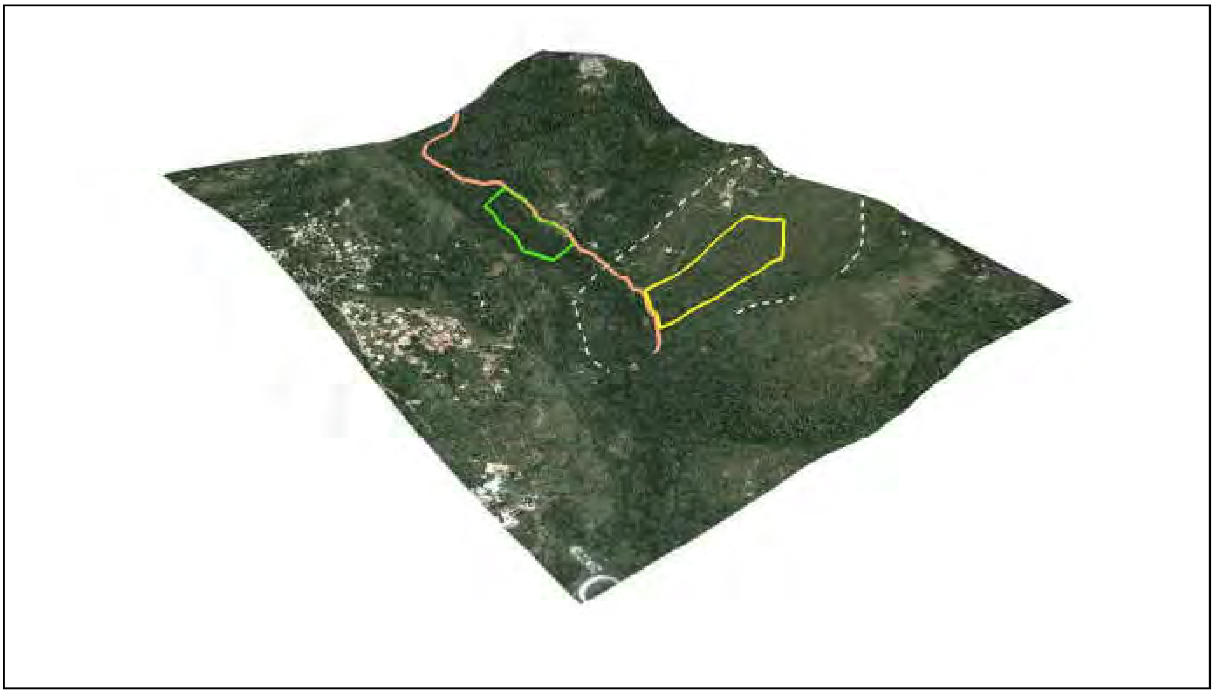


Figure 3.14 Topography at the general area for contractor's camp and office, and quarry site; 3-D perspective using 1:10,000 contour data and Google Earth Image

However, the adjacent Mahaweli River bank is very steep and appropriate precautions to be taken to avoid liquid wastes from the temporary installations, kitchens, wash rooms etc. Appropriate effluent treatment procedure to be adopted and required dilution process of 1:8 to be maintained. Suitable solid waste management plan is to be implemented to ensure that they are properly treated without dumping them in the near vicinity. Appropriate drainage facility to be maintained to divert the storm water and to avoid soil erosion upon site clearing etc.

Figure 3.15 General area for contractor's camp and office

3.2.1.3 Geology, Structure and Slope Stability

The entire site is underlain by thick colluviums and few outcrops of garnet biotite gneiss. Since there will not be significant excavations or blasting, there is no requirement for considering the slope stability conditions. However, according to NBRO Landslide hazard map (Map No. 3.11), the entire area lies within the area where landslides are not likely to occur and hence landslide free zone. As per the slope map for the site (Map No. 3.9), it shows that slope of the entire area surrounding the proposed site ranges from 0-10 degrees which can be categorized as almost flat terrain.

3.2.2 Biological Environment

3.2.2.1 Site Description

Area between the Mahaweli River and the Gampola-Kotmale road between 4 -5km post was sampled (Figure 3.16). However, sampling did not continue up to the river. A 50m wide stretch of vegetation along the river was not sampled as this region would be preserved as the river reservation.

Figure 3.16 Area selected for the construction of Office/camp site and workers quarters etc.

Macaranga peltata (Kenda) form the dominant tree canopy (cover) in the site (Figure 3.17). *Macaranga peltata* is an early colonizer of a disturbed site and hence it could be assumed that this site may have been subjected to anthropogenic disturbance sometimes back. The field survey team has noted scatted concrete rubbles across the sampling area. The villagers inform the survey team that this area was used as a spoil dumping site during the construction of Kotmale dam. *Alstonia macrophylla* (Havarinuga)and *Albizia falcataria* (Albizia) are the other dominant tree species in the site.

Figure 3.17*Macaranga* dominant tree cover in the site selected for the construction of workers camp

Figure 3.18*Clidemia hirta* (Katakalu bovitiya), dominant ground cover in the site

The ground cover of the site mainly consists of *Clidemia hirta* (Katakalubovitiya), which is an alien invasive species (Figure 3.18).

3.2.2.2 Current Status of Fauna and flora

3.2.2.2.1 Fauna

A total of 71 faunal species in 40 families were recorded from the site selected for the construction of worker's camp. Fauna recorded include 20 endemics, two proposed endemics and six threatened species (Table 3.6). This site supports comparatively a higher faunal richness. The site has a good tree (canopy) cover and a moist forest floor which are favourable habitats for many species of animals. Species such as *Suncus zeylanicus* and *Ratufa macroura* have been recorded from this site. These two species have not been recorded during the EIA study for the project area. List of endemic and threatened fauna is given in Appendix II and the detailed list of fauna recorded is given in the Appendix III.

Table 3.6 Summary of the fauna recorded and their conservation status

Animal group	Families	No. of Species		Conservation status* of the species recorded			
		Total	Endemics	CR	EN	VU	NT
Invertebrates							
Land Molluscs	2	5	3	-	-	1	2
Dragonflies	2	6	-	-	-	-	-
Butterflies	4	11	1	-	1	1	-
Vertebrates							
Amphibians	2	5	5	-	1	-	-
Reptiles	5	10	4	-	-	-	-
Birds	16	24	5+2‡	-	-	1	1
Mammals	9	10	2	-	1	1	-
Total	40	71	20+2	-	3	3	7

*Conservation status follows National Redlist 2012

CR- Critically endangered

EN-Endangered } Threatened

VU-Vulnerable

NT – Near Threatened

‡ Proposed endemic

3.2.2.2.2 Flora

A total of 73 plant species including three endemics have been recorded in the sampling area (Table 3.7).

Table 3.7 Summary of the flora recorded from the camp site

Site	Family	Species	Life form categories					
			Tree	**Small tree**	**Shrub**	**Herb**	**Liana**	**Grass**
Camp site	41	73	32	10	9	15	7	1

Most of the plants recorded are characteristic species of disturbed sites (Table 3.8). List of plant species recorded in is given in the Appendix V.

Table 3.8 Ecological status of the flora recorded from the camp site

Site	Family	Species	Ecological Status				
			Native	Endemic	Cultivated	Introduced	Ornamental
Camp Site	41	73	60	3	2	6	2

Endemicity of plants is very poor (only three endemics recorded) and no threatened plants were found in the site sampled.

3.2.3 Social Environment

The site is located in Gampolawatte GND in Udapalatha DSD in Kandy District (see Map 3.3). Table 3.9 provides basic information of the two GN Divisions where the components of the project are located.

Table 3.9 Social variables in Gampola Wela and Galatha as per 2012 and 2011 data

Social Variable		**Gampola Wela -1077** (According to 2012 data)	**Galatha - 1185** (According to 2011 data)
Total Population		2469	3456
Total Families		668	662
House Holder (Families)	F	129	14
	M	539	648
Population	Female	1283	1676
	Male	1186	1780
	Total	2469	3456
Religious Composition of the population	Buddhist	1945	2040
	Hinduism	20	1377
	Islam	40	0
	Roman Catholic	464	39
	Other	0	0
Ethnic Composition of the population	Sinhala	1942	2043
	Sri Lankan Tamil	48	16
	Indian Tamil	0	1389
	Sri Lankan Muslims	476	0
	Burger	0	8

The site is located in a narrow stretch of land between the Mahaweli River and the Gampola-Kotmale road(see Map 3.4) and the land remains in a state of abandonment. There are no houses or any other structures within the foot print of the contractor's office and camp area.

A Buddhist Shrine and an old Bo tree (a tree sacred to the Buddhists) are located within the foot print bordering the main road. Although there are no permanent temples here, the land between the Bo Tree and Shrine room is paved and during the religiously sacred days, devotees come here to observe "*sil*" and to practice meditation. During the interviews, the people did not object to the proposed construction but they insisted that the project develop the site and allow unhindered access to it at all times.

A government agricultural farm, popularly known as "Hadabima" is located within the 100 meter buffer zone on the eastern side of the site and the main road (see Map 3.4 and 3.7). However, as this complex is located on the other side of the main road, it is less likely to be affected by the construction work. The officers in the Hadabima complex also did not object to the project but they were concerned about the possible traffic congestion, especially at the entrance gate which is located almost in front the proposed site.

3.2.4 Issues and Impacts

3.2.4.1 Physical Environment

The impacts identified due to clearing the site, construction of temporary structures and operation period and mitigation measures proposed;

Soil Erosion

Soil erosion at the site is anticipated during clearing the site for contractor's camp/Office area on the right bank of Mahaweli River along the narrow strip of land between the river and secondary road.

Carrying out this site clearing and excavations during dry period is encouraged to minimize soil erosion. Construction of appropriate drainage system to divert storm water and the water to be discharged from the facility can mitigate the problem.

Pollution of Groundwater and soil overburden

Groundwater and soil pollution due to effluents discharged from the sanitary facilities, liquid wastes from the temporary installations, kitchens, wash rooms, vehicle yards etc. Appropriate effluent treatment procedure should be adopted and required dilution process of 1:8 to be maintained for the discharging liquid wastes if any. Suitable solid waste management plan to be implemented to ensure that they are properly handled without dumping them in the near vicinity which may eventually be washed out to the Mahaweli River.

Surface Water and Soil Pollution

Soil and surface water along the streams may get polluted due to oil spills, cleaning and washing of machineries (loaders, dump trucks or other machineries) operating at the quarry site and other construction sites.

As a large fleet of heavy vehicles are to be deployed, appropriate measures to be taken to avoid pollution of the soil and surface water due to spilling of oil and other liquid wastes etc. Special areas should be maintained for maintenance of such vehicles or machineries.

3.2.4.2 Biological Environment

Removal of trees

One hundred eighty seven (187) trees (in 18 species) will have to be removed from the site designated for the construction of camp site (Table 3.10).

Table 3.10. Trees to be removed from the camp site

Family	Species	Common name	No. of trees
Anacardiaceae	*Mangifera indica*	Amba	1
Apocynaceae	*Alstonia macrophylla*	Hawarinuga	25
Bignoniaceae	*Spathodea campanulata*	Spathodia	4
Combretaceae	*Terminalia catappa*	Bulu	8
Combretaceae	*Terminalia arjuna*	Kumbuk	3
Euphorbiaceae	*Mallotus tetracoccus*	Bu kanda	4
Euphorbiaceae	*Macaranga peltata*	Kenda	74
Fabaceae	*Acacia mangium*	Accasia	15
Fabaceae	*Albizia falcataria*	Albizea	28
Fabaceae	*Albizia lebbeck*	Hurimara	1
Fabaceae	*Delonix regia*	Mi Mara	9
Leguminosea	*Gliricidia sepium*	Ginisiriya	4
Magnoliaceae	*Michelia champaca*	Sapu	2
Moraceae	*Ficus exasperata*	Budeliya	1
Moraceae	*Artocarpus nobilis*	Waldel	2
Sterculiaceae	*Petrospermum suberifolium*	Welan	1
Tiliaceae	*Grewia damine*	Daminiya	3
Verbenaceae	*Vitex altissima*	Milla	2
		Total	**187**

Of the species needs to be removed *Terminalia arjuna, Vitex altissima*, *Michelia champaca* are valuable timber species. *Terminalia arjuna* is a water lowing species and considered to be important in strengthening stream banks. It is legally prohibited to cut this species and hence approval from the Forest Department will be required to cut and remove this species. Few other species such as *Alstonia macrophylla*, *Macaranga peltata*, and *Acacia mangium* are low grade timber species.

Environmental Impact Assessment Report of the Moragolla Hydropower Project (CEB, 2012) indicates that 18 trees (>20 cm DBH) needs to be removed from the site originally identified for the construction of the camp site.

3.2.4.3 Social Environment

The Buddhist Shrine and the Bo Tree should not be disturbed as it is a culturally very sensitive. The following steps are suggested

1. Construct a wall separating the shrine and Bo tree from the contractors office and camp complex.
2. Discuss with the local civic leaders and the meditators and provide a better surface as the existing cement surface is heavily damaged.
3. Construct a small hall with a roof so that religious observers and meditators can practise even under bad weather.
4. Construct a modern toilet for the benefit of the devotees who come for religious observances and meditation.
5. The project should also ensure that the entrance to the Hadabima will not be obstructed during the construction period.

3.3 Proposed Site for Spoil Dumping

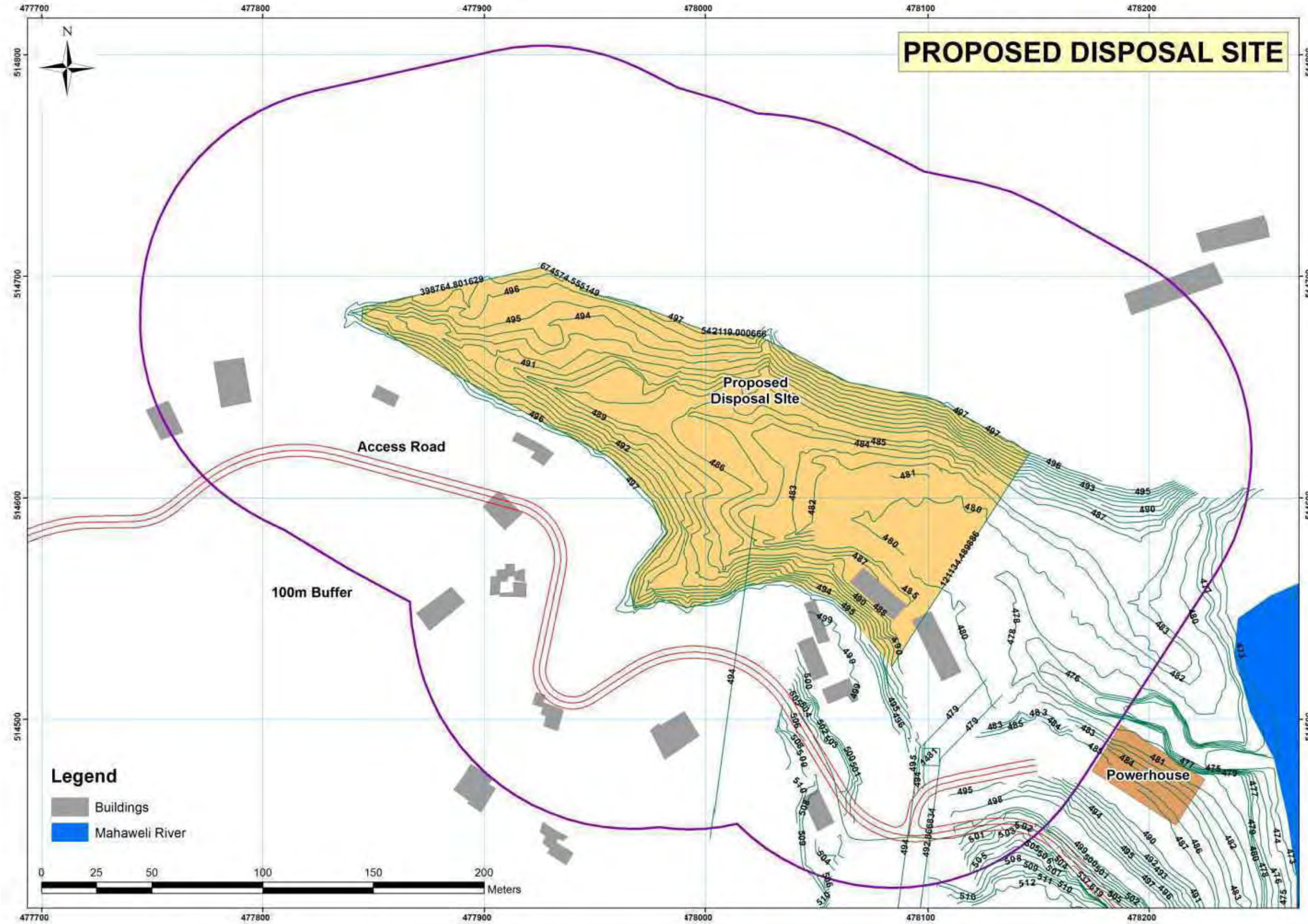
3.3.1 Physical Environment

3.3.1.1 Topography and Drainage

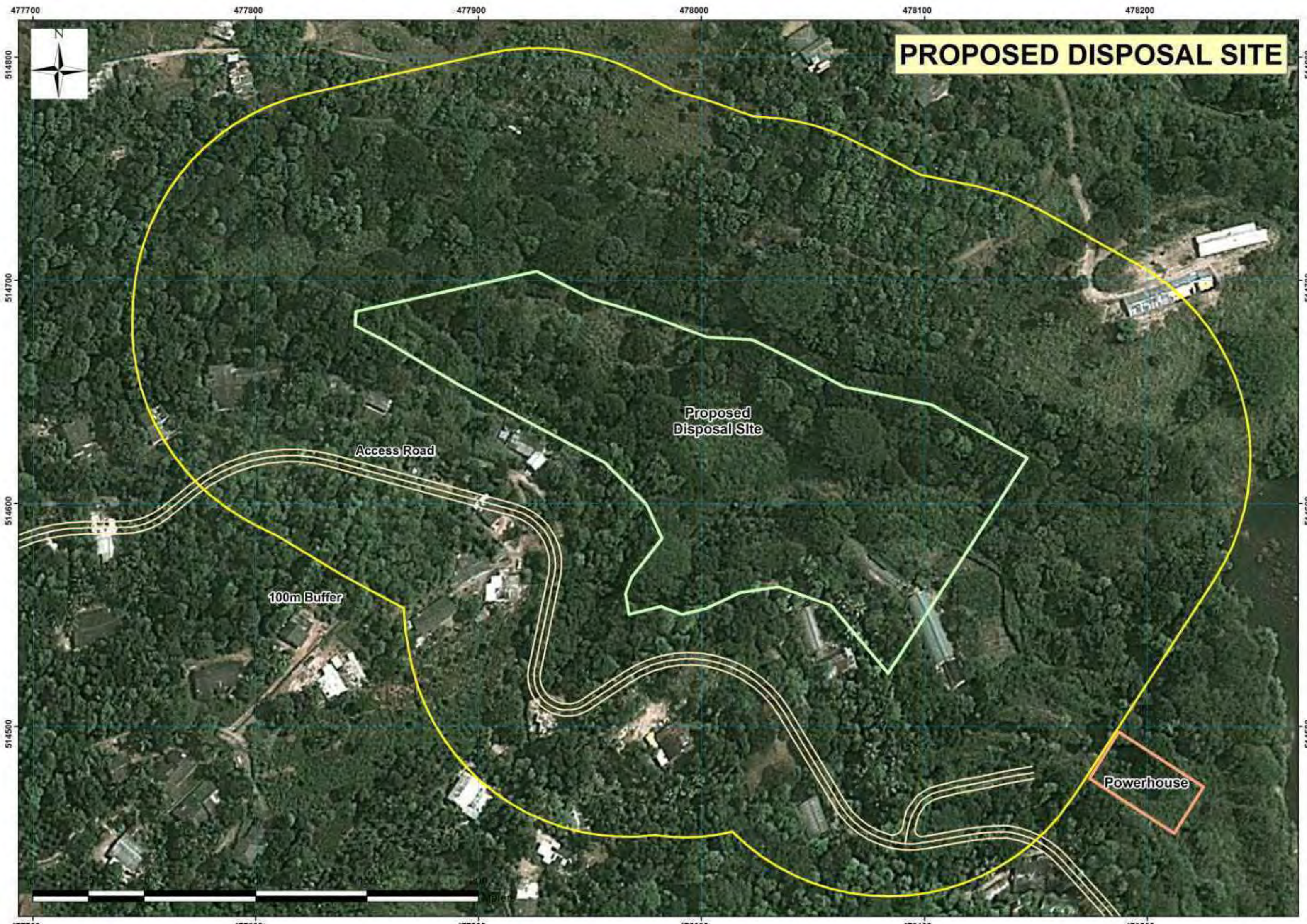
Proposed dumping site is located in a low land along a valley of the small stream just downstream of the power house at Ethgala. The area is surrounded by higher grounds where elevation of the area ranges from 475 m to 500 m above MSL showing a 25 m relief difference. Western side of the upstream part of the valley consists of gentle slope showing irregular patterns due to the colluviums of old landslides (Map No. 3.14 and 3.15).

As per the slope map for the site (Map No. 3.9), it shows that slope of the entire area surrounding the proposed quarry site ranges from 10-30 degrees which can be categorized as gentle slope. However, some sections of the slopes adjacent to the stream valley are as steep as 30-40 degrees.

Constructed irrigation channel follows the higher elevation contour line around the proposed dumping site. There are few streams flowing across the proposed dumping site and, gullies are developed due to the leakage flow of the irrigation channel around dump site (Figure 3.19). These are connected with main stream flowing towards southeast direction. Lowest part of the area consists of flood plain and stream shows irregular patterns in this region. The general topography is consisting valleys with steep slopes. Slopes in the area vary from gentle to steep slopes. Map No. 3.15 and Figure 3.20 shows the general topography of the area.



Map 3.14 Contour map of the proposed dumping/disposal site; 100 m buffer zone and the buildings/houses which are to be affected
Source; Survey Maps – Moragolla HEP



Map 3.15 Satellite image of the proposed dumping/disposal site Source; Google Earth Images, Survey Maps – Moragolla HE

Figure 3.19 Left; Irrigation cannel along the upper level of the spoil bank; Right; Area to be filled during dumping operation.

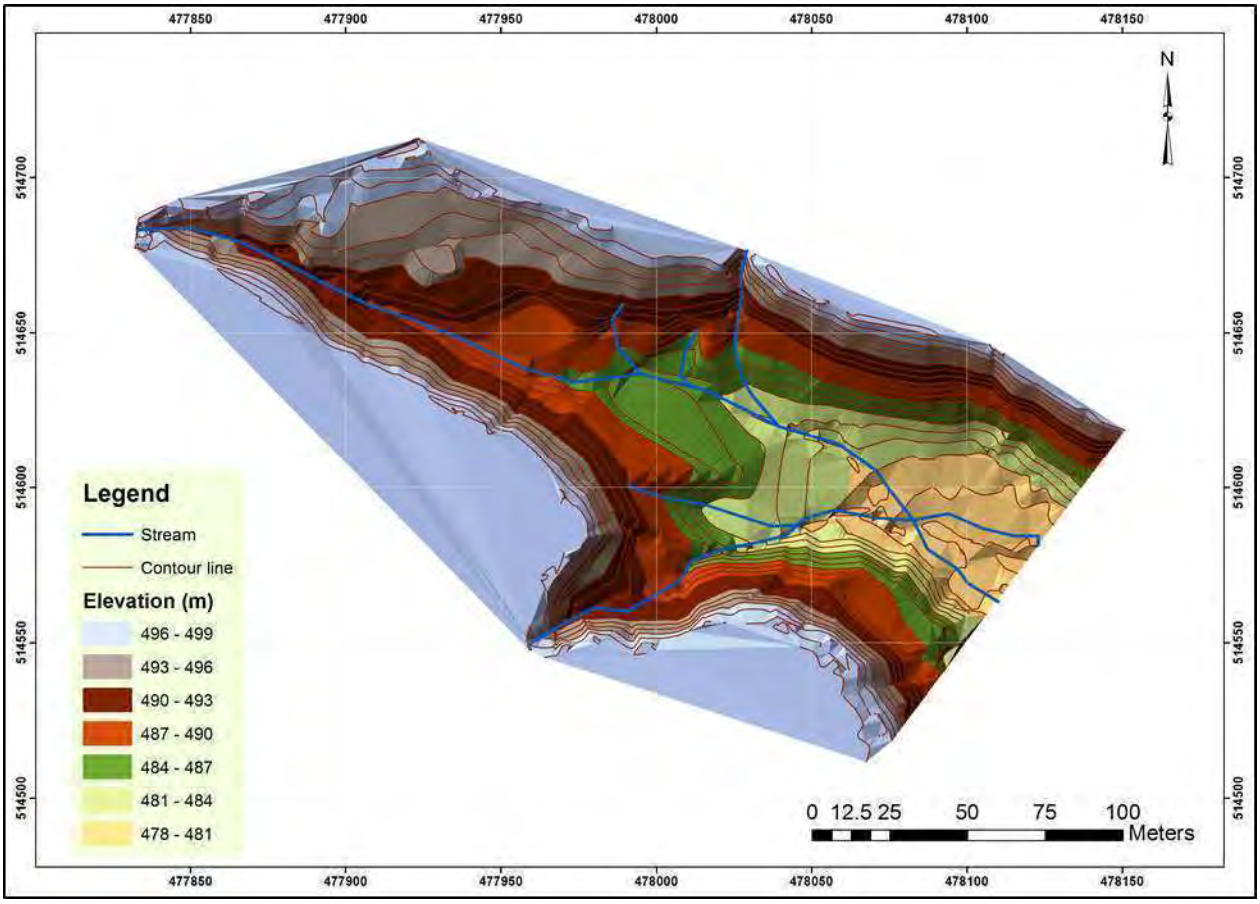


Figure 3.20 Digital Elevation Model for the proposed dumping site showing topography of the area

3.3.1.2 Geology, Structure and Slope Stability

Generally the area consists of two types of high grade metamorphic rocks namely charnockitic gneiss as lower rock formation and khondalite as upper formation. Charnockitic gneiss rock is exposed in the valley in the upstream (Figure 3.21). Khondalite exposure is observed in the escarpment slope on the left bank of irrigation channel (Figure 3.21). General strike of the Northwest region shows that the rocks dip towards Northwest and Northeast directions.

There are three types of subsurface soil in the proposed dumping site. They are alluvial soils transported into the lower flood plains, residual soil that is a product of weathering of underlain basement rock and colluviums soil transported by gravity. The alluvial deposit comprises of boulders, coarse gravels, sand and clay (Figures. 3.21 and 3.22).

Figure 3.21 Charnockitic gneiss exposure and the Khondalite exposure along the stream

Figure 3.22 Alluviums in the flood plain; Coarse gravel and boulders along the valley

According to the landslide hazard map of NBRO, the area is categorized as an area landslides are not likely to occur (map No. 3.9). However, prior to commence dumping operation, carefully laid subsurface drainage system to be introduced for this stream valley. Diameter and the sizes etc. will have to be determined considering the flow rates of this stream during heavy rain fall. The existing irrigation cannel should be properly protected in order to avoid any damage, possibly replacing with a sub surface concrete cannel.

3.3.2 Biological Environment

3.3.2.1 Site description

The site is located between the "Dunhinda Ela" (which is a part of the Gampola Wela Raja Ela Scehme" and the left bank of the Mahaweli River in Ethgala village (Figure 3.23). The area has been used in the past to cultivate *Piper nigram* (Gammiris). Pepper cultivation in the area has been abandoned sometimes back. *Gliricidiasepium* (Giniseria) sticks planted as a support for the piper veins now have grown in to moderate size trees and dominate understory layer of the site.

Figure 3.23 Planted *Gliricidiasepium* (Giniseria) fence along the irrigation cannel Gampolawela Raja Ela.

Macarangapeltata(Kanda) has established well in the site and form the dominant tree cover of the site. The other tree species found in considerable numbers in the site is *Swieteniamahagoni*(Mahogany) which has also colonized the abandon land. The ground cover of the land mainly consists of panicum grass (*Panicum maximum*) (Figure 3.24)

Figure 3.24*Macaranga* dominant tree cover and the *Panicam* covered ground layer in the site

3.3.2.2. Current Status of Fauna and Flora

3.3.2.2.1 Fauna

A total of 64 faunal species in 41 families were recorded from the site. Fauna recorded include 10 endemics, 1 proposed endemic and four threatened species (Table 3.11). List of endemic and threatened fauna is given in Appendix II and the detailed list of fauna recorded is given in the Appendix III.

Table 3.11 Summary of the fauna recorded from the spoil dump site and their conservation status

Animal group	Families	No. of Species		Conservation status* of the species recorded			
		Total	Endemics	CR	EN	VU	NT
Invertebrates							
Land Molluscs	3	6	2	-	-	-	1
Dragonflies	3	8	1	-	-	-	-
Butterflies	4	10	1	-	1	-	-
Vertebrates							
Amphibians	3	4	2	-	1	-	-
Reptiles	6	10	2	-	-	1	1
Birds	16	20	2+1‡	-	-	-	2
Mammals	6	6	-	-	-	-	-
Total	41	64	10+1‡	1	2	1	4

*Conservation status follows National Redlist 2012

CR- Critically endangered

EN-Endangered

VU-Vulnerable

} Threatened

NT – Near Threatened

‡Proposed endemic

Summary of the fauna recorded in all three sites is given in Appendix IV.

3.3.2.2.2 Flora

A total of 80 plant species including two endemics have been recorded in the sampling area (Table 3.12).

Table 3.12 Summary of the flora recorded from the spoil dump site

Site	Family	Species	Life form categories					
			Tree	Small tree	Shrub	Herb	Liana	Grass
Dump site	42	80	33	11	15	12	7	2

Most of the plants recorded are characteristic species of Kandyan home gardens which also include some ornamental species. Spoil dump site harboured the highest number of cultivated, introduced and ornamental species (Table 3.13). The plant species recorded in is given in the Appendix V.

Table 3.13 Ecological status of the flora recorded from the spoil dump site

Site	Family	Species	Ecological Status				
			Native	Endemic	Cultivated	Introduced	Ornamental
Spoil dump site	42	80	59	2	9	6	4

Kandyan home gardens are known to support high plant diversity as they include both planted species (such as herbs, spices, ornamental plants as well as some economically important timber species as well as naturally occurring species). This site contain a combination of native species as well as cultivated and the introduced ornamental species. Endemicity of plants is very poor (only for endemics recorded) and no threatened plants were found in the sites sampled.

Summary of the flora recorded from all three sites is given in the Appendix VI and ecological status of the flora recorded from all three sites is summarized in Appendix VII.

3.3.3 Social Environment

The site is located in Gampola Wela GND in Ganga Ihala Korale DSD in Kandy District (see Map 3.3). Table 3.14 provides basic information of the two GN Divisions where the components of the project are located.

Table 3.14 Social variables at Gampola Wela and Galatha as per the 2012 and 2011 data

Social Variable		**Gampola Wela 1077** (According to 2012 data)	**Galatha -1185** (According to 2011 data)
Total Population		2469	3456
Total Families		668	662
House Holder (Families)	F	129	14
	M	539	648
Population	Female	1283	1676
	Male	1186	1780
	Total	2469	3456
Religious Composition of the population	Buddhist	1945	2040
	Hinduism	20	1377
	Islam	40	0
	Roman Catholic	464	39
	Other	0	0
Ethnic Composition of the population	Sinhala	1942	2043
	Sri Lankan Tamil	48	16
	Indian Tamil	0	1389
	Sri Lankan Muslims	476	0
	Burger	0	8

The current land use in the area demarcated is characterized primarily by thick home gardens (see Map 3.12). On the proposed site there is a complex of green houses growing vegetables for the local super markets and for export (see Figures 3.25 and 3.26).

Figure 3.25: Greenhouse that will be affected

Figure 3.26: Greenhouse that will be affected

Map 3.12: Home gardens in the Proposed Spoil Bank Site.

The owners of the land and the proprietor of the green houses were willing to allow the project to dump the spoil on their land located on a valley and in return, they expect the following

1. A reasonable compensation for the monthly loss of income. The compensation value is to be negotiated taking into account the current production levels.
2. The spoil dumping should be done in such a way that upon completion, the utility and the value of the land should increase. Thus spoil dumping ground should be terraced and levelled for them to recommence their business.
3. At least a few member of this family is to be provided with jobs in the project. There are no other houses or structures in the spoil dumping area.

The access road from Gampola-Nawalapitiya road through the spoil dump to the proposed powerhouse has already been dealt in the original EIA.

3.3.4 Issues and Impacts

3.3.4.1 Physical Environment

The impacts identified due to clearing the site and dumping operation and mitigation measures proposed;

Soil Erosion

Soil erosion is anticipated during clearing the site and dumping spoil material. Maintaining a stable slope at the boundary of the operation of dumping site and diverting the stream through sub surface Hume pipe (with appropriate diameter) beyond the designated dumping area will help to mitigate the problem to most extent.

3.3.4.2 Biological Environment

Removal of trees

One hundred sixty one (161) trees (in 21 species) need to be removed from the spoil dump site (Table 3.15).

Table 3.15 Trees to be removed from the spoil dump site

Family	Species	Common name	No of trees
Anacardiaceae	*Mangifer aindica*	Amba	1
Anacardiaceae	*Anacardium occidentale*	Kaju	1
Apocynaceae	*Alstonia macrophylla*	Hawarinuga	1
Bigoniaceae	*Spathodea campanulata*	Spathodia	5
Euphorbiaceae	*Mallotus tetracoccus*	Bukenda	3
Euphorbiaceae	*Macaranga peltata*	Kanda	59
Euphorbiaceae	*Hevea brasiliensis*	Rubber	2
Fabaceae	*Albizia falcataria*	Albezia	2
Fabaceae	*Erythrina sabumbrans*	Eramudu	*3*
Fabaceae	*Gliricidia sepium*	Ginisiriya	28
Lauraceae	*Persea americana*	Alipera	5
Lauraceae	*Neolitsea cassia*	Kududawula	2
Lauraceae	*Cinnamomum capparu*	Kurundu	2
Magnoliaceae	*Michelia champaca*	Sapu	2
Meliaceae	*Swietenia mahagoni*	Mahogany	27
Moraceae	*Ficus asperrima*	Budaliya	6
Moraceae	*Artocarpus nobilis*	Del	1
Moraceae	*Artocarpus heterophyllus*	Kos	*2*
Sapindaceae	*Filicium decipiens*	Pihimbiya	1
Tiliaceae	*Grewia damine*	Damanu	3
Ulmaceae	*Trema orientalis*	Gadumba	5

Species such as *Michelia champaka, Artocarpus heterophyllus,* and *Filicium decipiens* are naturally occurring valuable timber species in Kandyan home gardens.
Total number of trees to be removed from all three sites is summarized in Appendix VIII.

Environmental Impact Assessment (EIA) Report of the Moragolla Hydropower Project (CEB, 2012) states that 15 trees should be removed from five sites originally selected for spoil dumping.

The EIA report state that a total of 489 trees need to be removed due to various project activities. From the sites originally designated for camp site and spoil dumping, 33 trees were identified for removal. Since new sites have been identified for quarrying, workers camps and spoil dumping, the number of tree to be removed from the original list could be reduced to 456 (i.e. 489-33).

3.3.4.3 Social Environment

Although, spoil dumping activity, at first glance, seems to be a negative activity, at this location, it will be a positive activity as the filling up of a land that is currently underutilized will first increase its land value and second it opens up new opportunities to use the land.

Two issues that can arise by the spoil dump is the final decision on the compensation package to be given to the owners of the land of the dump site.

1. The project needs to get comprehensive and accurate details on the legal ownership of land. Most rural lands in the central highland have multiple owners although all of them may not occupy the land. However, when issues of compensation arise, these "hidden" owners may surface and could create legal hurdles.
2. The actual determination of the compensation package can also become an issue. Since there is no acquisition of lands involved, it is best that the project enters into an agreement with the affected party on a mutually acceptable basis.

4 CONCLUSIONS

This study assessed the physical, biotic and social status of the locations where the quarry, construction offices and spoil bank are located and possible impacts due to the construction and operation of activities in these sites.

The existing environment of all three sites has been used for various purposes in the past. The study found that the three activities will not lead to the loss of any sensitive ecological resources.

The study revealed several negative and positive impacts arising from the construction activities of the three sites.

Environmental Component	Positive or Negative	Impact
Physical	Negative	Soil Erosion
	Negative	Surface Water Pollution
	Negative	Air pollution and Noise pollution and vibration
	Negative	Noise and Vibration due to Drilling and Blasting
Biological		No significant impacts except removal of some trees
Social	Positive	Increased employment to the local people who will be hired to work at the three sites
	Negative	Temporary evacuation of three houses near the quarry site
	Negative	Potential structural damages to the three buildings near the quarry site
	Negative	Loss of the Green houses at the spoil dump site and thus an income source to one family
	Positive	Reclamation of land to be economically more valuable at the spoil dump site upon completion of work
	Negative	Threat to the safety of the road users and the users of the access road

However all these impacts can be mitigated to acceptable levels as can be seen from the table below.

Impact	Mitigation
Soil Erosion	Divert the stream running through the quarry to one of the adjacent stream Construction of appropriate drainage systems at all sites.
Surface Water and soil Pollution	Divert the stream running through the quarry to one of the adjacent stream Appropriate measures to be taken to avoid pollution of the ground due to spilling of oil and other liquid wastes etc. Construction of sedimentation/ settling ponds and discharge water to Mahaweli River
Air Pollutionand Noise pollution	Use of efficient vehicles Controlled blasting Wetting using sprinklers to avoid dispersion of dust
Noise and Vibration due to Drilling and Blasting	Controlled blasting, Blasting to be limited to definite time gap, Avoid blasting during night time,
Removal of some trees	Initially unavoidable but reforestation and after reclaiming the quarry site. Maintain 50 m riverine buffer zone undisturbed
Increased employment to the local people who will be hired to work at the three sites	No mitigation needed
Temporary evacuation of three houses near the quarry site	Compensation during the temporary evacuation.
Potential structural damages to the three buildings near the quarry site	Temporary evacuation, Compensation or repair damages upon completion of the quarry operation (Crack survey to be carried out before commencing quarry operation)
Loss of the Green houses at the spoil dump site and thus an income source to one family	Compensation and assisting in rebuilding after completion of the reclamation.
Reclamation of land to be economically more valuable at the spoil dump site upon completion of work	No mitigation needed
Threat to the safety of the road users and the users of the access road	Controlled blasting, Sufficient warning to be issued to the traffic and the Users of the access road, Use piles of debris or excavated rock as a shield to minimize fly rock

The study found that the project does not lead to resettlement (only temporary evacuation of three houses) and thus preparation of a resettlement action plan is not necessary. Those who were affected did not oppose the project but expect reasonable compensation. The project needs to negotiate with the affected people regarding compensation.

If the above stated mitigation measures are complied with, the severity of the impacts can be avoided and or minimized.

APPENDICES

APPENDIX 1: TOR

MORAGOLLA HYDROPOWER PROJECT
REVIEW OF FEASIBILITY STUDY AND PREPARATION OF DETAILED DESIGN & BIDDING DOCUMENTS
TERMS OF REFERENCE FOR ADDITIONAL STUDIES IN THE NATURAL ENVIRONMENT
SURVEY OF THE ENVIRONMENTAL FEATURES OF NEW PROJECT SITES

1. BACKGROUND

The Ceylon Electricity Board (CEB) plans to develop a new 30.8 MW hydropower project at Moragolla in Kandy District. The scheme involves construction of a 35 m high concrete gravity dam (with a 5-gate spillway) across the Mahaweli Ganga at Weliganga, to create a 38.5 ha, 1.98 MCM reservoir with a Full Supply Level (FSL) at 548 masl. Water will be diverted through a 3 km underground tunnel, surge shaft and penstock on the left bank of the river, to a powerhouse and outfall located opposite the confluence with the Atabage Oya (see land-use map, Attachment 1).

A Feasibility Study (FS) for the project was conducted in 2009, and this included an Environmental Impact Assessment (EIA)[1], which is expected to be approved by the Mahaweli Authority of Sri Lanka (MASL) in the near future. In 2012 CEB appointed Nippon Koei Co., Ltd. (NK) to review the FS and prepare detailed designs and tender documents for project construction and to upgrade the EIA to comply with the Safeguard Policy[2]of the Asian Development Bank, the principal funding agency.

To upgrade the EIA, surveys were conducted in certain key fields in 2013, to supplement existing baseline data and update the assessment of impacts. Some further study is now needed, so that mitigation measures can be properly planned and designed.

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[1] Ceylon Electricity Board (2012): *Moragolla Hydropower Project, Feasibility Study*. Final Report: Volume 3 Environmental Impact Assessment (Central Engineering Consultancy Bureau, Sri Lanka and Al-Habshi Consultants Office, Kuwait), November 2012.
[2] Asian Development Bank (2009) *Safeguard Policy Statement*.ADB, Manila, 90pp. (http://www.adb.org/site/safeguards/policy-statement).

2. RATIONALE

The EIA report describes the main physical, biological and social features of areas that will be directly affected by the project, assesses the impacts of activities to be conducted at each site, and proposes mitigation for negative impacts. This includes five areas that were under consideration at that time for the disposal of tunnel muck and other excavated spoil. Certain additional sites (for spoil dumping, quarrying and the Contractors' area) have been identified during the FS Review, so the impacts of these activities in these areas now need to be assessed. The surveys described in these ToR will provide baseline data for that assessment.

3. SCOPE OF WORK

1. This work will be conducted by a nationally-recognised environmental consultancy company, with 10 years or more of professional experience in environmental survey, analysis, data interpretation and report preparation, including extensive experience of assessing the physical, biological and social features of terrestrial sites.

2. The field survey work shall be led by three senior experts, who have 15 years or more of research and consultancy experience in Sri Lanka in: a) field geology/topographic studies; b) terrestrial ecology (flora and fauna); and c) rural social studies. Each expert should also have an appropriate record of academic publications in refereed journals.

3. The senior experts and any necessary support staff shall visit each of the areas shown on the attached maps (Attachment 2) and should conduct sufficient qualitative site observations and investigations to enable them to confidently describe the main features and importance of each site in each of these fields. The investigation should include but not be limited to:

Physical: topography, drainage, geology, distance from Mahaweli Ganga and inflowing streams.

Biology: flora, fauna, habitats and their importance, type and number of trees.

Social: location and proximity of any houses, commercial or industrial buildings, other infrastructure, or locations or features of community importance at or near the site or alongside likely access routes.

4. The results of the surveys shall be presented and discussed in a report, which shall be set out as shown in Box 1 below. The text should be divided into each of the main sections indicated (Executive Summary, Introduction, etc) and each section should be

further subdivided as necessary. The text in each section should cover at least the topics shown in the annotations, plus any other topics necessary to provide an informed discussion of the issues.

5. The report should be written in the style of an academic paper and should be concise and informative and written in grammatically correct, good quality English.

6. Significant statements should be substantiated by reference to the relevant literature where appropriate, and all references should be provided in full in the bibliography

7. Readers of the report will be professional persons, but not experts in geology, ecology or social studies, so any technical terms must be explained in footnotes or a glossary.

8. Species should be referred to in the text by their scientific name and common English name; local names may also be shown if species are listed in tables. All names must be spelled correctly whenever they are used.

9. The report should be illustrated by maps, photographs, graphs, tables of data, etc and other forms of presentation as appropriate.

4. PROGRAMME

The work will be conducted over a period of one month in August and September 2013. The draft report will be submitted to NK on or before 13 September 2013: 3 hard copies and 1 soft copy (in a single MS Word file). NK will review the report and provide their comments, which the contractor shall address in full within two weeks of receipt. The contractor shall then submit the final version of the report: 3 hard copies and 1 soft copy (in a single MS Word file).

Box 1: Layout and content of report on the Environmental Features of new sites being considered for spoil disposal, quarrying and other project activities.

EXECUTIVE SUMMARY	Concise summary of the report, key findings and recommendations.
INTRODUCTION	The project; reasons for this study; aims and objectives.
APPROACH	How this work was done. Full written descriptions of: site observations; sample collection and analysis; identification of species, rock samples; etc. With a map of the site locations(with boundaries plotted accurately).
SITE DESCRIPTIONS	A detailed description of each site individually, dealing in each case with: 1. Physical Features; 2. Ecology; and 3. Social Environment. Each section should deal with those aspects specified in Item 3 of the Scope of Work, plus any others that are relevant. Any important or sensitive features should be clearly identified, and the reasons for their importance should be explained. Discussions should be illustrated with photographs of each site and any key features, tables of data, etc.
CONCLUSION	Overall conclusions regarding the characteristics of each site and any important features.
APPENDICES	ToR; tables of all data collected; any other supporting material that is too large to include in the text.

Attachments:

1. Land use map of the area in the vicinity of the proposed Moragolla project (NBRO, 2013).
2. Maps showing the location and boundaries of all potential project sites introduced during the FS Review and Detailed Design, including: quarry; spoil disposal sites; potential Contractor's area; etc.

Appendix II. List of Endemic and Threatened Fauna

GROUP **Family** *Species*	English Name	Sinhala Name	NCS*	Sampling Sites		
				Quarry site	Camp site	Spoil disposal site
MOLUSCS						
Family: Ariophantidae						
*Cryptozonachenui**			NT		+	+
*Euplecta partita**			NT		+	
*Ratnadvipiairradians**						+
Family: Corillidae						
*Corillacolletti**			VU		+	
DRAGONFLIES						
Family - Protoneuridae						
*Elattoneuracentralis**	Dark-glittering Threadtail			+		+
BUTTERFLIES						
Family - Nymphalidae						
Phalanthaalcippe	Small leopard	Punchithith-thambiliya	CR	+		
*Lethe daretis**	Ceylon treebrown	Lanka gas-dumburuwa	EN		+	+
Family - Hesperiidae						
Notocryptacurvifascia	Restricted Demon		VU		+	
AMPHIBIANS						
Family - Nyctibatrachidae						
*Lankanectescorrugatus**	Corrugated water frog	Vakaralimadiya		+		+
Family - Dicroglossidae						
*Fejervaryagreenii**	Sri Lanka paddy firld frog	Lanka velmadiya	EN			+

Appendix II. ctd.

GROUP **Family** *Species*	**English Name**	**Sinhala Name**	**NCS**	**Sampling Sites**		
				Quarry site	**Camp site**	**Spoil Disposal site**
AMPHIBIANS ctd						
Family - Rhacophoridae						
*Psedophilautuspopularis**	Common shrub frog	Sulabapadurumediya			+	
*Psedophilautusrus**	Kandiyan shrub frog	Nuvarapadurumediya	NT		+	
*Polypedatescruciger**	Common hour-glass tree frog	Sulabapahimbu gas madiya			+	
*Polypedateseques**	Mountain tree frog	Kandukaragasmediya	EN		+	
Family - Ranidae						
*Hylarana temporalis**	Common wood frog	Sulababandimadiya	NT		+	
REPTILES						
Family - Gekkonidae						
*Cnemaspisclivicola**	Montain day gecko	Kandukaradivasarihuna			+	
*Cnemaspiskandiana**	Kandyan day gecko	Kandukaradivasarihuna	DD		+	
*Cnemaspissilvula**	Forest day gecko	Vanadivasarihuna			+	
Family - Scincidae						
*Lankascincusfallax**	Common lankaskink	Sulabalakhiraluva			+	+
Family - Colubridae						
Ahaetullanasuta	Green vine snake	Ahaetulla		+	+	
Boigaceylonensis	Sri Lanka cat snake	Nidimapila	VU			+
Lycodonaulicus	Wolf snake, house snake	Aluradanakaya			+	
Ptyas mucosa	Rat snake	Gerandiya				+
Family - Elapidae						
*Bungarusceylonicus** 1	Sri Lanka krait / Ceylon krait	Mudukarawala	NT			+

Appendix II. ctd.

GROUP **Family** *Species*	**English Name**	**Sinhala Name**	**NCS**	**Sampling Sites**		
				Quarry site	**Camp site**	**Spoil Disposal site**
REPTILES ctd						
Family - Viperidae						
Daboia russelii1	Russell's viper	Tithpolonga				+
BIRDS						
Family - Phasianidae						
*Gallus lafayetii**	Sri Lanka Jungle fowl	Sri Lanka Wali-kukula			+	
Family - Picidae						
Chrysocolapteslucidus‡	Greater Flameback	LepitaMaha-karela	NT		+	+
Family - Ramphastidae						
*Megalaimaflavifrons**	Sri Lanka Yellow-fronted Barbet	Sri Lanka RanmhunathaKottoruwa			+	
Megalaimarubricapilla‡	Crimson-fronted Barbet	RathmhunathKottoruwa			+	
Family - Psittacidae						
*Loriculusberyllinus**	Sri Lanka Hanging Parakeet	Sri Lanka Giramaliththa			+	+
*Psittaculacalthropae**	Sri Lanka Layard's Parakeet	Sri Lanka AluGirawa	NT		+	
*Graculaptilogenys**	Sri Lanka Myna	Sri Lanka Salalihiniya	VU		+	
MAMMALS						
Family - Soricidae						
*Suncuszeylanicus**	Sri Lanka jungle shrew	Sri Lanka KeleHik-miya	EN		+	
Family - Cercopithecidae						
*Macacasinica**	Sri Lanka toque monkey	Sri Lanka Rilawa	NT		+	
Family - Sciuridae						
Ratufamacroura	Giant squirrel	Dandu-leena	VU		+	

Appendix III. Fauna recorded from tree sampling sites

GROUP Family *Scientific Name*	English Name	Sinhala Name	NCS*	Sampling Sites Quarry site	 Camp site	 Spoil Disposal site
MOLUSCS						
Family: Ariophantidae						
Cryptozonabistrialis					+	+
*Cryptozonachenui**			NT		+	+
*Euplecta partita**			NT		+	
Euplectatravancoricii					+	+
*Ratnadvipiairradians**						+
Family: Achatinidae						
Achatinafulica						+
Family: Corillidae						
*Corillacolletti**			VU		+	
Family: Veronicellidae						
Laevicaulisalte						+
DRAGONFLIES						
Family - Coenagrionidae						
Onychargiaatrocyana	Marsh Dancer			+	+	+
Family - Protoneuridae						
*Elattoneuracentralis**	Dark-glittering Threadtail			+		+
Family - Libellulidae						
Orthetrumglaucum	Asian Skimmer			+	+	+
Orthetrumluzonicum	Marsh Skimmer			+		+
Orthetrumpruinosum	Pink Skimmer			+		+
Orthetrumsabina	Green Skimmer			+		+
Crocothemisservilia	Oriental Scarlet			+	+	+
Neurothemistullia	Pied Parasol			+	+	

Appendix III ctd.

GROUP Family *Scientific Name*	English Name	Sinhala Name	NCS*	Sampling Sites Quarry site	 Camp site	 Spoil Disposal site
Family - Libellulidaectd						
Trithemisfestiva	Indigo Dropwing			+	+	
Trithemispallidinervis	Dancing Dropwing			+	+	+
BUTTERFLIES						
Family - Papilionidae						
Pachlioptaaristolochiae	Common rose	Podurosapapilia			+	+
Papiliopolytes	Common mormon	Kalupapilia		+		
Papiliopolymnestor	Blue mormon	Mahanilaya		+	+	+
Graphiumagamemnon	Green jay / Tailed jay	Kola papilia				
Family - Pieridae						
Leptosianina	Psyche	Kalu-thithsudda		+		
Delias eucharis	Jezebel	PoduMaha-sudda				+
Ceporanerissa	Common gull	PoduPunduru-sudana		+		
Euremahecabe	Common grass yellow	Mahakahakolaya		+		
Family - Nymphalidae						
Paranticaaglea	Glassy tiger	Suduwan nil-kotithiya		+		+
Euploea core	Common crow	Podu kaka-kotithiyaya				+
Phalanthaalcippe	Small leopard	Punchithith-thambiliya	CR	+		
Junoniaiphita	Chocolate soldier	Podualankarikya			+	
Neptishylas	Common sailor	Gomaraselaruwa		+	+	
Acraeaviolae	Tawny costor	Thambilypanduru- boraluwa			+	
*Lethe daretis**	Ceylon treebrown	Lanka gas-dumburuwa	EN		+	+
Orsotriaenamedus	Medus Brown /Nigger	Maha-iripanduru-dumburuwa		+	+	+
Mycalesisperseus	Common bushbrown	Podupanduru-dumburuwa			+	+
Ypthimaceylonica	White four-ring	Poduheen-dumburuwa		+	+	+

Appendix III ctd.

GROUP **Family** *Scientific Name*	**English Name**	**Sinhala Name**	**NCS***	**Sampling Sites** **Quarry site**	 **Camp site**	 **Spoil Disposal site**
Family - Lycaenidae						
Castaliusrosimon	Common Pierrot	Podu Mal-nilaya		+	+	+
Family - Hesperiidae						
Notocryptacurvifascia	Restricted Demon		VU		+	
Oriensgoloides	Common Dartlet			+		
AMPHIBIANS						
Family - Bufonidae						
Duttaphrynusmelanostictus	Common house toad	Sulabageaigemba				+
Family - Nyctibatrachidae						
*Lankanectescorrugatus**	Corrugated water frog	Vakaralimadiya		+		+
Family - Dicroglossidae						
*Fejervaryagreenii**	Sri Lanka paddy firld frog	Lanka velmadiya	EN			+
Fejervaryalimnocharis	Common paddy field frog	Sulabavelmadiya		+		+
Family - Rhacophoridae						
*Psedophilautuspopularis**	Common shrub frog	Sulabapadurumediya			+	
*Psedophilautusrus**	Kandiyan shrub frog	Nuvarapadurumediya	NT		+	
*Polypedatescruciger**	Common hour-glass tree frog	Sulabapahimbu gas madiya			+	
*Polypedateseques**	Mountain tree frog	Kandukaragasmediya	EN		+	
Family - Ranidae						
*Hylarana temporalis**	Common wood frog	Sulababandimadiya	NT		+	

Appendix III ctd.

GROUP **Family** *Scientific Name*	**English Name**	**Sinhala Name**	**NCS***	**Sampling Sites**		
				Quarry site	**Camp site**	**Spoil Disposal site**
REPTILES						
Family - Agamidae						
Calotescalotes	Green garden lizard	Pala katussa		+	+	+
Calotesversicolor	Common garden lizard	Garakatussa		+	+	+
Family - Gekkonidae						
*Cnemaspisclivicola**	Montain day gecko	Kandukaradivasarihuna			+	
*Cnemaspiskandiana**	Kandyan day gecko	Kandukaradivasarihuna	DD		+	
*Cnemaspissilvula**	Forest day gecko	Vanadivasarihuna			+	
Family - Scincidae						
Eutropiscarinata	Common skink	Sulabahikanala		+	+	+
*Lankascincusfallax**	Common lankaskink	Sulabalakhiraluva			+	+
Family - Varanidae						
Varanussalvator	Water monitor	Kabaragoya				+
Family - Colubridae						
Ahaetullanasuta	Green vine snake	Ahaetulla		+	+	
Boigaceylonensis	Sri Lanka cat snake	Nidimapila	VU			+
Lycodonaulicus	Wolf snake, house snake	Aluradanakaya			+	
Ptyas mucosa	Rat snake	Gerandiya				+
Family - Elapidae						
*Bungarusceylonicus** 1	Sri Lanka krait / Ceylon krait	Mudukarawala	NT			+
*Najanaja*1	Indian cobra	Naya				+
Family - Viperidae						
Daboia russelii1	Russell's viper	Tithpolonga				+

[1]Information received from villagers

Appendix III ctd.

GROUP **Family** **Scientific Name**	**English Name**	**Sinhala Name**	**NCS***	**Sampling Sites** **Quarry site**	**Camp site**	**Spoil Disposal site**
BIRDS						
Family - Phasianidae						
*Gallus lafayetii**	Sri Lanka Junglefowl	Sri Lanka Wali-kukula			+	
Family - Picidae						
Chrysocolapteslucidus‡	Greater Flameback	LepitaMaha-karela	NT		+	+
Family - Ramphastidae						
Megalaimazeylanica	Brown-headed Barbet	PolosKottoruwa			+	+
*Megalaimaflavifrons**	Sri Lanka Yellow-fronted Barbet	Sri Lanka RanmhunathaKottoruwa			+	
Megalaimarubricapilla‡	Crimson-fronted Barbet	RathmhunathKottoruwa			+	
Family - Alcedinidae						
Alcedoatthis	Common Kingfisher	Mal Pilihuduwa			+	+
Pelargopsiscapensis	Stork-billed Kingfisher	ManathuduMadi-pilihuduwa			+	
Halcyon smyrnensis	White-throated Kingfisher	LayasuduMadi-pilihuduwa			+	+
Family - Cuculidae						
Eudynamysscolopacea	Asian Koel	Kowula				+
Centropussinensis	Greater Coucal	Ati-kukula			+	+
Family - Psittacidae						
*Loriculusberyllinus**	Sri Lanka Hanging Parakeet	Sri Lanka Giramaliththa			+	+
Psittaculacyanocephala	Plum-headed Parakeet	PanduGirawa			+	
*Psittaculacalthropae**	Sri Lanka Layard's Parakeet	Sri Lanka AluGirawa	NT		+	
Family - Apodidae						
Cypsiurusbalasiensis	Asian Palm Swift	AsiaaThal-thurithaya				+
Family - Strigidae						
Ketupazeylonensis	Brown Fish Owl	Bora Kewul-bakamoona			+	

Appendix III ctd.

GROUP **Family** *Scientific Name*	**English Name**	**Sinhala Name**	**NCS***	**Sampling Sites** **Quarry site**	 **Camp site**	 **Spoil Disposal site**
BIRDS Ctd						
Family - Columbidae						
Streptopeliachinensis	Spotted Dove	AluKobeiyya		+	+	+
Chalcophapsindica	Emerald Dove	Neela-Kobeiyya			+	
Family - Rallidae						
Amaurornisphoenicurus	White-breasted Waterhen	Laya-suduKorawakka				+
Family - Accipitridae						
Spilornischeela	Crested Serpent Eagle	SiluSarapakussa			+	
Family - Ardeidae						
Ardeolagrayii	Indian Pond Heron	Kana-koka				+
Family - Chloropseidae						
Chloropsisjerdoni	Blue-winged Leafbird	NilpiyaKolarisiya			+	
Family - Oriolidae						
Orioluschinensis	Black-naped Oriole	Kalu-gelasiKahakurulla			+	+
Family - Dicruidae						
Dicruruscaerulescens	White-bellied Drongo	Kawuda			+	+
Family - Corvidae						
Corvuslevaillantii	Large-billed Crow	KaluKaputa				+
Family - Campephagidae						
Pericrocotuscinnamomeus	Small Minivet	PunchiMiniviththa			+	
Family - Muscicapidae						
Copsychussaularis	Oriental Magpie Robin	Polkichcha				+

Appendix III ctd.

GROUP **Family** *Scientific Name*	**English Name**	**Sinhala Name**	**NCS***	**Sampling Sites**		
				Quarry site	**Camp site**	**Spoil Disposal site**
BIRDS Ctd						
Family - Sturnidae						
Acridotherestristis	Common Myna	Mayna			+	+
*Graculaptilogenys**	Sri Lanka Myna	Sri Lanka Salalihiniya	VU		+	
Family - Pycnonotidae						
Pycnonotuscafer	Red-vented Bulbul	Kondaya		+	+	+
Family - Cisticolidae						
Priniasocialis	Ashy Prinia	AluPriniya		+		
Family - Dicaeidae						
Dicaeum agile	Thick-billed Flowerpecker	MathuduPililichcha		+		
Family - Nectariniidae						
Nectarinazeylonica	Purple-rumped Sunbird	Nithamba Dam Sutikka			+	+
MAMMALS						
Family - Soricidae						
*Suncuszeylanicus**	Sri Lanka jungle shrew	Sri Lanka KeleHik-miya	EN		+	
Family - Cercopithecidae						
*Macacasinica**	Sri Lanka toque monkey	Sri Lanka Rilawa	NT		+	
Family - Herpestidae						
Herpestesbrachyurus	Brown mongoose	Bora Mugatiya		+	+	+
Family - Viverridae						
Viverriculaindica	Ring-tailed civet	Urulewa			+	+

Appendix III ctd.

GROUP **Family** *Scientific Name*	**English Name**	**Sinhala Name**	**NCS***	**Sampling Sites** **Quarry site**	 **Camp site**	 **Spoil Disposal site**
MAMMALS ctd						
Family - Cervidae						
*Muntiacus muntjak*1	Barking deer	OluMuwa / WeliMuwa		+	+	
Family - Suidae						
Susscrofa	Wild boar	WalUra		+	+	+
Family - Hystricidae						
Hystrixindica	Porcupine	Ittewa		+	+	+
Family - Muridae						
Bandicotaindica	Malabar bandicoot	Uru-miya				+
Family - Sciuridae						
Funambuluspalmarum	Palm squirrel	Leena		+	+	+
Ratufamacroura	Giant squirrel	Dandu-leena	VU		+	
Family - Leporidae						
Lepusnigricollis	Black-naped hare	WalHawa		+	+	

*NCS – National Conservation Status

Appendix IV Summary of the fauna recorded and their conservation status

Animal group	Families	No. of Species		Conservation status of the species recorded			
		Total	Endemics	CR	EN	VU	NT
Invertebrates							
Land Molluscs	4	8	4	-	-	1	2
Dragonflies	3	10	1	-	-	-	-
Butterflies	5	21	1	1	1	1	-
Vertebrates							
Amphibians	5	9	7	-	2	-	2
Reptiles	7	1	5	-	-	1	1
Birds	23	32	5	-	-	1	2
Mammals	10	11	2	-	1	1	1
Total	**57**	**106**	**25+2**	**1**	**4**	**5**	**8**

*Conservation status follows National Redlist 2012

CR- Critically endangered

EN-Endangered Threatened

VU-Vulnerable

NT – Near Threatened

‡Proposed endemic

Appendix V List of recorded flora from three sites

Family	Species	Common name	Life form	Quarry site	Camp site	Dump site
Acanthaceae	*Justiciabetonica*	Sudupuruk	Herb	+	+	+
Aeaceae	*Pothosscandens*	Potawel	Liana	-	+	+
Anacardiaceae	*Mangiferaindica*	Amba	Tree	+	+	+
Apiaceae	*Centellaasiatica*	Gotukola	Herb	+	+	+
Apocynaceae	*Alstoniascholaris*	Rukattana	Tree	+	+	+
Araceae	*Cocosnucifera*	Pol	Tree	-	-	+
Arecaceae	*Areca catechu*	Puwak	Tree	-	-	+
Aristolochiaceae	*Aristolochiaringens*	Tara mal	Liana	+	+	-
Astaraceae	*Centratherumpunctatum*		Herb	+	+	-
Astaraceae	*Vernoniazeylanica**		Shrub	+	-	-
Astaraceae	*Tageteserecta*	Daspethiya	Herb	-	-	+
Asteraceae	*Ageratum conyzoides*	Hulantala	Herb	+	+	+
Asteraceae	*Eupatorium odoratum*	Podisinno	Shrub	+	-	+
Asteraceae	*Mikeniacordata*	Gahalawel	Liana	+	+	+
Asteraceae	*Tithoniadiversifolia*	Walsuriyacantha	Shrub	+	+	+
Bignoniaceae	*Tecomastans*	Kelanitissa	Small tree	-	+	+
Caesalpiniaceae	*Sennaspectabilis*	Kahakoona	Tree	-	+	+
Combretaceae	*Terminaliacatappa*	Kottamba	Tree	+	-	-
Euphorbiaceae	*Brideliaretusa*	Ketakela	Tree	+	+	+
Euphorbiaceae	*Heveabrasiliensis*	Rubber	Tree	-	-	+
Euphorbiaceae	*Macarangapeltata*	Kenda	Tree	+	+	+
Euphorbiaceae	*Mellotustetracoccus*	Bu kenda	Tree	+	+	+
Fabaceae	*Acacia mangium*		Tree	+	+	+
Fabaceae	*Albiziamoluccana*	Mara	Tree	+	+	+

*endemic species

Appendix V ctd.

Family	Species	Common name	Life form	Quarry site	Camp site	Dump site
Fabaceae	*Centrosemapubescens*		Liana	-	-	+
Fabaceae	*Crotalaria micans*		Herb	+	-	-
Fabaceae	*Crotalaria retusa*	Kahaandanahiriya	Shrub	+	-	+
Fabaceae	*Desmodiumtriflorum*	Udupiyaliya	Herb	+	+	+
Fabaceae	*Mimosa pudica*	Nidikumba	Herb	+	+	+
Fabaceae	*Pongamiapinnata*	Karanda	Tree	+	+	+
Fabaceae	*Sesbaniagrandiflora*	Kathurumurunga	Small tree	+	-	+
Fabaceae	*Delonixregia*	Mai mara	Tree	+	+	-
Flacourtiaceae	*Hydnocarpusvenenata*	Makulu	Tree	-	+	-
Gleicheniaceae	*Dicranopterislinearis*	Kakilla	Herb	+	+	-
Graminaea	*Bambusaventricosa*	Una	Tree	-	+	-
Lauraceae	*Neolitsea cassia*	Kududawla	Tree	+	+	+
Lauraceae	*Persia americana*	Alipera	Tree	-	+	+
Lecythidaceae	*Careyaarborea*	Kahata	Tree	+	+	+
Leeaceae	*Leeaindica*	Burulla	Small tree	+	+	+
Leguminosea	*Albizialebbeck*	Hurimara	Tree	+	+	+
Leguminosea	*Gliricidiasepium*	Vetahira	Small Tree	+	+	+
Liliaceae	*Gloriosasuperba*	Niyagala	Liana	+	+	-
Lobeliaceae	*Laurentialongiflora*		Herb	+	+	+
Magnoliaceae	*Micheliachampaca*	Ginisapu	Tree	+	+	+
Malvaceae	*Hibiscus rosasinensis*	Wada mal	Shrub	-	-	+
Malvaceae	*Malvaviscuspenduliflorus*		Shrub	-	+	+
Malvaceae	*Sidarhombifolia*		Herb	+	+	+
Malvaceae	*Urenalobata*	Pattaepala	Herb	+	+	+

Appendix V ctd.

Family	Species	Common name	Life form	Quarry site	Camp site	Dump site
Melastomataceae	*Clidemiahirta*	Katakalubovitiya	Shrub	+	+	+
Melastomataceae	*Osbeckiaoctandra**	Heenbowitiya	Shrub	+	+	+
Meliaceae	*Meliaazedarach*	Lunumidella	Tree	-	-	+
Meliaceae	*Swieteniamacrophylla*	Mahogani	Tree	+	+	+
Meliaceae	*Toonaciliata*	Tuna	Tree	-	+	+
Menispermaceae	*Cycleapeltata*	Kehipiththan	Liana	+	+	-
Mimosaceae	*Calliandracalothyrsus*		Small tree	+	+	+
Mimosaceae	*Mimosa invisa*		Liana	-	+	+
Moraceae	*Artocarpusheteropyllus*	Kos	Tree	+	+	+
Moraceae	*Artocarpusindicus*	Del	Tree	-	-	+
Moraceae	*Artocarpusnobilis**	Waldel	Tree	-	+	+
Moraceae	*Ficusexasperata*	Budeliya	Tree	+	+	+
Moraceae	*Ficushispida*	Kotadimbula	Small tree	+	+	+
Moraceae	*Ficusreligosa*	Bo	Tree	+	+	-
Musaceae	*Musa paradisiaca*	Kehel	Shrub	-	-	+
Myrtaceae	*Psidiumguajava*	Pera	Small tree	+	+	+
Myrtaceae	*Psidiumlittorale*	Cheenapera	Small Tree	+	+	-
Myrtaceae	*Syzygiumaromaticum*	Karabu	Tree	-	-	+
Myrtaceae	*Syzygiumsp*		Tree	-	+	-
Oxalidaceae	*Oxalis berrelieri*		Herb	+	+	-
Palmae	*Caryotaurens*	Kitul	Tree	+	+	+
Pandanaceae	*Pandanusamaeyllifolius*	Rampe	Shrub	-	-	+
Passifloraceae	*Passifloraedulis*	Passion fruit	Liana	-	-	+
Phyllanthaceae	*Phyllanthusamarus*	Pitawakka	Herb	+	-	-

Appendix V ctd.

Family	Species	Common name	Life form	Quarry site	Camp site	Dump site
Phytolaccaceae	*Rivinahumilis*		Herb	+	-	+
Piperaceae	*Piper nigrum*	Gammiris	Liana	-	-	+
Poaceae	*Cymbopogoncitratus*	Sera	Grass	+	-	-
Poaceae	*Cymbopogonnardus*	Pengirimana	Grass	+	-	-
Poaceae	*Heteropogoncontortus*	E thana	Grass	+	-	+
Poaceae	*Panicum maximum*	Rata tana	Grass	+	-	+
Polygonaceae	*Persicariacapitata*		Herb	+	+	-
Polygonaceae	*Persicariachinensis*		Herb	+	+	-
Proteaceae	*Grevillearobusta*	Sabukku	Tree	+	+	-
Rubiaceae	*Coffeaarabica*	Kopi	Small tree	-	+	+
Rubiaceae	*Mitracarpushirtus*		Herb	+	+	-
Rubiaceae	*Mussaendafrondosa*	Welbuthsarana	Shrub	+	+	+
Rubiaceae	*Wendlandiabicuspidate**	Wanaidala	Tree	+	+	-
Rutaceae	*Cirtusgrandis*	Jambola	Tree	-	-	+
Rutaceae	*Thodaliaasiatica*	Kudu miris	Liana	+	+	+
Sapindaceae	*Filiciumdecipiens*	Pihimbiya	Tree	+	+	+
Sapotaceae	*pouteriacampechiana*	Rata lawulu	Tree	-	-	+
Solanaceae	*Solanumviolaceum*	Tibbtu	Shrub	-	-	+
Sterculiaceae	*Petrospermumsuberifolium*	Welan	Tree	+	+	+
Sterculiaceae	*Theobroma cacao*	Coco	Small tree	-	-	+
Symplocaceae	*Symplocoscochinchinensis*	Bomu	Small tree	+	+	+
Theaceae	*Camellia sinensis*	Te	Shrub	+	-	+
Theaceae	*Camellia sinensis*	Tea	Shrub	-	+	+
Tiliaceae	*Grewiadamine*	Daminiya	Tree	+	+	+

Appendix V ctd.

Family	Species	Common name	Life form	Quarry site	Camp site	Dump site
Tiliaceae	*Muntingiacalabura*	Jam	Small tree	-	+	+
Ulmaceae	*Tremaorientalis*	Gadumba	Tree	+	+	+
Urticaceae	*Laporteainterrupta*	Hahabiliya	Herb	+	-	+
Verbenaceae	*Clerodendrumserratum*	Kanhenda	Shrub	-	+	-
Verbenaceae	*Durantarepens*		Shrub	-	+	+
Verbenaceae	*Lantana camara*	Gandapana	Shrub	+	+	+
Verbenaceae	*Lantana trifolia*		Shrub	+	-	-
Verbenaceae	*Stachytarphetaurticaefolia*	Balunakuta	Herb	+	+	+
Verbenaceae	*Vitexaltissima*	Milla	Tree	+	+	+

Appendix VI Summary of the flora recorded and Their conservation status

Sites	Family	Species	Life form categories					
			Tree	Small tree	Shrub	Herb	Liana	Grass
Quarry site	42	72	26	8	10	19	5	4
Camp site	41	73	32	10	9	15	7	1
Spoil Dump site	42	80	33	11	15	12	7	2

<u>Note:</u>

Total number of plants recorded: 105 plant species

Total number of endemics recorded: Four (04)

Appendix VII Summary of ecological status of the flora recorded from the three sites

Site	Family	Species	Ecological Status				
			Native	Endemic	Cultivated	Introduced	Ornamental
Quarry site	42	72	64	3	-	5	-
Camp Site	41	73	60	3	2	6	2
Spoil dump site	42	80	59	2	9	6	4

Appendix VIII Number of trees to be removed from all three sites

Family	Species	Common name	No. of trees to be removed: Quarry site	Camp site	Spoil dump site
Anacardiaceae	*Mangifer aindica*	Amba	-	1	1
Anacardiaceae	*Anacardium occidentale*	Kaju	-	-	1
Anacardiaceae	*Spndias mombin*	Ambalanga	1	-	-
Apocynaceae	*Alstonia macrophylla*	Hawarinuga	-	25	1
Apocynaceae	*Alstonia scholaris*	Rukattana	1	-	-
Bigoniaceae	*Spathodea campanulata*	Spathodia	-	4	5
Combretaceae	*Terminalia catappa*	Bulu	-	8	-
Combretaceae	*Terminalia arjuna*	Kumbuk	-	3	-
Euphorbiaceae	*Mallotus tetracoccus*	Bukenda	-	4	3
Euphorbiaceae	*Macaranga peltata*	Kanda	2	74	59
Euphorbiaceae	*Hevea brasiliensis*	Rubber	-	-	2
Euphorbiaceae	*Homalanthus populifolius*	Ginikanda	1	-	-
Euphorbiaceae	*Bridelia retusa*	Ketakala	1	-	-
Fabaceae	*Albizia falcataria*	Albezia	10	28	2
Fabaceae	*Erythrina sabumbrans*	Eramudu	-	-	*3*
Fabaceae	*Gliricidia sepium*	Ginisiriya	-	4	28
Fabaceae	*Acacia mangium*	Accasia	36	15	-
Fabaceae	*Albizia lebbeck*	Hurimara	-	1	-
Fabaceae	*Delonix regia*	Mi Mara	10	9	-
Lauraceae	*Persea americana*	Alipera	-	-	5
Lauraceae	*Neolitsea cassia*	Kududawula	-	-	2
Lauraceae	*Cinnamomum capparu*	Kurundu	-	-	2
Lecythidaceae	*Careya arborea*	Kahata	7	-	
Magnoliaceae	*Michelia champaca*	Sapu	-	-	2
Magnoliaceae	*Michelia champaca*	Sapu	-	2	
Meliaceae	*Swietenia mahagoni*	Mahogany	-	-	27
Moraceae	*Ficus asperrima*	Budaliya	-	1	6
Moraceae	*Artocarpus nobilis*	Del	-	-	1
Moraceae	*Artocarpus heterophyllus*	Kos	-	-	*2*
Moraceae	*Artocarpus nobilis*	Waldel	-	2	-
Moraceae	*Ficus religiosa*	Bo	1	-	-
Moraceae	*Ficus benghalensis*	Nuga	1	-	-
Sapindaceae	*Filicium decipiens*	Pihimbiya	-	-	1
Sterculiaceae	*Petrospermum suberifolium*	Welan	-	1	-
Tiliaceae	*Grewia damine*	Damanu	-	-	3
Tiliaceae	*Grewia damine*	Daminiya	-	3	-
Ulmaceae	*Trema orientalis*	Gadumba	-	-	5
Verbenaceae	*Vitex altissima*	Milla	-	2	-
TOTAL			71	187	161

Note: Total number of trees to be removed: 419

MORAGOLLA HYDROPOWER PROJECT

ADDITIONAL STUDIES IN THE NATURAL ENVIRONMENT

REPORT ON RIVER USERS DOWNSTREAM OF THE PROPOSED MORAGOLLA DAM

OCTOBER 2013

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ABBREVIATIONS

CEB	Ceylon Electricity Board
NWS & DB	National Water Supply and Drainage Board
WMS	Water Management Secretariat
FS	Feasibility Study
MASL	Mahaweli Authority of Sri Lanka
EIA	Environmental Impact Assessment
TOR	Terms of Reference
GN	Grama Niladhari

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INTRODUCTION

1. BACKGROUND

The Ceylon Electricity Board (CEB) plans to develop a new 30.8 MW hydropower project at Moragolla in Kandy District. The project involves construction of a 35 m high concrete gravity dam (with a 5-gate spillway) across the Mahaweli River at Weliganga, to construct a 38.5 ha, 1.98 MCM reservoir with a Full Supply Level (FSL) at 548 msl. Water will be diverted through a 3 km underground tunnel, surge shaft and penstock on the left bank of the river, to a powerhouse and the outfall is located opposite the confluence with the Atabage Oya (see land-use map, Attachment 1).

A Feasibility Study (FS) of the project was conducted in 2009, and this included an Environmental Impact Assessment (EIA), which has been approved by the Mahaweli Authority of Sri Lanka (MASL) in the near future. In 2012 CEB appointed Nippon Koei Co., Ltd. (NK) to review the FS and prepare detailed designs and tender documents for project construction; and to upgrade the EIA to comply with the Safeguard Policy of the Asian Development Bank, the principal funding agency.

To upgrade the EIA, surveys were conducted in certain key fields in 2013, to supplement existing baseline data and update the assessment of impacts. A further study is now needed, so that mitigation measures can be properly planned and designed.

2. OBJECTIVES

The EIA report examined human uses of the river in the immediate project area (between the predicted upstream end of the reservoir and the tailrace outfall) and identified the locations used for washing and bathing, sand mining, one water extraction and discharge point (Crysbro Poultry Processing) and the intake of the Dunhinda irrigation canal. The locations of these activities are shown on the attached land-use map, produced following a detailed field analysis by the National Building Research Organisation (NBRO) in March - July 2013. A further survey of river users between the tailrace outfall and Gampolla Bridge was conducted in 2013 as part of a socio-economic study.

CEB is committed to mitigate all negative impacts of the project including impacts on the river users whose socio-economic activities are affected by the project and compensating them via a favourable Resettlement Policy to be spelt out in the Resettlement Action Plan (RAP) , currently under preparation. CEB will also take measures to ensure the safety of downstream river users who might be prone to risk due to fluctuations of the water level once the project starts operation. The additional survey, in keeping with the TOR, examined the users of the river in the downstream between the bridges at Gampola and the Peradeniya, to identify the numbers of people involved in each activity. The results of the additional survey were analyzed together with the findings of the original survey, so that appropriate measures can be designed and established to secure the safety of river users. An early warning system will be installed for the benefit of the river users of the downstream. Similar system has been installed in the already commissioned Upper Kotmale Hydropower Project.

3. METHODOLOGY AND APPROACH

The field surveys were led by a senior social studies expert, with more than 15 years of practical experience in design, implementation and analysis of data from social surveys. All members of the survey team possess previous experience of conducting field surveys.

- The survey covered the Mahaweli Ganga from Gampolla Bridge to Peradeniya Bridge, a stretch of 13 km approximately.

- The aim of the survey was to a) identify all users of the river along the surveyed stretch and the number of people involved in each activity; and b) geo-reference the location of each activity via GPS recorder and plot the locations accurately on a map.

- Information was obtained by a combination of: a) direct observation; b) interviews with river users and local communities; and c) collecting official data and information from Grama Niladharies and other local level government offices (eg sand mining licences, locations of irrigation scheme off-takes and users, industrial facilities, etc)

- Survey team travelled along both riverbanks over a period of two weeks, observing the river uses and their locations, visiting each area at different times on different days to ensure all users were recorded. Survey team interviewed people engaged in each activity to collect data on the numbers of people involved and their identity, and obtain information on other locations and different river users.
- Interviews properly structured, with answers entered into a data recording sheet (attached as an appendix).

- Results of the survey were analysed and compiled, together with the findings of the original survey so that it will facilitate designing a Resettlement Policy and an Entitlement Policy to be implemented by the project.

4. THE ADDITIONAL STUDIES IN THE NATURAL ENVIRONMENT- SURVEY ON THE DOWNSTREAM RIVER USES

The census survey which has already been completed (original survey) had studied the socio-economic impacts of five kilo metre (05km) stretch of the downstream of the proposed dam and the data collected at the survey has already been compiled. Therefore, this report will focus on the additional survey carried out in respect of river stretch up to the bridge at Peradeniya.

4.1 Impacts on Economic Activities

4.1.1 Sand Mining

The major economic activity along the 13 km stretch of the downstream of the river is sand mining. In the survey, twenty one (21) sand mining locations have been identified. According to the survey, the number of people engaged in sand mining is 83. In most cases sand mining is not a regular activity. There are only eleven (11) permit holders (permits are issued by respective Divisional Secretaries) who have gained the right to do sand mining along the river. Permits are given to extract sand only for 3 days per week. Majority are illicit miners. Some of the permit holders have abandoned extraction of sand.

Average volume of sand extracted by a sand mining labourer has been estimated as **1.42m^3** per day. The market price of one meter cube (**m^3**) of sand at mining location is Rs. **1060/=**

4.1.1.1 Impacts on the Sand Mining

It is observed that no negative impact will be caused to sand mining due to the proposed dam. There will be continuous environmental flow of 1.5 m3/s of water in the downstream. Also, water released after generation of power will accumulate in the downstream of the river. Besides, water carried by Atabage Oya, Nillambe Oya , Geli Oya and some other fairly large streams (See flow chat in appendix), is a major feeding source of the Mahaweli River in the downstream of the proposed Dam. There are also 19 streams flowing in to the Mahaweli River in the river stretch between the Atabage Oya and the bridge at Peradeniya. The sediments brought by these streams (See flow chat in appendix) into the downstream of the proposed dam quite substantial and thus formation of sand in this stretch is sufficient to carryout sand mining without disruptions. The Table-1 provides details of sand mining in the additional study area.

The Moragolla reservoir is not a storage type and hence according to the technical literature “Trap Efficiency Curves” by Brune and Churchill given in small dams, this reservoir is capable to retain 40% of sediment coming from the upstream due to its operation nature. Therefore, 60% of sediment from upstream of the dam and sediments from 19 streams confluence with Mahaweli River is available to downstream sand miners. Therefore, it is clear that the sand miners in the downstream to the Moragolla outfall will not be impacted significantly.

However, the project has taken measures to mitigate impact to sand mining livelihood within certain distance from the dam (3km upstream and 8km downstream) by providing assistance to acquire alternative sources of income opted by the affected sand miners. Furthermore, a payment of cash compensation will be made to them for loss of income for the period from the date on which sand mining will be disturbed and start of the new source of income.

TABLE 1 - DOWN STREAM RIVER USERS SURVEY - SAND MINING

Item No.	Location ID	Name of Mining Place	Name of Sand miner	Sand mine Labours	Volume Extracted per Day (Cubes)	Frequency of Mining days (Per Week)	Net Income per working Day (Rs)	Remarks
01	S1	Atuwewatta	M.T. M. Naleeze	3	1.50	3	4,500.00	-
02	S2	Ihalawela 2	M.T. M. Naleeze	4	2.00	3	6,000.00	-
03	S3	KapukotuwaThotupala	M.G. Dulip Kumara	5	3.50	3	10,500.00	-
04	S5	Iskolawatta	U.G. G. Manike	2	1.00	3	3,000.00	-
05	S6	Ganthotapitiya	D.K. Senevirathna	3	1.50	3	4,500.00	-
06	S7	Wellathota	M.P.C. Jayasundara	3	1.50	3	4,500.00	-
07	S8	Kotta Gas Handiya	AjithPadmasiri	4	3.00	3	9,000.00	-
08	S9	Walawwawatta	D. W. Gunathilake	2	0.75	3	2,250.00	-
09	S10	Hindagala 1	UpulChandralal	2	1.00	3	3,000.00	-
10	S11	Hindagala 2	UpulChandralal	3	1.00	3	3,000.00	-
11	S12	Kandy South Intake (NWS & DB)	H.M.A. Rathnayake	5	5.50	3	16,500.00	-
12	S13	Kurunduwatta	S.L.R.A. Senevirathna	3	2.00	3	6,000.00	-
13	S14	PahingamaThotupala 1	P.G. Jayarathna	2	1.25	3	3,750.00	-
14	S15	PahingamaThotupala 2	P.G. Jayarathna	0	-	0	-	*Currently Abundant*
15	S16	PahingamaThotupala 3	K. Nawarathna	2	1.00	3	3,000.00	-
16	S17	PahingamaThotupala 4	Hemalatha	2	0.50	3	1,500.00	-
17	S18	No.8 Thotupala	M.L.M. Haneefa	2	1.50	3	4,500.00	-
18	S19	KottunnaThotupala	O.L.M. Azam	2	1.00	3	3,000.00	-
19	S20	Wali-UllahPallithota	M. Irfam	3	1.25	3	3,750.00	-
20	S21	Pussathota	D. Dehideniya	2	1.00	3	3,000.00	-
21	S22	Pussangolla	P.D.A.B. Gunarathne	4	2.00	3	6,000.00	-
22	S23	ParuThota	K.G. Sriyani	5	3.50	3	10,500.00	-

Some scenes of sand mining activities in downstream

Atuwewatta (Location S1)

Atuwewatta (Location S1)

Ihalawela (Location S2)

Ihalawela (Location S2)

Kapukotuwa (Location S3)

Paruthota (Location S23)

4.1.2 Fishing

No commercial fishing has been observed in the downstream of the river up to the bridge at Peradeniy. Fishing for household consumption is also not very significant in this particular stretch of the river. Occasional fishing by a very few individuals has been observed. Even such isolated fishing will not be affected as depletion of fish will not be resulted due to lack of water in the downstream as large volumes of water are carried by 19 streams. The method of fishing is by using fishing rods. Fishing is not very popular as it takes long hours to catch a few fish. Therefore, people who are busy with other important work do not consider fishing as a profitable activity. A few species of fish such as Kaha Korali (*Orange Chromide*), Mal Korali (*Perl Spot*) Wala Poththa (*Butter Catfish*) are the most common fish caught by those go fishing in their leisure times.

4.1.3 Irrigation – Dunhinda Cana l(This has been already included in the original study)

Dunhinda irrigation canal which feeds about 200 acres of paddy lands is located one kilo metre (01 km) downstream of the proposed dam and irrigational water requirement is 0.28 m^3/s. The project management has consulted the farmers of three Farmer Organizations, namely, Mangalaketha, Maligapurana and Vewa and assured that this irrigation system will be improved by renovating already damaged canal at several places. Also, action will be taken to construct a weir at the present intake to make sure that no shortage of water will occur for irrigation.
Apart from Dunhinda irrigation scheme, utilization of river water for irrigation purposes along the stretch subjected to the additional study has not been observed.

A scene of the Dunhinda Canal

4.1.4 Business activity
No business activities depend on river water are observed within the study area

4.1.5 Industry
Industries which use river water have not been observed within the study area, except for the Crysbro Chicken Processing Industry, details of which have been included in the original study

4.2 IMPACTS ON SOCIAL ACTIVITIES

4.2.1 Bathing and Washing

Along either side of the river within the stretch under study there are a fairly large number of bathing and washing places. The study revealed that there are 34 bathing and washing places within the stretch under survey. These bathing places are always busy with the people, mostly with the people of low income groups, who come for bathing and washing.

According to the inference of the downstream river user survey only one bathing place (location B34) has disclosed the awareness of river water level fluctuation by their self-judgment when Kotmale Plant is in operation. The water level fluctuation in the other locations covered by the survey is not significant even though Kotmale Plant releases 110.0 m^3/s of flow to the river at full load operation.

The downstream river users may believe that the river water level fluctuation by the power plant operation is a normal occurrence of the river flow pattern as they have accustomed to such situation over last 30 years. This is further substantiated by not reporting any accident caused by the water level fluctuation in the river downstream, so far after commissioning of Kotmale Power Plant in 1983.

As per the present analysis, peak discharge of Kotmale Plant alone could influence to raise the downstream river water level by nearly 1.0m. This will increase further by 0.5m with the addition of Moragolla Plant. Based on that it is planned to organize public awareness programs on river water level rise in future with the operation of Moragolla plant as an initial precautionary measure.

To ensure safeguard of downstream users from the anticipated river water level fluctuations, it is proposed to introduce public awareness system through mass media and public warning system using sirens when both plants release more than 110.0 m^3/s of flow to the river.

Some scenes of downstream Bathing and washing

Wellathota (Location B10)

Iskolawatta (Location B7)

It has been established that the proposed dam will not pose a threat to the bathing or washing activities along this particular stretch of river as large volume water is brought in by several large and small steams flowing from either side of the river. Also, the environmental flow released from the reservoir will supplement the above volume. The Table- 2 gives the details of bathing and washing places in the additional study area.

TABLE 2 - DOWN STREAM RIVER USERS SURVE - BATHING & WASHING

Item No.	Location ID	Name of the Place	No. of User Families		Key Informant details	
			Wet Season	Dry Season	Name	Address
01	B1	Walkotuwa	10	50	JanakaAshoka	84, Pallewela, Millawatta, Gampola
02	B2	Palliyathota	15	50	Ajmaal	Atuwewatta, Gampola
03	B3	Daraande	10	15	H.M.L. Fowser	159C, Andiyakadawatha, Gampola
04	B4	Ihalawela 1	15	25	M.T. M. Naleeze	199B, Ihalawela, Polwatta, Gampola
05	B5	Ihalawela 2	15	25	M.T. M. Naleeze	199B, Ihalawela, Polwatta, Gampola
06	B6	Polwatta	3	10	N. Dasanayake	Polwatta, Naranvita
07	B7	Iskolawatta	6	25	U.G.G. Manike	IskolaWatta, Niyamgama, Gampola
08	B8	Ganthotapitiya	10	25	D.K. Senevirathna	Liyandeniya, Doluwa
09	B9	Walapẽlawala	20	10	D.K. Senevirathna	Liyandeniya, Doluwa
10	B10	Wellathota	5	15	M.P.C. Jayasundara	Godawela, Doluwa
11	B11	Kotta Gas Handiya	5	15	AjithPadmasiri	132/4, MegogaKalugamuwa
12	B12	Pipe Bridge-Kalugamuwa	10	25	AjithPadmasiri	132/4, MegogaKalugamuwa
13	B13	Walawwawatta	5	5	D. W. Gunathilake	142, Doluwa Road, Hindagala
14	B14	PahingamaThotupala 1	2	5	P.G. Jayarathna	46/3, Pahingama, Gelioya
15	B15	PahingamaThotupala 3	1	2	K. Nawarathna	35, Pahingama, Gelioya
16	B16	Nape thota	10	10	T.M. Munnah	516/1A, Kalugamuwa Road, Gelioya
17	B17	Pallithota	30	40	A.N. Maujude	505/3, Kalugamuwa, Gelioya

Contd..

DOWN STREAM RIVER USERS SURVEY - BATHING & WASHING Contd..

Item No.	Location ID	Name of the Place	No. of User Families		Key Informant details	
			Wet Season	Dry Season	Name	Address
18	B18	No.8 Thotupala	40	60	M.L.M. Haneefa	479/3, Kalugamuwa, Gelioya
19	B19	BangalaThota	60	100	S.M. Waseem	454, Kalugamuwa, Gelioya
20	B20	Elpitiya 1	3	8	T.G.N. Bandara	391A, Elpitiya, Weligalla
21	B21	Elpitiya 2	2	5	T.G.N. Bandara	391A, Elpitiya, Weligalla
22	B22	Elpitiya 3	8	20	S.H.D Ruwankumara	280/48/1, Elpitiya,Weligalla
23	B23	Pussathota	5	10	D. Dehideniya	Elpitiya, Weligalla,Gampola
24	B24	Pussangolla	15	30	P.D.A.B. Gunarathne	"Asiri", Udowita, Weligalla
25	B25	ParuThota	2	10	K.G. Sriyani	21/51, Bothalapitiya, Gampola
26	B26	Illawathura - 1	3	10	M.J.M. Ashfer	79, Illawatura, Gampola
27	B27	Illawathura - 2	5	10	M. Amanulla	12/2B, Illawatura, Gampola
28	B28	Illawathura - 3	10	20	M. Amanulla	12/2B, Illawatura, Gampola
29	B29	Illawathura - 4	10	15	M.T.M. Ikbal	13/12, Illawatura, Gampola
30	B30	Illawathura - 5	7	18	M.T.M. Ikbal	13/12, Illawatura, Gampola
31	B31	Illawathura - 6	5	25	M. Nazeer	56/37, Illawatura, Gampola
32	B32	Illawathura - 7	10	30	M.N.M. Navaz	52, Illawatura, Gampola
33	B33	Illawathura - 8	5	15	M.S.M. Asvin	56/8, Illawatura, Gampola
34	B34	Illawathura - 9	5	15	J.A. Gafur	17/48, Illawatura, Gampola

4.2.2 Swimming

Swimming is a very remote recreation activity due to the risk factor and no safety measures are in place in this particular river stretch.

4.2.3 Domestic Water Supply Schemes

Kandy South Water Supply Scheme and the water supply scheme for University of Peradeniya are the only Domestic Water Supply Schemes implemented by the National Water Supply and Drainage Board (NWS&DB() which harness Mahaweli Water, observed in the study area.

The Kandy South Water Supply Scheme has already given connections to 45,000 houses and it has the capacity to give 15,000 more connections. A small weir with gates is constructed across the river as intake structure and that is not obstructing the fish movements of the river.

Some scenes of the intake of the Kandy South Water Supply Scheme

Meewathura (Location P1+S12)

A scene of the water intake for water supply scheme for University of Peradeniya

Although the proposed Dam of the Moragolla Hydropower Project will restrict the flow of water in the downstream to a certain extent, it will not debilitate these two water supply schemes as there will be no shortage of water for the purpose as the water from the following sources will supplement the requirement.

- **Environmental flow to be released from the Moragolla Reservoir**.

  It has been planned to release 1.5 m^3/s of water from the Moragolla Reservoir, as an environmental flow.

- **Water carried to the river in the downstream of the proposed Dam by 19 streams including large streams such as Atabae Oya, Nillabe oya, Nanu Oya and Geli Oya**

In between Moragolla dam and Peradeniya Bridge there are 19 streams having different flow capacities confluence with the Mahaweli River. According to downstream survey of the river there are several large scale water users such as National Water Supply and Drainage Board (NWS&DB), University of Peradeniya and the Municipality of Kandy and they utilize large amounts of water in this river stretch. Beyond 1 km downstream of the Peradeniya Bridge in Getambe, certain studies are being carried out to build a weir across Mahaweli River to construct 10MW power plant. According to them, at this weir location the 95% exceedance flow would be 9.0m^3/s. Conversely the 95% exceedance flow at Moragolla dam would be 3.6 m^3/s

Therefore, the 95% exceedance flow of all the streams confluence with Mahaweli River in between Moragolla dam and Getambe weir location would be 5.4 m^3/s plus the river water required for all downstream river water users in between these two points. Based on them when Moragolla reservoir will be in operation, the 95% exceedance flow available at Getambe would be 6.9 m^3/s , i.e (5.4+1.5) It is equal to 77% of the 95% exceedance flow at Getambe before the operation of Moragolla reservoir.

Furthermore, Atabage Oya contributes around 2.0 m^3 /s as the 95% exceedance flow. Therefore, in lean flow period of the river at least 60% of the normal river flow is available in the river just downstream of the project.

A scene of the Atabage Oya

A Scene of Geli Oya

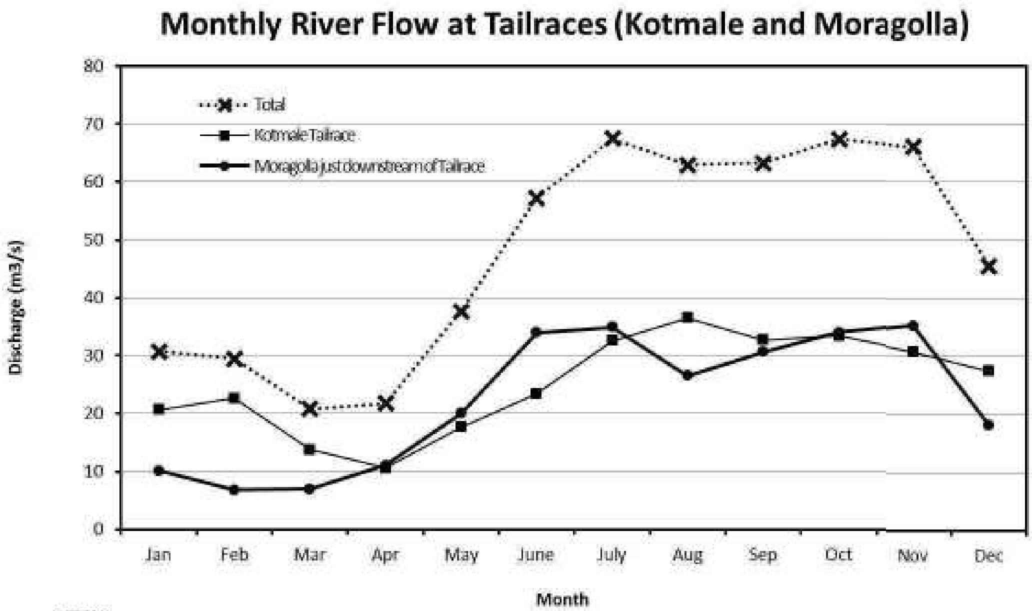
- **Release of water from the Kotmale Reservoir**

The Water Management Secretariat (WMS) functioning under the Ministry of Irrigation and Water Resources Development has the authority to allocate Mahaweli water for different purposes on priority basis. In the order of priority allocation of water for irrigation comes first. Next priority of allocation of water is for domestic water supply.

Meetings of the WMS are held weekly. Representatives from the Ceylon Electricity Board (CEB) and the National Water Supply and Drainage Board attend these meetings regularly. At these meetings water requirements of different agencies and for different purposes are discussed and decisions are made on allocation of water based on the priority. It has been confirmed that water requirements of NWS&DB for the above water supply schemes are guaranteed by the WMS and the decisions on the amount of water to be released are made at the weekly meetings. Therefore, operation of Kandy South Water Supply Scheme and the water supply scheme for University of Peradeniya will not be hampered because of the Moragolla Hydropower Project.
In addition, when the operation of both Moragolla & Kothmale plants in future, river water flow just downstream location of tailraces is analysed and tabulated in Table-3 with a graphical output as follows,

Table 3 - Monthly river flow at tailrace downstream of Kothmale & Moragolla

	River Flow at Tailrace (m^3/s)		
Month	**Moragolla**	**Kotmale**	**Total**
Jan	10.10	20.63	30.73
Feb	6.80	22.63	29.43
Mar	7.00	13.77	20.77
Apr	11.10	10.65	21.75
May	20.00	17.66	37.66
June	33.90	23.38	57.28
July	34.90	32.53	67.43
Aug	26.50	36.48	62.98
Sep	30.60	32.68	63.28
Oct	34.00	33.37	67.37
Nov	35.30	30.76	66.06
Dec	18.10	27.48	45.58



Source
Kotmale: CEB Operation Records (Power flow at Kotmale 1990-2011)

4.3 Cultural activity

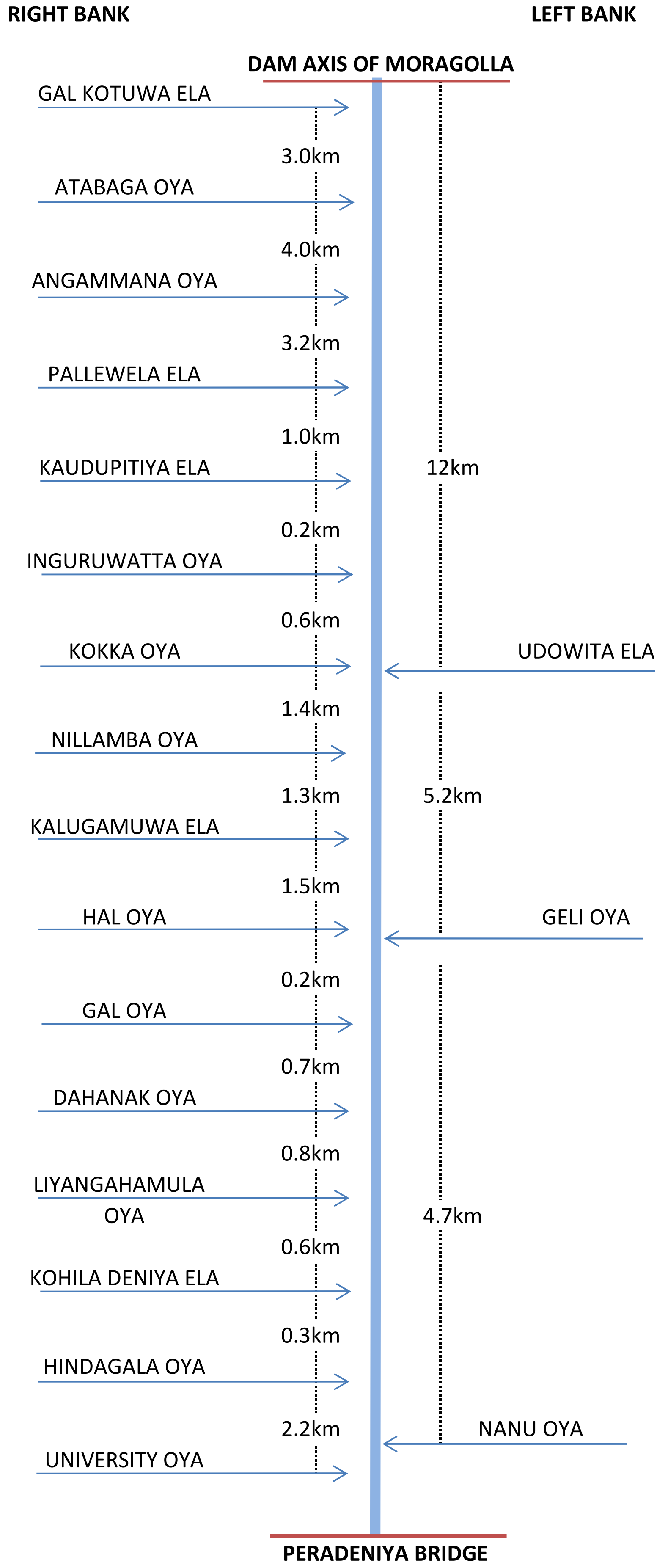
No cultural activity linked to the river water has been observed in the study area.

APPENDICES

- MAJOR DOWNSTREAM CONFLUENCES – FLOW CHART
- GEO-REFERENCE MAP OF LOCATIONS
- SUMMARY TABLE OF COLLECTED DATA
- SURVEY DATA SHEETS OF DOWNSTREAM RIVER USERS

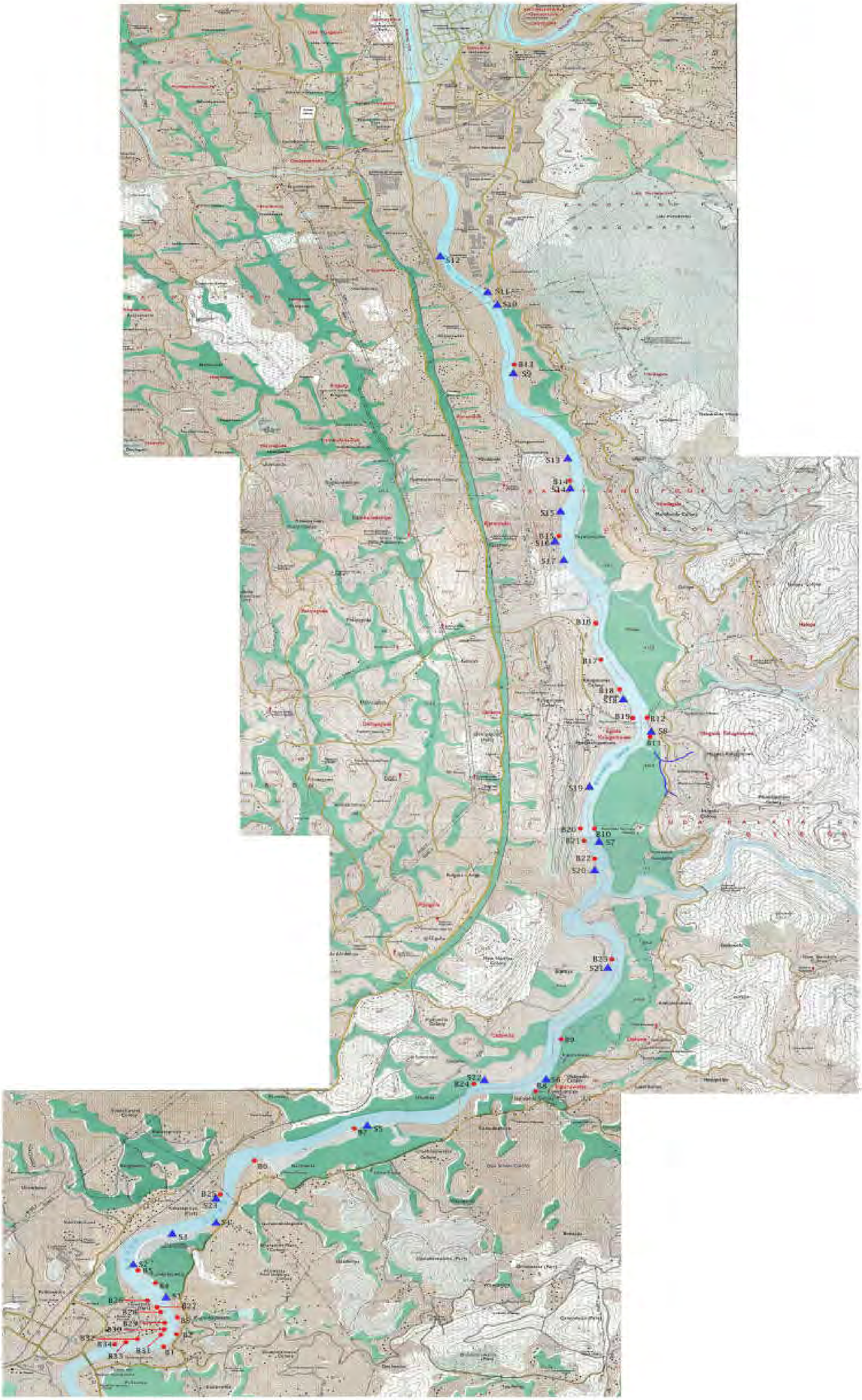
APPENDIX - I

- **MAJOR DOWNSTREAM CONFLUENCES – FLOW CHART**


RIGHT BANK
LEFT BANK
DAM AXIS OF MORAGOLLA
GAL KOTUWA ELA
3.0km
ATABAGA OYA
4.0km
ANGAMMANA OYA
3.2km
PALLEWELA ELA
1.0km
KAUDUPITIYA ELA
12km
0.2km
INGURUWATTA OYA
0.6km
KOKKA OYA
UDOWITA ELA
1.4km
NILLAMBA OYA
1.3km
5.2km
KALUGAMUWA ELA
1.5km
HAL OYA
GELI OYA
0.2km
GAL OYA
0.7km
DAHANAK OYA
0.8km
LIYANGAHAMULA OYA
4.7km
0.6km
KOHILA DENIYA ELA
0.3km
HINDAGALA OYA
2.2km
NANU OYA
UNIVERSITY OYA
PERADENIYA BRIDGE

APPENDIX - II

- **GEO-REFERENCE MAP OF LOCATIONS**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B27
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APPENDIX - III

- **SUMMARY TABLE OF COLLECTED DATA**

DOWN STREAM RIVER USERS SURVEY – MORAGOLLA HYDROPOWER PROJECT

Location ID	Name of the Place	Village	GPS Coordinates		Washing /Bathing Families		Fishing	Sand mine workers	Key Informent details			GN Division	Remarks
			N	E	Wet	Dry			Name	Address	Contact No.		
B1	Walkotuwa	Andiya Kadawatha	218005	178297	10	50	No	–	Janaka Ashoka	84, Pallewela, Millawatta, Gampola	071 3354119	Naranvita	
B2	Palliyathota	Andiya Kadawatha	218139	178473	15	50	rare	–	Ajmaal	Atuwewatta, Gampola	077 0616747	Naranvita	
B3	Daraande	Andiya Kadawatha	218298	178424	10	15	No	–	H.M.L. Fowser	159C, Andiya kadawatha, Gampola	077 9811797	Naranvita	
S1	Atuwewatta	Ihalawela	218714	178146	–	–	No	9	M.T. M. Naleeze	199 B, Ihalawela, Polwatta, Gampola	077 9598782	Atuwewatta	
B4	Ihalawela 1	Ihalawela	218803	178165	15	25	rare	–	M.T. M. Naleeze	199 B, Ihalawela, Polwatta, Gampola	077 9598782	Atuwewatta	
B5 + S2	Ihalawela 2	Ihalawela	218845	178252	15	25	rare	4	M.T. M. Naleeze	199 B, Ihalawela, Polwatta, Gampola	077 9598782	Atuwewatta	
S3	Kapukotuwa Thotupala	Kapukotuwa	218917	178569	–	–	No	5	M.G. Dulip Kumara	17, Gampola watta, Gampola	077 9786937	Atuwewatta	
B6	Polwatta	Naranvita	219488	178958	3	10	rare	–	N. Dasanayake	Polwatta, Naranvita	081 5610454	Naranvita	
B7 + S5	Iskola watta	Iskola watta	219777	179884	6	25	rare	2	U.G.Gunarathne Manike	Iskola Watta, Niyamgama, Gampola	081 5733416	Inguruwatta	
B8 + S6	Ganthota pitiya	Kawudu pitiya	220073	180866	10	25	rare	3	D.K. Senevirathna	Liyandeniya, Doluwa	081 4927235	Inguruwatta	
B9	Wala pēla wala	Doluwa	220252	181004	20	10	No	–	D.K. Senevirathna	Liyandeniya, Doluwa	081 4927235	Doluwa	
B10 + S7	Wella thota	Doluwa	221308	181217	5	15	rare	3	M.P.C. Jayasundara	Godawela, Doluwa	077 6168464	Godawela	
B11 + S8	Kotta Gas Handiya	Megoda Kalugamuwa	222771	181631	5	15	No	4	Ajith Padmasiri	132/4, Megoga Kalugamuwa	077 6167570	Megoda Kalugamuwa	
B12	Pipe Bridge–Kalugamuwa	Megoda Kalugamuwa	222983	181641	5	10	rare	–	Ajith Padmasiri	132/4, Megoga Kalugamuwa	077 6167570	Megoda Kalugamuwa	
B13 + S9	Walawwa watta	Hindagala	225728	180759	5	5	No	2	D. W. Gunathilake	142, Doluwa Road, Hindagala	–	Hindagala	
S10	Hindagala 1	Hindagala	226565	180689	–	–	No	2	Upali Chandralal	"Musdale", Galaha road, Peradeniya	–	Palle – Peradeniya	
S11	Hindagala 2	Hindagala	226778	180592	–	–	No	3	Upali Chandralal	"Musdale", Galaha road, Peradeniya	–	Palle – Peradeniya	
P1 + S12	Kandy South Intake (NWS & DB)	Meewathura	227396	180262	–	–	No	6	H.M.A. Rathnayake	Kandy South NWS & DB office, Meewathura, Peradeniya	081 2385725	Angunawela East	Supply water for 45000 nos. of connection in area. 24hrs in operating, Plant Capacity 20000
P2	University Intake	Meewathura	227129	180285	–	–	No	–	H.M.A. Rathnayake	Kandy South NWS & DB office, Meewathura, Peradeniya	081 2385725	Angunawela East	Operating from 4am to 10pm hrs. Capacity 5500 m^3
S13	Kurunduwatta	Kurunduwatta	225389	180906	–	–	No	3	S.L.R.A. Senevirathna	B/53, New Peradeniya, Kossinna, Gelioya	081 4980143	Godapala West	

Location ID	Name of the Place	Village	GPS Coordinates		Washing /Bathing Families		Fishing	Sand mine workers	Key Informent details			GN Division	Remarks
			N	E	Wet	Dry			Name	Address	Contact No.		
P3	Brick Manufacturing Place	Pahingama	225141	181027	-	-	No	-	K. Bandara	Pahingama, Gelioya	-	New Peradeniya	Approx. 500 bricks per day
B14 + S14	Pahingama Thotupala 1	Pahingama	224706	181148	2	5	No	2	P.G. Jayarathna	46/3, Pahingama, Gelioya	077 9914938	New Peradeniya	
S15	Pahingama Thotupala 2	Pahingama	224585	181084	-	-	No	-				New Peradeniya	Currently Abundant
B15 + S16	Pahingama Thotupala 3	Pahingama	224197	181087	1	2	No	2	Kanchana Nawarathna	35, Pahingama, Gelioya	077 7030950	New Peradeniya	
S17	Pahingama Thotupala 4	Pahingama	224169	181101	-	-	No	2	Hemalatha	Pahingama, Gelioya	-	New Peradeniya	
B16	Nape thota	Pol Mandiya	223783	181311	10	10	rare	-	T.M. Munnah	516/1A, Kalugamuwa Road, Gelioya	075 6692427	Egoda Kalugamuwa	
B17	Pallithota	Egoda Kalugamuwa	223567	181284	30	40	rare	-	A.N. Maujude	505/3, Kalugamuwa, Gelioya	-	Egoda Kalugamuwa	
B18 +S18	No.8 Thotupala	Egoda Kalugamuwa	223308	181402	40	60	rare	2	M.L.M. Haneefa	479/3, Kalugamuwa, Gelioya	-	Egoda Kalugamuwa	
B19	Bangala Thota	Egoda Kalugamuwa	222935	181583	60	100	No	-	S.M. Waseem	454, Kalugamuwa, Gelioya	-	Egoda Kalugamuwa	
S19	Kottunna Thotupala	Egoda Kalugamuwa	221521	181158	-	-	No	2	O.L.M. Azam	Elpitiya, Weliganga	-	Egoda Kalugamuwa	
B20	Elpitiya 1	Elpitiya	221247	181178	3	8	rare	-	T.G.N. Bandara	391A, Elpitiya, Weligalla	077 7963279	Udowita	
B21	Elpitiya 2	Elpitiya	221241	181228	2	5	rare	-	T.G.N. Bandara	391A, Elpitiya, Weligalla	077 7963279	Udowita	
B22	Elpitiya 3	Elpitiya	220905	181334	8	20	No	-	S.H.D Ruwankumara	280/48/1, Elpitiya,Weligalla	-	Udowita	
S20	Wali-Ullah	Elpitiya	220776	181259	-	-	rare	3	M. Irfam	380/2/1, Elpitiya,Weligalla	077 0501051	Udowita	
B23 +S21	Pussathota	Udowita	220595	181017	5	10	No	2	D. Dehideniya	Elpitiya, Weligalla,Gampola	-	Udowita	
B24+S22	Pussangolla	Udowita	219888	180279	15	30	No	4	P.D.A.B. Gunarathne	"Asiri", Udowita, Weligalla	-	Udowita	
B25+S23	Paru Thota	Jayasengama	219141	178745	2	10	rare	5	K.G. Sriyani	21/51, Bothalapitiya, Gampola	-	Bothalapitiya	
B26	Illawathura - 1	Illawathura	218437	178198	3	10	rare	-	M.J.M. Ashfer	79, Illawatura, Gampola	-	Illawatura	
B27	Illawathura - 2	Illawathura	218220	178392	5	10	No	-	M. Amanulla	12/2B, Illawatura, Gampola	077 9196220	Illawatura	
B28	Illawathura - 3	Illawathura	218280	178350	10	20	No	-	M. Amanulla	12/2B, Illawatura, Gampola	077 9196220	Illawatura	
B29	Illawathura - 4	Illawathura	218162	178387	10	15	No	-	M.T.M. Ikbal	13/12, Illawatura, Gampola	-	Illawatura	
B30	Illawathura - 5	Illawathura	218154	178375	7	18	No	-	M.T.M. Ikbal	13/12, Illawatura, Gampola	-	Illawatura	
B31	Illawathura - 6	Illawathura	218090	178301	5	25	No	-	M. Nazeer	56/37, Illawatura, Gampola	-	Illawatura	
B32	Illawathura - 7	Illawathura	218080	178250	10	30	No	-	M.N.M. Navaz	52, Illawatura, Gampola	-	Illawatura	
B33	Illawathura - 8	Illawathura	218053	178196	5	15	No	-	M.S.M. Asvin	56/8, Illawatura, Gampola	-	Illawatura	
B34	Illawathura - 9	Illawathura	218057	178117	5	15	No	-	J.A. Gafur	17/48, Illawatura, Gampola	-	Illawatura	

APPENDIX - IV

- **SURVEY DATA SHEETS OF DOWNSTREAM RIVER USERS**

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola.	Location ID	B1	
Surveyor	A.H. Dissanayake	Date	2013	08	26
DS Division	DOLUWA	GN Division	Naranwita	1149
Location Name	WALKOTUWA			

GPS

N	218005
E	178297

Type of activity

Business

Sand mining	
Fishing	
Irrigation	
Industry	

Other : ....

Cultural

Bathing & Washing	✓
Camping	
Swimming	

Other : ....

Key Informant

Name	JANAKA ASHOKA
Address	84, PALLEWELA, WÊLLA WATTA, GAMPOLA
Telephone	+94713354119

Number of users (Families)

Dry Season	50
Wet Season	10

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/08 Gampola		Location ID	B2
Surveyor	A. H. DISSANAYAKE		Date	2013 08 26
DS Division	DOLUWA	GN Division	NARANWITA	1149
Location Name	PALLI THOTA			

GPS

N	218139
E	178473

Type of activity

Business

- Sand mining [ ]
- Fishing [✓]
- Irrigation [ ]
- Industry [ ]
- Other : ....

Cultural

- Bathing & Washing [✓]
- Camping [ ]
- Swimming [ ]
- Other : ....

Key Informant

Name	AJMAL
Address	ATUWA WATTA
Telephone	+94770616747

Number of users (Families)

Dry Season	50
Wet Season	15

Any effect of Kotmale HPP operation

Notes

Fishing - rare ; as a hobby

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/08 Gampola.	Location ID	B3
Surveyor	A.H. DISSANAYAKE	Date	2013 08 26
DS Division	DOLUWA	GN Division	NARANWITA 1149
Location Name	DARĀNDE NĀNA THOTA		

GPS

N	178424
E	218298

Type of activity

Business

- Sand mining [ ]
- Fishing [ ]
- Irrigation [ ]
- Industry [ ]
- Other : ....

Cultural

- Bathing & Washing [✓]
- Camping [ ]
- Swimming [ ]
- Other : ....

Key Informant

Name	H.M.L. FOUZAR
Address	159C, ANDIYA KADAWATHA, GAMPOLA
Telephone	+94779811797

Number of users (Families)

Dry Season	15
Wet Season	10

Any effect of Kotmale HPP operation

Notes

④

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/68 Gampola	Location ID	S1	
Surveyor	A.H. DISSANAYAKE	Date	2013	08	26
DS Division	DOLUWA	GN Division	ATUWE WATTA	1151

Location Name: IHALA WELA, ATUWE WATTA

GPS

N	218714
E	178146

Type of activity

Business

- Sand mining ✓
- Fishing
- Irrigation
- Industry
- Other : ....

Cultural

- Bathing & Washing
- Camping
- Swimming
- Other : ....

Key Informant

Name: M.T.M. NALEEZ

Address: 199 B, IHALAWELA, POLWATTA, GAMPOLA

Telephone: 0779598782

Number of users (Families)

Dry Season:

Wet Season:

Any effect of Kotmale HPP operation

Notes

No. of sand mining workers - 09

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/08 Gampola		Location ID	B5, S2	
Surveyor	A. H. DISSANAYAKE		Date	2013	08	26
DS Division	DOLUWA	GN Division	ATUWEWATTA	1151	
Location Name	IHALAWELA 2				
GPS	N	178252			
	E	218845			

Type of activity

Business		*Cultural*	
Sand mining	✓	Bathing & Washing	✓
Fishing	✓		
Irrigation		Camping	
Industry		Swimming	
Other :		Other :	

Key Informant

Name	M. T. M. NALEEZ
Address	199/B, IHALAWELA, POLWATTA, GAMPOLA
Telephone	+94779598782

Number of users (Families)		
	Dry Season	25
	Wet Season	15

Any effect of Kotmale HPP operation

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____

____

Notes

No. of Sand mining workers - 04

Fishing - rare

____

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/08 Gampola.	Location ID	B4	
Surveyor	A. H. DISSANAYAKE	Date	2013	08	26
DS Division	DOLUWA	GN Division	ATUWEWATTA	1151
Location Name	IHALAWELA 1			

GPS

N	218803
E	178165

Type of activity

Business

Sand mining	
Fishing	✓
Irrigation	
Industry	

Other : ....

Cultural

Bathing & Washing	V
Camping	
Swimming	

Other : ....

Key Informant

Name	M. T. M. Naleez
Address	199 B, IHALAWELA, POLWATTA, GAMPOLA
Telephone	077959 8782

Number of users (Families)

Dry Season	25
Wet Season	15

Any effect of Kotmale HPP operation

Notes

Fishing - rare

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/08 Gampola.	Location ID	83
Surveyor	A. H. DISSANAYAKE	Date	2013 08 26
DS Division	DOLUNA	GN Division	ATUWEWATTA 1151
Location Name	KAPUKOTUWA THOTUPALA		

GPS

N	218917
E	178569

Type of activity

Business

- Sand mining ✓
- Fishing
- Irrigation
- Industry
- Other : ....

Cultural

- Bathing & Washing
- Camping
- Swimming
- Other : ....

Key Informant

Name	M.G. DULIP KUMARA
Address	17, GAMPOLA WATTA, GAMPOLA
Telephone	0779786937

Number of users (Families)

Dry Season	-
Wet Season	-

Any effect of Kotmale HPP operation

Notes

No. of sand mining workers - 05

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/08 Gampola.	Location ID	B6	
Surveyor	A. H. DISSANAYAKE	Date	2013	08	26
DS Division	DOLUWA	GN Division	NARANWITA	1149
Location Name	POLWATTA			

GPS

N	219488
E	178958

Type of activity

Business

Sand mining	
Fishing	✓
Irrigation	
Industry	

Other : ....

Cultural

Bathing & Washing	✓
Camping	
Swimming	

Other : ....

Key Informant

Name	N. DASANAYAKE (MRS.)
Address	POLWATTA, NARANVITA
Telephone	0815610454

Number of users (Families)

Dry Season	10
Wet Season	3

Any effect of Kotmale HPP operation

Notes

Fishing - rare

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/08 Gampola.	Location ID	B7, S5	
Surveyor	A.H. DISANAYAKE	Date	2013	08 / 26
DS Division	DOLUWA	GN Division	INGURUWATTA	1153
Location Name	ISKOLAWATTA			

GPS

N	219717
E	179884

Type of activity

Business

Sand mining	✓
Fishing	✓
Irrigation	
Industry	

Other : ....

Cultural

Bathing & Washing	✓
Camping	
Swimming	

Other : ....

Key Informant

Name	U.G. GUNARATHNA MENIKE
Address	ISKOLA WATTA, NIYAMGAMA, GAMPOLA
Telephone	081 5733416

Number of users (Families)

Dry Season	25
Wet Season	6

Any effect of Kotmale HPP operation

Notes

Fishing -rarely
Sand mining workers - 02

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number: 61/3 Gampola.

Location ID: S6, B8

Surveyor: A. H. DISSANAYAKE

Date: 2013 | 08 | 26

DS Division: DOLUWA

GN Division: INGURUWATTA

Location Name: GANTHOTA PITIYA, KAWDU PITIYA

GPS

N	220073
E	180866

Type of activity

Business

- Sand mining: ✓
- Fishing: ✓
- Irrigation:
- Industry:
- Other : ....

Cultural

- Bathing & Washing: ✓
- Camping:
- Swimming:
- Other : ....

Key Informant

Name: D.K. SENEVIRATHNA

Address: LIYANDENIYA, DOLUWA

Telephone: 081 4927235

Number of users (Families)

Dry Season: 25

Wet Season: 10

Any effect of Kotmale HPP operation

Notes

Fishing - rare

Sand mining workers - 03

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola.	Location ID	B9	
Surveyor	A. H. DISSANAYKE	Date	2013	08	26
DS Division	DOLUWA	GN Division	DOLUWA	1155
Location Name	WALA PĒLA WALA			

GPS

N	220252
E	181004

Type of activity

Business

- Sand mining [ ]
- Fishing [ ]
- Irrigation [ ]
- Industry [ ]
- Other : ....

Cultural

- Bathing & Washing [✓]
- Camping [ ]
- Swimming [ ]
- Other : ....

Key Informant

Name	D. K. SENEVIRATHNA
Address	LIYANDENIYA, DOLUWA
Telephone	0814927235

Number of users (Families)

Dry Season	20
Wet Season	10

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola.	Location ID	S7, B10	
Surveyor	A.H. DISSANAYAKE	Date	2013	08 / 26
DS Division	DOLUWA	GN Division	GODAWELA	1156
Location Name	WELLA THOTA			

GPS

N	221308
E	181217

Type of activity

Business

Sand mining	✓
Fishing	✓
Irrigation	
Industry	

Other : ....

Cultural

Bathing & Washing	✓
Camping	
Swimming	

Other : ....

Key Informant

Name	M.P.C. JAYASUNDARA
Address	GODAWELA, DOLUWA
Telephone	0776168464

Number of users (Families)

Dry Season	15
Wet Season	5

Any effect of Kotmale HPP operation

Notes

Fishing - rare

Sand mining Workers - 03

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola.	Location ID	B11, 58
Surveyor	A. H. DISSANAYAKE	Date	2013 08 26
DS Division	DOLUWA	GN Division	MEGODA KALUGAMUWA 1157
Location Name	KOTTA GAS HANDIYA		

GPS

N	222771
E	181631

Type of activity

Business

Sand mining	V
Fishing	
Irrigation	
Industry	

Other : ....

Cultural

Bathing & Washing	V
Camping	
Swimming	

Other : ....

Key Informant

Name	AJITH PADMASIRI
Address	132/4, MEGODA KALUGAMUWA, PERADENIYA
Telephone	0776167570

Number of users (Families)

Dry Season	15
Wet Season	5

Any effect of Kotmale HPP operation

Notes

No. of Sand mining workers - 04

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola	Location ID	B12
Surveyor	A.H. DISSANAYAKE	Date	2013 08 26
DS Division	DOLUWA	GN Division	MEGODA KALUGAMUWA 1157
Location Name	PIPE BRIDGE - KALUGAMUWA		
GPS	N 222983		
	E 181641		

Type of activity

Business

- Sand mining ☐
- Fishing ☑
- Irrigation ☐
- Industry ☐
- Other : ....

Cultural

- Bathing & Washing ☑
- Camping ☐
- Swimming ☐
- Other : ....

Key Informant

Name	AJITH PATHMASIRI
Address	132/4, MEGODA KALUGAMUWA
Telephone	0776167570

Number of users (Families)

Dry Season	10
Wet Season	05

Any effect of Kotmale HPP operation

Notes

Fishing - rarely

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	54/23 Kandy
Location ID	B13, S9
Surveyor	A.H. DISSANAYAKE
Date	2013 08 27
DS Division	GANGAWATA KORALE
GN Division	HINDAGALA 267
Location Name	WALAWWA WATTA

GPS

N	225728
E	180759

Type of activity

Business

- Sand mining ✓
- Fishing
- Irrigation
- Industry
- Other : ....

Cultural

- Bathing & Washing ✓
- Camping
- Swimming
- Other : ....

Key Informant

Name	D. W. GUNATHILAKE
Address	142, DOLUWA ROAD ROAD, HINDAGALA
Telephone	

Number of users (Families)

Dry Season	5
Wet Season	5

Any effect of Kotmale HPP operation

Notes

No. of Sand mining workers -02

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	54/23 Kandy	Location ID	310	
Surveyor	A.H. DISSANAYAKE	Date	2013	08	27
DS Division	GANGAWATA KORALE	GN Division	PALLE PERADENIYA	248
Location Name	HINDAGALA 1			

GPS

N	226565
E	180689

Type of activity

Business		***Cultural***	
Sand mining	✓	Bathing & Washing	
Fishing			
Irrigation		Camping	
Industry		Swimming	
Other :		Other :	

Key Informant

Name	UPALI CHANDRALAL
Address	"MUSSDALE", GALAHAROAD, PERADENIYA
Telephone	

Number of users (Families)

Dry Season	
Wet Season	

Any effect of Kotmale HPP operation

Notes

No. of Sand mining workers - 02

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	54/23 Kandy	Location ID	S11	
Surveyor	A. H. DISANAYAKE	Date	2013	08 / 27
DS Division	GANGAWATA KORALE	GN Division	PALLE PERADENIYA	248
Location Name	HINDAGALA 2			
GPS	N	226778		
	E	120592		

Type of activity

Business		***Cultural***	
Sand mining	✓	Bathing & Washing	
Fishing			
Irrigation		Camping	
Industry		Swimming	
Other :		Other :	

Key Informant

Name	UPALI CHANDRALAL
Address	"MUSSDALE", GALAH ROAD, PERADENIYA
Telephone	

Number of users (Families)		
	Dry Season	
	Wet Season	

Any effect of Kotmale HPP operation

Notes

No. of Sand mining workers - 03

(18)

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	54/23 Kandy	Location ID	P1 + S12
Surveyor	A. H. DISSANAYAKE	Date	2013 08 27
DS Division	UDUNUWARA	GN Division	ANGUNAWELA EAST 0018

Location Name: KANDY SOUTH INTAKE (NWS&DB)

GPS

N	227396
E	180262

Type of activity

Business

Sand mining	✓
Fishing	
Irrigation	
Industry	

Other : Water Supply Intake

Cultural

Bathing & Washing	
Camping	
Swimming	

Other : ....

Key Informant

Name: PROJECT DIRECTOR

Address: WATER SUPPLY AND DRAINAGE BOARD, GAMPOLA ROAD, MEEWATHURA, PERADENIYA

Telephone: 081 2385725

ksouth@sltnet.lk

Number of users (Families)

Dry Season	
Wet Season	

Contact Person :
H.M.A. Rathnayake

Any effect of Kotmale HPP operation

Notes

Sand mining workers - 06
Water supply for Kandy city - South area.
Max^{m} capacity 32000 m^3/day
present prod^{n} 20000 m^3/day
Num of water Connections 45,000

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	54/23 Kandy.	Location ID	P2	
Surveyor	A. H. DISANAYAKE	Date	2013	08 / 27
DS Division	UDUNUWARA	GN Division	ANGUNAWELA EAST	0018
Location Name	UNIVERSITY INTAKE			

GPS

N	227129
E	180285

Type of activity

Business

Sand mining ☐

Fishing ☐

Irrigation ☐

Industry ☐

Other : Water supply scheme

Cultural

Bathing & Washing ☐

Camping ☐

Swimming ☐

Other : ....

Key Informant

Name: PROJECT DIRECTOR

Address: NATIONAL WATER SUPPY AND DRAINAIGE BOARD GAMPOLA ROAD, MEEWATHURA, PERADENIYA

Telephone: 0812385725

ksouth@sltnet.lk

Number of users

Dry Season ☐

Wet Season ☐

Contact person:
H.M.A. Rathnayake

Any effect of Kotmale HPP operation

Notes

Plant Capacity 5500 m^3/day

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola	Location ID	S13	
Surveyor	A. H. DISANAYAKE	Date	2013	08 / 28
DS Division	UDUNUWARA	GN Division	GODAPOLA WEST	0028
Location Name	KURUNDUWATTA			

GPS

N	225389
E	180906

Type of activity

Business

- Sand mining: ✓
- Fishing:
- Irrigation:
- Industry:
- Other : ....

Cultural

- Bathing & Washing:
- Camping:
- Swimming:
- Other : ....

Key Informant

Name	S. L. R. A. SENEVIRATHNA
Address	B/53, NEW PERADENIYA, KOSSINNA, GELIOYA
Telephone	0814980143

Number of users

Dry Season	
Wet Season	

Any effect of Kotmale HPP operation

Notes

No. of Sand mining workers - 03

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola.	Location ID	P3
Surveyor	A. H. DISSANAYAKE	Date	2013 08 28
DS Division	UDUNUWARA	GN Division	NEW PERADENIYA 0026
Location Name	BRICK MANUFACTURING PLACE 1		

GPS

N	225141
E	181027

Type of activity

Business		*Cultural*	
Sand mining		Bathing & Washing	
Fishing			
Irrigation		Camping	
Industry	✓	Swimming	
Other :		Other :	

Key Informant

Name: K. BANDARA

Address: PAHINGAMUWA, GELI-OYA

Telephone:

Number of users

Dry Season:

Wet Season:

Any effect of Kotmale HPP operation

Notes

Small scale brick manufacturing place, around 500Nos of bricks a day.
Un-authorized water usage from river.

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DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola.	Location ID	B14, S14
Surveyor	A. H. DISSANAYAKE	Date	2013 / 08 / 28
DS Division	UDUNUWARA	GN Division	NEW PERADENIYA 0026
Location Name	PAHINGAMA THOTUPALA 1		

GPS

N	224706
E	181148

Type of activity

Business		***Cultural***	
Sand mining	✓	Bathing & Washing	✓
Fishing			
Irrigation		Camping	
Industry		Swimming	
Other :		Other :	

Key Informant

Name	P. G. JAYARATHNA
Address	46/3, PAHINGAMA, GELIOYA
Telephone	0779914938

Number of users (Families)

Dry Season	5
Wet Season	2

Any effect of Kotmale HPP operation

Notes

No. of sand mining workers - 02

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola	Location ID	S 15	
Surveyor	A. H. DISSANAYAKE	Date	2013	08 / 28
DS Division	UDUNUWARA	GN Division	NEW PERADENIYA	0026
Location Name	PAHINGAMA THOTUPALA 2			

GPS

N	224585
E	181084

Type of activity

Business

Sand mining	✓
Fishing	
Irrigation	
Industry	

Other : ....

Cultural

Bathing & Washing	
Camping	
Swimming	

Other : ....

Key Informant

Name

Address

Telephone

Number of users Dry Season ______ Wet Season ______

Any effect of Kotmale HPP operation

Notes

Abondoned - no one available to collect information.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola.	Location ID	B15 + S16
Surveyor	C. Aberathne	Date	2013 08 28
DS Division	Udu nuwara.	GN Division	New Peradeniya. 0026
Location Name	Pahingama 3		

GPS

N	224169
E	181087

Type of activity

Business		***Cultural***	
Sand mining	✓	Bathing & Washing	✓
Fishing			
Irrigation		Camping	
Industry		Swimming	
Other : ……………………….		Other : ……………………….	

Key Informant

Name	Kanchana Nawarathna.
Address	35, Paingamuwa, Geli oya
Telephone	077 7030950

Number of users (Families)

Dry Season	02
Wet Season	01

Any effect of Kotmale HPP operation

Notes

sand mining workers - 02 Nos. approx.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola	Location ID	S 17
Surveyor	A. H. Dissanayake	Date	2013 08 28
DS Division	Udu Nuwara.	GN Division	NEW PERADENIYA 0026
Location Name	Paingamuwa thotupala 04		

GPS

N	224169
E	181101

Type of activity

Business

- Sand mining ✓
- Fishing
- Irrigation
- Industry
- Other : ....

Cultural

- Bathing & Washing
- Camping
- Swimming
- Other : ....

Key Informant

Name	Hemalatha
Address	Paingamuwa, Gelioya.
Telephone	–

Number of users (Families)

Dry Season	–
Wet Season	–

Any effect of Kotmale HPP operation

Notes

Approx. 02 workers involved in sand mining.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola	Location ID	B 16	
Surveyor	A.H. Dissanayake	Date	2013	08	28
DS Division	Uda Palatha	GN Division	Egoda Kalugamuwa	1159
Location Name	Nape thota, Polmandiya			

GPS

N	223783
E	181311

Type of activity

Business

- Sand mining [ ]
- Fishing [✓]
- Irrigation [ ]
- Industry [ ]
- Other : ....

Cultural

- Bathing & Washing [ ]
- Camping [ ]
- Swimming [ ]
- Other : ....

Key Informant

Name: T.M. Munnah

Address: 516/1A, Kalugamuwa road Geli oya,

Telephone: 075 6692427

Number of users (Families)

Dry Season: 10

Wet Season: 10

Any effect of Kotmale HPP operation

Notes

Fishing is a rare activity in this place as a hobby.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola	Location ID	B 17	
Surveyor	A.H. Dissanayake	Date	2013	08	28
DS Division	Uda Palatha	GN Division	Egoda Kalugamuwa	1159
Location Name	Pallithota			

GPS

N	223567
E	181284

Type of activity

Business

- Sand mining [ ]
- Fishing [✓]
- Irrigation [ ]
- Industry [ ]
- Other : ....

Cultural

- Bathing & Washing [✓]
- Camping [ ]
- Swimming [ ]
- Other : ....

Key Informant

Name	A.N. Maujude
Address	505/3, Kalugamuwa, Gelioya
Telephone	

Number of users (Families)

Dry Season	40
Wet Season	30

Any effect of Kotmale HPP operation

Notes

Fishing is a rare activity only for domestic purpose.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola	Location ID	B18+S18	
Surveyor	A.H. Dissanayake	Date	2013	08 28
DS Division	uda Palatha	GN Division	Egoda Kalugamuwa	1159
Location Name	No. 8 thotupala			

GPS

N	223308
E	181402

Type of activity

Business

Sand mining	✓
Fishing	✓
Irrigation	
Industry	

Other : ....

Cultural

Bathing & Washing	✓
Camping	
Swimming	

Other : ....

Key Informant

Name	M.L.M. Haneefa
Address	479/3, kalugamuwa, Gelioya.
Telephone	-

Number of users (Families)

Dry Season	60
Wet Season	40

Any effect of Kotmale HPP operation

Notes

sand mining workers - 02 Nos.
Fishing is very rare activity.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola	Location ID	B19	
Surveyor	C. Aberathne	Date	2013	08	28
DS Division	uda palatha	GN Division	Egoda Kalugamuwa	1159
Location Name	Bangalathota (near pipe bridge)			

GPS

N	222935
E	181583

Type of activity

Business

- Sand mining [ ]
- Fishing [ ]
- Irrigation [ ]
- Industry [ ]
- Other : ....

Cultural

- Bathing & Washing [✓]
- Camping [ ]
- Swimming [ ]
- Other : ....

Key Informant

Name	S.M. Waseem
Address	454, Kalugamuwa, Gelioya.
Telephone	

Number of users (Families)

Dry Season	100
Wet Season	60

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola	Location ID	S 19
Surveyor	A.H. Dissanayake	Date	2013 09 13
DS Division	Uda Palatha	GN Division	Egoda Kalugamuwa 1159
Location Name	Kottunna thotupala.		

GPS

N	221521
E	181158

Type of activity

Business		*Cultural*	
Sand mining	✓	Bathing & Washing	
Fishing			
Irrigation		Camping	
Industry		Swimming	
Other :		Other :	

Key Informant

Name: O.L.M. AZAM

Address: Elpitiya, weligalla.

Telephone: –

Number of users (Families)

Dry Season: –

Wet Season: –

Any effect of Kotmale HPP operation

Notes

Sand mining workers - 02 Nos. approx.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola	Location ID	B 20	
Surveyor	A.H. Dissanayake	Date	2013	09 / 13
DS Division	uda Palatha	GN Division	udo wita	1125
Location Name	Elpitiya - 01			
GPS	N	221247		
	E	181178		

Type of activity

Business		***Cultural***	
Sand mining		Bathing & Washing	✓
Fishing	✓		
Irrigation		Camping	
Industry		Swimming	
Other :		Other :	

Key Informant

Name	T.G.N. Bandara
Address	391 A, Elpitiya, weligalla
Telephone	077 7963279

Number of users (Families)	Dry Season	08
	Wet Season	03

Any effect of Kotmale HPP operation

Notes

Fishing is rare activity in this place in minor scale.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola	Location ID	B 21	
Surveyor	C. Aberathne	Date	2013	09 / 13
DS Division	Uda Palatha.	GN Division	Udowita	1125
Location Name	Elpitiya-02			

GPS

N	221241
E	181228

Type of activity

Business

Sand mining	
Fishing	✓
Irrigation	
Industry	

Other : ....

Cultural

Bathing & Washing	✓
Camping	
Swimming	

Other : ....

Key Informant

Name: T. G. N. Bandara

Address: 391 A, Elpitiya, Weligalla.

Telephone: 077 7963279

Number of users (Families)

Dry Season	5
Wet Season	2

Any effect of Kotmale HPP operation

Notes

Very occational fishing activity.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola.	Location ID	B 22	
Surveyor	A.H. Dissanayake	Date	2013	09 / 13
DS Division	Uda Palatha	GN Division	Udowita	1125
Location Name	Elpitiya -03			

GPS

N	220905
E	181334

Type of activity

Business		***Cultural***	
Sand mining		Bathing & Washing	✓
Fishing			
Irrigation		Camping	
Industry		Swimming	
Other :		Other :	

Key Informant

Name	S.H.D. Ruwankumara
Address	280/48/1, Elpitiya, Weligalla.
Telephone	–

Number of users (Families)

Dry Season	20
Wet Season	08

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola	Location ID	S 20	
Surveyor	A.H. Dissanayake	Date	2013	09 / 13
DS Division	Uda Palatha	GN Division	Udowita	1125
Location Name	Wali ullah Pallithota, Elpitiya			

GPS

N	220776
E	181259

Type of activity

Business		***Cultural***	
Sand mining	✓	Bathing & Washing	
Fishing	✓		
Irrigation		Camping	
Industry		Swimming	
Other :		Other :	

Key Informant

Name	M. Irfam
Address	380/2/1, Elpitiya, Weligalla.
Telephone	0770501051

Number of users (Families)

Dry Season	-
Wet Season	-

Any effect of Kotmale HPP operation

Notes

Fishing is done as hobby and rarely. 03 workes involved in sand mining.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola	Location ID	B23 + S21	
Surveyor	C. Aberathne	Date	2013	09 / 13
DS Division	uda palatha	GN Division	udowita	1125
Location Name	Pussathota, udowita.			

GPS

N	220595
E	181017

Type of activity

Business

Sand mining	✓
Fishing	
Irrigation	
Industry	

Other : ....

Cultural

Bathing & Washing	✓
Camping	
Swimming	

Other : ....

Key Informant

Name: D. Dehideniya.

Address: Elpitiya, Weligalla, Gampola.

Telephone: -

Number of users (Families)

Dry Season	10
Wet Season	05

Any effect of Kotmale HPP operation

Notes

Sand mining workers - 02 NOS. approx.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/3 Gampola	Location ID	B24+S22		
Surveyor	C. Aberathna	Date	2013	09	13
DS Division	Uda Palatha	GN Division	Udowita	1125	
Location Name	Pussangolla				

GPS

N	219 888
E	180 279

Type of activity

Business

- Sand mining ✓
- Fishing
- Irrigation
- Industry
- Other : ....

Cultural

- Bathing & Washing ✓
- Camping
- Swimming
- Other : ....

Key Informant

Name	P. D. A. B. Gunarathne
Address	"Asiri", Udowita, Weligalla.
Telephone	-

Number of users (Families)

Dry Season	30
Wet Season	15

Any effect of Kotmale HPP operation

Notes

Approx. 04 workers involved in sand mining activity.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola	Location ID	B25 + S23
Surveyor	A.H. Dissanayake	Date	2013 / 09 / 13
DS Division	UDA PALATHA	GN Division	Bothalapitiya / 1109
Location Name	Jayasengama, Paruthota		
GPS	N 219 141		
	E 178 745		

Type of activity

Business

Sand mining	✓
Fishing	✓
Irrigation	
Industry	
Other :	

Cultural

Bathing & Washing	✓
Camping	
Swimming	
Other :	

Key Informant

Name	MS. K.G. Sriyani
Address	21/51, Bothalapitiya, Gampola.
Telephone	–

Number of users (Families)

Dry Season	10
Wet Season	02

Any effect of Kotmale HPP operation

Notes

Fishing is a rare activity in this place done as a hobby. Approximately 5 workers involve in sand mining.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola	Location ID	B 26
Surveyor	C. Abevathne.	Date	2013 09 13
DS Division	UDA PALATHA	GN Division	ILLAWATURA 1110
Location Name	ILLAWATURA - 01		
GPS	N 218437		
	E 178198		

Type of activity

Business

Sand mining	
Fishing	✓
Irrigation	
Industry	

Other : ....

Cultural

Bathing & Washing	✓
Camping	
Swimming	

Other : ....

Key Informant

Name	M.J.M. ASHFER
Address	79, ILLAWATURA, GAMPOLA
Telephone	—

Number of users (Families)

Dry Season	10
Wet Season	3

Any effect of Kotmale HPP operation

Notes

Fishing is rare activity only as a hobby who done for individual use.

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola		Location ID	B 27	
Surveyor	A.H. Dissanayake		Date	2013	09 / 13
DS Division	UDA PALATHA	GN Division	ILLAWATURA	1110	
Location Name	ILLAWATURA -02				

GPS

N	218220
E	178392

Type of activity

Business

- Sand mining [ ]
- Fishing [ ]
- Irrigation [ ]
- Industry [ ]
- Other : ....

Cultural

- Bathing & Washing [✓]
- Camping [ ]
- Swimming [ ]
- Other : ....

Key Informant

Name	A. Amanulla
Address	12/2B, ILLAWATURA GAMPOLA
Telephone	0779196220

Number of users (Families)

Dry Season	10
Wet Season	5

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola	Location ID	B 28	
Surveyor	C. Aberathne	Date	2013	09	13
DS Division	UDA PALATHA	GN Division	ILLAWATURA	1110

Location Name: ILLAWATURA - 03

GPS

N	218280
E	178350

Type of activity

Business

- Sand mining ☐
- Fishing ☐
- Irrigation ☐
- Industry ☐
- Other : ....

Cultural

- Bathing & Washing ☑
- Camping ☐
- Swimming ☐
- Other : ....

Key Informant

Name: A. Amanulla.

Address: 12/2B, ILLAWATURA GAMPOLA

Telephone: 0779196220

Number of users (Families)

Dry Season	20
Wet Season	10

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola	Location ID	B 29		
Surveyor	A.H. Dissanayake	Date	2013	09	13
DS Division	UDA PALATHA	GN Division	ILLAWATURA	1110	
Location Name	ILLAWATURA - 4				

GPS

N	218 162
E	178 387

Type of activity

Business

Sand mining	
Fishing	
Irrigation	
Industry	

Other : ....-...........

Cultural

Bathing & Washing	✓
Camping	
Swimming	

Other : ....-..........

Key Informant

Name	MTM IKBAL
Address	13/12, ILLAWATURA, GAMPOLA
Telephone	-

Number of users (Families)

Dry Season	15
Wet Season	10

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola	Location ID	B 30
Surveyor	C. Aberathne.	Date	2013 / 09 / 13
DS Division	UDA PALATHA	GN Division	ILLAWATURA / 1110
Location Name	ILLAWATURA - 5		
GPS	N 218154		
	E 178375		

Type of activity

Business

- Sand mining ☐
- Fishing ☐
- Irrigation ☐
- Industry ☐
- Other : ....

Cultural

- Bathing & Washing ☑
- Camping ☐
- Swimming ☐
- Other : ....

Key Informant

Name	M.T.M. IKBAL
Address	13/12, ILLAWATURA, GAMPOLA
Telephone	—

Number of users (Families)

Dry Season	18
Wet Season	07

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola	Location ID	B 31	
Surveyor	A.H. Dissanayake	Date	2013	09 / 13
DS Division	UDA PALATHA	GN Division	ILLAWATURA	1110
Location Name	ILLAWATURA -6			

GPS

N	218090
E	178301

Type of activity

Business

Sand mining	
Fishing	
Irrigation	
Industry	

Other : ....

Cultural

Bathing & Washing	✓
Camping	
Swimming	

Other : ....

Key Informant

Name	M. NAZEER
Address	56/37, ILLAWATURA, GAMPOLA
Telephone	–

Number of users (Families)

Dry Season	25
Wet Season	05

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola	Location ID	B-32
Surveyor	A.H. Dissanayake.	Date	2013 09 13
DS Division	UDA PALATHA	GN Division	ILLAWATURA 1110
Location Name	ILLAWATURA - 07		

GPS

N	218 080
E	178 250

Type of activity

Business		***Cultural***	
Sand mining		Bathing & Washing	✓
Fishing			
Irrigation		Camping	
Industry		Swimming	
Other :		Other :	

Key Informant

Name	M N M NAVAZ
Address	52, ILLAWATURA GAMPOLA
Telephone	–

Number of users (Families)

Dry Season	30
Wet Season	10

Any effect of Kotmale HPP operation

People have the feeling of water level fluctuations with times. In extream case relevant authorities & institutions disseminate the message of warning.

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola	Location ID	B 33	
Surveyor	C. Aberathne	Date	2013	09 / 13
DS Division	UDA PALATHA	GN Division	ILLAWATURA	1110

Location Name: ILLAWATURA - 08

GPS

N	218053
E	178196

Type of activity

Business

- Sand mining ☐
- Fishing ☐
- Irrigation ☐
- Industry ☐
- Other : ....-...............

Cultural

- Bathing & Washing ☑
- Camping ☐
- Swimming ☐
- Other : ....-...............

Key Informant

Name: M.S.M. ASVIN

Address: 56/8, ILLAWATURA, GAMPOLA

Telephone: -

Number of users (Families)

Dry Season	15
Wet Season	05

Any effect of Kotmale HPP operation

Notes

DOWN STREAM RIVER USERS SURVEY - MORAGOLLA HPP

Map Number	61/8 Gampola	Location ID	B 34		
Surveyor	A.H. Dissanayake	Date	2013	09	13
DS Division	UDA PALATHA	GN Division	ILLAWATURA	1110	
Location Name	ILLA WATURA - 9				

GPS

N	218 057
E	178 117

Type of activity

Business

Sand mining	
Fishing	
Irrigation	
Industry	

Other : ……………………

Cultural

Bathing & Washing	✓
Camping	
Swimming	

Other : ……………………

Key Informant

Name	J.A. GAFUR
Address	17/48, ILLAWATURA, GAMPOLA
Telephone	–

Number of users
Families.

Dry Season	15
Wet Season	05

Any effect of Kotmale HPP operation

With the long term experiance, people know the water level fluctuations well.

Notes

All houses nearby to this place have water connections from NWS & DB.

Moragolla Hydropower Project

Additional Studies in the Natural Environment: Expert Report on Mitigating the Impacts of the Moragolla Hydropower Project on Fish

FINAL REPORT

August 2013

IUCN - International Union for Conservation of Nature, Sri Lanka Country Office

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ABBREVIATIONS

CEB	–	Ceylon Electricity Board
CR	–	Critically Endangered
DWC	–	Department of Wildlife Conservation
EIA	–	Environmental Impact Assessment
EN	–	Endangered
FD	–	Forest Department
IUCN	–	International Union for Conservation of Nature
LC	–	Least Concern
MASL	–	Mahaweli Authority of Sri Lanka
MHP	–	Moragolla Hydropower Project
NBRO	–	National Building Research Organization
NK	–	Nippon Koei Co. Ltd
NT	–	Near Threatened
VU	–	Vulnerable

EXECUTIVE SUMMARY

The proposed Moragolla Hydropower Project (MHP) involves the construction of a 35 m high concrete gravity dam (with a 5-gate spillway) across the Mahaweli Ganga at Weliganga, to create a 38.5 ha, reservoir with a Full Supply Level (FSL) of 548 m asl. Water will be diverted through a conveyance system to the powerhouse, while the outfall is located opposite the confluence with Atabage Oya.

The main objective of the study is to identify the critical freshwater species that occur in project area and to propose a plan to mitigate the impacts of the MHP on the fish fauna of the area. The EIA report for the MHP reported a total of 12 fish species from the project area. Additional studies on the aquatic ecology of the area indicate the existence of a total of 47 fish species from Moragolla downstream up to the Polgolla dam near Katugasthota (NBRO, 2013). According to these reports, 14 endemic fish species are found in the area.

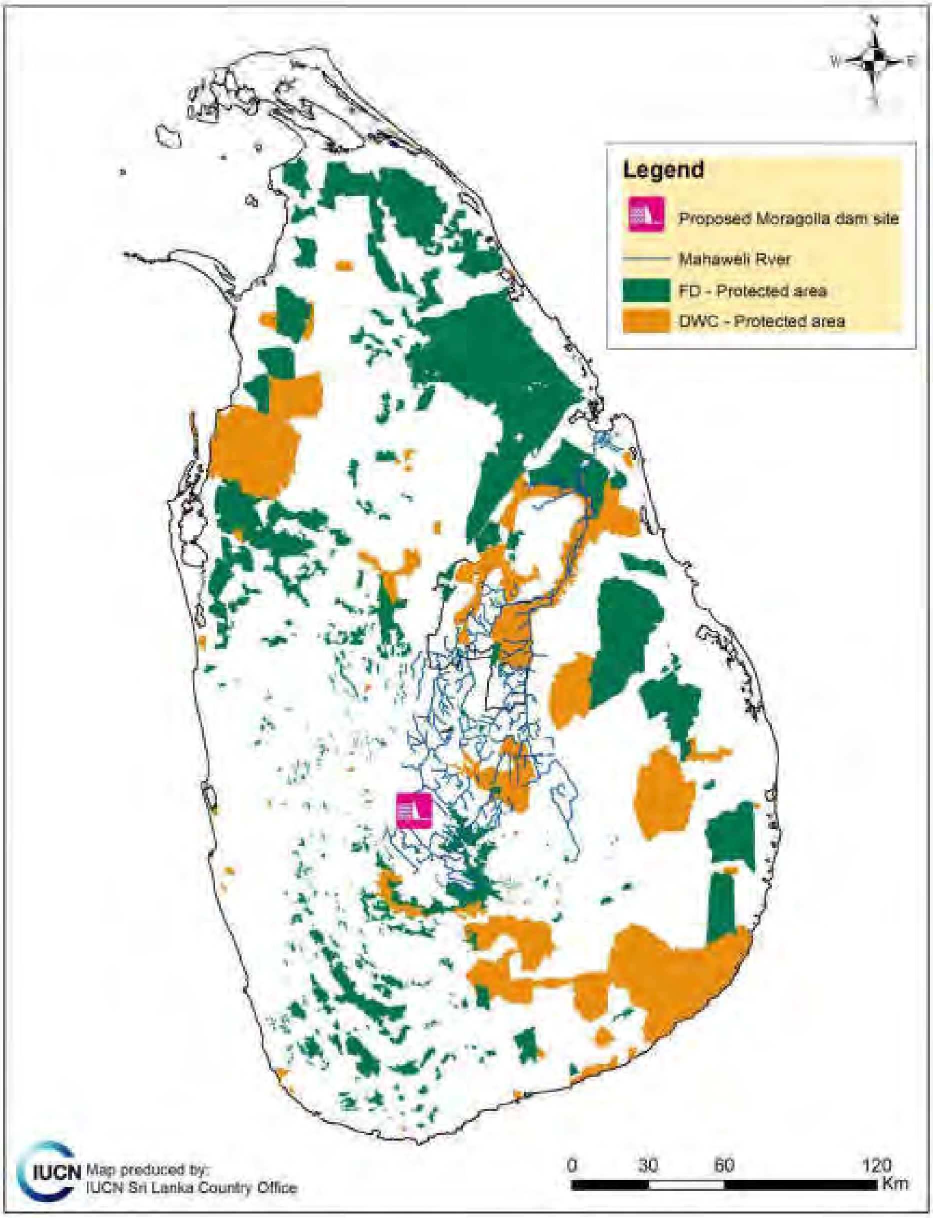
A points-based system was developed to identify critical fish species that will be impacted by the project. As part of this activity indigenous fish were categorized into three groups - low priority, moderate priority and high priority. *Labeo fisheri* (Mountain labeo) is categorized as a high priority species that can be affected significantly due to the project. A mitigation plan highlighting the importance of translocating the Moragolla population of *L. fisheri* to the Kelani River basin has been proposed. Although two catadromous fish species - *Anguilla bicolour* (Level-finned eel) and *Anguilla nebulosa* (Long-finned eel) - have been recorded by NBRO (2013), a recovery plan was not proposed for these species after careful consideration of relevant factors.

The impacts of the MHP on the fish fauna of the area have been identified, while a mitigation plan has been developed in order to facilitate minimization of these impacts. Some of the mitigation measures proposed in the Terms of Reference (ToR) for the assignment have been rejected after careful consideration of the relevant ground realities. A habitat management plan for the upper catchment of the Mahaweli River, up to Nawalapitiya, is proposed in order to provide offset habitat protection.

1. INTRODUCTION

1.1 Background

The Ceylon Electricity Board (CEB) is planning to develop a 30.8 MW hydropower project in Moragolla, Sri Lanka. The proposed Moragolla Hydropower Project (MHP) is located in the Kandy District of the Central Province. The project involves the construction of a 35 m high concrete dam across the Mahaweli River at Weliganga, resulting in the formation of a 38.5 ha reservoir with a Full Supply Level (FSL) of 548 m asl.



Map 1. Location of the Moragolla Hydropower Project

Map 2. Land use map of the project area.

The water diverted from this reservoir will be transported through a conveyance system to the power house, which is located three and a half kilometres downstream of the proposed dam. The water discharge point is located near Ethgala and the Atabage sub-catchment of the Mahaweli River. The Kotmale power station using water diverted from Kotmale Oya, one of the main sub-catchments of the Mahaweli River, also discharges in to the main river system very close to the tailrace outlet of the proposed power station.

The Mahaweli River (known locally as Mahaweli Ganga) is the longest river in Sri Lanka, and consists of a catchment that is 10, 448 km^2 in area, draining almost 16 percent of the total land area of Sri Lanka, and discharging 4, 009 million cubic meters of water per year (Survey Department of Sri Lanka, 2012). The Mahaweli River is also the most important river in Sri Lanka from an economic perspective. The largest integrated agricultural, hydro-electricity and rural development programme ever undertaken in Sri Lanka is based on the water resources of the Mahaweli River basin. According to the 2010 Annual Report of the Ceylon Electricity Board, the Mahaweli complex contributed 22.8 percent of the total power generation of the network. Water from the Mahaweli River has fed many thousands of hectares of agricultural land in many districts in northern Dry Zone of the country since the diversion of the Mahaweli River at Polgalla in 1976.

In addition to its social and economic significance, the Mahaweli River basin is of great environmental and ecological significance. The Mahaweli River crosses the entire central mountain area with its unique drainage pattern, and flows through many protected areas spanning from Horton Plains National Park located in the third peneplain to Flood Plains National Park located in the first peneplain, passing number of other protected areas, such as the Knuckles Conservation Forest of the Central Highlands World Heritage Site, the Hakgala Strict Nature Reserve, Somawathiya National Park, the Victoria-Randenigala-Rantambe Sanctuary and the Wasgamuwa National Park on its way to the discharge point located in Trincomalee. Further, the Mahaweli River supports some of the unique faunal species of Sri Lanka, including several species of freshwater fish, such as *Dawkinsia srilankensis*[1] (Sri Lanka blotched filamented barb), *Systomus martenstyni*[1] (Martenstynis barb), *Labeo fisheri* (Mountain labeo), *Labuca insularis* (Knuckles labuca) and *Devario aequipinnatus* (Knuckles danio), that are found only in the Mahawali River and its tributaries. Likewise, the endemic freshwater crab, *Ceylonthelphusa durrelli* is also restricted to the tributaries of the Mahaweli River that flow through Cobert's Gap. Further, several terrestrial faunal species endemic to Sri Lanka, such as *Ceratophora tennentii* (Leaf-nosed lizard), *Cophotis dumbara* (Knuckles pygmy lizard) and *Nannophrys marmorata* (Kirtisinghe's rock frog), are found only within the Mahaweli River basin.

As such, it was necessary to conduct an environmental Feasibility Study, including an Environmental Impact Assessment (EIA), for the proposed project – which is based within the Mahaweli River basin – in 2009. This was followed by a supplementary assessment of the aquatic ecology of the area in 2013 by the National Building Research Organization (NBRO) in order to investigate the aquatic species and habitats present in the site, and the ways in which they would be impacted by the project. Given that these studies indicated the presence of some threatened fish species in the project area, an additional study on the mitigation of the impacts of the project on the fish fauna of the area has been deemed necessary in order to assist Nippon Koei Co. Ltd. (NK) in planning such mitigation measures, as well as to provide the CEB with information necessary for key decision making processes. The present study has been designed to address this need.

[1] Formally considered to belong to the Genus *Puntius.*

1.2 Objectives

The overall objective of the study is to propose a plan for the mitigation of ecological impacts of the Moragolla Hydropower Project on the fish fauna of the area.

The specific objectives of the study are:

- To provide an overview of the fish fauna of the Mahaweli River and the impacts of hydropower and other development projects on these species;
- To provide data on the fish species found in the project area and their importance both locally, and from national and global conservation perspectives;
- To provide information on the natural history, ecology, distribution and *ex-situ* conservation of all Critically Endangered (CR), Endangered (EN), Vulnerable (VU) and Near Threatened (NT) fish species recorded in the project area;
- To analyse the potential impact of the MHP on the fish fauna of the area during the construction period, as well as the operational period, of the MHP; and
- To propose recommendations for the mitigation of impacts on fish due to the MHP.

2. Methodology and approach

This report is based primarily on the findings of the Moragolla Hydropower Project Feasibility Study: Volume 3 - Environmental Impact Assessment (EIA) compiled by the CECB and ACO (2012), and the report on the Aquatic Ecology of the Mahaweli River (NBRO, 2013). The list of fish species recorded in the area (see Annex 2 and 3) has been obtained from these two reports, and it is assumed that all species listed in these reports occur within project site.

A brief field visit was also undertaken by the IUCN team between 21 and 22 August, 2013, in order to ascertain the ground situation in the area, and gain better insights into the relevant technical reports. Further this short field visit helped to gain a better understanding of the impact of the project on the fish fauna of the area. This has aided the development of the proposed impact mitigation plan and the translocation plan.

In addition, a comprehensive literature survey was carried out to gather necessary information and analyse these technical reports, in order to compile the present report on the impacts of the project on fish and to develop and provide suitable recommendations for the mitigation of impacts of the MHP on the fish fauna of the area.

The Terms of Reference (ToR) for the study (see Annex 6), states that all threatened – Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) species - and Near Threatened (NT) species should be considered as critical species for the purpose of the study. However it should be noted that each of these species will be affected by the construction of the Moragolla dam differently. As such, the priority species that will be impacted by project activities should be identified and mitigation measures should be developed for these species, in order to better utilize the limited funds available for environmental impact mitigation.

As such, a set of criteria were developed in order to identify priority species relevant to the MHP. Six critical factors were considered in the development of these criteria, and a points-based system was developed in order to rank and select priority species objectively. It should be noted that only native species were considered during this analysis. The criteria used and details of the scoring system are as follows:

1. **Status of the species**: native but recent introduction to area (0), Indigenous (+1), Endemic (+2);

2. **Distribution**: Island wide (0), Mahaweli basin and Dry Zone (+1), Mahaweli basin and Wet Zone (+2), Mahaweli basin only (+3);

3. **Impact to species due to the proposed reservoir/dam:** Positive (-3), Low negative (+3), High negative (+5); no impact (0);

4. **Conservation status (based on the National Red List 2012 of Sri Lanka):** LC (0), NT (+1), DD (+2), VU (+2), EN (+4), CR (+6);

5. **Generalist or specialist** with respect to reproduction, habitat and feeding habits: generalist (0), specialist (+1); and

6. **Captive breeding**: successfully bred species (0), hard to breed (+1), captive breeding not successful (+2).

Two of the criteria used to identify priority species – conservation status and impact to the species due to construction – were identified as the most crucial factors that should be considered in the evaluation of species. Conservation status was identified as a most important factor when considering the concept of a critical habitat, as defined in the ADB Safeguard Policy. Similarly, the impact of the project on each species is also identified as significant with regard to the concept of a critical habitat as defined by the ADB (2009). Therefore, relatively high scores were given to threatened species, and species that are likely to be impacted negatively as a result of the project.

According to this points-based system, each species could, potentially, get a maximum score of 18 points. Therefore, scores were grouped into three categories by dividing the maximum score (18) by three, and allocating each species to a group based on its score. These groups are: (i) High priority group (12 to 18 points), (ii) moderate priority group (6 to 11.9 points) and (iii) low priority group (0 to 5.9 points).

Based on this evaluation the native fish fauna of the MHP area were classified under three groups

(i) High priority group;

(ii) Moderate priority group; and

(iii) Low priority group.

The cut off points used to assign fish into these three groups is presented in the table below.

Table 1. The cut of points used in the prioritization process.

Priority group	Points
High priority	12 to 18
Moderately priority	6 to 11.99
Low priority	0 to 5.99

Detailed profiles of the priority species identified using these criteria, including information on their conservation status, distribution, ecology, breeding season and captive breeding, along with distribution maps, were then prepared.

Similarly, the major potential impacts of the construction and operational elements of the MHP were identified, with management recommendations for the mitigation of these impacts, and the conservation and recovery of these species, being developed for these priority species.

Nomenclature and classification of freshwater fish was based on Goonatilake (2012), Pethiyagoda *et al.* (2012), Pethiyagoda *et al.* (2008), Deraniyagala (1952), Senanayake (1980) and Pethiyagoda (2001) for the purpose of the study. These sources were also used to compile data and information on the distribution, ecology, habitat, reproduction and captive breeding of each fish species. Critical habitats for each species were analysed based on the ADB (2009) Safeguard Policy Statement. The mitigation and conservation management plan was developed based on previous relevant experience (IUCN, 2007), and other relevant sources (Cowx and Welcomme, 1998). Information on the conservation status and endemicity of fish was based on Goonatilake (2012).

3. Discussion

3.1 Ecology

3.1.1 Fish fauna of the Mahaweli River basin

A total of 47 species of freshwater fish have been recorded from the entire Mahaweli River basin (Senanayake 1981; Pethiyagoda, 1991). A total of 23 of these species are considered to be endemic to Sri Lanka, while five of these species - *Labeo fisheri* (Sri Lanka mountain labeo), *Dawkinsia srilankensis*[2] (Sri Lanka blotched filamented barb), *Systomus martensytyni* (Sri Lanka Martenstyn's barb)[2], *Laubuca insularis* (Sri Lanka Knucles laubuca) and *Devario cf. aquipinatus* (Sri Lanka Knuckles danio) - are endemic to the Mahaweli River basin, specifically (see Annex 1). These species - apart from *Labeo fisheri* - are restricted to the Knuckles sub-catchment (Kalu Ganga Valley) of Mahaweli River. Due to the significance of the fish distribution pattern and endemism, the Mahaweli River basin is considered to be a discrete ichthilological province within Sri Lanka (Senanayake, 1980). The Mahaweli basin is further sub-divided in to three zones from an icthyological perspective (see Map 3):

1. The wet part of the Mahaweli River, which flows through the second and third Peneplains;

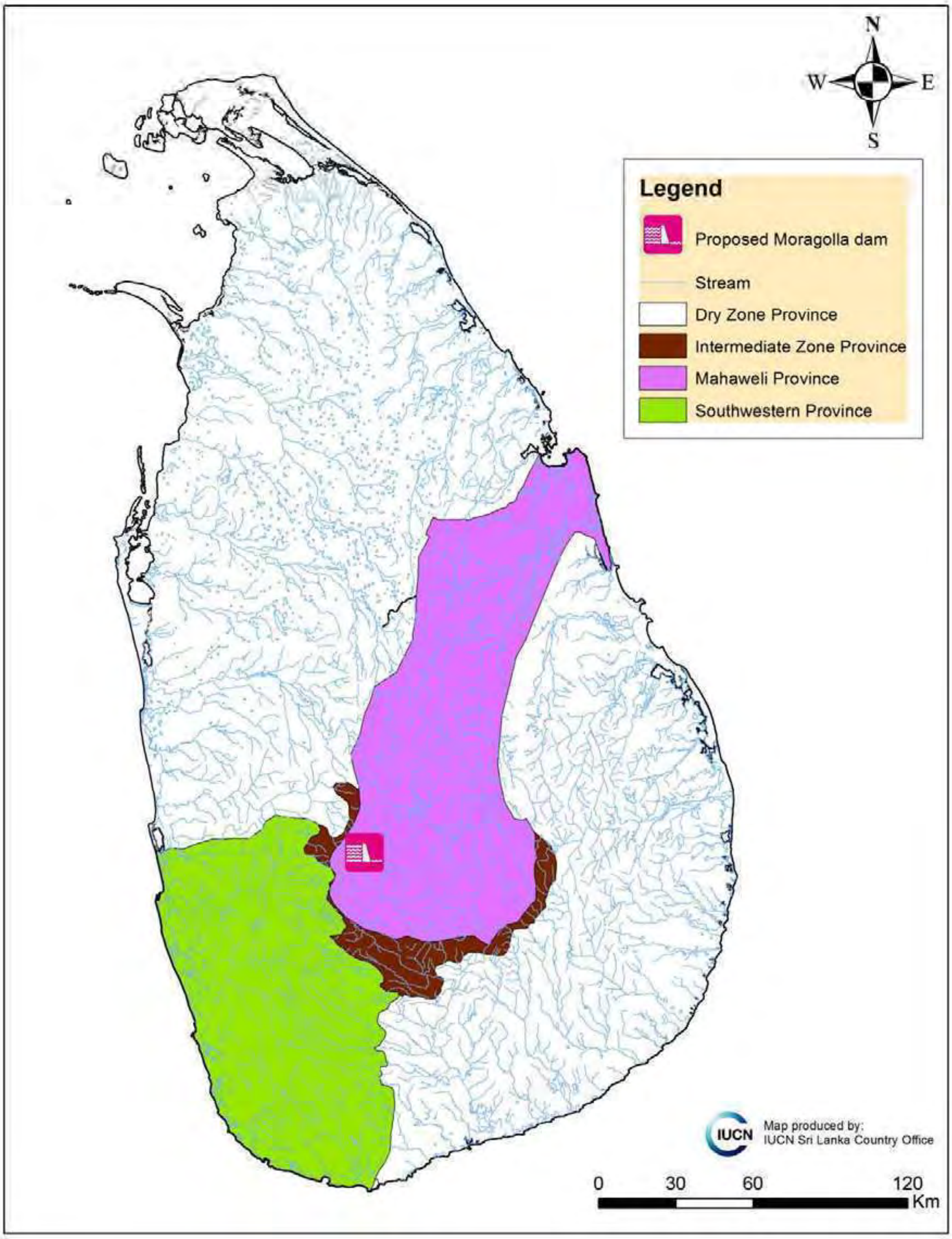
2. The dry part of the Mahaweli River, which flows through the first peneplain; and

3. The Knuckles sub-catchment, which consists of tributaries of Amban Ganga and Kalu Ganga.

The taxonomy of freshwater fish in Sri Lanka has changed significantly over the last few years (Goonatilake, 2012) and it is likely that there will be further taxonomic changes in the near future. It is likely that these changes will result in revisions to present knowledge on the distribution and endemicity of some species, and may include additions to the list of freshwater fish species found in the Mahaweli River basin.

In addition to these fish species, four endemic freshwater fish species, *Pethia nigrofasiata*[3] (Sri Lanka black ruby barb), *Pethia reval*[3] (Sri Lanka red-finned barb), *Rasboroides vateriflorис* (Sri Lanka golden rasbora) and *Puntius titteya* (Sri Lanka cherry barb), which were restricted to the southwestern ichthyological province were introduced to the Mahaweli River basin near Ginigathhena, which is located upstream of Moragolla, by Senanayake and Moyle in 1982. These introductions were made in an effort to conserve these species.

[2] Formally considered to belong to the Genus *Puntius.*
[3] Formally considered to belong to the Genus *Puntius.*



Map 3: Ichthyological zones within Sri Lanka

3.1.2 A general overview of the impacts of hydropower and other development activities on the fish of the Mahaweli River

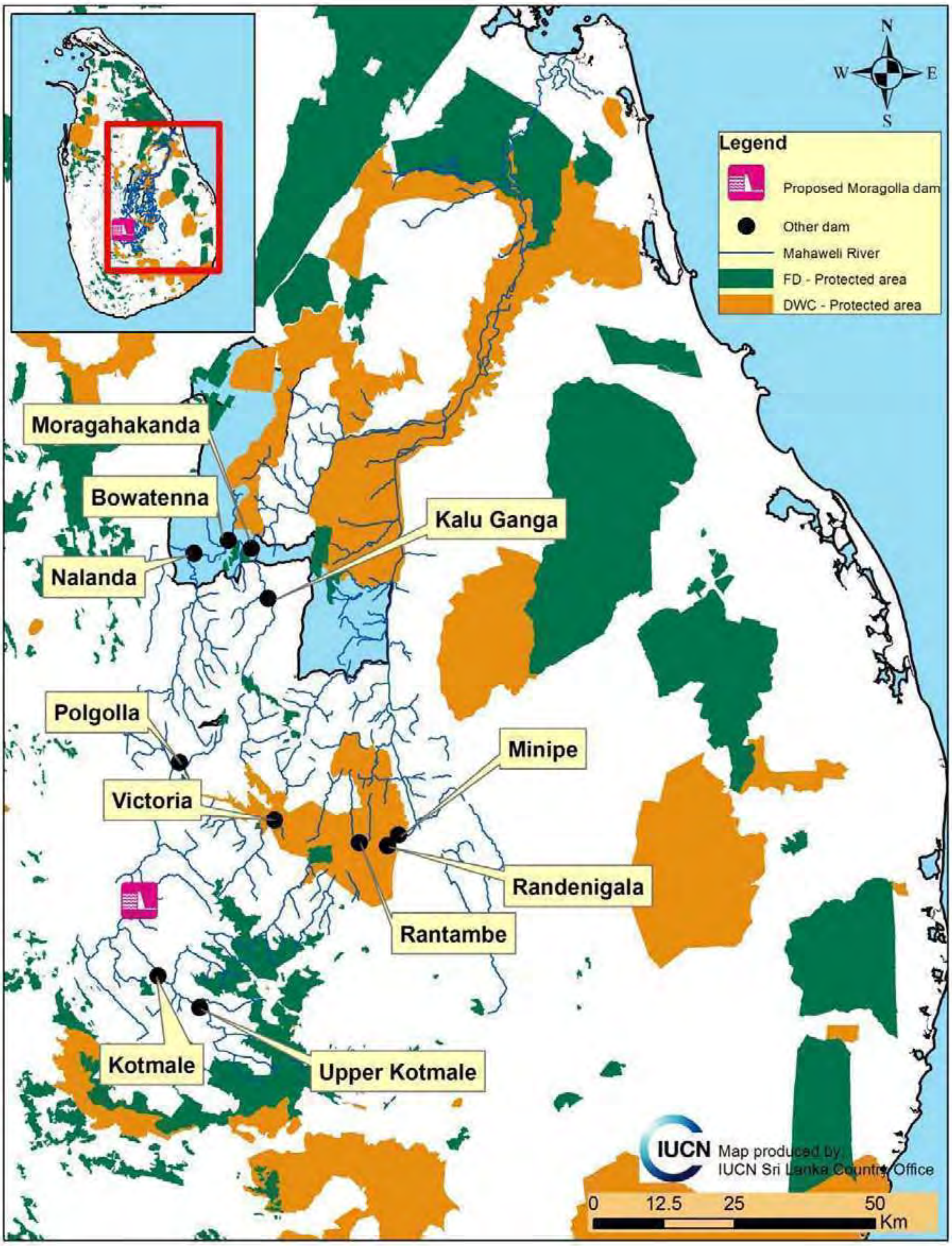
Among the vertebrate taxa of Sri Lanka, freshwater fish are one of the most severely affected vertebrate taxa with respect to past, and ongoing, development projects (Pethiyagoda, 1999; Senanayake and Moyle, 1982). Most of the endemic and threatened freshwater fish in Sri Lanka occur in the southwestern ichthyological zone and the wet part of the Mahaweli River basin. The population densities of these areas are considered to be immensely high, with less than two percent of the land area of the wet zone having natural forest, which can be considered as prime habitat for most of endemic fish species (Pethiyagoda, 1999). Further, many sub-populations of endemic and threatened freshwater fish are found outside the protected area network. The fish of the Mahaweli River have also been impacted due to various factors, including Mahaweli hydropower and agricultural extension projects, and other infrastructure developments in the area.

Dams, reservoirs and water diversion

Dams and reservoirs are irreversible physical changes, which can affect some fish species adversely, but can also benefit some species. Dams block the natural flow of river systems, which impacts migratory fish species, such as *Anguilla bicolour* (Level-finned eel) and *Anguilla nebulosa* (Long-finned eel), significantly. Further, dams affect the local movements of fish, and subsequently stop the free exchange of genes among populations, resulting in the fragmentation of populations (see Annex 5 for a full list of possible impacts resulting from dams). The Mahaweli River has been blocked in such ways at many points in the past, and further blockages can be expected in future, including the MHP.

Many authors have highlighted the links between the decline of *Labeo fisheri* and the dams found within the Mahaweli River basin (Wikramanayake, 1990, Pethiyagoda, 1999 Shirantha 2012). The proposed Kalu Ganga and Moragahakanda reservoirs are also being constructed at present, with direct implications for other endemic species, such as *Dawkinsia srilankensis*[3] (Sri Lanka blotched filamented barb), *Systomus martensytyni*[3] (Sri Lanka Martenstynis barb), *Laubuca insularis* (Sri Lanka Knuckles laubuca), in addition to *Labeo fisheri* (Sri Lanka mountain labeo).

Constructing dams for river diversion also results in low flows in the river downstream of the dam site, making the habitat unsuitable for many species. Further changes in the flow regime of the river due to river diversion may also impact the life cycles of some aquatic species such as aquatic insects and some freshwater fish species, including *Labeo fisheri* (Sri Lanka mountain labeo), that require seasonal floods to trigger some aspects of their life cycles such as moulting or breeding (triggering flows). Further, low flows will also result in changes in the river geomorphology and the resultant changes in the channel structure will result in changes to the aquatic habitats in the areas where such low flows occur (absence of channel maintenance flows). Therefore, it has become compulsory for river diversion projects to release an environmental flow to meet such ecological demands. However, in practice, most development products fail to release adequate flows or comply with even the flows prescribed by the project approving agencies.



Map 4. Dams and reservoirs within the Mahaweli River system, including the proposed Moragolla, Kalu Ganga and Moragahakanda dams.

Deforestation

Deforestation affects fish – both directly and indirectly - in numerous ways. The removal of natural vegetation leads to soil erosion and siltation, which result in changes to the physical and chemical conditions of rivers. Biological changes associated with these physical and chemical changes are then often observed. For instance, silt accumulates in rivers following deforestation, resulting in rocks and other substrate being covered in a layer of silt. As a consequence, the algae found usually on this substrate are lost, which has a profound impact on species, such as *Labeo fisheri* (Sri Lanka mountain labeo) and *Garra ceylonenis* (Sri Lanka stone sucker), that feed exclusively on the algae found on the substrate. Many of the freshwater fish species found in Sri Lanka, especially the endemic species, live in clear water, and rapid declines of the populations of these species are expected due to excessive siltation (Pethiyagoda, 1999; Senanayake, 1980). The clearance of river bank vegetation also impacts shade-loving species, such as *Pethia nigofasciata*[4] (Sri Lanka black ruby barb) and *Belontia signata* (Sri Lanka combtail), directly, through the loss of suitable shade conditions.

Agricultural extensions projects and agro-chemicals

The entire upper Mahaweli catchment, with only a few exceptions such as Horton Plains National Park, is occupied by agricultural lands. These agricultural lands include tea estates and highland vegetable plots, which require large amounts of agro-chemicals (Pethiyagoda, 1999). Although the impacts of agrochemicals on the freshwater fish of Sri Lanka have not been documented at present, a number of major impacts – both direct and indirect – are expected. Further, agriculture also contributes to soil erosion, which impacts river systems and fish directly.

Introduction of exotic fishes in to reservoirs within the Mahaweli system

According to Petr.(ed) 1985 3,538.7 ton per annum were estimated Mahaweli reservoirs and this catch totally depends on exotic species. Exotic fish species, such as *Labeo rohita* (Rohu), *Catla catla* (Indian carp), *Oreochormis* spp. (Tilapia) and *Cyprinus carpio* (Common carp), have been introduced to several reservoirs within the Mahaweli system in order to develop the inland freshwater industry in these areas. Some of these species, including *Labeo rohita* (Rohu) *and Cyprinus carpio* (Common carp), are direct competitors of indigenous species such as *Labeo fisheri* (Sri Lanka mountain labeo), *Labeo dussumieri* (Common labeo) and *Labeo lanke* (Sri Lanka orange fin labeo). Although almost all the exotic fish species introduced to these reservoirs are either herbivorous or omnivorous, studies have shown that the introduction of such species has impacted native fish species negatively (Pethiyagoda, 1999). For example, tilapia is a resilient species that breeds throughout the year. Their breeding success is very high compared to that of native species, and as such, this species has become dominant in a diverse range of habitats, including tanks, slow flowing rivers and reservoirs, depriving native species of the resources they require. Intensive fishing practices introduced with the introduction with exotic species have also resulted in increased fishing pressure on native species in the Mahaweli basin, leading to a decline of these native species (Pethiyagoda, 1999).

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[4] Formally considered to belong to the Genus *Puntius*.

3.1.3 Fish fauna of the project area

A total of 12 fish species are reported from the Moragolla project area in the EIA report for the MHP. In contrast to the EIA report, additional studies on aquatic ecology of the project site conducted by the NARA has listed a total of 47 fish species within the project area and downstream areas up to Polgolla dam near Katugasthota. Out of these 47 species, only 14 are recorded in the Moragolla project area are considered to be endemic to Sri Lanka. In addition, a total of eight exotic fish species are also reported from the project site.

A summary of the threatened and Near Threatened (NT) fish species recorded within the Moragolla project area is presented in the table below.

Table 2. Summary of the threatened and Near Threatened (NT) fish species recorded within the Moragolla project area.

(CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened)

Red List	Number of species found under each conservation status			
	CR	EN	VU	NT
National Red List 2012 of Sri Lanka	1	4*	3	4
Global Red list	0	2	0	1

*Including introduced *Pethia reval*[5] *and Pethia nigrofasiata*[5].

The list of threatened and Near Threatened (NT) fish species recorded within the project area are presented in the table below.

Table 3. Threatened, Near Threatened (NT) and Data Deficient (DD) Species recorded within the project area.

(Endemic species are indicated in **bold** text; CR – Critically Endangered; EN – Endangered; VU – Vulnerable; DD – Data Deficient; NT – Near Threatened)

No.	Family	Species	Common name	Conservation status (MOE, 2012)
1	Balitoridae	***Schistura notostigma***	Banded mountain loach	NT
2	Belontiidae	***Belontia signata***	Comb-tail	NT
3	Channidae	***Channa ara***	Giant snakehead	EN
4		***Channa orientalis***	Smooth-breasted snakehead	VU
5	Clariidae	***Clarias brachysoma***	Marble catfish	NT
6	Cyprinidae	***Garra ceylonensis***	Ceylon stone-sucker	VU
7		***Labeo fisheri***	Mountain/ Green labeo	CR
8		***Pethia melanomaculata***	Fire fin barb	VU

[5] Formally listed under the Genus *Puntius.*

No.	Family	Species	Common name	Conservation status (MOE, 2012)
9		***Pethia reval***	Red fin barb	EN
10		***Pethia nigrofasciata***	Black ruby barb	EN
11		***Systomus spilurus***	Sri Lanka olive barb	DD
12		*Tor khudree*	Mahseer	NT
13	Siluridae	*Wallago attu*	Shark Catfish	EN

A total of seven nationally threatened species, including one Critically Endangered (CR) species, four Endangered (EN) species and two Vulnerable (VU) species, have been recorded from the Moragolla project site.

In addition, two globally Endangered (EN) freshwater fish species, *Labeo fisheri* (Sri Lanka mountain labeo) and *Tor khudree* (Mahseer) and one globally Near Threatened (NT) species, *Wallago attu* (Shark catfish), have been recorded from the site. *Tor khudree* and *Wallago attu* are not endemic to Sri Lanka, but are listed as globally threatened species due to global decline of their populations.

3.1.4 Priority fish species recorded within the MHP area

Details of points allocated to each of the native fish species recorded within the MHP area using the criteria described (see methodology and approach) are provided in the table below.

Table 4. Points allocated to native fish species within the MHP area based on identified criteria.

Species	Points allocated for each criterion						Total points	Priority category
	Criteria 1 (Species status)	Criteria 2 (Distribution)	Criteria 3 (Impact of the project)	Criteria 4 (Conservation status)	Criteria 5 (Generalist or specialist)	Criteria 6 (Success of captive breeding)		
Labeo fisheri	+2	+2	+5	+6	+1	+2	+18	High priority
Pethia reval	0	+1	+3	+4	+1	0	+9	Moderate priority
Channa ara	+2	0	0	+4	+1	+1	+8	Moderate priority
Garra ceylonensis	+2	0	+3	+2	+1	+1	+8	Moderate priority
Schistura notostigma	+2	0	+3	+1	+1	+1	+8	Moderate priority
Channa orientalis	+2	0	+3	+2	+1	0	+8	Moderate priority
Belontia signata	+2	0	+3	+1	+1	0	+7	Moderate priority
Pethia melanomaculata	+2	0	+3	+1	0	0	+6	Moderate priority
Pethia nigrofasciata	0	+1	0	+4	+1	0	+6	Moderate priority
Tor khudree	+1	0	+3	+1	0	+1	+6	Moderate priority
Anguilla bicolour	+1	0	+3	0	+1	0	+5	Low priority

Species	Points allocated for each criterion						Total points	Priority category
	Criteria 1 (Species status)	Criteria 2 (Distribution)	Criteria 3 (Impact of the project)	Criteria 4 (Conservation status)	Criteria 5 (Generalist or specialist)	Criteria 6 (Success of captive breeding)		
Anguilla nebulosa	+1	0	+3	0	+1	0	+5	Low priority
Clarias brachysoma	+2	0	0	+1	0	0	+3	Low priority
Puntius thermalis	+2	0	0	0	0	0	+2	Low priority
Anabas testudineus	+1	0	0	0	0	0	+1	Low priority
Mystus seengi	+1	0	0	0	0	0	+1	Low priority
Mystus vittatus	+1	0	0	0	0	0	+1	Low priority
Channa gachua	+1	0	0	0	0	0	+1	Low priority
Channa punctata	+1	0	0	0	0	0	+1	Low priority
Channa striata	+1	0	0	0	0	0	+1	Low priority
Lepidocephalichthys thermalis	+1	0	0	0	0	0	+1	Low priority
Amblypharyngodon melettinus	+1	0	0	0	0	0	+1	Low priority
Dawkinsia singhala	+2	0	-1	0	0	0	+1	Low priority
Esomus thermoicos	+2	0	-1	0	0	0	+1	Low priority
Puntius bimaculatus	+1	0	0	0	0	0	+1	Low priority
Puntius dorsalis	+1	0	0	0	0	0	+1	Low priority
Puntius vittatus	+1	0	0	0	0	0	+1	Low priority

Species	Points allocated for each criterion						Total points	Priority category
	Criteria 1 (Species status)	Criteria 2 (Distribution)	Criteria 3 (Impact of the project)	Criteria 4 (Conservation status)	Criteria 5 (Generalist or specialist)	Criteria 6 (Success of captive breeding)		
Rasbora dandia	+1	0	0	0	0	0	+1	Low priority
Awaous melanocephalus	+1	0	0	0	0	0	+1	Low priority
Glossogobius giuris	+1	0	0	0	0	0	+1	Low priority
Heteropneustes fossilis	+1	0	0	0	0	0	+1	Low priority
Mastacembelus armatus	+1	0	0	0	0	0	+1	Low priority
Ompok bimaculatus	+1	0	0	0	0	0	+1	Low priority
Aplocheilus parvus	+1	0	-1	0	0	0	0	Low priority
Etroplus maculates	+1	0	-1	0	0	0	0	Low priority
Etroplus suratensis	+1	0	-1	0	0	0	0	Low priority
Devario malabaricus	+1	0	-1	0	0	0	0	Low priority

Only one species, *Labeo fisheri* (Sri Lanka mountain labeo), was identified as a high priority species. Nine species - *Schistura notostigma* (Sri Lanka banded mountain loach), *Belontia signata* (Sri Lanka combtail), *Channa ara* (Sri Lanka giant snakehead), *Channa orientals* (Smooth-breasted snakehead), *Garra ceylonensis* (Sri Lanka stone sucker), *Pethia reval*[6] (Sri Lanka red-finned barb), *Pethia nigrofasciata*[6] (Sri Lanka black ruby barb), *Systomus spilurus*[6] (Sri Lanka olive barb) *and Wallago attu* (Shark catfish) were identified as moderate priority species. The remaining 30 species are considered as low priority species as they have wider distribution, and therefore, only a small proportion of their populations will be impacted by the MHP. Based on this analysis, *Labeo fisheri* (Sri Lanka mountain labeo) is the only fish species that can be considered as a fish species that will be critically affected by the proposed MHP.

Therefore, a species recovery plan is proposed for *Labeo fisheri* (Sri Lanka mountain labeo/ Green labeo) in order to minimize the impacts of the MHP on this species, while general guidelines for the mitigation of impacts of the MHP are provided for moderate priority species.

The study on the aquatic ecology of the MHP area conducted by the NBRO (2013), indicates the existence of two catadromous (migrate from freshwater to the sea or downstream in freshwater to spawn) eel species - *Anguilla bicolour* (Level-finned eel) and *Anguilla nebulosa* (Long-finned eel) within the MHP area. This report has not considered these two species as priority species for two reasons. First, both *Anguilla* species were categorised as Least Concern (LC) species in the National Red List 2012 of Sri Lanka (MOE, 2013), as well as in the global Red List. Secondly, and more importantly, there are at least four major dams between the Mahaweli estuary and the proposed Moragolla dam site. The first of these large dams, Polgolla, was commissioned in 1977 (approximately 35 years ago), and is followed by other large dams including Victoria, Randenigala and Rantambe. As a result, the major impacts and conservation needs relevant to these species have been overlooked.

3.2 Potential impacts of the project

3.2.1 Impact of the MHP on fish fauna during the construction period

The period of construction of the dam and other structures is crucial for many species that occur in close proximity to, and downstream of, the project area. Fish, as well as other aquatic fauna and flora, are more vulnerable than many other terrestrial animals due to limitations of their mobility. Therefore, anything destructive or damaging associated with the water can be harmful to aquatic fauna and flora. The possible impacts of the MHP on the fish fauna of the area, during the construction phase are discussed below. Although this section focuses on native fresh water fish, many of these impacts are also likely to affect other aquatic species as well.

Habitat destruction and removal of natural vegetation

It can be anticipated that habitat destruction, and the removal of natural vegetation, top soil and riverine rocks, will occur during the construction period. Such impacts will result in numerous direct, and indirect, as well as short, and long, term impacts on fish fauna. The removal of natural vegetation will lead to sudden heavy soil erosion, especially during the rainy season. Consequently, this silt will cover the rocky substrate of the river, affecting the specific critical

[6] Formally listed under the Genus *Puntius.*

micro-habitat conditions required by *Labeo fisherii* (Mountain labeo). Pethiyagoda (1999) and Senanayake (1980) have discussed the adverse effects of sudden heavy siltation on freshwater fish in detail. Senanayake (1980) observed heavy siltation as a result of gem mining in Kalu Ganga in the Knuckles area, and concluded that this may cause the extinction of some sensitive freshwater fish species.

Release of fuel, cement, machine oils and other chemicals in to the main river system and its tributaries during the construction period

Large amounts of fuel, machine oils, cement and other chemicals will be transported to the construction site. There is a high possibility that such materials can be released accidentally into the water during the construction period. The release of such harmful substances, even in small quantities, can be harmful to aquatic fauna, including fish, over a period of time.

Temporary blocking and diversion of the main river

Temporary blocking and diversion of the main river can be expected during the construction period. Such changes may result in sudden decreases of the water level, exposing previously submerged habitats. Large fish, such as *Labeo fisherii* (Mountain labeo), *Tor kudree* (Mahseer), *Wallago attu* (Shark catfish) and *Ompok bimaculatus* (Butter catfish), are the most vulnerable in such situations.

Impact of blasting in and around the river during the construction period

It is anticipated that blasting will take place in the dam axis, as well as other areas such as quarry sites, during the construction period. Fish that inhabit the main river will be directly affected by any blasting activities carried out at the dam axis, particularly those involving submerged areas or adjacent rocks. Further, all fish, from juveniles to breeding adults, that inhabit the direct impact zone of these blasts will be killed as they will be affected by the resulting vibrations as has been demonstrated in other such sites (e.g. rock blasting for the construction of the weir of the Getambe Mini-hydro project resulted in such fish deaths). Further, an illegal form of fishing called blast fishing that uses an explosion inside the water to catch fish also shows that a large vibration created under water will result in the death of all fish in the direct impact zone. In addition, fish that occur away from the direct impact zone will be forced to move away from their habitats, spawning grounds and hiding places, due to weak shock waves resulting from the blast.

Opportunistic fishing by construction workers and villagers

Illegal and destructive exploitation of wild animals and fish by construction workers has been reported in other similar projects. Given that the fish inhabiting the construction area will be disturbed and their movements are restricted by temporary structures built for water diversion during the construction period, they will be more vulnerable to opportunistic and destructive fishing. Locally developed blast methods to catch large fish in the main rivers of Sri Lanka have been recorded in the past. Construction related blasting activities may trigger, or encourage, such destructive practices further.

3.2.2 Impacts of the MHP on fish fauna during the operational period

The operational impacts of the MHP consist of long term irreversible impacts, long term reversible impacts, short term impacts and seasonal impacts.

Long term irreversible impacts

Transverse blocking of the river channel

This can have a major impact on many aquatic species, particularly migratory species. Two catadromous migratory fish species - *Anguilla bicolour* (Level-finned eel) and *Anguilla nebulosa* (Long-finned eel) have been reported from the project area (NBRO, 2013). Further, freshwater fish species, such as *Labeo fisherii* (Mountain labeo), *Garra ceylonensis* (Stone sucker) and *Tor khudree* (Mahseer), are known to show local movements during the breeding season (Pethiyagoda 1991; Shirantha, 2012). The permanent blockage of the river may disturb the upstream movement of such species. Further, large fish species, such as *Wallago attu* (Shark catfish) and *Channa ara* (Giant Snakehead), may require a larger area of the river to maintain a minimum viable population. Fragmentation of such populations may affect the genetic diversity of these large and territorial fish species adversely. The free flow of river water, and the longitudinal connectivity between mountains and the ocean, are important to most aquatic species, particularly when the availability of nutrients in downstream areas is considered (Cowx and Welcomme, 1998). Therefore, changes and restrictions to this flow will affect access to these nutrients.

Formation of the reservoir upstream

The majority of Sri Lankan freshwater fish species are either stream dwellers (*Pethia reval*) or river dwellers (*Wallago attu* and *Labeo fisheri*). There are no records of natural lake dwelling fish in Sri Lanka apart from relatively common and opportunistic species such as *Dawkinsia singhala* (Sri Lanka filamented barb). Therefore, the formation of a reservoir is not favourable to the majority of native freshwater fish species found in the area, particularly critical species such as *Labeo fisherii* (Mountain labeo).

Long term reversible impacts

Change of downstream flow pattern

Naturally, almost all Sri Lankan rivers are subject to seasonal changes of river flow. Rains and dry seasons are the main drivers of such seasonal changes, and most native aquatic faunal and floral species have become adapted to these seasonal changes that are triggered by rainfall (Pethiyagoda, 1991; Senanayake 1980). Local movements, spawning periods and other behaviours are often linked closely with these changes.

Therefore, the daily changes and irregular flow patterns that are anticipated as a result of the project can have significant impacts on the fish fauna of the area. Although such a change is long term, it is categorised as a reversible impact, as the maintenance of a minimum e-flow, as outlined in the EIA report for the MHP, can minimise the impact of such changes.

Impact of exotic species and intensive fishing practices on native species

Given that there are no specialised lake fish among the native fish fauna of Sri Lanka, the prospect of introducing exotic fish suited to such conditions is always an attractive one. Some exotic fish species have been introduced to reservoirs accidentally (e.g. *Xiphophorus helleri* – Green swordtail), while others have been introduced deliberately for fisheries (e.g. *Labeo rohita* - Rohu). It has been observed that the introduction of such species has affected native species adversely (Pethiyagoda, 1999; Senanayake and Moyle, 1982). These exotic fish can exert further pressure on native species that are already stressed due to the impacts arising as a result of changes in the flow regime of the river. Further, the introduction of exotic species for fisheries may encourage intensive fishing practices. Although native species are not targeted in reservoir fisheries, increasing and intensive fishing practices can result in an unintentional decline of these species.

Short term and occasional impacts

Gas bubble trauma disease and heavy flooding downstream

Juvenile fish are the most vulnerable to gas bubble trauma disease, which is caused by super-saturation of atmospheric gases in river water due to the heavy mobility of water during power generation (Williams, 2008). Although there is no published evidence of such incidents in Sri Lanka, it is important that this phenomenon is considered in the context of the MHP, as the tail race of both Kotmale hydropower generation tunnel and the proposed Moragolla hydropower tunnel will discharge their waters into the main river in very close proximity to one other. This may increase super-saturation of atmospheric gas immediately downstream of the discharge points, and thereby, affect the fish of the area. The discharge of water from both Kotmale and Moragolla simultaneously may also cause sudden and heavy floods in downstream areas. This can be identified as a potential adverse impact of the MHP, as it can impact fish and other aquatic fauna downstream of the Mahaweli River, significantly.

Impact of MHP on Labeo fisheri (Green labeo)

The following impacts on *Labeo fisheri* (Mountain labeo or green labeo) can be expected as a result of construction activities associated with the project:

- Removal of natural vegetation and subsequent soil erosion at the construction site will cause sedimentation, altering the substrate, and affecting the feeding habits of this species;

- The accidental release of cements, machinery oils and fuels, and other hazardous chemicals during the construction period will affect the *Labeo fisheri* population in Moragolla project area; and

- Temporary blocking of the main river during the construction period will reduce the flow of water downstream, and as a result, may disturb the habitats of this species in project area.

The *Laebo fisheri* (Green labeo) population within the project area will become fragmented permanently due to the construction of the Moragolla dam and reservoir, affecting this Critically Endangered (CR) species in several ways. *Labeo fisheri* (Green labeo) is not a common fish species in the Mahaweli River system, and according to Shirantha (2012), the population density of this species is limited to 0.5 per km^2. Therefore, this fragmentation will affect the free flow of genes within the existing population due to the isolation of certain individuals and the difficulties of finding mating partners during the breeding season. It can also be anticipated that the permanent drying of the area downstream of the dam up to powerhouse will result in the depletion of habitats that are important to *Labeo fisheri* (Green labeo) in Moragolla project area.

3.3 Mitigation of impacts

The appropriateness of the possible measures for mitigating the impacts of the MHP mentioned in the ToR (see Annex 6) were explored as part of the study, and our findings are discussed in the mitigation plan presented below. Additional measures that can be taken to minimize or mitigate the impacts of the project are also discussed as part of this plan.

Hatchery

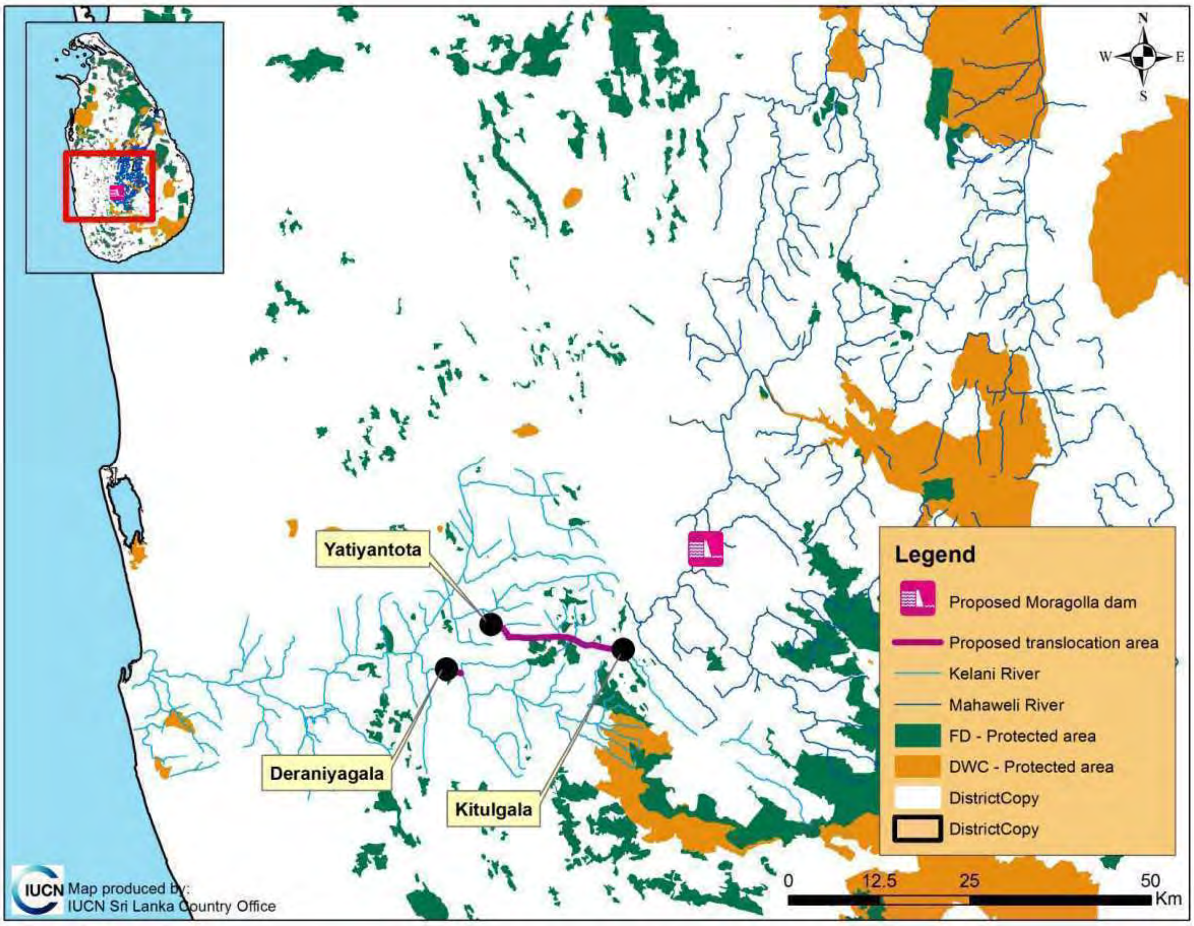
Although captive breeding coupled with reintroduction is a popular conservation action with respect to protecting threatened fish species by boosting their population size, it is not recommended in the context of the MHP as a mitigation or conservation action. The proposed MHP area is not considered to be a critical habitat for the majority of fish species found in the area, with the exception of the sole high priority species identified during the study - *Labeo fisherii* (Mountain labeo).

All other populations of moderate priority species - *Schistura notostigma* (Banded mountain loach), *Belontia signata* (Combtail), *Channa ara* (Giant snakehead), *Channa orientals* (Smooth-breasted snakehead), *Garra ceylonensis* (Stone sucker), *Pethia reval* (Red-fin barb), *Pethia nigrofasciata* (Sri Lanka black ruby barb), *Systomus spilurus* (Sri Lanka olive barb) and *Wallago attu* (Shark catfish) – which are considered to be nationally threatened or Near Threatened (NT), are not likely to be impacted directly by this project. Although, it has been observed that there is a need for captive breeding and *ex-situ* conservation of some of these species, including *Wallago attu* (Shark catfish) and *Channa ara* (Giant snakehead), these activities should be undertaken on a national scale, giving consideration to the national status of these species and the involvement of relevant stakeholders.

There is an urgent need for *in-situ* and *ex-situ* conservation of *Labeo fisheri* (Mountain labeo), which can be considered as the only critical high priority species with respect to the MHP. However, as reported in Shirantha (2012), Pethiyagoda (1991), Senanayake (1980) and Deraniyagala (1952), there is a lack of information with respect to captive breeding of *L. fisheri* (Mountain labeo). Therefore, it is not possible to breed this specialized *Labeo* species in captivity successfully, at present. As such, captive breeding will not be a viable action for the mitigation of the impacts of the MHP on this species.

Catch-and-haul

Catch-and-haul activities have not been documented or reported as a mitigation measure for dam construction in Sri Lanka in the past (pers. com. R. Pethiyagoda), with the exception of fish rescue operations implemented jointly by IUCN and the Mahaweli Authority of Sri Lanka (MASL) for the MASL Moragahakanda and Kalu Ganga projects. This translocation programme has yielded positive results, and has resulted in the rescue of several sub-populations that inhabit the inundation and downstream areas of the proposed dam sites. As part of this translocation work, it was been possible to translocate critical fish species, including *Systomus martenstyni* (Martenstyn's barb), *Dawkinsia srilankensis* (Blotched filamented barb) and *Laboe lanke* (Sri Lanka orange-finned labeo) to the upper catchment of the Amban Ganga and Kalu Ganga sub-basins during the construction period. Based on IUCN's experience with this programme, it is recommended that a similar programme is implemented to rescue and translocate less mobile and cryptic fish species reported in the EIA report for the MHP and the study carried out by the NBRO (2013) (see Annex 6 for details of the proposed translocation programme). It is recommended that all translocation activities are carried out by in accordance with the Guidelines for Reintroductions and Other Conservation Translocations (IUCN/SSC, 2013).



Map 5. Proposed translocation sites (from Kitulgala to Yatiyantota stretch and Deraniyagala area) of *Labeo fisheri* in the Kelani River basin.

Offset habitat protection

The Mahaweli River upper catchment of the Moragolla proposed reservoir is identified as a key area for habitat protection with respect to the conservation of critical and moderate priority fish of the area. Given that the Moragolla upper catchment of Kotmale Oya up to the Kotmale dam remains relatively dry, except at spillage time, only the Mahaweli upper catchment provides suitable habitats for species such as *Labeo fisheri* (Mountain labeo), *Wallago attu* (Shark catfish), *Channa ara* (Giant snakehead) and *Tor khudree* (Mahseer). Preliminary observations show that the area between the upper catchment of the Moragolla reservoir up to Nawalapitiya is the most suitable area for the species that are likely to move upstream, including *Tor khudree* (Mahseer), *Labeo fisheri* (Mountain labeo) and *Wallago attu* (Shark catfish). The removal of river bank vegetation up to Nawalapitiya and the depletion of the upper catchment due to encroachment have been observed. Therefore, it is recommended that the upper catchment of MHP, spanning from Moragolla up to Nawalapitiya, is protected and strict conservation measures are implemented to improve the quality of natural habitats present in this region (see Annex7).

Fish pass or ladder

Although fish passes and ladders are suitable for the facilitation of the migration and local movement of fish species in general (Cowx and Welcomme, 1998), they cannot be considered as a viable options in the context of mitigating the impacts of the MHP. There are at least four major dams between the Moragolla proposed dam site and the Mahaweli estuary, and there are two more large dams - Kotmale and Upper Kotmale - upstream of Kotmale Oya (see Map 4). Given that these dams were constructed without fish passes or ladders, the establishment of a fish pass or fish ladder in the Moragolla project area would be futile. As such, the establishment of such structures is not recommended in the context of the MHP.

Prohibition of the introduction of competitive exotic species to the Moragolla reservoir

Large reservoirs tend to be attractive to the fisheries industry. However, given that there are no natural lakes in Sri Lanka, large reservoir conditions are not suitable for majority of the native fish species. As a result, many exotic species have been introduced to the reservoirs of Sri Lanka. Some of these exotic species are similar to native species, and as such, compete with these indigenous species for resources. For instance, the introduced species *Labeo rohu* is considered a direct competitor of the threatened native species *Labeo fisheri* and *Labeo lankae*. Therefore, a ban on the introduction of competitive fish species, such as *Labeo rohu*, in to the Moragolla reservoir is recommended.

Further, some researchers have observed that the introduction of fast growing exotic species leads to intensive fishing efforts, which also impacts native fish species negatively (Pethiyagoda, 1999). Therefore, this should be considered during the development of current or future fisheries development plans for the Moragolla reservoir.

4. Conclusions and recommendations

The MHP area is identified as critical area only for one fish species - *Labeo fisheri* (Mountain labeo). This species only occurs in the middle catchment of the Mahaweli basin, including the Knuckles sub-catchment area. According to Senanayake (1980), *L. fisheri* (Mountain labeo) was not a rare species in its distribution range, but decades later Pethihagoda (1991) reported *L. fisheri* as a rare species. Further, he indicated the rapid decline of fish populations with local extinction. The declining period is overlapped by the period during which the major dams of the Mahaweli system were commissioned. Therefore, many researchers have observed a direct link between the Mahaweli reservoirs and the rapid decline of *L. fisheri* (Pethiyagoda, 1991). The depletion of feeding grounds due to heavy siltation in the upper and middle Mahaweli catchment, the heavy use of agrochemicals, fishing and competition from exotic species are identified as the other factors that have contributed to the sharp decline of the population of this species. As such, a recovery plan for this species in relation to the MHP is provided. A trans-river basin relocation programme can be introduced to save this species from extinction. *L. fisheri* is the most sensitive faunal species with regard to the MHP and its impacts. Therefore, it is recommended that a national level recovery plan is developed (Annex 9), involving the relevant authorities and experts. It is recommended that the CEB facilitates such a recovery plan, although this initiative will extend beyond the Moragolla area.

Although all other species were not identified as critical species with regard to the impacts of the Moragolla project, it is recommended that less mobile and cryptic fish species are rescued and translocated during the construction period. Further, the conservation and enrichment of the upper catchment of Mahaweli River up to the Nawalapitiya area is recommended in order to preserve the habitat of fish that move upstream or are translocated to these areas. An estimated budget (Annex 8) for the translocation programme of *Labeo fisheri* and other moderately priority species is provided. This estimated budget is based on the translocation plan (Annex 6) and the offset habitat protection plan (Annex 7). Given that the latter is included in the afforestation and watershed management plan, it was not given a separate budget in this report.

BIBLIOGRAPHY

ADB (2009), Safeguard Policy Statement (policy Paper), Asian Development Bank, 92pp.

CEB (2010) Annual Report and accounts (preliminary report), Ceylon Electricity Board, http://www.ceb.lk/sub/publications/annual.aspx.

CECB & ACO (2012) Moragolla Hydropower Project Feasibility Study. Environmental Impact assessment Vol: 3, Final Report. Ceylon Electricity Board. Unnumbered.

Cowx, I.G. and Welcomme, R.L. (1998) Rehabilitation of Rivers for Fish, FAO 260pp.

Deraniyagala, P. E. P. (1952) *A colored atlas of some vertebrate from Ceylon*. (*Fishes*) National Museum Colombo.Vol 01.150pp.

Goonatilake S. de. A.(2012) The taxonomy and Conservation Status of Freshwater Fishes of Sri Lanka, In: The National Red list 2012 of Sri Lanka; Conservation Status of the Fauna and Flora. Weerakoon D.K. & S. Wijesundara Eds. Ministry of Environment, Colombo, Sri Lanka 77-81.

Gunasekara R.S. (2011) Export Trade of Indigenous Freshwater Fish Species in Sri Lanka. Pp iv-126

IUCN (2007) Biodiversity Assessment of the Moragahakanda Agriculture Development Project, Final Report, IUCN Sri Lanka office, Colombo.

IUCN (2013). IUCN Red List of Threatened Species.Version 2013.1.<www.iucnredlist.org>. Downloaded on 16 September 2013.

IUCN/SSC (2013). Guidelines for Reintroductions and Other Conservation Translocations. Version 1.0. Gland, Switzerland: IUCN Species Survival Commission, viiii + 57 pp.

McAllister, D. E., Craig, J. F., Davidson, N., Delany,S. and Seddon, M. (2001*) Biodiversity Impacts of Large Dams.* Background Paper Nr. 1 Prepared for IUCN / UNEP / WCD. International Union for Conservation of Nature and Natural Resources and the United Nations Environmental Programme. 68pp.

NBRO (2013) *Additional Studies On Natural Environment For Review Of Feasibility Study And Preparation Of Detailed Design And Bidding Documents Moragolla Hydropower Project, Sri Lanka. Final report Aquatic ecology in the Mahaweli Ganga*. The National Building Research Organization 79pp

Pethiyagoda, R. (1991) Freshwater Fishes of Sri Lanka, Wildlife Heritage Trust, Colombo. 362pp.

Pethiyagoda, R. (1999) Fishes in trouble. The decline and fall of Sri Lanka's freshwater fish fauna, *Loris* vol. 22 no 02, 56-64pp.

Pethiyagoda, R., Meegaskumbura, M. and Maduwage, K. (2012)A synopsis of the South Asian fishes referred to Puntius (Pisces: Cyprinidae.) Ichthyol.Explor. Fresh waters, 23 (1), pp.69-95.

Pethiyagoda, R., Kottelat, M., Silva, A., Maduwage, K. and Meegaskumbura, M. (2008) A review of the genus *Labuca*in Sri Lanka, with description of three new species (Teleostei: Cyprinidae). *Ichthyol.Explor. Freshwaters,* 19(1), p. 726.

Senanayake, R. (1980) *The biogeography and ecology of the Inland fishes of Sri Lanka*. PhD dissertation (unpublished), University of California. 421pp.

Senanayake, F.R. and Moyle, P.B. (1982) Conservation of Freshwater fishes of Sri Lanka, *Biological Conservation* 22, 181-195pp.

Shirantha, R.R.A. R. (2012) Socio ecological dimensions on Labeofisheri (Family: Cyprinidae) in mahaweli middle catchments of Sri Lanka; an endemic fish species of enigmatic population decline, *International Conference on Biodiversity & Sustainable Energy Development*, September 14-15, 2012 Hyderabad International Convention Centre, India.

Survey Department of Sri Lanka (2007) The National Atlas of Sri Lanka (2nd edition), Survey Department of Sri Lanka, Colombo.

Wikramanayake, E.D. (1990) Conservation of Endemic rain forest fishes of Sri Lanka: Results of a translocation experiment. Conservation Biology.,Vol 4(1); 32-37.

Williams, J.G. (2008), Mitigating the effects of high-head dams on the Columbia River, USA: experience from the trenches, *Hydrobiologia*, 609:241-251.

ANNEXES

Annex 1. List of fish species found in the Mahaweli River basin (after Pethiyagoda 1991, Senanayake 1981, Pethiyagoda et al 2012, Pethiyagoda 2008 and Goonatilake 2012).

Note: Bold text indicates endemics.

No.	Family	Species	Common name	Conservation status (MOE, 2012)
01	Cyprinidae	*Amblypharyngodon melettinus*	Silver carplet	LC
02		***Dawkinsia srilankensis***	Sri Lanka blotched filamented barb	CR
03		***Dawkinsia singhala***	Sri Lanka filamented barb	LC
04		*Devario malabaricus*	Giant danio	LC
05		***Devario cf. aequipinnatus***	Sri Lanka Knuckles danio	CR
06		***Esomus thermoicos***	Sri Lanka flying barb	LC
07		***Garra ceylonensis***	Sri Lanka stone sucker	VU
08		*Labeo dussumieri*	Common labeo	LC
09		***Labeo fisheri***	Sri Lanka mountain labeo	CR
10		***Labeo lankae***	Sri Lanka orange-fin labeo	CR
11		***Laubuca insularis***	Sri Lanka Knuckles laubuca	CR
12		***Laubuca lankensis***	Sri Lanka blue laubuca	VU
13		***Pethia melanomaculata***	Sri Lanka tic tac barb	VU
14		***Pethia nigrofasciata***	Sri Lanka black ruby barb	EN
15		***Pethia reval***	Sri Lanka red-fined barb	EN
16		*Puntius bimaculatus*	Redside barb	LC
17		*Puntius dorsalis*	Long-snouted barb	LC
18		*Puntius thermalis*	Swamp barb	LC
19		*Puntius vittatus*	Silver barb	LC
20		*Rasbora dandiya*	Broad line strip rasbora	LC
21		*Rasbora microcephalus*	Narrow line rasbora	LC
22		***Systomus spilurus***	Sri Lanka olive barb	DD
23		*Tor khudree*	Mahseer	NT

No.	Family	Species	Common name	Conservation status (MOE, 2012)
24	Balitoridae	***Schistura notostigma***	Banded mountain loach	NT
25	Cobitidae	*Lepidocephalichthys thermalis*	Common spiny loach	LC
26	Bagridae	*Mystus gulio*	Long-whiskered catfish	LC
27		*Mystus vittatus*	Striped dwarf catfish	LC
28		*Mystus seengtee*	Yellow catfish	LC
29	Claridae	***Clarias brachysoma***	Sri Lanka walking catfish	NT
30	Siluridae	*Ompok bimaculatus*	Butter catfish	LC
31		*Wallago attu*	Shark catfish	EN
32	Heteropneustidae	*Heteropneustes fossilis*	Stinging catfish	LC
33	Gobiidae	*Awaous melanocephalus*	Scribbled goby	LC
34		*Glossogobius giuris*	Bar-Eyed goby	LC
35	Anguillidae	*Anguilla bicolor*	Level-finned eel	LC
36		*Anguilla nebulosa*	Long-finned eel	LC
37	Mastacembelidae	*Mastacembelus armatus*	Marbled spiny eel	LC
38	Channidae	***Channa ara***	Sri Lanka giant snakehead	EN
39		*Channa gachua*	Brown snakehead	LC
40		*Channa punctata*	Spotted snakehead	LC
41		*Channa striata*	Murrel	LC
42	**Aplocheilidae**	*Aplocheilus parvus*	Dwarf panchax	LC
43	**Cichlidae**	*Etroplus suratensis*	Green chromide	LC
44		*Etroplus maculatus*	Orange chromide	LC
45	**Belontidae**	***Belontia signata***	Sri Lanka combtail	NT
46	**Anabantidae**	*Anabas testudineus*	Climbing perch	LC

Annex 2: Fish species recorded from the project area (as reported in the EIA)

Note: **Bold** text indicates endemism and Ex. Indicates exotic species.

No.	Family	Species	Common name	Conservation status (MOE, 2012)
1	Balitoridae	***Schistura notostigma***	Banded mountain loach	NT
2	Belontiidae	***Belontia signata***	Combtail	NT
3	Channidae	*Channa gachua*	Brown snakehead	LC
4	Cobitidae	*Lepidocephalichthys thermalis*	Common spiny loach	LC
5	Cyprinidae	***Dawkinsia singhala***	Sri Lanka filamented barb	LC
6		***Devario cf. aequipinatus***	Giant danio	CR
7		***Garra ceylonensis***	Ceylon stone-sucker	VU
8		***Pethia reval***	Red fin barb	EN
9		***Pethia nigrofasciata***	Black ruby barb	EN
10		***Puntius bimaculatus***	Redside barb	LC
11		*Puntius dorsalis*	Long snouted barb	LC
13		*Rasbora dandiya*	Striped rasbora	LC
14		***Systomus spilurus***	Sri Lanka olive barb	DD
15		*Tor khudree*	Mahseer	NT
16	Poeciliidae	*Poecilia reticulata* Ex.	Guppy	

Annex 3: Fish species recorded from the project area (as reported in NBRO, 2013).

Note: **Bold** text indicates endemism and Ex. Indicates exotic species.

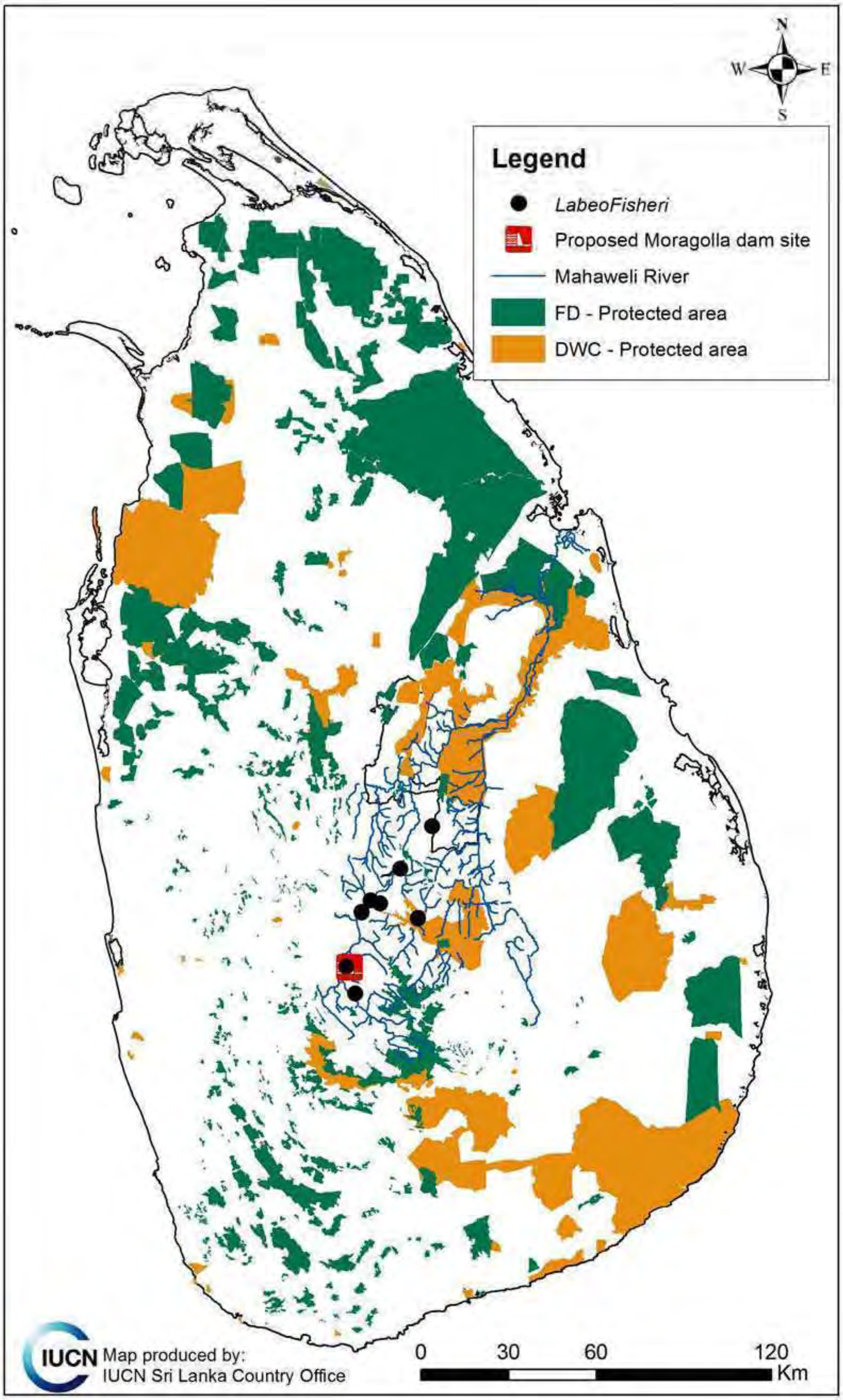
No.	Family	Species	Common Name	Conservation status (MOE, 2012)
1	Anabantidae	*Anabas testudineus*	Climbing perch	LC
2	Anguillidae	*Anguilla bicolor*	Level finned eel	LC
3		*Anguilla nebulosa*	Long finned eel	LC
4	Aplocheilidae	*Aplocheilus parvus*	Dwarf panchax	LC
5	Bagridae	*Mystus seengtee*	Yellow catfish	LC
6		*Mystus vittatus*	Striped dwarf catfish	LC
7	Balitoridae	***Schistura notostigma***	Banded mountain loach	NT
8	Belontiidae	***Belontia signata***	Comb-tail	NT
9	Channidae	***Channa ara***	Giant snakehead	EN
10		*Channa gachua*	Brown snakehead	LC
11		***Channa orientalis***	Smooth-breasted snakehead	VU
12		*Channa punctata*	Spotted snakehead	LC
13		*Channa striata*	Murrel	LC
14	Cichlidae	*Etroplus maculatus*	Orange chromide	LC
15		*Etroplus suratensis*	Pearl spot	LC
16		*Oreochormis mossambicus* Ex.	Mozambique tilapia	
17		*Oreochormis niloticus* Ex.	Nile tilapia	
18	Clariidae	*Clarias batrachu* Ex.	Marble catfish	
19		***Clarias brachysoma***	Walking catfish	NT
20	Cobitidae	*Lepidocephalichthys thermalis*	Common spiny loach	LC
21	Cyprinidae	*Amblypharyngodon melettinus*	Silver carplet	LC
22		*Cyrinus carpio* Ex.	Common carp	
23		***Dawkinsia singhala***	Sri Lanka filamented barb	LC
24		*Devario malabaricus*	Giant Danio	LC
25		***Esomus thermoicos***	Flying barb	LC
26		***Garra ceylonensis***	Ceylon stone-sucker	VU
27		***Labeo fisheri***	Mountain/ Green Labeo	CR
28		*Laboe rohita* Ex.	Rohu	
29		***Pethia melanomaculata***	Fire fin barb	VU
30		***Pethia reval***	Red fin barb	EN
31		***Pethia nigrofasciata***	Black ruby barb	EN
32		***Puntius bimaculatus***	Redside barb	LC
33		*Puntius dorsalis*	Long snouted barb	LC
34		***Puntius thermalis***	Swamp barb	LC

No.	Family	Species	Common Name	Conservation status (MOE, 2012)
35		*Puntius vittatus*	Silver barb	LC
36		*Rasbora dandia*	Striped rasbora	
37		***Systomus spilurus***	Sri Lanka olive barb	DD
38		*Tor khudree*	Mahseer	NT
39	Gobiidae	*Glossogobius giuris*	Scribbled goby	LC
40		*Awaous melanocephalus*	Bar eyed goby	LC
41	Heteropneustidae	*Heteropneustes fossilis*	Stinging catfish	LC
42	Loricaridae	*Pterygoplichthyes multiradiatus* Ex.	Sail fin catfish	
43	Mastacembelidae	*Mastacembelus armatus*	Marbled spiny eel	LC
44	Osphronemidae	*Osphronemus goramy* Ex.	Giant gourami	
45	Poeciliidae	*Poecilia reticulata* Ex.	Guppy	
46	Siluridae	*Ompok bimaculatus*	Butter catfish	LC
47		*Wallago attu*	Shark catfish	EN

Annex 4: Profiles of threatened (CR, EN and VU) species and Near Threatened (NT) species found in the project area.

Labeo fisheri (Sri Lanka mountain labeo)

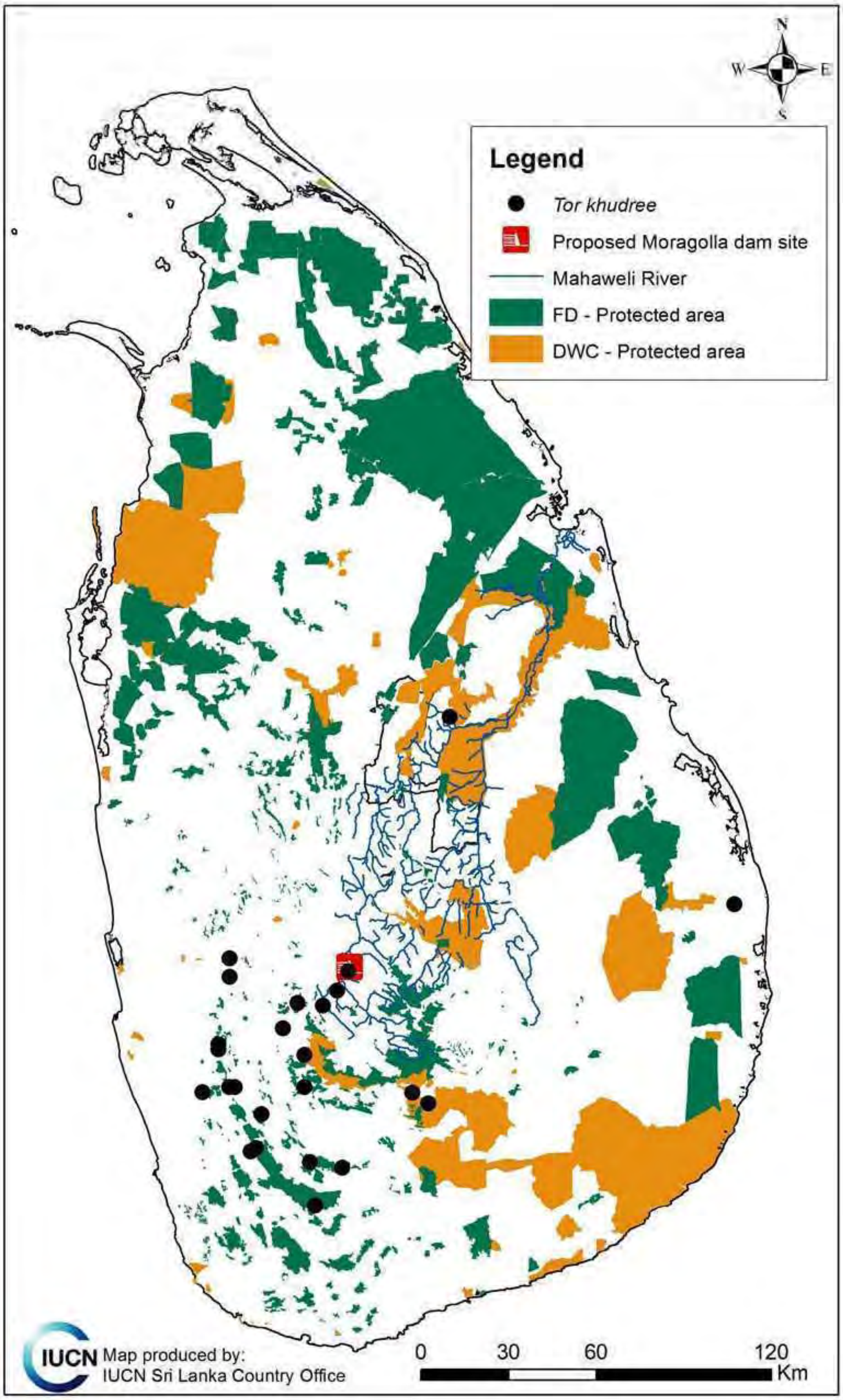
Scientific name	*Labeo fisheri*
Common names	Green labeo, Mountain labeo, Kalu gadeya, Gadeya
Synonyms	*Labeo gadeya*, *Morulius gadeya*
Conservation status	Endangered (Global Red List, 2009), Critically Endangered (National Red List 2012).
Distribution within Sri Lanka	Endemic to Sri Lanka and restricted to the Mahaweli River basin.
Distribution within the Mahaweli River system	The distribution of *Labeo fisheri* is restricted to the upper and middle reaches of the Mahaweli River basin, including tributaries that originate from the Knuckles mountain area. *Labeo fisheri* was a common edible fish species in middle reaches of the Mahaweli River until the late 1970s.
Feeding, habitat preference, life cycle and population density	Pethiyagoda (1991) reports that the juvenile of *Labeo fisheri* feed on algae that grows on rocky surfaces. The external morphology of the fish also indicates bottom dwelling and grazing feeding habits. The preferred habitat of this mysterious fish is clear, fast flowing water, and rocky mountainous pools in the main river system (Pethiyagoda, 1991; Shirantha, 2012). Breeding has not been recorded, but Shirantha (2012) suggests an upstream movement for spawning. In 1990, Wickramanayake reported the possible extinction of this fish. However, Pethiyagoda (1991) recorded this species from a few locations within the Mahaweli basin. A recent study on the distribution of *L. fisheri* shows that the population density of this species in middle reaches of the Mahaweli River is 1 per 0.5 km^2 (Shirantha, 2012).
Reproduction	Not recorded (Pethiyagoda, 1991; Shirantha, 2012).
Captive breeding and *ex-situ* conservation	According to the available data, this is one of the most difficult fish to breed in captivity. Pethiyagoda (1991) stated that there is no record of aquarium kept *L. fisherii*. Further, Shirantha (2012) reported that all efforts to keep this species in captivity were unsuccessful. It can, therefore, be concluded that the likelihood of breeding this species in captivity successfully is extremely low.
Critical habitats	The project area can be considered as a critical habitat area for the survival of *Labeo fisheri*. Although the historical distribution of this species ranges from the project area to the Victoria–Randenigala area, and the Kalu Ganga sub-catchment in the Knuckles area, this species has become extinct locally from many areas. Therefore, the Moragolla project area is critical for the existing sub-population of *L. fisheri*.



Distribution map of *Labeo fisheri*

Tor khudree (Mahseer)

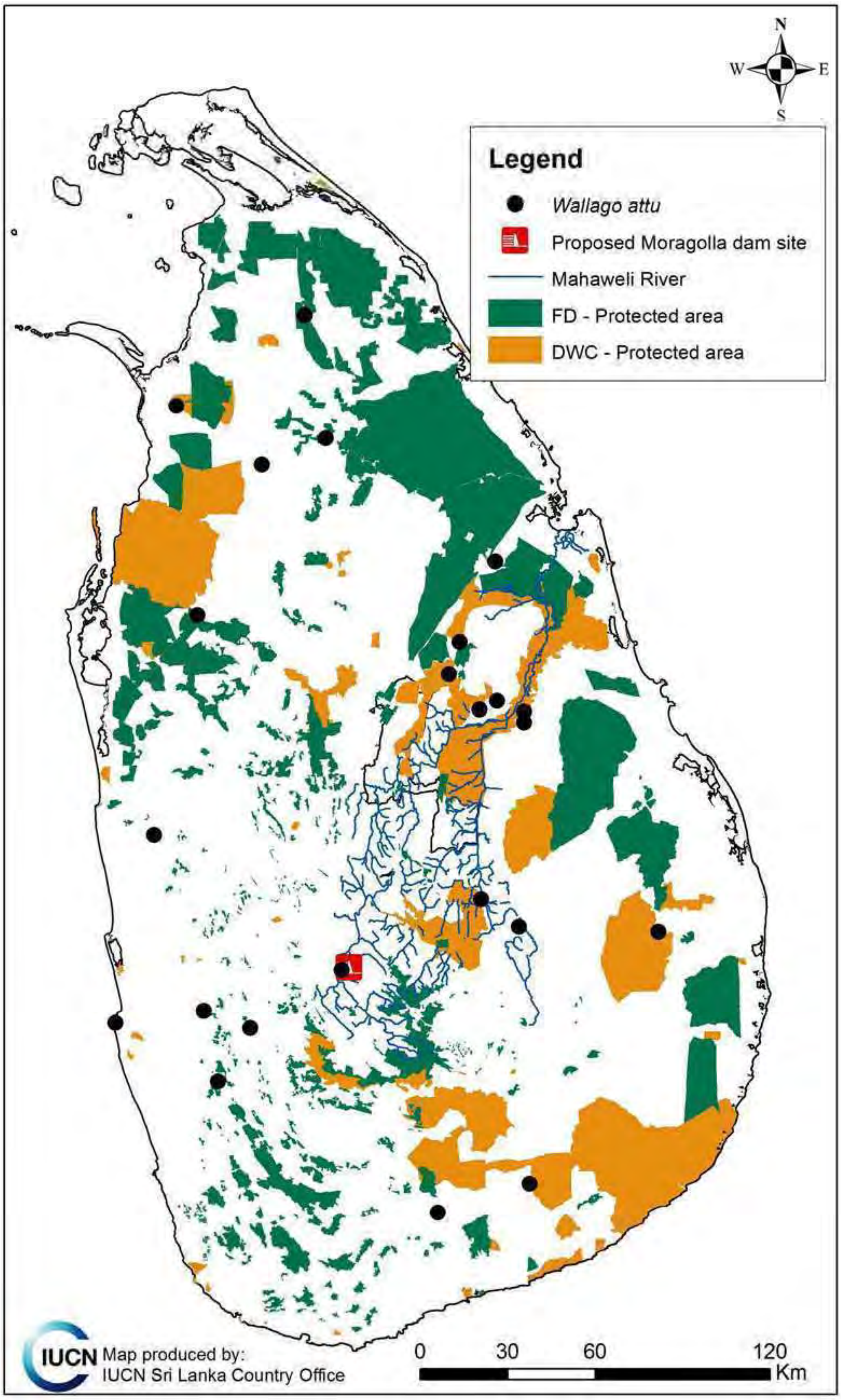
Scientific name	*Tor khudree*
Common names	Mahseer
Synonyms	*Barbus khudree*
Conservation status	Near Threatened (National Red List 2012).
Distribution within Sri Lanka	*Tor khudree* occurs in streams, rivers and tanks up to an elevation of 1, 000 m. It is restricted to the mid hills in the second peneplain.
Distribution within the Mahaweli River system	Distributed commonly within the Mahaweli River system, including in the Knuckles range.
Feeding, habitat preference, life cycle and population density	Omnivorous. Feeds on many type of plant material including leaves, flowers and substrate algae. Lies in fast flowing clear water, with large individuals living in major rivers and large water bodies, while juveniles live in streams. Pethiyagoda (1991) observes that breeding adults move up small streams after the rains begin for spawning. *Tor khudree* is locally common and schools with other individuals in deep areas of rivers.
Reproduction	According to published sources (Pethiyagoda, 1991) *Tor khudree* moves up small tributaries to breed, although it lives usually in large deep areas.
Captive breeding and *ex-situ* conservation	Not recorded, but adapt easily to aquarium conditions.
Critical habitats	*Tor khudree* is a widely distributed species. Healthy populations of this species even occur within protected areas in Sri Lanka. Therefore, the project area is not considered to be a critical habitat area for *Tor khudree*.



Distribution map of *Tor khudree*

***Wallago attu* (Shark catfish)**

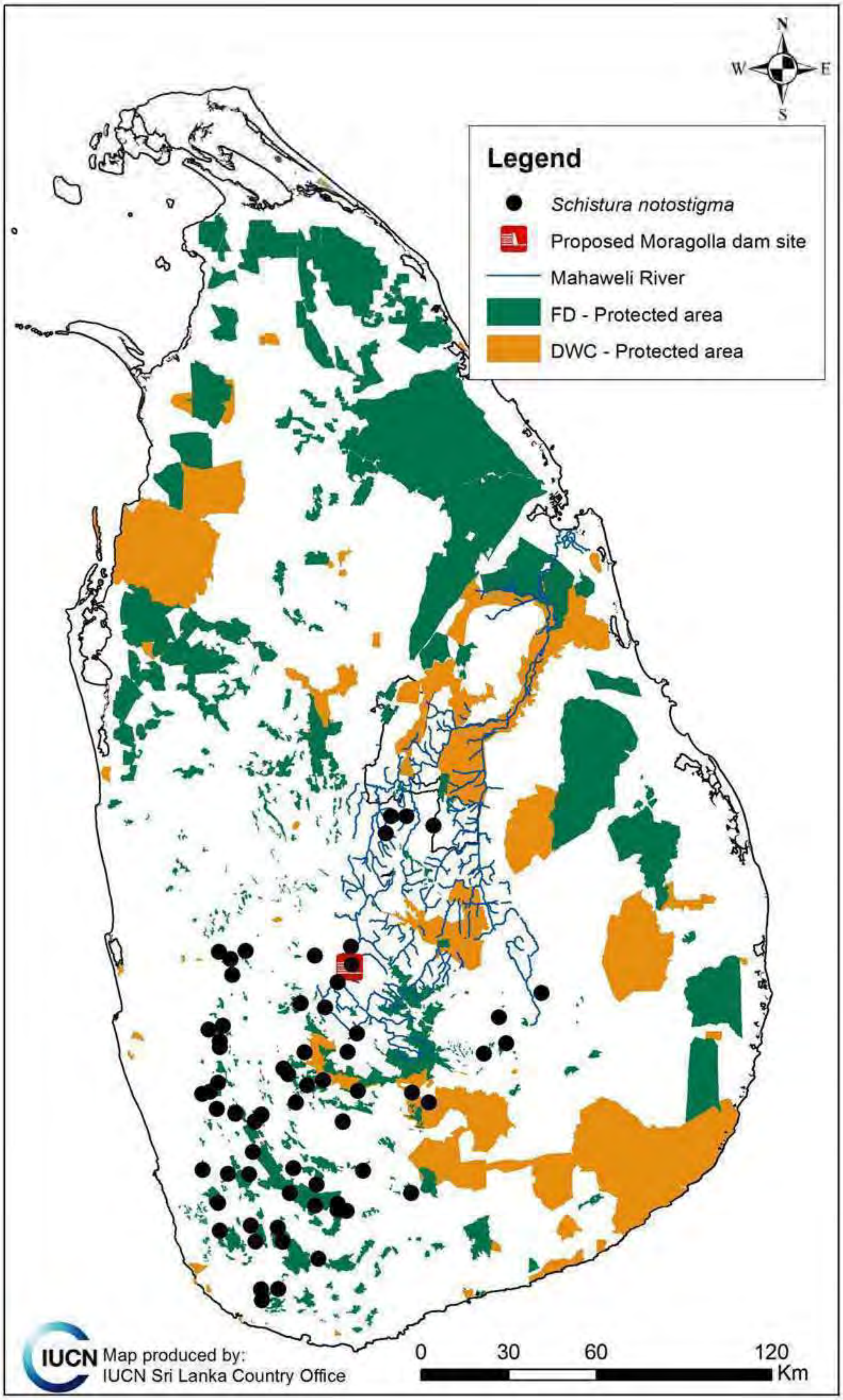
Scientific name	*Wallago attu*
Common names	Shark catfish
Synonyms	*Silurus attu*
Conservation status	Endangered (National Red List 2012)
Distribution within Sri Lanka	According to Senanayake (1982) *W. attu* was a common food fish and was recorded in many places within the Dry Zone, including tanks and rivers, as well as at several sites in Wet Zone rivers. Pethiyagoda (1991) observed the local extinction of this species in many places, as well as the fact that the species was becoming rare at sites in which it has been common previously.
Distribution within the Mahaweli River system	Both Pethiyagoda (1991) and Senanayake (1982) did not record *W. attu* in the wet part of the Mahaweli river, but did record it from the dry part of Mahaweli River from Mahiyanganaya to Polonnaruwa. The study conducted by NBRO (2013) reported this species from the Moragolla project area. However, there are discrepancies between the record of this species in the area, and the historical distribution of this species.
Feeding, habitat preference, life cycle and population density	Primarily carnivorous, and feeds on fish and small crustaceans. Naturally Occurs naturally in deep areas of large rivers and tanks. Nocturnal. Senanayake (1982) reports that *W. attu* prefers quiet waters with tree roots and vegetation. There is no record of the life cycle of this species in Sri Lanka. Drastic declines of populations have been recorded during past few decades.
Reproduction	No published information available.
Captive breeding and *ex-situ* conservation	Although there is no record of successful captive breeding of *W. attu* in Sri Lanka, this species has been bred in captivity as part of the aquaculture industry in some other Asian countries.
Critical habitats	*Wallago attu* is a widely distributed species. Further, the project area does not fall within the historical distribution range of this species. Therefore, the Moragolla project area is not considered to be a critical habitat area for *Wallago attu.*



Distribution map for *Wallago attu*

Schistura notostigma (Banded mountain loach)

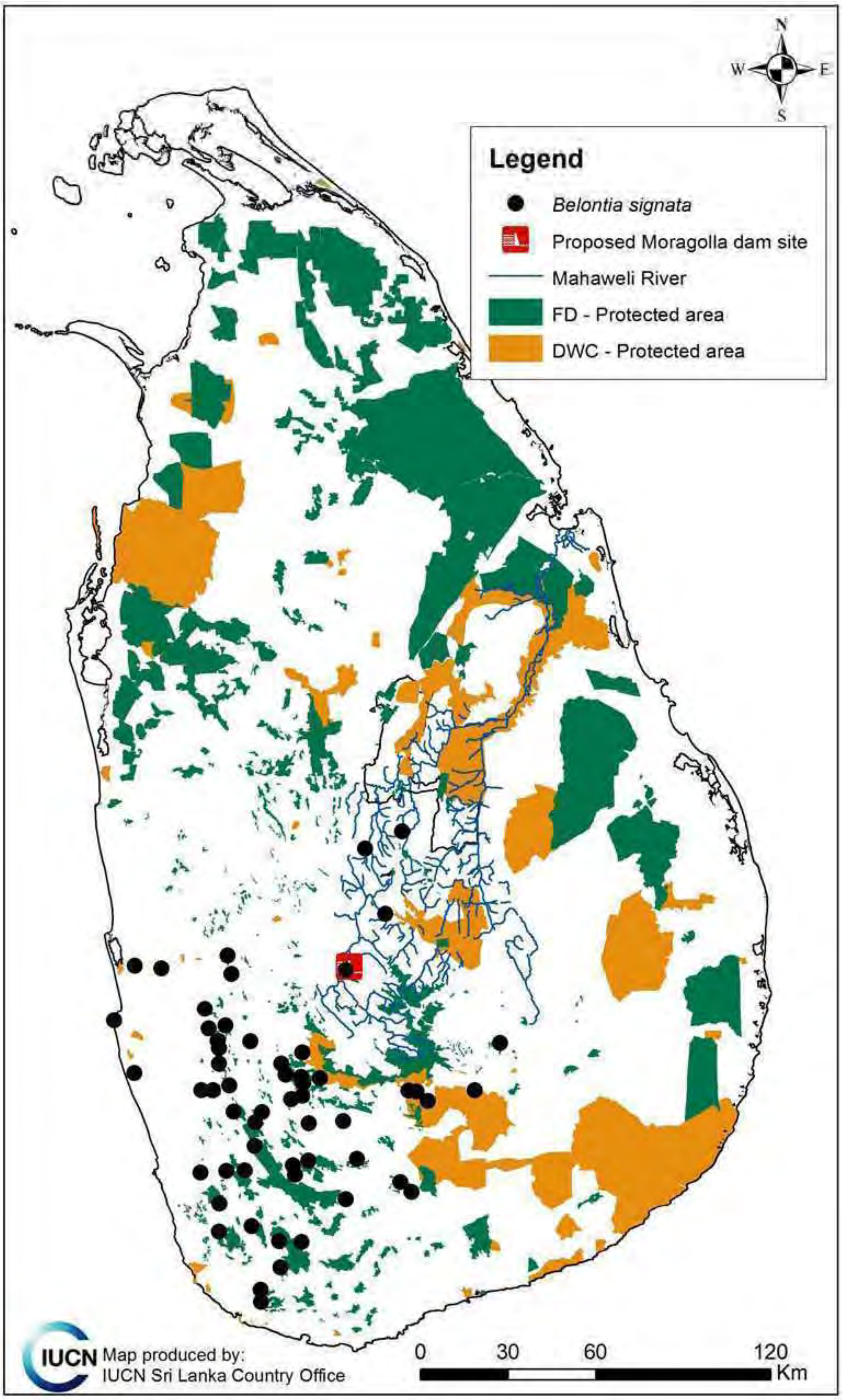
Scientific name	*Schistura notostigma*
Common names	Banded mountain loach
Synonyms	*Nemacheilus notostigma*
Conservation status	Near Threatened (National Red List 2012).
Distribution within Sri Lanka	Endemic to Sri Lanka. Common in small tributaries in southwestern icthyological zone of the country and also recorded from other areas up to an elevation of 1, 500 m.
Distribution within the Mahaweli River system	There are records of this species from the Knuckles area and main Mahaweli system, including the project area.
Feeding, habitat preference, life cycle and population density	Feeds primarily on benthic foods. *S. notostigma* prefers fast flowing and clear water, and is always associated with rocky substrates. This species is common locally in small to medium sized streams from the Kelani River basin to the Nilwala River basin. *S. notostigma* shows a restricted population size within the Mahaweli basin.
Reproduction	Not recorded.
Captive breeding and *ex-situ* conservation	An easily adaptable fish species that is exported by aquarium fish traders.
Critical habitats	The natural habitat of *Schistura notostigama* is small and moderate sized streams, and the species is not normally recorded from major rivers. The proposed Moragolla project is unlikely to impact the small streams of the area severely. Further, this species shows a wide distribution and even occurs in protected areas. Therefore, the Moragolla project area is not considered to be a critical habitat area for *Schistura notostigma.*



Distribution map for *Schistura notostigma*

***Belontia signata* (Combtail)**

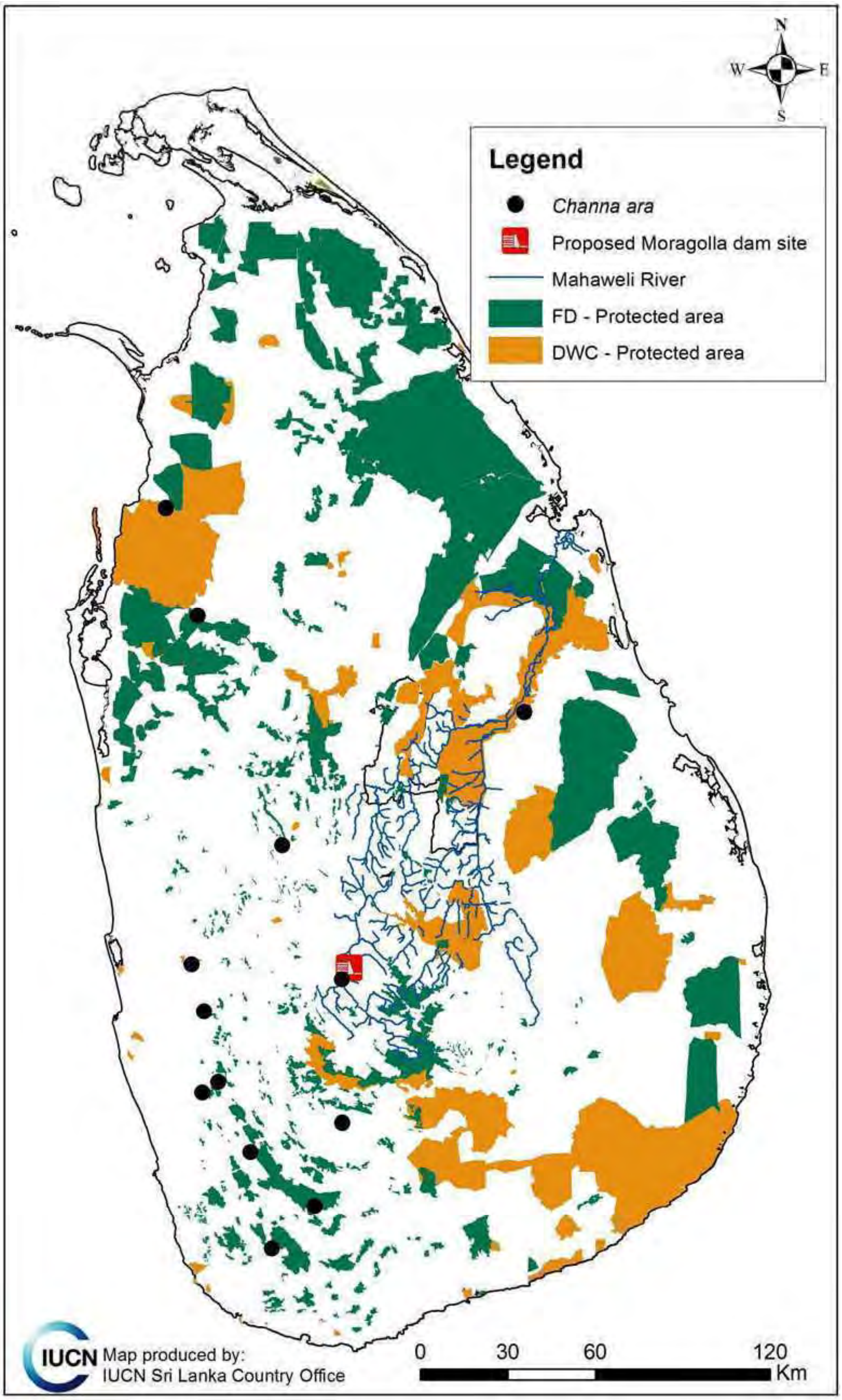
Scientific name	*Belontia signata*
Common names	Combtail
Synonyms	*Polycanthus signatus*
Conservation status	Near Threatened (National Red List 2012).
Distribution within Sri Lanka	Endemic to Sri Lanka. Recorded in many places in the southwest of the country from the Kelani River to the Nilwala River basin. There are also some records from the Intermediate Zone of Sri Lanka.
Distribution within the Mahaweli River system	Not common in the Mahaweli basin, and restricted to the Knuckles range and a few other sites within the main river system, including project area.
Feeding, habitat preference, life cycle and population density	Carnivorous. *Belontia signata* lives usually in shady, clear, slow flowing shallow streams. Although it is considered to a hardy species in general, it is not recorded outside its preferred habitat. Usually, this species is found associated with submerged roots, branches and leaves. It is not a rare species, and although adults are territorial, it can relatively common within its distribution range in southwestern ichyological zone of Sri Lanka.
Reproduction	This species makes bubble nests. Males guard the nests, while both parents protect juveniles in the first few weeks.
Captive breeding and *ex-situ* conservation	This is a very hardy species that is easy to keep under aquarium conditions. Captive breeding of *Belontia signata* is well documented, and individuals are observed to defend their territories.
Critical habitats	This species shows a wide distribution and even occurs in protected areas. As such, the Moragolla project area is not considered to be a critical habitat area for *Belontia signata*.



Distribution map for *Belontia signata*

***Channa ara* (Giant snakehead)**

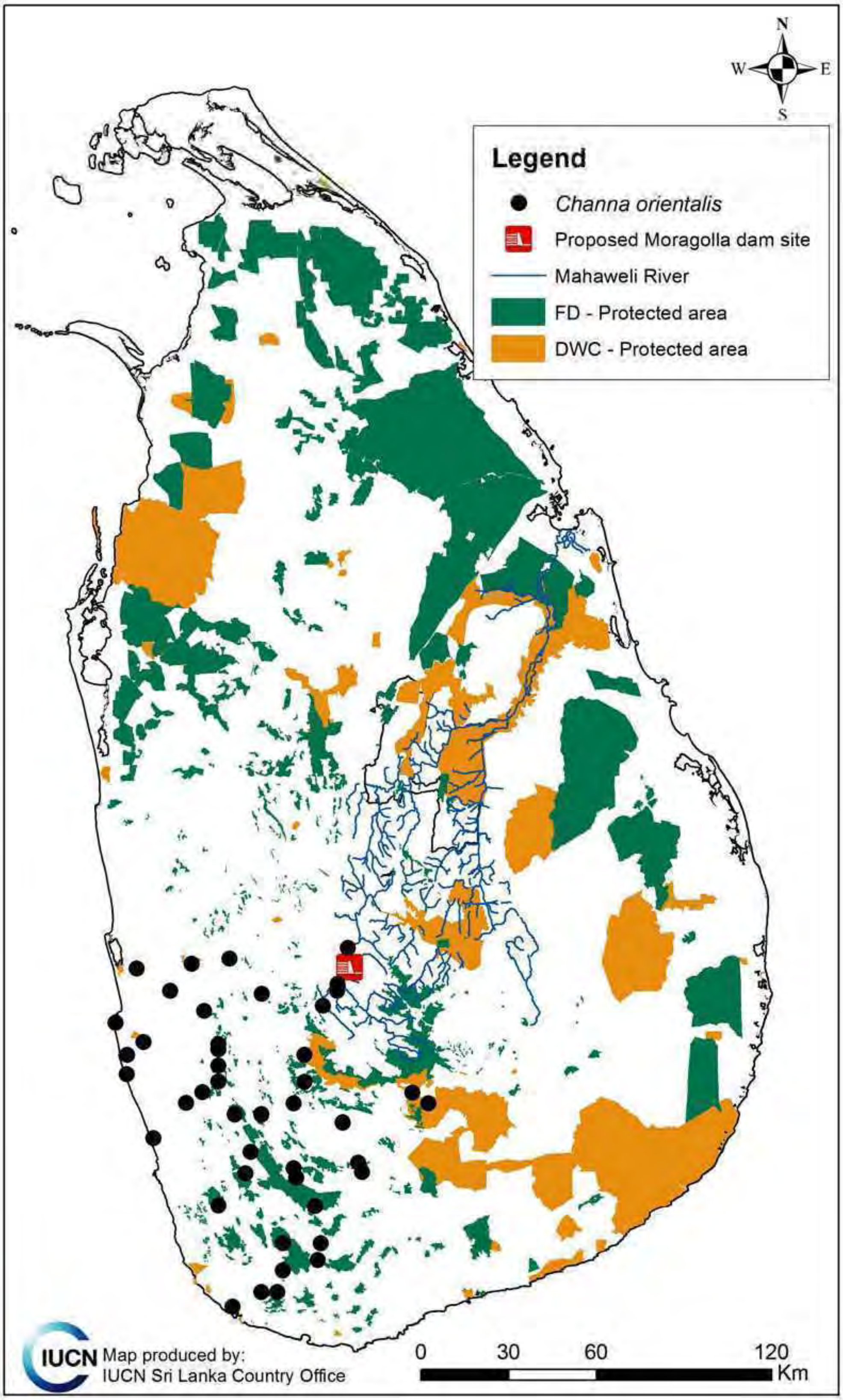
Scientific name	*Channa ara*
Common names	Giant snakehead
Synonyms	*Channa marulius*
Conservation status	Endangered (National Red List 2012)
Distribution within Sri Lanka	Endemic to Sri Lanka. According to Pethiyagoda (1991) and Senanayake (1982) this species is widely distributed in low country areas up to 500 m, but current records show a rapid decline of *Channa ara* from many areas.
Distribution within the Mahaweli River system	*Channa ara* occurs in the lower and middle part of the Mahaweli basin up to Kandy (Pethiyagoda, 1991). Sennayake (1982) also observes that the distribution of *Channa ara* in the Mahaweli basin is restricted to dry lowland part of the river. Records of *Channa ara* from project site represent an extension of the range of this species to a higher altitude.
Feeding, habitat preference, life cycle and population density	Carnivorous. Occupies deep pools in rivers, and is found occasionally in lakes (Pethiyagoda, 1991).
Reproduction	This species builds a nest of aquatic weeds, within which its eggs are laid. Both parents guard the eggs and the young, and are highly territorial during the breeding season, attacking possible predators of their hatchlings.
Captive breeding and *ex-situ* conservation	They are considered to be hardy fish, and it is possible to keep them captivity. However, a large space is required to rear this species. Although there are no reports available on captive breeding of *Channa ara*, international attempts to breed similar species, such as *Channa striata*, indicate that it is possible to breed this species in captivity.
Critical habitats	*Channa ara* is a widely distributed species in Sri Lanka. Therefore, the Moragolla project area is not considered to be a critical habitat area for this species.



Distribution map for *Channa ara*

Channa orientalis (Smooth-breasted snakehead)

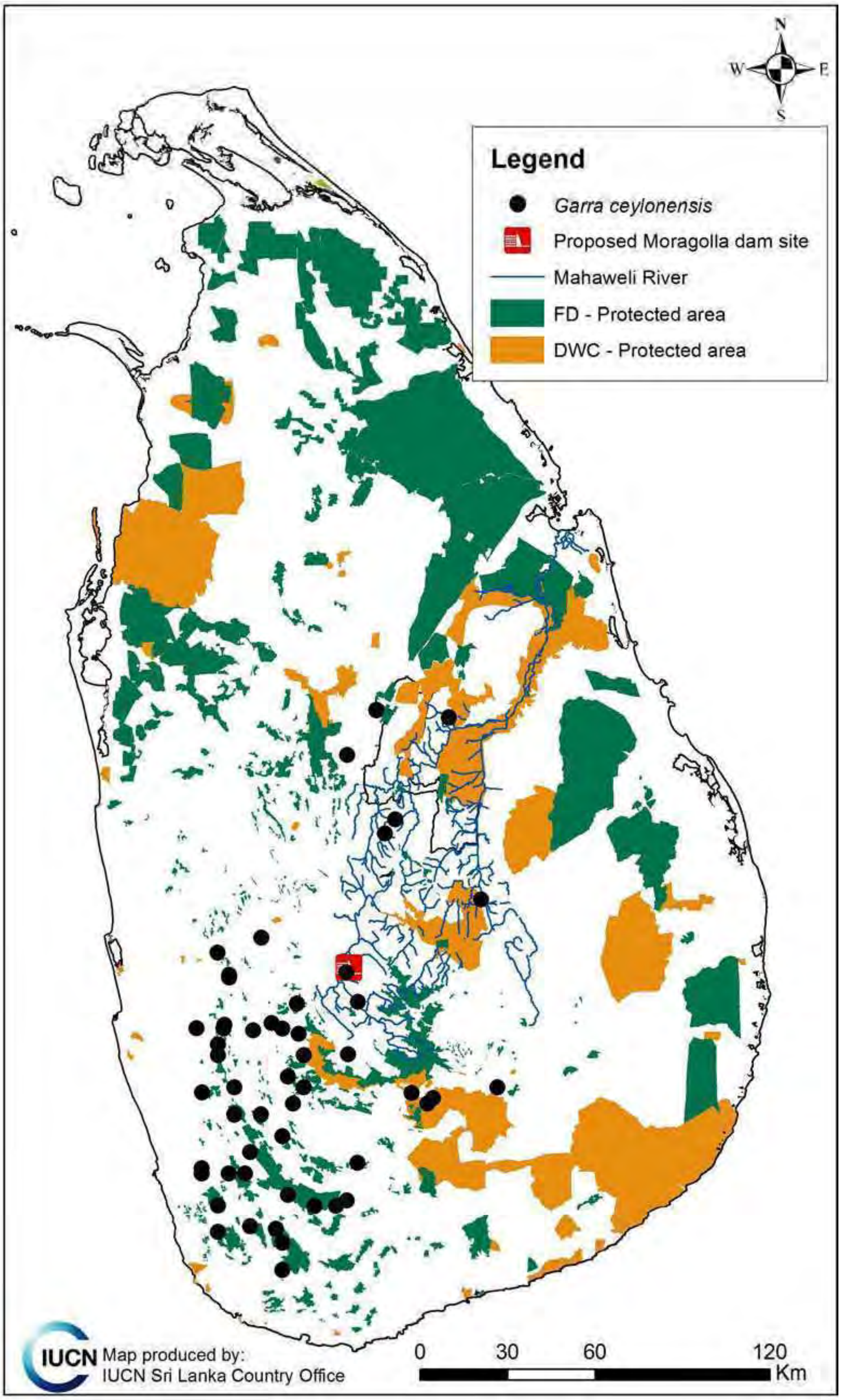
Scientific name	*Channa orientalis*
Common names	Smooth-breasted snakehead
Conservation status	Vulnerable (National Red List 2012)
Distribution within Sri Lanka	Endemic to Sri Lanka. According to Pethiyagoda (1991), this species is restricted to the southwestern ichyological zone of the country from the Attanagalu River basin to the Nilwala River basin. Deraniyagala (1952) also reports this distribution pattern.
Distribution within the Mahaweli River system	According to the majority of past studies, this species has not been recorded from the Mahaweli River basin (Pethiyagoda, 1991; Deraniyagala, 1952). Only Senanayake (1980) reported a single record near Ginigathhena. However, this species was recorded from the Amban Ganga and Kalu Ganga tributaries, during recent studies in the Knuckles area.
Feeding, habitat preference, life cycle and population density	Carnivorous. Feeds on terrestrial insects, small crustaceans and fish. Usually found in slow flowing, shady, clear streams. *Channa orientallis* is considered to be a mouth breeder, and eggs are hatched in mouth of the male. Either the male or female may keep the brood in its mouth for protection after hatching (Pethiyagoda, 1991). *Channa orientalis* is widely distributed in the low country Wet Zone and is locally common.
Reproduction	Both parents protect eggs and hatchlings.
Captive breeding and *ex-situ* conservation	Captive breeding of *Channa orientalis* has not been reported in literature. However, it is likely that it is possible to breed this species in captivity, as other *Channa* species are bred widely in captivity for the aquarium trade.
Critical habitats	*Channa orientalis* is a widely distributed species and occurs in many protected area. Therefore, the Moragolla project area is not considered to be a critical habitat area for this species.



Distribution map for *Channa orientalis*

Garra ceylonensis (Stone sucker)

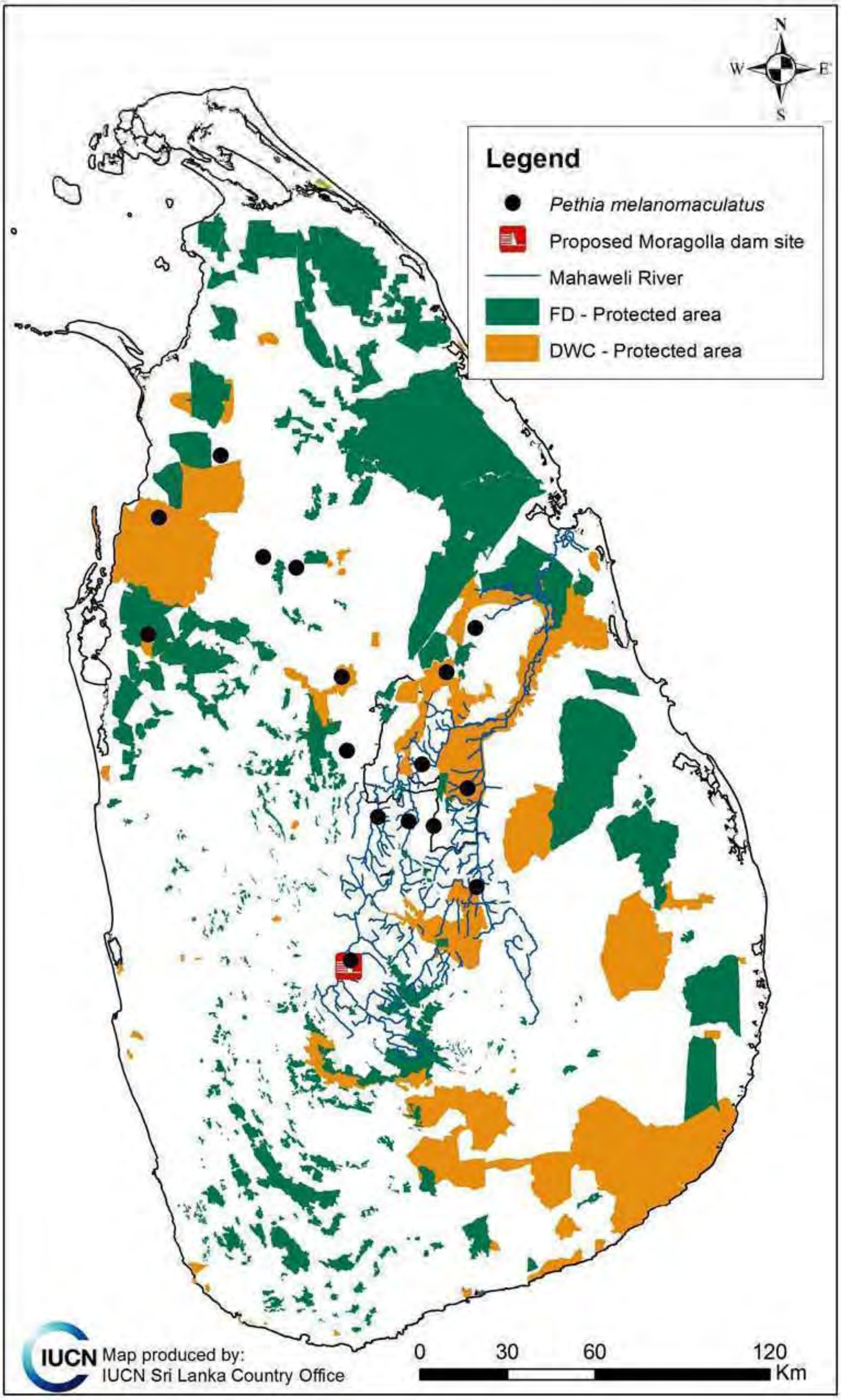
Scientific name	*Garra ceylonensis*
Common names	Stone sucker
Synonyms	*Discognathus lamta*
Conservation status	Vulnerable (National Red List 2012)
Distribution within Sri Lanka	Endemic to Sri Lanka. Widely distributed throughout the island. It is the one of the species that has been recorded at very high altitudes.
Distribution within the Mahaweli River system	*Garra ceylonensis* is distributed throughout the Mahawali basin, except in its lower reaches (Pethiyagoda, 1991). Occurs commonly in the main river system, as well as rivulets of the Mahaweli basin.
Feeding, habitat preference, life cycle and population density	Feeds primarily on substrate algae. This species is mainly restricted to fast flowing and clear water, with rocky substrate. Adults tend to live associated with rocky substrates, while juveniles are free swimmers. Adults live in rivers and larger rivulets, while juveniles have been recorded from small streams and stagnant area on the periphery of the main river. *Garra ceylonensis* is not a rare species and common within its core distribution areas.
Reproduction	According to published information, this species shows upstream movement for spawning (Pethiyagoda, 1991). Juveniles also live in slow flowing streams in the first stages of their lives, and come down to the main river gradually. Records of *Garra* juveniles from outskirt pools of the main river areas indicate that possibility of spawning in such areas.
Captive breeding and *ex-situ* conservation	There are some records of captive rearing of this species under aquarium conditions (Pethiyagoda, 1991). However, literature on the captive breeding of this species is not available.
Critical habitats	*Garra ceylonesis* shows a wide distribution in the second peneplain, and most of the major river basins in Sri Lanka. It also occurs in protected areas. Therefore, the Moragolla project area is not considered to be a critical habitat area for this species.



Distribution map for *Garra ceylonensis*

Pethia melanomaculata (Tic-tac barb)

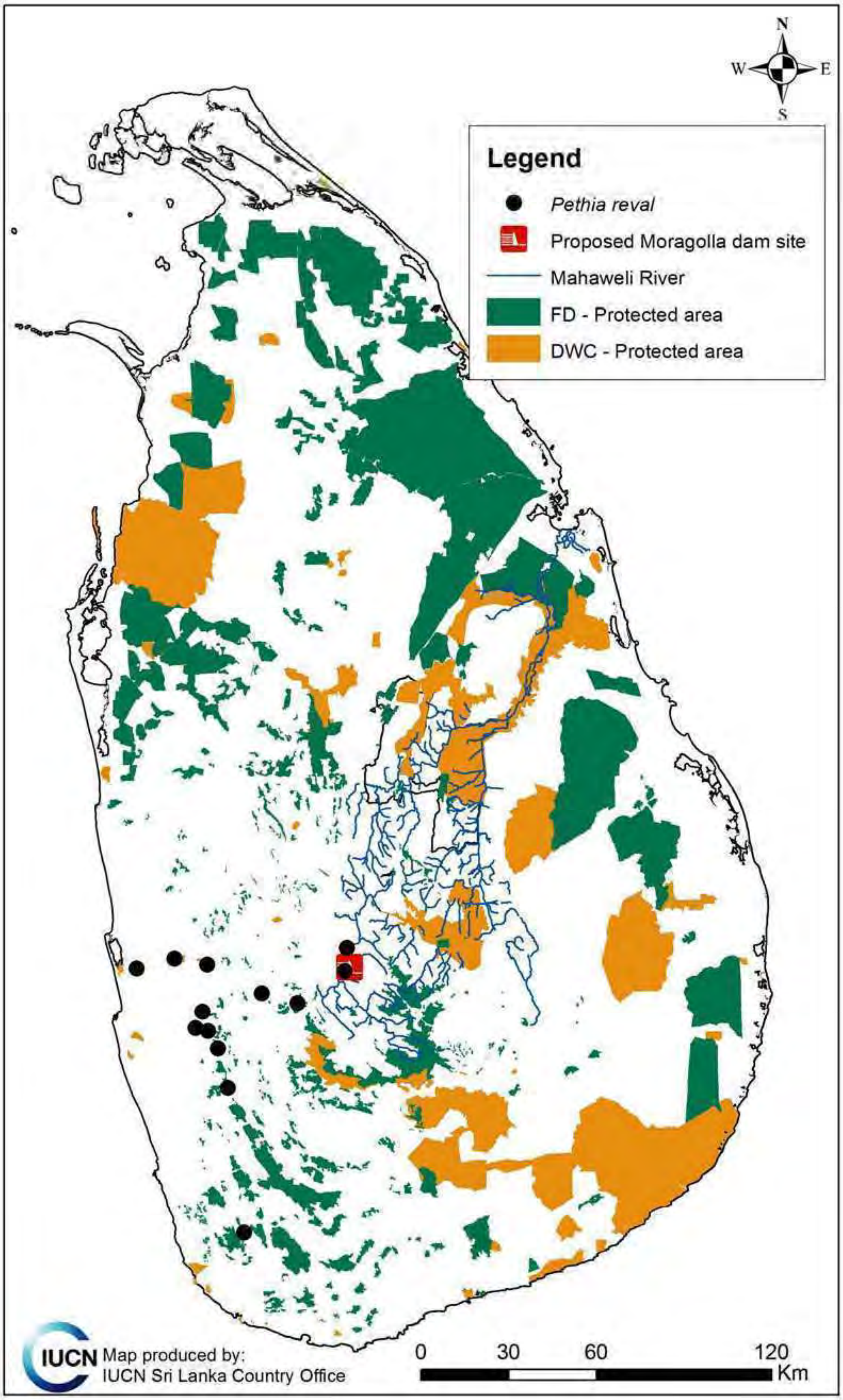
Scientific name	*Pethia melanomaculata*
Common names	Tic-tac Barb
Synonyms	*Puntius ticto*
Conservation status	Vulnerable (National Red List 2012).
Distribution within Sri Lanka	Endemic to Sri Lanka. Considered to be a Dry Zone species. According to Pethiyagoda (1991) and Senanayake (1982), this species is confined to the Dry Zone lowland and the Mahaweli Dry Zone lowland.
Distribution within the Mahaweli River system	This species is recorded in the dry lowland part of the Mahaweli River basin. There are some records from below the Victoria dam site, and the lower part of the Knuckles region, which are not in close proximity to Moragolla project area. Therefore, there are discrepancies between the known distribution of this species, and the record reported from the Moragolla project area in NBRO (2013).
Feeding, habitat preference, life cycle and population density	Feeds primarily on plant materials, as well as on zooplankton and phytoplankton (Pethiyagoda, 1991). Found in smaller tanks or small, clear, rocky rivers in the Dry Zone. Not considered to be rare.
Reproduction	Reproduction in this species is similar to that of other barb species, and is well documented (Pethiyagoda, 1991).
Captive breeding and *ex-situ* conservation	According to the published information, breeding of *P. melanomaculata* is possible under captive conditions (Pethiyagoda, 1991).
Critical habitats	*Pethia melanomaculata* shows a wide distribution in the northern low country Dry Zone. Therefore, the Moragolla Project area is not considered to be a critical habitat area for this species.



Distribution map for *Pethia melanomaculata*

***Pethia reval* (Red-fin barb)**

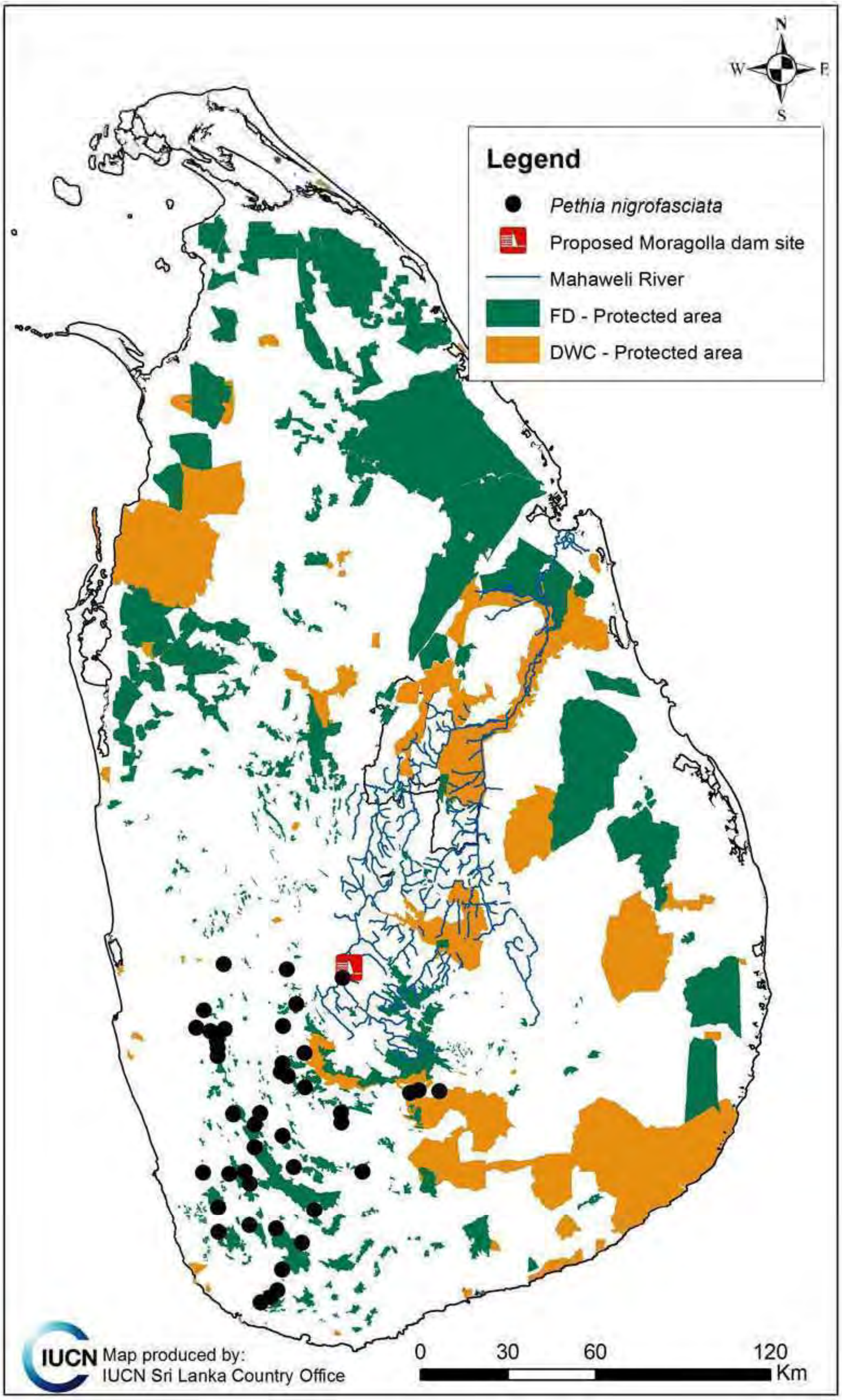
Scientific name	*Pethia reval*
Common names	Red-fin barb
Synonyms	*Puntius cumingi*
Conservation status	Endangered (National Red List 2012).
Distribution within Sri Lanka	Endemic to Sri Lanka, and confined to the Attanagalu and Kelani River basins.
Distribution within the Mahaweli River system	Senanayake and Moyle (1982) introduced this species into the Mahaweli River near the Ginigathhena area for conservation purpose. The existing population of *P. reval (Puntius cumingii)* in project area are direct decedents from that translocated population, which is currently distributed in Gampola, Nawalapitiya and Ginigathhena within the Mahaweli river basin.
Critical habitats	The natural distribution range of *Pethia reval* is restricted from the Attanagalu River to the Kelani River in the Western Province, and the introduced population in the Mahaweli basin is not considered in the Red Listing process. Therefore, the Moragolla project area is not considered to be a critical habitat area for this species.



Distribution map for *Pethia reval*

***Pethia nigrofasciata* (Sri Lanka black ruby barb)**

Scientific name	*Pethia nigrofasciata*
Common names	Sri Lanka black ruby barb
Synonyms	*Puntius nigrofasiatus*
Conservation status	Endangered (National Red List 2012)
Distribution within Sri Lanka	Endemic to Sri Lanka, and confined from the Attanagalu River basin to the Nilwala River basin.
Distribution within the Mahaweli River system	Senanayake and Moyle (1982) introduced this species into the Mahaweli River near the Ginigathhena area for conservation purposes. The existing population of *P. nigrofasiata* in project area are direct decedents from this translocated population, which is currently distributed in Gampola, Nawalapitiya and Ginigathhena in the Mahaweli River basin.
Critical habitats	The natural distribution of *Pethia nigrofasciata* ranges from the Attanagalu River to the Nilwala River, and the introduced population in the Mahaweli basin is not considered during the Red Listing process. Therefore, the Moragolla project area is not considered to be a critical habitat area for this species.



Distribution map for *Pethia nigrofasciata*

Note: A species profile has not been prepared for *Systomus spilurus* (Olive barb) as there is some taxonomic uncertainty surrounding this species, and as it is considered to be a Data Deficient (DD) species.

Annex 5: Impacts of dams and mini-hydro power projects on freshwater biodiversity (Adapted partly from McAllister *et al.*, 2001).

Dams and associated reservoirs impact freshwater biodiversity in the following ways:

- Blockage and restriction of the movement of migratory species up and down rivers, causing extirpation or extinction of genetically distinct stocks or species.
- Changes to the turbidity or sediment levels of rivers, the natural levels of which species and ecosystems have become adapted to. Trapping of silt in reservoirs deprives downstream deltas and estuaries of the materials and nutrients necessary for their maintenance as productive ecosystems.
- Filtering out of woody debris, which would otherwise contribute to creating habitats and sustaining food webs.
- Changes to the conditions of rivers flooded by reservoirs, with running water becoming still, silt being deposited, deepwater zones being created, and new temperature and oxygen conditions being created. These conditions are unfavourable to the riverine species adapted to occupy these areas in the past.
- The provision of new habitats for waterfowl, in particular for overwintering, or in arid regions, which may increase their populations.
- The increased possibility of fostering exotic species, and the likelihood that these exotic species will tend to displace the indigenous biodiversity.
- Colonization of reservoirs by species that are considered to be vectors of human and animal disease agents.
- Management of the dam may alter or prevent normal flooding conditions, which will impact the maintenance of surrounding flood plains that support a rich diversity of species during high water periods. This will have implications for the biodiversity of the area, and well as on fisheries resources.
- Changes to the normal seasonal estuarine discharge, which can reduce the supply of entrained nutrients, impacting the food chains that sustain fisheries in inland and estuarine deltas.
- Modification of the water quality and flow patterns in downstream areas.
- Cumulative effects of a series of dams, especially where the impact footprint of one dam overlaps with that of the next downstream dam, can exacerbate the impacts on biodiversity.
- Other human activities, including agriculture, forestry, urbanization and fishing, that increase with the development of the area, can impact the biodiversity associated with these systems despite the fact that these activities are primarily land-based.

As such, dams are considered to be a significant threat to freshwater diversity. The impacts associated with such development activity occur largely through the frequent loss of habitat, modifications to the natural flow regime and blockage of migrations.

Annex 6: Proposed translocation action plan

All the translocation activities should be implemented according to the Guidelines for Reintroduction and Other Conservation Translocations (IUCN/SSC, 2013).

A technical committee including representatives from the Ceylon Electricity Board (CEB), the Department of Wildlife Conservation (DWC), the Forest Department (FD), the National Zoological Gardens (NZG), IUCN and other experts, should be established in order to oversee and evaluate the implementation of this programme.

Species name	Common name	Proposed area for collection	Proposed translocation destination site	Proposed period of implementation
Labeo fisheri	Mountain labeo	Inundation area and downstream areas (up to the proposed power house) of proposed Moragolla dam axis.	Suitable from Kitulgala to Yatiyanthota in the Kelani River or Sitawake River*.	During the construction period.
Belontia signata	Combtail	Inundation area of the proposed MHP.	Atabage Oya and Ulapone Oya.	During the construction period.
Schistura notostigma	Banded mountain loach	Inundation area of the proposed MHP.	Atabage Oya and Ulapone Oya.	During the construction period.
Species of the Family Bagridae		Inundation area of the proposed MHP.	Atabage Oya and Ulapone Oya.	During the construction period.
Tor kudree	Marsheer	Downstream areas (up to the proposed power house) of the proposed Moragolla dam axis.	Atabage Oya or the upper catchment of Moragolla up to Nawalapitiya.	During the construction period.
Channa ara	Giant snakehead	Downstream areas (up to the proposed power house) of proposed the Moragolla dam axis.	The upper catchment of the Moragolla reservoir up to Nawalapitiya.	During the construction period.
Channa orientalis	Smooth-breasted snakehead	Inundation area and downstream areas (up to the proposed power house) of the proposed Moragolla dam axis.	Atabage Oya and Ulapone Oya.	During the construction period.

Species name	Common name	Proposed area for collection	Proposed translocation destination site	Proposed period of implementation
Wallago attu	Shark catfish	Downstream areas (up to the proposed power house) of the proposed Moragolla dam axis.	The upper catchment of the Moragolla reservoir up to Nawalapitiya.	During the construction period.
Ompoc bimaculatus	Butter catfish	Downstream areas (up to the proposed power house) of the proposed Moragolla dam axis.	The upper catchment of the Moragolla reservoir up to Nawalapitiya.	During the construction period.

*Translocation of *Labeo fisheri.*

Labeo fisheri (Mountain labeo) is the only critical fish species that is present in the Moragolla project area that was identified as a high priority fish species according to points-based analysis carried out in order to identify priority species. *Labeo fisheri* is restricted to the middle part of the Mahaweli River, including the Amban Ganga and Kalu Ganga sub-catchments of the Mahaweli basin. All known primary habitats of *Labeo fisheri* (Mountain labeo) are being affected severely due to dams and reservoirs in the Mahaweli River system. Therefore, the translocation of this species to another river basin, - in this case the Kelani River basin - after analysing all factors regarding the survival of this critical endemic fish species, is recommended. This trans-river basin translocation should be carried out after thorough assessments of the existing population of *Labeo fisheri* (Mountain labeo), and the habitat conditions and species composition of both the source site (Mahaweli River) and the destination site (Kelani River) have been conducted and considered.

Annex 7: Offset habitat protection plan for the upper catchment of Moragolla up to Nawalapitiya*

No.	Action	Resources required	Potential implementing agency / agencies	Outcome / output	Monitoring
1	Identification of critical areas for fish in order to facilitate natural movement and relocation – this action is linked with translocation plan presented in Annex 6.	GIS expert and fauna expert.	Technical experts with relevant experience.	Map of the critical and suitable areas in the Mahaweli River system for natural upstream relocation and facilitation of natural upstream movement of fish in the proposed Moragolla project area.	A period of six months is necessary for monitoring and mapping - this action is linked with translocation plan presented in Annex 6.
2	Identification of the most depleted areas in the upper catchment and preparation of suitable habitat improvement plans.	GIS expert and flora expert.	Forest Department and technical experts with relevant experience.	Map of the upper catchment up to Nawalapitiya prepared along with habitat improvement plans.	
3	Implementing an afforestation programme in the identified locations. This action can be linked with the afforestation and watershed management plans of the MHP.	Forestry expert and labourers.	Forest Department.	Suitable areas in the upper watershed are replanted.	Monitoring of the progress of growth.
4	Community awareness programme - this action can be linked with other awareness programmes related to the mitigation of impacts on the terrestrial fauna of the area, and the afforestation and watershed management plan.	Community mobilizers and environmental communicators.	Forest Department and technical experts with relevant experience.	Communities are educated about the importance of upper watershed management for the conservation of the native fish of the area.	Re-visiting relevant sites to evaluate the impacts of the awareness programmes.

*Note: Most of these activities are a part of the afforestation and watershed management activities of the MHP and are not,therefore, not budgeted separately.

Annex 8: Estimated budget for the fish translocation programme for the Moragolla hydropower project

No	Description	Amount (LKR)
01	Project staff	900, 000.00
02	Transport (Field Team/Fish)	350, 000.00
03	Equipment purchase and Hire	200, 000.00
04	Awareness programme for relocated sites	100, 000.00
05	Allowance for Government staffs (DWC,)	40, 000.00
06	Communication and Stationeries	50, 000.00
07	Surveying and selection of translocation sites	400, 000.00
	Total cost	**1, 940, 000.00**

Annex 9: National level recovery Plan for *Labeo fisheri* (Green Labeo)

Justification

Labeo fisheri is a Critically Endangered (CR) endemic freshwater fish species and occurs only in the Mahaweli River basin. According to published information, *L. fisheri* is restricted to fast flowing, clear and rocky areas of main river and the adjacent main branches (Senanayake 1980, Deraniyagala 1952, Pethiyagoda 1991, Shirantha 2012). All known localities of *Labeo fisheri* overlap with existing or proposed dams and reservoirs and such altered habitats are not suitable for *L. fisheri* (Pethiyagoda 1991, Senanayake and Moyle 1982). According to the Shiratha (2012), attempts to breed this species in captivity have failed and according to the Pethiyagoda (1991) there is no records of captive rearing of *L . fisheri*. *L. fisheri* is one of the freshwater fish species that is on the brink of extinction due to the above reasons and habitat deterioration due to heavy siltation of the upper Mahaweli catchment, large scale use of agrochemicals and destructive fishing activities (Wikramanayake 1990, Pethiyagoda 1991, Shirantha 2012).

Therefore, it is recommended that a national level recovery plan is developed and implemented for this species. It is not expected that this will be done through the MHP alone, but some activities are relevant to the MHP.

Conservation status of *Labeo fisheri*

According to the National Red List 2012, *Labeo fisheri* is categorized as a Critically Endangered freshwater fish and is included in Schedule VI of the Fauna and Flora protection Ordinance (Amended act No. 22 of 2009) as a protected species (Gunasekara, 2011).

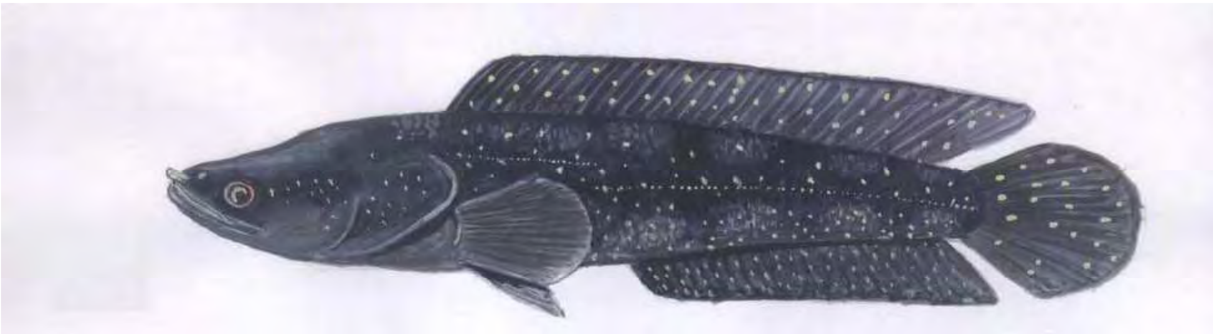
Proposed activities and responsible organization/s

No.	Activity	Organization/s
01	Habitat assessment of *L. fisheri* historical range in the Mahaweli basin	Mahaweli Authority of Sri Lanka (MASL), CEB, DWC, IUCN, University of Peradeniya
02	Implementing research on captive breeding and ex-situ conservation of *L.fisheri*	University of Peradeniya, DWC, National Zoological Gardens
03	Recovery and translocation of Moragolla subpopulation of *L.fisheri* to new location/s	MHP, IUCN
04	Habitat protection and watershed management of critical habitats which will identify by Activity 1 and 3	DWC, Mahaweli Authority, MHP
05	Community awareness programmes to improve the sustainable use of upper watershed management and reduce destructive fishing activities	DWC, Mahaweli Authority, MHP
06	Reintroduce captive bred individuals into natural habitats	University of Peradeniya, DWC
07	Study the impact of competitive exotic fish species such as *Labeo rohita* on *Labeo fisheri*.	University of Peradeniya, IUCN,DWC

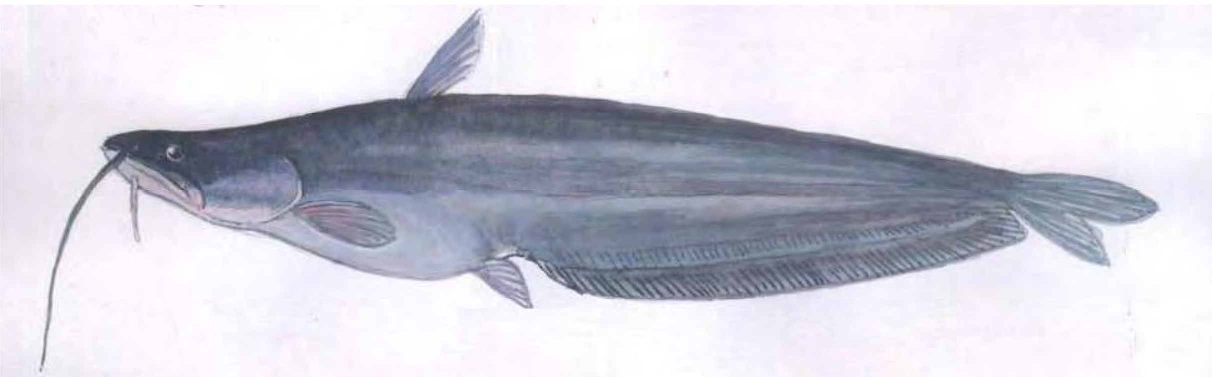
Annex 10: Illustrations of important fish of the Moragolla Project Area

(All illustrations by Sampath A. de Goonatillake)

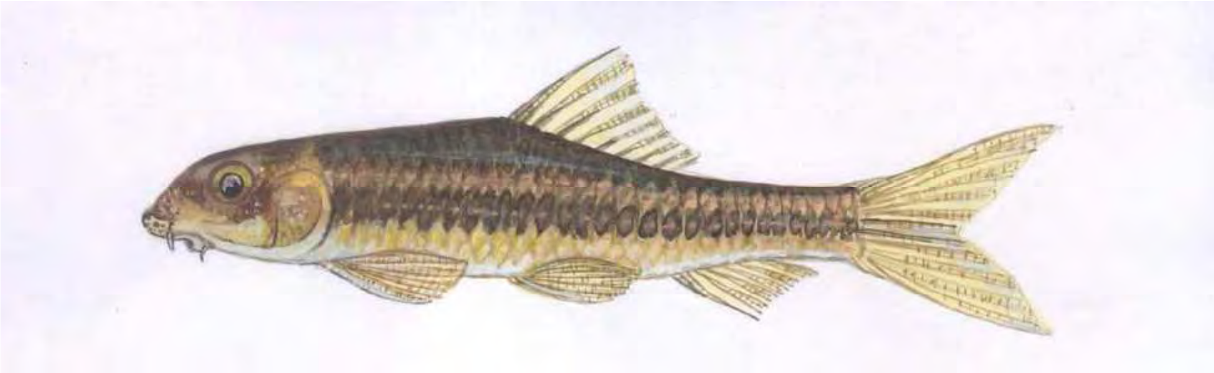
Labeo fisheri **(Green Labeo)**



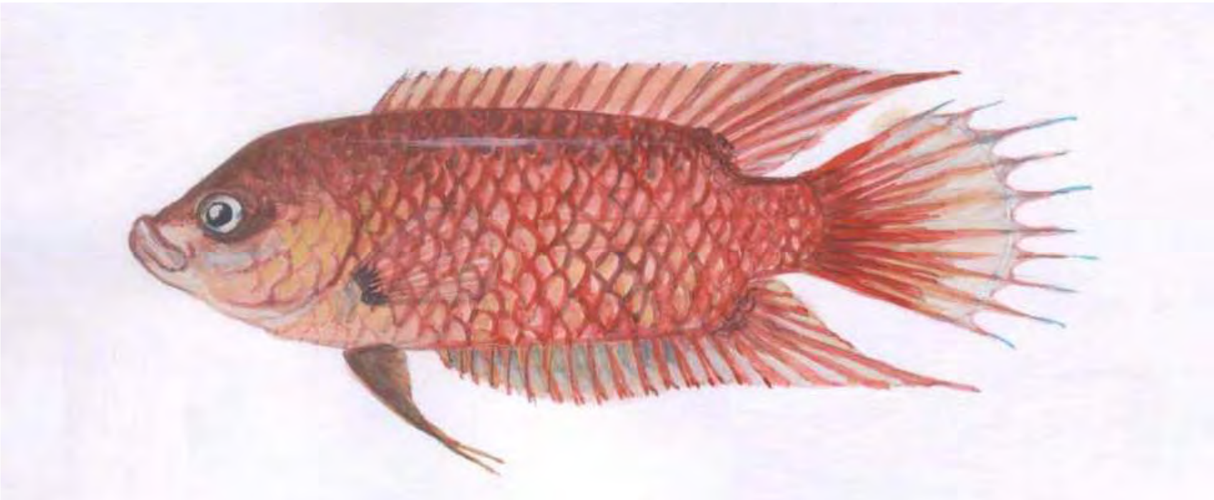
Channa ara **(Giant Snakehead)**



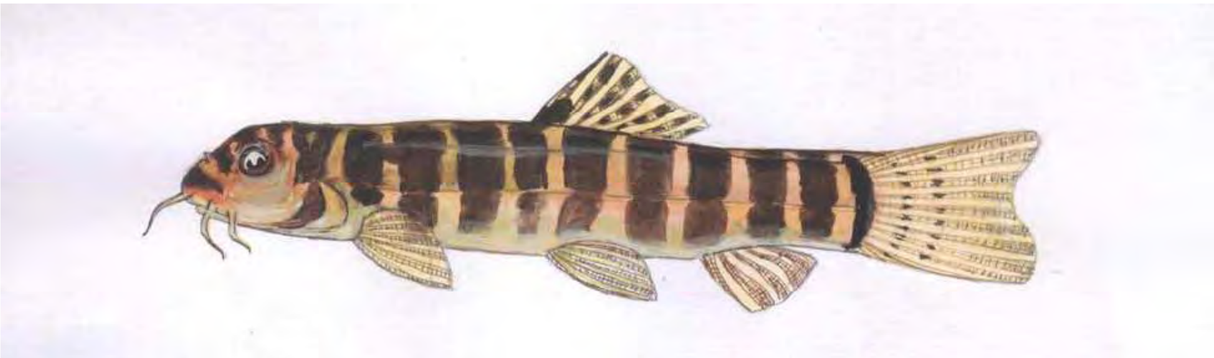
Wallago attu **(Shark Catfish)**



Garra ceylonensis **(Stone Sucker)**



Belontia signata **(Comb tail)**



Schistura notostigma **(Banded mountain loach)**

Pethia nigrofasciata **(Black-ruby barb)**

Pethia reval **(Red fin barb)**

IUCN, International Union for Conservation of Nature

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Moragolla Hydropower Project

Additional Studies in the Natural Environment: Expert Report on Habitat Creation and Management to enhance Terrestrial Biodiversity

FINAL REPORT

August 2013

IUCN - International Union for Conservation of Nature, Sri Lanka Country Office

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ABBREVIATIONS

CEA	–	Central Environmental Authority
CEB	–	Ceylon Electricity Board
CR	–	Critically Endangered
DWC	–	Department of Wildlife Conservation
EIA	–	Environmental Impact Assessment
EN	–	Endangered
EPA	–	Environmental Protection Area
FD	–	Forest Department
IUCN	–	International Union for Conservation of Nature
LC	–	Least Concern
MASL	–	Mahaweli Authority of Sri Lanka
MHP	–	Moragolla Hydropower Project
NBRO	–	National Building Research Organization
NK	–	Nippon Koei Co. Ltd
NT	–	Near Threatened
VU	–	Vulnerable

EXECUTIVE SUMMARY

The Ceylon Electricity Board (CEB) plans to develop a new 30MW hydropower project at Moragolla in the Kandy District. The involves the construction of a 35 m high concrete gravity dam across the Mahaweli Ganga, in order to form a 38.5 ha reservoir with a Full Supply Level (FSL) of 548 m asl. Water will be diverted through a conveyance system to a powerhouse and with the outfall located opposite the confluence with the Atabage Oya.

As the project will be located in the middle catchment of the Mahaweli river - which is the longest river in Sri Lanka, and supports a wide variety of habitats inhabited by a number of endemic and threatened fauna - an Environment Impact Assessment (EIA) has been carried out to ascertain the impact of the project on biodiversity of the area, as well as on the biodiversity of Sri Lanka as a whole. This assessment has been supplemented by additional studies for further analysis of the impacts of the project on local biodiversity. The present study has been undertaken with the objective of identifying and prioritizing terrestrial faunal species that require mitigation measures in order to minimize the impacts of the proposed Moragolla Hydropower Project (MHP), and to propose mitigation measures to reduce the negative impacts of the proposed project on identified priority species.

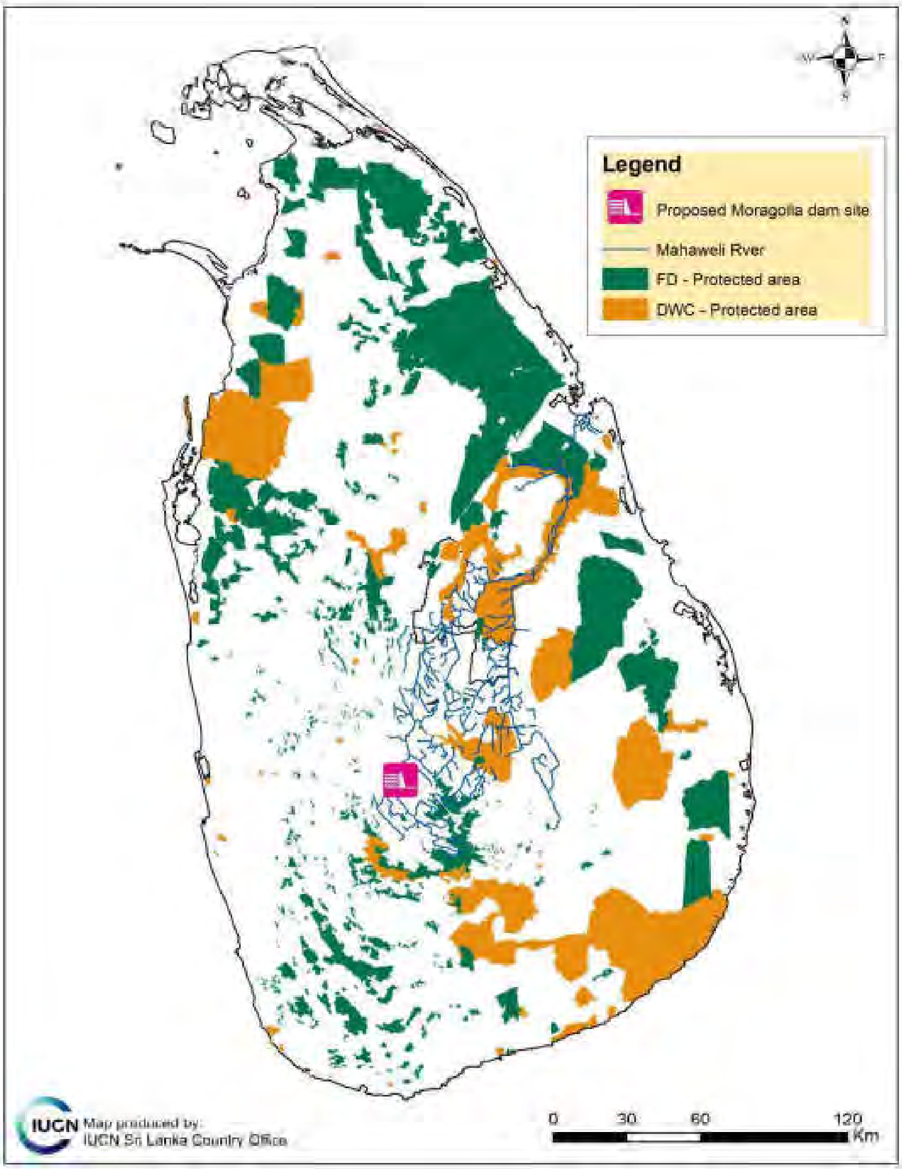
Based on direct and indirect observations (evidence such as scats and tracks) made during the EIA study (CECB and ACO, 2012), and the Additional Study (NBRO, 2013) , a total of 173 species of terrestrial fauna have been recorded in the area that is directly impacted by the proposed project. A total of 23 of these species are endemic to Sri Lanka, while 16 are listed as threatened species and 12 are listed as Near Threatened (NT) species. Further, ten of the 23 species of endemic species are listed as threatened or Near Threatened (NT) species. Therefore, overall, a total of 41 species that were recorded in the area were considered as critical species. These species were evaluated using an impact index developed in order to determine how these species will be affected by the proposed project during the present study. Other species were not evaluated as they show a wide distribution in Sri Lanka, as well as outside Sri Lanka, and therefore, the proportions of their populations impacted by the project will be insignificant.

Based on the evaluations carried out, none of the 41 identified threatened and endemic species will be significantly affected by the proposed project. Five species have been identified as moderately affected due to loss of habitat as a result of the project, and the impact of the project on these species can be mitigated by creating suitable habitats within the reservation of the proposed reservoir that will act as a refuge for the species that become displaced as a result of project activities. Further, the site will become colonized by species showing high mobility such as birds, mammals and butterflies. The ideal example for such colonization is the establishment of a butterfly garden in Lady Ridgeway Hospital in the city of Colombo as this garden was colonized by rare butterfly species that do not occur in any of the urban habitats within a radius of about 25 km around the hospital. As this reserve is in close proximity to natural habitats compared to the above scenario, the probability of colonization is expected to be much higher.

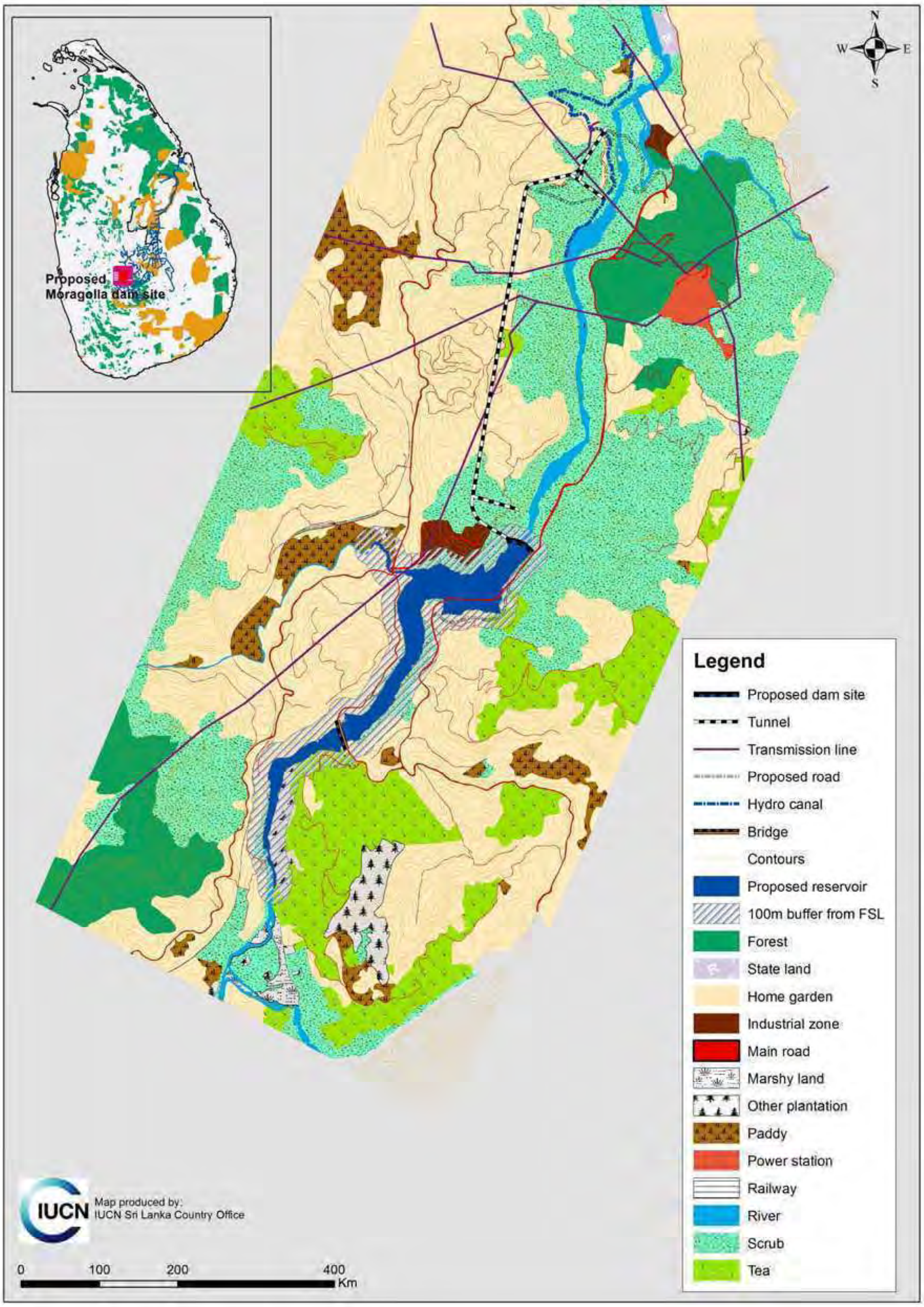
1. INTRODUCTION

1.1 Background

The Ceylon Electricity Board (CEB) is planning to develop a 30.8 MW hydropower project in Moragolla, Sri Lanka. The proposed Moragolla Hydropower Project (MHP) is located in the Kandy District of the Central Province. The project involves the construction of a 35 m high concrete dam across the Mahaweli River at Weliganga, resulting in the formation of a 38.5 ha reservoir with a Full Supply Level (FSL) of 548 m asl.



Map 1. Location of the Moragolla Hydropower Project

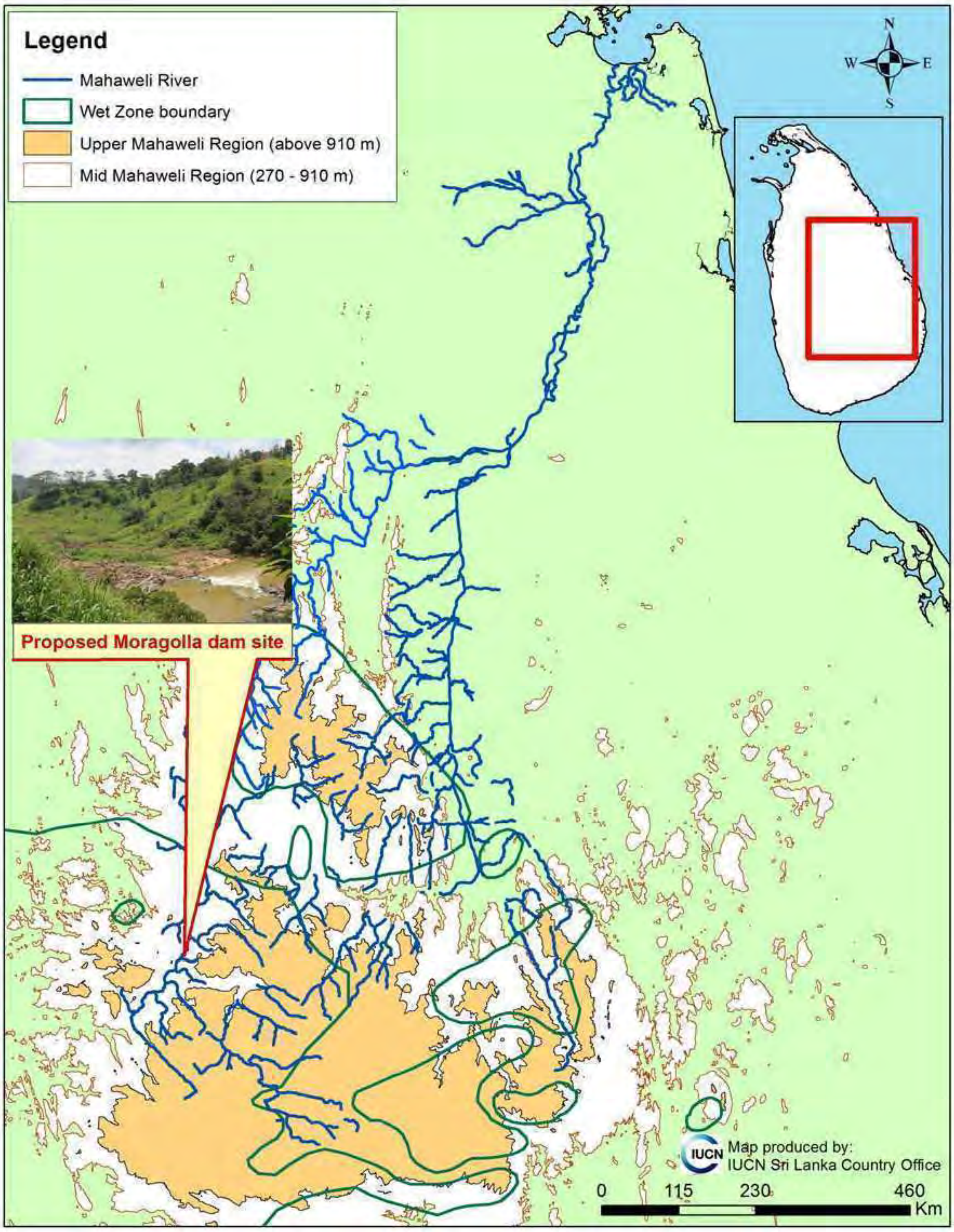


Map 2. The project area including land uses.

The Mahaweli River (known locally as Mahaweli Ganga) is the longest river in Sri Lanka, and is of great economic and social importance. It is also an ecologically important system, supporting a large number of endemic and threatened species, including several terrestrial faunal species, such as *Ceratophora tennentii* (Leaf-nosed lizard), *Cophotis dumbara* (Knuckles pygmy lizard) and *Nannophrys marmorata* (Kirtisinghe's rock frog),that are found only within the Mahaweli River basin.

An environmental Feasibility Study, including an Environmental Impact Assessment (EIA) (CECB and ACO, 2012), was conducted for the proposed Moragolla Hydropower Project – which is based within the Mahaweli River basin – in 2009. Another additional study (NBRO, 2013) was undertaken in 2013 to upgrade the EIA and to supplement existing data.

The Proposed Moragolla Hydropower project area lies within the second peneplain of the Wet Zone of the Sri Lanka. Overall, the Mahaweli basin can be divided in to three major parts based on peneplains. The Upper Mahaweli area lies within the third peneplain (above 910 m from mean sea level), while the mid-Mahaweli region lies within the second peneplain (270 – 919 m from mean sea level) and the lower Mahaweli region lies mainly within the third peneplain in the Dry Zone of the island (up to 210 m from mean sea level). The project area is belongs to mid-Mahaweli region, where the rivers flow fast and feature rocky substrate (See Map 3 and Figure 1).



Map 3. Mahaweli basin showing the upper, mid and lower Mahaweli regions.

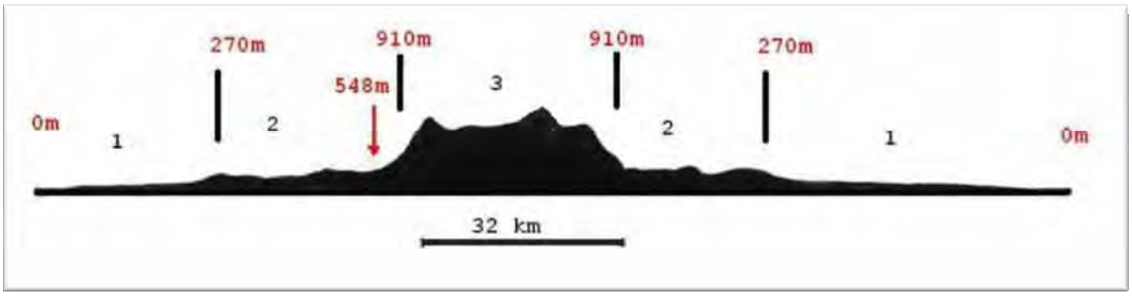


Figure 1. Diagrammatic cross-section of Sri Lanka showing the three peneplains (after Wadia, 1942).
(1 - first peneplain; 2 - second peneplain; 3 - third peneplain; red arrow - project area)

The EIA report (CECB and ACO, 2012) and additional study (NBRO, 2013) indicate that the project area – which consists primarily of degraded habitats - has been selected with consideration to avoiding and minimizing the environmental impacts of the hydropower project to the greatest extent possible. The terrestrial area that will be impacted directly due to project activities consists primarily of secondary vegetation, and is subject to a number of anthropogenic pressures, including farming. Therefore, the project is not expected to have significant impacts on terrestrial species and their habitats, as none of these species are restricted to the project area, and can be observed in other parts of the lowland Wet Zone, the Intermediate Zone or in similar habitats throughout the country. Nevertheless, a number of potential impacts of the project, including the loss of habitats and disturbances to habitats during construction, have been identified in the EIA report (CECB and ACO, 2012). Therefore, habitat creation and management activities will result in a positive contribution to the conservation of biodiversity in the area.

The EIA study, and subsequent supplementary surveys (CECB and ACO, 2012; NBRO, 2013 have identified a total of 41 terrestrial and aquatic associate faunal species that are endemic, threatened or Near Threatened within the direct impact zone of the project. Therefore, a further study has been deemed necessary to facilitate the planning and design of suitable measures to mitigate the impacts of the MHP on these terrestrial faunal species.

1.2 Objectives

The overall objective of the study is to identify suitable measures necessary to mitigate the impacts of the MHP on priority faunal species found in the area.

The specific objectives of the project are as follows:

- To identify priority species and their habitats within the project area;
- To assess the impacts of the project on priority species, as well as the need for any mitigation measures or management actions; and
- To prepare specific protection, mitigation, management and monitoring plans for the sustainability of each priority species.

2. METHODOLOGY AND APPROACH

The priority species list provided in Annex 1 of the Terms of Reference (ToR) for the study does not include the updated taxonomic and species status information. As such, it was necessary to update this list in order to identify priority species for which mitigation measures are necessary.

The study is based primarily on information from the EIA report for the MHP (CECB and ACO, 2012), as well as information from additional biodiversity assessments (NBRO, 2013). According to these two reports, the species documented within the project area were observed at the project site through direct sightings or indirect evidence, such as footprints or dung analysis. Therefore, the word "recorded", in this document, refers to species that have actually been encountered – either directly or indirectly – within the site. A brief field visit was also undertaken by the IUCN team between 21 and 22 August, 2013, in order to ascertain the ground situation in the area, and gain better insights into the findings of these two reports.

The initial listing of species was based on the 2007 Red List of Threatened Species of Sri Lanka (IUCN and MENR, 2007)[1]. Given that the National Red List of Sri Lanka was updated recently (MOE, 2012), the total list of terrestrial and aquatic associate fauna recorded from the project area was updated based on the new taxonomic nomenclature given in the updated Red List. Further, the conservation statuses of the species has been updated according to the National Red List 2012 of Sri Lanka (MOE, 2012) and the Global IUCN Red List[2], in order to gain better insights into the current conservation status of each species (see Annex 2). Distribution maps for the identified critical species – including endemic, threatened (CR, EN or VU) and Near Threatened (NT) species were developed using data from the Red List database housed at the Ministry of Environment and Renewable Energy.

[1] http://www.environmentmin.gov.lk/web/pdf/Red_List.pdf
[2] http://www.iucnredlist.org/

3. Discussion

3.1 Existing ecology and biodiversity

3.1.1 Terrestrial ecology and biodiversity of the Mahaweli River and the impact of hydropower and other development activities

The Mahaweli River is the longest river in Sri Lanka. It is 355 km long and drains an area of approximately 10, 448 km^2 (16 percent of the land area of Sri Lanka). The Mahaweli basin is spread across three types of bio-climatic zones – the dry zone, the low and mid-country intermediate zone and the montane zone), due to its geographical variations (IUCN Sri Lanka, 2007). Further, the Mahaweli River flows through a number of unique floral zones, such as tropical wet evergreen forests, humid zone dry patana grasslands, central mountains, northern intermediate lowlands, and dry and arid lowlands (Gunatilleke and Gunatilleke, 1990). Due to this high variation of geographical features and floristic regions, the Mahaweli basin harbours a rich faunal diversity.

The upper montane region of the Mahaweli basin (see Map 3) has been shown to be an important region for the *in-situ* conservation of many localized endemic faunal species recently. Manamendra-Arachchi and Pethiyagoda (2006) discovered 29 amphibian species, including 23 rhacophorids[3] of the genus *Pseudophilautus,* that are confined to the Mahaweli basin. Some of these species are confined to the central montane range (CMR), while the others are confined to the Knuckles mountain range (KMR). Further, Dutta and Manamendra-Arachchi (1996) have observed that the endemic frog species *Microhyla zeylanica* (Sri Lanka narrow mouthed frog) and *Nannophrys marmorata* (Kirtisinghe's rock frog) that are found only in the central and Knuckles massif up to approximately 2, 000 m in altitude. Likewise, several species of endemic reptiles are also restricted to the upper montane region of the Mahaweli basin. For instance, two species belonging to the endemic genus *Ceratophora* (horned lizards) – *Ceratophora stoddartii* (Rhino horn lizard) and *Ceratophora tennentii* (Leaf-nosed lizard) - and two species belonging to the endemic genus *Cophotis* (pygmy lizards) - *Cophotis dumbara* (Knuckles pygmy lizard) and *Cophotis zeylanica* (Pygmy lizard) - are restricted to this region.

An endemic bird species - *Myophonus blighi* (Sri Lanka Whistling Thrush) and three indigenous birds - *Saxicola caprata* (Pied Bush Chat), *Aviceda jerdoni* (Jerdon's Baza) and *Turdus merula* (Eurasian Blackbird)- are also confined mainly to the upper montane region of the Mahaweli basin. A number of endemic mammals, including *Solisorex pearsoni* (Sri Lanka Pearson's long-clawed shrew), *Suncus fellowes-gordoni* (Sri Lanka pygmy shrew) and *Rattus montanus* (Nelu rat), are also restricted to the montane region of the Mahaweli basin. Considering their high species diversity and endemicity, Peak Wilderness Sanctuary, Horton Plains National Park and Knuckles Conservation Forest were declared, collectively, as natural World Heritage Site serial property – know as the Central Highlands World Heritage Site - by UNESCO in 2012. The upper Mahaweli basin, despite its high biodiversity value, is under heavy pressure. Most of the upper catchment of the Mahaweli basin has been converted to tea plantations and vegetable cultivation land since the eighteenth century. This has led to heavy deforestation in the upper catchment. Further, it has increased the rate of soil erosion, as well as contamination of the river with fertilizers. All

[3] Amphibian species belonging to Family Rhacophoridae. In Sri Lanka, this family is represented by the genera *Pseudophilautes, Taruga* and *Polypodates.*

these activities have contributed to a reduction of the biodiversity of the upper Mahaweli basin.

In 1979, under the Mahaweli accelerated development project, the Mahaweli basin has subjected to a number of water diversion projects, which have affected the whole ecology of the river and its natural environments. Apart from the main river, small tributaries of the Mahaweli River at the borders of the upper and mid-Mahaweli regions have also been blocked off for mini-hydro power generation. Such diversions have resulted in low flows downstream of the diversion point. When the flow is restricted due to the diversion of water, the water retained in downstream areas tends to become stagnated, and the quality of the water deteriorates rapidly making it unsuitable for most fish. Further, low flows downstream of the dam, and conversion of the river upstream of the dam into a reservoir, has impacted the ecology of the fish species found in these areas, resulting in a marked reduction in the population sizes of some native riverine fish species, such as *Labeo lankae* (Sri Lanka orange fin labeo) and *Labeo fisheri* (Mountain labeo), and causing them to be listed as Critically Endangered (CR) species.

Further, the construction of large dams across the Mahaweli River at several sites has resulted in the blockage of the river, preventing free movement of aquatic organisms. This is particularly relevant to migratory fish species, as it has disrupted their breeding ecology. Even populations of non-migratory fish have become fragmented due to the establishment of dams. In addition, the inundation of large areas due to the establishment of large reservoirs has resulted in a loss of habitat for many terrestrial species that inhabited these areas previously.

3.1.2 Terrestrial fauna of the project area and their conservation importance (IUCN and Sri Lanka Red List)

As reported in the EIA report and relevant supplementary studies, a total of 173 terrestrial faunal species have been recorded in the direct impact zone of the MHP area. This includes 23 dragonfly species, 32 butterfly species, seven amphibian species, ten reptile species, 88 bird species and 14 mammal species. The recorded species include 28 endemic species, 11 species of migratory birds and one species of domestic mammal. An overview of the faunal species richness of the project area is given in Table 1.

A complete list of faunal species recorded from the project area, including species status and conservation status information, is presented in Annex 3.

Table 1. Overview of the terrestrial faunal diversity recorded within the project area

Taxon	Number of species							
	Total	Species status			National conservation status			
					Nationally Threatened[4]			NT
		Endemic	Exotic	Migrant	CR	EN	VU	
Butterflies	32	3	0	0	1	0	2	2
Dragonflies	23	6	0	0	0	4	4	4
Amphibians	7	3	0	0	0	0	1	1
Reptiles	10	2	0	0	0	0	0	0
Birds	88	7	0	11	0	0	0	5

[4] According to the National Red List 2012 of Sri Lanka (MOE, 2012).

Taxon	Number of species							
	Total	Species status			National conservation status			
					Nationally Threatened[4]			NT
		Endemic	Exotic	Migrant	CR	EN	VU	
Mammals	14	2	1	0	0	2	2	0
Total	**173**	**23**	**1**	**11**	**1**	**6**	**9**	**12**

As described in the methodology and approach section, the conservation statuses of species listed in the EIA report are based on the 2007 Red List of threatened fauna and flora. Therefore, as the first step, the conservation statuses of the species listed in the EIA study and supplementary studies were revaluated according to the National Red List 2012 of Sri Lanka. An updated detailed list of the threatened and Near Threatened (NT) species – based on the National Red List 2012 of Sri Lanka and the Global Red List 2013 - is given in Annex 2.

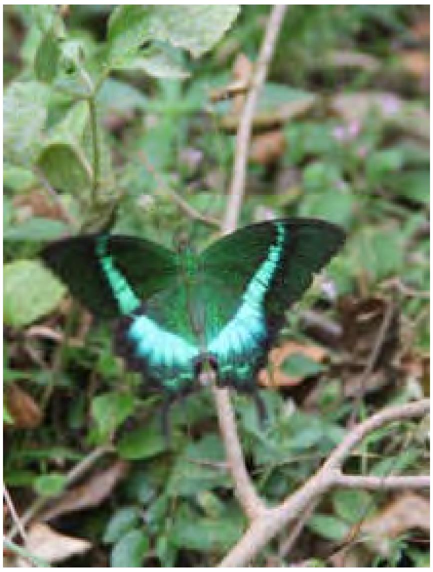
According to this evaluation, a total of 16 species have been identified as nationally threatened species have been recorded from the MHP area. This includes one nationally Critically Endangered (CR) species - *Cepora nadina* (Lesser gull) - six nationally Endangered (EN) species - *Libellago greeni* (Green's gem), *Paragomphus henryi* (Brook hooktail), *Orthetrum triangulare* (Triangle skimmer), Red-veined Darter - *Sympetrum fonscolombii* (Red-veined darter), *Prionailurus rubiginosus* (Rusty spotted cat) and *Prionailurus viverrinus* (Fishing cat) - and nine nationally Vulnerable (VU) species - *Papilio crino* (Banded peacock), *Eurema andersoni* (One spot grass yellow), *Libellago adami* (Adam's gem), *Libellago finalis* (Ultima gem), *Indolestes gracilis* (Mountain reedling), *Trithemis festiva* (Indigo dropwing), Corrugated water frog - *Lankanectes corrugates* (Corrugated water frog), *Lutra lutra* (Otter) and *Moschiola kathygre* (Sri Lanka pygmy mouse-deer). In addition, 12 Near Threatened (NT) species have also been recorded from the MHP area.

Species profiles for all threatened – Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) – species and all Near Threatened (NT) terrestrial faunal species recorded from the project area are presented below.

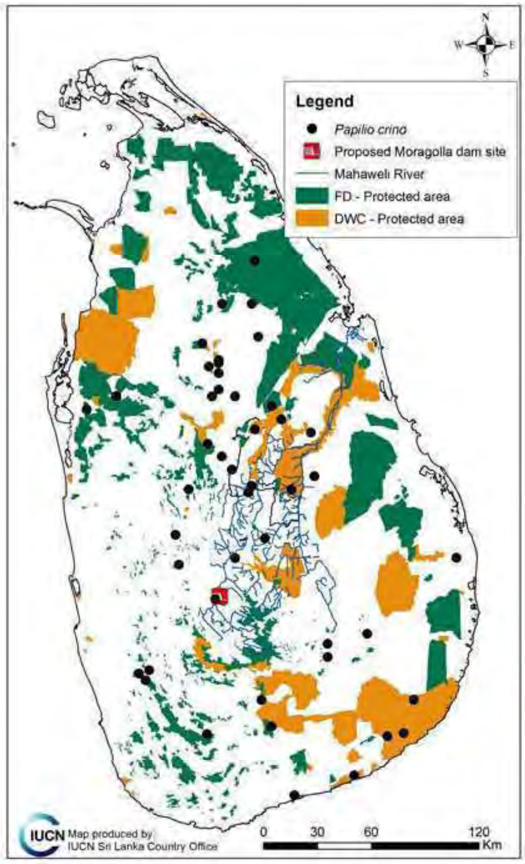
Butterflies

Papilio crino (Banded peacock)

Scientific name	*Papilio crino*
English name	Banded peacock
Sinhala name	Monara papilia
Family	Papilionidae
Species status	Indigenous
National conservation status	Vulnerable (VU)
Ecology	This species can be found throughout the island in forested areas, as well as open area, in both wet and drier areas, but is common in the dry part of the island. Its larvae feed on *Chloroxylon swietenia* (Satinwood) leaves.
Geographical distribution	This species has an island wide distribution up to 1, 800 ft from sea level. It can be found in Sri Lanka and southern India up to Kolkota.
Critical habitat	As this species shows a wide distribution, the project area does not function as one of its critical habitats. The host plant of this species - *Chloroxylon swietenia* (Satinwood) - can be planted in the reservation of the reservoir to increase its population.



Source: © Sampath de A Goonatilake

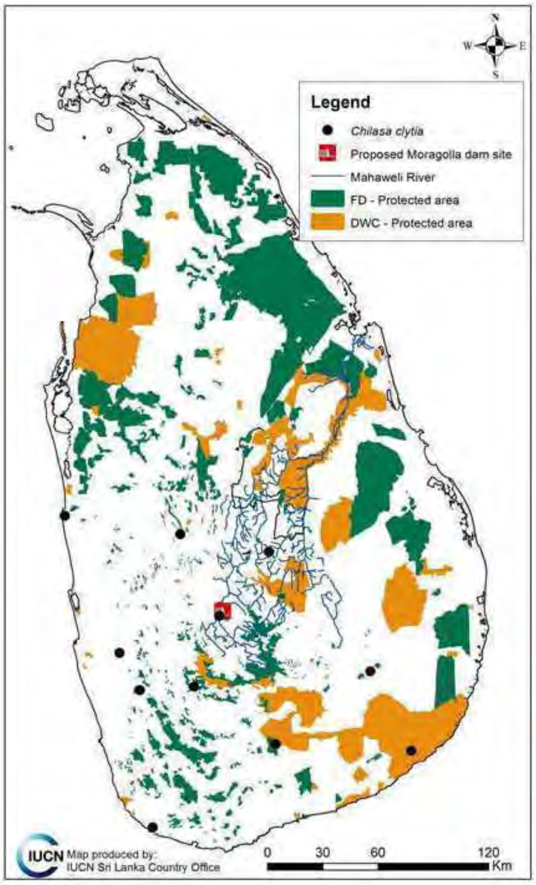


Distribution map (developed based on the 2007 Red List database

***Chilasa clytia* (Mime)**

Scientific name	*Chilasa clytia*
English name	Mime
Sinhala name	Rawana papilia
Family	Papilionidae
Species status	Indigenous
National conservation status	Near Threatened (NT).
Ecology	This species shows an island wide distribution as its host plants – species belonging to Family Lauracea, especially Camphor laurel and Cinnamon – are available island wide.
Geographical distribution	This species shows a distribution up to 2, 800 ft from sea level. It can be found in Sri Lanka and in the oriental region[5].
Critical habitat	As this species shows a wide distribution, the project area does not function as one of its critical habitats. Its host plants (species belonging to Family Lauracea) can be planted in the reservation of the reservoir to increase its population.

Source: http://butterflyclub.greenpower.org.hk/



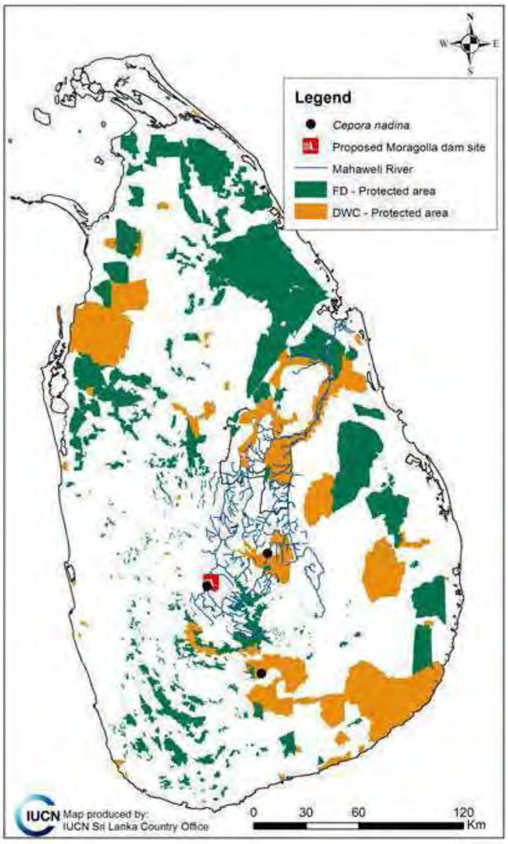
Distribution map (developed based on the 2007 Red List database)

[5] The South Asia and Malaysian region.

Cepora nadina (Lesser gull)

Scientific name	*Cepora nadina*
English name	Lesser gull
Sinhala name	Heen punduru-sudana
Family	Pieridae
Species status	Indigenous
National conservation status	Critically Endangered (CR)
Ecology	Exact habitat unknown. Shows low flight closer to the ground and settles among the under growth.
Geographical distribution	It is distributed from 600 m to 1, 800 m from sea level in high rain fall areas. According to museum records, it has been recorded from Madugoda in the Knuckles area in the Central Province, and Gallelletota in Sabaragamuwa Province. It can be found in Sri Lanka and in the oriental region.
Critical habitat	Its habitat has not been recorded as yet. However, the project area is situated between its known locations. Therefore, it may have wider distribution and the project area may not function as one of its critical habitats.

Source: © Adrian Hoskins

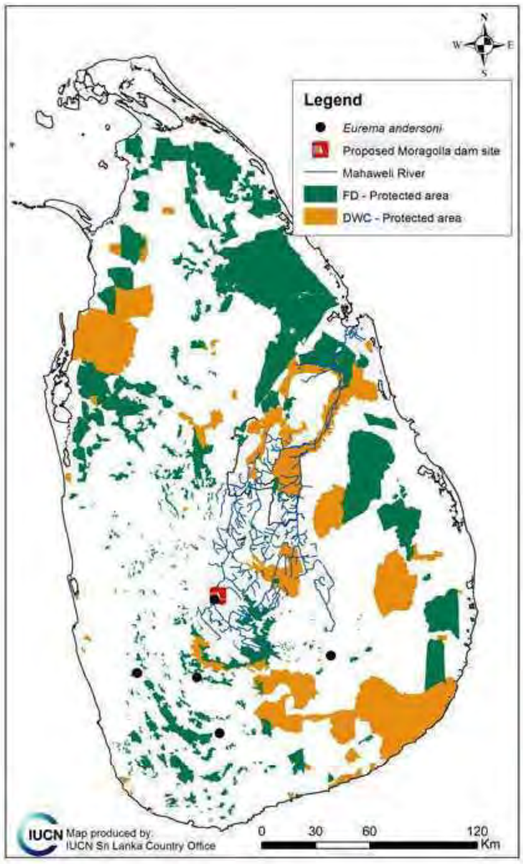


Distribution map (developed based on the 2007 Red List database)

Eurema andersoni (One-spot grass yellow)

Scientific name	*Eurema andersoni*
English name	One-spot grass yellow
Sinhala name	Kela kahakolaya
Family	Pieridae
Species status	Endemic
National conservation status	Vulnerable (VU)
Ecology	Exact habitat unknown. Recorded in the wettest areas of the island.
Geographical distribution	This species is found up to 3, 500ft from sea level in the Wet Zone. It has been recorded in the Kandy, Ratnapura, Deniyaya and Wellawaya areas of the Central, Southern and Sabaragamuwa Provinces. This species is endemic to Sri Lanka.
Critical habitat	Its habitat has not been recorded as yet. However, the project area is situated between its known locations. Therefore, it may have wider distribution and the project area may not function as a critical habitat for this species.

Source: © Peter Eeles

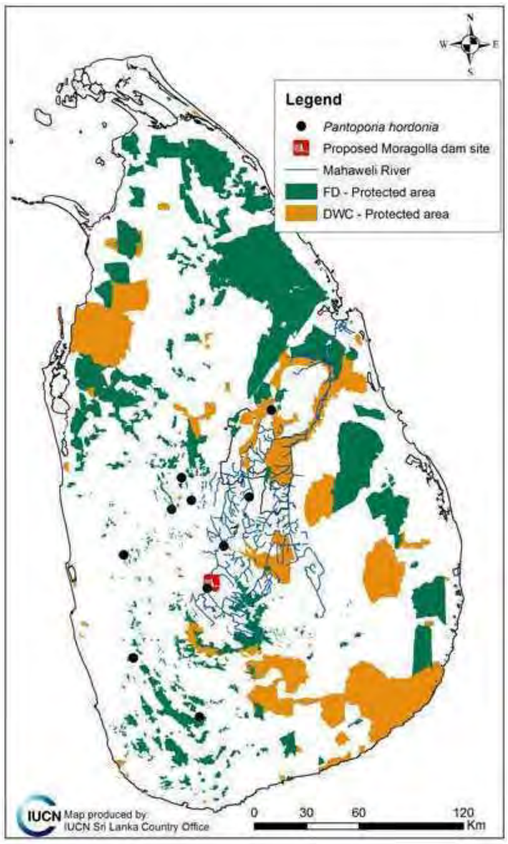


Distribution map (developed based on the 2007 Red List)

Pantoporia hordonia (Common lasker)

Scientific name	*Pantoporia hordonia*
English name	Common lasker
Sinhala name	Kaha selaruwa
Family	Nymphalidae
Species status	Indigenous
National conservation status	Near Threatened (NT)
Ecology	The exact habitat of this species is unknown. It is found in the wettest areas of the island. The larval host plants are species belonging to the genera *Acacia* and *Albizzia.*
Geographical distribution	This species has been recorded from the coastal belt up to 4, 500 ft in the central mountains. It can be found Sri Lanka, as well as all over the oriental region.
Critical habitat	The feeding plants of this species have a wide distribution in Sri Lanka. Therefore, it is likely that this species may also have a wider distribution. As such, the project area may not function as a critical habitat for this species.

Source: ©Kai-Wing Leung



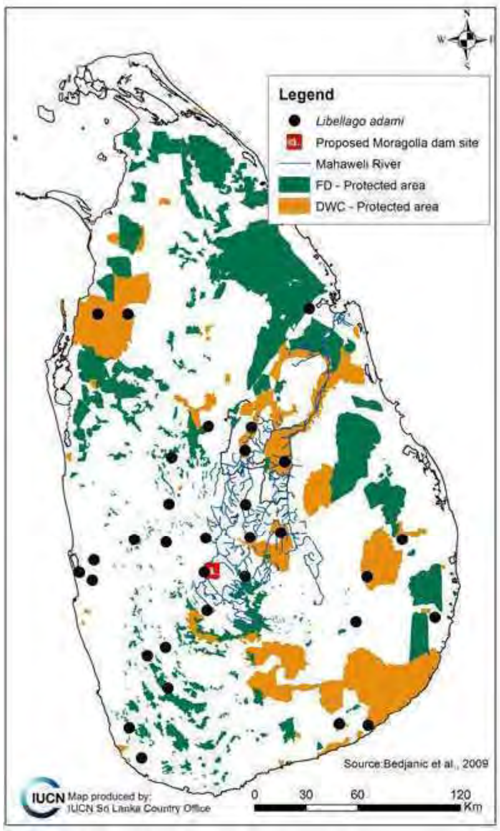
Distribution map (developed based on the 2007 Red List database)

Dragonflies

Libellago adami (Adam's gem)

Scientific name	*Libellago adami*
English name	Adam's gem
Family	Cholorocyphidae
Species status	Endemic
National conservation status	Vulnerable (VU)
Ecology	Occurs around both fast and slow moving Rivers, canals and streams from low wetland areas to the lower hill areas.
Geographical distribution	This species has been recorded recently from the lowland wet zone, and wet montane and intermediate zones. Historically, it has been recorded in both the Wet and Dry zones of the island. This species is endemic to Sri Lanka.
Critical habitat	This species has been recorded from riverine and stream side habitats. Due to project activities, the existing riverine habitats will be lost. However, at the same time, new habitats will be created along the edge of the reservoir. Therefore, the habitat of this species will not be affected significantly due to the proposed MHP.

Source: © Gehan de Silva Wijeyratne

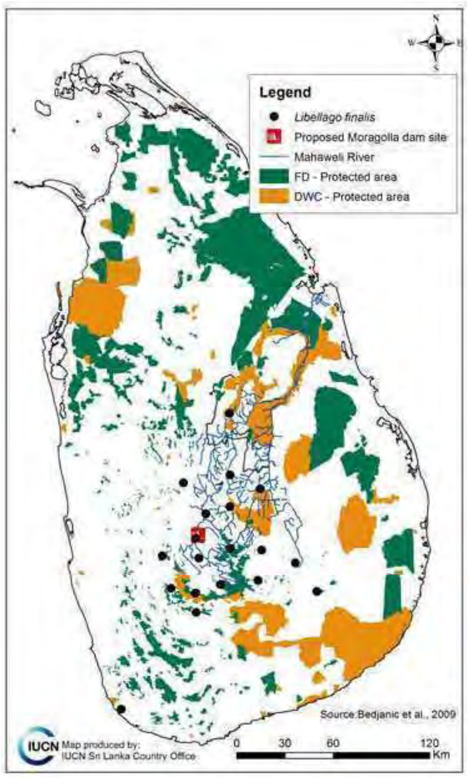


Distribution map (based on Bedjanic *et al*., 2009)

Libellago finalis (Ultima gem)

Scientific name	*Libellago finalis*
English name	Ultima gem
Family	Cholorocyphidae
Species status	Endemic
National conservation status	Vulnerable (VU)
Ecology	Occurs in shaded rivers and small streams from the mid hills to mountain areas.
Geographical distribution	Most of the previous records are from both wet montane and dry montane areas. It has also been recorded from the southern tip of the wet lowland zone. This species is endemic to Sri Lanka.
Critical habitat	Given that it is found along stream side habitats, the project activities will not affect its habitat critically. In fact, the shallow areas of the edge of the reservoir will function as a new habitat for this species.

Source: © Imesh Nuwan Bandara

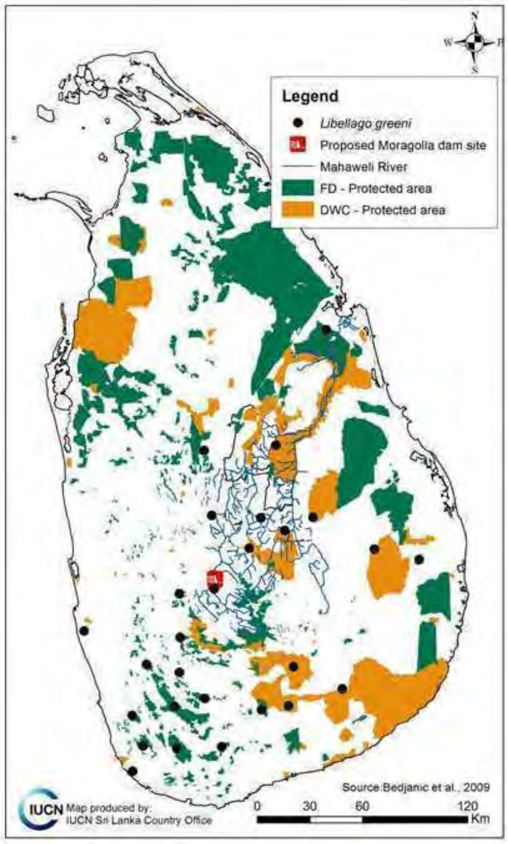


Distribution map (based on Bedjanic *et al.*, 2009)

Libellago greeni (Green's gem)

Scientific name	*Libellago greeni*
English name	Green's gem
Family	Cholorocyphidae
Species status	Endemic
National conservation status	Endangered (EN)
Ecology	Shaded rivers and streams.
Geographical distribution	This species has been recorded from the lowland wet zone, and the wet montane (low and mid hills to higher elevations) and intermediate zones. It is endemic to Sri Lanka.
Critical habitat	Given that it is found along stream side habitats, this species and its habitats will not be affected critically due to the proposed MHP. In fact, the shallow areas at the edge of the reservoir will function as new habitats for this species.

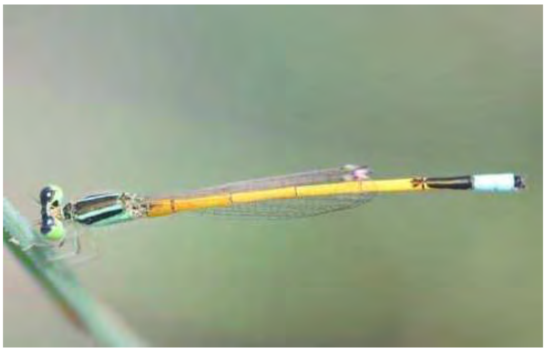
Source: © Niluka Herath



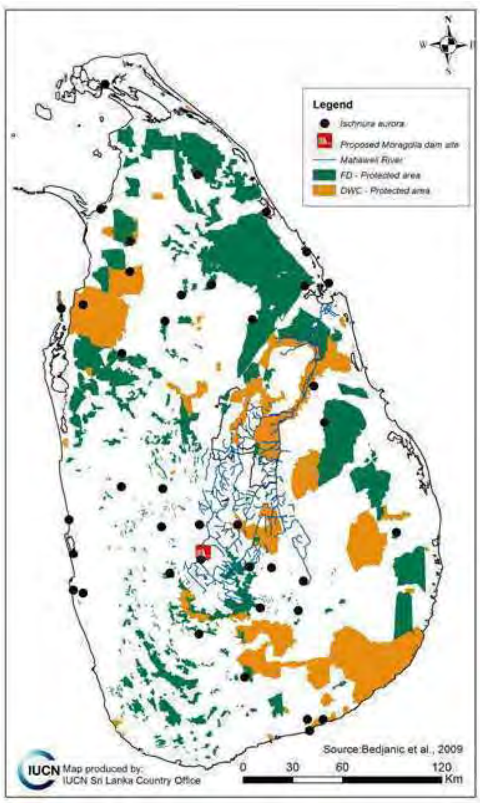
Distribution map (based on Bedjanic *et al.*, 2009)

Ischnura aurora (Dawn bluetail)

Scientific name	*Ischnura aurora*
English name	Dawn bluetail
Family	Coenagrionidae
Species status	Indigenous
National conservation status	Near Threatened (NT)
Global conservation status	Least Concern (LC)
Ecology	In vegetation next to a wide range of slow moving and stagnant water habitats from the coast to the mountains.
Geographical distribution	This species has been recorded all over the island throughout the lowland wet zone, the wet and dry montane zone (low and mid hills to higher elevations), the Dry Zone, the Arid Zone and the Intermediate Zone. It is also found in India.
Critical habitat	Given that this species is found along stream side habitats as well as stagnant water edges, its habitats will not be critically affected due to the proposed MHP. The hallow areas of the reservoir will function as a new habitats for this species.



Source: © Dennis Farrell

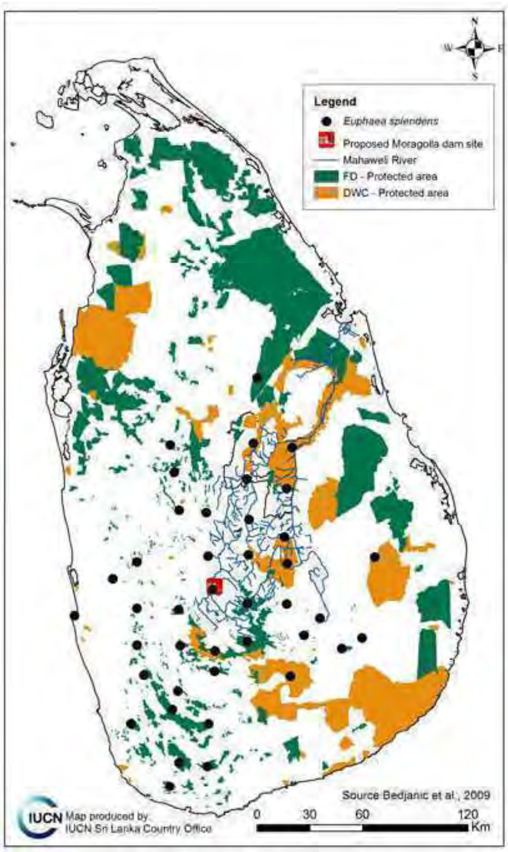


Distribution map (based on Bedjanic *et al.*, 2009)

Euphaea splendens (Shining gossamerwing)

Scientific name	*Euphaea splendens*
English name	Shining gossamerwing
Family	Euphaeidae
Species status	Endemic
National conservation status	Near Threatened (NT)
Ecology	All types of moderate to fast flowing streams and rivers surrounded by mixed vegetation in hilly areas.
Geographical distribution	This species has been recorded from the lowland wet zone, the wet and dry montane zone (low and mid hills to higher elevations) and the intermediate zone. It is endemic to Sri Lanka.
Critical habitat	Given that it is found along stream side habitats, its habitats will not be critically affected due to the proposed MHP. The shallow edges of the proposed reservoir will function as new habitats for this species.

Source: © David Cook

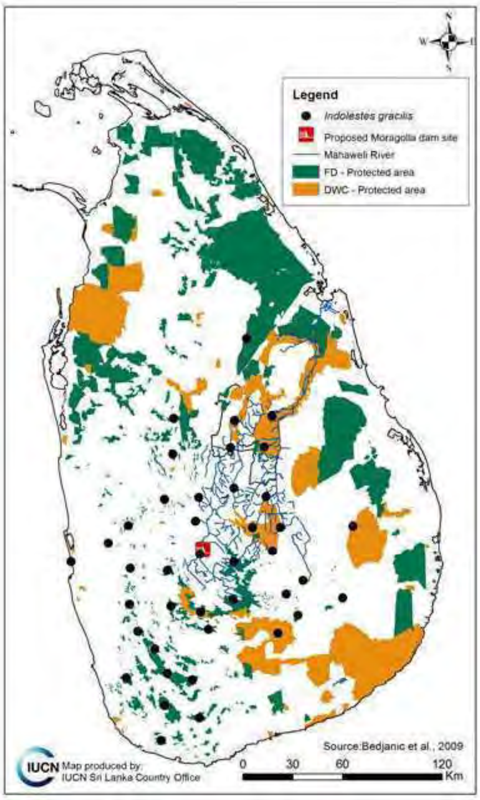


Distribution map (based on Bedjanic *et al.*, 2009)

Indolestes gracilis (Mountain reedling)

Scientific name	*Indolestes gracilis*
English name	Mountain reedling
Family	Lestidae
Species status	Indigenous
National conservation status	Vulnerable (VU)
Global conservation status	Least Concern (LC)
Ecology	All types of moderate to fast flowing streams and rivers surrounded by mixed vegetation in hilly areas.
Geographical distribution	This species has been recorded from the lowland wet zone, the wet and dry montane zone (low and mid hills to higher elevations) and the intermediate zone. It is also found in India.
Critical habitat	Given that it is found along stream side habitats, its habitats will not be critically affected due to the proposed MHP. The shallow edges of the proposed reservoir will function as new habitats for this species.

Source: © Karen Conniff

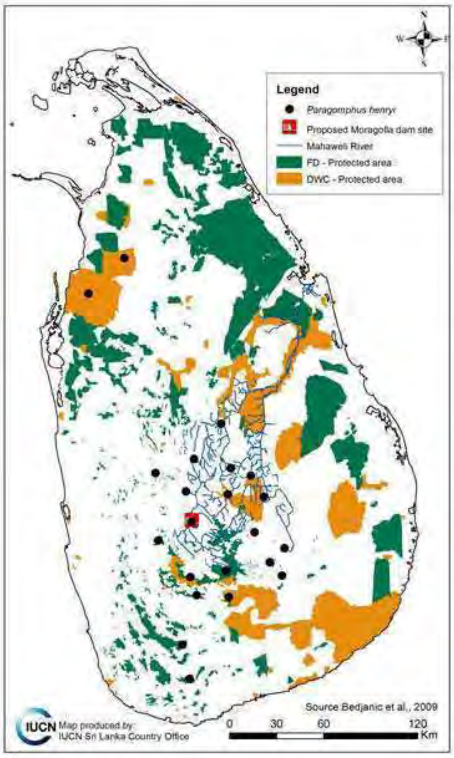


Distribution map (based on Bedjanic *et al.*, 2009)

Paragomphus henryi (Brook hooktail)

Scientific name	*Paragomphus henryi*
English name	Brook hooktail
Family	Gomphidae
Species status	Endemic
National conservation status	Endangered (EN)
Global conservation status	Near Threatened (NT)
Ecology	Occurs in moderate to fast flowing streams and rivers in the hilly and montane regions.
Geographical distribution	This species has been recorded from the lowland wet zone, and the wet and dry montane zone (low and mid hills to higher elevations). However, there are also some historical records from the northern arid zone. It is endemic to Sri Lanka.
Critical habitat	Given that it is found along stream side habitats, its habitats will not be critically affected due to the proposed MHP. The shallow edges of the proposed reservoir will function as new habitats for this species.

Source: © Karen Conniff

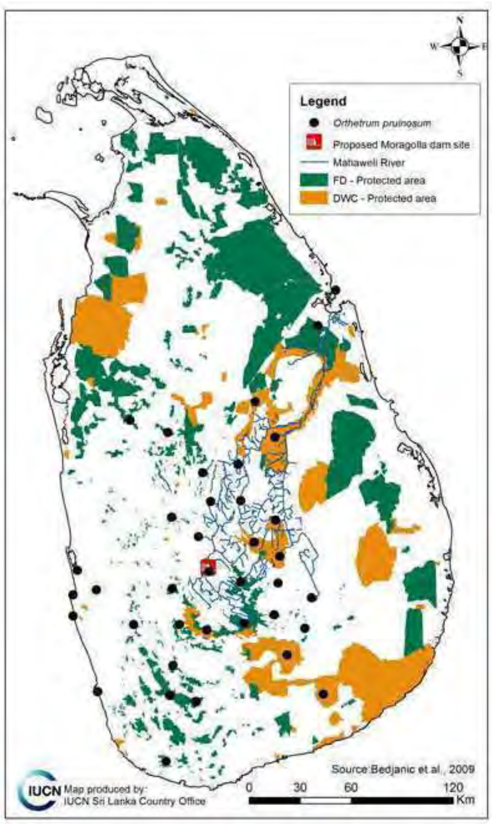


Distribution map (based on Bedjanic *et al.*, 2009)

Orthetrum pruinosum (Pink skimmer)

Scientific name	*Orthetrum pruinosum*
English name	Pink skimmer
Family	Libellulidae
Species status	Indigenous
National conservation status	Near Threatened (NT)
Global conservation status	Least Concern (LC)
Ecology	Occurs in weedy tanks, ponds, marshes, paddy fields and shallow slow flowing streams in the lowlands. Also found in India.
Geographical distribution	This species has been recorded from the lowland wet zone, the wet and dry montane zone (low and mid hills to higher elevations) and the intermediate zone. However, there are also two historical records from the eastern coast.
Critical habitat	Given that it is found along stream side habitats, its habitats will not be critically affected due to the proposed MHP. The shallow edges of the proposed reservoir will function as new habitats for this species.

Source: © Sampath de A Goonatilake

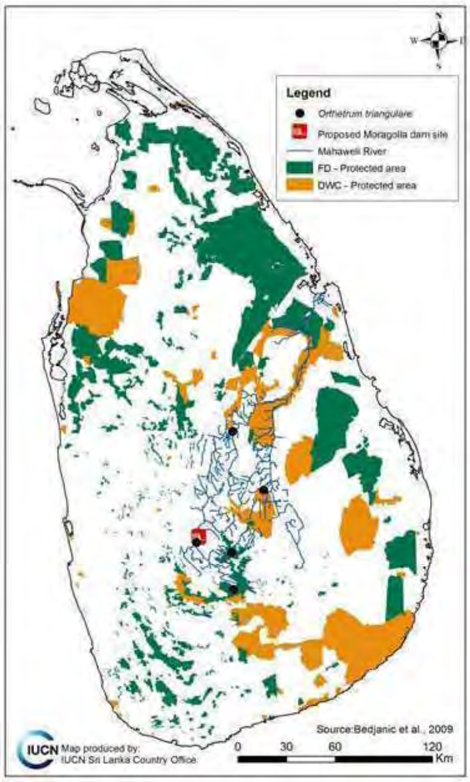


Distribution map (based on Bedjanic *et al.*, 2009)

Orthetrum triangulare (Triangle skimmer)

Scientific name	*Orthetrum triangulare*
English name	Triangle skimmer
Family	Libellulidae
Species status	Indigenous
National conservation status	Endangered (EN)
Global conservation status	Least Concern (LC)
Ecology	Small tanks and puddles in the montane and hilly regions.
Geographical distribution	This species has been recorded from the wet montane to the central mountains and the Knuckles range. It is also found in India.
Critical habitat	Given that it is found along stream side habitats, its habitats will not be critically affected due to the proposed MHP. The shallow edges of the proposed reservoir will function as new habitats for this species.

Source: © Gary Feulner and Narayan Karki

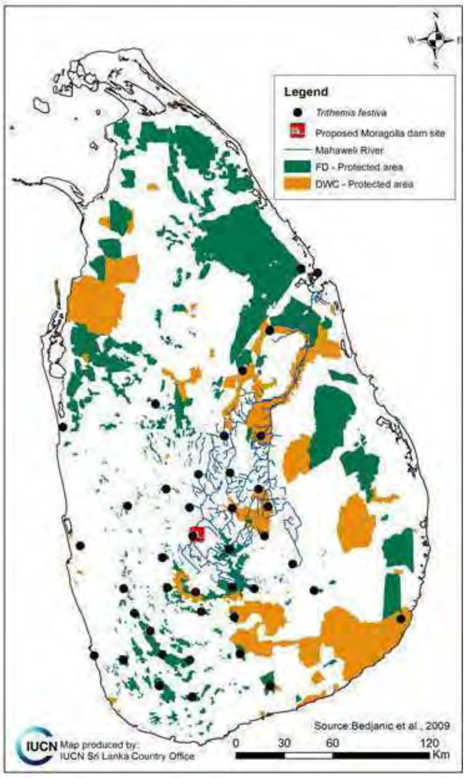


Distribution map (based on Bedjanic *et al.*, 2009)

Trithemis festiva (Indigo dropwing)

Scientific name	*Trithemis festiva*
English name	Indigo dropwing
Family	Libellulidae
Species status	Indigenous
National conservation status	Vulnerable (VU)
Global conservation status	Least Concern (LC)
Ecology	Occurs in moderate to fast flowing streams and rivers in the mid-hills to montane areas.
Geographical distribution	This species has been recorded from the lowland wet zone, the wet and dry montane zone (low and mid hills to higher elevations) and the intermediate zone. However, there are also a few historical records from the Dry Zone. It is also found in India.
Critical habitat	Given that it is found along stream side habitats, its habitats will not be critically affected due to the proposed MHP. The shallow edges of the proposed reservoir will function as new habitats for this species.

Source: © Sampath de A Goonatilake

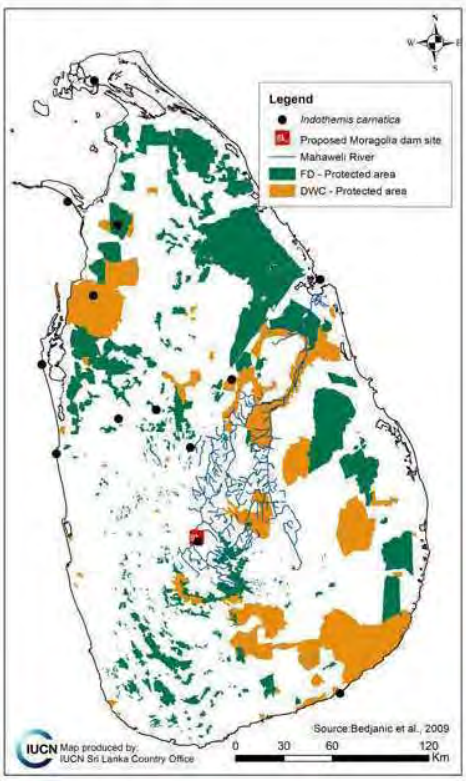


Distribution map (based on Bedjanic *et al.*, 2009)

Indothemis carnatica (Light tipped demon)

Scientific name	*Indothemis carnatica*
English name	Light tipped demon
Family	Libellulidae
Species status	Indigenous
National conservation status	Near Threatened (NT)
Global conservation status	Near Threatened (NT)
Ecology	Occurs in tanks and ponds in the lowlands
Geographical distribution	This species has been recorded in the northern and southern arid zones. It is also found in India.
Critical habitat	This species was recorded during the supplementary study carried out in the MHP area. However, this species is unlikely to be present in the Kotmale area based on its known current distribution. Therefore, this is likely to be a misidentification as this species is similar to *Trithemis festiva* which has a similar colour pattern, and it is unlikely that the MHP area is one of its critical habitats.

Source: © Oleg Kosterin

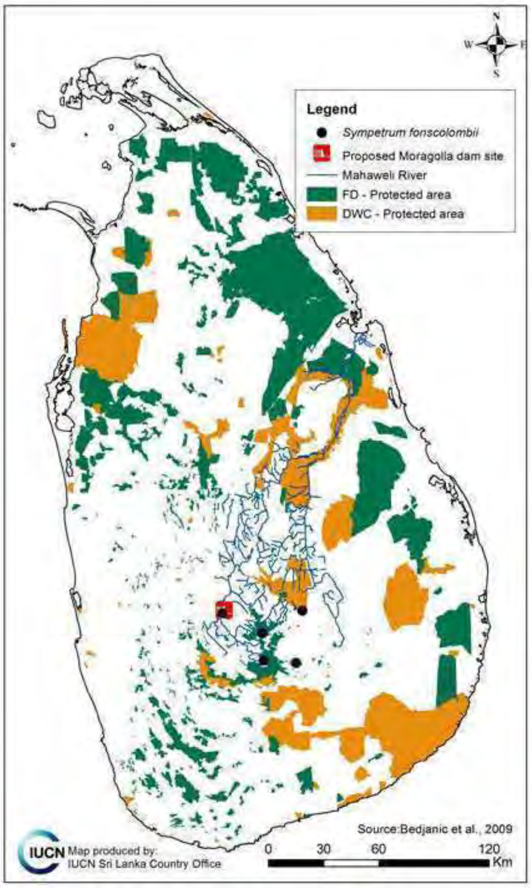


Distribution map (based on Bedjanic *et al.*, 2009)

Sympetrum fonscolombii (Red veined darter)

Scientific name	*Sympetrum fonscolombii*
English name	Red veined darter
Family	Libellulidae
Species status	Indigenous
National conservation status	Endangered (EN)
Ecology	Occurs in ponds, lakes and marshes in the montane region.
Geographical distribution	This species has been recorded only from the wet and dry montane zone (especially in the Nuwara Eliya area) within Sri Lanka. It is also found in India.
Critical habitat	Given that this species has been recorded around ponds and lakes, the reservoir will create suitable habitats it. Therefore, its habitats will not be critically affected due to the proposed MHP.

Source: © Robert Thomas



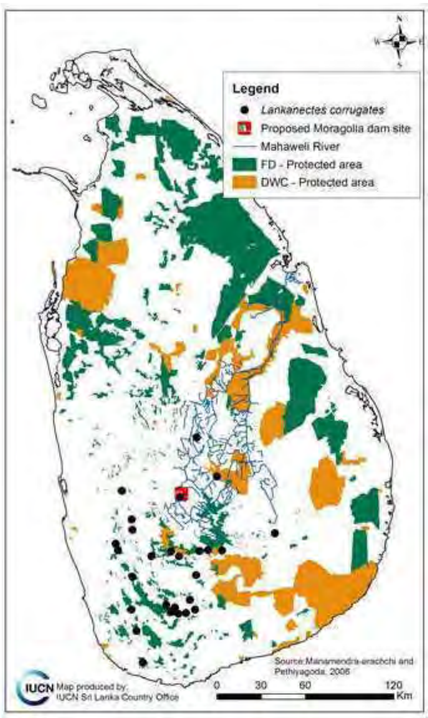
Distribution map (based on Bedjanic *et al.*, 2009)

Amphibians

Lankanectes corrugates (Corrugated water frog)

Scientific name	*Lankanectes corrugates*
English name	Corrugated water frog
Sinhala name	Vakarali madiya
Family	Nyctibatrachidae
Species status	Endemic
National conservation status	Vulnerable (VU)
Ecology	Entirely aquatic and appears to be a sub-montane species, having been recorded between elevations of approximately 60 to 1, 525 m. It prefers shaded, narrow, shallow and slow flowing streams, and also occurs under grass tussocks in marshes.
Geographical distribution	Entirely aquatic and appears to be a sub-montane (foot hills to central highlands) species being recorded between elevations of approximately 60 to 1, 525 m in the lowland wet zone, the wet and dry montane zone and the intermediate zone. This species is endemic to Sri Lanka.
Critical habitat	This species has been recorded in ponds and marshes. Therefore, the reservoir will create new habitats for this species. Therefore, its habitats will not be critically affected due to the MHP.

Source: © Sampath de A Goonatilake

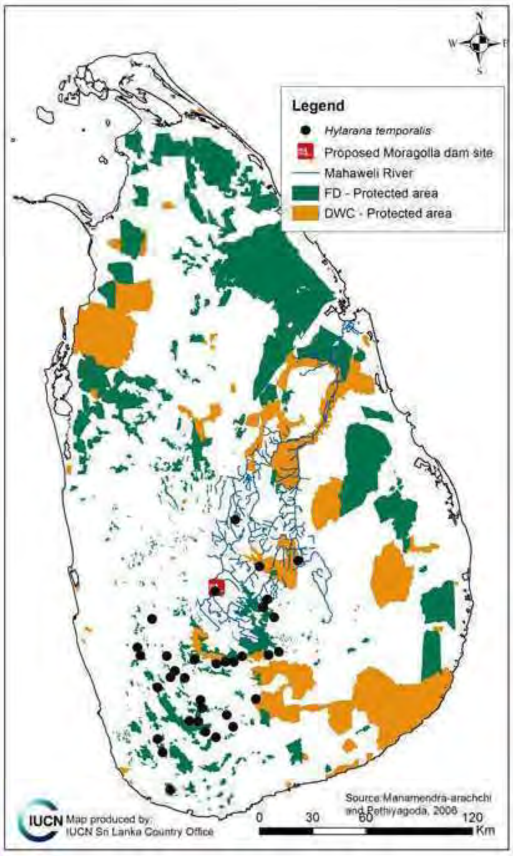


Distribution map (based on Manamendra-arachchi and Pethiyagoda, 2006)

Hylarana temporalis (Common wood frog)

Scientific name	*Hylarana temporalis*
English name	Common wood frog or bronze frog
Sinhala name	Sulaba bandi madiya
Family	Ranidae
Species status	Endemic
National conservation status	Near Threatened (NT)
Ecology	This species prefers rocky and shaded streams in rainforests. It has been observed mainly on wet boulders in streams, rather than in the water itself.
Geographical distribution	This species is common in the foot hills and montane region up to 1, 830 m. It is endemic to Sri Lanka.
Critical habitat	This species prefers rocky and shaded streams, and as such suitable habitats will be created in the area downstream of the dam axis. Therefore, its habitats will not be critically affected due to the proposed MHP.

Source: © Sampath de A Goonatilake



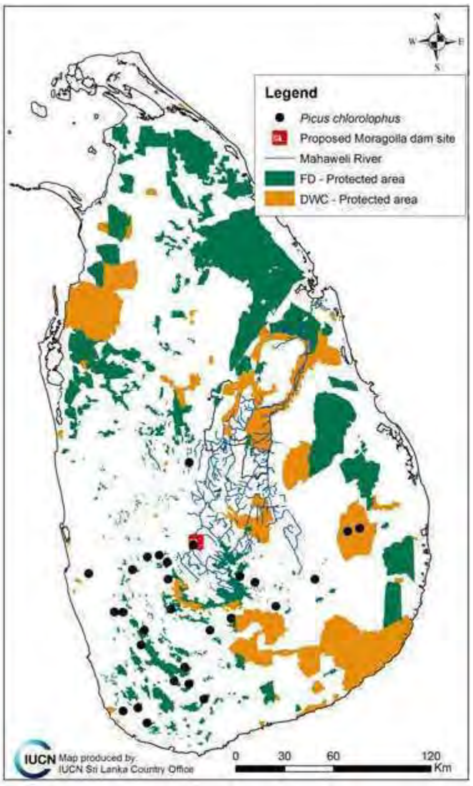
Distribution map (based on Manamendra-arachchi and Pethiyagoda, 2006)

Birds

Picus chlorolophus (Lesser yellow-naped woodpecker)

Scientific name	*Picus chlorolophus*
English name	Lesser yellow-naped woodpecker
Sinhala name	Heen Kaha-gelasi Karela
Family	Picidae
Species status	Indigenous
National conservation status	Near Threatened (NT)
Global conservation status	Least Concern (LC)
Ecology	This species prefers well wooded forests and home gardens.
Geographical distribution	Restricted to the lowland wet zone up to 1, 800 m from sea level. It is also found in India.
Critical habitat	This is a widely distributed species and therefore its habitat will not be affected critically due to the proposed MHP.

Source: http://lananhbirds.com

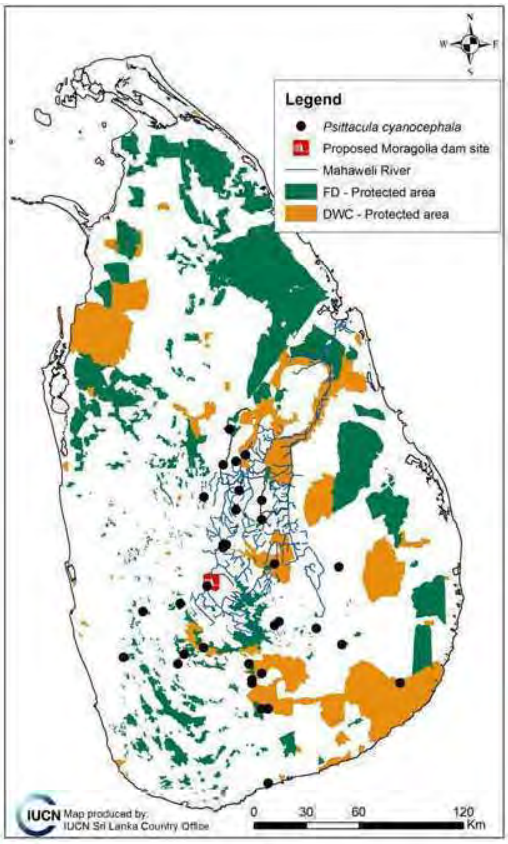


Distribution map (developed based on the 2007 Red List database)

Psittacula cyanocephala (Plum-headed parakeet)

Scientific name	*Psittacula cyanocephala*
English name	Plum-headed parakeet
Sinhala name	Pandu Girawa
Family	Psittacidae
Species status	Indigenous
National conservation status	Near Threatened (NT)
Global conservation status	Least Concern (LC)
Ecology	Occurs in primary forests and secondary forests. It also occurs in home gardens and tea plantations with tall trees.
Geographical distribution	Occurs in mid hill areas of both the wet and intermediate zone. This species is also found in South India.
Critical habitat	This species shows a wide distribution within the home gardens of the area, and the project area does not function as a critical habitat of this species.

Source: http://lananhbirds.com

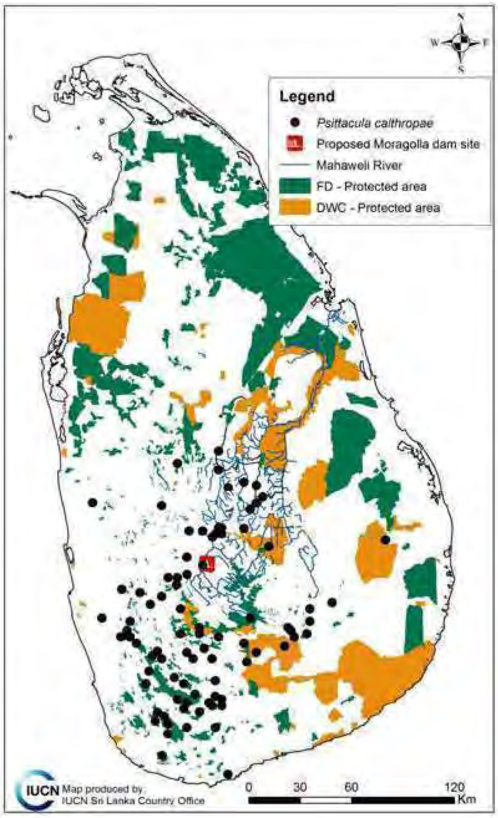


Distribution map (developed based on the 2007 Red List database)

Psittacula calthropae (Sri Lanka Layard's parakeet)

Scientific name	*Psittacula calthropae*
English name	Sri Lanka Layard's parakeet
Sinhala name	Sri Lanka alu girawa
Family	Psittacidae
Species status	Endemic
National conservation status	Near Threatened (NT)
Global conservation status	Least Concern (LC)
Ecology	Occurs in primary forest and secondary forest areas. It also occurs in home gardens and tea plantations with tall trees.
Geographical distribution	An inhabitant of the lowland wet zone and the intermediate zone up to the mid mountain area. This species is endemic to Sri Lanka.
Critical habitat	This species is widely distributed within home gardens in the area, and therefore, the project area does not function as a critical habitat for this species.

Source: © Pathmanath Samaraweera

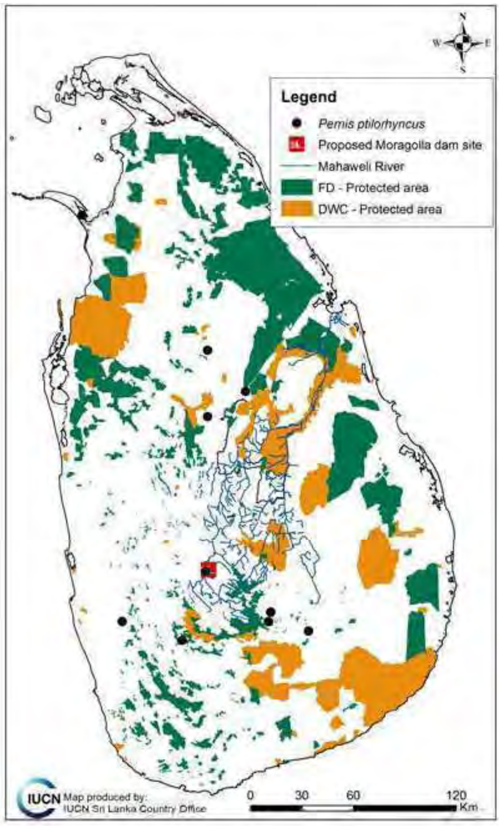


Distribution map (developed based on the 2007 Red List database)

Pernis ptilorhyncus (Oriental honey-buzzard)

Scientific name	*Pernis ptilorhyncus*
English name	Oriental honey-buzzard
Sinhala name	Silu Bambarakussa
Family	Accipitridae
Species status	Breeding resident/ winter visitor/ vagrant
National conservation status	Near Threatened (NT)
Global conservation status	Least Concern (LC)
Ecology	Occurs in forested areas.
Geographical distribution	This species has both a resident and migrant population in Sri Lanka. Apart from Sri Lanka, this species can be found in Borneo, Java and Philippines, within the Asian region.
Critical habitat	The habitat in the project area is only important as feeding ground for this species. Therefore, the project area does not function as a critical habitat for this species.

Source: © P. J. Vasanthan

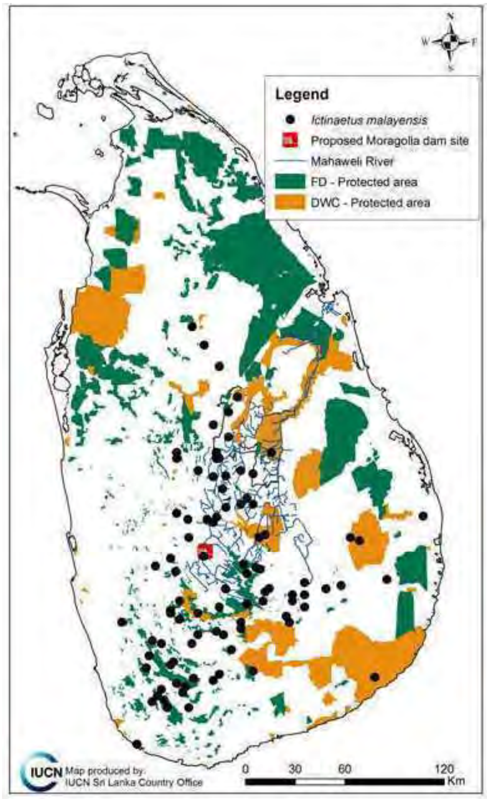


Distribution map (developed based on the 2007 Red List database)

Ictinaetus malayensis (Black eagle)

Scientific name	*Ictinaetus malayensis*
English name	Black eagle
Sinhala name	Kalukussa
Family	Accipitridae
Species status	Indigenous
National conservation status	Near Threatened (NT)
Global conservation status	Least Concern (LC)
Ecology	Prefers forested and hilly areas with high slopes.
Geographical distribution	This species can be found in forested and hilly areas in both the wet and dry zone up to the montane region. Apart from Sri Lanka, it can be found in India, South China and South East Asia.
Critical habitat	The habitat in the project area is only important as a feeding ground for this species. Therefore, the project area does not function as a critical habitat for this species.

Source: © K. Arul



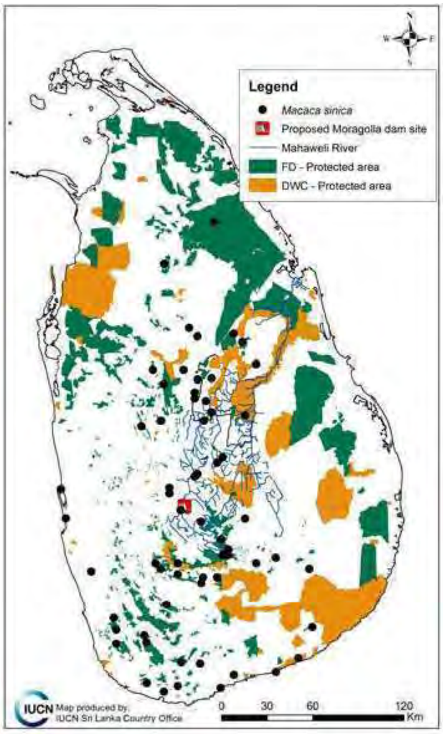
Distribution map (developed based on the 2007 Red List database)

Mammals

Macaca sinica (Sri Lanka toque monkey)

Scientific name	*Macaca sinica*
English name	Sri Lanka toque monkey
Sinhala name	Rilawa
Family	Cercopithecidae
Species status	Endemic
National conservation status	Least Concern (LC)
Global conservation status	Endangered (EN)
Ecology	This species prefers secondary forest and scrub forest to thick primary forest. In wet zone forests, it prefers to live at the edges of the forest edges rather than in deep forest. This species enters home gardens and vegetable plots frequently. It is more common in the dry zone.
Geographical distribution	This species occurs throughout the island, except in northern most part. It is restricted to the island.
Critical habitat	It is generalized species that can live in forest areas, as well as human modified landscapes. Only a very small area of forest where this species occurs will be cleared due to the MHP. Therefore, it cannot be considered as a critical habitat for this species. Further, reforestation along the edges of the reservoir will create new habitats for this species.

Source: © Sampath de A. Goonatilake

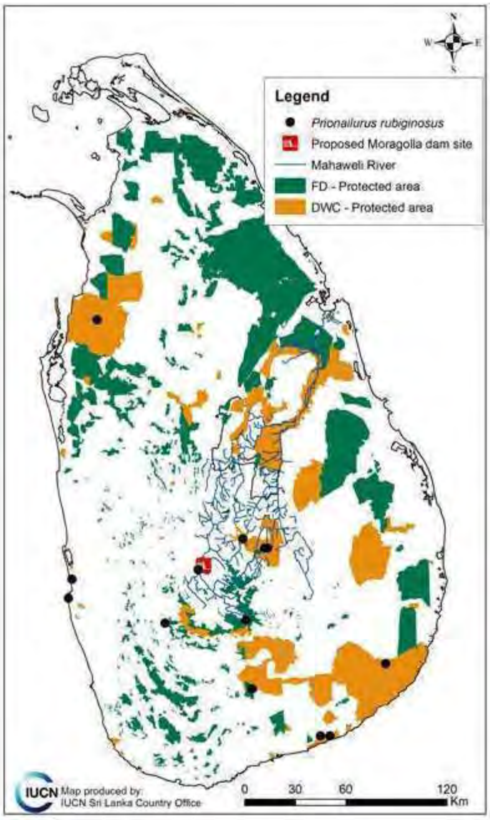


Distribution map (based on 2007 Red List database)

Prionailurus rubiginosus (Rusty spotted cat)

Scientific name	*Prionailurus rubiginosus*
English name	Rusty spotted cat
Sinhala name	Kola diviya / Balal diviya
Family	Felidae
Species status	Indigenous
National conservation status	Endangered (EN)
Global conservation status	Vulnerable (VU)
Ecology	This species occupies shrub lands, grasslands and forested areas throughout the island.
Geographical distribution	It has been recorded throughout the island in all the bio-climatic zones. It has also been recorded within South Asia and South East Asia.
Critical habitat	This species prefers to live in the forested areas and shrub lands around the project area. Due to project activities Only a very small area of forest inhabited by this species will be cleared due to project activities. Therefore, it cannot be considered as a critical habitat for this species. Further, reforestation along the edges of the reservoir will create new habitats for this species.

Source: © Terry Whittaker

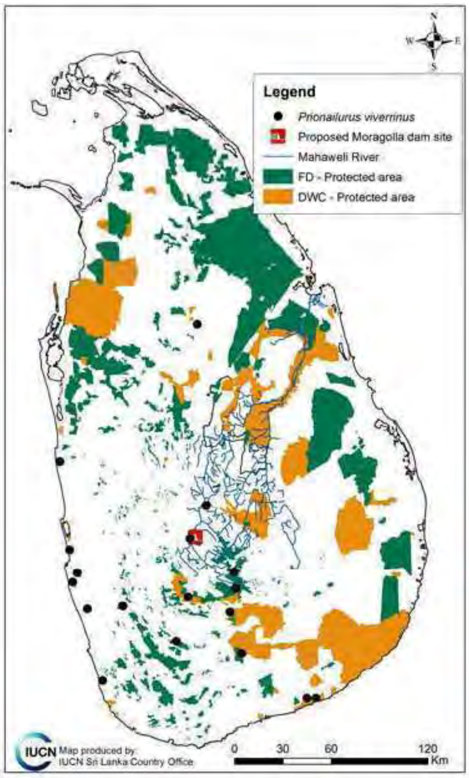


Distribution map (based on 2007 Red List database)

Prionailurus viverrinus (Fishing cat)

Scientific name	*Prionailurus viverrinus*
English name	Fishing cat
Sinhala name	Handun diviya
Family	Felidae
Species status	Indigenous
National conservation status	Endangered (EN)
Global conservation status	Endangered (EN)
Ecology	This species occurs in marshy areas and riverine forests throughout the island.
Geographical distribution	It has been recorded throughout the island in all the bio-climatic zones. It is also found within South Asia and South East Asia.
Critical habitat	This species prefers riverine habitats around the Mahaweli river bank. Due to the project activities Only a very small riverine forest patch will be lost as a result of the MHP. Therefore, the project area cannot be considered as a critical habitat for this species. Further, reforestation along the edge of the reservoir will create new habitats for this species.

Source: http://www.kattengedoe.nl

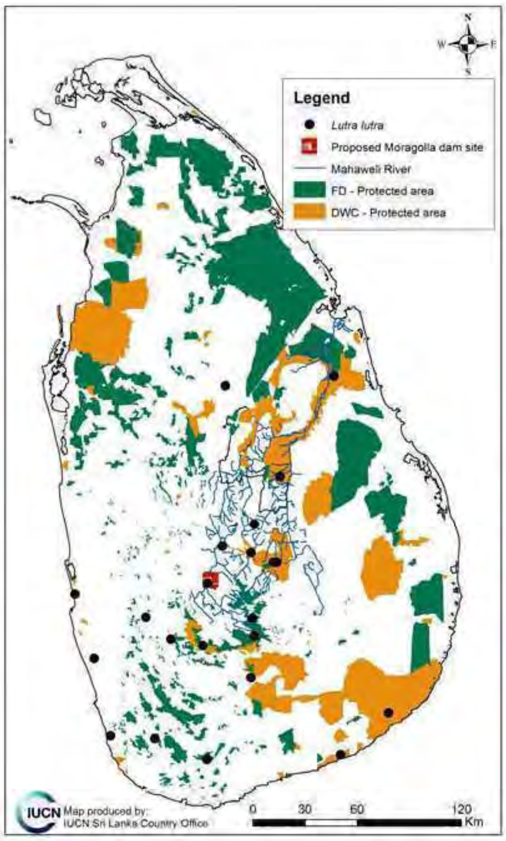


Distribution map (based on 2007 Red List database)

Lutra lutra (Otter)

Scientific name	*Lutra lutra*
English name	Otter
Sinhala name	Diya balla
Family	Mustelidae
Species status	Indigenous
National conservation status	Vulnerable (VU)
Global conservation status	Near Threatened (NT)
Ecology	This species occurs in marshy areas and riverine forests throughout the island.
Geographical distribution	It has been recorded throughout the island in all bio-climatic zones. Apart from Sri Lanka, it is found throughout Asia.
Critical habitat	Otters prefer the riverine habitats around the Mahaweli river bank. Only a very small patch of riverine forest will be lost due to the MHP. Therefore, the project area cannot be considered as a critical habitat for this species. Further, reforestation along the edge of the reservoir will create new habitats for this species.

Source: © Bild Jiri Bohdal

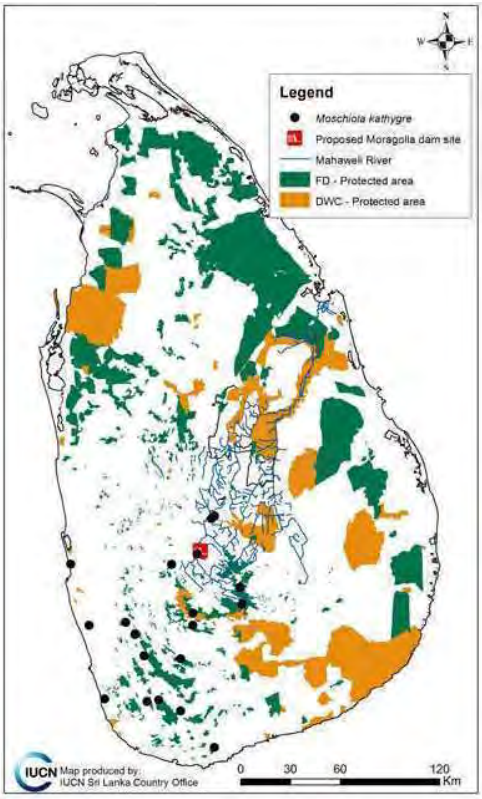


Distribution map (based on 2007 Red List database)

Moschiola kathygre (Sri Lanka pygmy mouse-deer)

Scientific name	*Moschiola kathygre*
English name	Sri Lanka pygmy mouse-deer
Sinhala name	Sri Lanka kuru meeminna
Family	Tragulidae
Species status	Endemic
National conservation status	Vulnerable (VU)
Global conservation status	Vulnerable (LC)
Ecology	This species prefers secondary forests that have dense shrub vegetation, rather than primary forests. This species has also been recorded from well wooded home gardens.
Geographical distribution	This species is restricted to wet zone lowland areas up to mid mountain areas. It is restricted to island (endemic).
Critical habitat	This species prefers to live in the forested both secondary and riverirne areas and shrub lands around the project area. Only a very small area of forest inhabited by this species will be cleared due to the MHP. Therefore, the project area cannot be considered as a critical habitat for this species. Further, reforestation along the edge of the reservoir will create new habitats for this species.

Source: http://valueofnature.blog.com



Distribution map (based on 2007 Red List database)

3.2 Project impacts

3.2.1 Context

Assessment of project impacts on critical habitats

According to the ADB Safeguard policy statement, a critical habitat includes areas with high biodiversity value, including habitats required for the survival of Critically Endangered (CR) or Endangered (EN) species, areas of special significance for endemic or restricted-range species, sites that are critical for the survival of migratory species, areas that support globally significant concentrations or numbers of individuals of congregatory species, areas with unique assemblages of species, that are associated with key evolutionary processes or provide key ecosystem services, and areas with biodiversity of significant social, economic, or cultural importance to local communities. Critical habitats include those areas either legally protected or officially proposed for protection, such as areas that meet the criteria of the World Conservation Union classification, the Ramsar List of Wetlands of International Importance, and the United Nations Educational, Scientific, and Cultural Organization's Natural World Heritage Sites (ADB, 2009).

As such, it is necessary first to identify whether the project affected area qualifies as a critical habitat. Therefore, it is pertinent that the project site is analyzed against the criteria that are detailed above. The list of threatened and Near Threatened species found in the project area is presented in Annex 2. Therefore, it is necessary to ensure that the project, is aligned with ADB's Safeguard Policy Statement (2009), and that the CEB should identify measures to avoid, minimize, or mitigate potentially adverse impacts and risks and, as a last alternative, propose compensatory measures, such as biodiversity offsets, to achieve no net loss or net gain of the affected biodiversity. Therefore, the project area was evaluated against the ADB definition of critical habitats. Simultaneously, species prioritization was done to evaluate species that have a high risk of becoming threatened or extinct due to project activities.

An area with high biodiversity value

An area with high biodiversity value is defined based on a broad set of attributes, such as the relative size of the area, the condition of the area, whether it supports threatened, endemic or restricted range species, or whether it provides crucial connectivity across the landscape. However, as reported in the EIA report, the project impacted area is less than 38.5 ha in extent. This area is too small to be considered as an ecologically significant landscape. The forest that exists in the area cannot be considered as primary forest as these areas have been remodelled and modified extensively over the last few centuries. Therefore, these habitats support a much smaller proportion of threatened and endemic species when compared to some of the high biodiversity habitats of the wet zone, such as Peak Wilderness Nature Reserve or Knuckles Conservation Forest. Further, the site does not function as a critical habitat for any of the threatened or endemic species that have been recorded from the project affected area (see species profiles above). Additionally, none of the species recorded in the project affected area are restricted to the area. Similarly, the area does not function as a habitat that supports range-restricted species. Finally, the project affected area does not function as a crucial corridor connecting important habitats or landscapes. Therefore, even though the site selected for the project supports a diverse species assemblage, it cannot be considered as an area of high biodiversity value.

Habitat required for the survival of critical species

A total of 173 terrestrial and aquatic associated faunal species have been recorded in the project area. This includes 23 endemic fauna (ten of which are listed as threatened or Near Threatened), one Critically Endangered (CR) species, six Endangered (EN) species, nine Vulnerable (VU) species and 12 Near Threatened (NT) species.

The 41 endemic, threatened or Near Threatened (NT) species are considered to be the critical species that inhabit the project area. All other species recorded from the area are considered to be common species that show a wide distribution within, and in some cases, outside, Sri Lanka. Therefore, the proportions of their populations impacted by the project are insignificant.

An assessment was carried out to evaluate whether the project area functions as a critical habitat that is necessary for the survival of the 41 species identified critical species (endemic, threatened or Near Threatened) that inhabit the project area.

The key parameter that can be used to ascertain the importance of a given habitat or area for the long term survival of a critical species, is to determine the proportion of the population of that critical species that occupies the habitat. However, information on the overall population sizes of these 41 critical species is not available, and therefore, such a determination was not possible in the present context. However, in the absence of population data, alternate proxies can be used to make such an assessment. Therefore, in this study an index (impact score) using the conservation status of the species, as well as their distribution data, was developed as a proxy to determine the importance of the habitat affected by the project for the survival of the recorded 41 threatened (CR, EN or VU), Near Threatened (NT) or endemic species.

Species prioritization

A list of priority species that require special conservation attention in order to mitigate the impacts of the MHP was developed in order to ensure that available conservation resources can be allocated and spent in the most effective and efficient ways possible.

An index (impact score) was developed in order to identify priority species found within the project area. This index was developed taking into consideration the four factors described below. A suitable marking scheme was also developed for each of these criteria.

Species status: This indicates the overall status of the species. Species status was scored as follows:

(i) Indigenous (1 point);

(ii) Endemic (3 points); and

(iii) Possible new species (3 points)

Distribution: A species that shows a wider distribution within a country across several bio-climatic zones is less likely to be affected by a single catastrophic event that might result in large scale mortality of members of that species. Distribution was scored as follows:

(i) Island wide (0 points) ;

(ii) Mahaweli basin and Dry Zone (1 point);

(iii) Mahaweli basin and Wet Zone (2 points);

(iv) Mahaweli basin only (3 points); and

(v) Restricted to the project area (4 points).

Habitat impact: Some species can be affected negatively, while others may benefit, through that habitat changes that take place as a result of the project. Habitat impact was scored as follows:

(i) Positive impact (-2 points);

(ii) No impact (0 points); and

(iii) Negative impact (+ 2 points).

For all terrestrial faunal species the project is considered to have a net negative impact, as the project will result in the conversion of the terrestrial habitats of the area in to aquatic habitats, causing loss of suitable habitats. However, the project is expected to impact aquatic associate species positively due to the creation of more aquatic habitats (See Annex 2 for details regarding scoring for each of the 41 critical species).

Conservation status: This indicates the long term survival potential of the species, and has been determined based on overall population trends, as well as threats that are operating on the species at a national scale. Conservation status was scored as follows:

(i) Not evaluated (2 points, as this indicates species that have been described after 2012);

(ii) Least Concern (LC) (0 points);

(iii) Near Threatened (NT) (1 point);

(iv) Data Deficient (DD) (2 points, as Data Deficient species may be extremely rare species);

(v) Vulnerable (VU) (3 points);

(vi) Endangered (EN) (4 points); and

(vii) Critically Endangered (CR) (5 points).

Based on this marking scheme the maximum possible score is 14, and the cut-off point was taken to be seven points (the mid-point). A species that obtains a score above the cut-off point was considered as moderately or significantly affected by the proposed project.

The scores obtained by each of the 41 critical species evaluated using this index are presented in Figure 1.

The level of impact of the MHP on these species can be ascertained based on the scoring system as shown in the table below.

Table 2. The level of impact of the MHP on endemic, threatened and Near Threatened (NT) species based on the scoring system.

Group	Score
Low impact on the survival of the species	7 points or below
Moderate impact on the survival of the species	8 to 12 points
Significant impact on the survival of the species	13 to 17 points

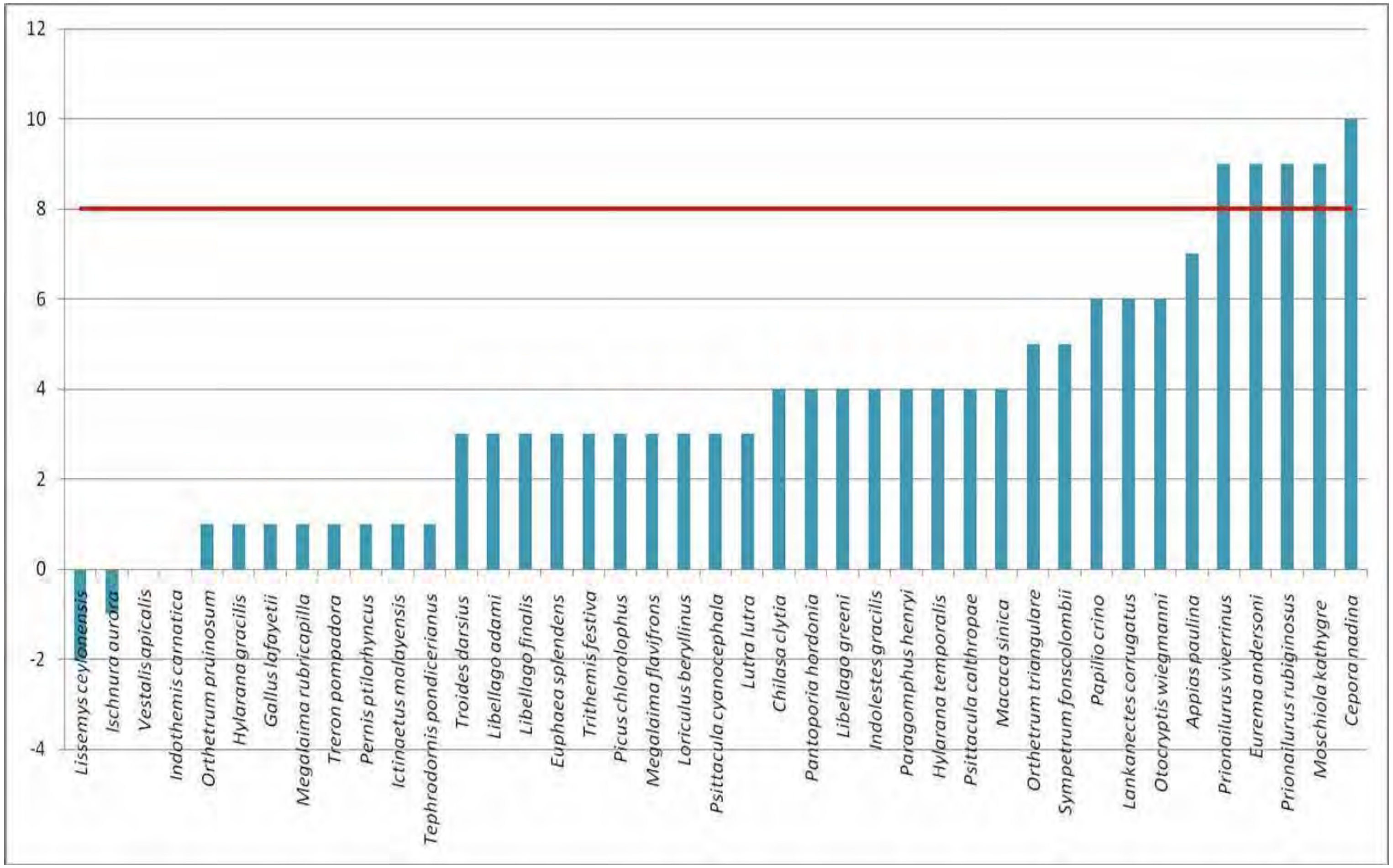


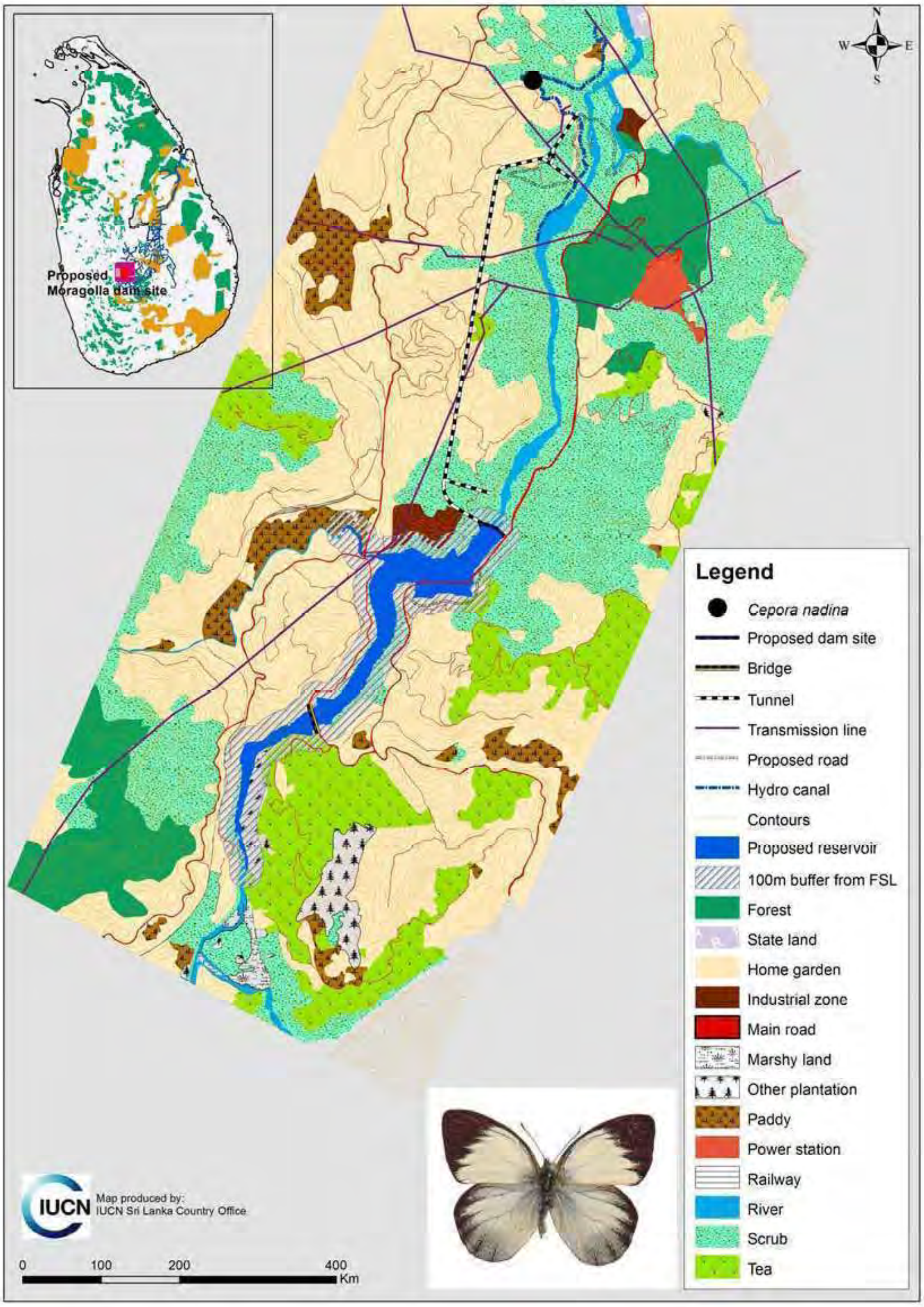
Figure 1. The impact score received by each of the 41 species that were evaluated and the cut-off mark.

According to scores attributed to the 41 critical species that have been recorded from the project area, none of the species will be impacted significantly due to the proposed project. Five species were identified as being moderately affected by the project, while the impact on the remaining 36 species was found to be low. Therefore, mitigation measures are proposed only for the five species that will be moderately affected by the project. These species are listed in the table below.

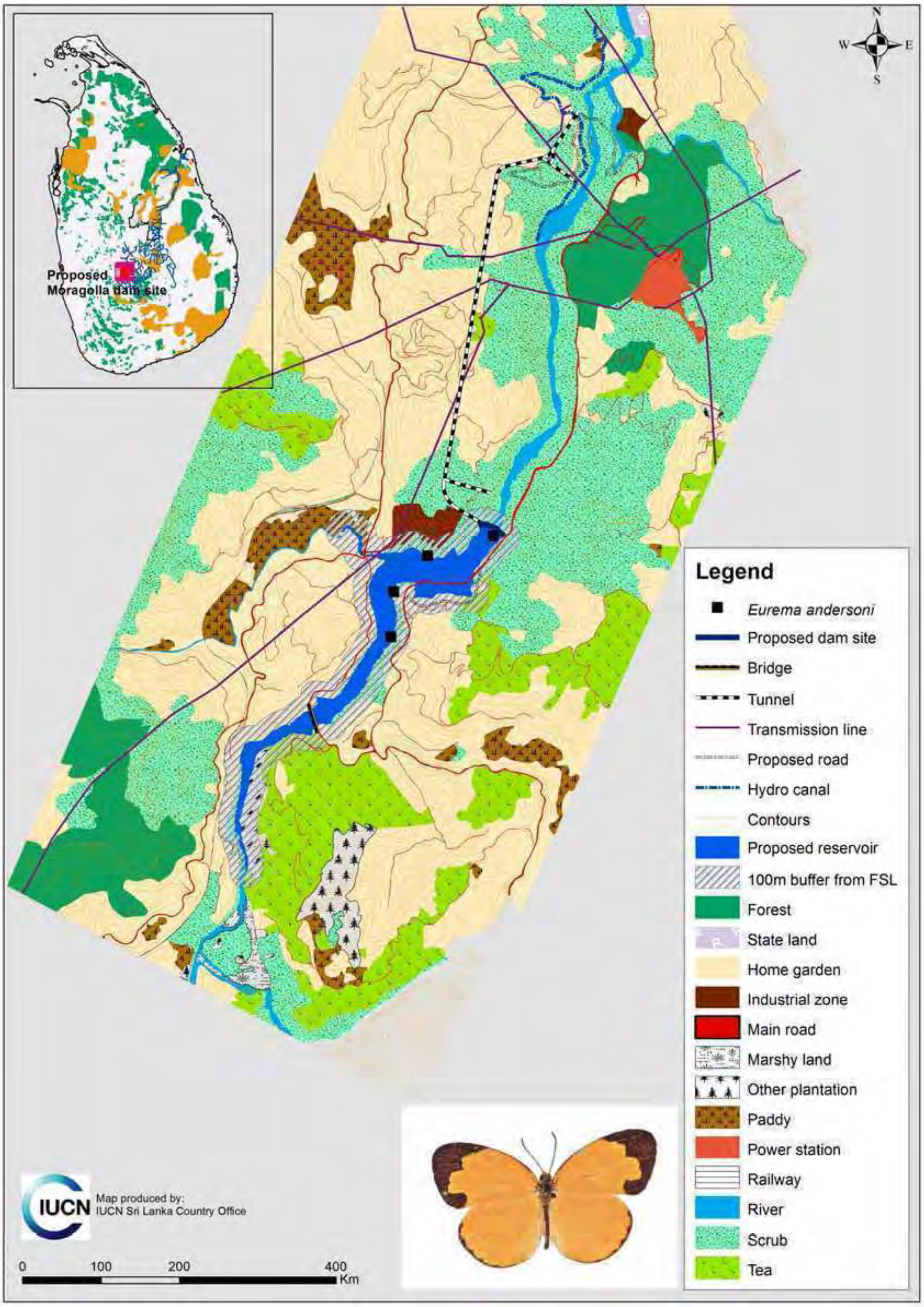
Table 3. Priority species that are likely to be impacted the most due to the MHP.

Family	Species	Common name	Species status	Conservation status		Nature of the Impacts
				National	Global	
Butterflies						
Pieridae	*Cepora nadina*	Lesser gull	Indigenous	CR		Habitat destruction (reduction of feeding plants and nectar plants).
	Eurema andersoni	One-spot grass yellow	Endemic	VU		Habitat destruction (reduction of feeding plants and nectar plants).
Mammals						
Felidae	*Prionailurus rubiginosus*	Rusty-spotted cat	Indigenous	EN	VU	Habitat destruction (reduction of hiding places and hunting grounds).
	Prionailurus viverrinus	Fishing cat	Indigenous	EN	EN	Habitat destruction (reduction of hiding places and hunting grounds).
Tragulidae	*Moschiola kathygre*	Sri Lanka pygmy mouse-deer	Endemic	VU	LC	Habitat destruction (reduction of hiding places and feeding grounds).

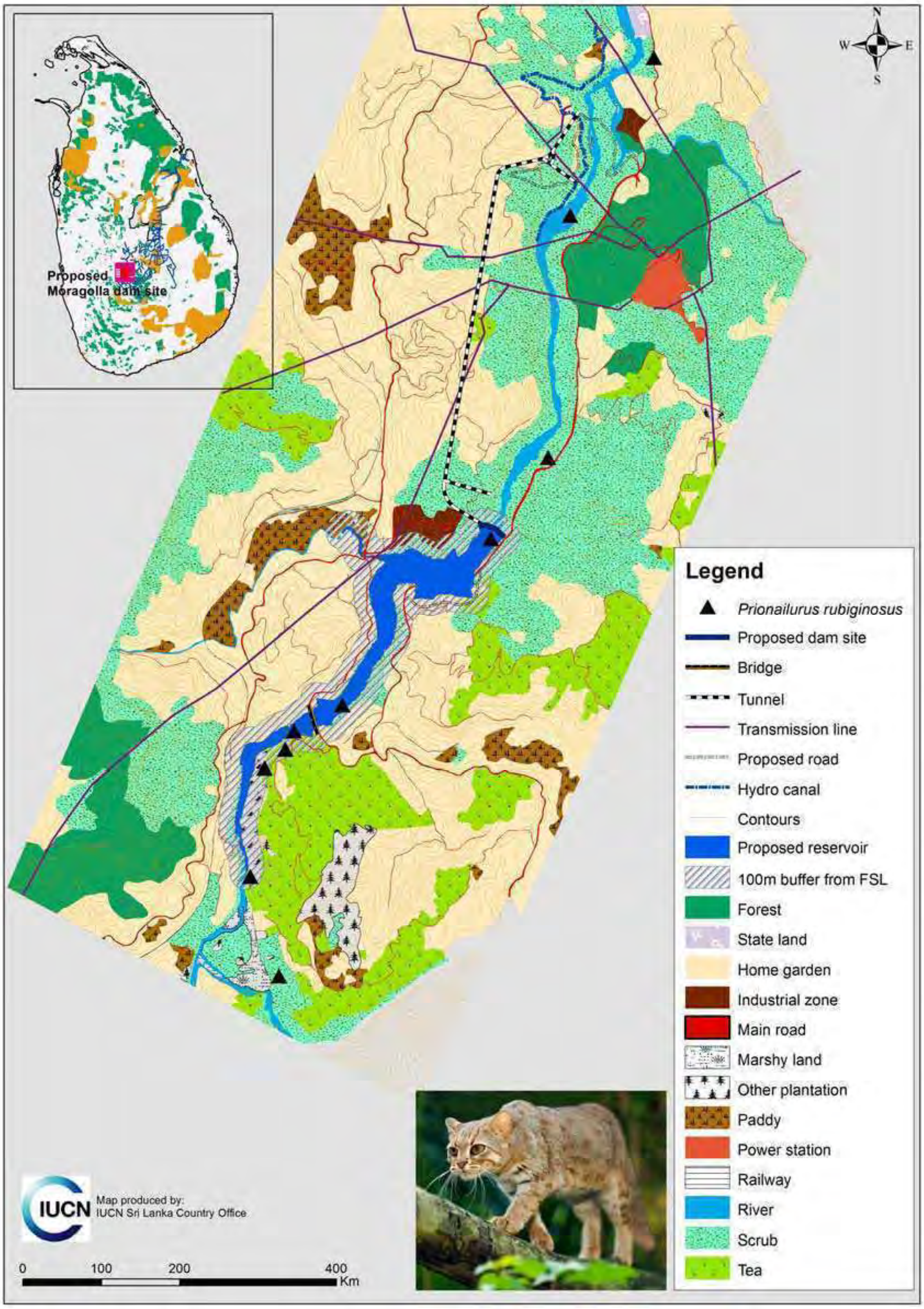
The distribution of these five species within the project is illustrated in the maps below.



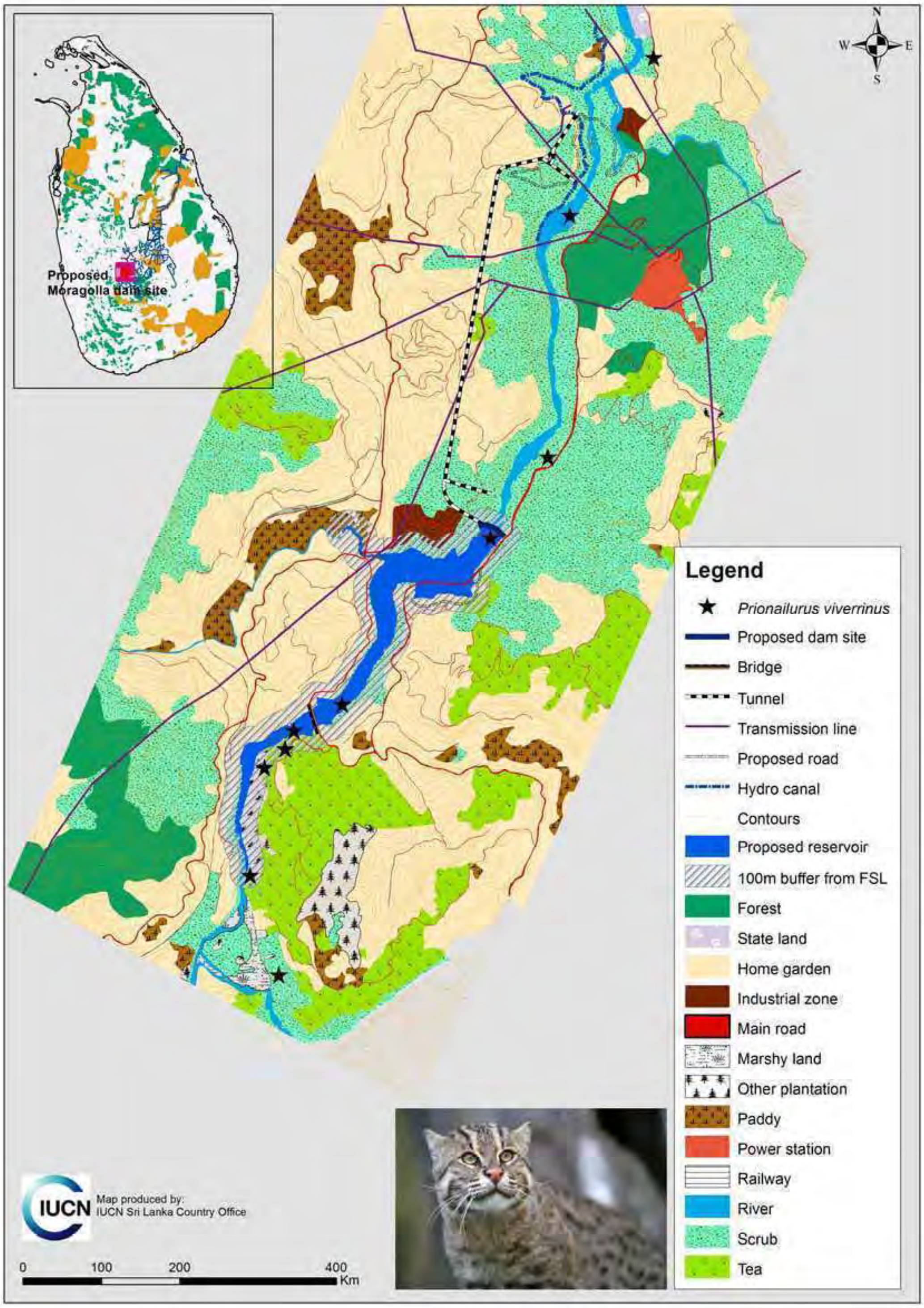
Map 4. Distribution of *Cepora nadina* (Lesser gull) within the project area.



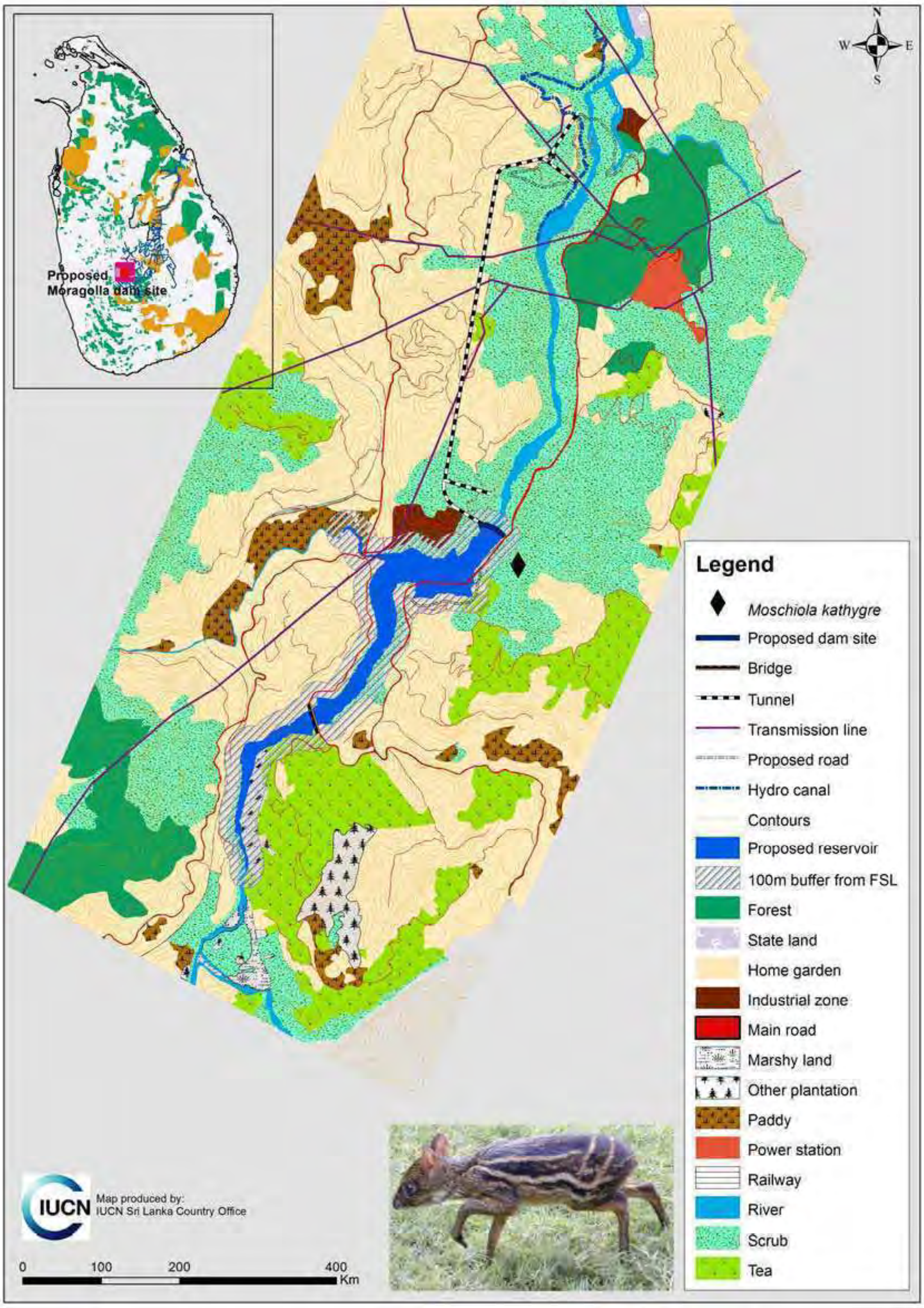
Map 5. Distribution of *Eurema andersoni* (One-spot grass yellow) within the project area.



Map 6. Distribution of *Prionailurus rubiginosus* (Rusty-spotted cat) within the project area.



Map 7. Distribution of *Prionailurus viverrinus* (Fishing cat) within the project area.



Map 8. Distribution of *Moschiola kathygre* (Sri Lanka pygmy mouse deer) within the project area.

3.2.2 Potential impacts during construction

The direct impacts of the proposed project on the identified priority faunal species include habitat loss due to the removal of trees and disturbance of ground cover. As such, construction work will result in the temporary or permanent loss of habitat for priority species, as well as a number of other endemic and threatened species that inhabit the direct impact zone of the project.

During the construction period, the five priority species identified above are expected to be impacted as follows:

- Death or injury of individuals;
- Loss or disturbance of limited foraging resources;
- Loss or disturbance of limited breeding resources;
- Disturbance due to noise and vibrations;
- Loss of habitat quality due to the emission of dust; and
- Loss of hiding places.

Limited resources are specialized habitat components that species are dependent on for their ongoing survival. Such resources include specialized breeding habitats - including tree hollows or suitable nest or maternity roost sites - that occur at low densities, with high levels of competition from a range of species. Further, for some species, limiting resources include specialized foraging or breeding habitats that have a restricted distribution.

3.2.3 Potential impacts during operation

During the operational period, the level the impact on the terrestrial fauna is less compared to that of the construction phase. At present, both banks of the river exist in a degraded state. Therefore, if afforestation of the reservation along the periphery of the reservoir is implemented properly, with consideration of recommended species, the terrestrial fauna of the area will stand to benefit from the project due to the creation of new habitats, as well as the enhancement of the carrying capacity of the project area. Further, given that access to the reservation will be regulated by the CEB, this area will function as a protected area, providing additional protection to the species that inhabit the area.

3.3 Mitigation of impacts

The following key recommendations can be proposed for the mitigation of the impacts resulting from the MHP.

- Relocation of species at risk- Less mobile species such as small amphibians, reptiles and mammals may be directly, or indirectly, at risk. Therefore, the relocation of such species is recommended.

- **Habitat creation and management** - to mitigate habitat loss, restore habitats in degraded areas and manage the restored reservation area. This includes:

    - Declaration of the catchment, and the wider landscape, as a protected area, such as an Environmental Protection Area (EPA) by the Central Environmental Authority; and
    - Law enforcement and creation of awareness among the general public on environmental conservation.

- **Collection of voucher specimens of flora and fauna from the inundation area.**

- **Strict adherence to environmental guidelines pertaining to construction activities** – It is possible that unexpected mass-scale erosion may occur during the construction phase, and that explosions may lead to habitat destruction. Therefore, it is imperative that environmental guidelines are applied strictly during the construction phase. This includes:
    - Creation of awareness regarding environmental guidelines among relevant stakeholders, including construction workers and engineers;
    - Allocation of of dedicated staff for project related environmental matters;
    - Introduction of biodiversity-friendly livelihood strategies, including eco-agriculture and eco-tourism; and
    - Incorporation of biodiversity concerns into human settlement policies.

- **Ensuring that Invasive Alien Species (IAS) do not proliferate in the project area** – There is a possibility that invasive species may spread rapidly due to clearing of natural vegetation during the construction period. Therefore, suitable controls for invasive species must be put in place.

- **Maintenance of an environmental flow by releasing water from the main dam**.- The downstream area - between the main dam and proposed power house - will dry out due to the physical barrier effect of the dam. Therefore, the proposed e-flow must maintained in order to facilitate the maintenance and support of the biodiversity of the area. This will involve regulation of the release of water.

- **Introduce appropriate local area development policies for likely industries to minimize impacts on biodiversity** - At present, the left bank of the proposed dam area declared for the industrial area. Therefore, a plan should be developed to manage the industrial activities in this area.

Details of the impacts of the MHP and the relevant mitigatory measures proposed, are presented in the table below.

Table 4. Mitigation plan for the MHP.

Phase	Location	Impact	Mitigation measure(s)	Mitigation plan					
				General approach	**Experience in Sri Lanka and elsewhere**	**Likely suitability in the context of the MHP**	**Periodicity**	**Cost in LKR**	**Responsibility of implementation and monitoring**
Construction phase	Upstream	Total disappearance of some habitats (riparian forests), causing a loss of habitat for some of the terrestrial species observed in the project area and resulting in reduction of their populations.	Relocate species at risk.	Animal rescue programme immediately prior to and during the construction period along the dam axis, the powerhouse and all quarry areas.	1. Upper Kotmale – translocation of *Ravana politicima* monitored by the CEB. 2. Moragahakanda Project – Translocation of multiple critical species by IUCN Sri Lanka and monitored by MASL. 3. Vavuniya Water Project – translocation of multiple critical species by the Water Board. 4. HOLCIM Aruwakkalu Quarry site by IUCN.	Animal rescue programme.	This process should be initiated just before construction work has started and continued during the ground clearance and excavation period.	1, 000, 000	Ceylon electricity Board (CEB).
			Habitat creation and management.	Reforestation within the reservation of the proposed reservoir and upper catchment.	Moragahakanda (MASL).	Creation of riparian forests along the full flood level.	This activity can be started before the start of construction.	Will be addressed by the reforestation programme.	CEB, Mahaweli Authority of Sri Lanka (MASL), Forest Department (FD) and local villagers.
				Planting host plants associated with identified endemic and			This activity can be started before the start of		CEB, Mahaweli Authority of Sri Lanka (MASL),

Phase	Location	Impact	Mitigation measure(s)	Mitigation plan					
				General approach	**Experience in Sri Lanka and elsewhere**	**Likely suitability in the context of the MHP**	**Periodicity**	**Cost in LKR**	**Responsibility of implementation and monitoring**
				threatened fauna (see Table 3 and the relevant species profiles) in the reservation of the proposed reservoir.			construction.		Forest Department (FD) and local villagers.
				Creating hiding places for faunal species by placing logs and boulders along the upper water level.		Applicable.	This activity can be started before the start of construction.		CEB.
			Collection of voucher specimens of flora and fauna from the inundation area.	Placing a collection of specimens in the National Herbarium, National Museum and Plant Genetic Resource Centre for future reference and research.	Moragahakanda (MASL) This also involved the following National Agencies: o National Herbarium o National Botanic Gardens o National Museum o Plant Genetic Resource Center o National Zoological Gardens. IUCN facilitated the involvement of these	Applicable.	This activity can be started before the start of construction.	200, 000	CEB with technical facilitation by IUCN.

Phase	Location	Impact	Mitigation measure(s)	Mitigation plan					
				General approach	Experience in Sri Lanka and elsewhere	Likely suitability in the context of the MHP	Periodicity	Cost in LKR	Responsibility of implementation and monitoring
					agencies in project activities.				
		Destructive land use practices outside the proposed protected area.	Declaration of the catchment, and the wider landscape as a protected area.	Initiate a dialogue with the FD and CEA, together with IUCN to discuss plans to declare the Moragolla reservoir area as an Environmental Protection Area (EPA).	Moragahakanda (MASL).	To reduce destructive activities in the surrounding habitats in future.	After the commission of project.	50, 000	CEB, with technical support from IUCN. Declaration of the protected area through relevant authorities such as the Central Environmental Authority (CEA).
			Law enforcement, and restoration of degraded habitats.					The cost is included in the reforestation.	CEA, FD and DWC.
		Habitat destruction and deterioration, and disturbance to wildlife due to construction activities (including quarrying, dumping, clearing of habitats, camp sites, temporary road network and transmission	Strict adherence to environmental guidelines pertaining to construction activities. Awareness of relevant stakeholders.	This can be implemented by the CEB through awareness of, and compliance with, the conditions laid down by the CEA throughout the project period.	Moragahakanda (MASL) by IUCN.	Applicable.	During the whole of the construction period until the end of commission.	The cost is included in the contract sum for implementation of the EMP. 100, 000	CEB, CEA and construction company.

Phase	Location	Impact	Mitigation measure(s)	Mitigation plan					
				General approach	Experience in Sri Lanka and elsewhere	Likely suitability in the context of the MHP	Periodicity	Cost in LKR	Responsibility of implementation and monitoring
		lines)	Employ dedicated staff for project related environmental matters.	This can be implemented by the CEA and suitable technical experts through awareness campaigns targeting relevant stakeholders at regular intervals throughout the project. This can be done by the CEA through the appointment of an environmental officer to monitor environmental activities relating to the project.				Cost included in the contactors payment.	
		Proliferation of IAS and suppression of native biodiversity	Ensure that IAS[6] do not proliferate in the project area (see	The CEA and suitable technical experts can conduct	Moragahakanda (MASL) IUCN has provided the guidelines.	Applicable.		200, 000	CEB, CEA and construction company. Technical

[6] Alien Invasive Species.

Phase	Location	Impact	Mitigation measure(s)	Mitigation plan					
				General approach	Experience in Sri Lanka and elsewhere	Likely suitability in the context of the MHP	Periodicity	Cost in LKR	Responsibility of implementation and monitoring
			Annex 5).	awareness campaigns addressing this issue at regular intervals for relevant stakeholders throughout the project. Appointment of a CEB environmental officer to monitor the environmental activities.					support can be provided by IUCN.
	Downstream	Deterioration of the quality of the downstream riverine habitats and species.	Maintain an environmental flow by releasing water from the main dam.	Recreate annual flooding events to ensure water requirements and habitat creation for terrestrial fauna. Flash flush flow has to be maintained during the early rainy season.			After the commission of the project. During the wet season	No cost	CEB and CEA.
Operational phase	Upstream	Land based human activities such as land clearing, agriculture,	Introduce biodiversity friendly livelihood strategies	These activities can be implemented by agencies	Moragahakanda (MASL)		Can be started during the construction phase	500, 000	CEB and community-based organizations (CBOs),

Phase	Location	Impact	Mitigation measure(s)	Mitigation plan					
				General approach	Experience in Sri Lanka and elsewhere	Likely suitability in the context of the MHP	Periodicity	Cost in LKR	Responsibility of implementation and monitoring
		industries, expansion of settlements and soil waste will have devastating impacts on species and habitats.	including eco-agriculture and eco-tourism. Incorporate biodiversity concerns into human settlement policies. Introduce appropriate local area development policies for likely industries to minimize impacts on biodiversity.	such as the CEB, the Department of Agriculture, the CEA and the Tourist Board, through training programmes and pilot projects throughout the project and beyond.			and continued.	200, 000	
	Downstream	Degradation and deterioration of downstream riverine habitats.	Maintain a sustainable e-flow and recreate annual flash flood events to maintain riverine habitats.	The CEB can arrange for the minimum water flow to be released annually during the rainy season.		After the commission of the project. During the wet season.		No cost	CEB and CEA.
		Unregulated sudden opening of the sluice gates of the reservoir, affecting downstream wildlife and communities.	Regulate the release of water.	The CEB can regulate the release of water daily so that it is released gradually.	In Amban Ganga, the recent floods affected the Ukuwela sluice gates, which in turn impacted downstream habitats and faunal species.	After the commission of the project. During the wet season.		No cost	CEB and CEA.

3.4 Habitat creation and management plan

Based on the findings and analyses carried out as part of the present study, none of the 41 critical species (endemic, threatened or Near Threatened species) that have been recorded within the study area will be impacted significantly as a result of the MHP. Five species were found to be moderately affected by the project (see Table 3), while the impact on the remaining 36 species was found to be low. Therefore, mitigation measures are proposed only for the five species that will be affected moderately as a result of the project.

The impact of the project on the five moderately impacted species can be mitigated through habitat creation in the reservation of the reservoir area and the upper catchment of the reservoir. This aspect will be addressed in detail in the 'Preparation of an afforestation and watershed management plan' assignment also undertaken by IUCN. Therefore, it will not be discussed in detail here. The recommended list of floral species for reforestation, considering species that are important for terrestrial fauna, is presented in Annex 4.

Additionally, it is strongly recommended that the invasive floral species found within the project area are removed. A list of identified invasive plant species is given in Annex 5.

Habitat requirements for target species during the restoration phase are given in the Table 5.

Table 5. Habitat requirements for target species.

Family	Species	Common name	Impact	Restoration measure
Butterflies				
Pieridae	*Cepora nadina*	Lesser gull	Habitat destruction (reduction of feeding plants and nectar plants).	Planting of larval feeding plants and nectar plants along the reservation and home gardens around the proposed reservoir.
	Eurema andersoni	One-spot grass yellow	Habitat destruction (reduction of feeding plants and nectar plants).	
Mammals				
Felidae	*Prionailurus rubiginosus*	Rusty-spotted cat	Habitat destruction (reduction of hiding places and hunting grounds).	Replanting of thick riverine habitat along the reservoir bank to create hiding places as well as food sources.
	Prionailurus viverrinus	Fishing cat	Habitat destruction (reduction of hiding places and hunting grounds).	
Tragulidae	*Moschiola kathygre*	Sri Lanka pygmy mouse deer	Habitat destruction (reduction of hiding places and feeding grounds).	

It is not necessary to translocate these five species from the immediate impact area. If habitat creation activities are initiated in the buffer zone and surrounding areas prior to construction, these species will begin to move into the new and restored habitats, gradually, with the inundation of affected areas.

4. Conclusions and recommendations

Based on the results of the EIA study (CECB and ACO, 2012), and relevant additional studies (NBRO, 2013), a total of 173 species of terrestrial fauna have been recorded in the area that is to be impacted directly due to the MHP. A total of 23 of these species are endemic to Sri Lanka, while 16 species are considered to be threatened species, and 12 species considered to be Near Threatened (NT) species. Further, ten of the 23 endemic species found in the area are considered to be threatened or Near Threatened (NT) species. Therefore, a total of 41 species recorded from the area were considered to be threatened and endemic species. These species have been evaluated using an impact index developed in order to identify the species that will be most affected by the proposed project. Other species were not evaluated as they show a wide distribution in Sri Lanka, as well as outside Sri Lanka, and therefore, the proportion of their population impacted by the project will be insignificant. Based on the evaluations carried out as part of the study, none of the 41 identified threatened and endemic species were identified as being affected by the proposed project significantly. However, five species have been identified as moderately impacted species. The impacts of the project on these species can be mitigated by creating suitable habitats for these species in the reservation of the proposed reservoir.

In addition to this activity, the following recommendations are proposed in order to ensure the sustainability of the project:

- Avoid the introduction and transportation of alien invasive weeds, particularly into areas that currently have relatively low incidences of weeds, such as areas of woodland and open forest within the project area and within the vegetation surrounding the dam construction site. Measures that can be implemented to minimize the transportation of weeds include, cleaning the heavy vehicles used for construction activities before bringing them to the site, and periodic monitoring of the construction site, especially temporary soil storage areas and vehicle wash down areas, to ensure that there are no new infestations occurring in the project area.
- Avoid the removal of hollow-bearing trees and branches to the greatest extent possible in areas above the flood zone. Where the removal of such trees and branches is found to be unavoidable, this work should be undertaken by an appropriately qualified arborist under the observation of qualified ecologist or zoologist. Hollows should be inspected for resident fauna by a qualified ecologist prior to felling or trimming. If resident fauna are found, the appropriate action to follow should be determined in consultation with the qualified ecologist or zoologist.
- Habitat creation within the reservation area of the proposed reservoir should be done in a way that will benefit the prioritized threatened species.
- Construction of a dam over the Mahaweli River would result in the clearing of 2-3 ha of vegetation and faunal habitats. The proposed action would incur a low level impact on the habitats of prioritized threatened species considered in this assessment, given the small area of impact, and the large area of remaining habitat in the locality. Furthermore, it is recommended that any species rescue mission should be carried out immediately prior to undertaking land clearing work in order to prevent the cleared areas being re-colonized.

BIBLIOGRAPHY

- Asian Development Bank (2009) *Safeguard Policy Statement*. ADB, Manila, 90pp.

- Bedjanič, M., Conniff, K., Van Der Poorten, V. and A Šalamun (2009) *Preliminary results of the work on the odonatological database: Distribution Atlas of the Dragonflies of Sri Lanka – Version 2.0, April 2009*. 72 pp, 138 figs. < draft .pdf document distributed by authors >

- CECB & ACO (2012) Moragolla Hydropower Project Feasibility Study. Environmental Impact assessment Vol: 3, Final Report. Ceylon Electricity Board.

- Dutta, S. K. and Manamendra-arachchi, K. (1996) *Amphibian Fauna of Sri lanka.* Wildlife Hetritage trust of Sri Lanka.

- Gunatilleke, I. A. U. N. and Gunatilleke, C. V. S. (1990) Distribution of Floristic Richness and Its Conservation in Sri Lanka. *Conservation Biology*. 4, (1): 21-31.

- Harrison, J, and Worfolk, T. (1999) A Field Guide to the Birds of Sri Lanka, Oxford University Press Inc, New York, USA.

- IUCN Sri Lanka (2007) Biodiversity Assessment of the Moragahakanda Agriculture Development Project (Final report). 248pp.

- Jayasuriya, A. H. M., Kitchener, D. and Biradar, C. M. (2006) *Protected area management and wildlife conservation project. Portfolio of strategic conservation sites / protected area gap analysis in Sri Lanka*. EML Consultants. 284pp.

- Manamendra-arachchi, K. and Pethiyagoda, R. (2006) *Sri lankave Ubaya jeeveen*. Wildlife Hetritage Trust of Sri Lanka.

- MOE (2012) The National Red List 2012 of Sri Lanka; Conservation Status of the Fauna and Flora. Ministry of Environment, Colombo, Sri Lanka. viii + 476pp

- Sumith, A. J., Munkittrick, K. R. and Athukorale, N. (2011) Fish Assemblage Structure of Two Contrasting Stream Catchments of the Mahaweli River Basin in Sri Lanka: Hallmarks of Human Exploitation and Implications for Conservation. *The Open Conservation Biology Journal, 5,* 25-44.

- NBRO (2013) *Additional Studies On Natural Environment For Review Of Feasibility Study And Preparation Of Detailed Design And Bidding Documents Moragolla Hydropower Project, Sri Lanka. Final report Aquatic ecology in the Mahaweli Ganga*. The National Building Research Organization 79pp

ANNEXES

Annex 1: Endemic, threatened and Near Threatened (NT) fauna recorded from the project site, as provided in the ToR for the assignment.

Notes: Moragolla Hydropower Project EIA - Table 3.18
IUCN Conservation Status added in 2013
bbreviations used: CR - Critically Endangered, EN – Endangered, VU – Vulnerable, NT - Near Threatened,
LC - Least Concern, NE - Not Evaluated.

Moragolla Hydropower EIA (2012)					IUCN 2013[7]
Group	**Species**	**Common Name**	**Endemic**	**Threatened**	
Butterflies	*Troides darsius*	Sri Lankan birdwing	+	NT	NE
	Chilasa (*Papilio*) *clytia*	Common mime		NT	NE
	Cepora nadina	Lesser gull		CR	NE
	Eurema andersonii	One-spot grass yellow		EN	NE
	Pantoporia hordonia	Common Lascar		NT	NE
Dragonflies	*Vestalis apicalis*	Black-tipped forest glory			LC
	Libellago greeni	Green's Gem	+		NE
Fish	*Devario cf aequipinnatus*	Giant danio			LC
	Puntius (Pethia) nigrofasciata	Black ruby barb	+	VU	NE
	Puntius (Pethia) reval	Redfin two-banded carplet	+		NE
	Puntius (Dawkinsia) singhala	Filamented barb	+		NE
	Belontia signata	Combtail	+	NT	LC
Amphibians	*Hylarana gracilis*	Gravenhorst's frog	+		LC
	Hylarana temporalis	Bronzed frog		NT	NT
	Lankanectes corrugates	Corrugated water frog	+		LC

[7] http://www.iucnredlist.org/

Moragolla Hydropower EIA (2012)					IUCN 2013[7]
Group	**Species**	**Common Name**	**Endemic**	**Threatened**	
Reptiles	*Otocryptis wiegmanni*	Sri Lankan kangaroo lizard	+	NT	NE
	Xenochrophis cf piscator	Checkered keelback			NE
Birds	*Dendrocopos nanus*	Brown-capped woodpecker		NT	LC
	Celeus brachyurus	Rufous woodpecker		NT	LC
	Picus chlorolophus	Yellow-naped woodpecker		NT	LC
	Megalaima flavifrons	Sri Lanka yellow-fronted barbet	+		LC
	Megalaima rubricapilla	Crimson-fronted barbet	+		LC
	Loriculus beryllinus	Sri Lanka hanging parrot	+		LC
	Psittacula calthropae	Sri Lanka Layard's parakeet	+	NT	LC
	Collocalia unicolor	Indian swiftlet		NT	LC
	Sitta frontalis	Velvet-fronted nuthatch		NT	LC
	Hirundo daurica	Red-rumped swallow		NT	LC
	Iole indica	Yellow-browed bulbul		NT	LC
	Pellorneum fuscocapillum	Sri Lanka brown-capped babbler	+	NT	LC
	Pomatorhinus melanurus	Sri Lanka scimitar babbler	+	NT	LC
	Dumetia hyperythra	Tawny-bellied babbler		NT	LC
Mammals	*Macaca sinica*	Sri Lanka toque macaque	+	NT	EN
	Prionailurus viverrinus	Fishing cat		VU	EN
	Lutra lutra	European otter		VU	NT
	Moschiola kathygre	Yellow-striped chevrotain	+	NT	LC

Annex 2: Updated list of endemic, threatened and Near Threatened (NT) fauna recorded from the project site with impact scores.

Note: **NRL** – National Red List (MOE, 2012) and **GRL** - Global Red List (IUCN, 2013)
Abbreviations used: CR - Critically Endangered, EN – Endangered, VU – Vulnerable, NT - Near Threatened, LC - Least Concern, NE - Not Evaluated.

	Species name	English name	Species status	Conservation status		Selection criteria (with scoring in parentheses) **1. Status of species:** indigenous (0), endemic/ possible endemic (1), possibly new species (2). **2. Distribution:** island wide (0), Mahaweli basin and dry zone (1), Mahaweli basin and wet zone (2), Mahaweli basin only (3), restricted to project area (4). **3. Impact:** positive impact (-3), no impact (0), low negative impact (+3) high negative impact (+5). **4. Conservation status**: LC (0), NT (1), DD/NE (2), VU (3), EN (4), CR(5), both nationally and globally threatened (6).				
				NRL	GRL	Status of species	Distribution	Impact	Conservation status	Total
				BUTTERFLIES						
Family – Papilionidae										
1	***Troides darsius***	**Ceylon birdwing**	**Endemic**	**LC**	**NE**	*0*	*0*	*3*	*0*	**3**
2	*Papilio crino*	Banded peacock	Indigenous	**VU**	NE	*0*	*0*	*3*	*3*	**6**
3	*Chilasa clytia*	Mime	Indigenous	**NT**	NE	*0*	*0*	*3*	*1*	**4**
Family – Pieridae										
4	*Cepora nadina*	Lesser gull	Indigenous	**CR**	NE	*0*	*2*	*3*	*5*	**10**
5	***Appias paulina***	**Lesser albatross**	**Endemic**	**LC**	NE	*1*	*0*	*3*	*3*	**7**
6	***Eurema andersoni***	**One-spot grass yellow**	**Endemic**	**VU**	NE	*1*	*2*	*3*	*3*	**9**
Family - Nymphalidae										
7	*Pantoporia hordonia*	Common lasker	Indigenous	**NT**	NE	*0*	*0*	*3*	*1*	**4**
				DRAGONFLIES						
Family – Calopterygidae										
1	***Vestalis apicalis***	**Black-tipped flashwing**	**Endemic**	**LC**	**LC**	*1*	*2*	-3	*0*	**0**
Family - Cholorocyphidae										
2	***Libellago adami***	**Adam's Gem**	**Endemic**	**VU**	NE	*1*	*2*	-3	*3*	**3**
3	***Libellago finalis***	**Ultima Gem**	**Endemic**	**VU**	NE	*1*	*2*	-3	*3*	**3**
4	***Libellago greeni***	**Green's Gem**	**Endemic**	**EN**	NE	*1*	*2*	-3	*4*	**4**
Family - Coenagrionidae										
5	*Ischnura aurora*	Dawn Bluetail	Indigenous	**NT**	LC	*1*	*0*	-3	*1*	**-1**
Family - Euphaeidae										

6	***Euphaea splendens***	**Shining Gossamerwing**	**Endemic**	**NT**		*3*	*2*	*-3*	*1*	**3**
Family – Lestidae										
7	*Indolestes gracilis*	Mountain Reedling	Indigenous	**VU**	LC	*1*	*3*	*-3*	*3*	**4**
Family – Gomphidae										
8	***Paragomphus henryi***	**Brook Hooktail**	**Endemic**	**EN**	NT	*1*	*2*	*-3*	*4*	**4**
Family – Libellulidae										
9	*Orthetrum pruinosum*	Pink Skimmer	Indigenous	**NT**	LC	*1*	*2*	*-3*	*1*	**1**
10	*Orthetrum triangulare*	Triangle Skimmer	Indigenous	**EN**	LC	*1*	*3*	*-3*	*4*	**5**
11	*Trithemis festiva*	Indigo Dropwing	Indigenous	**VU**	LC	*1*	*2*	*-3*	*3*	**3**
12	*Indothemis carnatica*	Light tipped Demon	Indigenous	**NT**	NT	*1*	*1*	*-3*	*1*	**0**
13	*Sympetrum fonscolombii*	Red-veined Darter	Indigenous	**EN**	LC	*1*	*3*	*-3*	*4*	**5**
AMPHIBIANS										
Family – Nyctibatrachidae										
1	***Lankanectes corrugatus***	**Corrugated water frog**	**Endemic**	**VU**	LC	*1*	*2*	*0*	*3*	**6**
Family - Ranidae										
2	***Hylarana gracilis***	**Sri Lanka wood frog**	**Endemic**	**LC**	LC	*1*	*0*	*0*	*0*	**1**
3	***Hylarana temporalis***	**Common wood frog**	**Endemic**	**NT**	LC	*1*	*2*	*0*	*1*	**4**
REPTILES										
Family – Trionychidae										
1	***Lissemys ceylonensis***	**Flapshell turtle**	**Endemic**	**LC**	NE	*1*	*0*	*-3*	*0*	**-2**
Family – Agamidae										
2	***Otocryptis wiegmanni***	**Sri Lankan kangaroo lizard**	**Endemic**	**LC**	NE	*1*	*2*	*3*	*0*	**6**
BIRDS										
Family – Phasianidae										
1	***Gallus lafayetii***	**Sri Lanka Junglefowl**	**Endemic**	**LC**	LC	*1*	*0*	*0*	*0*	**1**
Family – Picidae										
2	*Picus chlorolophus*	Lesser Yellow-naped Woodpecker	Indigenous	**NT**	LC	*0*	*2*	*0*	*1*	**3**
Family – Ramphastidae										

3	***Megalaima flavifrons***	**Sri Lanka Yellow-fronted Barbet**	**Endemic**	**LC**	LC	*1*	2	*0*	*0*	**3**
4	***Megalaima rubricapilla***	**Crimson-fronted Barbet**	**Endemic**	**LC**	LC	*1*	*0*	*0*	*0*	**1**
Family – Psittacidae										
5	***Loriculus beryllinus***	**Sri Lanka Hanging Parakeet**	**Endemic**	**LC**	LC	*1*	2	*0*	*0*	**3**
6	*Psittacula cyanocephala*	Plum-headed Parakeet	Indigenous	**NT**	LC	*0*	2	*0*	*1*	**3**
7	***Psittacula calthropae***	**Sri Lanka Layard's Parakeet**	**Endemic**	**NT**	LC	*1*	2	*0*	*1*	**4**
Family – Columbidae										
8	***Treron pompadora***	**Pompadour Green-pigeon**	**Endemic**	**LC**	LC	*1*	*0*	*0*	*0*	**1**
Family – Accipitridae										
9	*Pernis ptilorhyncus*	Oriental Honey-buzzard	Indigenous/ Migrant	**NT**	**LC**	*0*	*0*	*0*	*1*	**1**
10	*Ictinaetus malayensis*	Black Eagle	Indigenous	**NT**	**LC**	*0*	*0*	*0*	*1*	**1**
Family – Campephagidae										
11	***Tephrodornis pondicerianus***	**Common Woodshrike**	**Endemic**	**LC**	**LC**	*1*	*0*	*0*	*0*	**1**
				MAMMALS						
Family - Cercopithecidae										
1	***Macaca sinica***	**Sri Lanka toque monkey**	**Endemic**	**LC**	**EN**	*1*	*0*	3	*0*	**4**
Family – Felidae										
2	*Prionailurus rubiginosus*	Rusty-spotted cat	Indigenous	**EN**	**VU**	*0*	*0*	3	6	**9**
3	*Prionailurus viverrinus*	Fishing cat	Indigenous	**EN**	**EN**	*0*	*0*	3	6	**9**
Family - Mustelidae										
4	*Lutra lutra*	Otter	Indigenous	**VU**	**NT**	*0*	*0*	*0*	3	**3**
Family – Tragulidae										
5	***Moschiola kathygre***	**Sri Lanka pygmy mouse-deer**	**Endemic**	**VU**	**LC**	*1*	2	3	3	**9**

Annex 3: Detailed list of species recorded in the project area by CECB and ACO (2012) and NBRO (2013) (conservation statuses as given in the 2012 National Red List and Global Red List 2013)

Butterflies

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
Family - Papilionidae						
1	***Troides darsius***	**Common birdwing / Ceylon birdwing**	**Maha kurulu piya papiliya**	**Endemic**	LC	
2	*Pachliopta hector*	Crimson rose	Maha rosa papilia	Indigenous	LC	
3	*Pachliopta aristolochiae*	Common rose	Podu rosa papilia	Indigenous	LC	
4	*Papilio crino*	Banded peacock	Monara papilia	Indigenous	**VU**	
5	*Papilio polytes*	Common mormon	Kalu papilia	Indigenous	LC	
6	*Papilio polymnestor*	Blue mormon	Maha nilaya	Indigenous	LC	
7	*Graphium sarpedon*	Blue bottle	Nil papilia	Indigenous	LC	
8	*Graphium agamemnon*	Tailed jay	Kola papilia	Indigenous	LC	
9	*Chilasa clytia*	Mime	Rawana papilia	Indigenous	**NT**	
Family - Pieridae						
10	*Leptosia nina*	Psyche	Kalu-thith sudda	Indigenous	LC	
11	*Delias eucharis*	Jezebel	Podu Maha-sudda	Indigenous	LC	
12	*Cepora nadina*	Lesser gull	Heen Punduru-sudana	Indigenous	**CR**	
13	*Appias paulina*	Lesser albatross	Kuda sudana	**Endemic**	LC	
14	*Catopsilia pyranthe*	Mottled emigrant / African emigrant	Thith-piya piyasariya	Indigenous	LC	
15	*Catopsilia pomona*	Lemon emigrant	Kaha piyasariya	Indigenous	LC	
16	*Eurema hecabe*	Common grass yellow	Maha kahakolaya	Indigenous	LC	
17	*Eurema andersoni*	One-spot grass yellow	Kela kahakolaya	**Endemic**	**VU**	
Family - Nymphalidae						
18	*Parantica aglea*	Glassy tiger	Suduwan nil-kotithiya	Indigenous	LC	
19	*Danaus chrysippus*	Plain tiger	Podu koti-thambiliya	Indigenous	LC	
20	*Junonia lemonias*	Lemon pansy	Dumburuwan alankarikya	Indigenous	LC	
21	*Junonia atlites*	Grey pansy	Aluwan alankarikya	Indigenous	LC	

22	*Junonia iphita*	Chocolate soldier	Podu alankarikya	Indigenous	LC	
23	*Junonia almana*	Peacock pansy	Monera alankarikya	Indigenous	LC	
24	*Pantoporia hordonia*	Common lasker	Kaha selaruwa	Indigenous	**NT**	
25	*Neptis hylas*	Common sailor	Gomara selaruwa	Indigenous	LC	
26	*Acraea violae*	Tawny costor	Thambily panduru-boraluwa	Indigenous	LC	
27	*Melanitis leda*	Common evening brown	Podu dumburuwa	Indigenous	LC	
28	*Orsotriaena medus*	Nigger	Maha-iri panduru-dumburuwa	Indigenous	LC	
29	*Mycalesis perseus*	Common bushbrown	Podu panduru-dumburuwa	Indigenous	LC	
30	*Ypthima ceylonica*	White four-ring	Podu heen-dumburuwa	Indigenous	LC	
Family - Lycaenidae						
31	*Castalius rosimon*	Common Pierrot	Podu Mal-nilaya	Indigenous	LC	
32	*Jamides celeno*	Common Cerulean	Podu Seru-nilaya	Indigenous	LC	

Dragonflies

	Species name	Common name	Species status	Conservation status	
				NRL 2012	GRL 2013
1	*Neurobasis chinensis*	Oriental green-wing	Indigenous	LC	LC
2	***Vestails apicalis***	**Black-tipped flashwing**	**Endemic**	**LC**	**LC**
Family - Cholorocyphidae					
3	***Libellago adami***	**Adam's Gem**	**Endemic**	**VU**	
4	***Libellago finalis***	**Ultima Gem**	**Endemic**	**VU**	
5	***Libellago greeni***	**Green's Gem**	**Endemic**	**EN**	
Family - Coenagrionidae					
6	*Agriocnemis pygmaea*	Wandering Wisp	Indigenous	LC	LC
7	*Pseudagrion rubriceps*	Red-headed Sprite	Indigenous	LC	
8	*Ischnura aurora*	Dawn Bluetail	Indigenous	**NT**	LC
9	*Ischnura senegalensis*	Common Bluetail	Indigenous	LC	LC
Family - Euphaeidae					
10	***Euphaea splendens***	**Shining**	**Endemic**	**NT**	

		Gossamerwing			
Family – Lestidae					
11	*Indolestes gracilis*	Mountain Reedling	**Indigenous**	**VU**	**LC**
Family – Gomphidae					
12	***Paragomphus henryi***	**Brook Hooktail**	**Endemic**	**EN**	**NT**
Family - Libellulidae					
13	*Orthetrum pruinosum*	Pink Skimmer	Indigenous	**NT**	LC
14	*Orthetrum sabina*	Green Skimmer	Indigenous	LC	LC
15	*Orthetrum triangulare*	Triangle Skimmer	Indigenous	**EN**	LC
16	*Crocothemis servilia*	Oriental Scarlet	Indigenous	LC	LC
17	*Crocothemis servilia*	Oriental Scarlet	Indigenous	LC	LC
18	*Neurothemis tullia*	Pied parasol	Indigenous	LC	LC
19	*Trithemis festiva*	Indigo Dropwing	Indigenous	**VU**	**LC**
20	*Indothemis carnatica*	Light tipped Demon	Indigenous	**NT**	**NT**
21	*Sympetrum fonscolombii*	Red-veined Darter	Indigenous	**EN**	
22	*Trithemis aurora*	Crimson Dropwing	Indigenous	LC	LC

Amphibians

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
Family – Bufonidae						
1	*Duttaphrynus melanostictus*	Common house toad	Sulaba geai gemba	Indigenous	LC	
Family – Microhylidae						
2	*Ramanella variegata*	White-bellied pugsnout frog	Bada-sudu motahombu madiyas	Indigenous	LC	
Family – Nyctibatrachidae						
3	*Lankanectes corrugatus*	Corrugated water frog	Vakarali madiya	**Endemic**	**VU**	
Family – Dicroglossidae						
4	*Euphlyctis cyanophlyctis*	Skipper frog	Utpatana madiya	Indigenous	LC	
5	*Fejervarya shyadrensis*	Common paddy field frog	Sulaba vel madiya	Indigenous	LC	
Family - Ranidae						

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
6	***Hylarana gracilis***	**Sri Lanka wood frog**	**Lanka bandi madiya**	**Endemic**	LC	
7	***Hylarana temporalis***	**Common wood frog**	**Sulaba bandi madiya**	**Endemic**	**NT**	

Reptiles

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
Family - Trionychidae						
1	*Lissemys ceylonensis*	Flapshell turtle	Kiri ibba	**Endemic**	LC	
Family - Agamidae						
2	*Calotes calotes*	Green garden lizard	Pala katussa	Indigenous	LC	
3	*Calotes versicolor*	Common garden lizard	Gara katussa	Indigenous	LC	
4	*Otocryptis wiegmanni*	Sri Lankan kangaroo lizard	Gomu talikatussa	**Endemic**	**LC**	
Family - Gekkonidae						
5	*Hemidactylus parvimaculatus*	Spotted housegecko	Pulli gehuna	Indigenous	LC	
Family - Varanidae						
6	*Varanus salvator*	Water monitor	Kabaragoya	Indigenous	LC	
Family – Colubridae						
7	*Ahaetulla nasuta*	Green vine snake	Ahaetulla	Indigenous	LC	
8	*Ptyas mucosa*	Rat snake	Gerandiya.	Indigenous	LC	
Family – Natricidae						
9	***Xenochrophis cf. piscator***	**Checkered Keelback**	**Diya bariya**	**Endemic**	**LC**	
10	*Xenochrophis asperrimus*	The checkered keelback	Diya polonga / Diya bariya	**Endemic**	LC	

Birds

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
Family - Phasianidae						
1	***Gallus lafayetii***	**Sri Lanka Junglefowl**	**Sri Lanka Wali-kukula**	**Endemic**	**LC**	**LC**
Family – Picidae						
2	*Dendrocopus nanus*	Brown-capped Pygmy Woodpecker	Bora Esasi Gomara-karela	BrR	LC	LC
3	*Celeus brachyurus*	Rufous Woodpecker	Borath Koda-karela	BrR	LC	LC
4	*Picus chlorolophus*	Lesser Yellow-naped Woodpecker	Heen Kaha-gelasi Karela	BrR	**NT**	LC
5	*Dinopium benghalense*	Black-rumped Flameback	Rath-karela	BrR	LC	LC
Family – Ramphastidae						
6	*Megalaima zeylanica*	Brown-headed Barbet	Polos Kottoruwa	BrR	LC	LC
7	*Megalaima flavifrons*	Sri Lanka Yellow-fronted Barbet	Sri Lanka Ranmhunatha Kottoruwa	**Endemic**	LC	LC
8	*Megalaima rubricapilla*	Crimson-fronted Barbet	Rathmhunath Kottoruwa	**Proposed Endemic**	LC	LC
Family – Alcedinidae						
9	*Alcedo atthis*	Common Kingfisher	Mal Pilihuduwa	BrR	LC	LC
10	*Pelargopsis capensis*	Stork-billed Kingfisher	Manathudu Madi-pilihuduwa	BrR	LC	LC
11	*Halcyon smyrnensis*	White-throated Kingfisher	Layasudu Madi-pilihuduwa	BrR	LC	LC
12	*Ceryle rudis*	Pied Kingfisher	Gomara-pilihuduwa	BrR	LC	LC
Family - Meropidae						
12	*Merops philippinus*	Blue-tailed Bee-eater	Nilpenda Binguharaya	WV	NE	LC
14	*Merops leschenaulti*	Chestnut-headed Bee-eater	Thambala-hisa Binguharaya	BrR	LC	LC
Family – Cuculidae						
15	*Eudynamys scolopacea*	Asian Koel	Kowula	BrR	LC	LC
16	*Centropus sinensis*	Greater Coucal	Ati-kukula	BrR	LC	LC
Family – Psittacidae						

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
17	*Loriculus beryllinus*	Sri Lanka Hanging Parakeet	Sri Lanka Giramaliththa	**Endemic**	LC	LC
18	*Psittacula krameri*	Rose-ringed Parakeet	Rana Girawa	BrR	LC	LC
19	*Psittacula cyanocephala*	Plum-headed Parakeet	Pandu Girawa	BrR	**NT**	LC
20	*Psittacula calthropae*	Sri Lanka Layard's Parakeet	Sri Lanka Alu Girawa	**Endemic**	**NT**	LC
Family – Apodidae						
21	*Collocalia unicolor*	Indian Swiftlet	Indu Upa-thurithaya	BrR	LC	LC
22	*Cypsiurus balasiensis*	Asian Palm Swift	Asiaa Thal-thurithaya	BrR	LC	LC
Family – Columbidae						
23	*Streptopelia chinensis*	Spotted Dove	Alu Kobeiyya	BrR	LC	LC
24	*Chalcophaps indica*	Emerald Dove	Neela-Kobeiyya	BrR	LC	LC
25	*Treron pompadora*	Pompadour Green-pigeon	Pompadoru Batagoya	**Proposed Endemic**	LC	LC
26	*Ducula aenea*	Green Imperial Pigeon	Neela Mahagoya	BrR	LC	LC
Family – Rallidae						
27	*Amaurornis phoenicurus*	White-breasted Waterhen	Laya-sudu Korawakka	BrR	LC	LC
Family - Accipitridae						
28	*Pernis ptilorhyncus*	Oriental Honey-buzzard	Silu Bambarakussa	BrR/WV/Va	**NT**	LC
29	*Haliastur indus*	Brahminy Kite	Bamunu Piyakussa	BrR	LC	LC
30	*Haliaeetus leucogaster*	White-bellied Sea-eagle	Kusa-ali Sayurukussa	BrR	LC	LC
31	*Spilornis cheela*	Crested Serpent Eagle	Silu Sarapakussa	BrR	LC	LC
32	*Accipiter badius*	Shikra	Ukussa	BrR	LC	LC
33	*Ictinaetus malayensis*	Black Eagle	Kalukussa	BrR	**NT**	LC
Family – Phalacrocoracidae						
34	*Phalacrocorax niger*	Little Cormorant	Punchi Diyakava	BrR	LC	LC
Family - Ardeidae						
35	*Egretta garzetta*	Little Egret	Punchi Ali-koka	BrR	LC	LC
36	*Bubulcus ibis*	Cattle Egret	Gava-koka	BrR	LC	LC
37	*Ardeola grayii*	Pond Heron	Kana-koka	BrR	LC	LC
Family – Ciconiidae						
38	*Anastomus oscitans*	Asian Openbill	Asia Vivarathuduwa	BrR	LC	LC
Family - Pittidae						
39	*Pitta brachyura*	Indian Pitta	Avichchiya	WV	NE	LC

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
Family – Chloropseidae						
40	*Chloropsis jerdoni*	Blue-winged Leafbird	Nilpiya Kolarisiya	BrR	LC	LC
Family – Laniidae						
41	*Lanius cristatus*	Brown Shrike	Bora Sabariththa	WV	NE	LC
Family – Artamidae						
42	*Artamus fuscus*	Ashy Woodswallow	Alu Wanalihiniya	BrR	LC	LC
Family – Oriolidae						
43	*Oriolus xanthornus*	Black-hooded Oriole	Kahakurulla	BrR	LC	LC
Family – Dicruidae						
44	*Dicrurus caerulescens*	White-bellied Drongo	Kawuda	BrR	LC	LC
Family - Monarchidae						
45	*Terpsiphone paradisi*	Asian Paradise- flycathcher	Asia Rahanmara	BrR/WV	LC	LC
Family – Corvidae						
46	*Corvus splendens*	House Crow	Kolamba Kaputa	BrR	LC	LC
47	*Corvus levaillantii*	Large-billed Crow	Kalu Kaputa	BrR	LC	LC
Family – Campephagidae						
48	*Coracina melanoptera*	Black-headed Cuckooshrike	Kalu-his Kovul-saratiththa	BrR	LC	LC
49	*Pericrocotus cinnamomeus*	Small Minivet	Punchi Miniviththa	BrR	LC	LC
50	*Pericrocotus flammeus*	Scarlet Minivet	Dilirath Miniviththa	BrR	LC	LC
51	*Coracina macei*	Large Cuckooshrike	Maha Kovul-saratiththa	BrR	LC	LC
52	*Tephrodornis pondicerianus*	Common Woodshrike	Podu Wana-saratiththa	**Proposed Endemic**	LC	LC
53	*Hemipus picatus*	Bar-winged Flycatcher-shrike	Wairapiya Masi-saratiththa	BrR	LC	LC
Family – Aegithinidae						
54	*Aegithina tiphia*	Common Iora	Podu Iorawa	BrR	LC	LC
Family – Muscicapidae						
55	*Muscicapa daurica*	Asian Brown Flycatcher	Asia Bora Masimara	WV	NE	LC
56	*Cyornis tickelliae*	Tickell's Blue Flycatcher	Tickel Nil-masimara	BrR	LC	LC
57	*Copsychus saularis*	Oriental Magpie Robin	Polkichcha	BrR	LC	LC
58	*Saxicoloides fulicata*	Indian Robin	Indu Kalukichcha	BrR	LC	LC
Family - Sturnidae						
59	*Acridotheres tristis*	Common Myna	Mayna	BrR	LC	LC

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	**GRL 2013**
60	*Gracula religiosa*	Hill Myna	Salalihiniya	BrR	LC	LC
Family - Sittidae						
61	*Sitta frontalis*	Velvet-fronted Nuthatch	Villuda Nalal Yatikuriththa	BrR	LC	LC
Family – Paridae						
62	*Parus major*	Great Tit	Maha Tikiriththa	BrR	LC	LC
Family - Hirundinidae						
63	*Hirundo rustica*	Barn Swallow	Atu Wahilihiniya	BrR	NE	LC
64	*Hirundo daurica*	Red-rumped Swallow	Nithamba rathu Wahilihiniya	**Proposed Endemic**	LC	LC
Family – Pycnonotidae						
65	*Pycnonotus cafer*	Red-vented Bulbul	Kondaya	BrR	LC	LC
66	*Iole indica*	Yellow-browed Bulbul	Bamakaha Guluguduwa	BrR	LC	LC
67	*Pycnonotus luteolus*	White-browed Bulbul	Bamasudu Kondaya	BrR	LC	LC
68	*Pycnonotus melanicterus*	Black-crested Bulbul	Kalu Hisasi Kondaya	BrR	LC	LC
Family – Cisticolidae						
69	*Prinia socialis*	Ashy Prinia	Alu Priniya	BrR	LC	LC
70	*Prinia inornata*	Plain Prinia	Sarala Priniya	BrR	LC	LC
Family - Zosteropidae						
71	*Zosterops palpebrosus*	Oriental White-eye	Peradigu Sithasiya	BrR	LC	LC
Family – Sylviidae						
72	*Acrocephalus dumetorum*	Blyth's Reed Warbler	Blyths Panraviya	WV	NE	LC
73	*Orthotomus sutorius*	Common Tailorbird	Battichcha	BrR	LC	LC
74	*Phylloscopus trochiloides*	Greenish Warbler	Kola Gassraviya	WV	NE	LC
75	*Phylloscopus magnirostris*	Large-billed Leaf Warbler	Mathusu Gassraviya	WV	NE	LC
Family – Timalidae						
76	*Pellorneum fuscocapillum*	Sri Lanka Brown-capped Babbler	Sri Lanka Boraga-demalichcha	**Endemic**	LC	LC
77	*Pomatorhinus melanurus*	Sri Lanka Scimitar Babbler	Da-demalichcha	**Endemic**	LC	LC
78	*Rhopocichla atriceps*	Dark-fronted Babbler	Wathanduru Panduru-demalichcha	BrR	LC	LC
79	*Dumetia hyperythra*	Tawny-bellied Babbler	Kusakaha Landu-demalichcha	BrR	LC	LC
80	*Turdoides affinis*	Yellow-billed Babbler	Demalichcha	BrR	LC	LC

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	GRL 2013
Family – Dicaeidae						
81	*Dicaeum erythrorhynchos*	Pale-billed Flowerpecker	Lathudu Pililichcha	BrR	LC	LC
Family – Nectariniidae						
82	*Nectarina zeylonica*	Purple-rumped Sunbird	Nithamba Dam Sutikka	BrR	LC	LC
83	*Nectarina lotenia*	Loten's Sunbird	Lotenge Sutikka	BrR	LC	LC
Family – Passeridae						
84	*Passer domesticus*	House Sparrow	Gekurulla	BrR	LC	LC
Family – Motacillidae						
85	*Dendronanthus indicus*	Forest Wagtail	Wana-halapenda	WV	NE	LC
86	*Motacilla cinerea*	Grey Wagtail	Alu Halapenda	WV	NE	LC
Family – Estrididae						
87	*Lonchura striata*	White-rumped Munia	Nithamba Sudu Weekurulla	BrR	LC	LC
88	*Lonchura punctulata*	Scaly-breasted Munia	Laya Kayuru Weekurulla	BrR	LC	LC

Mammals

	Species name	Common name	Local name	Species status	Conservation status	
					NRL 2012	**GRL 2013**
Family - Pteropodidae						
1	*Pteropus giganteus*	Flying fox	Ma-vavula	Indigenous	LC	LC
Family – Rhinolophidae						
2	*Rhinolophus rouxii*	Rufous horse-shoe bat	Borath Ashladan-vavula	Indigenous	LC	LC
Family – Cercopithecidae						
3	*Macaca sinica*	Sri Lanka toque monkey	Sri Lanka Rilawa	**Endemic**		EN
Family – Felidae						
4	*Prionailurus rubiginosus*	Rusty-spotted cat	Kola Diviya / Balal Diviya	Indigenous	**EN**	**VU**
5	*Prionailurus viverrinus*	Fishing cat	Handun Diviya	Indigenous	**EN**	**EN**
Family - Herpestidae						
6	*Herpestes fuscus*	Brown mongoose	Bora Mugatiya	Indigenous	LC	
Family – Mustelidae						
7	*Lutra lutra*	Otter	Diya-balla	Indigenous	**VU**	**NT**
Family – Canidae						
8	*Canis aureus*	Jackal	Nariya / Hiwala	Indigenous	LC	LC
Family – Bovidae						
9	*Bos indicus*	Domestic hump-backed cattle	Sinhala Elaharaka	domestic	NE	NE
Family – Tragulidae						
10	***Moschiola kathygre***	**Sri Lanka pygmy mouse-deer**	**Sri Lanka Kuru Meminna**	**Endemic**	**VU**	**LC**
Family – Suidae						
11	*Sus scrofa*	Wild boar	Wal Ura	Indigenous	LC	LC
Family – Hystricidae						
12	*Hystrix indica*	Porcupine	Ittewa	Indigenous	LC	LC
Family – Sciuridae						
13	*Funambulus palmarum*	Palm squirrel	Leena	Indigenous	LC	LC
Family – Leporidae						
14	*Lepus nigricollis*	Black-naped hare	Wal Hawa	Indigenous	LC	LC

Annex 4: List of floral species proposed for planting river-side and in reservation areas within the project site.

Planting the species listed as follows in dense patch will helpe to create the habitats necessary for the three mammal species and two butterfly species that are likely to be impacted moderately due to project activities. A mixed-species planting approach (polyculture) – whereby a range of species are planted in the buffer zone - should be used in order to create suitable habitat conditions.

Further details are provided in the afforestation and watershed management plan for the Moragolla project area.

	Plant species	**Common name**	**Beneficiary species**
1	*Trema orientalis*	Gedumba	Insect eating birds
2	*Macaranga peltata*	Kenda	Fruit eating birds
3	*Macaranga indica*	Kenda	Fruit eating birds
4	*Mallotus tetracoccus*	Bu Kenda	Fruit eating birds
5	*Ficus* sp.	Nuga	Fruit eating birds, *Moschiola kathygre* (Sri Lanka pygmy mouse deer) and *Macaca sinica* (Toque monkey).
6	*Ficus racemosa*	Attikka	Insect eating birds and mammals (e.g. *Macaca sinica* and *Moschiola kathygre*), and butterflies for which this species is a host plant.
7	*Acacia* sp.		Insect eating birds and species for which it is a host plant.
8	*Albizia lebbeck*	Kabal mara	*Pantoporia hordonia* (Common lasker) (as a host plant).
9	*Madhuca neriifolia*	Gam Mi	Fruit eating birds and mammals (e.g. *Macaca sinica* and *Moschiola kathygre*).
10	*Symplocos cochinchinensis*	Bombu	Butterflies for which it is a feeding plant.
11	*Artocarpus nobilis*	Wal del	Fruit eating birds and mammals (e.g. *Macaca sinica*).
12	*Chloroxylon swietenia*	Satinwood	*Papilio crino* (Banded peacock) (as a host plant).
13	Plant species belonging to Family Lauracea[8]	Wal enasal	*Papilio clytia* (Mime) (as a host plant) and *Prionailurus rubiginosus* (Rusty-spotted cat), *Prionailurus viverrinus* (Fishing cat) and *Moschiola kathygre* (Sri Lanka pygmy mouse deer) as a hiding place.
14	*Erythrina subumbrans*	Erabadu	Shade loving flora and fauna.

[8] Camphor laurel and Cinnamon.

	Plant species	Common name	Beneficiary species
15	*Delonix regia*	Mara	Insect eating birds and species for which it is a host plant.
16	*Mangifera indica*	Amba	Fruit eating birds and mammals (e.g. *Macaca sinica*).
17	*Artocarpus heterophyllus*	Kos	Fruit eating birds and mammals (e.g. *Macaca sinica* and *Moschiola kathygre*).
18	*Capparis* sp.	Wellangiriya	Gulls (as a host plant) and *Prionailurus rubiginosus* (Rusty-spotted cat), *Prionailurus viverrinus* (Fishing cat) and *Moschiola kathygre* (Sri Lanka pygmy mouse deer) as a hiding place.
19	*Spathodea campanulata*	African tulip tree	Small mammals, birds and butterflies that feed on these plants.
20	*Ochlandra* sp.	Bata	Larval feeding plant for Butterflies as larval feeding plants and *Prionailurus rubiginosus* (Rusty-spotted cat), *Prionailurus viverrinus* (Fishing cat) and *Moschiola kathygre* (Sri Lanka pygmy mouse deer) as a hiding place.
21	*Cassia* sp.	Thora	Grass yellow butterfly larvae as a feeding plant.

Figure 1. A *Pinus* plantation – an example of monoculture planting, which is not recommended.

Monoculture planting, as in the images above, is not recommended. Instead, a mixed-species planting approach should be used. Habitats developed through planting activities must be diverse and should resemble existing riverine habitats. A series of photographs at different sites along the river within the project area are given below in Figure 2.

Figure 2. The existing riverine habitats within the project area.

Although some of the existing riverine habitats within the project area are somewhat degraded, they support mammalian species including *Prionailurus rubiginosus* (Rusty-spotted cat), *Prionailurus viverrinus* (Fishing cat) and *Moschiola kathygre* (Sri Lanka pygmy mouse deer). Therefore, efforts should be made to create riverine habitats such as those shown in Figure 2. An example of mixed species planting is also illustrated in the image below.

Figure 3. An example of mixed species planting, an approach that should be used for habitat creation.

Once the recommended planting activities have been carried out using the species listed above, and a mixed species approach, habitats around the reservoir should resemble that illustrated in Figure 4 below.

Figure 4. An example of mixed species planting around the Kotmale reservoir.

Annex 5: Invasive plant species that should be eradicated or removed due to dominance in the existing natural vegetation

- *Lantana camara* (Gandapana)
- *Eupatorium odoratum*
- *Mimosa pigra* (Yodha Nidi kumba)
- *Alstonia macrophylla* (Hawari Nuga)
- *Ludwigia peruviana*
- *Clusia rosea* (Gal Goraka)

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Moragolla Hydropower Project

Additional Studies in the Natural Environment: Afforestation and Watershed Management Plan

FINAL REPORT

August 2013

IUCN - International Union for Conservation of Nature, Sri Lanka Country Office

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ABBREVIATIONS

ADB	Asian Development Bank
AusAID	Australian Agency of International Development
AWMP	Afforestation and Watershed Management Plan
CBD	Convention on Biological Diversity
CC	Climate Change
CEA	Central Environmental Authority
CEB	Ceylon Electricity Board
CR	Critically Endangered
DAU	Department of Ayurveda
DOA	Department of Agriculture
DWLC	Department of Wildlife Conservation
EIA	Environmental Impact Assessment
EN	Endangered species
FD	Forest Department
FFPO	Fauna and Flora Protection Ordinance
FO	Forest Ordinance
FR	Forest Reserve
FS	Feasibility Study
GOSL	Government of Sri Lanka
ha	Hectares
IUCN	International Union for Conservation of Nature
LKR	Sri Lankan Rupee
MASL	Mahaweli Authority of Sri Lanka
MCM	Million Cubic Meters
NK	Nippon Koei Co. Ltd
NTFP	Non Timber Forest Product
OSF	Other State Forest
PA	Protected Area
PR	Proposed Reserve
STC	State Timber Corporation
UMC	Upper Mahaweli Catchment
UMW	Upper Mahaweli Watershed
USAID	United States Agency of International Development

EXECUTIVE SUMMARY

At present nearly 60 percent of the annual electricity demand of the country is met by various hydropower plants. The demand for electricity in Sri Lanka is growing at an annual rate of about 7-8 percent and this trend is expected to continue in the foreseeable future. As a contribution to meet this growing electricity demand, the Ceylon Electricity Board (CEB) plans to develop a new 30.8 MW hydropower project at Moragolla in the Kandy District by constructing a concrete gravity dam across the Mahaweli Ganga at Weliganga. The proposed reservoir is expected to be 38.5 ha in extent with a capacity of 1.98 MCM at Full Supply Level (FSL) at 548 m MSL. The Feasibility Study (FS) for this project was conducted in 2009, and included an Environmental Impact Assessment (EIA). Later it was decided to upgrade this EIA, and surveys were conducted in 2013 covering some key fields, to supplement existing baseline data and update the assessment of impacts. However, further studies were deemed necessary in order to plan and design mitigation measures to minimize the adverse impacts of the project. The preparation of an Afforestation and Watershed Management Plan (AWMP) is one such study identified for the mitigation of the adverse impacts of the Moragolla Hydropower Project (MHP).

The study consists of two components **-** afforestation and watershed management.

Afforestation plan: This section includes details of the forest cover of Sri Lanka, forest cover in the upper Mahaweli watershed, Protected Areas (PAs) in the upper Mahaweli catchment, the importance of protected areas, the impact of the Moragolla project on forests, the rationale for the reservoir buffer zone and AWMP, forestry and afforestation in Sri Lanka, legal requirements for afforestation in Sri Lanka and an afforestation/reforestation plan for the Moragolla watershed. The afforestation/reforestation plan includes proposed sites for afforestation, recommended tree species for planting, a brief description on each species, planning and preparation for afforestation/reforestation programme, afforestation/reforestation techniques, establishment of nurseries, post-planting maintenance and management, relevant cost estimates, implementation of the afforestation programme, and a schedule of activities and timeframe for the afforestation/reforestation programme. The proposed afforestation/reforestation sites for Moragolla project consist of riparian sites, degraded forest sites, abandoned lands, pine plantations and privately owned home gardens. Twenty nine tree species have been recommended for the afforestation/reforestation programme. Suitable tree species should be selected from this species list after conducting a site-species matching exercise. The nursery establishment and planting techniques are described within this section. The total area to be afforested (planted) is approximately 130 ha, and includes afforestation and planting of riparian sites, degraded forest sites, abandoned lands, pine plantations and privately owned home gardens. A total of 78, 000 plants are estimated to be required for the entire afforestation programme. The cost estimate for the total afforestation programme is LKR 25 million for a period of five years, including planning during the first year.

Watershed management plan: This section includes details of the topography and the land uses of the immediate watershed of the proposed Moragolla reservoir, the existing conditions of sections of the immediate watershed of the Moragolla reservoir, environmental and watershed-related issues in the Moragolla catchment, problems associated with the land use patterns of the watershed, and problems related to specific land uses in the area. The proposed management strategies for the Moragolla reservoir watershed include the construction of lock and spill drains, the construction of bunds and stone walls, small check dams along tributaries, cover crops, mulching, grass strips, reforestation, home garden improvement, establishment of wetlands, an awareness programme and monitoring. The cost estimate for the entire watershed management programme is LKR 3.7 million for two years.

1. INTRODUCTION

1.1 Context

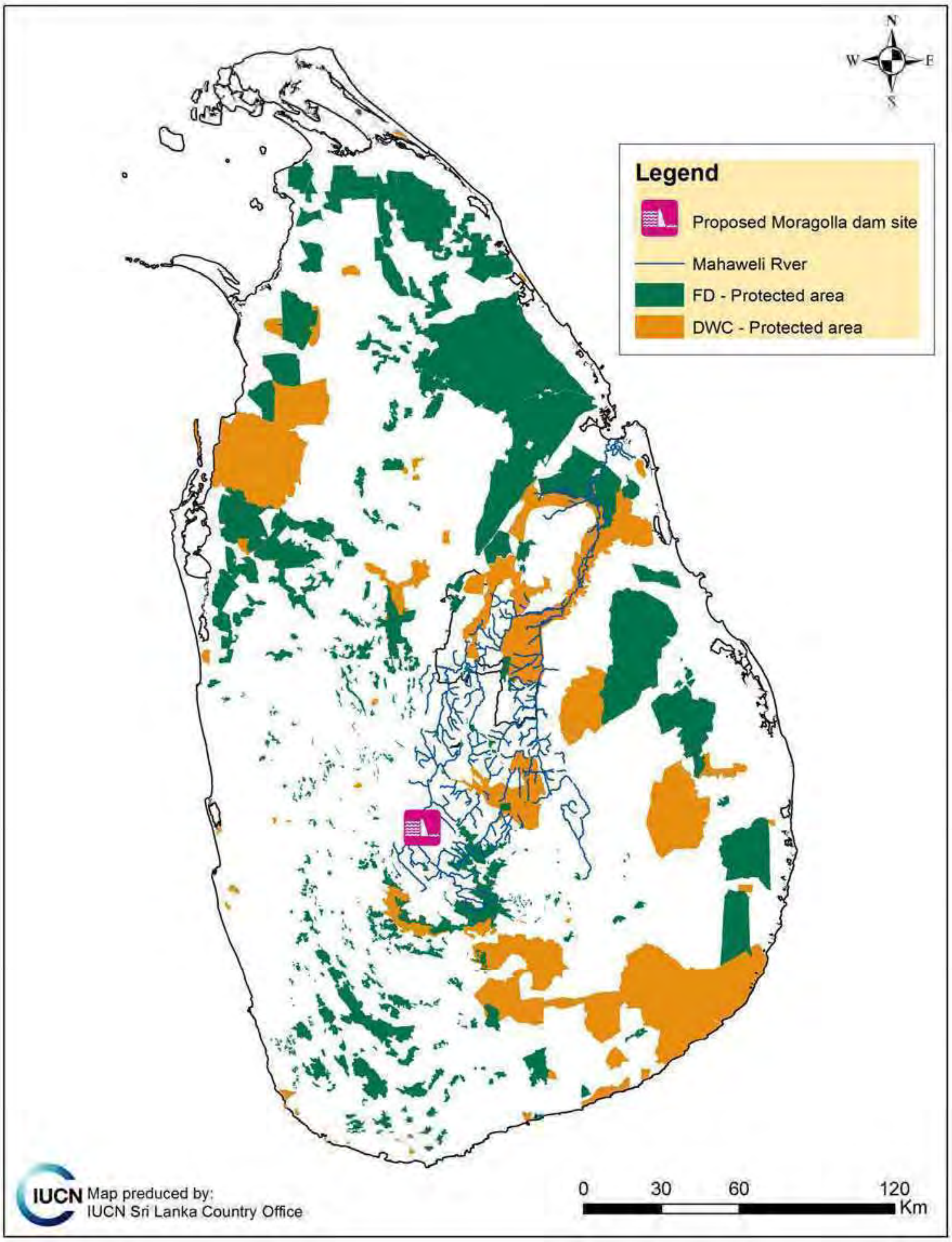
The demand for electricity in Sri Lanka has been growing at an annual rate of 7-8 percent, and this trend is expected to continue for the foreseeable future. As such, increased generating capacity is necessary in order to meet this growth in demand. At present, approximately some 60 percent of the annual demand is met by various hydropower plants (CEB, 2004). This is possible due to the large number of streams and rivers in the southwestern highlands, which are fed by the southwestern monsoon rains and the two inter-monsoon seasons. The Moragolla Hydropower Project (MHP) is likely to be the last medium scale hydropower scheme to be developed in Sri Lanka, aside from a few sites with potential for the development of mini-hydropower plants. In the future, additional power supply is likely to be provided from conventional fossil fuel based power plants, and to a small extent, by renewable energy sources. Therefore, the power system in Sri Lanka, which has been predominantly hydropower based in the past, will have to be transformed in to a thermal based system in the future. However, the National Energy Policy promotes the development of indigenous energy to minimize Sri Lanka's dependence on non-indigenous resources. Hence, realizing the remaining hydropower potential of country - even if it is through small or medium scale initiatives - is fast gaining attention from the CEB (CECB, 2012).

The growth in the demand for electricity has been linked closely with the growth in the economy in recent years closely, illustrating the need for a reliable and uninterrupted supply of electricity provided at a reasonable price if the current trend of economic growth is to continue. The 30.8 MW expected to be provided by the MHP would therefore, be a significant asset to the country.

As a contribution to meet this electricity demand, the Ceylon Electricity Board (CEB) plans to develop a new 30.8 MW hydropower project in Moragolla in the Kandy District. The proposed Moragolla Hydropower Project (MHP), and the area that will be impacted through associated development, are located around the southern slopes of the Central Highlands of Sri Lanka. Administratively, this area falls under the Uda Palatha and Ganga Ihala Korale Divisional Secretariat Divisions (DSDs) in the Kandy District of the Central Province.

1.2 The project

The proposed Moragolla Hydropower Project involves the construction of a 35 m high concrete gravity dam across the Mahaweli Riverat Weliganga. As part of this project, water will be diverted through a conveyance system to a powerhouse and outfall located opposite the confluence with the Atabage Oya. The proposed reservoir that will form as a result of the dam is expected be 38.5 ha in extent, with a capacity of 1.98 MCM at a Full Supply Level (FSL) of 548 m asl.



Map 1. Location of the Moragolla Hydropower Project.

The Feasibility Study (FS) for the project – including an Environmental Impact Assessment (EIA) - was conducted in 2009. In 2012, Nippon Koei Co. Ltd (NK) was appointed by the CEB to review these reports, and prepare detailed designs and tender documents for project, as well as to upgrade the EIA in order to comply with the Safeguard Policy of the Asian Development Bank (ADB), the principal funding agency. A number of additional surveys were conducted in 2013 to supplement existing baseline data and update the assessment of impacts, in order to upgrade the EIA. However, a further study is now been deemed necessary needed, so that mitigation measures can be properly planned and designed.

1.3 Reasons for the study

The topography of the project area is mountainous with a striking landscape of deep river valleys running beneath high cliffs and escarpments. The establishment of tea plantations in the hill country of Sri Lanka began in the 1850s. At present, the plantations cover a considerable land area in Kandy District. Most of the catchment area of the proposed project is covered by tea plantations and forest. The higher slopes and the tops of the hills remain forested with most of the forested areas designated as forest reserves. The project area is predominantly rural in character, with the majority of the population living in small rural communities. In general, most of the population is scattered over the area in traditional villages and tea estate worker communities. The dominant economic activities of the area are tea plantations and cultivation of other crops.

A detailed field analysis of land uses in the area conducted by the National Building Research Organization (NBRO) during the period March-July 2013, showed that approximately 133 ha of “forest” (6.3 percent of the total land area), which comprises primarily of secondary vegetation, is located within the project area. The forest area is degraded in nature at present due to human activities and anthropogenic pressures and can be categorized as a scrub jungle. Administratively, the forest area belongs to the category of Other State Forest (OSF), and falls under the purview of the Mahaweli Authority of Sri Lanka (MASL). According to the findings of the EIA, the most prominent tree species in the forest are *Albizia* spp. (Albizia), *Swietenia macrophylla* (Broadleaf Mahogany) and *Artocarpus heterophyllus* (Jak). A small proportion of this forest is expected to be affected by the proposed project due to activities includingland clearance for inundation, quarrying and spoil disposal.

According to the EIA carried out for the proposed project, approximately 489 trees over 20 cm in Diameter at Breast Height (DBH) are expected to be removed from the site. The species likely to be most affected will be *Mangifera indica* (27 trees), *Alstonia macrophylla* (32 trees), *Albizia falcataria* (48 trees), *Peltophorum pterocarpum* (25 trees), *Swietenia macrophylla* (60 trees) and *Artocarpus heterophyllus* (77 trees). A complete list of tree species (over 20 cm DBH) identified for removal is given in Annex 1.

The CEB is committed to mitigating all negative impacts associated with the project and compensating for the loss of trees. Therefore, an Afforestation and Watershed Management Plan (AWMP) has been deemed necessary in order to facilitate the mitigation of the negative impacts of the proposed project, including forest clearing and habitat disturbances. The present document has been prepared for this purpose.

1.4 Objectives

The general goal of the study is to ensure that the watershed of the Moragolla reservoir that provides water for the Moragolla Hydropower project is managed effectively and protected as natural asset of the highest importance in order to ensure its sustainable contribution to the electricity generation in Sri Lanka.

The specific objectives of the study are as follows:

1. To rehabilitate and restore ecologically the degraded forests and adjoining areas of the Moragolla catchment as a watershed;

2. To improve native forest diversity in the area by planting native tree species in the Moragolla catchment;

3. To control or prevent the establishment of invasive floral species that disrupt forest ecosystem process;

4. To provide a suitable habitat for fauna in the reservoir buffer zone and minimize the loss of flora and fauna belonging to species of high conservation significance during the construction phase of the project due to the clearing of vegetation and alteration of habitats.

5. To reduction soil erosion from the Moragolla catchment and minimize sedimentation within the proposed reservoir through the adoption of eco-friendly cultivation systems on privately owned lands within the catchment; and

6. To increase public awareness on the need to adopt soil conservation measures and environment-friendly land-use options in order to protect and maintain the Moragolla reservoir.

2. APPROACH

The methodology adopted for the development of the Afforestation and Watershed Plan is described briefly below.

The study consisted of an extensive survey of relevant literature, information and maps, and a brief field visit conducted between 21 and 22 August, 2013, in order to gain an understanding of the current ground situation at the project site.

Literature survey and office based work

- The EIA report and maps provided by Nippon Koei Co. Ltd (NK) were studied in order to obtain basic information necessary for the preparation of the plan.
- The environmental base maps were provided for the study area detailing types of land use, the terrain in the project area and important forest vegetation types.
- The presence of threatened floral species in the Upper Mahaweli watershed was investigated. Those species or communities that are considered to be of conservation significance were identified.
- A literature survey was carried out to identify the possible floral species present in the area, as well as information on their species statuses (endemic or introduced), and conservation statuses.

Field surveys

- A field survey was carried out in the proposed project area between 21 and 22 August, 2013, in order to investigate the land use types, land ownership, vegetation types, the status of forest vegetation present in the area, the status of private lands in the area and relevant development trends.
- A rapid survey was carried out to identify the species found in the remaining forests in the reservoir area, and plants or plant communities of conservation significance that have the potential to be impacted by the project.
- Consultations were held with representatives of the CEB and the Forest Department in the project area to clarify information on land use and land ownership. Forest Department officers provided the information on administrative and legal status of protection of forests in the project area.
- Public consultations were held with private land owners in the area to gather more information on land uses and crops grown in their lands including home gardens.
- Observations were made on the land uses in the Ulapane Industrial Park located in the immediate catchment area (left bank) of the proposed Moragolla reservoir.

3. BACKGROUND

The island of Sri Lanka has a land area of approximately 6.5 million hectares. Topographically, the country consists of a highland area in the south central part of the island, which rises to approximately 2, 500 meters, and the lowland plains that surround it The climate of Sri Lanka is generally tropical and maritime. Three major climatic zones can be recognized based on their rainfall patterns. They are the Wet Zone (over 2, 500 mm per year), the Intermediate Zone (1, 900 to 2, 500 m per year) and the Dry Zone where dry conditions prevail from May to September (below 1, 900 mm per year). The natural vegetation follows the pattern of the climatic zones of the country. In the wet zone, lowland rainforests form the climax vegetation type. From the southwestern lowlands, the vegetation gradually changes as it reaches the central mountains. At elevations of 1,000 to 1, 500 m, the natural vegetation is classified as sub-montane forest, and at even higher elevations, as montane forests. The characteristic natural vegetation of the dry zone is dry monsoon forest. The natural vegetation of the intermediate zone is moist monsoon forest.

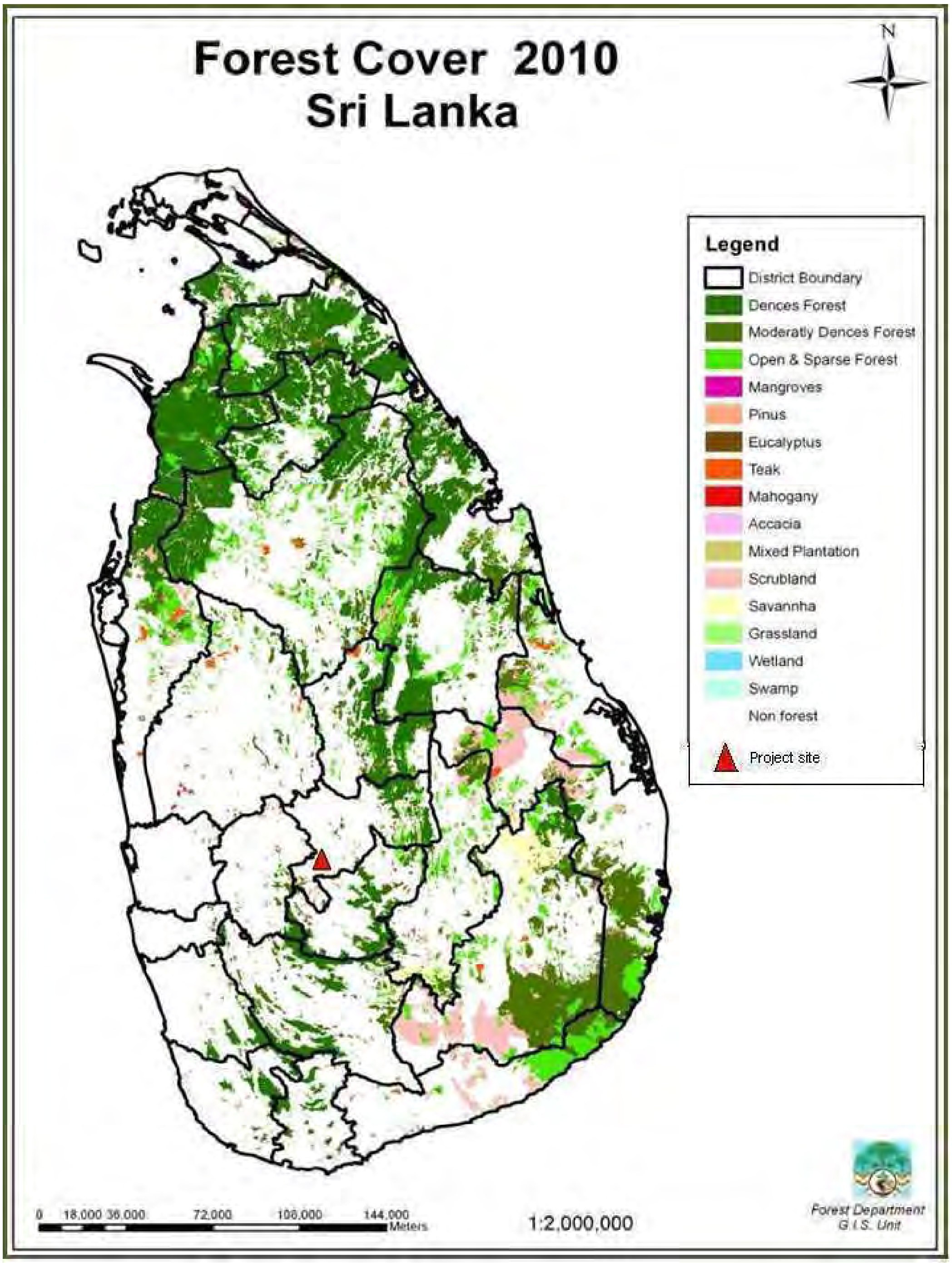
The 207 mile long Mahaweli River traverses from the Wet Zone to the Dry Zone and has been augmented by dams, canals and tunnels from over 2, 000 years ago. Of the annual precipitation in the Mahaweli River basin of 28, 000 MCM, 9, 000 MCM is discharged to the sea. The accelerated Mahaweli project, which was carried out during the 1980s, was the largest development project in Sri Lanka involving the generation of hydroelectricity, irrigation in the Dry Zone, land settlement, generation of employment opportunities and infrastructure development. This project resulted in the development of a hydropower generation capacity of 470 MW, and irrigation of an additional 365, 000 ha of land in the Dry Zone. Its catchment spans 10, 448 km^2 and feeds 1, 003 tanks. Subsequent to the associated construction, attention has shifted to watershed management, water management, crop diversification, participatory management and enterprise development. Similarly, there have been concerted efforts to manage the watershed in the upper reaches of the Mahaweli system.

The natural forest cover of the upper Mahaweli catchment (UMC) has been decreasing gradually over the last two centuries due to the large-scale deforestation for plantation agriculture. Subsequently, the forest cover of the hill country has been reduced further to a few isolated patches, in order to meet the demand for land for agriculture, developmental activities and human settlements. At present, vegetables are grown extensively on the steep slopes of the UMC without proper land management practices. Consequently, this agriculturally active land is exposed to severe soil erosion and landslides, in parallel with the rapid rate of deforestation.

The major portion of land in the UMC is under tea cultivation, which is known to result in severe soil erosion, at present. With population growth in the hill country, settlements and farming have expanded rapidly, even to steep slopes, thereby exacerbating existing erosion issues. Estimates of the rate of soil loss on these hill slopes and the associated sediment yields in the fluvial system of the UMC, indicate that human-mediated activities in the UMC have increased rates of ongoing erosion by over 100 times above the background rates of natural erosion (Hewawasam, 2010). Thus, the Mahaweli River and its tributaries carry enormous amounts of sediment during the rainy seasons, both as bed and suspension loads downstream, with large amounts of sediment deposited in multi-purpose reservoirs within this system, leading to reduction of their storage capacity. Siltation is a major issue in hydropower reservoirs, and can lead to reduced hydropower generation. If this is allowed to continue unabated, it can be anticipated that the situation will become worse in the future. Therefore, proper management of land by minimizing *in-situ* erosion and preserving the detached soil within the catchments through effective conservation measures is necessary in order to maintain and ensure a steady and continuous supply of power from the hydropower resources of the country.

3.1 Forest cover in Sri Lanka

According to the forest cover survey carried out by the Forest Department in 2010 based on the satellite images from 2008, the dense natural forest cover in Sri Lanka was 1.46 million ha (22.2 percent of the land area of the country). However, when all forests, including "sparse natural forests", which cover 6.5 percent of the land area, are also considered, the total forest cover of the country, excluding forest plantations and other forms of tree vegetation, is estimated to be 1.88 million ha (28.7 percent of the total land area) (MoAL&F, 1995). The total extent of forest plantations established for commercial or protective purposes amounts to 93, 000 ha (approximately 1.4 percent of the total land area). Therefore, the the total forest cover of Sri Lanka, including forest plantations, amounts to 1.975 million ha (30 percent of the total land area of the country), as illustrated in Map 2 (Forest Department, 2010).



Map 2. Forest cover of Sri Lanka (Forest Department, 2010).

In addition to these natural forests and forest plantations, a wide range of non-forest tree resources are available in the form of home gardens, rubber plantations, coconut plantations, ashade trees in tea plantations and trees on farmlands. These non-forest tree resources provide more than 70 percent of the industrial timber requirement of the country (MoAL&F, 1995).

As a result of its spatial variation in rainfall, altitude and soil, Sri Lanka features a striking variety of forest types. The forests that support much of the biodiversity of Sri Lanka include tropical wet lowland evergreen forests (lowland rainforests) in the Wet Zone, to tropical moist evergreen forests (moist monsoon forests) in the Intermediate Zone and tropical dry mixed evergreen forests (dry monsoon forests) in the Dry Zone (at elevations below 1, 000 m), tropical sub-montane forests (at elevations between 1, 000-1, 500 m in the Wet Zone), tropical montane forests (at elevations of 1, 500-2, 500 m in the Wet Zone); riverine forest (along river banks), tropical thorn forests (in the arid areas) and mangrove swamps in the coastal areas (Forest Department, 1995). The main forest types of Sri Lanka as a percentage of total forest cover in 2010 are shown in Table 1 below.

Table 1. Summary of natural forests in Sri Lanka in 2010
(based on Forest Department, 2011)
***included under sparse forest**

Forest type	Total forest area (ha)	Percentage of total land area
Montane forest	44, 787	0.68
Sub-montane forest	29, 022	0.44
Lowland wet evergreen forest	124, 032	1.89
Moist evergreen forest	117, 674	1.79
Dry mixed evergreen forest	1, 121, 438	17.09
Riverine dry forest	2, 446	0.04
Mangroves	16, 037	0.24
Scrubland*	317, 708	4.84
Savannah*	68, 044	1.04
Montane grassland*	40, 927	0.72
Total dense Forest	1, 455, 436	22.17
Total sparse forest	426, 679	6.5
Total forest cover	1, 882, 115	28.68

3.2 Forest cover in the upper Mahaweli watershed

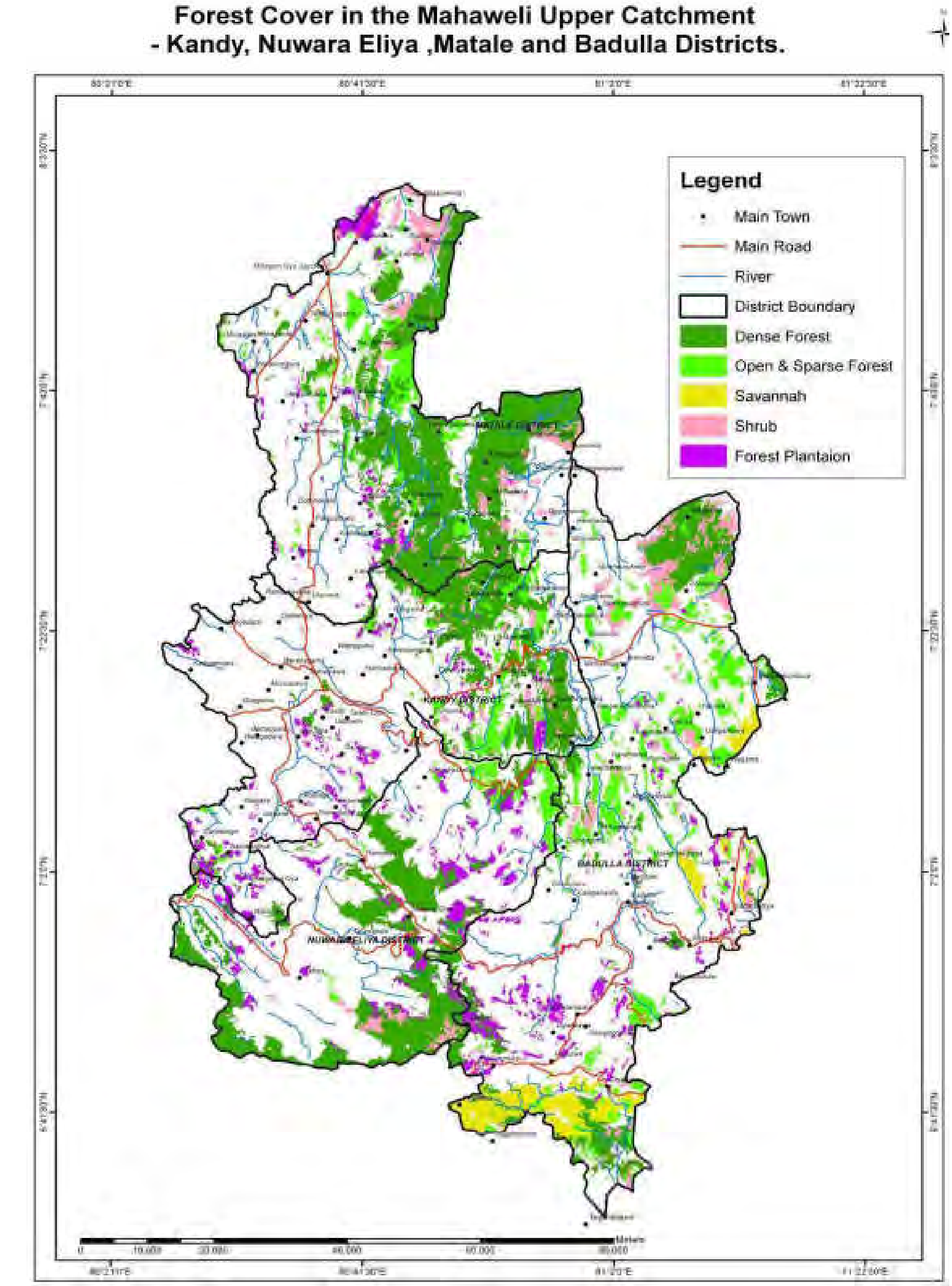
The upper Mahaweli watershed (UMW) is the upper portion of the Mahaweli watershed area, above the Rantambe dam, and extends into the Kandy, Nuwara Eliya, Badulla and Matale Districts, covering an area of approximately 3, 110 km^2 (Attygalle, 1998). The five reservoirs located within this catchment – Upper Kotmale, Kotmale, Victoria, Randenigala and Rantambe - contribute over 60 percent of the electricity supply in Sri Lanka through hydropower, as well as irrigation water for rice cultivation in lowland areas. Therefore, this watershed area is vital to national economy.

The natural forest cover of the Mahaweli watershed has decreased gradually over the last two centuries due to the large-scale deforestation for plantation agriculture. As in the national scenario, subsequently, the forest cover in this region has reduced further to a few isolated patches in order to meet the demand for land due to agriculture, developmental activities and human settlements. At present, vegetables are grown extensively on the steep slopes of the Mahaweli catchment without consideration of proper land management practices. Consequently, this agriculturally active land is exposed to severe soil erosion and landslides, in addition to rapid deforestation.

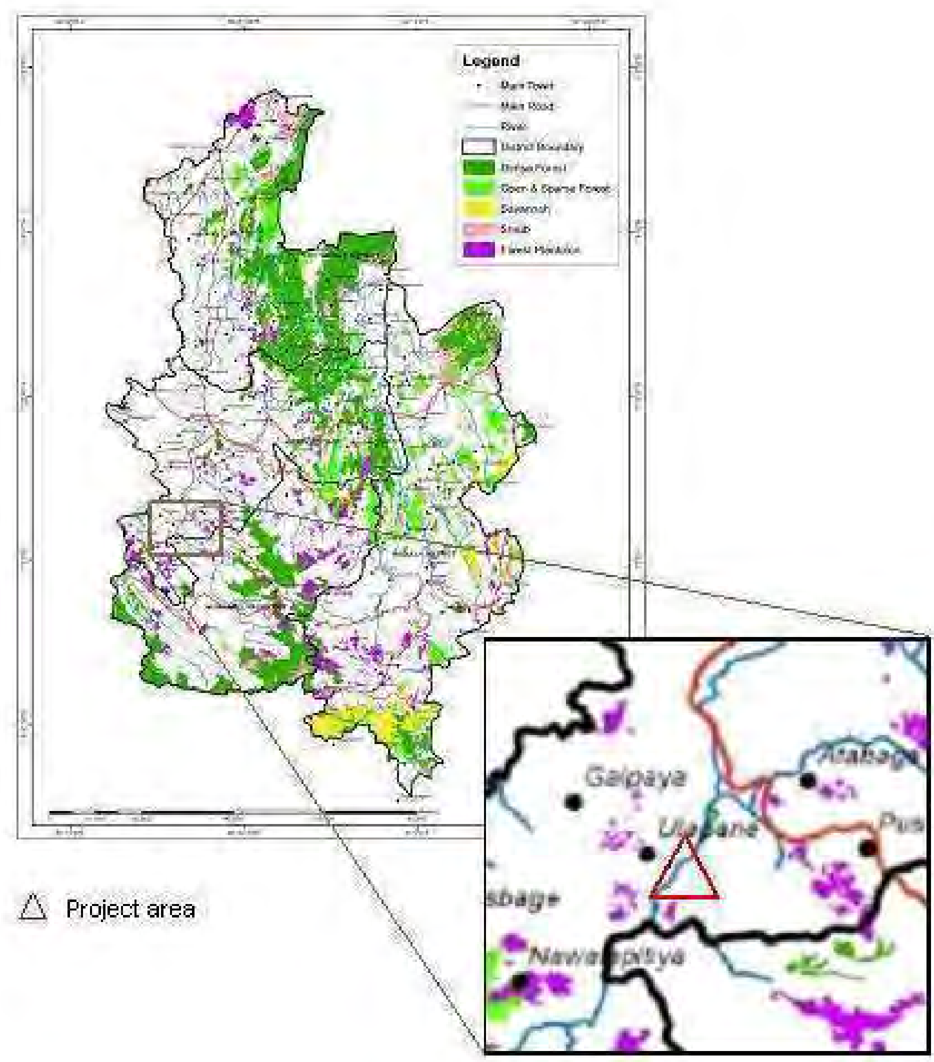
Six natural forest types – (i) montane forests, (ii) sub-montane forests, (iii) lowland rainforests, (iv)moist monsoon forests, (v) dry monsoon forests and (vi) savannah forests - can be observed in the upper Mahaweli watershed (Badulla, Kandy, Nuwara Eliya and Matale Districts).Natural forests are divided in to two categories - dense natural forests (canopy density over 80 percent) and sparse forests. The overall average forest cover in the Mahaweli watershed (Badulla, Kandy, Nuwara Eliya and Matale Districts) was estimated to be approximately 29.6 percent in 2010 (Forest Department, 2010). Information on the natural forest types and forest plantations (over five years old) in the Mahaweli catchment (Badulla, Kandy, Nuwara Eliya and Matale Districts) is provided in Table 2. A forest cover map of the upper Mahaweli watershed is provided in Map 3.

Table 2. Summary of the forests in the upper Mahaweli watershed

Forest type	Forest cover (ha) by district				
	Badulla	**Kandy**	**Nuwara Eliya**	**Matale**	**Total**
Montane forest	4,897	1,917	32,992	559	39,806
Sub-montane forest	576	6,204	2,065	4,323	8,845
Lowland rainforest	199	7,379	3,550	11,965	11,128
Moist monsoon forest	15,302	12,539	1,745	28,646	29,586
Dry monsoon forest	3,685	333	-	15,702	4,018
Total dense forest	24,659	28,372	40,352	61,195	93,383
Open sparse forest	27,832	9,001	5,483	11,453	42,316
Savannah forest	16,240	-	-	-	16,240
Forest plantation	5,833	5,408	7,203	3,186	18,444
Total forest	74,564	42,781	53,038	75,834	170,383
Forest cover (%)	26.4	22.3	31.1	38.8	29.6



Map 3. Forest cover in the Mahaweli upper catchment, covering the Kandy, Nuwara Eliya, Matale and Badulla Districts (Forest Department, 2010).



Map 4. Forest cover in the project area adopted from the Forest Department map (Forest Department, 2010).

Details of the different natural forest types observed in the Upper Mahaweli watershed area are provided below. The enlarged map above shows that there are dense forests within the project area.

Montane forests

The montane forests of the area are restricted to the uppermost elevations of (> 1500 m) the Nuwara Eliya and Badulla Districts (above 1, 500 m), and a small extent in the Knuckles area of the Kandy District. The average annual rainfall in this area is over 1, 800 mm, and is received ppedominantly during the southwest and northeast monsoon periods. These forests are dominated by Clusiaceae, Myrtaceae, Lauraceae, Symplocaceae and Rubiaceae species. Common tree species found within this forest type include *Calophyllum walker* (Keena), *Calophyllum trapezifolium* (Keena), *Garcinia echinocarpa* (Madol), *Syzygium revolutum, Syzygium rotundifolium, Syzygium umbrosum* (Heen damba), *Symplocos cochinchinensis* (Wal bombu), *Strobilanthes sexennis* (Nelu), *Semecarpus nigro-viridis*

(Badulla), *Neolitsea fuscata, Cinnamomum ovalifolium, Litsea ovalifolia* and *Actinodaphne speciosa* (Elephant's ears). Some of the shrub species present found montane forests include *Strobilanthes sexennis* (Nelu), *Gaertnera walker* and *Lasianthus oliganthus.* The forest floor of this habitat type harbours many species of ferns. In most areas, the understory of the forest is dense and dominated by *Strobilanthes* spp., bamboes and *Coleus* spp. These forests are characterized by trees that are approximately 8-10 m tall, and short in stature, with gnarled twisted branches an abundance of epiphytes dominated by mosses, leafy liverworts, ferns and orchids, colourful young foliage, relatively small, thick, leathery leaves and an absence of drip tips a. With an increase in elevation and windy conditions, the canopy species become quite stunted, giving way to pygmy forests.

Some of the endemic and threatened faunal species associated with montane forests are as follows:

Butterflies **-** Ceylon Tiger (*Parantica taprobana),* Blue Oakleaf (*Kallima philarchus),* Common Birdwing (*Troides darsius)* and Ceylon Palmfly (*Elymnias singhala).*

Amphibians - Sri Lanka Wood Frog (*Hylarana gracillis),* Montane Paddyfield Frog (*Fejervarya kirtisinghei),* Corrugated Water Frog (*Lankanectes corrugatus),* Hour-glass Tree-Frog (*Polypedates cruciger),* Small-eared Shrub Frog (*Pseudophilautus microtympanum)* and Ferguson's Shrub Frog (*Pseudophilautus fergusonianus)*.

Reptiles - Kangaroo Lizard (*Otocryptis wiegmanni),* Crestless Lizard (*Calotes liocephalus),* Whistling Lizard (*Calotes liolepis),* Great Forest Gecko (*Cyrtodactylus fraenatus),* Common Lanka Skink (*Lankascincus fallax),* Smooth Lanka Skink (*Lankascincus taprobanensis)* and Green Pit Viper (*Trimeresurus trigonocephalus)*.

Birds - Sri Lanka Spur Fowl (*Galloperdix bicalcarata),* Sri Lanka Wood Pigeon (*Columba torringtoniae),* Sri Lanka Jungle Fowl (*Gallus lafayetti)* and Mountain Hawk Eagle (*Spizaetus nipalensis).*

Sub-montane forests

The natural vegetation type of tropical sub-montane forests represents a transitional biological belt between the highlands and the lowlands. Tropical sub-montane forests are distributed in the middle elevations (1, 000–1, 500 m) in the Kandy and Nuwara Eliya Districts. The canopies of sub-montane forests are approximately 20–25 m high, and are dominated by the Dipterocarpaceae, Clusiaceae and Myrtaceae families. The soft and medium hardwood species dominant within this habitat include *Shorea gardneri, Calophyllum* spp. *Cryptocarya wightiana* (Gal mora), *Eleocarpus gladulifer* (Malveralu), *Myristica dactyloides* (Malaboda) and *Syzygium* spp., *Symplocos cochinchinensis* (Bombu), *Turpinia malabarica* (Gurenda). Some of the shrub species present in this forest type include *Strobilanthes* spp. (Nelu), *Hortonia floribunda* (Wawiya), *Lasianthus oliganthus, Rauvolfia densiflora, Rubus indicus* (Vel batu), *Stemonurus coriaceus.* Approximately, 50 percent of the species observed in sub-montane forests are considered to be endemic to Sri Lanka. Most species of the endemic genus *Stemonoporus* show a localized distribution in these montane forests. The major forest areas of this category include Peak Wilderness Sanctuary, Knuckles Conservation Forest (Dumbara hills) and Namunukula mountain range.

Some of the endemic and threatened faunal species associated with sub-montane forests are as follows:

Butterflies - Ceylon Palmfly (*Elymnias singhala),* Ceylon Tree Nymph (*Idea iasonia*), Ceylon Tiger (*Parantica taprobana),* Blue Oakleaf (*Kallima philarchus*), Clipper (*Parthenos sylvia*) and Common Birdwing (*Troides darsius).*

Freshwater fish - Stone Sucker (*Garra ceylonensis),* Mountain Labeo (*Labeo fisheri),* Banded Mountain Loach (*Schistura notostigma)* and Walking Catfish (*Clarias brachysoma).*

Amphibians: Kelaart's Dwarf Toad (*Adenomus kelaartii),* Sri Lanka Wood Frog (*Hylarana gracillis),* Montane Paddyfield Frog (*Fejervarya kirtisinghe),* Marbled Rock Frog (*Nannophyrus marmorata),* Hour-glass Tree-Frog (*Polypedates cruciger),* Small-eared Shrub Frog (*Pseudophilautus microtympanum*), Grey-Brown Pug-snouted Frog (*Ramanella obscura),* and Corrugated Water Frog *(Lankanectes corrugates).*

Reptiles: Kangaroo Lizard (*Otocryptis wiegmanni),* Crestless Lizard (*Calotes liocephalus),* Whistling Lizard (*Calotes liolepis),* Humpnose Lizard (*Lyriocephalus scutatus),* Great Forest Gecko (*Cyrtodactylus fraenatus),* Spotted Bowfinger Gecko (*Cyrtodactylus triedra),* Kandyan Gecko (*Hemidactylus depressus),* Smooth Lanka Skink (*Lankascincus taprobanensis),* Sri Lanka Flying Snake (*Chrysopelea taprobanica)* and Pipe Snake (*Cylindrophis maculata).*

Birds: Sri Lanka Spur Fowl (*Galloperdix bicalcarata),* Sri Lanka Jungle Fowl (*Gallus lafayetti),*Sri Lanka Wood Pigeon (*Columba torringtoniae),* Sri Lanka Hanging Parakeet (*Loriculus beryllinus),* Sri Lanka Emerald Collared Parakeet (*Psittacula calthropae),* Yellow-fronted Barbet (*Megalaima flavifrons),* Sri Lanka Yellow-eared Bulbul (*Pycnonotus penicillatus),* Spot-winged Thrush (*Zoothera spiloptera),* Sri Lanka Whistling Thrush / Arrenga (*Myophonus blighi),* Sri Lanka Dusky Blue Flycatcher (*Eumyias sordid)* and Blue Magpie (*Urocissa ornate).*

Mammals: Red slender Loris (*Loris tardigradus),* Purple-faced Leaf Monkey (*Semnopithecus vetulus),* Sri Lanka Bi-coloured Rat (*Srilankamys ohiensis)* and Golden Palm Civet (*Paradoxurus aureus),* Sri Lankan Toque Monkey *(Macaca sinica)* and Fishing Cat (*Prionailurus viverinus).*

Of the bird and mammal species present in the sub-montane forests the following species have been recorded in the EIA study carried out in Moragolla project site (November 2012):

Birds: Sri Lanka Jungle Fowl (*Gallus lafayetti),* Yellow-fronted Barbet (*Megalaima flavifrons),* Sri Lanka Hanging Parakeet (*Loriculus beryllinus)* and Sri Lanka Emerald Collared Parakeet (*Psittacula calthropae).*

Mammals: Sri Lankan Toque Monkey *(Macaca sinica)* and Fishing Cat (*Prionailurus viverinus).*

Lowland rainforests or lowland wet evergreen forests

Tropical lowland wet evergreen forests represent 6.4 percent of the natural forest cover of the country. This forest type is restricted to the Wet Zone in the southwest of the island, up to a mean elevation of 1, 000 m, and is, at present, highly fragmented. These forests are now represented primarily by isolated and very fragmented forest patches scattered over the Wet Zone. In the Mahaweli catchment area, these forests are located mainly in the Kandy and Nuwara Eliya Districts.

These forests are of particular importance as they constitute the last remnants of the once widespread mid-miocene tropical rainforests of Sri Lanka. They are exceptionally rich in biodiversity and high in endemism (approximately 60–75 percent of the tree species found in lowland rainforests are endemic to Sri Lanka), especially among the Dipterocarps, which constitute the characteristic tree flora and dominate the structural and floristic composition of this habitat type. Lowland wet evergreen forests harbour nearly all the woody endemic floral species found in Sri Lanka, as well as approximately 75 percent of the endemic fauna and all endemic genera. The level of endemism in these forests ranges from 37-64 percent for woody plants, and 14-52 percent for fauna, compared with 10-16 percent for species in Dry Zone forests. All endemic genera and over 90 percent of the woody endemic floral species and approximately 75 percent of the endemic fauna occur in these forests. In the lower slopes and valleys, these forests are characterized by a dense canopy of tree species reaching 30-40 m in height, with emergents rising to approximately 45 m, and woody lianas that form an intricate network (Gunatilleke *et al*. 2008).

Lowland wet evergreen forests are dominated by the families Dipterocarpaceae, Clusiaceae, Sapotaceae, Bombacaceae and Myrtaceae. At lower elevations (less than 100 m), *Dipterocarpus zeylanicus* (Hora) and *Dipterocarpus hispidus* (Bu hora) dominates the canopy within these forests, while *Mesua ferrea* (Na) and *Shorea trapezifolia,* dominate the canopy of these forests at higher elevations (above 100 m). Common species in the sub-canopy include *Cullenia rosayroana* (Katu boda)*, Cullenia Ceylanica* (Katu boda) and *Myristica dactyloides* (Mala boda)*,* while common species in the understorey include *Xylopia championii* (Dat ketiya) and *Garcinia hermonii* (Madol)*.* Some of the other tree species present in this forest type include *Dimocarpus longan* (Mora)*, Diospyros ebenoides* (Yabara)*, Pleurostylia opposite* (Panakka)*, Semecarpus nigro-viridis* (Badulla) and *Vitex altissima* (Milla)*.* Some of the shrub species present in this forest type include *Dimorphocalyx glabellus* (Weliwarana), *Glycosmis mauritiana* (Dodanpana), *Memecylon umbellatum* (Korakaha), *Miliusa indica* (Kekili messa) and *Streblus asper* (Kolapollan). Large leaves, drip tips on leaves, buttresses, cauliflory (fruiting and flowering from main stems), drooping young twigs, colourful young leaves and fewer lianas and epiphytes characterize this vegetation type (Gunatilleke, 2008).

Some of the endemic and threatened faunal species associated with lowland rainforests are as follows:

Butterflies: Ceylon Palm fly (*Elymnias singhala),* Ceylon Tree Nymph (*Idea iasonia*), Ceylon Tiger (*Parantica taprobana),* Blue Oakleaf (*Kallima philarchus)* and Common Birdwing (*Troides darsius*).

Amphibians: Kelaart's Dwarf Toad (*Adenomus kelaartii),* Sri Lanka Wood Frog (*Hylarana gracillis*), Corrugated Water Frog (*Lankanectes corrugatus*), Marbled Rock Frog (*Nannophyrus marmorata)*¸ Ferguson's Shrub Frog (*Pseudophilautus fergusonianus)*, Grey-Brown Pug-snouted Frog (*Ramanella obscur*), Sri Lanka Narrow-mouthed Frog (*Microhyla zeylanica*) and Bigfoot Shrub-Frog (*Pseudophilautus macropus).*

Reptiles: Leaf-nose Lizard (*Ceratophora tennentii),* Crestless Lizard (*Calotes liocephalus*), Whistling Lizard (*Calotes liolepis*), Great Forest Gecko (*Cyrtodactylus fraenatus*), Dwarf day Gecko (*Cnemaspis podihuna*), Kandyan Gecko (*Hemidactylus depressus*), Common Lanka Skink (*Lankascincus fallax*), Toeless Snake Skink (*Nessia monodactylus*), Dumeril's Kukri Snake (*Oligodon sublineatus*), Blyth's Earth Snake (*Rhinophis blythii*) and Green Pit Viper (*Trimeresurus trigonocephalus*).

Birds: Sri Lanka Spurfowl (*Galloperdix bicalcarata*), Sri Lanka Wood Pigeon (*Columba torringtoniae*), Sri Lanka Hanging Parrot (*Loriculus beryllinus*), Sri Lanka Emerald Collared Parakeet (*Psittacula calthropae*), Sri Lanka Yellow-eared Bulbul (*Pycnonotus penicillatus*), Spot-winged Thrush (*Zoothera spiloptera*), Sri Lanka Warbler (*Bradypterus palliseri*), Sri Lanka Hill Myna (*Gracula religiosa*) and Blue Magpie (*Urocissa ornata*).

Mammals: Red Slender Loris (*Loris tardigradus*), Purple-faced Leaf Monkey Toque (*Semnopithecus vetulus*), Sri Lanka Bi-coloured Rat (*Srilankamys ohiensis*) and Golden Palm Civet (*Paradoxurus aureus)*.

Moist monsoon forests or tropical moist evergreen forests

Tropical moist evergreen forests represent 11.4 percent of the natural forest cover of the country. Tropical moist evergreen forests constitute a distinct group in the lowland Intermediate Zone (below 1, 000 m). In the Mahaweli catchment, this forest type is located in the Badulla and Kandy Districts, as well as a small extent in the lower elevations of the Nuwara Eliya District. Trees in these forests are typically approximately 25-30 m tall, and represent the transition or ecotone between forests in aseasonal and seasonal climates. They bear similarities in species composition to both tropical lowland wet evergreen forests and tropical dry mixed evergreen forests, but also support some species of their own. The dominant floral families found within this forest type include Anacardiaceae, Sapindaceae, Euphorbiaceae and Moraceae. The dominant floral species observed in moist monsoon forests include *Mangifera zeylanica* (Etamba)*, Canarium zeylanicum* (Dik kakuna)*, Filicium decipiens* (Pehimbiya)*, Dimocarpus longan* (Mora)*, Nothopegia beddomei* (Andum telageddi), *Gironniera parvifolia* (Akmediya) and *Vitex altissima* (Milla). Some other tree species present include *Actinodaphne stenophylla* (Metidavula)*, Drypetes gardneri* (Etaweera)*, Gomphia serrata* (Rathgo)*, Mallotus philippensis* (Molabe) and *Psychotria gardneri* (Labutharana). Lianas are also abundant in this forest type. Only approximately 17 percent of the tree species in these forests are endemic to Sri Lanka.

Some of the endemic and threatened faunal species associated with moist monsoon forests are as follows:

Butterflies: Ceylon Tree Nymph (*Idea iasonia*), Ceylon Tiger (*Parantica taprobana*) and Common Birdwing (*Troides darsius*).

Freshwater fish: Stone Sucker (*Garra ceylonensis*), Phillips' Garra (*Garra phillipsi*), Blotched Filamented Barb (*Dawkinsia srilankensis*), Martenstyn's Barb (*Systomus martenstyni*) and Banded Mountain Loach (*Schistura notostigma*).

Amphibians: Kelaart's Dwarf Toad (*Adenomus kelaartii*), Sri Lanka Wood Frog (*Hylarana gracilis*), Corrugated Water Frog (*Lankanectes corrugatus*), Hour-glass Tree-Frog (*Polypedates cruciger*), Small-eared Shrub Frog (*Pseudophilautus microtympanum)* and Grey-Brown Pug-snouted Frog (*Ramanella obscura*).

Reptiles: Kangaroo Lizard (*Otocryptis wiegmanni*), Leaf-nose Lizard (*Ceratophora tennentii*), Crestless Lizard (*Calotes liocephalus*), Whistling Lizard (*Calotes liolepis*), Spotted Bowfinger Gecko (*Cyrtodactylus triedra*), Fourtoe Snake Skink (*Chalcidoseps thwaitesii*), Dumeril's Kukri Snake (*Oligodon sublineatus*), Pipe Snake (*Cylindrophis maculata*) and Green Pit Viper (*Trimeresurus trigonocephalus*).

Birds: Sri Lanka Spurfowl (*Galloperdix bicalcarata*), Sri Lanka Wood Pigeon (*Columba torringtoniae*), Sri Lanka Hanging Parrot (*Loriculus beryllinus*), Sri Lanka Emerald Collared

Parakeet (*Psittacula calthropae*), Yellow-fronted Barbet (*Megalaima flavifrons*), Brown-capped Babbler (*Pellorneum fuscocapillus*), Sri Lanka Dusky Blue Flycatcher (*Eumyias sordidus*) and Sri Lanka Hill Mynah (*Gracula religiosa*).

Mammals: Red Slender Loris (*Loris tardigradus*) and Purple-faced Leaf Monkey (*Semnopithecus vetulus*).

Dry monsoon forests or tropical dry mixed evergreen forests

Tropical dry mixed evergreen forests represent 53 percentage of the natural forest cover of country. These forests are the characteristic vegetation type of the Dry Zone. In the Mahaweli catchment, these forests are located in drier parts of the Badulla District. Generally, the trees within this habitat type are approximately 25 m tall, and shorter in towards the Arid Zone. Approximately 13 percent of the tree species in these forests are endemic to Sri Lanka (MoENR/EML, 2006).

The families Euphorbiaceae, Sapindaceae, Ebenaceae, Sapotaceae and Rutaceae dominate this forest type. The dominant canopy species include *Manilkara hexandra* (Palu), *Chloroxylon swietenia* (Satinwood), *Schleichera oleosa* (Ceylon Oak) and *Pleurostylia opposite* (Panakka), while species observed in the understorey are *Pterospermum suberifolium* (Welang), *Drypetes sepiaria* and *Dimorphocalyx glabellus* (Weli wenna) (MoENR/EML, 2006). These forests comprise of a mixture of evergreen and deciduous canopy species. In general, the latter are found in the canopy, shedding their leaves during the late dry period, allowing light to filter to the forest floor. This enables grasses and herbaceous species to flourish at the onset of the rainy season, before new foliage emerges on denuded canopy trees.

Although Dry Zone forests are considered to be less diverse than Wet Zone forests floristically, they are important as habitats for large mammals including leopards (*Panthera pardus*), elephants (*Elephas maximus*), spotted deer (*Axis axis*), sambhur (*Rusa unicolor*), and wild boar (*Sus scrofa*), as well as primate species, with faunal groups, such as carnivores, ungulates and primates, showing their highest species diversity in tropical dry mixed evergreen forests within Sri Lanka.

Savannah forests

The savannah forest type has evolved due to frequent fires related to human activities in the area. Typical savannah forests can be found in the Haldumulla area of the Badulla District. These savannah forests have a very simple structure, with isolated trees scattered over a vast expanse of grassland. An important characteristic feature of the tree species present in savannah forests is that they are well adapted to survive fires. This may be attributed to the thick bark covering their stems, which protects the internal tissues from heat. The annual occurrence of fires during the dry season between May and August is a common incidence almost every year. While all the grasses and herbaceous vegetation are destroyed by fire, but the underground parts of these species remain alive to produce new shoots with the onset of the rains. Lemon grass is the typical dominant grass species found in this community. The exotic species *Panicum maximum* (Guinea grass) also grows quite aggressively in savannah forests. This species is a good fodder plant for herbivorous mammals, and young grass shoots appear after the burning season, making the savannah a good feeding ground for wild herbivores.

Some of the tree species common to savannah forests include *Albizia odoratissima* (Panimara), *Alstonia scholaris* (Ruk attana), *Bridelia retusa* (Ketakela), *Chukrasia tabularis* (Barawahik), *Grewia damine* (Damunu), *Phyllanthus embilica* (Nelli), *Semecarpus nigro-viridis* (Badulla) and *Trema orientalis* (Gedumba).

3.3 Forest types in the Moragolla project area

The Moragolla project area falls within the wet climatic zone. Two types of natural forests were typical in this area - (i) sub-montane forests or tropical sub-montane forests (1, 000 – 1, 500 m) and (ii) lowland rainforests or lowland wet evergreen forests (<1000 m) - prior to the 1830s, before the clearing of forests for plantation agriculture such as coffee and tea. These forest formations occur in the project area primarily due to its rainfall and altitude. Deforestation in the last two centuries has resulted in the removal of a large part of natural forest cover for agricultural usage, including plantation agriculture (e.g. coffee and tea). At present, natural forest patches have been persevered only in very small areas on hilltops, especially in higher elevations. Generally, almost all the forests in the Moragolla project area at present are degraded secondary forests of original sub-montane and lowland rainforest types. Apart from these two forest types, other forest types, such as montane forests, moist monsoon forests, dry monsoon forests and savannah forests, present in the Upper Mahaweli catchment, are not found in the Moragolla project area. Further details regarding the forest cover and tree species present in the project area are presented in a separate section below.

3.4 The importance of protected areas

Protected areas (PAs) are designated with the objective of conserving nature and biodiversity, along with associated ecosystem services and cultural values. In addition to the conservation of the fauna and flora of a site, PAs provide many important ecosystem services, as well as several localized goods and services, including watershed protection, the provision of drinking water, the prevention of floods and soil erosion, carbon storage, water conservation and soil stabilization, eco-tourism, the regulation of rainfall, limiting the prevalence of disease and the provision of livelihoods for local people. In addition, PAs also hold important gene reservoirs that are of value in a variety of sectors including medicine, agriculture and forestry.

In the face of climate change, these roles become even more critical with regard to the enhancement of the adaptive capacity of local people to cope with climate change. PAs can contribute considerably to physical protection against major disasters, such as earth slips and landslides, by helping to maintain natural ecosystems, as the maintenance of ecosystems and protection of forests protection can reduce such impacts of climate change.

PAs can also provide a direct means of enhancing revenue, particularly through Non Timber Forest Products (NTFP) and nature tourism, as well as through the valuable services they provide. In addition, PA management can help to empower marginalized populations and communities through approaches such as community forest management.

a. The role of Protected Areas in the maintenance of watershed protection functions

Protected forest areas play an important role in the conservation of soil and water resources. Natural forest vegetation protects the soil from splash erosion by intercepting rainfall, dissipating droplet energy and protecting the surface of the land with a covering of leaf litter. As a result of the presence of forest vegetation, rainfall infiltration is increased, while surface runoff and soil erosion are reduced. In addition, natural forests stabilize groundwater levels and stream flows. The relative importance of forests in watershed protection, soil and water conservation and minimizing flood hazards, differs between the Dry and Wet Zones of Sri Lanka due to differences in the intensity of rainfall and the steepness of the terrain.

There are several hydropower reservoirs within the Mahaweli basin in the hill country of the Wet Zone, including Victoria, Randenigala, Rantambe, Minipe, Kotmale and Upper Kotmale. The watersheds of these reservoirs are under severe population pressure, which has already resulted in severe deforestation and forest degradation. In the long term, if the forests in the catchment areas are not protected adequately, the sedimentation of reservoirs associated with excessive soil erosion may reduce their capacity to store water for hydropower and irrigation substantially, jeopardizing the agro-industrial base of the economy.

b. The role of Protected Areas in the conservation of biodiversity

It is believed that tropical rainforests support over half of the world's floral and faunal species. As such, these systems are considered to be some of the most biodiverse terrestrial systems to have evolved.

Sri Lanka is one of the smallest, but most biodiverse, countries in Asia. Hence, the economic value of its biodiversity is inestimable. There are many products harvested from forests that provide food and livelihood necessities to local communities, often at little to no cost. Some of these products enter more formal markets, while other items, including some items, such as yams, fruits, nuts, spices, leaf vegetables, medicinal herbs, rattan, bamboo, gums, resins and *kitul* (*Caryota urens*) products, are used by local communities on a domestic basis. Almost all the medicinal plants used in the traditional Ayurvedic medicinal practices are forest products that form a significant component of forest biodiversity. Similarly, the cottage industry developed through the manufacture of traditional crafts from rattan and bamboo extracted from forests is an important income source for some villagers in Sri Lanka.

c. The role of Protected Areas in nature tourism

Nature based tourism is considered to be rapidly growing component of the tourism industry world-wide. Nature based tourism focuses primarily around Protected Areas (PAs). In Sri Lanka, eco-tourism has been recognized as a high priority area capable of driving the country's economic development effectively. Accordingly, the national target for tourist arrivals in Sri Lanka is two million tourists by 2016, with tourism becoming a major foreign exchange earner for the country. Sri Lanka, with its rich biodiversity and high rate of endemism, holds very high potential for the development of nature based tourism, as promoted in current tourism development policies and plans.

3.5 Protected areas in the Mahaweli catchment

Protected Areas (PAs) are locations that receive protection due to their recognized natural, ecological and cultural values. The definition for PAs that has been accepted widely across regional and global frameworks has been provided by the International Union for Conservation of Nature (IUCN). The IUCN definition for a Protected Area is *"A clearly defined geographical space, recognized, dedicated and managed, through legal or other* *effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values"* (IUCN, 2008). In practice, Pas are managed for a wide variety of purposes, including for scientific research, wilderness protection, preservation of species and ecosystems, maintenance of environmental services, protection of specific natural and cultural features, tourism and recreation, education, sustainable use of resources from natural ecosystems and maintenance of cultural and traditional attributes (MoENR/EML, 2006).

In Sri Lanka, the forest sector falls under the jurisdiction of the Forest Department (FD), the Department of Wildlife Conservation (DWC) and the State Timber Corporation (STC). In addition, a small fraction of forest areas (approximately two percent) falls under the jurisdiction of several other state sector institutions, as well as under private ownership. However, forest PAs within the country are managed by the Forest Department (FD) and the Department of Wildlife Conservation (DWC), The STC does not have any forest management authority and is only a commercial organization dealing with the extraction and sale of state timber. In the case of Forest Department PAs, Forest Reserves (FRs), Proposed Reserves (PRs) and Other State Forests (OSFs) (with protected forest vegetation), which are predominantly in a natural condition (at least two-thirds) and managed long-term protection of biodiversity, meet the criteria of IUCN Category VI – Managed Resource Protected Area *(Protected Area with Sustainable Use of Natural Resources)*. Commercial forest plantations do not qualify under the criteria for PA categories of IUCN (MoALF, 1995). All forest areas under the jurisdiction of the DWC are recognized as PAs, and are protected legally under the *Fauna and Flora Protection Ordinance.* The legal protection for PAs under the FD is provided under the *National Heritage and Wilderness Areas Act*, as well as different sections of the *Forest Ordinance*.

In addition, based on a policy decision taken in 1990, all the natural forests in Sri Lanka have been withdrawn from commercial logging through the imposition of a logging ban since 1990, as a strategy for achieving forest conservation. Therefore, since 1990, all the natural forests of the country, including natural forests in the Mahaweli catchment, are managed based on conservation objectives.

The PAs network within the Mahaweli catchment includes six PAs under the jurisdiction of DWC, and 57 PAs under the FD. The most prominent of all the PAs within the Mahaweli catchment is the Central Highlands serial property World Heritage Site, which consists of the Knuckles Conservation Forest, Horton Plains National Park and the Peak Wilderness Protected Area (excluding the Peak itself and associated pathways). The Central Highlands of Sri Lanka was inscribed as a World Heritage Site in 2010, on account of its outstanding universal value as a Natural World Heritage Site. Of the three PAs included in the Central Highlands World Heritage Site, the Knuckles Conservation Forest falls under the jurisdiction of FD, while the other two PAs – the Horton Plains National Park and Peak Wilderness Protected Area - fall under the jurisdiction of the DWC. The aerial distance from the Moragolla project area to the Knuckles Conservation Forest of the Central Highlands World Heritage Site is approximately 35 km.

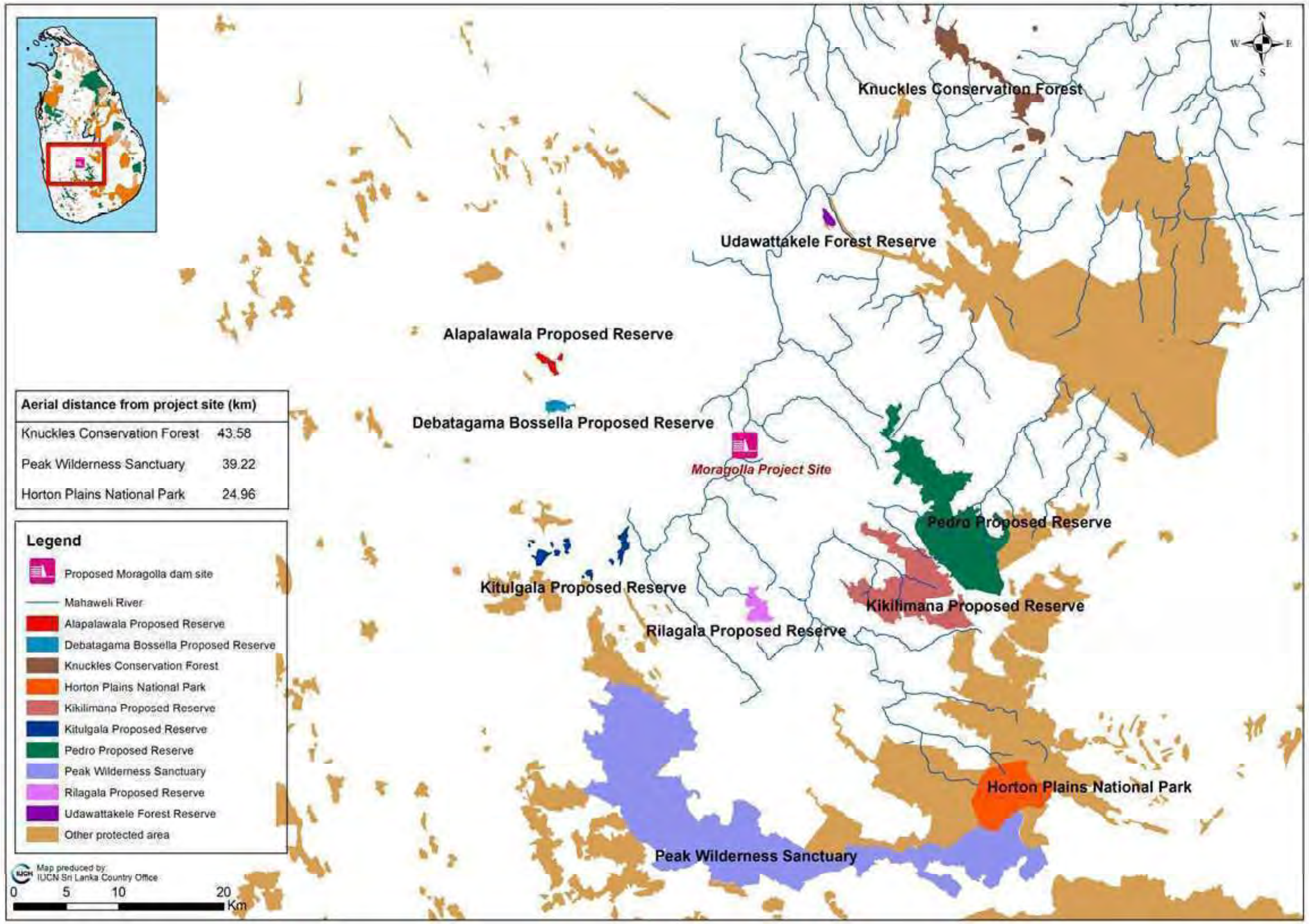
Individual PAs within the Mahaweli system under the jurisdiction of DWC include the Peak Wilderness Sanctuary (22, 380 ha), the Victoria-Randenigala-Rantambe Sanctuary (42, 087 ha), the Udawattakele Sanctuary (104 ha), the Horton Plains National Park (3, 160 ha), Galway's Land National Park (27 ha) and the Hakgala Strict Nature Reserve (1, 142 ha). The PAs within this area that fall under the jurisdiction of the FD consist of 17 Conservation

Forests including Knuckles, and 49 Forest Reserves. Udawattakele has been gazetted as both a Sanctuary (under the DWC) and a Forest Reserve (under the FD).

Details of Protected Areas within the Mahaweli catchment (Kandy, Nuwara Eliya and Badulla Districts) are provided in Table 3.

Table 3. Protected Areas within the Mahaweli catchment

Protected area	Management	Number	Location/District	Extent (ha)
World Heritage Site	DWC and FD	1	Kandy and Nuwara Eliya	42, 539
Strict Nature Reserve	DWC	1	Nuwara Eliya	1, 142
National Park	DWC	2	Nuwara Eliya	3,1 87
Sanctuary	DWC	2	Kandy	42, 191
Conservation Forest	FD	16	Kandy and Nuwara Eliya	
Forest Reserve	FD	49	Kandy and Nuwara Eliya	
Total		**71**		



Map 5. Key protected areas in close proximity to the Moragolla project area

3.6 The impact of the project on forests

The present status of the forest cover within the MHP area is discussed briefly below.

3.6.1 Forest cover within the project area

The proposed Moragolla reservoir area extends to approximately 3 km upstream of the proposed dam along the river, and will cover a surface area of approximately 36.5 ha, with a perimeter of 7, 100 m. The proposed elevation of the reservoir, once filled, will be 548 m MSL. The water level will increase by approximately 25-30 m, and as a result, the banks of the first 500 m upstream from the dam are likely to become inundated. Approximately 90 percent of the land area near the dam that will get inundated due to the proposed reservoir, will be the river bed and reservation area, which consists of degraded forest vegetation. The remaining ten percent of the land that will be inundated consists of residential lands with home gardens and mixed crops. These lands are owned by private parties.

Relatively undulating topography with mixed vegetation is prominent in the proposed project area at present, with tea lands, abandoned tea lands, home gardens and shrubs being the dominant land uses observed in the area.

In the right bank the river close to the dam site, A stretch of degraded secondary forest can be observed on the right bank of the river, in close proximity to the proposed dam site, between the road and the Mahaweli River. . Abandoned lands under different serial stages of regeneration are also found in patches within the area. Further, degraded grasslands are present on the slopes of hill tops (see photocatalogue for images).

The MHP is likely to impact the forests of the area due to establishment of permanent and temporary structures such as the dam, tunnel power house, switch yard, transmission lines, the development of new roads and widening of old roads, and the formation of the reservoir. In addition, the establishment of temporary structures such as labour camps, quarry sites, waste disposal sites and vehicle service areas, may also result in temporary impacts on the forest vegetation of the area. The impact of the proposed project on forest vegetation is due primarily to forest clearing in the inundation and construction areas, and disturbances to the forests in the vicinity of the construction areas. As such, it is anticipated that forest areas will be affected at the following sites:

- The inundation area;
- The dam site and surrounding area;
- The power house and surrounding area;
- Areas associated with the transmission line; and
- Areas where roads are constructed or widened.

Details of the vegetation present in these areas are presented in the tables below.

a) The inundation area

The vegetation in the inundation area includes grass and shrub dominated vegetation with a few scattered trees. The main species found in this area are presented in the following table.

Table 4. Grass, shrub and tree species found in the inundation area

No.	Species	Local name	Nature of vegetation
1.	*Panicum maximum*	Rata tana or Guinea grass	Grass
2.	*Arundo donax*	Giant cane	Shrub
3.	*Mimosa pigra*	Giant (*Yoda*) nidikumba	Shrub
4.	*Trema orientalis*	Gedumba	Tree
5.	*Symplocos cochinchinensis*	Bombu	Tree
6.	*Macaranga peltata*	Kenda	Tree
7.	*Macaranga indica*	Kenda	Tree
8.	*Cipadessa baccifera*	Hal bambiya	Tree
9.	*Syzygium caryophyllatum*	Dan	Tree
10.	*Alstonia macrophylla*	Hawari nuga	Tree
11.	*Acacia mangium*	Acacia	Tree
12.	*Syzygium jambos*	Seeni Jambu	Tree
13.	*Madhuca nerifolia*	Gam mi	Tree
14.	*Albizia falcataria*	Mara	Tree
15.	*Mallotus tetracoccus*	Bu-kenda	Tree
16.	*Homonoia riparia*		Tree
17.	*Aporusa lanceolata*	Heen kebella	Tree
18.	*Clusia rosea*	Gal goraka	Tree
19.	*Ficus* spp.	Nuga	Tree
20.	*Artocarpus nobilis*	Wal Del	Tree
21.	*Actinodaphne elegans*		Tree
22.	*Ficus racemosa*	Attikka	Tree

b) The dam site and surrounding area

The vegetation found in the proposed dam site and its surrounding area is highly disturbed as a result of human activities, with grasses, shrubs and pioneer tree species being reported from the proposed dam site. The main species found in this area are given in the table below.

Table 5. Vegetation found in the dam site and surrounding area

No.	Species	Local name	Nature of vegetation
1.	*Panicum maximum*	Rata tana or Guinea grass	Grass
2.	*Mimosa pigra*	Giant (*Yoda*) nidikumba	Shrub
3.	*Trema orientalis*	Gedumba	Tree
4.	*Macaranga peltata*	Kenda	Tree
5.	*Symplocos cochinchinensis*	Bombu	Tree
6.	*Eupatorium odoratum*	Podisinnomaran	Tree
7.	*Acacia mangium*	Acacia	Tree

c) The power house and surrounding area

The power house will be located in the abandon land near the river. The vegetation in this area is dominated by grasses and shrubs, with a few scattered trees. The main species found in this area are given in the table below.

Table 6. Vegetation in the power house and surrounding area

No	Species	Local name	Nature of vegetation
1.	*Panicum maximum*	Rata tana or Guinea grass	Grass
2.	*Mimosa pigra*	Giant (*Yoda*) nidikumba	Shrub
3.	*Lantana camara*	Gandapana	Shrub
4.	*Trema orientalis*	Gedumba	Tree
5.	*Macaranga peltata*	Kenda	Tree
6.	*Alstonia macrophylla*	Hawari nuga	Tree
7.	*Eupatorium odoratum*	Podisinnomaran	Tree
8.	*Makania cordata*	Watu palu	Tree
9.	*Ipomoea cairiea*		Tree
10.	*Gliricidia sepium*	Weta mara	Tree
11.	*Hyptis suaveolens*	Maduruthala	Tree
12.	*Stachylarpheta jamaicensis*	Balu nkuta	Shrub

d) Areas associated with the transmission line

About 80 percent of the length of the transmission line traverses above home gardens, while the rest passes over abandoned lands. The vegetation in the home gardens are given below. The abandoned lands are covered mostly by a secondary growth dominated by pioneering herbaceous and shrub species. The most significant species in these lands are given in the table below.

Table 7. Vegetation in the areas associated with the transmission line

No.	Species	Local name	Nature of vegetation
1.	*Panicum maximum*	Rata tana or Guinea grass	Grass
2.	*Lantana camara*	Gandapana	Shrub
3.	*Eupatorium odoratum*	Podisinnomaran	Tree
4.	*Ageratum conyzoides*	Hulan tala	Shrub
5.	*Blechnus orientais*	Pattara werella	Tree
6.	*Crotalaria spp*		Tree
7.	*Dicranopteris linearis*	Kekilla	Shrub

e) Areas where roads are constructed or widened

Homegardens, abandoned lands and tea lands are the main land use types affected by proposed new road and road expansion areas. The main species found in this area are given in the table below.

Table 8. Vegetation in the areas where roads are constructed or widened

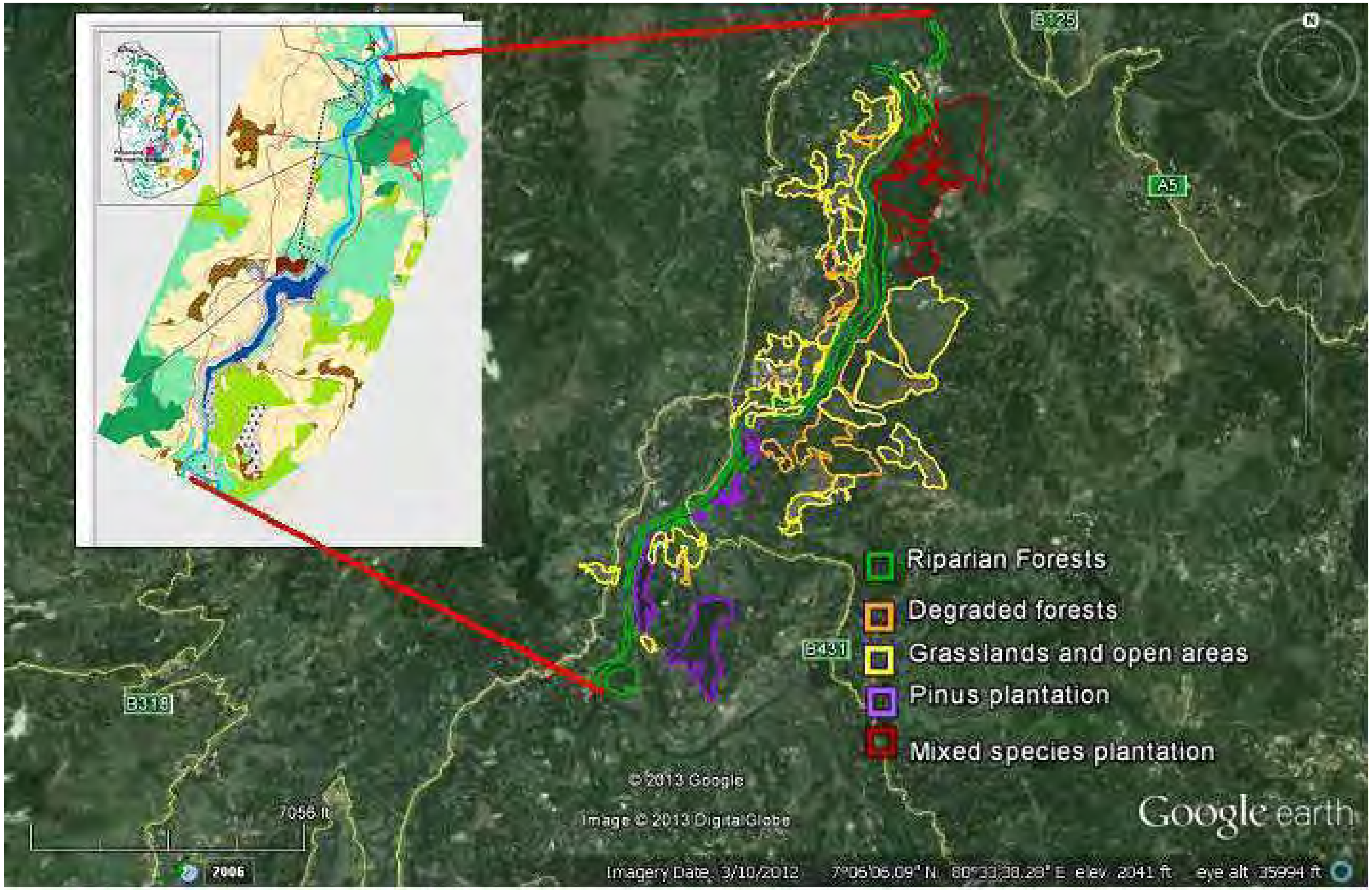
No.	Species	Local name	Nature of vegetation
1.	*Panicum maximum*	Rata tana or Guinea grass	Grass
2.	*Trema orientalis*	Gedumba	Tree
3.	*Macaranga peltata*	Kenda	Tree
4.	*Alstonia macrophylla*	Hawari nuga	Tree
5.	*Mangifera indica*	Amba	Tree
6.	*Artocarpus heterophyllus*	Kos	Tree
7.	*Persea americana*	Ali pera	Tree
8.	*Michelia champaca*	Sapu	Tree
9.	*Switenia macrophylla*	Mahogany	Tree
10.	*Cocos nucifera*	Pol	Tree
11.	*Areca catechu*	Puwak	Tree
12.	*Syzygium aromaticum*	Karabu	Tree
13.	*Melastoma malabathricum*	Maha bovitiya	Tree
14.	*Cymbopogon nardus*	Pangirimana	Grass
15.	*Lantana camara*	Gandapana	Shrub
16.	*Dicranopteris linearis*	Kekilla	Shrub

g) Home garden vegetation

Home garden vegetation in this area is dominated by cultivated plant species. The following are the main species in home gardens.

Table 9. Main species found in home gardens

No.	Species	Local name	Nature of vegetation
1.	*Macaranga peltata*	Kenda	Tree
2.	*Alstonia macrophylla*	Hawari nuga	Tree
3.	*Mangifera indica*	Amba (Mango)	Tree
4.	*Artocarpus heterophyllus*	Kos (Jak)	Tree
5.	*Persea americana*	Ali pera	Tree
6.	*Michelia champaca*	Sapu	Tree
7.	*Switenia macrophylla*	Mahogany	Tree
8.	*Cocos nucifera*	Pol (Coconut)	Tree
9.	*Areca catechu*	Puwak	Tree
10.	*Syzygium aromaticum*	Karabu	Tree
11.	*Nephelium lappaceum*	Rambutan	Tree
12.	*Albizia falcataria*	Mara	Tree



Map 6. Forest cover within the project area
(Based on a satellite image obtained from Google Earth)

3.6.2 Removal of trees due to project activities

The removal of trees from the project area due to various project activities is discussed below.

a. Road construction: According to the EIA Report for the proposed MHP (CECB, 2012), a total of 489 trees with Diameter at Breast Height (DBH) of more than 20 cm will be removed or impacted due to various activities planned under the project. The construction of new roads and widening of existing roads will account for the removal of more than 48 percent of these trees.According to estimates, approximately 231 trees, belonging to 28 species, with DBH over 20 cm will be affected as a result. The species that will be affected the most due to road construction are *Artocarpus heterophyllus* (Jak)(58 trees) and *Swietenia macrophylla* (Mahogany) (53 trees). The area in which these activities will take place consist primarily of abandoned lands and home gardens located near the dam site and power house. As the affected area is spread over a large area, the magnitude of the impact on the area due to the removal of trees for road construction is expected to be minimal (CECB, 2012).

b. Establishment of the reservoir: An estimated 179 trees, belonging to 26 species, with DBH over 20 cm will be affected due to the establishment of the reservoir. This activity will have the second highest impact on trees as nearly 38 percent of the trees that will be lost due to the project will be lost as a result ofreservoir construction. The species affected the most by the establishment of the reservoir are *Albizia falcataria* (Mara) (34 trees) and *Peltophorum pterocarpum* (23 trees). The river-side vegetation consists primarily of grasses and herbs with a few scattered trees. Given that the impact is spread over a large area, the magnitude of the impact is expected to be minimal.

c. Construction of the transmission line: A total of 28 individual trees, belonging to nine species, with DBH over 20 cm will be affected due to the construction of the transmission line. Four of the species affected are exotic, while the remaining five species are indigenous to Sri Lanka. No endemic or nationally threatened plant species will be removed as a result of the construction of the transmission line.

d. Other construction activities: According to the EIA study carried out by CECB and ACO in 2012, removal of trees due to other construction activities is insignificant; as most of these activities are carried out in abandoned lands or on private lands that has no natural habitats and only a few trees will be lost due to rest of the activities[1].

3.7 Rationale for the reservoir buffer zone and AWMP

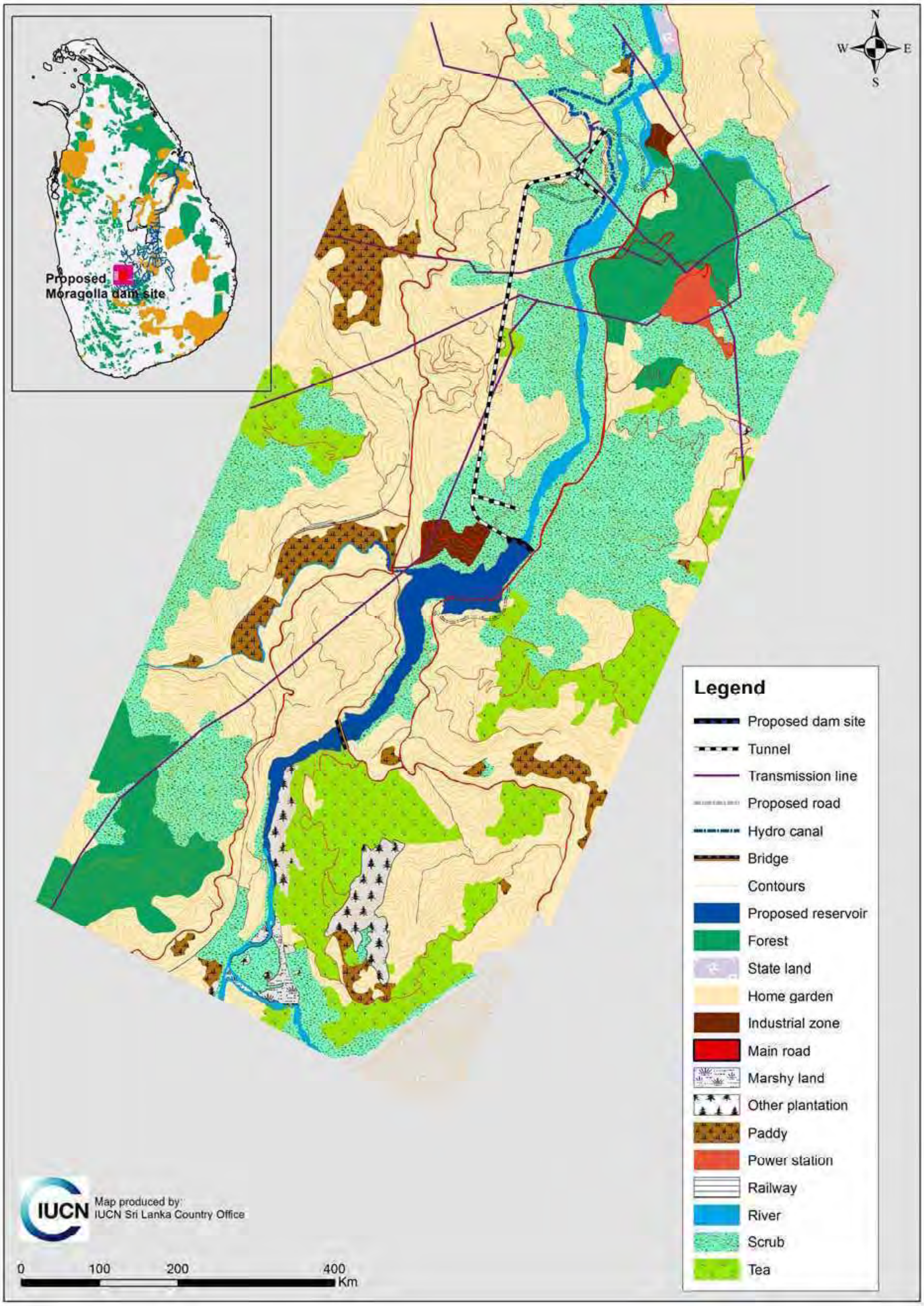
The project location has been selected to avoid and minimize the environmental impacts of the MHP to as great an extent as possible. The terrestrial area within the project site is already degraded due to human activities, including farming. The remaining forest area is highly degraded, and its vegetation is secondary in nature, with many pioneer species and introduced (exotic) tree species. However, the reforestation of an area approximately 100 ha in extent around the proposed reservoir has been planned in order to mitigate the negative impacts of the project, and to compensate for the loss of trees, by providing new habitats and creating a buffer zone, in which human activities are to be prohibited. This proposal serves the following purposes:

[1] CECB and ACO (2012) Environmental Impact Assessment Study, Final Report, Vol. 3, (Page 106).

- This proposed new forested buffer zone around the reservoir will provide effective protection for the immediate catchment of the reservoir against soil erosion and potential siltation of the proposed reservoir.
- The proposed reservoir buffer zone will serve as a refuge to fauna displaced due to project activities. The most suitable tree and shrub species for this purpose will be planted in this area at the time of planting. Suitable tree and shrub species and methods of planting to be decided at the stage of site-specific selection of suitable species (refer to section on Planning and Preparation for Afforestation/Reforestation programme).
- A section of the new buffer zone may be used for the conservation of threatened and endangered floral species by planting and protecting such species within the buffer zone.

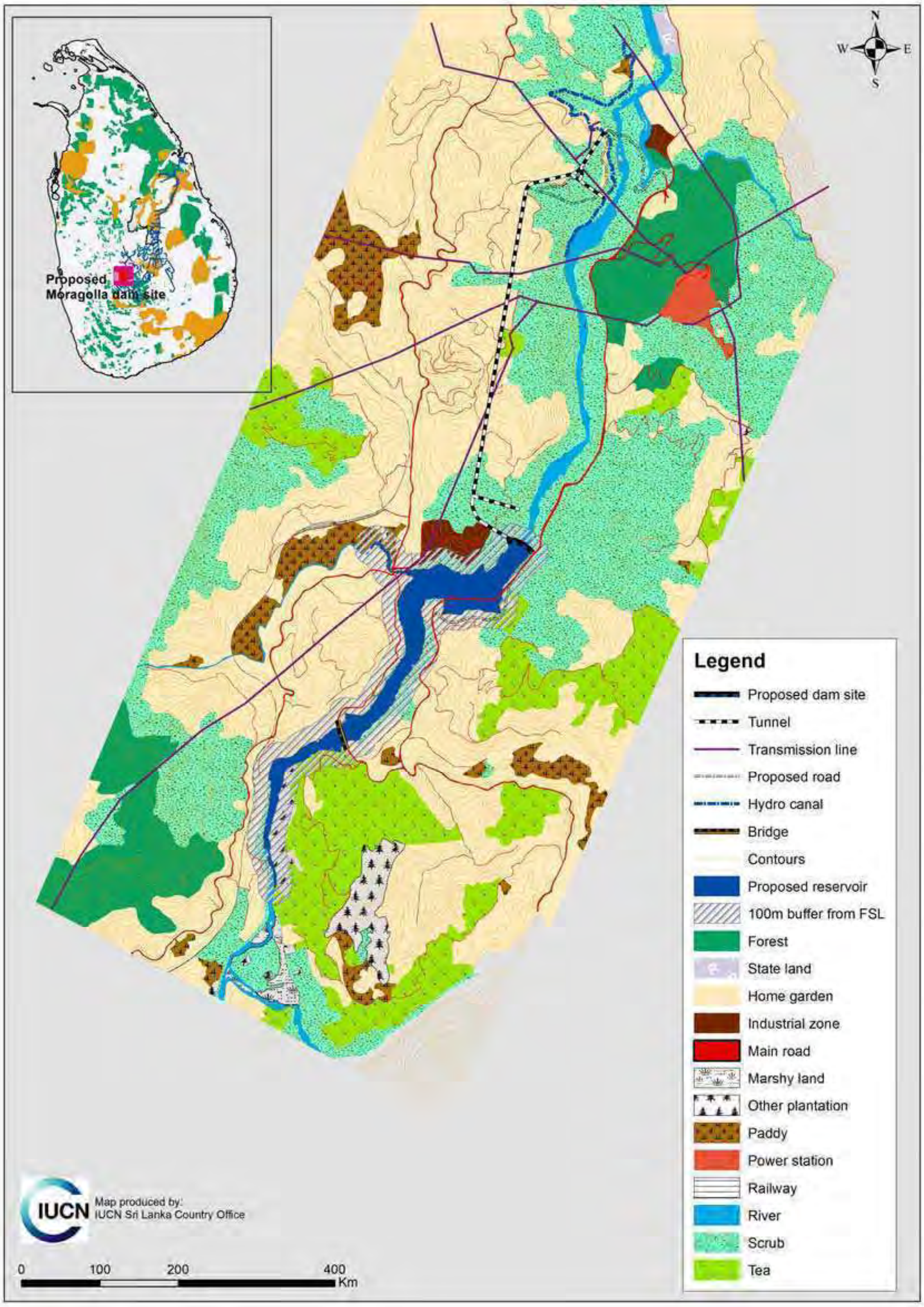
The present land use types observed within the project area includedegraded and abandoned tea lands, abandoned lands, residential areas, home gardens, small scale agricultural areas, paddy lands, degraded forests and an industrial estate. Tea lands that lack adequate soil conservation measures occupy a large extent of land within the proposed Moragolla reservoir catchment area. Additionally, most of other land use systems within the area, including the industrial estate, do not provide adequate vegetative cover to protect against soil erosion and prevent siltation of the reservoir.

A land use map of the Moragolla Project given below.



Map 7. Land use map of the Moragolla project area.

A land use map of the area showing the proposed buffer zone is presented in Map 8 below.



Map 8. Land use map showing the proposed 100 m buffer zone around the reservoir.

With consideration of the land use types within the catchment, and the associated soil erosion issues, the Natural Resources Management Center of the Department of Agriculture has recommended the following:

- Implementation of soil conservation activities within the immediate catchment of the reservoir without delay;
- Initiation of conservation measures from the crest of the immediate catchment and downwards; and
- Taking steps to create awareness among local communities on the need for soil conservation.

Therefore, in order to prevent siltation and ensure the sustainability of the proposed Moragolla reservoir, it is necessary to develop a suitable plan to control soil erosion in the catchment area. Hence, one of the key purposes of the Afforestation and Watershed Management Plan (AWMP) for the Moragolla reservoir area, is to provide effective protection against soil erosion from the catchment and siltation of reservoir.

According to the present land use in the area, the 100 m buffer zone includes state lands (reservations with degraded forests), private home gardens, cultivated lands, tea lands and RDA lands (road reservations). New legislation is required to regulate land use activities in these areas in order to ensure legal protection of the buffer zone. The most appropriate action would be to declare the buffer zone as an "Environmental Protection Area" under the National Environment Act. The Central Environmental Authority (CEA) is the authority for the administration of the National Environment Act. No one is authorized to carry out prohibited actions in "Environmental Protection Areas".

3.8 Forestry and afforestation in Sri Lanka: history and current programmes

The history of afforestation in Sri Lanka

The Forest Department (FD), the State Timber Corporation (STC) and the Department of Wildlife Conservation (DWC), are the three main institutions active within the forestry sector in Sri Lanka. The FD manages approximately 55 percent of the natural forests in the country, as well as approximately 90, 000 ha of forest plantations, including teak, mahogany, *Eucalyptus*, *Pinus* and other local species, which account for nearly 1 percent of the land area of the country. The remaining areas of natural forest (approximately 43 percent) are managed by the DWC and other government institutions, as well as by the private sector (approximately two percent).

All the forests managed by the DWC fall under the category of Protected Areas (PAs). The natural forests under the jurisdiction of the FD include both PAs and Multiple Use Management Forests. The STC has a monopoly on harvesting and marketing timber from state owned forests and forest plantations. The FD is the state agency that is responsible for the afforestation of state owned lands. However, there is no restriction to or prohibition of afforestation by other state parties or private institutions, as long as they have the required technical capability for conducting such work.

The Forest Department of Sri Lanka was established in 1887, during the colonial administration period. It has engaged in afforestation and reforestation activities in Sri Lanka since the beginning of the twentieth century. Teak is the oldest species planted in the country, and was introduced by the Dutch during the seventeenth century. The FD engaged in cooperative reforestation through the Burmese 'Taungya System' in the Dry Zone between the 1960s and 1980s. The main tree species planted under this programme was teak. This was later expanded to other parts of the country, including the Intermediate Zone.

The planting tropical pines, including the Caribbean pine – an exotic species - on a large scale commenced in the early 1970s in the hill country, as well as in lowlands of the Wet Zone. However, the planting of pines ceased during the mid-1990s. The extraction of oleoresins from pines has been a lucrative business in Sri Lanka, but is being practiced only on a minor scale at present.

The planting of *Eucalyptus* in Sri Lanka was first reported in 1915. Several *Eucalyptus* species are now grown extensively in the hill country.

The establishment of *Artocarpus heterophyllus* (Jak) and *Swietenia macrophylla* (Mahogany) mixed plantations in the Intermediate Zone commenced during 1930s. These uneven aged plantations are managed on a selection system. The last decade is characterized by the increasing trend to plant *Khaya senegalensis* (African mahogany) in the second rotation areas of the Dry and Intermediate Zones.

In addition, many other native and exotic tree species are planted on a minor scale by the Forest Department. This includes species such as *Dipterocarpus zeylanicum* (Hora), Halmilla (*Berrya cordifolia* (Halmilla), *Azadirachta indica* (Margosa), *Artocarpus integrifoia* (Jak) and a few *Acacia* species, such as *Acacia mangium* and *Acacia auriculiformis*.

The FD introduced community forestry programmes to Sri Lanka around the mid 1980s. A more enhanced version of community participation established through the Participatory Forestry Project (1993-2000) implemented by the FD with the financial assistance from the Asian Development Bank (ADB). Each farmer was given a land of 0.4 ha on lease for 25 years, along with 400 utility timber seedlings. They were planted at a wider spacing of 2 x 5 m, while intercropping was practiced. As part of this programme, the beneficiaries were entitled to the entire timber yield raised by them. In addition to these woodlots, the project also consisted of three other components - planting trees in home gardens, establishing protective woodlots and miscellaneous planting, such as planting along roads, avenues and alleys. At present, the same programme is being implemented on a benefit sharing basis, through which 80 percent of the timber yield goes to the beneficiary, while 20 percent goes to the state.

The afforestation programmes carried out by the FD during the last three decades were financed by mainly by donor agencies. The key donors that provided funding for these programmes include USAID, the World Bank, ADB and AusAID. In addition, small-scale afforestation programmes were carried out with funding from the General Treasury. These donor assisted afforestation programmes include the Reforestation and Watershed Management Project (USAID), the Forest Resources Development Project (World Bank), the Forestry Sector Development Project (World Bank), the Community Forestry Project (ADB), the Participatory Forestry Project (ADB), the Forest Resources Management Project (ADB) and the Sri Lanka Australia Natural Resources Management Project (AusAID).

A summary of the key forestry projects and programmes implemented during the last 30 years in Sri Lanka is presented in Table 10 below.

Table 10. Key forestry projects and programmes implemented in Sri Lanka during the last 30 years.

(Developed based on information from the Forest Department)

No	Project and funding source	Period and implementation agency	Objective
1.	Reforestation and Watershed Management Project (USAID)	1980-1987 (FD)	Reforestation and watershed management in the Mahaweli basin.
2.	Community Forestry Project (CFP) (ADB)	1985-1989 (FD)	Community forestry development.
3.	Forestry Sector Development Project (FSDP) (World Bank)	1989-2004 (FD)	Development of the forestry sector in Sri Lanka.
4.	Participatory Forestry Project (PFP) (ADB)	1994–1998 (FD)	Participatory forestry development.
5.	Conservation and Sustainable Use of Medicinal Plants Project (World Bank/GEF)	1998-2004 (DAU/FD/DWC)	Conservation and sustainable use of medicinal plants, including *in-situ* and (In-situ & Ex-situ Conservation)
6.	Southwest Rainforest Conservation Project (UNEP/GEF andGEF/UNDP)	2000-2006 (FD)	Participatory forest conservation.
7.	Forest Resources Management Project (FRMP) (World Bank/GEF/DFID)	2000-2006 (FD)	Forest resource management in Sri Lanka.
8.	The Protected Area Management and Wildlife Conservation Project (ABD/GEF)	2001-2008 (DWC)	Protected area management and wildlife conservation.
9.	Sri Lanka Australia Natural Resources Management Project (AusAID)	2003-2008 (FD)	Poverty reduction through improved natural resource management.
10.	Sri Lanka Community Forestry Programme (SLCFP and AusAID)	2012 – 2015 (FD)	Community forestry.

Currently, only one donor assisted programme is implemented for afforestation in Sri Lanka. T is the Sri Lanka Community Forestry Programme funded by AusAID. This programme is implemented in 17 administrative districts in Sri Lanka.

The main objectives of afforestation programmes implemented by the Forest Department have been production of timber in order to meet the requirements of the country, and conservation and stabilization of soil associated with steep slopes and stream reservations.

Large-scale forest tree planting in Sri Lanka commenced in late 1950's. An estimated extent of approximately 105, 000 ha of forest plantations exist within the country at present. Of this, approximately 96, 000 ha belong to the FD, while the remaining area falls under private ownership particularly, in the plantation sector. The main plantation species are teak (*Tectona grandis*), eucalyptus for timber (mainly *Eucalyptus grandis and Eucalyptus mycrocoris*), pine(*Pinus caribaea*), mahogany (*Swietenia macrophylla*), acacias (*Acacia mangium* and *Acacia auriculiformis*) for timber and fuel wood, and mixed species of *Albizzia*, *Khaya* (*Khaya senegalensis*), and indigenous species such as Kohomba (*Azadirecta indica*), Halmilla (*Berrya cordifolia*), Lunumidella (*Melia dubiya*) and Godakirilla (*Holopelea integrifolia*) for timber. Some of these forest plantations (approximately five percent) are protective plantations that are located in steep slopes with gradients over 30 percent. These forest plantations are maintained for soil conservation purposes, and are not harvested due to conservation reasons.

The FD has prepared Forest Plantation Management Plans for key forest plantation species such as teak, *Eucalyptus*, *Pinus* and mahogany, in order to ensure sustainable management of these resources. These plans provide the guidelines necessary for management operations, including the harvesting of timber by the STC. Forest plantations with these species are managed according to the management guidelines provided in the management plans. A summary of the forest plantations established by the FD until 2009 is provided in Table 11 below.

Table 11. Forest plantations established by the Forest Department (Forest Department, 2010)

Species	Extent (ha)
Teak	30, 277
Eucalyptus (up country)	9, 338
Eucalyptus (dry zone)	15, 008
Pine	17, 240
Mahogany	5, 325
Acacia	8, 830
Albizia	405
Kohomba	1, 040
Alastonia	390
Kaya	293
Jak	90
Hora	72
Indigenous species	7, 942
Total	**96, 250**

3.9 Legal requirements for afforestation in Sri Lanka: laws, responsible agencies, approval procedure and requirements

As discussed, there are no specific legal requirements related to implementing afforestation work in Sri Lanka. Usually, afforestation in state owned lands is carried out by the FD. However, there are no prohibitions or restrictions preventing other state or private institutions from performing afforestation work, provided that they have the land and technical capability required.

Although there are no legal requirements related to afforestation, legal requirements exist where forest clearing is involved. Clearing of forests over one hectare for reforestation or any other purpose requires an Environmental Impact Assessment (EIA) to be carried out according to the legal provisions of the National Environment Act. It is also necessary for approval to be obtained from the project approving agency. Furthermore, legal provisions are available under the Forest Ordinance for the protection of forests, including afforested areas, such as that proposed for the MHP area. The FD is the authority responsible for implementing this law. Unauthorized clearing or felling of trees in forests or forest plantations is prohibited under the Forest Ordinance and legal action can be taken against violation of this law.

4 AFFORESTATION/REFORESTATION[2] PLAN

4.1 Rationale and guiding principles

The growth of the demand for electricity in Sri Lanka has followed the growth in the economy closely in recent years, illustrating the need for a reliable and uninterrupted supply of electricity provided at a reasonable price if the current trend of economic growth is to continue. The proposed MHP, which is expected to produce 30.8 MW, will, therefore, make a significant contribution to the electricity generating capacity of the country, as well as the economy. The proposed project involves the construction of a dam, forming a reservoir with a storage capacity of 4.23 MCM at full supply level, covering a surface area of 36.5 ha, with a perimeter of 7, 100 m.

4.1.1 Justification for the proposed afforestation programme

Both banks of the proposed reservoir consist of steep to very steep (30-50) slopes. According to the soil conservation plan for the Moragolla catchment prepared by the Natural Resources Management Center of the Agriculture Department, approximately 14 percent of the reservoir catchment is on a slope of over 45 percent. Such areas are vulnerable to severe soil erosion, which ultimately results in siltation of the reservoir. These lands in the immediate catchment of the reservoir should be kept as undisturbed forest vegetation, which provides the best protection against such erosion.

The forests in the project area are currently degraded in nature due to various anthropogenic activities and pressures. In addition, there are abandoned lands in the catchment area that consist of grass dominated vegetation and a few scattered trees. These land uses are also vulnerable to the risk of erosion, and as such, protective forest vegetation is the ideal soil cover for these areas. Degraded forest areas may be enriched to improve forest cover, while abandoned areas should be afforested with suitable tree species.

Similarly, the establishment of a refuge - a protected area that can support key species including endemic and threatened species - of adequate size is necessary within the afforestation area in order to provide suitable habitats for terrestrial species that are displaced due to the construction of the dam, the development of the reservoir and other proposed project activities. Such sites are important for the minimization of the negative impacts of the MHP, as well as the conservation of threatened and endemic species found within the project area. It is important to identify such areas within the afforestation area, and to plant suitable tree species within such a refuge, so as to create a suitable environment. It is also necessary to ensure that these areas are protected adequately from anthropogenic and natural pressures, including fires.

4.2 Proposed afforestation/reforestation sites for Moragolla project

Potential sites for the implementation of an afforestation/reforestation programme include areas belonging to the following land categories:

a. Riparian sites: This includes afforestation on the banks and shoulder lands of the Mahaweli River. Riverine vegetation can be observed around the reservation of the river, particularly on the right bank, as well as in steep areas adjacent to the river. Riverine

[2] Afforestation refers to the planting of trees on areas that were not covered with forests, while reforestation refers to the re-planting of trees on areas that were once covered with forests.

vegetation is disturbed or absent towards the Ulapane area, where settlers have encroached on the reservation area.

b. Degraded forest sites: This habitat is highly disturbed and is only restricted to isolated patches of forest in certain areas of the immediate catchment, for example at the ridges of the watershed. The vegetation in such areas consists of degraded secondary wet evergreen forests, at present. Such sections are very limited and fragmented. In between these fragments of degraded forest, the vegetation has regenerated as grasslands and shrub lands.

c. Abandoned lands: These lands are predominantly abandoned tea lands, or lands that have been cleared for other cultivations. These areas are dominated by grasslands with some scattered trees, shrubs and herbs.

d. Pine plantations: There are a few blocks of pine plantations in the catchment area. There is a pine plantation of approximately 9 ha in extent around 2 km upstream on the left bank of the proposed reservoir. This plantation is estimated to be over 25 years, and is suitable for felling. It has been used for resin tapping, and is now in a bad condition. Hence, this over-aged pine plantation can be felled in strips, and re-planted with suitable local species.

e. Home gardens: Kandyan type home gardens are the other major land use in the catchment area. These home gardens are dominated with fruit trees, trees with timber value and multi-purpose trees. However, these lands are managed poorly in terms of soil and water conservation. The average size of a homestead ranges from 0.2 to 0.4 ha.

4.3 Species recommended for the afforestation/reforestation programme

A list of species that are recommended for the afforestation programme in the Moragolla catchment is presented in Table 12 below.

Table 12. Species recommended for the afforestation programme

Species	Local name	Occurrence of species at present
Albizia lebbeck	Albizia (Sooriya Mara)	Yes
Albizia odoratissima	Albizia (Mara)	Yes
Anacardium occidentale	Cashew (Kaju)	Yes
Annona muricata	Anoda	Yes
Artocarpus nobilis	Waldel	Yes
Artocarpus altilis	Breadfruit (Del)	Yes
Artocarpus heterophyllus	Jakfruit (Kos)	Yes
Azadirachta indica	Margosa, Neem (Kohomba)	Yes
Bamboo spp (Bambusa vulgaris)	Bamboo (Bata)	Yes
Capparis sp.	Wellangiriya	No
Caryota urens	Kithul	Yes
Carallia brachiata	Dawata	No
Cassia siamea	Waa	No
Cassia sp.	Thora	Yes
Chloroxylon swietenia	Satinwood (Burutha)	No
Cinamoum mooniana	Kududaula	No

Species	**Local name**	**Occurrence of species at present**
Dendrocalamus spp.	Una	Yes
Dipterocapus zeylanicus	Hora	No
Elaeocarpus serratus	Veralu	Yes
Erythrina subumbrans	Erabadu	Yes
Ficus sp.	Nuga	Yes
Ficus racemosa	Attikka	Yes
Filicium decipiens	Pihimbiya	Yes
Gliricidia sepium	Gliricidia	Yes
Macaranga indica	Kenda	Yes
Macaranga peltata	Kenda	Yes
Madhuca longifolia	Mee	No
Madhuca nerifolia	Gam Mee	Yes
Mallotus tetracoccus	Bu Kenda	Yes
Mangifera indica	Amba	Yes
Mangifera zeylanicus	Atamba	Yes
Michelia champaca	Gini sapu	Yes
Ochlandra sp.	Bata	No
Paraserianthes falcataria	Albizia (Rata Mara)	Yes
Phyllanthus emblica	Nelli	Yes
Spathodea campanulata	African tulip tree	No
Strobilanthus sp.	Nelu	Yes
Swietenia macrophylla	Broadleaf Mahogany	Yes
Symplocos cochinchinensis	Bombu	Yes
Tamarindus indica	Tamarind (Siyambala)	Yes
Terminalia arjuna	Kumbuk	Yes
Trema orientalis	Gedumba	Yes
Toona sinensis	Toona	Yes
Vateria copallifera	Hal	No
Species belonging to Family Lauracea	Wal enasal	Yes

***Albizia lebbeck* (Sooriya mara)**

Albizia lebbeck (Sooriya Mara) can attain a height of 30 m and a diameter of 1 m. More often, it is 15-20 m tall with a diameter of 50 cm. It has a grey-violet bark with rusty brown breathing pores, and is rough and fissured. *Albizia lebbeck* is a dominant species in semi-evergreen forests (monsoon forest) in areas with a mean annual rainfall of 1, 300-1, 500 mm. It is also found on the banks of riverine sites.

Albizia lebbeck coppices well, responds to pollarding, pruning and lopping, and will produce root suckers if the roots are exposed. However, these trees are vulnerable to strong winds and fires. Due to its extensive, fairly shallow root system, *A. lebbek* is a good soil binder, and is recommended for erosion control on eroded lands. This species is commonly grown as a shade tree in pastures, and tea, coffee and cardamom plantations, as well as along avenues. The nitrogen-rich leaves of this species are also valuable as mulch and green manure.

This species also is important as a host plant for butterflies.

Anacardium occidentale (Cashew)

Anacardium occidentale (Cashew) is a medium-sized tree, that is spreading, evergreen, and heavily branched. It grows to a height of 12 m, with a smaller crown diameter (4-6 m). The root system of mature cashew trees, when grown from the seed, consist of a very prominent taproot, and a well-developed and extensive network of lateral and sinker roots. The nut, which is the true fruit, dries and does not split open. Inside the poisonous shell is a large curved seed, nearly 2.5 cm long, that is the edible cashew nut. As the nut matures, the stalk (receptacle) at the base enlarges rapidly within a few days into a fleshy fruitlike structure, broadest at the apex, popularly known as the fruit. This thin-skinned edible cashew fruit has light yellow spongy flesh, which is very juicy, pleasantly acidic, and slightly astringent when eaten raw and highly astringent when green.

Cashew plants requires high temperatures and the distribution of rainfall is more important to this species than the amount of rain. The tree fruits well if rains are not abundant during flowering, and if nuts mature in a dry period. Given its extreme tolerance of external conditions, it can be planted in poor soils to control erosion.

Annona muricata (Anoda)

Annona muricata (Anoda) is a slender, evergreen tree that is 5-10 m in height and 15 cm in diameter. Its root system extensive and superficial, and spreads beyond the diameter of the crown. Fruit from this species can be 14-40 x 10-18 cm, and can weigh up to 7 kg. It is ovoid and heart shaped, and has an oblong syncarp composed of numerous united pistils, which end in a fleshy spine.

A. muricata survives in the humid tropical and subtropical lowlands. The species is cultivated commonly in home gardens. This tree species can tolerate dry soil conditions, but the sheds its leaves if it experiences a prolonged drought. *A. muricata* fruits can be consumed fresh when fully ripe. The wood of this tree is soft and light (specific gravity of 0.4), and is not durable. Therefore, it is rarely used as timber. In addition, the leaves of this species have a good medicinal value. This species may be planted as an intercrop between larger fruit trees such as *Mangifera indica* (Mango) and *Persea americana* (Avocado).

Artocarpus altilis (Breadfruit)

Artocarpus altilis (Breadfruit) is a large, attractive, evergreen tree, reaching heights of 15-20 m. Its bark is smooth and light in colour. Its trunk grows up to 1.2 m in diameter, and the tree may reach a height of 4 m before branching. It is a crop for the hot, humid, tropical lowlands. Rain stimulates extension growth, flowering and the rate of growth of the fruit. It prefers rainfall of fairly equal distribution, but is quite tolerant of short dry periods.

Breadfruit is versatile and can be cooked and eaten at all stages of its development. It can be eaten raw, boiled, steamed or roasted. *A. altilis* is a long-lived, perennial tree crop that provides beneficial shade and cooler micro-climates for humans, plants and animals beneath its canopy. It is an important component of traditional agro-forestry systems.

Artocarpus heterophyllus (Jakfruit)

Artocarpus heterophyllus reaches 8-25 m in height, and is straight stemmed, branching near the base at an angle of 32-88 degrees. Its canopy is dense, dome shaped or rarely pyramidal, and its diameter varies with age. In 5-year-old trees it ranges from 3.5 to 6.7 m. *A. heterophyllus* grows in tropical, near tropical and sub-tropical regions. The tree will not tolerate drought or flooding, and for optimum production requires a warm, humid climate and evenly distributed rainfall. Its wood is classified as medium hardwood. It is resistant to termite attack, as well as fungal and bacterial decay and is easy to season and polish.

Artocarpus nobilis **(Waldel)**

Artocarpus nobilis (Waldel) is a large, attractive, evergreen tree, reaching heights of 15-20 m. Its leaves are thick, leathery, dark green in colour on top, and often glossy. *A. altilis* is a crop for the hot, humid, tropical lowlands. Rain stimulates extension growth, flowering and the rate of growth of the fruit. This species prefers rainfall of fairly equal distribution, but is quite tolerant of short dry periods. It is known to grow and fruit well without irrigation, even in areas with a distinct dry season. Regardless of the methods used for propagation, young plants do best under shade, but trees require full sun once established. It should be noted that seeds lose viability within a few weeks. The fruit is versatile and can be cooked and eaten at all stages of its development. It can be eaten raw, boiled, steamed or roasted. The seeds are a good source of protein and are low in fat. This species is important as a feeding resource to frugivorous birds and mammals, including *Macaca sinica* (Sri Lanka toque monkey).

Azadirachta indica **(Margosa or Neem)**

Azadirachta indica is a small to medium-sized tree, usually evergreen, up to 15 m (30 m maximum) tall, with a round, large crown up to 10 m (20 m maximum) in diameter. *A. indica* is said to grow 'almost anywhere' in the lowland tropics. It requires large amounts of light, but tolerates fairly heavy shade during its first few years. Weeding of *A. indica* plantations in dry areas is essential, as the tree cannot withstand competition from weeds. These trees coppice freely, and early growth from coppice is faster than growth from seedlings. The *A. indica* fruit is an important source of food for some wildlife, especially birds and bats, although they digest only the pulp, and not the seed.

Bamboo species (Bata bamboo)

Bamboo is one of the fastest-growing plants on earth. However, its growth rate is dependent on local soil and climatic conditions, as well as species. This rapid growth can be attributed to the fact that bamboo is a form of grass. It is a woody plant that is usually hollow, erect and straight, and has smooth culms with internodes. Some species are up to 30 m tall with a 25 cm culm diameter. Branches and culms arise from internodes. The culm sheets, which usually fall off when the culm matures, often have irritant hairs on the outside. Each branchlet bears 8 -18 leaves. Most species have lance shaped, thin leaves with a parallel pattern and leafstalk. New culm shoots are produced every year from the rhizomes (underground stems).

Capparis zeylanica **(Wellangiriya)**

Capparis zeylanica is a climbing shrub that is common within the forest habitats of the country. This species is mainly used for its fruit, which is rich in micronutrients, and is considered important for its medicinal and nutritional values. It is useful in minimizing soil erosion and preserving agricultural lands. It is a climbing shrub with curved thorns, elliptical leaves and simple flowers, while its fruits form as clusters.

***Caryota urens* (Kitul)**

Caryota urens (Kithul) is a medium-sized palm up to 20 m tall. Its bole is straight, unbranched, and obscured at first by persistent fibrous leaf bases and sheaths. The species naturally inhabits the understorey tree stratum in moist lowland and sub-montane forests. Ecologically, it is found in monsoon climates and humid regions. It prefers moist, shady and cool places. *C. urens* is a slow-growing, shade-tolerant or shade-demanding species. The daily yield per tree of sap for wine and sugar from *C. urens* is 20-27 litres. Its trunk also yields 100-150 kg of starch. At room temperature, the seeds remain viable for 30-90 days, depending on storage conditions.

A primary product of *C. urens* in rural communities is the sugar substitute called known as kitul honey or jaggary. The leaves of *C. urens* are traditionally used as a 'delicacy fodder' for domesticated elephants. In areas where the trees are not tapped, they are cut down to feed elephants.

In addition, this species is an important feeding resource for frugivorous birds and mammals, and is also a good source of nesting materials.

***Chloroxylon swietenia* (Satinwood/Burutha)**

Chloroxylon swietenia is a hardwood tree, that is native to Sri Lanka. It is a medium-sized deciduous tree, growing to about 15-20 m tall with a thick, fissured, and slightly corky bark. Its leaves are 15-22 cm long, and are arranged alternately. They are pinnately divided into 10-20 pairs of oblong, blunt leaflets. The flowers of this species are small, and creamy-white in colour. The buds are round, while the fruit is oblong and consists of a three segmented capsule (2.5-4.5 cm). Each of these segments contains 1-4 seeds. The wood is often golden in colour and has a reflective sheen. It is used for small luxury items and as a veneer in wooden furniture. It is one of the best known woods in Sri Lanka. This species is important as the host plant of the butterfly species *Papilio crino* (Banded peakcock).

***Cinamoum mooniana* (Kududaula)**

Cinnamomum mooniana is a small, glabrous tree, up to 40 m tall with a diameter of up to 3 m. The bark is yellow or brown with vertical fissures. Although yields of *C. mooniana* are greater for old trees, leaves and woody material can be harvested regularly from plants over five years of age, which are kept in a bushy form by coppicing. Propagation by seed is the normal practice. Germination can be rather slow and may continue up to one year after sowing.

***Cinnamon zeylanicum* (Wal kurundu)**

Cinnamomum zeylanicum – known as "true cinnamon" or "Sri Lanka cinnamon" - is a small evergreen tree belonging to the family Lauraceae. It is native to Sri Lanka. These trees are 10–15 m tall, with ovate-oblong leaves that are 7–18 cm long. Its flowers are arranged in panicles, and are greenish in colour, with a distinct odor. Its fruit (1 cm) is purple, and contains a single seed**.** This species is a leafy canopy species, and also exists as under storey trees or shrubs in lowland rainforest and high elevation wet evergreen montane tropical rainforests. Cinnamon is a spice obtained from the inner bark of several trees from the genus *Cinnamomum* that is used in both sweet and savoury foods. It is harvested by growing the tree for two years, and then coppicing it. The next year, about a dozen shoots will form from the roots. It has a very thin, smooth bark that is light-yellowish brown in colour and has a highly fragrant aroma. Cinnamon is also used in traditional medicine.

***Dipterocapus zeylanicus* (Hora)**

Dipterocarpus zeylanicus is a medium sized to large tree up to 43 m tall. It requires partial shade in its early stages of development. Seeds are observed to have a short viability (3-5 days), and as such, must be sown as soon as possible. This species improves soil conditions through its fast rate of litter deposition and organic matter decomposition.

***Erythrina subumbrans* (Erabadu)**

A deciduous, medium-sized tree, that is 5-25 m tall, with a trunk reaching 60 cm in diameter. Its crown is spreading, while its bark is whitish in colour. Its trunk and branches have stout prickles. Its leaves are alternate and trifoliate, while its rachis is 10-21 cm long, and its petiole is up to 7 mm long. Its inflorescence is racemose, brownish and tomentose. It has many flowers that are arranged in groups of three. The flower has five petals that are red in colour. *E. subumbrans* – also known as 'dadap' - is planted widely. The necklace-shaped pods of this species are highly characteristic and can be used to identify this species. It is used as a shade tree in tea and cacao plantations. These trees are considered to be support trees for climbing crops, and are also valued as a nitrogen fixing trees. It also provides suitable shade conditions for faunal species.

***Ficus benghalensis* (Nuga)**

Ficus benghalensis is a large tree that grows throughout the Indian subcontinent. It produces propagating roots that grow downwards as aerial roots. Once these roots reach the ground, they grow into woody trunks that can become indistinguishable from the main trunk. The figs of this tree are eaten by birds and mammals, while its seeds are dispersed by frugivorus birds. It has been noted that the seeds that pass through the digestive systems of the birds are more likely to germinate and sprout relatively early. This species also plays a major role in the provision of shelter. Propagation of this species is conducted through seeds, transplanting and stem-cutting.

***Ficus racemosa* (Attikka)**

Ficus racemosa is a popular medicinal plant that has long been used in Ayurveda medicinal system for the treatment of various ailments including diabetes, liver disease, diarrhea, inflammatory conditions, hemorrhoids, respiratory problems and urinary diseases. A wide range of phyto-chemical constituents have been identified and isolated from various parts of *F. racemosa*. Its fruit is eaten by wild animals and frugivorous birds, and is valuable as a host plant for butterflies.

***Gliricidia sepium* (Gliricidia)**

Gliricidia sepium grows to a height of 2-15 m, has a medium crown and may be single or multi-stemmed. The tree has deep roots when mature, and establishes well on steep slopes. Pruning and pollarding are the main management activities related to this species. Pruning at 0.3-1.5 m will stimulate leaf production. Pollarding at 2 m or above is recommended for optimal wood biomass production.

Gliricidia is propagated most commonly through cuttings. *G. sepium* has been planted to reclaim denuded land or land infested with *Imperata cylindrica*. Hedgerows in alley cropping serve to suppress weed growth and control erosion. It is also used as a nurse tree for shade-loving species. The tree is capable of fixing atmospheric nitrogen, and its leaves are rich in protein and are highly digestible, while they are low in fibre and tannin. There is evidence of improved animal production (both milk and meat) in large and small ruminants when *G. sepium* is used as a supplement.

Its fast growth, ease of propagation, nitrogen-fixing ability and light canopy make it ideal as green manure. *G. sepium* increases soil organic matter, and aids in the recycling of soil nutrients as it produces much litter. It also improves soil aeration and reduces soil temperature. It is a drought-resistant and valuable water-conserving species, as in the dry season, it sheds most of its leaves, reducing water loss through transpiration.

***Macaranga indica* (Kenda)**

This species is found in degraded forest areas. Trees are usually approximately 16 m tall. They are gregarious trees, with grey, smooth bark. Its exudation is red and watery. The leaves of this species are simple. *Macaranga* species are used as food plants by the larvae of some Lepidoptera species, and while their hollow stems serve as nesting sites for some ant species. They also provide nectar to these species occasionally. Macaranga gum - a crimson resin – is obtained from this species. In addition, it is a feeding resource for frugivrous birds.

***Macaranga peltata* (Kenda)**

This is one of the most common early successional woody species found in Sri Lanka, especially in the low country Wet Zone. It is a resinous tree, up to 10 m tall. The young parts of this tree are velvety and hairy. Its leaves are 20 to 50 cm, while its flowers are yellow-green in colour and occur in the long panicles of leaf axils between January and February. Kenda leaves are used commonly for flavouring in Sri Lanka. Halapa dough is often flattened on a kenda leaf to soak in the flavour. Kenda leaves are also used to wrap jaggery and other sweetmeats. This tree is a useful feeding resource for frugivorous birds.

***Madhuca longifolia* (Mee)**

Madhuca longifolia (Mee) is a large, much branched deciduous tree up to 18 m high and 80 cm DBH. Its bole is short, while its crown rounded and its bark is grey to black with vertical cracks. Fire tracing and fencing of plantations are essential in the early stages, along with clean weeding and soil working around seedlings. The tree is a light demander, and is also drought resistant and frost hardy. It coppices well if felled in the hot season. *Madhuca longifolia* has a large spreading superficial root system that holds the soil together.

***Madhuca neriifolia* (Gam Mi)**

This species is endemic to the forests of southwest Sri Lanka. It is a rare species that was only found in four localities during the comprehensive forest surveys conducted for the National Conservation Review in 1997. This tree provides food for frugivorous birds and mammals, such as *Macaca sinica* (Sri Lanka toque monkey).

***Mallotus tetracoccus* (Bu Kenda)**

The trees of this species grow up to 12 m tall. Its bark is brown while its blaze is cream in colour. Its young branchlets are flat, while its leaves are simple, alternate and spiral. Its petiole is 3-12.5 cm long. This species is found along the margins of evergreen forests up to 1, 600 m. It is a pioneer species that can be found in disturbed forests, along roadsides, in thickets in cultivated areas, at the boundaries of gardens and in secondary forests. This tree provides valuable food resources for frugivorous birds.

***Paraserianthes falcataria* (Rata Mara)**

Paraserianthes falcataria is a fairly large tree, up to 40 m tall. Its bole is branchless for up to 20 m. It grows to 100 cm or sometimes more in diameter, with a spreading flat crown. Its fruit is a flat, and found in a straight pod (10-13 x 2 cm) and is not segmented. *P. falcataria* occurs in primary, but more characteristically in secondary, lowland rainforests. It is adapted to semi-humid and monsoonal climates with a dry season of up to 2 months months. It is sensitive to fire and damaged easily by strong winds. *P. falcataria* grows so fast that it is sometimes called the 'miracle tree'. Within good suitable sites, it can attain a height of 7 m in just over a year. *P. falcataria* is commonly used in agro-forestry systems. When planted, it can grow in comparatively poor sites and survive without fertilizer. However, it does not thrive in poorly drained, flooded or waterlogged soils.

P. falcataria requires great amounts of light and regenerates naturally. It provides a good protective cover to prevent erosion on slopes. It also coppices fairly well.

In addition, its nodules and fixes atmospheric nitrogen. The natural drop of leaves and small branches contributes nitrogen, organic matter and minerals to upper layers of soil. The extensive root system of this species further improves soil conditions by breaking up soils to provide channels for drainage and aeration.

***Strobilanthus* spp. (Nelu)**

Strobilanthes species are tropical soft-wood shrubs growing to approximately 1.2 m in height. They are important as food plants by the larvae of some Lepidoptera species. Similarly, it provides hiding places for small mammalian species.

***Swietenia macrophylla* (Broadleaf Mahogany)**

Swietenia macrophylla (Broadleaf Mahogany) is a very large tree, reaching a height of 30-40 m and a girth of 3-4 m. In favourable conditions, it can reach 60 m high and 9 m in girth. Its trunk is straight, cylindrical, with a buttressed base. Its bark is rough, flaking off in small patches. Young trees are fairly tolerant of shade, but conditions for optimum growth require full overhead light combined with side protection. Mahogany is planted extensively in Sri Lanka. The high value attached to *S. macrophylla* wood in the international markets is also well known.

***Symplocos cochinchinensis* (Bombu)**

These are evergreen trees that grow to a height of approximately 15 m. Its bark is light grey in colour and is thin and smooth, while its blaze is creamy white. Its leaves are simple, alternate and estipulate. Its petiole is 0.4-2.5 cm, while its leaf blade (6-27 x 0.9-10 cm) is narrowly elliptic, elliptic or obovate-elliptic in shape. This species is used in ayurvedic medicine. The plant can be grown from seeds or from stem cuttings.

***Tamarindus indica* (Tamarind)**

Tamarindus indica (Tamarind) is a large evergreen tree up to 30 m tall. Its bole is usually 1-2 m up to 2 m diameter. Its crown is dense, widely spreading and rounded. Its bark is rough, fissured, and grayish-brown. Its fruit consists of a pod (10-18 x 4 cm), and is indehiscent, sub-cylindrical, straight or curved, velvety and rusty-brown. The shell of the pod is brittle, while the seeds are embedded in a sticky edible pulp. *T. indica* grows well over a wide range of soil and climatic conditions, occurring in low-altitude woodlands. This spcies prefers semi-arid areas and wooded grasslands, and can also be found growing along stream and riverbanks. Its extensive root system contributes to its resistance to drought and wind. The fruit pulp, mixed with a little salt, is a favourite ingredient of the curries and chutneys and is popular throughout the country.

***Terminalia arjuna* (Kumbuk)**

Terminalia arjuna (Kumbuk) is a deciduous large-sized fluted tree that grows to 30 m tall and 2-2.5 m DBH, with an often buttressed trunk. Its superficial, shallow root system spreads radially along stream banks. The large, spreading crown produces drooping branches. It occurs naturally along the banks of streams and rivers, and seasonally dry water courses at low elevations. The species is a characteristic component of dry tropical riverine forests, and tropical moist and dry deciduous forests. It is an initial slow-grower, that later grows very fast to attain 2–3 m in height in approximately three years.

The species is commonly found and planted along the banks of rivers, streams, old irrigation channels, the edges of tank bunds and alluvial bars in seasonally dry water courses, helping to reduce soil erosion on the banks of these water bodies through its root-mass.

***Toona sinensis* (Toona)**

Toona sinensis is a large deciduous tree with a spreading crown, and commonly attains a height of 20-30 m and a girth of 1.8-3 m. Its bark is dark grey or reddish-brown, and smooth up to middle age, while it becomes rough after this time. It is a tree of subtropical climates and grows in moist localities such as ravines, banks of streams and even swamps. It grows best in fire-protected savannah habitats, abandoned cultivationand in small gaps in forests.

Toona is a moderate light demander. However, young plants require some side protection from the direct sun. Trees growing in such situations develop a tall, clean bole up to a height of 9-12 m. In the open, they tend to have a large, spreading crown and short, clean bole 3.6-4.2 m. This species has a spreading superficial root system. Natural regeneration of this species is profuse, even in areas outside its natural range.

***Trema orientalis* (Gedumba)**

This tree is a fast-growing species that is found in previously disturbed areas and on forest margins. It is a pioneer species that can grow on poor soil and can be used to regenerate forest areas by providing shade and protection to the saplings of forest hardwoods. It is also a nitrogen fixing species, and can, thereby, improve soil fertility for other plant species. It grows up to approximately 10-15 m, and is immensely important ecologically, as a larval food plant for several butterfly species. In addition, several species of birds eat its fruit or feed on the insects that live in these trees. Similarly, it provides nesting material to birds such as pigeons and doves. Browsing animals feed on its leaves, which along with its pods and seeds, are also used as fodder for cattle.

4.4 Planning and Preparation for Afforestation/Reforestation programme

Afforestation or reforestation and forest restoration in the degraded habitats are important environmental restoration programmes under the proposed MHP. The chronological sequence of recommended afforestation or reforestation measures is presented below.

1. Selection of afforestation/reforestation sites

Afforestation and reforestation sites should be identified precisely by the organization or agency responsible for carrying out this work (see Chapter 6 for details of implementation). The land owning agency and private land owners (in the case of private lands) should be consulted, with their consent regarding the proposed planting programme obtained. A brief feasibility survey, and other relevant studies, may be necessary, while conditions such as soil and land types, water logging if any, and soil depth should be assessed in order to make informed decisions regarding the final site-specific suitability of species, and appropriate species combinations to be planted. Such feasibility surveys should also ascertain the estimated numbers of plants required from each species for the planting scheme.

The refuge – a protected area selected specifically to harbour priority species, including threatened species - should be of adequate size within the afforestation area in order facilitate the successful translocation of priority fauna and flora displaced due to construction of the dam, the formation of the reservoir and other project activities.

2. Survey and demarcation of planting areas

The periphery of the selected afforestation and reforestation sites, and various blocks within those sites, need to be surveyed. Then, these blocks and the periphery of these sites, should be demarcated by fixing concrete posts at approximately 5 mintervals, in order to prevent encroachment and unauthorized expansion of cultivation lands in to the afforested and reforested areas. This will also allow for easy identification of the boundaries of these blocks.

3. Final site-specific selection of suitable species

The growth and vigor response of a tree species planted at a given site depends largely on the soil type, soil depth and nutrient status, as well as water logging conditions, that the species is subject to. If the site and species are not matched appropriately, afforestation and reforestation efforts are likely to fail. Therefore, the suitability of species for different land types and situations (blocks) should be evaluated carefully. In consideration of the conditions described above, suitable tree species should be selected from the species list provided in Table 12. In addition, site specific species selection should be done carefully in order to develop appropriate habitats for faunal species.

The refuge area should be planted with species that are suitable for displaced fauna and flora, including fruit bearing species such as *Annona muricata* (Anoda), *Artocarpus nobilis* (Waldel), *Artocarpus heterophyllus* (Jakfruit), *Caryota urens* (Kitul), *Mangifera zeylanicus* (Atamba) and *Phyllanthus emblica* (Nelli).

4. Preparation of the detailed afforestation and reforestation plan

The next step is to prepare a detailed planting plan which should include the species name and number of the tree species proposed to be planted in each block, as well as the extent of the proposed reforestation area and block (ha). This can be done fairly accurately once the feasibility survey has been carried out.

5. Preparation of detailed planting maps.

Detailed planting maps should be prepared as the next step. This includes marking of tree species that need to be planted in each block. The area set aside for the establishment of the refuge site within the afforestation area should also be marked on this map.

6. Supply of planting material

All the tree species recommended for use in the afforestation and reforestation programme should be raised in Forest Department (FD) nurseries. The FD has vast experience in raising the species recommended for the programme. In order to avoid transport costs and damage to plants during transport, a nursery should be established by the FD within the project area. The seedlings should be raised in poly bags that are 9×6 inches (23 × 15 cm), and need to be raised to an appropriate size in the nursery for approximately 8-10 months before planting when approximately 15-20" tall.

7. Planting and maintenance

Planting should be carried out by an agency with extensive experience agency in such programmes, such as the FD or other suitable organizations (see Chapter 6). Planting should involve employing under the supervision of FD officers. After planting, maintenance (weeding) is required for three years. Fire protection programmes also need to be implemented simultaneously, in order to protect young seedlings against the risk of fire.

4.5 Afforestation and reforestation techniques

Afforestation and reforestation activities in the Moragolla catchment should involve the following programmes:

(i) Enrichment planting

(ii) Afforestation/reforestation; and

(iii) Home garden improvement.

The techniques associated with these programmes are described below.

(i) Enrichment planting

Enrichment planting (EP) refers to the planting of trees to increase the tree density (number of trees per hectare) in already established degraded forests. It is recommended for riparian sites and degraded forest sites in the immediate catchment area of the Moragolla reservoir.

In enrichment planting, existing trees are not removed and new seedlings are not planted near existing trees. This technique has been recognized as an afforestation method that provides an opportunity to introduce valuable tree species in existing, but degraded, secondary forests. It can be used to increase the value of secondary forests successfully, as well as to prevent their conversion to other land uses. This technique has also been recognized as a land-use alternative to reduce emissions from deforestation and forest degradation (Dalle *et al.*, 2006).

Site preparation for enrichment planting:

Planting should be done in lines in a systematic manner. Each planting line should be marked along the contour on a straight line using a rope. Positions of planting holes should be marked on a straight line along the contour in the planting line. Weeding should be done in strips to a width of 1.5 m, and should not involve clean weeding to expose the bare soil. Instead only grasses and shrubs need to be removed up to the ground level. This will prevent possible soil erosion due to exposing bare soil.

Planting holes should then be marked by placing sticks where seedlings need to be planted. This is done at a spacing of approximately 6–8 m, depending on the existing tree cover. The distance between two planting rows needs to be approximately 5 m(250 trees/ha). The size of each planting hole should be 1×1×1” (30 × 30 × 30 cm).

Planting: Seedlings should be placed in planting holes, seedlings should be treated carefully, so that their fine roots do not break. The topsoil should be used first to fill the bottom of the hole, as it is more fertile, and fertility is needed at this depth for the development of roots. Full advantage should be taken of this naturally fertile soil during reforestation and afforestation efforts. The land should be planted at a density of approximately 250 trees per ha (8 x 5 m spacing) with a mixture of naturalized and indigenous tree species that form the upper canopy of nearby areas. Compost may be applied to the planting hole at the time of planting.

(ii) Afforestation/reforestation

Site preparation for afforestation and reforestation:

Normal afforestation and reforestation should be carried out in abandoned lands, as well as in conversion of pine plantations to areas that support local tree species. Planting should be done in lines in a systematic manner as mixed species, and not as monoculture. The plant-to-plant distance in a given line, as well as the distance between two adjacent lines, is important. In this case, land preparation should be done by low slashing of the existing vegetation (grasses, herbs and shrubs) and patch weeding around the planting hole to approximately three feet in diameter. Positions of planting holes should be marked on a straight line along the contour in the planting line or in a straight line if it is a flat land. Planting should be done with a spacing of approximately 3 × 3 m (1, 110 seedlings/ha). The size of the planting hole should be 1×1×1” (30 × 30 × 30 cm) (Forest Department, 2009; PRP, 1997).

Planting: Seedlings should be placed in planting holes and treated carefully so the fine roots do not break. The topsoil should be used first to fill the bottom of the hole, as it is more fertile, and fertility is needed at this depth for the development of roots. As there is no existing tree cover on the land, planting spacing for afforestation and reforestation should be approximately 3 × 3 m. Compost may be applied to the planting hole at the time of planting.

(iii) Home garden improvement

Home gardens constitute a traditional system of perennial cropping for a wide range of valuable crops, such as food, fruits, timber, medicinal and spice crops, and are considered important sites for *in-situ* conservation of crop germplasm. Kandyan home gardens are essentially a luxuriant system of mixed cropping with a variety of economically valuable tree crops, and form an essential component of land use. These home gardens are like forests in many respects. They provide shelter to birds and other wildlife, and conserve soil and water, almost as well as the natural forest. In addition, they produce timber, fuelwood and non-wood forest products. However, some of the home gardens in the Moragolla catchment are managed poorly in terms of soil conservation. Therefore, a home garden improvement programme is critical component of the Afforestation and Watershed Management

Programme. Plants required for the homegarden improvement programme can be raised in the nurseries developed under the afforestation programme.

The average size of a home garden is approximately 0.2–0.4 ha. Twenty (20) seedlings should be provided for each home garden free of charge, for planting on their land. On that basis, the seedling requirement will be 50 seedling/ha. The choice of tree species should be based on the choices of the home garden owner.

4.6 Establishment of nurseries (based on Forest Department, 2007)

Important aspects of the establishment of a semi-permanent nursery for the afforestation programme are described briefly below.

Planning and site selection for the nursery

In order to avoid transport costs and damage during transport of plants, a semi-permanent nursery may be established in a suitable site within the project area. Identification of nursery sites needs to be done in consultation with the CEB. The following aspects should be considered in selecting a site for this semi-permanent nursery:

- To reduce the transport cost of seedlings, the nursery should be closer to the afforestation site; and
- The nursery site should be located with easy access to tractors and trucks transporting seedlings and other nursery material.

Required nursery area

The space required to raise approximately 80, 000 plants is approximately 0.4 ha (nearly 1 acre). This land should be provided to the relevant agency responsible for the afforestation programme.

Source of water for the nursery

A permanent water source should be available in the close proximity. The nursery should be supplied with water of good quality throughout the year. Generally, 3, 000 liters (3 m^3) of water are required daily to water 50, 000 seedlings.

Layout and construction

Generally, a semi-permanent nursery requires the following:

- External fencing;
- Seed germination and nursery beds;
- An access road to the nursery;
- A nursery hut (shed) for seed germination and composting;
- A semi-permanent building for stores, workers facilities and accommodation; and
- A drainage system.

The layout of these features should be planned prior to the construction of the nursery.

Shade

Shade is essential to seedlings in seed beds and in standout beds after transplanting. Shade is necessary to maintain humidity, temperature and adequate light conditions, especially those required for seed germination and better growth of seedlings.

Nursery schedule

The planting season commences with the onset of the northeast monsoon in November, and therefore, all nursery activities should be well planned in advance to produce good quality seedlings in order to meet the target planting period. Preferably, nursery activities should commence at the beginning of the year in January or February.

Seed sources

Seeds stocks required for raising in nurseries should be collected well in advance from suitable seed sources. The best seeds come from strong healthy parent trees. Fully ripened fruits should be collected directly from trees. Seeds should be collected as soon as they are ripe. If not, many of them may be eaten or damaged by birds, animals or insects.

Seed storage

The two most important factors in good seed storage are keeping the seeds dry and cool. Wet seeds spoil and rot in storage, and so must be dried in air first. Then they can be stored in dry containers. Care should be taken to keep containers off floors and away from walls, as this practice helps to keep insects and dampness away from the seed containers. The containers should be stored in such a way that air can circulate around them. This helps to keep the seeds drier and cooler.

4.7 Production of nursery stock

Seedlings are grown commonly in poly bags. First, seeds are sown in seed beds and then sticking out of poly bags when the seedling is approximately 8-10 cm in size. Poly bags are filled with a mixture of top soil, sand and compost in the ratio 2:1:1. Poly bags used for this purpose should be 9 × 6” (23 × 15 cm). Medium or large size seeds that have good germination (over 40 percent) can be sown directly in poly bags. Young seedlings usually require some shade during their first two weeks, especially when they have just been transplanted from germination beds into poly bags.

In addition, regular watering, weeding, fertilizing and control of pests and diseases are important aspects in the production of a good nursery stock. Seedlings need to grow in the nursery for approximately 8-10 months (until they reach approximately 12– 15 ” in height) before planting in the field.

4.8 Post-planting maintenance and management

Weeding

Intensive caretaking is required for a minimum period of three years for the successful establishment of an afforestation site. Weeding is one of the most important operations that needs to be carried during this time. In general, weeding should be done two times a year or whenever weeds are noticed around the feet of the planted saplings during the first two years. The frequency of weeding will vary based on different factors, including rainfall and the nature of undergrowth vegetation. However, weeding two times a year is sufficient for the first two years following planting, while once or twice a year is sufficient in the third year.

In general, no weeding is required subsequently until approximately four years after planting. However, if the weed competition is very high after four years, another two or three rounds of weeding may be required.

The ideal weeding technique for this programme is strip weeding along the planting line to a width of about 1.5 m.

Fire protection

Ground fire during drought periods is a common problem encountered in the project area. In addition to continuous surveillance during the dry periods, other required preventive measures include opening and maintenance of fire lines in the periphery of the afforestation site. For large afforestation sites, internal fire lines may also be established in addition to external fire lines. The width of each external fire line should be approximately 10 m, while internal fire line should be approximately 5 m in width. Cutting and clearing of fire lines should be carried out for three years.

Application of fertilizer

If the parent soil is poor and quick growth of the seedlings is desired, chemical fertilizer may be applied as a top dressing. Mixed fertilizer comprised of equal proportions of NPK (at 13:9:9 formula) should be applied at 25-30 g per plant per application. Fertilizer should be applied during the growing season. The first dose should be applied a month after the actual date of planting. This should be done before the end of the rainy season. Fertilizer, if required, should be applied for three consecutive years after planting.

Climber/creeper cutting

In some situations climbers and creepers invade high grounds and grow on plants. Plants soon bend under the weight of the creeper, sometimes being brought to the ground. When that happens, such plants never stand erect or grow upright again. Therefore, cutting down of creepers and climbers should be done regularly in infested stands, as necessary. Creepers are so fast growing that fresh tendrils can develop just a few weeks after cutting. Therefore, they will have to be cut frequently in order to avoid such issues.

Only the climbers or creepers suppressing the growth of other plants should be removed. The need for some of these species as a habitat for fauna needs to be considered at the time of cutting climbers and creepers. Climber and creeper species that are beneficial to fauna should not be removed.

Pest control

The incidence of pests and diseases should be observed constantly and assessed carefully, with outbreaks being detected quickly. Usually, at a young stage, tree saplings are attacked by leaf eating insects. If any incidence of pests or diseases is noticed, the advice of local FD officers or local agricultural officers should be sought, with recommended remedial measures implemented swiftly.

Vacancy planting

Vacancy planting or filling up of gaps should be undertaken during the following planting season. As such, adequate amounts of seedlings need to be raised in the nursery for this vacancy planting operation in year following planting.

4.9 Monitoring of the afforestation programme

Monitoring activities are important components of the afforestation programme. Monitoring of these aspects on a regularly basis is very important in order to ensure the success of the afforestation programme. These activities are as follows:

- Regular monitoring of the progress of the afforestation programme;
- Survival counts approximately two months after planting (if the survival rate is below 85 percent necessary steps should be taken to fill the vacancies or gaps);
- Regular surveillance of pests and diseases;
- Careful monitoring of invasive species;
- Monitoring of changes in the floral and faunal composition of the area;
- Monitoring of significant soil erosion in the afforestation sites; and
- Monitoring of encroachments or unauthorized activities in the afforestation area.

4.10 Cost estimate

The cost estimate for the afforestation programme for the Moragolla watershed has been developed based on the following assumptions:

(i) The area for enrichment planting is approximately 40 ha in extent;

(ii) The area for afforestation/ reforestation (bare-land planting) is approximately 30 ha in extent;

(iii) The area for home garden improvement is approximately 60 ha in extent; and

(iv) The total area in which planting activities will take place is approximately 130 ha in extent.

Based on these assumptions, the numbers of plants required for each component programme based on the density of planting are given in Table 13.

Table 13. Estimated number of plants required

Purpose	Number of plants
Enrichment planting programme	10, 000
Afforestation/reforestation programme (bare-land planting)	33, 300
Home garden improvement	15, 000
Total required for programmes	58, 300
Total number of plants required for initial planting activities, including additional plants to compensate for damages and other issues (10%)	65, 000
Total number of plants required for the entire programme, including plants required for vacancy filling during the year following initial planting (20%)	78, 000

The total number of plants required will be 58,300, with additional 10 percent to compensate for damages in the nursery and transport. As such, the number of plants required for initial planting activities (first year) will be approximately 65,000 plants for the afforestation programme. An additional 20 percent of plants are expected to be required for vacancy filling in the year following initial planting. Including these plants, the total number of plants required for the entire afforestation programme will be approximately 78,000 plants. These plants should be raised in the nursery to be established at the Moragolla project site. The area required for the proposed nursery is approximately 0.4 ha (about 1 acre).

Based on these calculations, the total cost estimate for the afforestation programme is presented in Table 14 below.

Survey and demarcation will be done only in enrichment planting and afforestation or reforestation (bare-land planting) areas (40 ha + 30 ha = 70 ha). The home garden improvement programme will be done on private lands, while survey and demarcation activities will not be done on private lands.

The transport of plants to planting sites is based on the number of plants. (Enrichment planting 250 trees per ha; other afforestation (ie, bare land) 1, 110 plants per ha; and 50 seedlings per ha for home gardens). 85 ha is the average figure for calculating the transport costs.

Table 14. Estimated costs associated with the afforestation programme (covering a period of five years).

Item no.	Activity	Unit cost (LKR)	Number of units	Estimated cost (LKR)
1.	Selection of afforestation/reforestation sites	-	130 ha	60, 000
2.	Survey and demarcation of planting sites	14, 000 per ha	70 ha	980, 000
3.	Preparation of afforestation plan	-	-	50, 000
4.	Preparation of detailed planting maps	-	-	100, 000
5.	Establishment of nurseries and production of plants	20 per plant	78, 000 plants	1, 560, 000
6.	Transport of plants to planting sites, including loading and unloading	6,000 per ha	85 ha	510, 000
7.	Holing and planting	32 per plant	78, 000 plants	2, 425, 000
8.	Weeding	41, 400 per ha (calculated at two weeding events per year)	70 (for three years)	8, 694, 000
9.	Fire protection	22,500 per ha (for three years)	70	1, 575, 000
10	Application of fertilizer	18, 000 per ha (two times)	70	900, 000
11.	Cutting of climbers and creepers	10,000 per ha (two times)	70	700, 000
12.	Pest control (including at the nursery stage)	Lump-sum amount	For three years	800, 000
13.	Vacancy planting	20 percent of planting cost		485, 000
14.	Monitoring	10,000 per ha	130 ha	1, 300, 000
Total estimated cost of activities				20, 139, 000
Contingencies (10 percent)				2, 014, 000
Total				22, 153, 000
Administrative and supervision cost (13 percent)				2, 880, 000
Grand total (for five years)				**25, 033, 000**

As such, the total cost for the afforestation programme would be approximately LKR 25 million (US Dollars (USD) 191.000)[3].

[3] USD = SLR 131.00

4.11. Implementation of the afforestation programme

Details on the implementation of the afforestation programme, including activities, descriptions of activities and the scheduled timeframe, are provided in Table 15 below. The total programme is planned for five years, including planning, implementation, post planting maintenance and management, and monitoring of progress and impacts.

Table 15. Summary of activities and tentative time frame for the afforestation/reforestation programme

No.	Activity	Description	Time frame
1.	Selection of afforestation/reforestation sites.	Afforestation sites should be more precisely identified by the organization responsible for carrying out this work.	Year 1 - February
2.	Survey and demarcation of planting sites.	The periphery of the selected afforestation sites and various blocks within those sites should be surveyed and demarcated.	Year 1 - April
3.	Final site-specific selection of tree species	Final selection of tree species and matching with suitable sites.	Year 1 - June
4.	Preparation of detailed afforestation plan.	Preparation of a detailed planting plan, including the species names and numbers to be planted in each block.	Year 1 - July
5.	Preparation of detailed planting maps.	Detailed planting maps, including tree species that should be planted in each block.	Year 1 - August
6.	Establishment and maintenance of nurseries	Establishment of a semi-permanent nursery for the afforestation programme.	Year 2 - January
7.	Land preparation for planting.	Preparation of the planting sites for planting including holing.	Year 2 - September
8.	Supply of planting material.	All tree species recommended for use in the afforestation programme should be supplied from nurseries.	Year 2 - October
9.	Afforestation planting.	Planting should be carried out by an experienced agency or organization.	Year 2 – October to December
10.	Post-planting maintenance and management	Post-planting maintenance and management activities are essential.	Years 3, 4 and 5 (March – October)
11.	Weeding	Weeding is one of the most important operations that needs to be carried during the first three years after planting.	Years 3 and 4 (March – August)
12.	Fire protection	Maintenance of fire lines in the afforestation sites.	Year 3, 4 & 5 – July to August
13.	Application of fertilizer	Chemical fertilizer may be applied as a top dressing, if required.	Years 2 and 3 – October
14.	Cutting of climbers and creepers	Creeper/climber cutting should be a regular operation in infested stands, as necessary.	Years 3, 4 and 5 (May – June)
15.	Pest and disease control	If incidence of pests or diseases is noticed, appropriate action should be taken.	When the need arises.
16.	Vacancy planting	Filling up of vacancies should be undertaken in the year following initial planting.	Year 3 (October – November)

No.	Activity	Description	Time frame
17.	Monitoring	Monitoring activities are an essential component of the afforestation programme. It should be done on regularly basis.	On a regular basis after the second year.

The schedule of activities planned for the afforestation programme for the Moragolla area is presented in Table 16 below.

Table 16. Schedule of activities planned for the afforestation programme for the Moragolla area.

No	Activity	Time frame																			
		Year 1				Year 2				Year 3				Year 4				Year 5			
		Q1	Q2	Q3	Q4	Q 1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1.	Selection of afforestation sites																				
2.	Survey and demarcation of planting sites																				
3.	Final site-specific selection of species																				
4.	Preparation of detailed afforestation plan																				
5.	Preparation of detailed planting maps																				
6.	Establishment and maintenance of nurseries																				
7.	Land preparation for planting																				
8.	Supply of planting material																				
9.	Afforestation planting																				
10.	Post-planting maintenance and																				

No	Activity	Time frame																			
		Year 1				Year 2				Year 3				Year 4				Year 5			
		Q1	Q2	Q3	Q4	Q 1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	management																				
11.	Weeding																				
12.	Fire protection																				
13.	Application of fertilizer																				
14.	Cutting of climbers and creepers																				
15.	Pest and diseases control									As and when required											
16.	Vacancy planting																				
17.	Monitoring									To be done on a regular basis											
Q1- 1st Quarter, Q2 – 2nd Quarter, Q3 – 3rd Quarter, Q4 – 4th Quarter																					

5 WATERSHED MANAGEMENT

5.1 Overview

Topography and land uses of the immediate watershed of the proposed Moragolla reservoir

The immediate watershed of the Moragolla reservoir can be identified as the left and right banks of the Mahaweli River from the confluence of Kotmale Oya with the Mahaweli River up to the proposed dam site of the Moragolla reservoir. The general topography of the watershed area can be described as a steep valley with the river flowing at the bottom of the narrow valley. The slope of the left bank is steeper (30^o to 35^o) and appears to be more rocky compared to that of t the right bank, which has a slope of approximately 18^o (CEB, 2012). The slopes of both banks are very high at the proposed dam site and its immediate upstream area, up to the confluence of Ulapane Oya. The topography indicates that a large number of seasonal streams and temporary waterways flow through the slopes to join the main stream at the bottom of the valley (see photo-catalogue for photographs).

The watershed comprises of mixed vegetation, and a number of land use types can be observed within the area. Riverside vegetation, scrublands, grasslands, cultivated and abandoned tea lands, homesteads, plantation forests and degraded forest patches are the major types of vegetation found in the immediate watershed of the Moragolla reservoir. In addition, paddy cultivation areas are found on the left bank of the Moragolla reservoir, in the Ulapane area. Some marshlands are located in the upper most area of the immediate catchment, where the Kotmale Oya tributary confluences with the Mahaweli River. Apart from these land uses, industrial areas, new settlements and traditional villages are also present within the watershed.

Ownership and existing conditions of sections of the immediate watershed of the Moragolla reservoir

Apart from the stream reservation, the land area on the left bank consists predominantly of private lands. Immediately upstream of the proposed dam, the steep slope of the left bank bears grasslands, scrublands and some tea cultivation. Natural vegetation that has been disturbed by anthropogenic activities has regenerated as grasslands on the steep slopes of the river banks.

The Ulapane Industrial Estate is situated on the ridge of this landscape. From the point where the Ulapane Oya joins the reservoir up to the steel bridge at the Ulapane-Pussallawa road, the left bank of the reservoir is occupied heavily by settlements. Typical Kandyan home gardens containing woody perennial trees, fruit trees, multi-purpose trees and some annual crops, can be identified as the major land use type of this area. The average size of an individual land block is approximately half to one acre. Although the tenants have occupied these settlements for long periods - even for generations - they do not have legal ownership of certain blocks of land within this area of the watershed. The upstream area of the left bank from the Ulapane steel bridge, up to the point where the Kotmale Oya confluences with the reservoir, bears a relatively narrow strip of land in between the stream and the steep left bank slope. This area is also occupied by settlements with home gardens. In addition, some areas are cultivated with tea, while abandoned tea lands can also be observed in this area.

The land on the right bank can be divided primarily into two categories. The land strip between the stream and the road comprises of the stream and road reservation. The land masses above the road are private blocks of land. Some of these lands are been set aside for sale, while others consist of scrublands with a lack of anthropogenic development, settlements, home gardens, cultivated and abandoned tea lands, and degraded forest patches at higher elevation, mainly at the uppermost parts of the watershed.

5.2 Environmental and watershed-related issues

Environmental and watershed related issues associated with the land use patterns of the Moragolla watershed and approaches recommended for their management

The identified immediate catchment area of the proposed Moragolla reservoir has undergone high levels of anthropogenic activities, mainly for settlements and cultivation. Unplanned and unsustainable land development activities in the area have led to a number of soil and water related environmental problems. Habitat and land degradation, quick loss of runoff, poor soil water retention, soil erosion and sedimentation of the bottom of the valley are some such problems. In addition, water pollution caused by domestic and industrial effluents, occasional fires in grasslands and scrublands, encroachment of the riparian reservation and illegal sand mining, have been described as issues associated with the watershed (CEB, 2012).

The environmental and watershed-related issues associated with each of the major land use types are detailed below.

a. Riparian vegetation

Riverine vegetation can be observed in the stream reservation, particularly on the right bank and also in the steep sloped areas adjacent to the stream. This riverine vegetation is disturbed towards the Ulapane area, where more settlements are found. Some sections of the stream reservation have been encroached. During an informal discussion with CEB officers in the area, it was understood that the stream-side strip of land extending from the Ulapane Industrial Zone up to the steel bridge at the Ulapane-Pussallawa road has been encroached, although the tenants occupying these lands have been doing so for long periods of time.

Properly planned replanting programmes are recommended to be carried out for the restoration of this degraded riparian vegetation. A variety of native plants should be selected for replanting. During the selection of plant species for replanting, consideration must be given to their ability to protect the stream bank, their capacity for preventing erosion, their ability to conserve water, their resistance to fluctuations in the water level, and their ability to provide habitats for other species.

b. Wet evergreen forests

This habitat is highly disturbed and only restricted to isolated patches of forest in certain areas of the watershed, particularly at the ridges of the watershed. Such forest areas are highly fragmented. Other sections of wet evergreen forests have become highly degraded secondary forests (e.g. the strip of forest between the reservoir and main road on the right bank of the reservoir). Inbetween these degraded sections, the vegetation has regenerated as grasslands and scrublands. The establishment of forest vegetation in the upper catchment helps to sustain the soil water, as well as recharge groundwater, which will benefit the reservoir directly through the maintenance of the dry weather flow in the stream. Furthermore, it will reduce soil erosion and the risk of siltation. Establishment of this vegetation also creates habitats for numerous animals and other plant species. However, the main constraint for re-establishment of this vegetation is the availability of land for reforestation. As discussed, the strips of land that are most suitable for reforestation fall under private ownerships, with only very limited amounts of land being held under state ownership.

c. Abandoned land

These lands are predominantly abandoned tea lands or lands that have been cleared for other cultivations. These areas are dominated by grasslands with some scattered trees, shrubs and herbs. In areas with grass cover, the topsoil layer is well protected and less prone to erosion. However, the major problem associated with these grasslands is annual burning of the grasses by local local communities just before the onset of rainfall. This exposes the bare soil to the intense rains, causing large-scale soil erosion and siltation.

As a watershed management intervention, these degraded lands can be replanted under the afforestation programme recommended by the CEB. However, the plants used for replanting have to be fire resistant species. Fire belts should be established to prevent the spreading of fire. Raising public awareness also is essential to minimizing the impacts of the burning of the grasslands. It is recommended that the FD takes responsibility in implementing relevant regulations and protecting the grasslands from such burning events.

d. Tea plantations

Tea plantations are one of the two major land uses of the catchment of the proposed Moragolla reservoir. However, most of these cultivation areas do not have any soil conservation measures, and gullies and waterways across the tea fields are not maintained properly. Tea cultivation does not have a good ground cover, as the tea bushes are scattered with gaps inbetween them. The bare ground lacks undergrowth or organic matter, and therefore, the soil is prone to erosion. The steep slopes facilitate quick surface runoff, increasing the vulnerability of the top soil of these areas to erosion.

Establishing lock and spill drains, stone bunds and terraces, and maintaining proper drainage, are some of the possible interventions for soil and water conservation within the tea lands.

e. Home gardens

Kandyan home gardens are the other major land use type within the catchment area. These home gardens are dominated by fruit trees, trees with timber value and multi-purpose trees. However, these lands are managed poorly in terms of soil and water conservation. The average size of a home garden ranges from 0.2 to 0.4 ha. A lack of space within the land was found to be a major obstacle for the development of these lands. The management of solid waste and wastewater is recommended in order to reduce soil and water pollution in homesteads.

f. Ulapane Industrial Park

A lack of soil conservation measures around the industrial premises and improper waste disposal are causing soil and water pollution issues that have to be addressed.

5.3 Management strategies proposed for the Moragolla reservoir watershed

Considering the land use patterns and related problems associated with the immediate watershed of the proposed Moragolla reservoir, the watershed management plan the area was developed focusing on the board land categories shown in Figure 1.

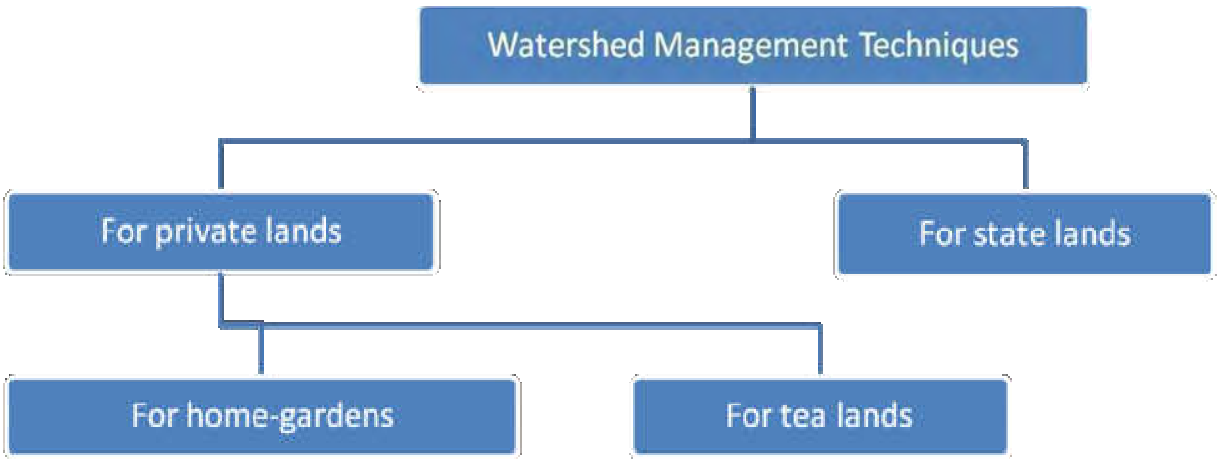


Figure 1. Land use categorization for watershed management of the Moragolla reservoir area

The techniques that can be adopted for watershed management in the Moragolla watershed area are presented in Table 17 below.

Table 17. Summary of the watershed management techniques that can be applied to the Moragolla area

Technique	Description	Purpose(s)	Applicable land uses
Lock and spill drains	Specific type of drains along contours that capture runoff in small stilling ponds.	Slowing down of runoff, temporary storage of runoff water, promotion of infiltration and thereby groundwater recharge, and trapping of silt.	Tea cultivation areas.
Bunds and stone	Embankments along contours that intercept	Slowing down of runoff, trapping of sediments, and	Cultivated lands

Technique	Description	Purpose(s)	Applicable land uses
walls	runoff and sediments, and lead runoff to exit the land.	disposal of runoff water from the fields.	and home gardens.
Small check dams along tributaries	Small scale embankments across tributaries to create ponds along these tributaries.	Slowing down of storm water, prevention of flash flooding, trapping of silt, and temporary holding of water allowing groundwater recharge through the banks.	Streams.
Cover crops	Crops that provide either continuous ground cover or a multi-layer canopy to intercept rainfall.	Reduction of soil detachment and transport (soil erosion), reduction of runoff velocity, possible provision of additional income depending on the type of cover crop used.	Tea cultivation areas and home gardens.
Mulching	Covering the ground with organic matter.	Reduction of soil detachment and transport (soil erosion), reduction of runoff velocity, provision of fertilizers to crops and thereby increasing yields and income, and increasing of the water holding capacity of the soil.	Tea cultivation areas.
Grass strips	Establishing vegetative barriers along the contour lines at a relatively low cost, with little labour and maintenance.	Slowing down runoff, settling sediments, provision of a good quality and quantity of runoff to streams and reservoirs.	Tea cultivation areas, stream reservations, home gardens and abandoned lands.
Reforestation (see the afforestation plan for details)	Replanting blocks of lands with suitable tree species, particularly those that are consistent with the natural vegetation of	Provision of canopy cover to intercept rainfall, provision of litter layer on the ground further reducing the runoff velocity and allowing	Stream banks, degraded forest areas and other reservations owned by the state.

Technique	Description	Purpose(s)	Applicable land uses
	the area.	infiltration, improvement of soil texture, support of cover crops, interception of with fog and thereby provision of additional precipitation, and creation of habitats.	
Home garden improvement (see the afforestation plan for details)	To establish a suitable vegetative cover in private home gardens to provide effective protection against soil erosion.	Minimization of soil erosion.	Home gardens.
Establishment of wetlands	To establish and maintain areas that are inundated seasonally and feature aquatic and semi-aquatic vegetation.	Trapping of silt, allowing groundwater recharge, purification of water and creation of habitats.	Suitable places within the stream reservation.
Awareness raising	To carry out public awareness programmes in order to raise the awareness of local communities on the importance of protecting the watershed.	Encouragement of the local community - particularly the private land owners - to adopt environmentally friendly land use options.	Tea cultivation areas, cultivated lands and home gardens.

Details of these watershed management techniques are provided below. Specific locations for applying these soil conservation measures should be identified after a detailed survey.

a. Lock and spill drains

Lock and spill drains are constructed along the contour lines and across slopes for the purpose to intercepting surface runoff and sediment load. The lock and spill drains slow down the speed of runoff water, and thereby reduce soil erosion. Advantages of lock and spill drains include protection of cultivated lands from hillside runoff, control of gully erosion and slowing down of the erosive power of runoff.

b. Bunds and stone walls

These artificial embankments are constructed and graded so as to intercept rainfall and sediments, and lead runoff away from the cultivated land. Stone walls are usually constructed along contours in fields or at road sides, and provide an irregular form of terracing.

c. Small check dams along tributaries

Small check dams can be constructed in order to prevent gully erosion. Check dams are barriers erected across seasonal waterways, such as gullies, to decelerate the flow of water, allowing soil particles to sediment. The excess water will spill over the barrier once the check dam is filled. They can be constructed as concrete, masonry, earthen or loose stone check dams. For small gullies, check dams can be constructed using branch wood. The recent trend is to construct check dams using Gabion cages filled with stones collected locally. It is necessary to observe the erosion in progress in major gullies and to construct at least a loose stone check dam as a preventive measure. Advantages of these structures include control of gully erosion, slowing down of the erosive power of runoff, and increasing retention time to facilitate groundwater recharge.

d. Cover crops

Cover crops are grown to protect the soil from erosion and to improve soil through green manuring. These are usually short rotation crops (less than two years), planted in fields or under trees, during fallow periods. Some of the advantages of cover crop planting include improvement of soil fertility, reduction of soil erosion and water loss, suppression of weeds, reduction of the need for fertilizers and herbicides, and an increase of soil organic matter.

Figure 2. Check dams constructed by IUCN during a previous project (Kumudu Herath @ IUCN)

e. Mulching

Mulching is a soil and water conservation practice in which a covering of cut grass, crop residues or other organic material is spread over the ground, between rows of crops or around the trunks of trees. This practice helps to retain soil moisture, prevents weed growth and enhances the structure of the soil. advantages of mulching include interception of rain, reducing the direct impact of raindrops on bare soil, reducing surface runoff and soil loss, suppression of weeds and reduction of the labour cost of weeding, increased soil organic matter and increased moisture holding capacity of the soil.

f. Grass strips

Planting grass along contour lines creates barriers to minimize soil erosion and runoff. It includes a process of natural terracing on slopes as soil collects behind the grass barrier, even in the first year. Grass can be planted along the bottom and sides of ditches to stabilize them, and to prevent erosion of the upper slope. Grasses can also be planted on the ridges of bench terraces to prevent erosion and maintain the stability of the benches. Advantages of grass cover include control of soil erosion and runoff (i.e. the root systems of vetivera grass acts as a natural barrier to bind soils), and provision of fodder.

g. Reforestation

Forest cover with a good canopy and well developed litter on the forest floor can reduce or prevent soil erosion. Vegetation is the primary factor that changes the rate of soil erosion most radically within a given site. Forest vegetation, along with other factors such as the nature of the canopy, understorey vegetation, ground vegetation and ground cover by leaf litter, provides the best possible protection against soil erosion. Apart from reducing soil erosion, forest cover can reduce nutrient losses from the soil, and can build up the nutrient status and fertility of the soil. Forest vegetation also increases soil organic matter, as well as the moisture holding capacity of the soil. The details of the afforestation/reforestation programme of the project have been discussed in the previous section of the report.

h. Home garden improvement

As discussed previously, home gardens constitute a traditional system of perennial cropping for a wide range of valuable crops providing commodities such as food, fruits, timber, medicines and spices, and are considered important sites for the *in-situ* conservation of crop germplasm. Kandyan home gardens are essentially a luxuriant system of mixed cropping with a variety of economically valuable tree crops and form an essential component of the land use. These home gardens are like forests in many respects. They provide shelter to birds and other wildlife, and conserve soil and water almost as well as the natural forest. They also provide a range of products including timber, fuelwood and non-wood forest products. However, some of the home gardens in the Moragolla catchment are managed poorly in terms of soil conservation. Therefore, a home garden improvement programme is an essential component of the watershed management programme. This component has been incorporated in to the afforestation programme of this report.

i. Establishment of wetlands

Wetlands affect the landscape by virtue of their capability to retain water and decrease its velocity, controlling erosion. They also provide valuable habitats for wildlife and enhance water quality. Hydrological functions of wetlands include flood buffering, water storage, groundwater discharge and recharge, surface flow augmentation, and removal of pollutants, such as nutrients and heavy metals. Therefore, in addition to biodiversity conservation, the establishment of wetlands in the Moragolla watershed will also facilitate these hydrological functions.

j. Awareness raising

The objective of the public awareness programme will be to promote public awareness on the conservation and management of soil and water resources in the Moragolla project area, in order to emphasize the need to protect these resources among local communities. Such a public awareness programme will enhance and facilitate the other soil and water conservation and management activities implemented in the Moragolla reservoir area.

5.4 Implementation of the watershed management programme

The activities to be implemented under the watershed management programme are as follows:

1. Detailed field survey to identify specific locations to establish proposed soil conservation structures and measures appropriately;
2. Design of mechanical structures required, including lock and spill drains, bunds and stone walls, and small check dams;
3. A brief feasibility study on establishment of wetlands;
4. Preparation of a detailed programme on awareness raising, including identification of different target groups;
5. Provision of inputs to the afforestation programme for implementation of home garden improvement activities;
6. Preparation of an implementation plan; (see Chapter 6)
7. Establishment of lock and spill drains, bunds and stone walls and small check dams, as necessary.
8. Establishment of cover crops, mulching and grass strips, as well as implementation of home garden improvement programmes;
9. Establishment of wetlands, as necessary;
10. Implementation of the awareness programme; and

11. Monitoring.

The schedule for the implementation of activities related to watershed management is presented in Table 18 below.

Table 18. Schedule for the implementation of activities related to watershed management in the Moragolla Project area.

	Activity	**Timeframe**							
		Year 1				**Year 2**			
		Q1	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
1.	Detailed field survey to identify specific locations for the implementation of proposed soil conservation measures								
2.	Design of mechanical structures required, including lock and spill drains, bunds and stone walls, and small check dams								
3.	A brief feasibility study on establishment of wetlands								
4.	Preparation of a detailed awareness programme on awareness								
5.	Provision of inputs to the afforestation programme for the implementation of the home garden improvement component								
6.	Preparation of an implementation plan								
7.	Establishment of lock and spill drains, bunds and stone walls and small check dams.								
8.	Establishemnt of cover crops, mulching and grass strips, and implementation of home garden improvement programmes								
9.	Establishment of wetlands								
10.	Implementation of awareness programme								
11.	Monitoring								
Q1- 1st Quarter, Q2 – 2nd Quarter, Q3 – 3rd Quarter, Q4 – 4th Quarter									

5.5. Cost estimate

The cost estimate for activities proposed as part of the watershed management programme are presented in the table below.

Table 19. Cost estimate for activities proposed as part of the watershed management programme.

No	Activity/technique	Unit cost (LKR)	Total length /area	Estimated cost (LKR)
1.	Detailed field survey to identify specific locations to establish proposed soil conservation measures	Lump sum	-	30,000
2.	Design of proposed mechanical measures	Lump sum	-	45,000
3.	Brief feasibility study on the establishment of wetlands	Lump sum	-	15,000
4.	Preparation of a detailed awareness programme	Lump sum	-	45,000
5.	Provision of inputs for the implementation of the home garden improvement component	Lump sum	-	15,000
6.	Preparation of implementation plan	Lump sum	-	30,000
7.	Construction of lock and spill drains.	LKR 225 per metre	2, 000 m	450,000
8.	Construction of earthen bunds	LKR 225 per metre	1, 700 m	382,500
9.	Construction of stone walls	LKR 360 per metre	1, 200 m	432,000
10.	Construction of small check dams	LKR 1200 per m^3	24 m^3	28,800
11.	Cover crops and mulching	LKR 15,000 per ha	20 ha	300,000
12.	Grass strips	LKR 450 per metre (2 m width)	1, 400 m	630,000
14.	Establishment of wetlands	LKR 15,000 per ha	1 ha	15,000
15.	Implementation of the awareness programme	1 year		375, 000
16.	Monitoring	Lump sum		450,000
Total estimated cost of activities				2,973,300
Contingencies (10%)				297,330
Total including contingencies				3,270,630
Administrative and supervision Cost (13%)				425,182
Grand total				**3,695,812**

As such, the total cost for the watershed management programme would be approximately LKR 3.7 million (US Dollars 28,212).

The assumptions and estimates used to calculate the costs are as follows:

i. Lock and spill drains - Approximately 30 m of lock and spill drains to be constructed for each hectare of tea lands in 63 ha of tea in the immediate catchment;

ii. Earthen dams - Approximately 20 m of earthen dams for each hectare of land in the 31-60% slope category (83 ha) of tea in the immediate catchment;

iii. Stone walls - Approximately 14 m of stone walls for each hectare of land in 31-60% slope category (83 ha) of tea in the immediate catchment;

iv. Small check dams - Ten (10) cubic meters for each hectare of 10 percent of the total land area (24 ha) of immediate catchment occupied by water bodies;

v. Mulching and cover crops - Eight percent (8%) of the total extent (about 100 ha) of tea and 5% of the total extent (about 230 ha) of home-gardens/degraded tea lands in the immediate catchment up to a distance of 100 m from the FSL around the reservoir periphery ;

vi. Grass strips - in twenty percent (20%) of the total periphery of the reservoir up to 100 m from the FSL in the immediate catchment ; and

vii. Wetlands - Roughly 5% of the total land area of the immediate catchment is occupied by water bodies.

6 IMPLEMENTATION AND MONITORING

The most feasible option for implementing the proposed AWMP successfully is to have it implemented through to professional organizations in Sri Lanka with adequate experience in planning and implementing such activities. It is recommended that the following government institutions are involved in this activity.

6.1 Programme implementation

Forest Department (FD)

The FD has a vast amount of experience in the implementation of afforestation and biodiversity conservation programmes Sri Lanka. While the headquarters of this agency is located in Battaramulla, it has a well distributed district office network throughout the country. It also has many experienced professional staff in the field of forestry. The Moragolla project area comes under the authority of Divisional Forest Officer of the Kandy District. The field-level authority for the Moragolla project area is Range Forest Officer located at Nawalapitiya. The Beat Forest Officer of the Gampola Beat operates under the Divisional Forest Officer. In addition, a number of Field Assistants are also stationed in the project area. Considering this field-based structure, and the experience of the FD in afforestation work, the involvement of the FD in the implementation of the afforestation component of the AWMP is highly recommended.

Natural Resources Management Center (NRMC)

The Natural Resources Management Center of the Department of Agriculture is a professional organization with much experience in handling watershed management related activities. It has experienced professional staff in the field of soil conservation and watershed management. The NRMC is located in Peradeniya, and can be recommended for the implementation of watershed management related work within the AWMP.

6.2 Monitoring

Programme implementation should be monitored by a monitoring committee comprising of the CEB, implementing partners (see Chapter6) and community organizations in the area. This programme monitoring committee should meet once each quarter to monitor the progress of implementation. If there are any issues adversely affecting the progress of the programme, immediate action should be taken to resolve such issues.

7 CONCLUSIONS AND RECOMMENDATIONS

A. Objectives of the programme

1. Rehabilitation and ecological restoration of degraded forests and adjoining areas of Moragolla catchment on watershed basis;

2. Improvement of native forest diversity by planting native tree species in the Moragolla catchment;

3. Prevention of the establishment or control of the spread of invasive plants species that disrupt forest ecosystem process;

4. Minimization of the loss of floral and faunal species of conservation significance during the construction phase of the project due to vegetation clearing and alteration of habitats;

5. Reduction of soil erosion from the Moragolla catchment and minimization of sedimentation of the proposed reservoir by adopting eco-friendly cultivation systems in privately owned lands within the catchment; and

6. Increased public awareness on the importance of protecting the Moragolla reservoir by adopting soil conservation measures and sediment-friendly land-use options.

The programme activities have been designed to meet these objectives. Objectives 1-4 are met through the afforestation component of the AWMP, while objectives 5 and6 are met through the watershed management component of the programme.

B. Expected outcomes of the Afforestation programme

1. The forests in the Moragolla catchment and adjoining areas are highly productive in terms of forest products and services. There are no abandoned lands and degraded areas that are prone to soil erosion in the immediate catchment of the Moragolla reservoir. Forests in the catchment area provide good habitats for fauna and flora living in the area. Forest services such as the conservation of soil and water, the provision of good quality water, reduction of soil erosion and conservation of biodiversity are provided to satisfactory level. These forests provide Non-Timber Forest Products (NTFP) that are extremely valuable.

2. The species composition of forests in the immediate catchment of Moragolla shows a high proportion of native species, which is favourable for faunal species living in these forests.

3. Alien and invasive plant species are not present in the forest areas in the catchment. Native tree species are growing at a healthy rate as there is no competition from invasive plants.

4. Flora and fauna species of conservation significance are not lost due to construction activities. Suitable flora and fauna are rescued and translocated to the refuge established for the conservation of these species.

C. Expected outcomes of the watershed management programme:

1. All privately owned lands within the Moragolla catchment, particularly poorly managed tea landsand home gardens, are properly managed with adequate soil conservation measures and vegetative cover. Soil erosion from these lands and sedimentation of the reservoir is minimized. The sustainability of the reservoir is ensured due to good land management in privately owned lands in the catchment.

2. The local people in the Moragolla project area are fully aware of the importance of adopting soil conservation measures and environment-friendly land-use options for protecting the Moragolla reservoir. Private land owners in the area are adopting soil conservation measures in their tea lands and home gardens in the catchment area, and these areas are well protected with a good vegetative cover.

BIBLIOGRAPHY

- Attygalle, Ranjan, (1998) Selecting Tree Species for the Restoration of Degraded Construction Sites In the Upper Mahaweli Catchment, Proceedings to the Second Annual Forestry Symposium 1996: Management and Sustainable Utilization of Forest Resources, Sri Lanka, 6-7 December 1996. Eds. Amarasekara, H.S., Ranasinghe, D.M.S.H.K. and Finlayson, W., Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Sri Lanka.
- CEB (2004) Environmental Management Plan (Pre-construction), Upper Kotmale Hydropower Project, Environmental Management Office, Ceylon Electricity Board.
- CEB (2009) Feasibility Report, Moragolla Hydropower Project.
- CECB and ACO (2012) Central Engineering Consultancy Bureau/ Al Habshi Consultants. (2012). Moragolla Hydropower Feasibility Study. Final Report-Volume 3 - Environmental Impact Assessment Study.
- Dalle, S. P., de Blois, S., Caballero, J. and Johns, T. (2006) Integrating analyses of local land-use regulations, cultural perceptions and land-use/land cover data for assessing the success of community-based conservation, *Forest Ecology and Management* 222: 370-383
- Forest Department (1995) Legg, C. and Jewell, N., Forest Map of Sri Lanka; Sri Lanka Forester, Forest Department, Special Issue (Remote Sensing): 3-24,.
- Forest Department (2007) Improved Forest Nursery Practices, Forest Department, Sri Lanka.
- Forest Department (2009) Silviculture Manual for Sri Lanka, Forest Department.
- Forest Department (2010) Forest Cover Map of Sri Lanka (Unpublished).
- Gunatilleke N., Pethiyagoda, R. and Gunatilleke, S., (2008) Biodiversity of Sri Lanka, Journal of the National Science Foundation Sri Lanka. 36:.25-62
- Hewawasam, T. (2010) Effect of land use in the upper Mahaweli catchment area on erosion, landslides and siltation in hydropower reservoirs of Sri Lanka, Journal of National Science Foundation Sri Lanka. 38 (1):3-14

- Dudley, N. (Editor) (2008). *Guidelines for Appling Protected Areas Management Categories*. IUCN, Gland, Switzerland, pp 86.
- MoALF (1995) Sri Lanka Forestry Sector Master Plan, Forestry Planning Unit, Ministry of Agriculture, Lands and Forestry, Sri Lanka.
- MoENR/EML (2006) Jayasuriya, A.H.M., Kitchener, D.J. and Biradar, C.M., Portfolio of Strategic Conservation Sites / Protected Area Gap Analysis in Sri Lanka, Ministry of Environment and Natural Resources, Sri Lanka.
- PRP (1997) Nursery Manual for Reforestation, Plantation Reform Project.
- Rusinow, T. (1992) Watershed Management in Sri Lanka's Upcountry: a Qualitative Assessment with Particular Emphasis on the USAID Reforestation Project, United States Agency for International Development, Sri Lanka, Available at http://pdf.usaid.gov/pdf_docs/PNABN323.pdf
- Soil Conservation Plan for mitigation of Soil Erosion threats for proposed Hydropower Project, Moragolla, Natural Resources Management Center, Department of Agriculture.

ANNEXURES

Annex 1: Trees (>20 cm DBH) likely to be removed or affected due to the Moragolla Hydropower Project, as provided in the ToR (Source: Moragolla Hydropower Project EIA, 2012)

Moragolla Hydropower EIA (2012)														
Family	**Species**	**Common Name**	**BG**	**D**	**R**	**P**	**PH**	**C**	**NR**	**R1**	**R2**	**DS**	**TL**	**CS[4]**
Anacardiaceae	Anacardiumoccidentale	Cashew	I							1			1	NE
	Lanneacoromandelica		N					1						NE
	Mangiferaindica	Mango	I		10			1	9	6	1			DD
Apocynaceae	Alstonia macrophylla	Hard milk wood	I		12				3	8	3	2	4	LC
	Alstonia scholaris	Milkwood pine	N		2								1	LC
Arecaceae	Areca catechu	Betel palm	N										2	NE
	Caryota urens	Jaggery palm	N		6			2						NE
	Cocos nucifera	Coconut palm	N		7					6	1			NE
Bignoniaceae	Spathodeacampanulata	Fountain tree	I						3	2	7			NE
	Tabebuiarosea	Savannah oak	I		4				1					NE
Malvaceae	Bombaxceiba	Cotton tree	N											NE
	Ceibapentandra	Java cotton	I							1	2			NE
	Duriozibethinus	Durian	I		1									NE
Combretaceae	Terminaliaarjuna	Arjun tree	N		4									NE
Tetramelaceae	Tetramelesnudiflora		N		1									LC
Elaeocarpaceae	Elaeocarpus serratus	Ceylon olive	N						2	1				NE
Euphorbiaceae	Hevea brasiliensis	Rubber	I							2	1			NE
	Macarangapeltata	Kenda	N	1	4	2				3	9	4	8	NE
	Mallotustetracoccus		N		2							3		NE
Fabaceae	Acacia mangium	Black wattle	I	3	14			3	1				4	NE
	Acacia melanoxylon	Hickory	I		3									
	Albizia falcataria	Silk tree	I		34			1	7		1	5		NE
	Albizia odoratissima		N						1	2	1		5	NE
	Cassia (Senna) spectabilis		I							1				LC
	Delonixregia	Flame tree	I		5					1				VU
	Gliricidia sepium	Gliricidia	I				2							NE
	Peltophorumpterocarpum	Yellow flame tree	N		23			1	1					NE
	Pterocarpusmarsupium	Indian kino tree	N					1						VU
Lauraceae	Neolitsea cassia	Sri Lanka laurel	N		1	2		1		2	4			NE
Magnoliaceae	Michelia (Magnolia) champaca	Magnolia	N		5	1		1	10		1			NE
Meliaceae	Meliaazedarach	Indian lilac	N								1			NE
	Swietenia macrophylla	Big-leaf mahogany	I		5					42	11		2	VU

[4] CS = IUCN Conservation Status 2013 (http://www.iucnredlist.org/)

Moragolla Hydropower EIA (2012)															
Family	**Species**	**Common Name**	**BG**	**D**	**R**	**P**	**PH**	**C**	**NR**	**R1**	**R2**	**DS**	**TL**	**CS[4]**
	Toona sp.	Mahogany	I					1	2					
Moraceae	Artocarpus heterophyllus	Jackfruit	I		13			5	32	14	12	1		NE
	Artocarpusnobilis		E		3						2			VU
	Ficusexasperata	Fig tree	N							1	2			NE
	Ficusracemosa	Cluster fig tree	N		6									NE
	Ficus sp.	Fig	N		6									
Myrtaceae	Eucalyptus (Corymbia) torelliana	Eucalypt	I		3		**PH**							NE
	Eucalyptus sp.	Eucalyptus	I						1	1				
Protaceae	Grevillearobusta	Silky oak	I						1					NE
Rhizophoraceae	Caralliabrachiata	Corkwood	N							3				NE
Sapindaceae	Nepheliumlappaceum	Rambutan	I		1									LC
Malvaceae	Grewiadamine		N										1	NE
Cannabaceae	Tremaorientalis	Indian charcoal	N	3	4	2	2		1					NE
			Sub Total	7	179	7	4	18	75	97	59	15	28	
			Total	489										

<u>Key to Appendix I</u>
BG = Biogeographic status: E = Endemic; N = Native; I = Introduced
D = Dam Site; **R** = Reservoir; **P** = Penstock; **PH** = Power House; **C** = Camp
NR = New Road; **R1, R2** = Expansion Road 1 and 2; **DS** = Dumping Sites; **TL** = Transmission Line
CS = IUCN Conservation Status: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; NE = Not Evaluated (From: http://www.iucnredlist.org/)
Source: CECB, 2012, Environmental Impact Assessment, Moragolla Hydropower Feasibility Study

PHOTO CATALOGUE

(Photographs by Avanti Wadugodapitiya @ IUCN)

Figure 1. The valley seen from the Ulapane industrial zone.

Figure 2. Stream at the proposed dam site.

Figure 3. Shrubs on the steep slope of the left bank of the valley at the proposed dam site.

Figure 4. Riparian vegetation at the stream reservation of the right bank at the proposed dam site – consists of shrubs and a grassy undergrowth.

Figure 5. Riparian vegetation of the stream upstream of the proposed dam site at the area where the existing road is to be submerged.

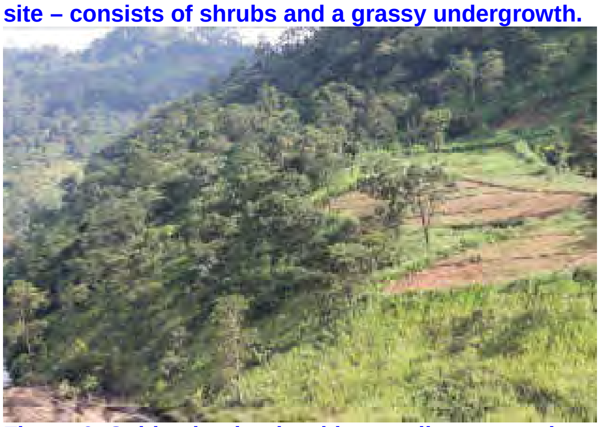


Figure 6. Cultivation lands without soil conservation located close to the riparian vegetation.


Figure 8. Degraded grasslands with patches of land cleared for cultivation.


Figure 9. Bare land prone to soil erosion.


Figure 10. Degraded forest area with patches of land cultivated with tea.


Figure 11. Remaining forest patches at the ridges of the watershed.


Figure 12. Degraded forest area with cultivated land.


Figure 13. Forest merged with home gardens at the ridge of the valley

Figure 14. Forest merged with home gardens provide habitats.

Figure 15. Home gardens consisting of trees such as kitul, jak, coconut, arecanut and banana.

Figure 16. Home gardens on the right bank of the proposed reservoir at the upper section of the immediate catchment.

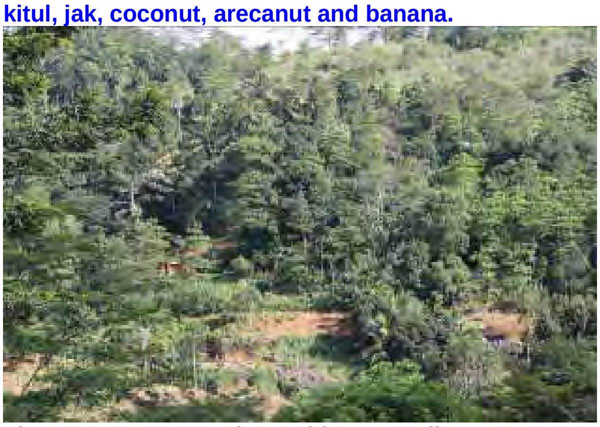


Figure 17. Home gardens with poor soil conservation.

Figure 18. Tea cultivated area adjacent to the Ulapane industrial zone – no soil conservation measures have been adopted.

Figure 19. Grasslands cleared for cultivation – stone walls are established for soil conservation.

Figure 20. A wetland area close to the quarry site on the right bank of the stream.

Figure 21. Home gardens at the banks of the stream at the upper section of the immediate catchment.

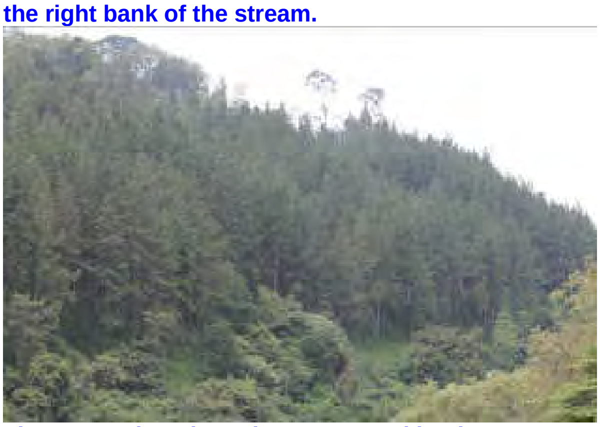


Figure 22. Pine plantations managed by the Forest Department at the right bank of the upper section of the immediate catchment. Monoculture planting such as that shown in this plantation is not recommended during afforestation.

Figure 23. Discussion with local people to collect information.

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MORAGOLLA HYDROPOWER PROJECT

ADDITIONAL STUDIES IN THE NATURAL ENVIRONMENT

PART A
SLOPE STABILITY IN THE RESERVOIR AREA

PART B
RESULT OF DAM BREAK ANALYSIS

NOVEMBER 2013

Nippon Koei Co., LTD.

in joint Venture with

Nippon Koei India PVT. LTD.

PART A

SLOPE STABILITY IN THE RESERVOIR AREA

CONTENTS

1. General .... - 1 -
2. Previous Study .... - 1 -
3. Geology of the Reservoir Area .... - 2 -
   3.1. Geological Component .... - 2 -
      (1) Garnetiferous gneiss/charnockitic gneiss .... - 2 -
      (2) Quartzite .... - 2 -
      (3) Terrace deposits .... - 2 -
      (4) Alluvial deposits .... - 2 -
   3.2. Geological Structure .... - 2 -
4. Slope Stability in the Reservoir Area .... - 3 -
   4.1. Type of Landslide .... - 3 -
   4.2. Slope Stability in the Reservoir Area .... - 4 -
5. Conclusion .... - 6 -

Table

Table 1 Types of Landslides

Figure

Figure 1 Major types of Landslide
Figure 2 Location map of Unstable Rock Mass (1)
Figure 3 Location map of unstable Rock Mass (2)

1. General

This report explains the study results on slope stability in the reservoir area of Moragolla Hydropower Project. For the purpose of evaluation of the slope stability, topographic analysis and ground mapping of the reservoir area was carried out from 9th-21st Sep. 2013 by Mr. MOMOSE (Sr. Geologist) and Mr. YOKOYAMA (Geologist). The following items were identified through the study, and geological map of the reservoir area was prepared.

Data collection

- Existing geological map, landslide analysis data

Topographic Analysis:

- Landslide scar, talus, terrace, plain, cliff

Ground mapping:

- Geological components, locations of outcrops;
- Rock condition, weathering, the structure of the strata, joints, fracture zone;
- Distribution of unconsolidated deposits, such as talus deposits, terrace deposits and river sand; and
- Location and water flow of spring, and tributary

2. Previous Study

Landslide hazard investigation was carried out in 2009 by NBRO for the preparation of EIA report. On the basis of the results of site reconnaissance and review of the existing data, the Report of the Landslide Hazard Investigation for the Proposed Moragolla Hydropower Project (August 2009) was prepared. According to the report, there are no landslide except for gully or some bank failures and it has concluded that the Project is feasible without provoking landslides, if suitable measures are given during construction. In the report, the following recommendations are listed to prevent/mitigate landslide.

- Prevention measures of soil erosion surrounding the reservoir area;
- Evacuation of several houses on steep soil slopes of the right bank whose toes will be inundated (<u>left bank?</u>);
- Protection measures for unstable rock mass about 500 m upstream of dam site;
- Dispatching a super visor during construction stage
- Minimizing heavy blasting and deep excavations, and installation of suitable measures; and
- Minimizing removal of vegetation for erosion control.

In previous study, the slopes stability in the dam reservoir was not evaluated. Although some unstable rock masses were identified, locations and sizes of unstable rock masses and their condition were not mentioned. Therefore, in this study, the landslide-prone slopes including unstable rock mass were identified based on the ground mapping in the reservoir area, and their slope stability was evaluated.

3. Geology of the Reservoir Area

The project area is located in the Central Highlands underlain by the Precambrian metamorphic rocks belonging to the Highland series. The bedrock of the project area is composed mainly of Precambrian garnetiferous gneiss/charnockitic gneiss, intercalated with thin bands of quartzite.

3.1. Geological Component

(1) Garnetiferous gneiss/charnockitic gneiss

Inter bedded bands of dark grey fine to medium grained charnockitic gneiss and pale grey medium grained garnetiferous gneiss. Fresh rocks are solid and dense. Bedrocks are exposed along riverbed, forming cliffs particularly on the left bank downstream of the dam site.

(2) Quartzite

White color, generally several meters layers. Due to the brittleness of the rock, weathering along the joints sometimes reaches several ten meters in depth. Relatively thick quartzite layers are extending north to south on the left bank of the dam site.

(3) Terrace deposits

Small terraces are distributed along the Mahaweli River, of about 20-30 m and 5 m above the river floor. Gravely silt and clay, very stiff-stiff, including sub-rounded gravels of 10-50 cm in diameter.

(4) Alluvial deposits

A small amount of river sand, boulders of 2-3 m diameters are found on the river floor. Bedrocks are exposed on most of locations along the river.

3.2. Geological Structure

The project area lies on the rim of a NW-SE trending broad anticline. The gneissosity 10-30 degrees dips to the southwest at the dam site, while to the north/northwest at the powerhouse site.

Geological The Mahaweli River runs to the north and northeast in the project area. Rock masses on the right bank are likely to induce plane failures sliding on the foliation of the foundation rocks, because the structures of the foundation rocks gently dip to the west.

4. Slope Stability in the Reservoir Area

4.1. Type of Landslide

The term of landslide describes a wide variety of processes that results in the downward and outward movement of slope-forming materials. Table 1 and Figure 1 shows a classification of landslides based on materials and mode of movement.

Table 1 Types of landslides.

Abbreviated version of Varnes' classification of slope movements (Varnes, 1978).

<table>
<tr><th colspan="2" rowspan="3">Type of Movement</th><th colspan="3">Type of Material</th></tr>
<tr><th rowspan="2">Bedrock</th><th colspan="2">Engineering soil</th></tr>
<tr><th>Predominantly coarse</th><th>Predominantly fine</th></tr>
<tr><td colspan="2">Falls</td><td>Rock fall</td><td>Debris fall</td><td>Earth fall</td></tr>
<tr><td colspan="2">Topples</td><td>Rock topple</td><td></td><td></td></tr>
<tr><td rowspan="2">Slides</td><td>Rotational</td><td rowspan="2">Rock slide</td><td rowspan="2">Debris slide</td><td rowspan="2">Earth slide</td></tr>
<tr><td>Translational</td></tr>
<tr><td colspan="2">Lateral Spreads</td><td>Rock spread</td><td>Debris spread</td><td>Earth spread</td></tr>
<tr><td colspan="2" rowspan="2">Flows</td><td rowspan="2">Rock flow
(deep creep)</td><td>Debris flow</td><td>Earth flow</td></tr>
<tr><td colspan="2">(soil creep)</td></tr>
<tr><td colspan="5">Complex: combination of two or more principal types of movement</td></tr>
</table>

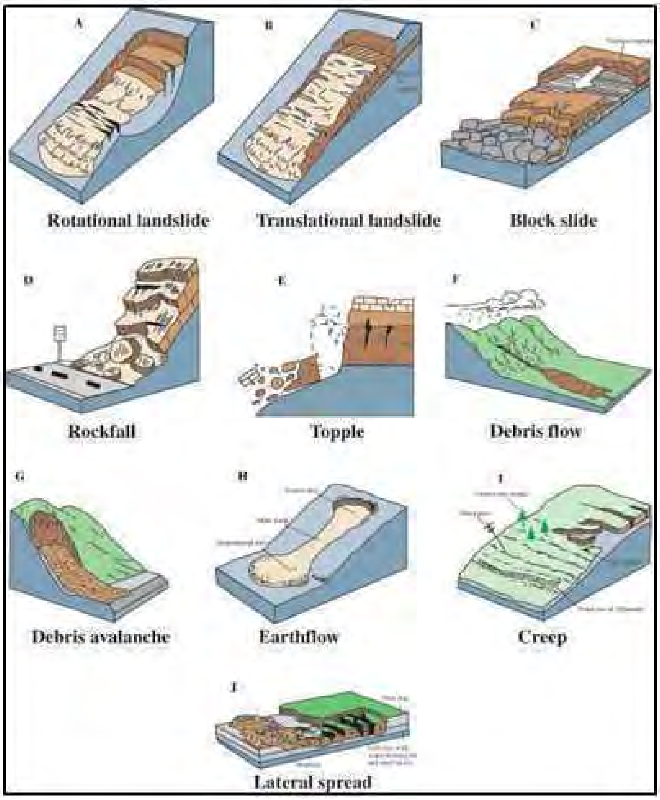


Figure 1 Major types of Landslide

Source: USGS Homepage (http://pubs.usgs.gov/fs/2004/3072/fs-2004-3072.html)

In addition to the these typical landslides, deep weathering and thick unconsolidated deposits such as talus deposits etc. need to be identified, because landslide might be induced consequently if these materials are strongly affected by dam impoundment and fluctuation of dam reservoir level.

4.2. Slope Stability in the Reservoir Area

Results of the ground mapping revealed that:

- There are no large scale landslide in the reservoir area;
- On the left bank of the Mahaweli River, structures of bed rocks are suitable in slope stability, gneissosity dipping to the mountain side;
- On the other hand, on the right bank, gneissosity dipping to the river, two locations of rock slide area on right bank of Mahaweli River approximately 1.0 km and 1.35 km upstream of dam site are identified (See Figure 2 and Figure 3 location Map); and
- Erosion of the coastal area caused by the fluctuation of the dam reservoir level will not be significant, because bedrocks crops out at most of toes of the steep slopes of the left bank, and thick vegetation covers both bank slopes in the reservoir area.

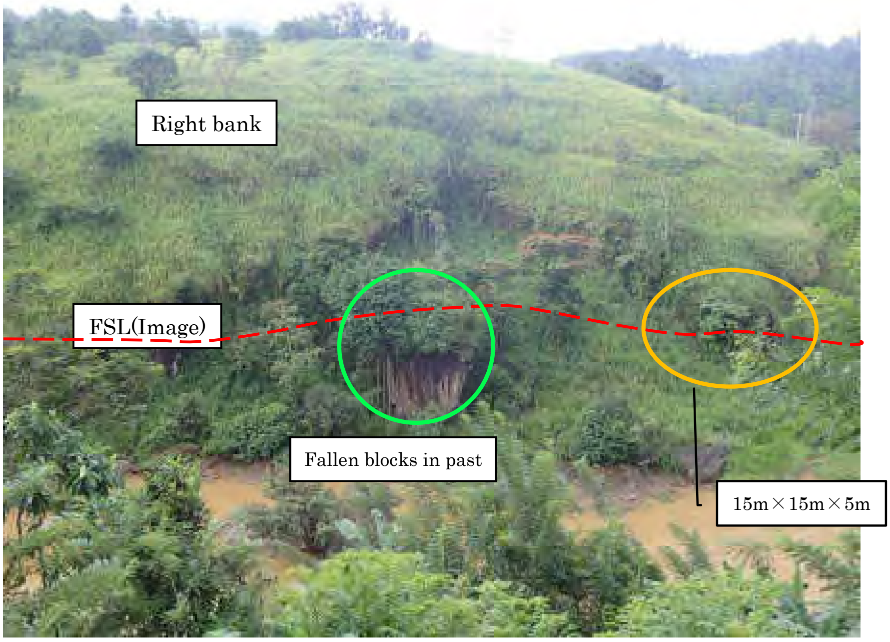
(1) Rock slide (Loc.1)

Location:	Right bank approximately 1.0 km upstream of dam site
Assumed unstable rock mass:	15 m (long) x 20 m (wide) x 5 m (thick) and 10 m (long) x 10 m (wide) x 5 m (thick)
Failure:	Blocks will be separated by two almost vertical joint systems striking N46E and N30W respectively, and slide on a plane of gneissosity to the river side.
Engineering assessment:	The greater part of unstable rock mass bodies are below MOL=542 m. This location is far from dam site. Even if these rock mass slides into the dam reservoir, the impact of landslide-generated waves will be negligible at dam site.

Picture 1 Unstable Rock mass Loc.1

(2) Rock slide (Loc.2)

Location:	Right bank approximately 1.35 km upstream of dam site
Assumed unstable rock mass:	15 m (long) x 15 m (wide) x 5 m (thick)
Failure:	Blocks will be separated by two almost vertical joint systems striking N70E and N10W respectively, and slide on a plane of gneissosity to the river side
Engineering assessment:	The greater part of unstable rock mass bodies are below MOL=542 m. This location is far from dam site. Even if these rock mass slides into the dam reservoir, the impact of landslide-generated waves will be negligible at dam site



Picture 2 Unstable Rock Mass Loc.2

5. Conclusion

There are no large scale landslides in the reservoir area.

On the left bank of the Mahaweli River, structures of bed rocks are suitable in slope stability, gneissosity dipping to the mountain side.

On the other hand, on the right bank, gneissosity dipping to the river side, two locations of rock slide area on right bank of Mahaweli River approximately 1.0 km and 1.35 km upstream of dam site are identified in this study. However, the greater part of unstable rock mass bodies these unstable rock masses are located below LWL=523 m. Even if these rock mass slides into the dam reservoir, the impact of landslide-generated waves will be negligible at dam site.

Erosion of the coastal area caused by the fluctuation of the dam reservoir level will not be significant, because bedrocks crops out along most of toes of the steep slopes of the both banks, and thick vegetation covers relatively gentle slopes of the both banks in the reservoir area.

This report concludes that there are no landslides which make significant impact on the dam. However, monitoring of the slopes in the reservoir area recommended during dam impoundment, because all potential of small scale landslides cannot be identified and small scale landslide might trigger larger landslides.

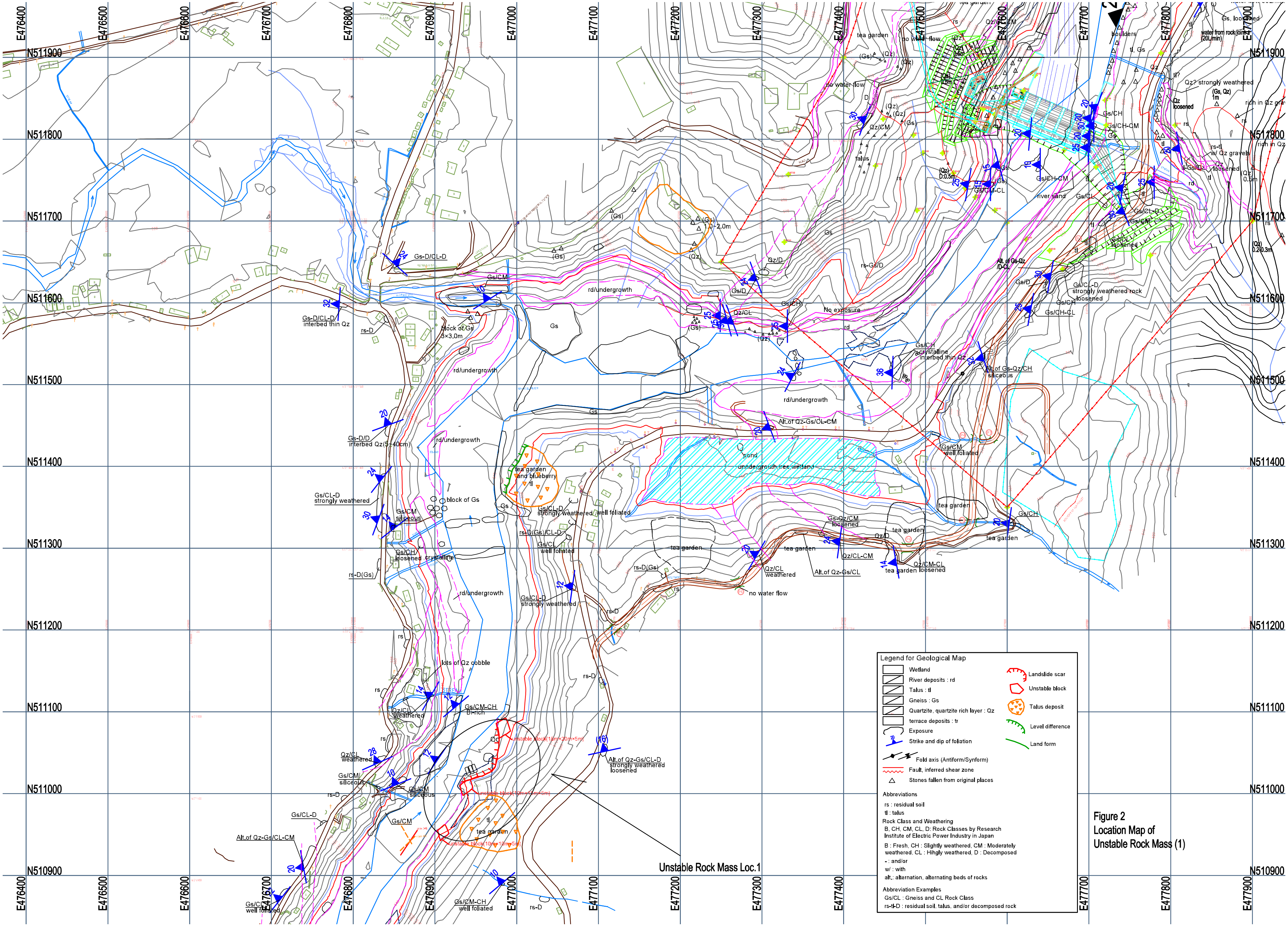


Figure 2
Location Map of
Unstable Rock Mass (1)

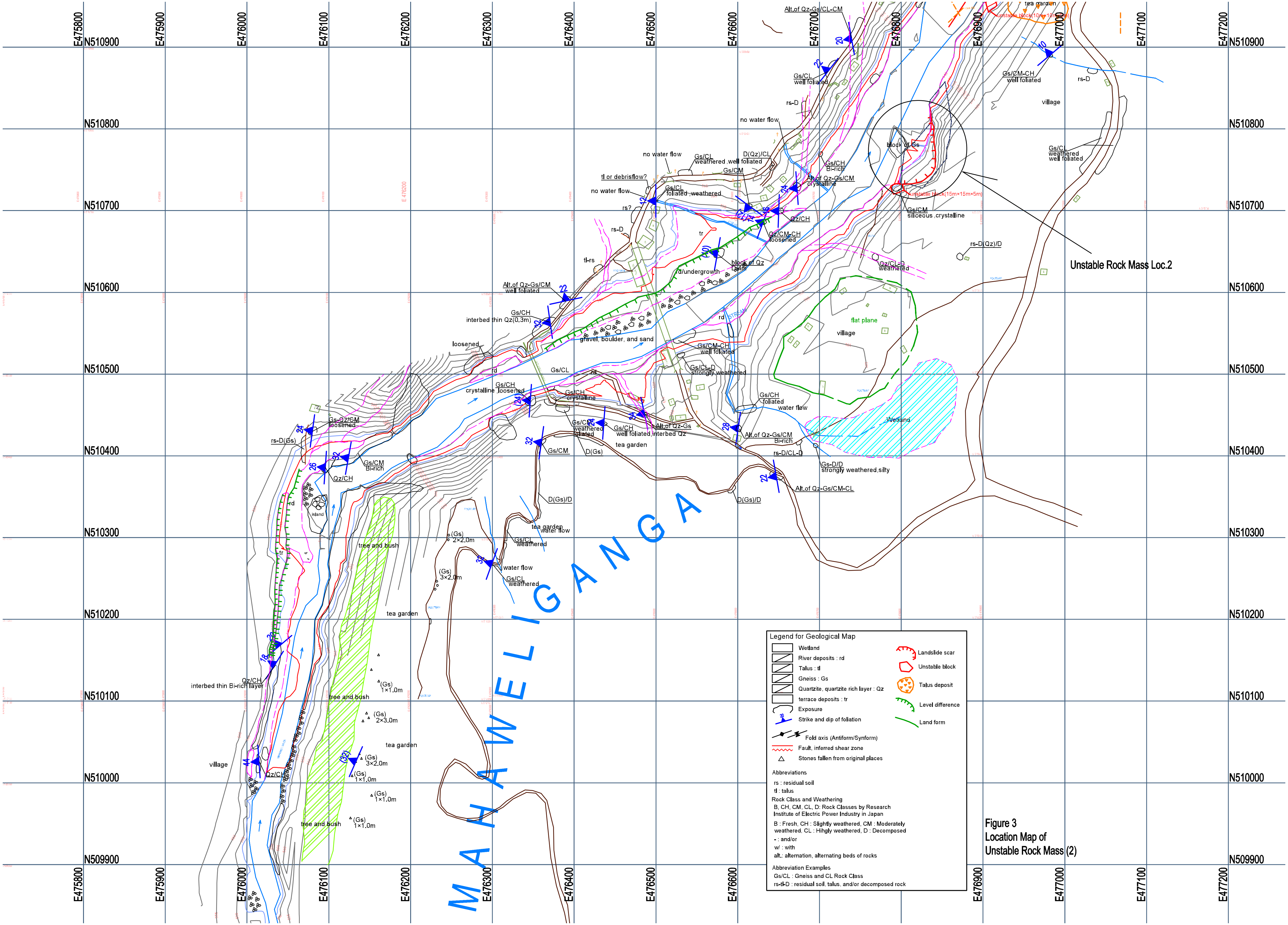


Figure 3
Location Map of
Unstable Rock Mass (2)

PART B

DAM SAFETY

CONTENTS

1. Safety of Moragolla Dam .... - 1 -
2. Failure of Maragolla Dam .... - 1 -

Figure

Figure 1 Discharge and Stage Hydrographs at Dam Failure
Figure 2 Inundation Area at Gampola at Dam Failure, below EL.488m
Figure 3 Inundation Area at Peradeniya at Dam Failure, below EL482m

1. Safety of Moragolla Dam

Moragolla dam is a concrete gravity dam.

In most cases of dam failure, foundation quality or large floods are the main cause. Foundation rocks of Moragolla dam are garnetiferous gneiss and charnockitic gneiss which are fresh and sound. The foundation has the safety factor more than 4 against share force even in the cases of the 10,000-year flood and the maximum credible earthquake with a seismic coefficient of 0.10. The dam is designed to meet the safety requirements in accordance with modern technical standards. The possibility that the dam will fail due to foundation failure or earthquake is remote.

The spillway has a capacity to pass the peak discharge of 10,000-year flood (6,700m3/s) with the reservoir level at FSL 548m, 2m below the top of dam. Even if one gate is completely blocked, the spillway is able to release the peak discharge of 10,000-year flood at the reservoir water level El.550, the top elevation of dam. The possibility of the dam being overtopped is remote. Even if the dam is overtopped, it is able to stand against water pressure with massive concrete body on sound rock foundation.

There is no possibility that the dam will cause catastrophic failure. Over 1% of concrete gravity dams built before 1930 but none of the 2500 more recent ones have failed (ICOLD Bulleting 117, "The Gravity Dam: a dam for the future-Review and recommendations, 2000").

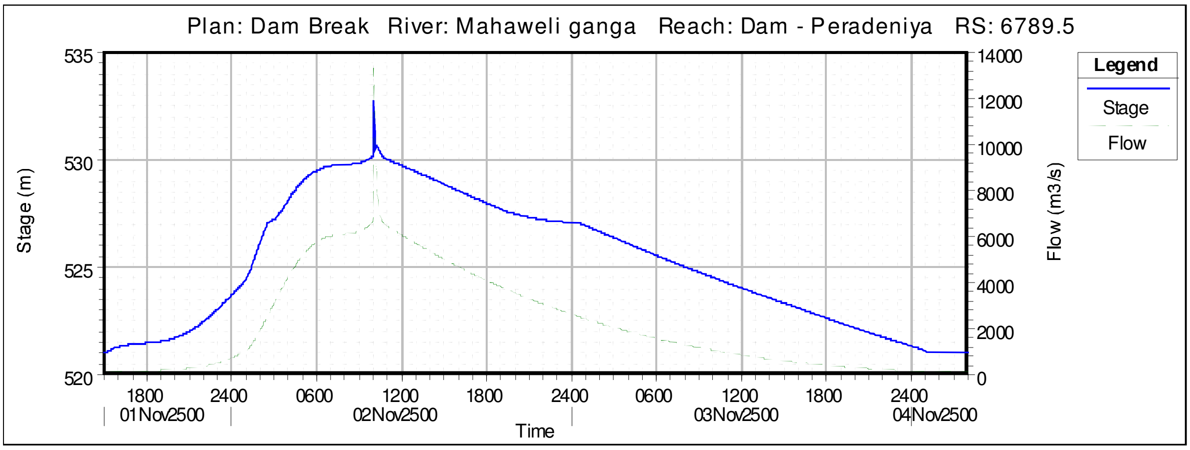
2. Failure of Maragolla Dam

Assuming that a 60m wide section of the dam above El. 520m could disappear instantaneously when the 10,000-year flood reaches the peak, it is estimated that a flood of 13,300m^3/s would pass down from the dam site. Discharge hydrographs and stage hydrographs at the dam site, Gampola and Peradeniya calculated using HEC RAS are shown in Figure 1 and summarized below.

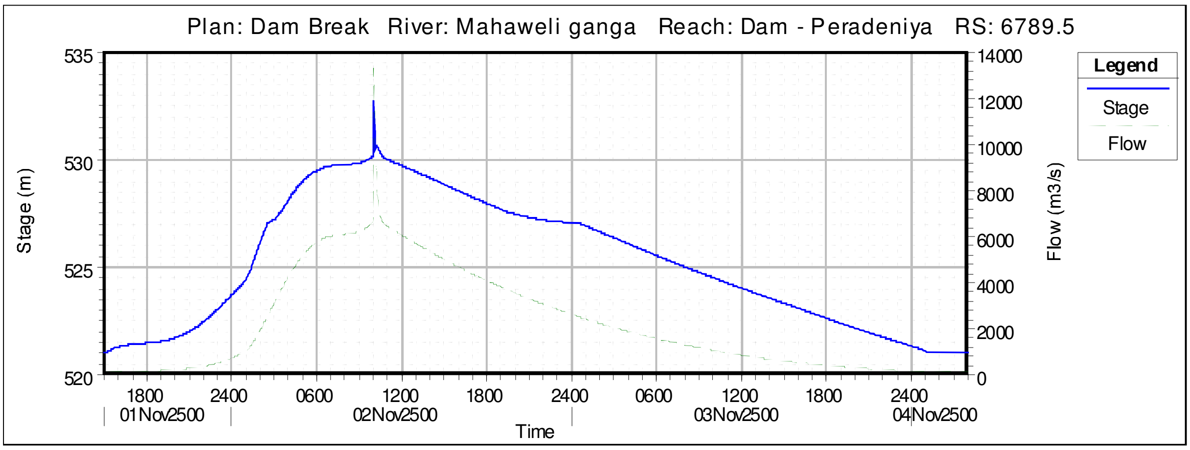
	Max. Discharge (m^3/s)	Max. Stage (El.m)
Dam Site	13,300	534
Gampola	8,800	488
Peradeniya	7,000	482

This would raise the water levels to El.488m at Gampola and El. 482m at

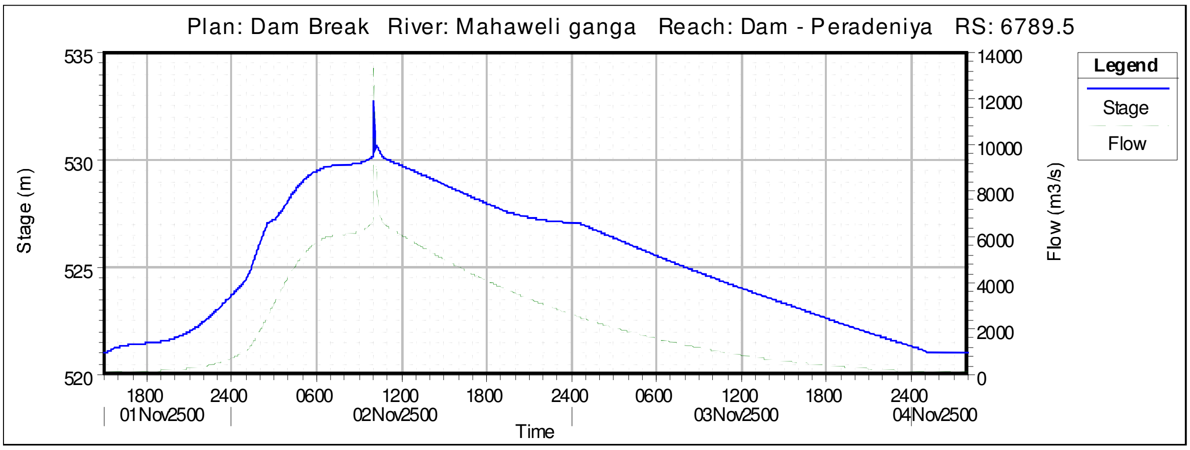
Peradeniya as shown in Figure 2 and Figure 3.



Dam Site



Gampola



Peradeniya

Figure 1 Discharge and Stage Hydrographs

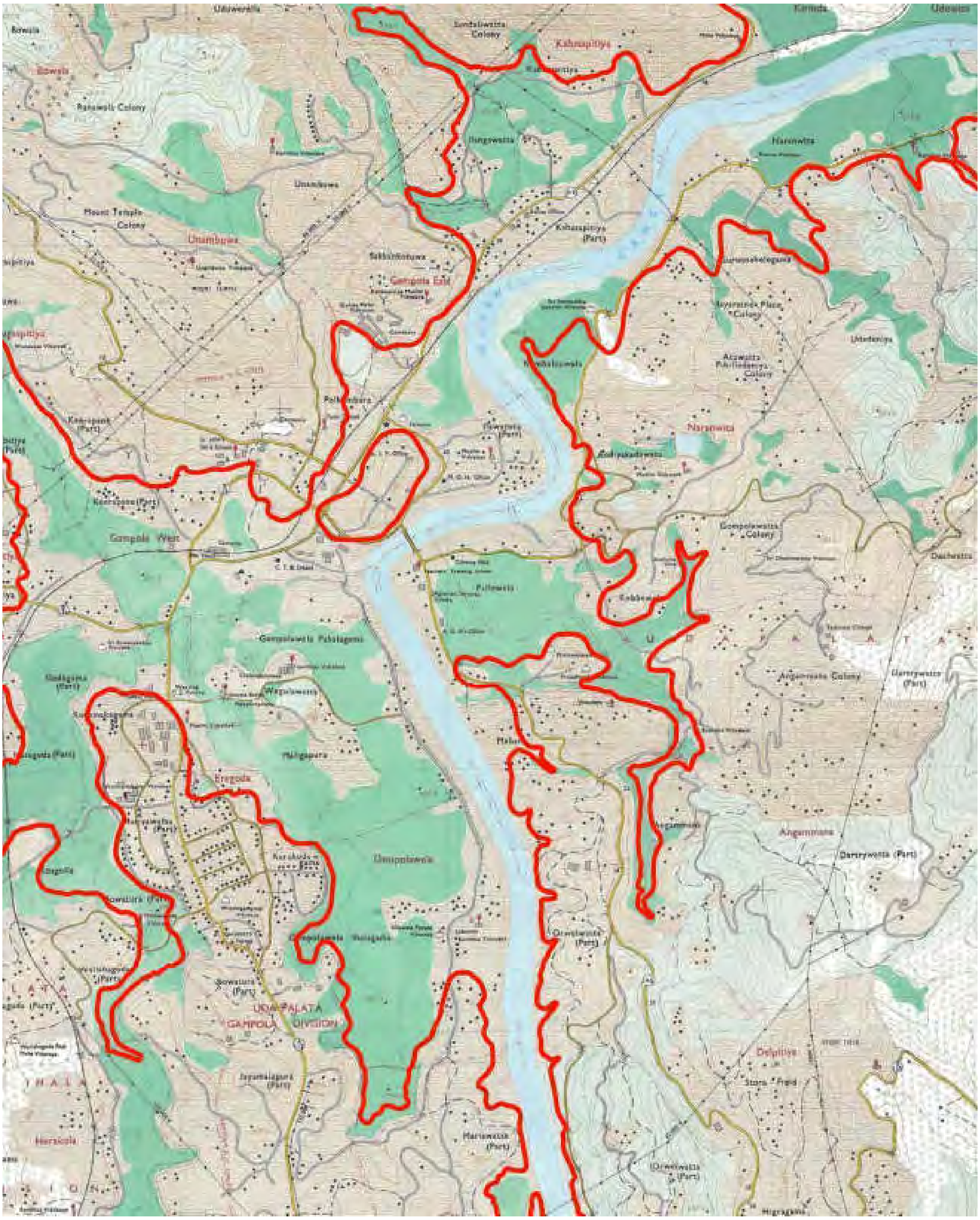


Figure 2 Inundation Area at Gampola at Dam Failure, below El. 488m

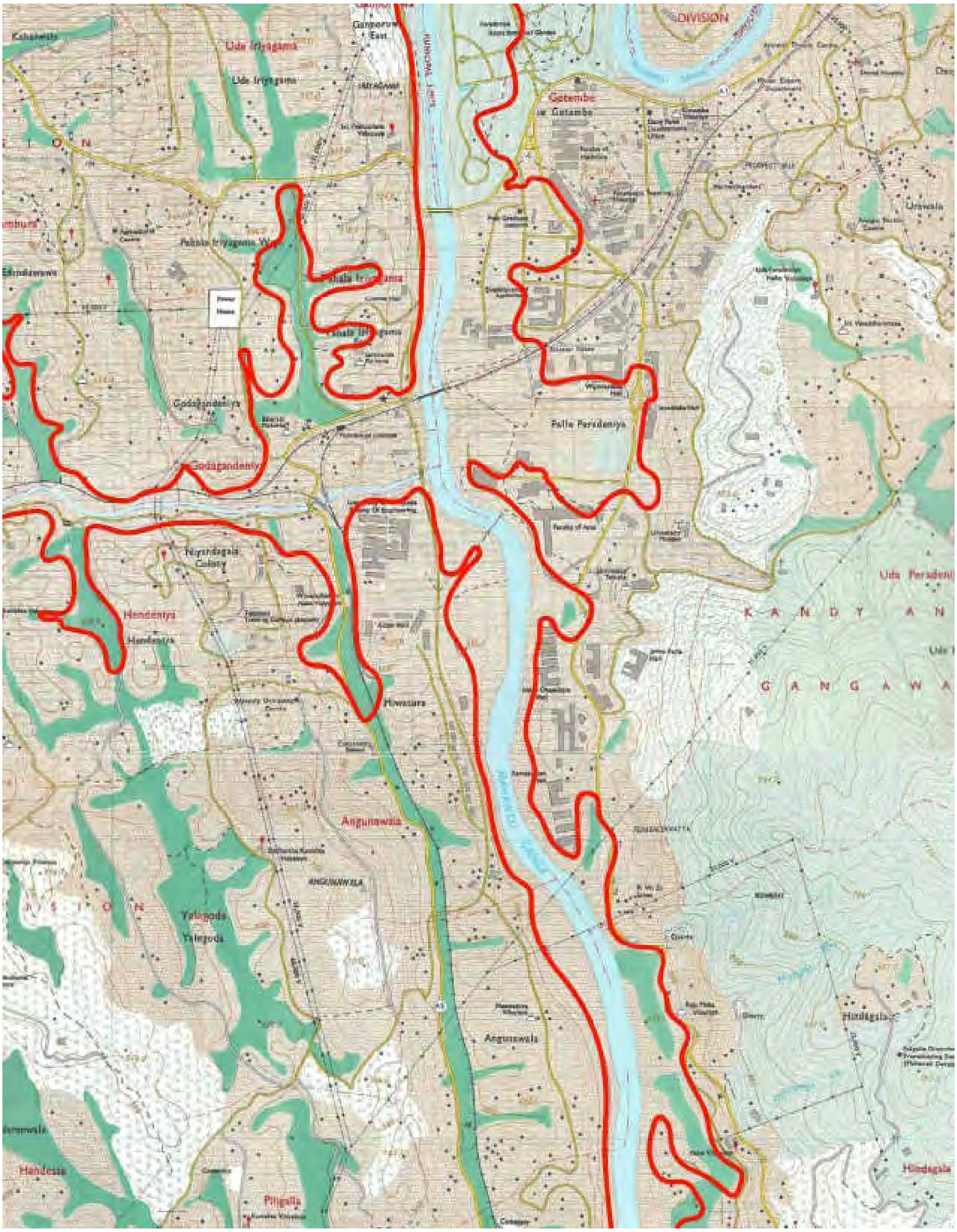


Figure 3　Inundation Area at Peradeniya at Dam Failure, below El.482m