Initial Environmental and Social Examination Report – Annex F

Project Number: 51327-001
October 2018
Document Stage: Final

Proposed Loan and Administration of Loans
Da Nhim - Ham Thuan - Da Mi Hydro Power Joint Stock Company
Floating Solar Energy Project
(Viet Nam)

Prepared by ERM for Asian Development bank (ADB) and Da Nhim - Ham Thuan - Da Mi Hydro Power Joint Stock Company

DA NHIM-HAM THUAN-DA MI HYDROPOWER JOINT STOCK COMPANY

Da Mi Floating Solar

Critical Habitat Assessment

FINAL

August 2018

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ERM

FINAL REPORT

DA NHIM-HAM THUAN-DA MI HYDROPOWER JOINT STOCK COMPANY

Da Mi Floating Solar

Critical Habitat Assessment

August 2018

Reference: 0463401

For and on behalf of ERM

Approved by: Mark Watson

Signed:

Position: Partner

Date: 01 October 2018

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1 PROJECT DESCRIPTION

1.1 OVERVIEW

The Project involves construction, operation and maintenance of the 47.5 MW floating solar photovoltaic (PV) power plant project which shall be installed at Da Mi Reservoir, which belongs to the Ham Thuan-Da Mi hydropower complex. The project is located at three communes including La Ngau Commune (Tanh Linh Disitrct), La Da Commune and Da Mi Commune (Ham Thuan Bac District), Binh Thuan Province, and developed by Da Nhim-Ham Thuan-Da Mi Hydropower Joint Stock Company (DHD) (the "Sponsors"). It is noted that the EIA for Da Mi Floating Solar Power Project was approved by Binh Thuan Province on 15 September 2017. At present, the Project is seeking international finance, it is required to comply with both Vietnamese regulatory requirements and the compliance reference framework detail in Section B.

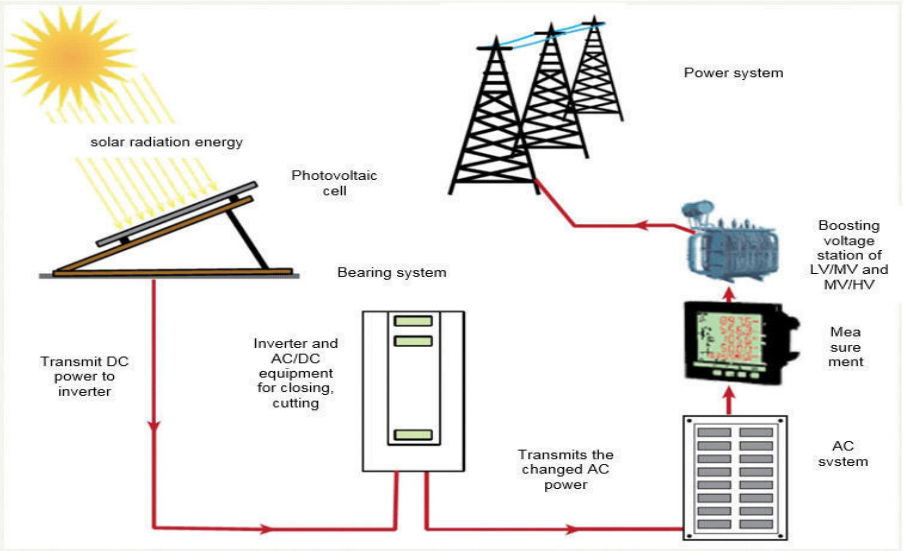
1.2 ELECTRICITY GENERATION TECHNOLOGY.

In general, the Project uses photovoltaic (PV) panel technology installed in Da Mi reservoir and a central inverter to convert the Direct Current (DC) into Alternating Current (AC) though transformers to upgrade voltage to the level of 0.4/22kV and 22/110kV, then connect to the national power system.

1.3 THE SCOPE OF THE PROJECT

The floating solar power plant in Da Mi hydro power reservoir in Binh Thuan province shall generate directly electricity to the national grid with a large capacity. Photovoltaic solar technology and direct grid connection shall be only used without storage.

Figure 1.1 The diagram of solar photovoltaic technology



Source: EIA, 2017.

PV module is a component that converts directly solar radiation into DC electricity through a photovoltaic effect with a completely clean process and does not require moving components such as ordinary rotary power. Each photovoltaic panel consists of several photovoltaic cells connected to each other. Photovoltaic panels are connected to string and parallel to the array to achieve the requirements DC output power.

1.3.1 Inverter

The power electronic device that converts DC current into AC current suitably for connecting to the national grid.

1.3.2 Supporting frame system:

The function of system is to fix photovoltaic panels stably. The system can be designed with a fixed angle or sun-tracking system.

1.3.3 Transformer (0.4/22kV)

The purpose of this is to raise the output voltage from the inverter to a higher voltage level that is suitable for connection to the power system. To connect with the national grid, substations will be set up, which will include protection, measurement and control equipment.

1.3.4 Solar PV installation technology

There are two popular solar PV installation technology: fixed arrays and dual-axis tracked array. For the Project, due to the unstable background with the

effect of waves, wind, currents, difficult transmission links, it is feasible to apply the fixed array of PV panels. With the fixed array installation technology, it is simple to install in different types of terrains and the spaces between solar panels is relatively small. Furthermore, its investment cost and does not occupy a large of land area. Since they have no moving parts, the fixed system are resilient and need little maintenances.

1.3.5 Capacity

The total capacity of Project is 47.5MW. The Project Components consists of a floating solar power PV Plant, substation, inverter station (A and B) and 3.3 km transmission line.

Table 1.1 The capacity of Da Mi Floating Solar Power Project

No	Categories	Quality	Total capacity
I	**Solar power plant**	1	47,5 MW
1	PV module panel 72 cell - 330Wp	143,940	47,5 MW
2	Inverter station A		
2.1	Inverter 2.500 kW	7	17,5 MW
2.2	Booster transformer 0,6/22kV - 2.500kVA	7	17,5 MVA
3	Inverter station B		
3.1	Inverter 2.500 kW	10	25 MW
3.2	Booster transformer 0,6/22kV - 2.500kVA	10	25 MVA
II	**Substation 22/110kV**	1	63MVA
1	Boosting voltage transformer 22/110kV - 63MVA	1	63 MVA

Source: EIA, 2017

Table 1.2 Specification of Photovoltaic (PV) panels

Specification	Value
Electrical characteristics	
Type	Single or multi-crystal silicon
Rated capacity P_{mpp}	>330 Wp
Rated voltage U_{mpp}	37.8V
Nominal current I_{mpp}	8.74A
Off-load voltage U_{oc}	46.9V
Short-circuit current I_{sc}	9.15A
Conversion efficiency	17%
Range of operating temperature	-40°C – 85°C
The maximum voltage of system (IEC standard)	1500 V DC
Rated current of fuse	15A
Measurement uncertainty of capacity	0-3%
Temperature characteristics	
NOCT	45±2°C
Temperature coefficient P_{max}	-0.40%/°C
Temperature coefficient V_{oc}	-0.30%/°C
Temperature coefficient I_{sc}	0.06%/°C
Physical characteristics	
The type of photovoltaic cells	c-Si 156x156 mm
The number of cells	72(6x12)
Size	1956 x 992 x 40 mm
Weight	26.5 kg

Specification	Value
The thickness level of glass cover	4.0 mm, heat resistant
Bracket	Aluminum alloy
Wire box	IP67 Standard
Connecting wire	MC4, 0.9 -1.1 m of length

Source: EIA, 2017

1.3.6 The location of solar power plant

In Figure 1.1 above, the Project layout is set up as follows:

- Zone A, B and F are PV panels which connect to inverter A station. The total area of floating solar panel installation is about 18.7 ha and Inverter Station A is 0.25 ha.
- Zone C, D and E (PV modules) are PV panels which connect to inverter B station. The total area of floating solar panel installation about 26.2 ha and Inverter Station B occupied 0.1 ha.

1.3.7 Location of 110kV substation

The 110kV substation area is 0.5ha, which is expected to be constructed at the shore of Da Mi Hydropower Reservoir in La Ngau Commune (Tanh Linh District, Binh Thuan Province). It should be noted that it is 100m from the reservoir protection corridor, so it is compliance with protection corridor requirements.

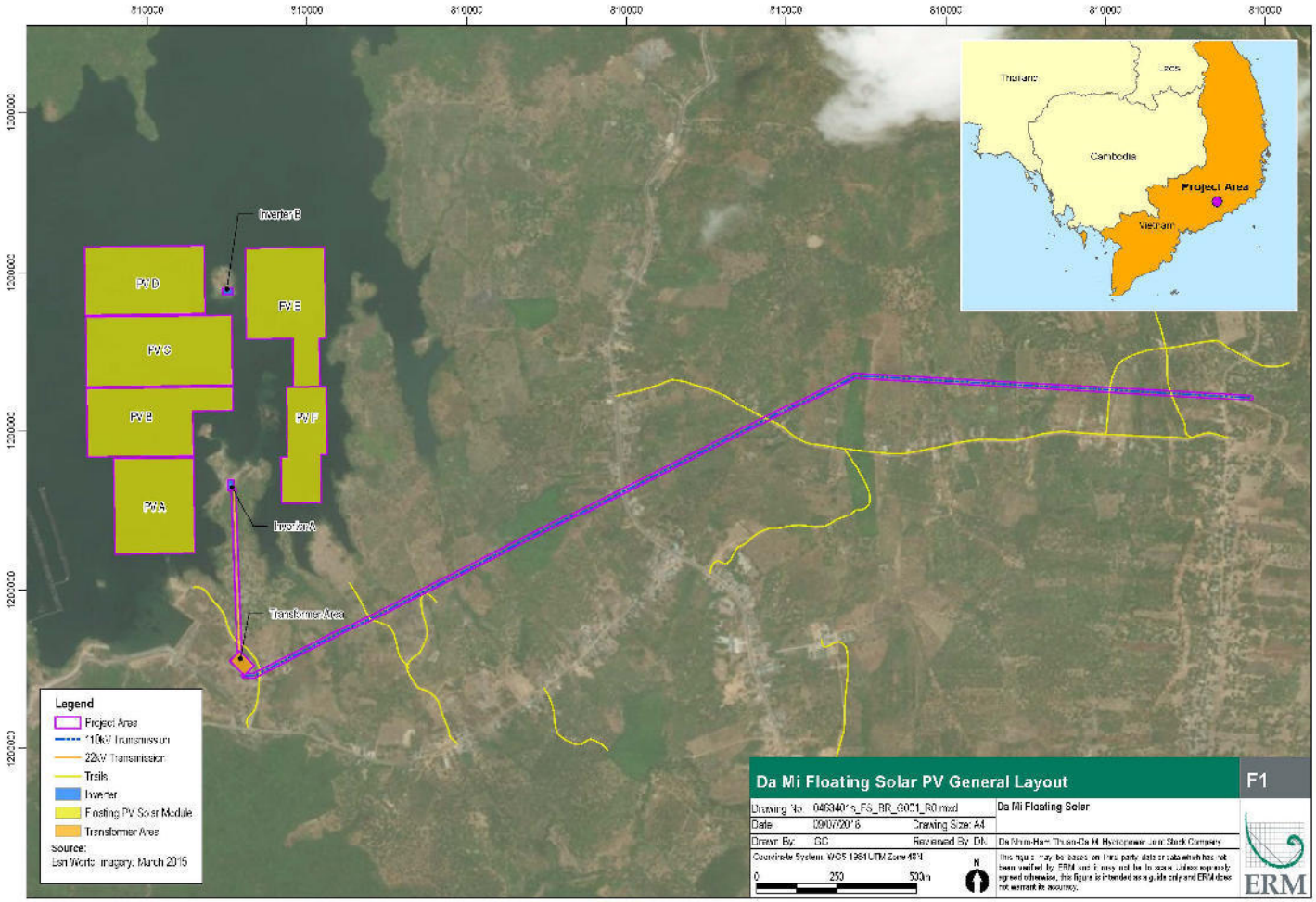
1.3.8 Electricity connection

Table 1.3 The description of electricity connection

No	Items	Description
1	Voltage level	110Kv
2	Number of electrical circuit	02 circuits
3	Beginning point	At the Column No. 24-25 which belongs to 110kV electricity line of 110kV Ham Thuan - Duc Linh.
4	Ending point	Connecting to the 110kV inverter station A of Da Mi Floating Solar Power Plant.
5	The total line length	Total 3,331m (as technical design)
6	Type of electricity line	ACSR 185/29
7	Lightning rods	All electricity lines shall have 02 lightning rods (GSW-50 type).

Source: EIA, 2017

Figure 1.2 Project layout in detail



2.1 DESKTOP ASSESSMENT

The following background assessment has been prepared from reports that have been provided from consultation and internet searches. ERM has used the International Finance Corporation Performance Standard 6 Guidance Note (IFC, 2012) and the ADB Source Book (ADB, 2012) in order to define the background assessment requirements. ERM's experience is that this approach is acceptable in defining the background assessment needs of the ADB SPS.

The background assessment includes a review of:

- environmental studies, scientific literature or any other type of pre-existing biodiversity assessments available for the project area;
- national or regional plans (e.g., Strategic Environmental Assessments, National Biodiversity Strategies and Action Plans);
- conservation programs or initiatives in the area and its surroundings;
- existing species data (e.g., IUCN Red List of Threatened Species, Global Invasive Species Database, IUCN Species Action Plans and nationally protected species lists), to identify if there are any known or potentially occurring threatened species, endemic species and/or migratory species associated within the project study area;
- existing data, to identify any potential invasive species in the project study area site and the surrounding landscape;
- location of any habitats of conservation significance, including World Heritage Areas; Protected Areas; Key Biodiversity Areas (Important Plant Areas, Important Bird Areas and Alliance for Zero Extinction sites).

The purpose of the background assessment is to identify potential biodiversity values that may occur within the vicinity of the Project area. Potential Natural Habitat and Critical Habitat values have been highlighted when identified.

Generally, a 50km buffer has been used to identify values however; this does not necessarily mean that these values interact with the Project area.

2.2 NATIONAL POLICIES AND INITIATIVES

2.2.1 *Vietnam National Biodiversity Strategy to 2020, Vision to 2030*

The main objectives of the Vietnam National Biodiversity Action Plan (NBSAP) are to: improve the quality and increase the area of protected ecosystems; to improve the quality and populations of endangered, rare and precious species; and to compile an inventory, to store, and to conserve native, endangered, rare and precious genetic resources to ensure that they are not impaired or eroded.

One key outcome from the Vietnam NBS is to improve the management of protected areas within the country and to preserve and protect endangered species. Vietnam has developed a comprehensive protected area network (under the Forestry Law 2007) as well as legislated for the protection of wildlife (under the Wildlife and Aquatic Law (2007).

A system of 128 protected areas has been established and developed in all ecoregions, covering an area of 2.5 million hectares (equal to about 7.6% of the national territory). In addition, a system of 45 interior protected wetlands was approved late in 2008. Plans for another system consisting of 15 marine protected areas have been designed and submitted for Government approval. In addition to the national protected areas system, 2 Natural World Heritage Sites, 4 ASEAN Natural Heritage Parks, 2 Ramsar Wetlands and 6 Biosphere Reserves have been internationally recognized. In situ conservation takes many different forms, ranging from species and population conservation to landscape, ecosystem and ecoregion conservation. Vietnam also accessioned the Convention on International Trade in Endangered Species of WiId Fauna and Flora in 1994.

2.2.2 *Viet Nam: Greater Mekong Subregion Biodiversity Conservation Corridors Project*

The Greater Mekong Sub-region Biodiversity Conservation Corridors project – Vietnam Component was approved by the Vietnamese Government through Decision No.2144/QD-BTNMT by the Minister of Natural Resources and Environment, in November 2010. The project is implemented through a loan from the Asian Development Bank, co-financing from the Government of Vietnam, and contributions from project beneficiaries at its field implementation locations. The project is to design and embed biodiversity conservation within a multipurpose, sustainable, biodiversity landscapes. The project area is located within an area identified as a potential biodiversity corridor.

2.3 ECOREGION DESCRIPTION

The Project area is located near to the boundaries of three (3) EcoRegions. Summaries of the Ecoregions are contained within ***Table 2.1*** below.

Table 2.1 EcoRegion Summary

Eco ID	EcoRegion Name	Status	Endemic Species
272	Southern Annamites montane rain forests	Vulnerable	• Hylobates gabriellae • Rattus hoxaensis • *Pygathrix nemaeus* • *Rattus osgoodi* • *Maxomys moi* • Edwards's pheasant *Lophura edwardsi* • Germain's peacock-pheasant *Polyplectron germaini* • Crested argus *Rheinardia ocellata* • Collared laughingthrush *Garrulax yersini* • Golden-winged laughingthrush *Garrulax ngoclinhensis* • Short-tailed scimitar-babbler *Jabouilleia danjoui* • Grey-faced tit-babbler *Macronous kelleyi* • Black-crowned barwing *Actinodura sodangorum* • Grey-crowned crocias *Crocias langbianis* • Vietnamese greenfinch *Carduelis monguilloti*
IMO210	Southeast Indochina dry evergreen forests	Critical/ Endangered	• *Dendrogale murina* • *Maxomys moi* • *Pygathrix nemaeus* • Orange-necked partridge *Arborophila davidi* • Germain's peacock-pheasant *Polyplectron germaini* • Grey-faced tit-babbler *Macronous kelleyi*
300	Southern Vietnam lowland dry forests	Critical/ Endangered	• Germain's peacock-pheasant *Polyplectron germaini* • Grey-faced tit-babbler *Macronous kelleyi*

2.4 WORLD HERITAGE AREAS

There are no identified World Heritage areas within 50km of the Project Area.

2.5 RAMSAR SITES

There is one (1) RAMSAR site (no. 1499) that is located within 50km of the Project area. This area is located approximately 35km West of the Project Area and is called the Bau Sau Wetlands and Seasonal Floodplain. Bau Sau is a key habitat for Siamese Crocodile, Asian Arowana, Black-shanked Douc, Asian Elephant, Wild Gaur, Yellow-cheeked Crested Gibbon and Smooth-coated Otter.

2.6 KEY BIODIVERSITY AREAS

There are Key Biodiversity Areas (KBA) within 50km of the Project area. These KBAs are summarized in ***Table 2.2***. The location of KBAs in relation to the Project areas is shown in ***Figure 2.1***.

Table 2.2 Key Biodiversity Areas Summary

S/N	KBA Name	Area (ha)	Distance from Project Area (km)	Trigger Species
1.	Deo Nui San	71,000ha	10km East	• *Capricornis sumatraensis* Serow VU • *Nycticebus pygmaeus* Pygmy Slow Loris VU • *Pygathrix nigripes* Black-shanked Douc Langur EN
2.	Bao Loc - Loc Bac	95,000ha	40km North West	• *Pygathrix nigripes* Black-shanked Douc Langur EN
3.	Bien Lac - Nui Ong	35,377ha	50km South West	• *Pygathrix nigripes* Black-shanked Douc Langur EN

2.6.1 *Important Bird Areas*

There are no Important Bird Areas (IBA) located within 50km of the Project area.

2.6.2 *Alliance for Zero Extinction Sites*

There are no Alliance for Zero (AZE) sites located within 50km of the Project area.

2.6.3 *Important Plant Areas*

There are no Important Plant Areas (IPA) located within 50km of the Project area.

2.7 ENDEMIC BIRD AREAS

It should be noted that Endemic Bird Areas (EBA)are not recognised as internationally recognised areas and are considered as important for habitat-based bird conservation only.

The Project area is located within the South Vietnamese Lowlands EBA. The trigger species for the EBA include Orange-necked Partridge (*Arborophila davidi*)

NT; Germain's Peacock-pheasant (*Polyplectron germaini*) NT; and the Grey-faced Tit-babbler (*Mixornis kelleyi*) LC.

2.8 TIGER CONSERVATION LANDSCAPES

The Project Area is located approximately 50km South of the (TCL). This area is a landscape level mapping of potential tiger habitat or habitat that has recorded individuals in the last 10 years. A review of available literature indicates that tiger populations in Vietnam may be approximately five (5) individuals located along border areas with China and Lao PDR (WWF, 2016).

The location of the Project area in relation to the TCL is shown in ***Figure 2.2***.

2.9 PROTECTED AREAS

2.9.1 Nationally Protected Areas

There are two (2) nationally protected areas within 50km of the Project site. These protected areas are outlined in ***Table 2.3***. The location of the Project area in relation to the TCL is shown in ***Figure 2.3***.

Table 2.3 Nationally Protected Areas within 100km

S/N	Protected Area	Status	Area	Distance from Project Area (km)
1.	Núi Ông Nature Reserve	IUCN IV	238.34km²	25km South
2.	Nui Dai Binh Nature Reserve	IUCN IV	50km²	30km North West

2.9.2 ASEAN Heritage Parks

There are no ASEAN Heritage Parks located within 50km of the Project site.

2.9.3 Biosphere Reserves

There is one (1) biosphere reserve located within 50km of the Project site. This site is known as the Cat Tien Man and the Biosphere Reserve. The area of the site is 7267.98 km² and it is located approximately 50km North of the Project site.

2.9.4 Protection Forests

Information has been requested from the Vietnam Department of Forestry however data was not provided in time for inclusion in this version of the report.

Figure 2.1 RAMSAR Sites and Key Biodiversity Areas

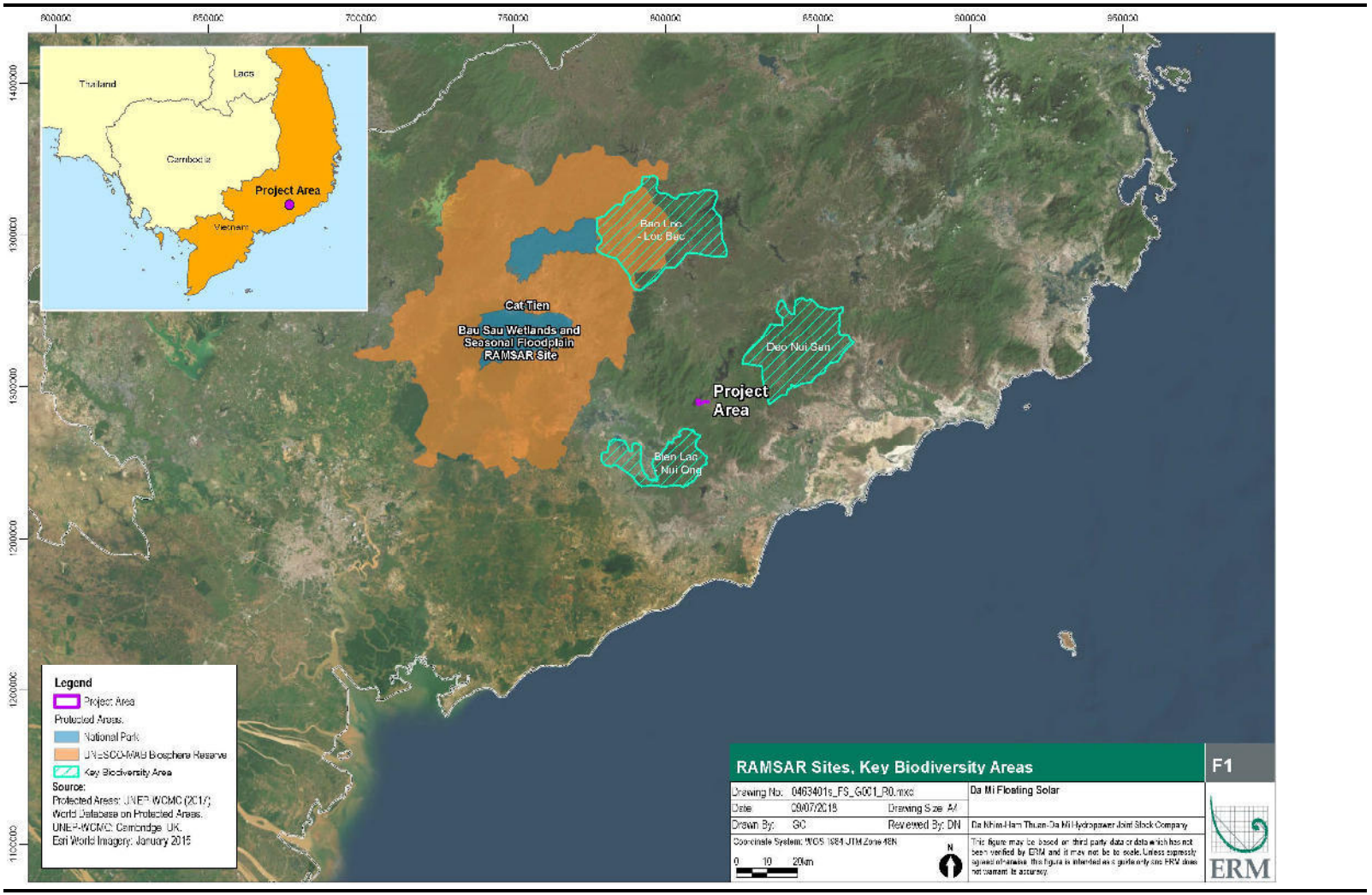


Figure 2.2 Endemic Bird Areas and Tiger Conservation Landscapes

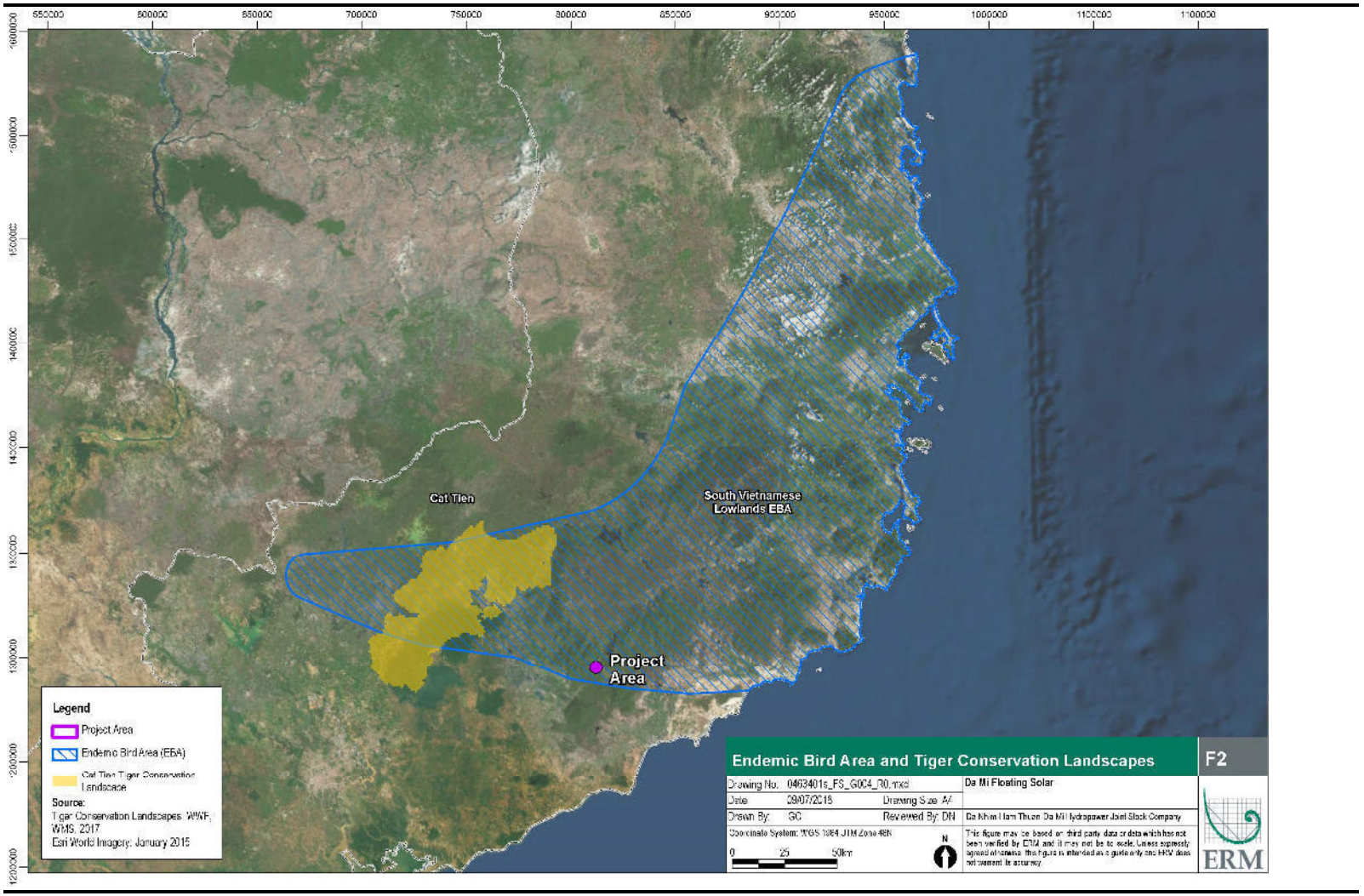
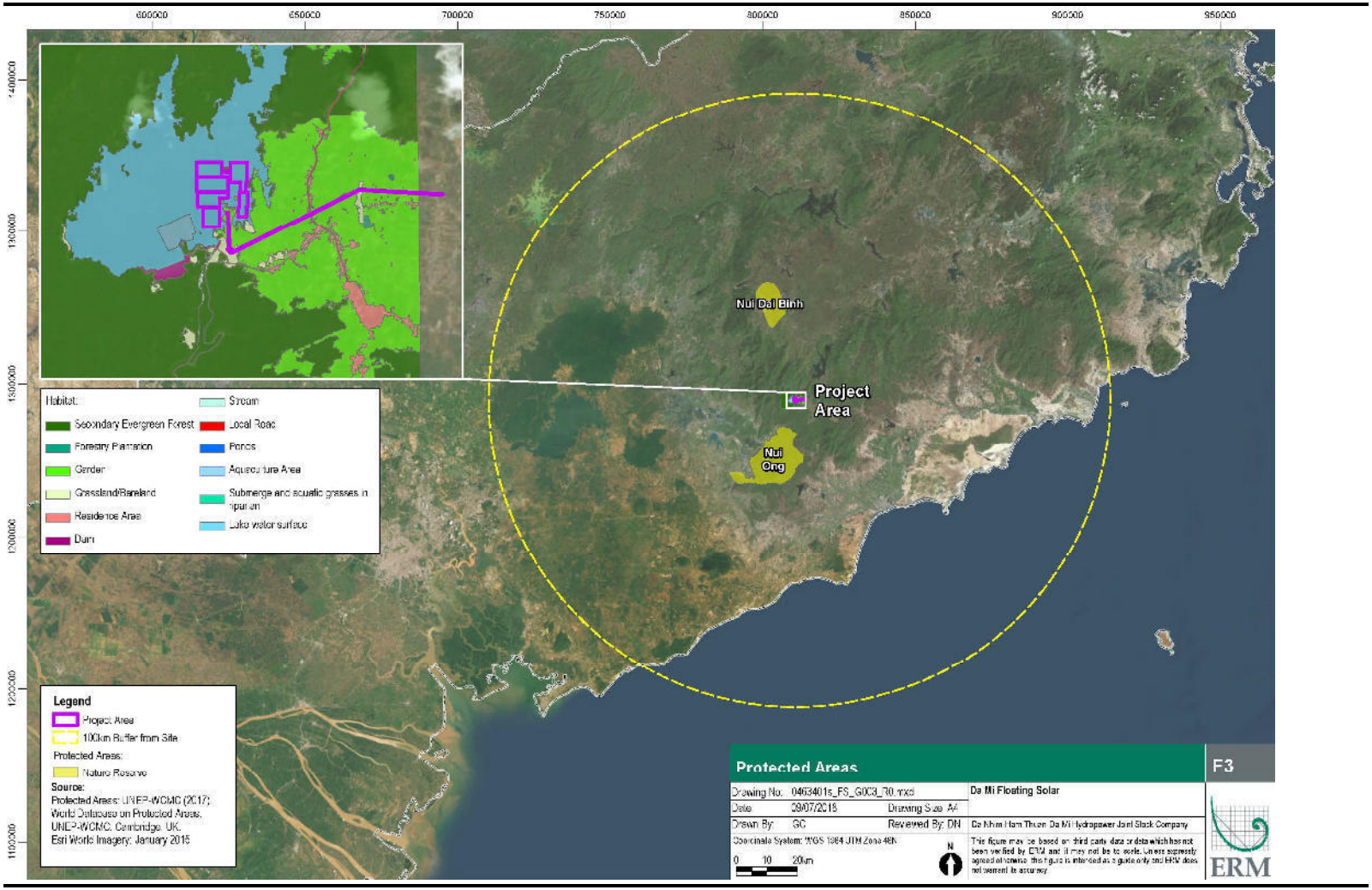


Figure 2.3 Protected Areas



2.10 IBAT SPECIES GRID

The results of data included within the Integrated Biodiversity Assessment Tool (IBAT) have identified a number of Critically Endangered and Endangered species that are predicted to occur within vicinity of the Project area. These species are outlined in ***Table 2.4***.

Table 2.4 Results from IBAT Species Grid

Taxonomic group	Species	Common name	IUCN Red List Category
Amphibians	*Kalophrynus cryptophonus*		EN
Amphibians	*Rhacophorus helenae*		EN
Birds	*Emberiza aureola*	Yellow-breasted Bunting	CR
Birds	*Gracula robusta*	Nias Hill Myna	CR
Birds	*Gracula venerata*	Tenggara Hill Myna	EN
Birds	*Gyps bengalensis*	White-rumped Vulture	CR
Birds	*Pavo muticus*	Green Peafowl	EN
Birds	*Sarcogyps calvus*	Red-headed Vulture	CR
Birds	*Sterna acuticauda*	Black-bellied Tern	EN
Fishes	*Catlocarpio siamensis*	Giant Carp	CR
Fishes	*Pangasianodon hypophthalmus*	Striped Catfish	EN
Fishes	*Scleropages formosus*	Golden Dragon Fish	EN
Mammals	*Chrotogale owstoni*	Owston's Civet	EN
Mammals	*Manis javanica*	Sunda Pangolin	CR
Mammals	*Muntiacus vuquangensis*	Large-antlered Muntjac	CR
Mammals	*Nomascus gabriellae*	Red-cheeked Gibbon	EN
Mammals	*Pygathrix nigripes*	Black-shanked Douc Langur	EN
Mammals	*Trachypithecus germaini*	Indochinese Lutung	EN
Mammals	*Viverra megaspila*	Large-spotted Civet	EN
Plants	*Magnolia cattienensis*		EN
Reptiles	*Crocodylus siamensis*	Siamese Crocodile	CR

Notes:

CR : Critically Endangered; EN : Endangered; VU : Vulnerable; NT: Near Threatened; DD : Data Deficient; NA : Not Assessed; LC: Least Concern

2.11 INVASIVE SPECIES

Invasive species are non-native species to a particular ecosystem and whose introduction and spread causes, or are likely to cause, socio-cultural, economic or environmental harm or harm to human health. These species become naturalized in their introduced range, and often reproduce in large numbers spread over a large area. This can result in competition and damage to native species.

Invasive species have the capacity to exacerbate their role in ecosystem degradation through combination threats by habitat change, climate change,

over-exploitation of ecosystem resources and pollution. These further enhance their threat to biodiversity and the human condition.

According to the Global Invasive Species Database (GISD) and WWF, a total of 119 species have been identified as invasive species in Vietnam.

3.1 BIODIVERSITY BASELINE STUDY

3.1.1 Baseline Study

A biodiversity baseline study was conducted within the Project Area from 1 June 2018 to 3 June 2018, including habitat mapping, aquatic surveys, terrestrial surveys and identification of ecosystem services. The aquatic and terrestrial surveys were conducted by ERM's sub-contractor:

Dr Pham Anh Duc
Vice Dean - Faculty of Environment and Labor Safety
Ton Duc Thang University
Ho Chi Minh City, Vietnam

A summary of the biodiversity baseline study undertaken in the Project Area and surrounds is detailed in ***Table 3.1***.

Table 3.1 Summary of Biodiversity Baseline Study

Study	Summary
Habitat Mapping	• Habitats within the Project Area were mapped.
Aquatic Survey	• Phytoplankton, zooplankton and macroinvertebrate surveys were conducted. • Fisheries resources were recorded and identified. • Fish samples were taken. • Secchi depth readings were taken.
Terrestrial Survey	• Vegetation, avifauna, herpetofauna and mammal surveys were conducted.
Ecological Services	• Interviews with relevant stakeholders and government officers were conducted.

Aquatic and terrestrial surveys were conducted to determine the location of any priority biodiversity values within the Project Area that may be affected by the installation of the floating solar PV project.

These priority values focused on Critical Habitat [(1)] triggers as well as species of conservation significance. The baseline study consisted of habitat mapping to identify and delineate ecological habitats within the Project Area; aquatic and terrestrial field surveys; and identification of ecological services. Habitat

[(1)] Critical Habitats are areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered and/or Endangered species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregator species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes

assessments were also undertaken to inform Natural Habitat [1] and Modified Habitat [2] mapping as required by IFC PS6.

3.1.2 Habitat Mapping

Habitats identified within the Project Area were mapped using satellite imagery (Google Earth) and updated during field surveys to identify and delineate the distribution of different ecological habitats found within the Project Area. Coloured photographs were taken of all habitat types surveyed, features, species of ecological importance, species of conservation value and invasive species. There were 10 habitat types identified in the Project Area, consisting of disturbed secondary evergreen forest, forestry plantation, gardens, grassland/bareland, residential area, ponds, aquaculture area, submeredg and aquatic grasses in riparian, stream and lake surface.

The identified habitat types are described in ***Table 3.2***. ***Figure 3.1*** shows the distribution of habitat types within the Project Area. Their respective areas within the Project Area are shown in ***Error! Reference source not found.***

Table 3.2 Habitat Type Descriptions within the Project Area

S/N	Habitat Type	Description
1	Disturbed secondary evergreen forest	Disturbed secondary evergreen forest were identified within forested areas surrounding Da Mi Lake. These forests surrounded the riparian area of the lake and on some small islands.
2	Forestry plantation	Plantation species were identified within the watershed of Da Mi Lake and the species included *Acacia auriculiformis* (Keo bong vang) and hybrid *Acacia*.
3	Gardens/agriculture	Gardens and agriculture were identified nearby human settlements and were the dominant habitats in the Project Area. The gardens and agriculture areas are used for planting cashew nuts, mangoes, coffees, rubber and jackfruit. The dominant grass species growing beneath the planted trees was *Ageratum connyzoides* (Cut lon).
4	Grassland/Bareland	Grassland and bareland were identified within the watershed of Ba Mi Lake. The area consisted of grasses, shrubs and some trees; the coverage of grasses was over 90% of area.
5	Residential area	Residential areas were identified within the watershed of Da Mi Lake and consisted of farm houses and some villages.
6	Ponds	Ponds were ide4ntified scattered within the gardens and agricultural areas. These ponds were utilised for watering plantation trees.
7	Aquaculture area	Aquaculture is practiced on a portion of Da Mi Lake for the production of fish.

[1] Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition.

[2] Modified habitats are areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition.

S/N	Habitat Type	Description
8	Submerged and aquatic grasses in riparian	These were habitats of submerged and aquatic grasses in flooded zones between maximum water levels and minimum water levels in the Da Mi Lake at the depth of under 1.0m and around 10m far from max-water level in the riparian.
9	Stream	This was a waterway of a previous existing stream, which has low water volume when the dam is closed. Some shrubs and grasses exist on the cliff.
10	Lake surface	The Da Mi Lake provides habitat for aquatic communities.

Figure 3.1 Habitats within the Project Area

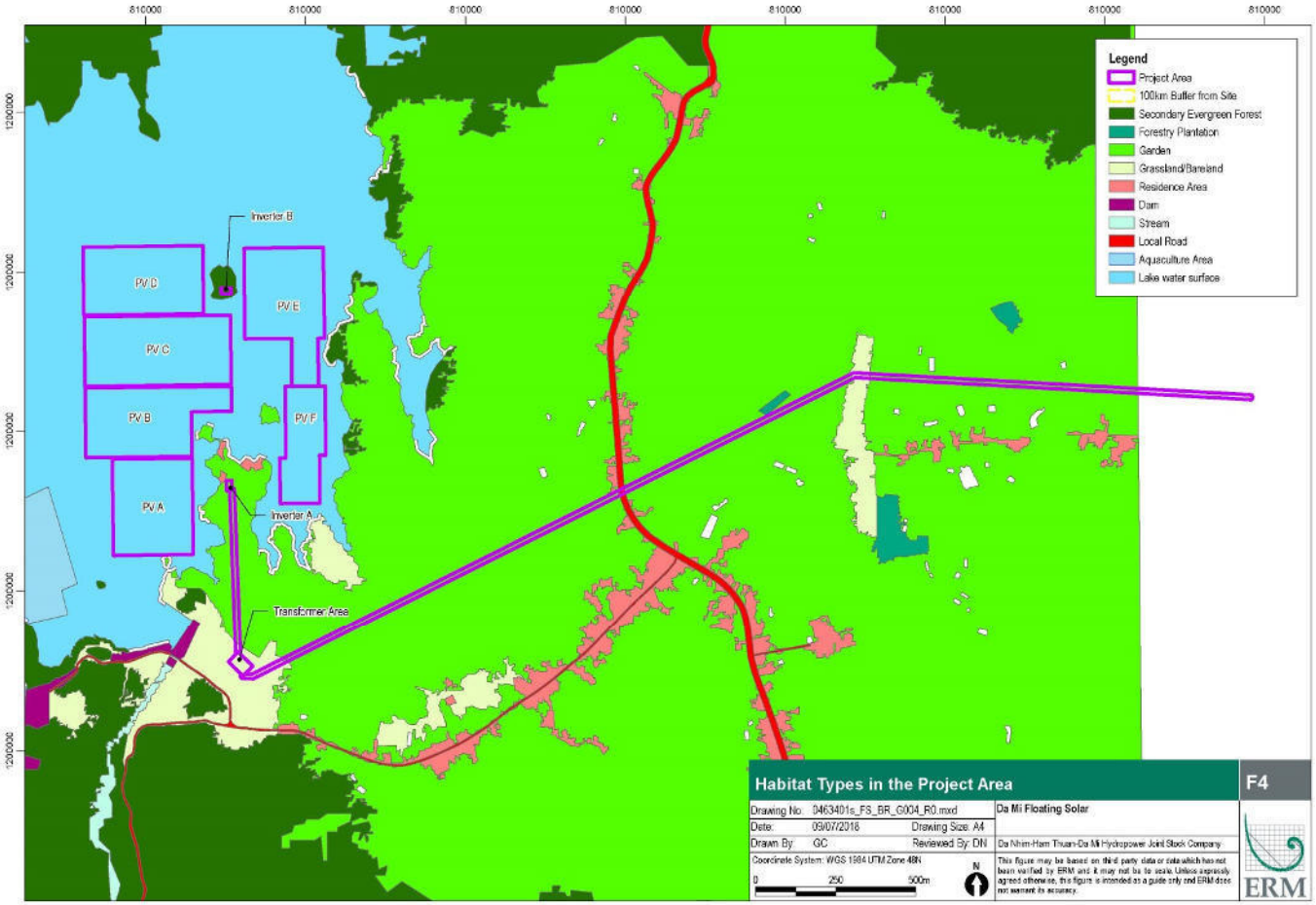


Table 3.3 Areas of Habitat Types occupied by the Project Area (To be completed)

No.	Habitat Type	Natural/Modified	Area of Influence (ha)	Project Area (ha)
1	Disturbed secondary evergreen forest			
2	Forestry plantation			
3	Gardens/agriculture			
4	Grassland/Bareland			
5	Residential area			
6	Ponds			
7	Aquaculture area			
8	Submerged and aquatic grasses in riparian			
9	Stream			
10	Lake surface			
	Total	**-**		

3.1.3 Natural Habitat and Modified Habitat

IFC PS6 requires the assessment of the distribution of Natural Habitat and Modified Habitat in order to identify risks and mitigations to biodiversity values during the impact assessment phase. There is currently no methodology within IFC PS6 and the associated Guidance Note (GN) on the approach to assess the distribution of these habitat types.

Habitat classification is has been made base on understanding of land cover classification and species assemblages within each habitat. Each land class has been assigned habitat classifications according to the definitions of IFC PS6. The justification for the classification is shown in ***Table 3.4*** below. The areas of Natural Habitat and Modified Habitat within the AoI and Project area are shown in ***Table 3.4*** and ***Table 3.5***.

Table 3.4 Natural and Modified Habitats within the Project Area and Area of Influence

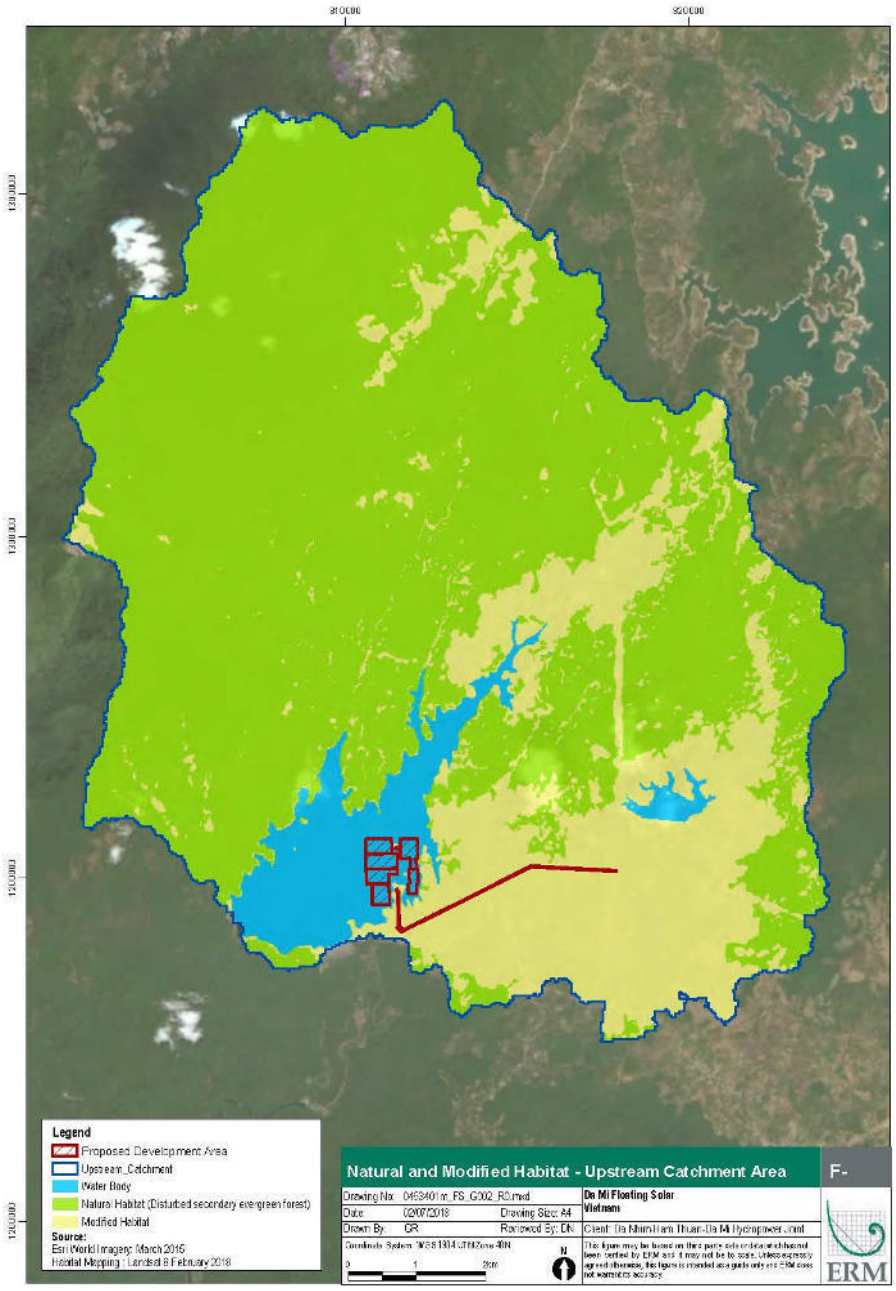
No	Land Class	IFC PS Habitat Classification
1.	Disturbed secondary evergreen forest	Natural Habitat
2.	Forestry plantation	Modified Habitat
3.	Gardens/agriculture	Modified Habitat
4.	Grassland/Bareland	Modified Habitat
5.	Residential area	Modified Habitat
6.	Ponds	Modified Habitat
7.	Aquaculture area	Modified Habitat
8.	Submerged and aquatic grasses in riparian	Modified Habitat
9.	Stream	Modified Habitat
10.	Lake surface	Modified Habitat

Table 3.5 ***Areas of Natural Habitat and Modified Habitat within the Project Area and AoI***

Habitat Type	Area of Influence (ha)	Project Area (ha)
Modified Habitat	2504.75	648.04
Natural Habitat	7407.73	0

The results of the Natural Habitat and Modified Habitat assessment are detailed in ***Figure 3.2.***

Figure 3.2 ***Natural Habitat and Modified Habitat within the Project Area and Area of Influence***



3.2 AQUATIC SURVEYS

3.2.1 Survey Methods

Aquatic organisms were collected at 14 sites at Da Mi Lake and one reference site upstream of the Project Area. Organisms, including aquatic phytoplankton, zooplankton and macroinvertebrates were recorded, counted and identified.

Phytoplankton samples were collected by deploying a conical hand net with 25 µm mesh size at each site for qualitative analysis. Further samples were then collected for quantitative analysis, by filtering 10 L of surface water through the same net. All samples were stored in plastic bottles and fixed with formalin solution (4%).

Zooplankton samples were collected by deploying a conical hand net with 40 µm mesh size at each site for qualitative analysis and then filtering 10 L of water through the same net for quantitative analysis. All samples were stored in plastic bottles and fixed with formalin solution (4%).

At each of the offshore lakesides, samples of benthic macroinvertebrates were taken a Petersen grab sampler and composited into a single sample, covering a total of 0.25 m^2. The samples sieved for macroinvertebrates and sediment materials were collected. For littoral macroinvertebrates in the riparian lakesides, samples were collected with a 10-sweep handnet, while those in drift stream samples were collected with 3-minute kicknets. All samples were stored in plastic bottles and fixed with formalin solution (4%).

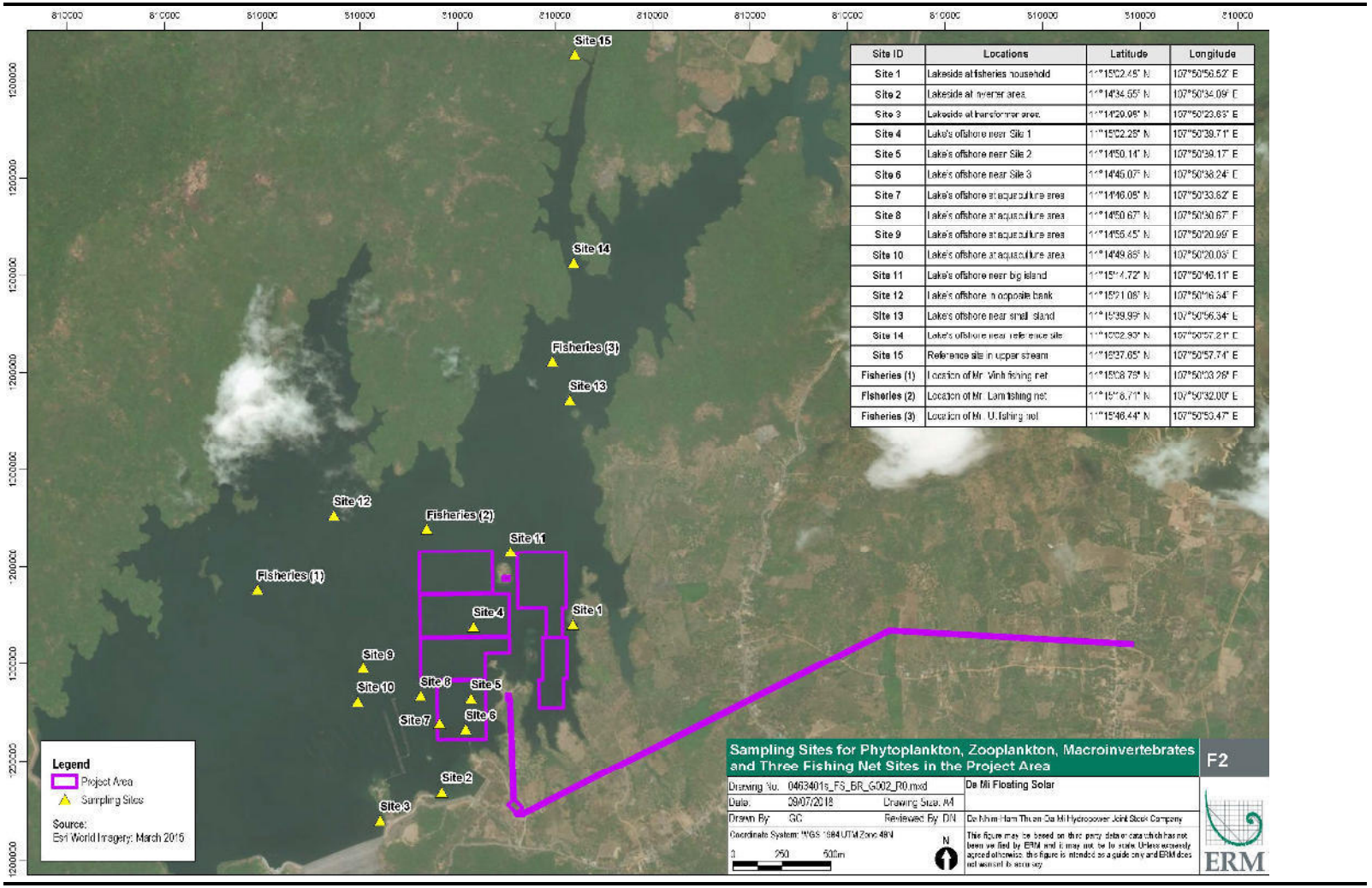
Fisheries resources of Da Mi Lake identified within the Project Area were visited and studied. Interviews were undertaken with local people and fishermen to identify the local fishing resources. Sampling of fishes was undertaken using a fishing net and rod as well as direct observation. The nets were fished at specialised locations at Da Mi Lake for about 12 hours from 3 pm to 3 am the next day.

The locations of the survey sites are shown in ***Table 3.6*** and ***Figure 3.3***.

Table 3.6 Sampling Sites for Phytoplankton, Zooplankton, Macroinvertebrates and Three Fishing Net Sites in the Project Area

Site	Locations	Longitude	Latitude
BT01	Lakeside at fisheries household	11°15′02.48″ N	107°50′56.52″ E
BT02	Lakeside at inverter area	11°14′34.55″ N	107°50′34.09″ E
BT03	Lakeside at transformer area	11°14′29.98″ N	107°50′23.63″ E
BT04	Lake's offshore near Site 1	11°15′02.26″ N	107°50′39.71″ E
BT05	Lake's offshore near Site 2	11°14′50.14″ N	107°50′39.17″ E
BT06	Lake's offshore near Site 3	11°14′45.07″ N	107°50′38.24″ E
BT07	Lake's offshore at aquaculture area	11°14′46.08″ N	107°50′33.82″ E
BT08	Lake's offshore at aquaculture area	11°14′50.67″ N	107°50′30.67″ E
BT09	Lake's offshore at aquaculture area	11°14′55.45″ N	107°50′20.99″ E
BT10	Lake's offshore at aquaculture area	11°14′49.86″ N	107°50′20.03″ E
BT11	Lake's offshore near big island	11°15′14.72″ N	107°50′46.11″ E
BT12	Lake's offshore in opposite bank	11°15′21.08″ N	107°50′16.34″ E
BT13	Lake's offshore near small island	11°15′39.99″ N	107°50′56.34″ E
BT14	Lake's offshore near reference site	11°16′02.93″ N	107°50′57.21″ E
BT15	Reference site in upper stream	11°16′37.65″ N	107°50′57.74″ E
Fisheries	Location of Mr. Vinh fishing net	11°15'08.76" N	107°50'03.28" E
Fisheries	Location of Mr. Lam fishing net	11°15'18.71" N	107°50'32.00" E
Fisheries	Location of Mr. Ut fishing net	11°15'46.44" N	107°50'53.47" E

Figure 3.3 Sampling Sites for Phytoplankton, Zooplankton, Macroinvertebrates and Fishing Sites in the Project Area



Site ID	Locations	Latitude	Longitude
Site 1	Lakeside at fisheries household	11°15'02.45" N	107°50'58.52" E
Site 2	Lakeside at riverine area	11°14'34.55" N	107°50'34.09" E
Site 3	Lakeside at transformer area	11°14'29.98" N	107°50'23.83" E
Site 4	Lake's offshore near Site 1	11°15'02.25" N	107°50'39.71" E
Site 5	Lake's offshore near Site 2	11°14'50.14" N	107°50'39.17" E
Site 6	Lake's offshore near Site 3	11°14'45.07" N	107°50'38.24" E
Site 7	Lake's offshore at aquaculture area	11°14'46.05" N	107°50'33.62" E
Site 8	Lake's offshore at aquaculture area	11°14'50.67" N	107°50'30.67" E
Site 9	Lake's offshore at aquaculture area	11°14'56.45" N	107°50'20.99" E
Site 10	Lake's offshore at aquaculture area	11°14'49.85" N	107°50'20.05" E
Site 11	Lake's offshore near big island	11°15'14.72" N	107°50'46.11" E
Site 12	Lake's offshore in opposite bank	11°15'21.05" N	107°50'16.54" E
Site 13	Lake's offshore near small island	11°15'39.99" N	107°50'56.34" E
Site 14	Lake's offshore near reference site	11°15'02.93" N	107°50'57.21" E
Site 15	Reference site in upper stream	11°15'27.65" N	107°50'57.74" E
Fisheries (1)	Location of Mr. Vinh fishing net	11°15'08.75" N	107°50'33.28" E
Fisheries (2)	Location of Mr. Lam fishing net	11°15'16.71" N	107°50'32.00" E
Fisheries (3)	Location of Mr. U fishing net	11°15'46.44" N	107°50'53.47" E

3.2.2 Analytical Methods

Samples were analysed both qualitative and quantitative samples in the laboratory using microscopes, lamme, lammelle, pipette, petri dishes. Identification of aquatic organisms was based on morphology and taxonomic books. Macroinvertebrate samples were analysed by quantitatively by counting all species abundance in the samples. Biodiversity and biotic indices were calculated from the results of the survey of aquatic environment (Shannon & Wiener, 1949).

(i) Biodiversity index (H') [Stiling, 2002]

$$H' = - \sum_{i=1}^{s} pi \ln pi$$

Where: H' = the values of biodiversity index; s = the species number per sample; pi = the rate of quantity of species number i over total quantity of a sample.

A higher value of H' suggests more species and more even numbers of various species. The diversity assessment for a range of H' values is presented in ***Table 3.7***.

Table 3.7 Score Range of the Biodiversity Index (H')

Values of Shannon-Wiener Index	Diversity Assessment
$H' \geq 2.5$	Very high diversity
$2.0 \leq H' < 2.5$	High diversity
$1.0 \leq H' < 2.0$	Medium diversity
$0.5 \leq H' < 1.0$	Low diversity
$H' < 0.5$	Very low diversity

(ii) Similarity index (S) [Stiling, 2002]

$$S = 2c/(a+b) \quad \text{(Sorensen, 1949)}$$

Where: a = the species occurred in the community A; b = the species occurred in the community B; c = the species number presented in both communities A and B.

The diversity assessment of S values is presented in ***Table 3.8***.

Table 3.8 Score Range of the Biodiversity Index (S)

Values of Sorenson Index	Similarity Assessment
$S \geq 0.8$	Very high similarity
$0.6 \leq S < 0.8$	High similarity
$0.4 \leq S < 0.6$	Medium similarity
$0.2 \leq S < 0.4$	Low similarity
$S < 0.2$	Very low similarity

(iii) SingScore [Blakely, 2014]

$$H' = \sum_{\underline{i=1}}^{i=S} a_i \times 20 \qquad \text{(Blakely et al., 2014)}$$

S

Where: S = the total number of taxa in the sample, and a_i is the tolerance value for the i^{th} taxon (**Annex A**).

The SingScore, a macroinvertebrate biotic index, was used to measure the health of the sample sites based on the tolerance or sensitivity of macroinvertebrates to an environmental gradient. The SingScore-tolerance scores for macroinvertebrates in Singapore's lotic waters are shown in **Annex A**. Macroinvertebrate families recorded in the survey which are not in **Annex A** were excluded from the SingScore analysis.

The derived SingScore value can inform on the likely water quality of the site as shown in ***Table 3.9***.

Table 3.9 Categories of likely water quality of a stream or site, based on SingScore tolerance values for macroinvertebrates in Singapore's lotic waterways

SingScore	Likely Water Quality
0 – 79	Poor
80 – 99	Fair
100 – 119	Good
120 +	Excellent

3.2.3 Results

Phytoplankton

A total of 36 species belonging to 5 phyla of phytoplankton were recorded at 15 sampling sites in the Project Area (**Annex B**). The phylum Chlorophyta recorded the highest number of species (13 species), followed by Cynanobacteria and Chrysophyta (8 species), Euglenophyta (5 species) and Dinophyta (2 species) (***Table 3.10***).

Table 3.10 Species Composition of Phytoplankton in the Project Area

Phylum	No. of Species	Percentage (%)
Chlorophyta	13	36.1
Chrysophyta	8	22.2
Cyanobacteria	8	22.2
Dinophyta	2	5.6
Euglenophyta	5	13.9
Total no. of species	36	

All species recorded were freshwater phytoplankton, revealing that all sites were located in a freshwater area. *Merismopedia glauca, Spirogyra ionia, Oedogonium crispum* and *Ceratium hirundinella* were the four species with the widest distribution as they occurred at all 15 sites. Nine species, namely *Pseudanabaena schmidlei, Lyngbya limnetica, Eunotia elegans, Nitzschia filiformis, Surirella biseriata, Ankistrodesmus falcatus, Closterium macilentum, Closterium acutum,* and *Staurastrum bigibbum,* were distributed widely as they were found at most sites. Of the 36 species, 11 were found at only three sites (sites 9, 11 and 15) (**Annex B**).

Widespread species are characteristic of those occurring in nutrient-rich conditions. These include all species of Cyanophyta and Euglenophyta, some species of Chrysophyta such as *Melosira granulata*, *Synedra ulna*, *Nitzschia filiformis*, *Pediastrum duplex*, *Pediastrum simplex* and *Scenedesmus quadricauda*.

Taxon richness ranged from 17 to 22 taxa. The highest richness occurred at BT15 (reference site), while BT07 had the lowest richness. However, number of phytoplankton species was not observed to have high fluctuations among the sampling sites.

The quantity of phytoplankton at 15 sites in the Project Area ranged from 3,070 (BT15) to 9,070 cells / liter^{-1} (BT01). *Merismopedia glauca* was dominant in 14 sites, while *Spirogyra ionia* was dominant at BT15 (**Annex C**).

The values of phytoplankton biodiversity index ranged from 1.53 to 2.02 (***Table 3.11***). Phytoplankton diversity at BT15 was the highest, while BT05 had the

lowest phytoplankton diversity. Most sites revealed medium biodiversity levels of phytoplankton communities, except BT15 with a high diversity level.

Table 3.11 Biodiversity Index of Phytoplankton in the Project Area

Site	Biodiversity Level
BT01	1.57
BT02	1.62
BT03	1.61
BT04	1.67
BT05	1.53
BT06	1.57
BT07	1.59
BT08	1.62
BT09	1.67
BT10	1.60
BT11	1.61
BT12	1.62
BT13	1.65
BT14	1.57
BT15	2.02

The values of similarity index of phytoplankton at the sites ranged from 0.49 to 0.92 (***Table 3.12***). The similarity levels of phytoplankton communities in Da Mi Lake ranged from levels of medium similarity to very high similarity. Medium to high similarity of phytoplankton communities across the sites can be attributed to the proximity of the sites in the small Project Area.

Table 3.12 Similarity Index of Phytoplankton in the Project Area

S	BT01	BT02	BT03	BT04	BT05	BT06	BT07	BT08	BT09	BT10	BT11	BT12	BT13	BT14
BT02	0.59													
BT03	0.70	0.61												
BT04	0.72	0.63	0.75											
BT05	0.59	0.78	0.61	0.63										
BT06	0.59	0.56	0.72	0.74	0.56									
BT07	0.56	0.86	0.63	0.65	0.80	0.69								
BT08	0.59	0.56	0.61	0.74	0.56	0.67	0.57							
BT09	0.58	0.65	0.65	0.77	0.59	0.65	0.61	0.70						
BT10	0.92	0.61	0.72	0.79	0.67	0.61	0.63	0.61	0.70					
BT11	0.67	0.79	0.68	0.70	0.79	0.58	0.86	0.58	0.67	0.68				
BT12	0.63	0.54	0.59	0.82	0.59	0.65	0.61	0.86	0.74	0.65	0.56			
BT13	0.65	0.62	0.67	0.73	0.62	0.62	0.63	0.72	0.85	0.72	0.63	0.65		
BT14	0.58	0.49	0.76	0.77	0.54	0.86	0.61	0.59	0.68	0.59	0.62	0.63	0.60	
BT15	0.63	0.60	0.75	0.86	0.60	0.80	0.67	0.65	0.68	0.67	0.62	0.68	0.70	0.78

Zooplankton

A total of 20 species and 4 larval forms of zooplankton were recorded at the 15 sampling sites in the Project Area (**Annex D**). The phylum Arthropoda recorded the highest number of species (11 species), followed by Rotifera (8 species) and 4 larval forms (***Table 3.13***).

Table 3.13 Species Composition of Zooplankton in the Project Area

Phylum/Form	No. of Species/Forms	Percentage (%)
Rotifera	9	37.5
Arthropoda	11	45.8
Larvae	4	16.7
Total no. of species/forms	24	

All species recorded were freshwater zooplankton, revealing that all sites were located at a freshwater area. *Bosmina longirostris*, *Ceriodaphnia rigaudi*, *Thermocyclops hyalinus*, and nauplius copepoda larva had the widest distribution of any taxon collected in June 2018, as they occurred at all 15 sites. *Polyarthera vulgaris*, *Eodiaptomus leuckarti*, and bivalvia larva were distributed widely in most sites. Of the 24 species/forms, 9 species were found at only two or three sites (**Annex D**).

Widespread species are characteristic of those occurring in nutrient-rich conditions. These include *Philodina roseola* and *Thermocyclops hyalinus*.

Taxon richness ranged from 10 to 14 taxa. The highest richness occurred at BT15, while lowest richness was observed at BT09 and BT10. However, number of zooplankton species and forms was not observed to have high fluctuations among the sampling sites.

The quantity of phytoplankton at 15 sites in the Project Area ranged from 32 (BT15) to 83 individuals/sample (BT01). *Ceriodaphnia rigaudi* was dominant at three sites (BT01, BT02, BT03), while the larva nauplius copepoda was dominant at the remaining sites (**Annex E**).

The values of zooplankton biodiversity index ranged from 1.51 to 2.02 (***Table 3.14***). Zooplankton diversity at BT15 was the highest, while BT01 had the lowest phytoplankton diversity. Most sites revealed medium biodiversity levels of zooplankton communities, except BT15 with a high diversity level.

Table 3.14 Biodiversity Index of Zooplankton in the Project Area

Site	Biodiversity Level
BT01	1.51
BT02	1.58
BT03	1.52

Site	Biodiversity Level
BT04	1.53
BT05	1.63
BT06	1.62
BT07	1.60
BT08	1.54
BT09	1.56
BT10	1.60
BT11	1.57
BT12	1.60
BT13	1.60
BT14	1.62
BT15	2.02

The values of similarity index of zooplankton at the sites ranged from 0.40 to 0.90 (***Table 3.15***). The similarity levels of zooplankton communities in Da Mi Lake ranged from levels of medium similarity to very high similarity. Medium to high similarity of zooplankton communities across the sites can be attributed to the proximity of the sites in the small Project Area.

Table 3.15 Similarity Index of Zooplankton in the Project Area

S	BT01	BT02	BT03	BT04	BT05	BT06	BT07	BT08	BT09	BT10	BT11	BT12	BT13	BT14
BT02	0.78													
BT03	0.82	0.87												
BT04	0.64	0.70	0.73											
BT05	0.42	0.56	0.50	0.75										
BT06	0.70	0.67	0.61	0.78	0.80									
BT07	0.55	0.70	0.64	0.81	0.75	0.70								
BT08	0.58	0.64	0.50	0.75	0.69	0.72	0.83							
BT09	0.48	0.64	0.48	0.67	0.58	0.73	0.67	0.70						
BT10	0.48	0.55	0.48	0.67	0.70	0.73	0.67	0.70	0.90					
BT11	0.55	0.61	0.45	0.67	0.67	0.70	0.73	0.75	0.70	0.67				
BT12	0.67	0.72	0.58	0.75	0.62	0.80	0.75	0.77	0.78	0.70	0.83			
BT13	0.61	0.58	0.61	0.87	0.64	0.75	0.78	0.80	0.64	0.64	0.78	0.80		
BT14	0.52	0.50	0.52	0.78	0.64	0.67	0.64	0.72	0.73	0.73	0.61	0.64	0.83	
BT15	0.40	0.54	0.48	0.56	0.59	0.46	0.64	0.74	0.73	0.58	0.56	0.59	0.62	0.69

Macroinvertebrates

A total of 27 species of littoral and benthic macroinvertebrates were recorded at the 15 sampling sites in the Project Area (**Annex F**). The phylum Arthropoda recorded the highest number of species (17 species), followed by Mollusca (9 species) and Annelida (1 species) (***Table 3.16***).

Table 3.16 Species Composition of Macroinvertebrates in the Project Area

Phylum	No. of Species	Percentage (%)
Annelida	1	3.7
Arthropoda	17	63.0
Mollusca	9	33.3
Total no. of species	27	

All species recorded were freshwater macroinvertebrates, revealing that all sites were located at a freshwater area.

The species belonging to Bivalvia and Insecta were distributed widely in most sites, while those belonging to Oligochaeta, Gastropoda, and Crustacea were recorded in few sites. Only one species *Limnoperna siamensis* had the widest distribution of any taxon collected in June 2018, occurring at 13 out of 15 sites. *Corbicula leviuscula* and *Corbicula cyreniformis* were also observed to have a high distribution and were observed in most sites. Of the 27 species, 4 species were found at only one site (**Annex F**).

A number of species that were widespread are characteristic of those occurring in nutrient-rich conditions. These include *Pristina longiseta* and *Polypedilum* sp. Species characteristic of swift-flowing streams at BT15 included many aquatic insect species. Additionally, the Channeled apple snail (*Pomacea canaliculata*) was identified as an invasive alien species in Circular 22/2011/TT-BTNMT on Invasive Alien Species of Ministry of Natural Resources and Environment, 2011 (***Figure 3.4***).

Figure 3.4 Invasive Alien Species Pomacea canaliculata

Taxon richness ranged from 5 to 14 taxa. The highest richness occurred at site BT15 which was observed to provide suitable habitat for littoral macroinvertebrates, while sites BT06 and BT09 had the lowest richness.

The quantity of macroinvertebrates at 15 sites in the Project Area ranged from 15 (BT09) to 43 individuals/sample (BT15). *Limnoperna siamenis* was dominant at 8 sites (BT01, BT02, BT03, BT04, BT05, BT06, BT09 and BT10), while *Pomacea canaliculata* was dominant at 6 sites (BT07, BT08, BT11, BT12, BT13 and BT14). The dominant species at BT15 was *Paraleptophlebia* sp. (**Annex F**).

The values of macroinvertebrate biodiversity index ranged from 1.24 to 2.35 (***Table 3.17***). Zooplankton diversity at BT15 was the highest, while BT05 had the lowest phytoplankton diversity. Most sites revealed medium biodiversity levels of macroinvertebrate communities, except BT15 with a high diversity level.

Table 3.17 ***Biodiversity Index of Macroinvertebrates in the Project Area***

Site	Biodiversity Level
BT01	1.47
BT02	1.41
BT03	1.31
BT04	1.35
BT05	1.27
BT06	1.24
BT07	1.41
BT08	1.32
BT09	1.37
BT10	1.44
BT11	1.47
BT12	1.39
BT13	1.49
BT14	1.47
BT15	2.35

The values of similarity index of macroinvertebrates at the sites ranged from 0.10 to 0.83 (***Table 3.18***). The similarity levels of macroinvertebrate communities in Da Mi Lake ranged from levels of low similarity to high similarity, revealing that the similarity of macroinvertebrates was different among varying substrates. Some sites had high similarity due to the close proximity of these sites from one another (BT01, BT02, BT03).

Table 3.18 Similarity Index of Macroinvertebrates in the Project Area

S	BT01	BT02	BT03	BT04	BT05	BT06	BT07	BT08	BT09	BT10	BT11	BT12	BT13	BT14
BT02	0.80													
BT03	0.80	0.71												
BT04	0.14	0.31	0.31											
BT05	0.43	0.62	0.46	0.33										
BT06	0.15	0.17	0.17	0.55	0.55									
BT07	0.29	0.31	0.46	0.67	0.55	0.36								
BT08	0.14	0.15	0.00	0.33	0.17	0.36	0.50							
BT09	0.31	0.17	0.33	0.36	0.55	0.60	0.36	0.36						
BT10	0.29	0.31	0.31	0.50	0.50	0.36	0.67	0.50	0.36					
BT11	0.13	0.27	0.27	0.29	0.29	0.62	0.43	0.57	0.31	0.43				
BT12	0.40	0.29	0.29	0.31	0.62	0.83	0.31	0.46	0.50	0.62	0.80			
BT13	0.40	0.29	0.29	0.46	0.46	0.67	0.31	0.31	0.33	0.31	0.67	0.71		
BT14	0.24	0.25	0.13	0.27	0.27	0.43	0.27	0.40	0.29	0.40	0.59	0.50	0.63	
BT15	0.27	0.10	0.10	0.10	0.20	0.11	0.20	0.10	0.21	0.10	0.27	0.10	0.10	0.17

The SingScore values of the 15 sites ranged from 40 to 140, with the likely water quality ranging from poor to excellent (***Table 3.19***). BT03 had the highest SingScore value of 140 which translates to having the best water quality among all the sites, while BT10 and BT12 had the lowest SingScore value of 30 which translates to the poorest water quality.

Table 3.19 SingScore Values and Corresponding Likely Water Quality of the 15 Sites

Site	SingScore Value	Likely Water Quality
BT01	124	Excellent
BT02	125	Excellent
BT03	140	Excellent
BT04	90	Fair
BT05	40	Poor
BT06	40	Poor
BT07	100	Good
BT08	90	Fair
BT09	90	Fair
BT10	30	Poor
BT11	107	Good
BT12	30	Poor
BT13	60	Poor
BT14	90	Fair
BT15	124	Excellent

3.2.4 Fisheries Resources

A total of 28 fish species were recorded in the Project Area (**Annex G**). The order Cypriniformes recorded the highest number of species (13 species), followed by Perciformes (7 species), Siluriformes (4 species), Synbranchiformes (2 species), Beloniformes (1 species) and Osteoglossiformes (1 species) (

Table 3.20).

Table 3.20 Species Composition of Fish in the Project Area

Order	No. of Species	Percentage (%)
Beloniformes	1	3.6
Cypriniformes	13	46.4
Osteoglossiformes	1	3.6
Perciformes	7	25.0
Siluriformes	4	14.3
Synbranchiformes	2	7.1
Total no. of species	28	

None of the species recorded in the Project Area were identified to be anadromous or catadromous. The fish in the Project Area have migrated into drift streams to feed or to reproduce.

Fish species with economic value observed in the Project Area include Nile tilapia (*Oreochromis niloticus*), Marble goby (*Oxyeleotris marmorata*), Java barb (*Barbonymus gonionotus*), Forest snakehead (*Channa lucius*) and Striped snakehead (*Channa strita)* (***Figure 3.5***). The turgeon fish was also recorded for commercial aquaculture the Da Mi Lake, where the breeding sturgeon was imported from Russia to be cultured in the area.

Figure 3.5 Important Economic Fish Species in the Project Area – Oreochromis nilotocus (left) and Oxyeleotris marmorata (right)

The weight of the total catch from the fishermen at Da Mi Lake was 16.5 kg/day, 13.8 kg/day and 15.2kg/day for Mr. Vinh, Mr. Lam and Mr. Ut respectively (**Annex H**).

Endemic, Rare and Protected Species

No species recognised in the IUCN Red Data Book and Vietnam's Red Data Book as endemic, rare and/or protected were observed during the surveys.

3.2.5 Aquatic Trophic State and Productivity

A Secchi disk was lowered into 10 sites at Da Mi Lake until it was no longer visible, and the depth was recorded. The level of eutrophication of Da Mi Lake can be determined by the Trophic State Index (TSI) using the recorded depths and the following formula:

TSI (SD) = 60 – 14.41 ln (SD) (Carlson, 1977)

Where: TSI (SD) = Trophic State Index (Secchi Depth), SD = Secchi Depth

Different ranges of TSI (SD) values correspond to varying TSI classes as shown in Table 1.26.

Table 3.21 Trophic Status Index (Secchi Depth) and Trophic Classes

Values of TSI (SD)	Trophic Class
TSI < 40	Oligotrophic
40 < TSI < 50	Mesotrophic
TSI > 50	Eutrophic

The measured Secchi depth readings, calculated TSI (SD) and corresponding trophic classes of the sites are presented in ***Table 3.22***.

All sites at Da Mi Lake were observed to be eutrophic, indicating that Da Mi Lake generally has low clarity, high productivity and high chlorophyll and phosphorus concentrations. The location of the sampling sites are shown on ***Figure 3.3***.

Table 3.22 ***Secchi Depth Reading and Light Extinction Coefficient at Da Mi Lake***

Site	Secchi Depth (m)	TSI (SD)	Trophic Class
SITE 4	1.7	52.3536469	Eutrophic
SITE 5	1.8	51.52999416	Eutrophic
SITE 6	1.9	50.7508855	Eutrophic
SITE 8	1.6	53.2272477	Eutrophic
SITE 10	1.8	51.52999416	Eutrophic
SITE 11	1.9	50.7508855	Eutrophic
SITE 12	2.0	50.01174913	Eutrophic
SITE 13	1.9	50.7508855	Eutrophic
SITE 14	1.7	52.3536469	Eutrophic
SITE 15	2.0	50.01174913	Eutrophic

3.2.6 Changes in Sunlight Penetration

Sunlight penetration into Da Mi lake was estimated by assessing changes in the amount of light penetrating the lakes surface on a monthly basis for the lake surface with and without the solar array.

This was estimated based on the average sunlight hours per day for each month of the year for Southern Vietnam. The average annual amount of solar radiation for Southern Vietnam is 5kWh per metre square each day[1]. The lake surface is 684.04ha prior to the solar array installation and 637.5ha following.

The average sunlight hours per month are shown in ***Table 3.23*** below.

Table 3.23 ***Estimated Reduction in Solar Penetration at the Lake Surface per Month***

Month	J	F	M	A	M	J	J	A	S	O	N	D
Sunlight day (hrs)	147	152	151	153	125	102	110	145	151	110	110	115

[1] Fernandez et al (2010) Maps of Solar Resource and Potential in Vietnam

Month	J	F	M	A	M	J	J	A	S	O	N	D
Solar radiation (kWh/m²)	735	760	755	765	625	510	550	725	755	550	550	575
Solar radiation lake/month (MWx1000)	503	520	516	523	428	349	376	496	516	376	376	393
Solar radiation lake/month with array (MWx1000)	469	485	481	488	398	325	351	462	481	351	351	367
Reduction (MWx1000)	**-34**	**-35**	**-35**	**-36**	**-29**	**-24**	**-26**	**-34**	**-35**	**-26**	**-26**	**-27**

Given that the solar PV are to be clustered within two nearshore areas on the south-eastern side of the lake, it would be expected that localised effects associated with a reduction in sunlight penetration would be expected underneath and immediately adjacent to the PV arrays. The remaining north-western side of the lake (comprising 93.2% of the lake surface) would not be expected to have a reduction in light penetration.

3.2.7 Aquatic Ecosystem Productivity

Using algal biomass as a surrogate for changes in ecological productivity was used to determine potential impacts to the lakes ecosystem. Given that algae are primary producers in the food chain, changes in algal biomass have flow on affects to other trophic levels within the waterbody.

Algal production in freshwater lakes is a function of: light availability, nutrient availability and temperature (Steele, 1962). The following points discuss these limiting factors in relation to Da Mi Lake and the potential changes in algal growth at the site that may arise due to the installation of the solar array.

Algal production occurs at optimum temperatures (estimated to be in range of 20-35^{0}C, dependent on the species). Temperature at the project site however is not considered to be a limiting factor given the climatic average temperatures for the area. Monthly average atmospheric temperatures for Dalat (50km North of the project site) indicate that daily average minimum and maximum temperatures vary between an average minimum temperature of 20^{0}C in January and an average maximum of 25^{0}C in May. An assessment of thermal dynamics of a reservoir in Singapore (Kranji Lake) supports this assumption with lake surface temperatures varying between 27^{0}C and 31^{0}C annually[1]. Given that water bodies tend to maintain a more static temperature than the surrounding atmosphere, it is expected that the water temperature of Da Mi Lake would not vary considerably so as to become a limiting factor in the production of algae.

[1] Xing et al (2004) Thermal structure and variability of a shallow tropical reservoir in Journal of Limnology and Oceanography.

Nutrient availability of the lake appears to be high. Water quality measurements undertaken at the site indicate that available nitrogen is elevated above recommended ecological guidelines for tropical waters, which are set at 0.01mg/l[1].Ammonium levels within Da Mi Lake are between 0.07 – 0.09mg/l as measured in June 2017. Therefore nutrient availability is also not seen as a limiting factor in relation to productivity of the lake. The production of phytoplankton within the lake subsequently is high.

The phytoplankton biomass of the lake was measured at between 3,070 to 9,070 cells per liter in June 2018. The dry weight mass of phytoplankton is highly variable, however an average of 0.01µg per cell has been used for analysis[2].

The estimation of phytoplankton biomass is therefore expressed as:

Cell Weight (µg) x Number of Cells per Litre = Dry weight per litre (µg/l)

0.01µg x 3070-9070 = 307 – 907µg/l

Given that both temperature and nutrient availability are considered to be relatively constant, light availability would therefore be the most limiting factor in relation to ecological productivity of the lake. This assumes that the lakes oxygenation remains static and sufficient mixing is available to reduce risks of anoxic conditions. It should be noted that no reports of anoxic conditions or fish kills within the lake were reported during survey by fishermen. It would appear that the lake, although eutropic, has sufficient mixing and oxygenation. This is supported by similar research in shallow lakes in Singapore that indicate that mixing occurs on a daily basis, with no observations of low oxygen conditions[3].

In order to consider changes in algal biomass, the lake was considered in terms of its entire extent (684.94ha) and the exent beneath the solar arrays (46.54ha). If light availability is the limiting factor in terms of ecological production, a reduction in light penetration would result in a subsequent reduction in productivity of the lake, particularly in areas below the solar array (46.54ha or 6.56% of the lake). Given that the solar penetration is higher in summer months (April to August), the reduction in productivity will be more pronounced during this time.

The location of the solar arrays on the south-eastern side of the lake within two bays are likely to result in a reduction of productive capacity of the waterbody at that location. Considering that the estimated dry weight of phytoplankton in the lake is high, a reduction of 50% of productivity of phytoplankton

[1] ANZECC (2000) National water quality management strategy Australian and New Zealand Guidelines for Fresh and Marine Water Quality

[2] Janek et al (1981) Estimating Phytoplankton Biomass and Productivity US Army Corp of Engineers.

[3] Xing et al (2004) Thermal structure and variability of a shallow tropical reservoir in Journal of Limnology and Oceanography.

immediately beneath the solar array would result in a dry weight of between 150 to 450 µg/l. Based on assessment of lake productivity, this level of dry weight productivity is two (2) times the measured productivity of tropical lakes measured by Melak[1].

Considering that fish communities feed on lower trophic levels (including phytoplankton and zooplankton), a reduction in the available biomass for foraging may result in reductions in fish biomass within the lake. However, the estimated reduction in productivity within the lake is considered to remain higher than other comparible tropical lakes. Therefore it is likely that sufficient foraging resource (biomass) is available for high tropic levels, including fish, within the ecosystem.

3.2.8 Terrestrial Surveys

Vegetation Survey

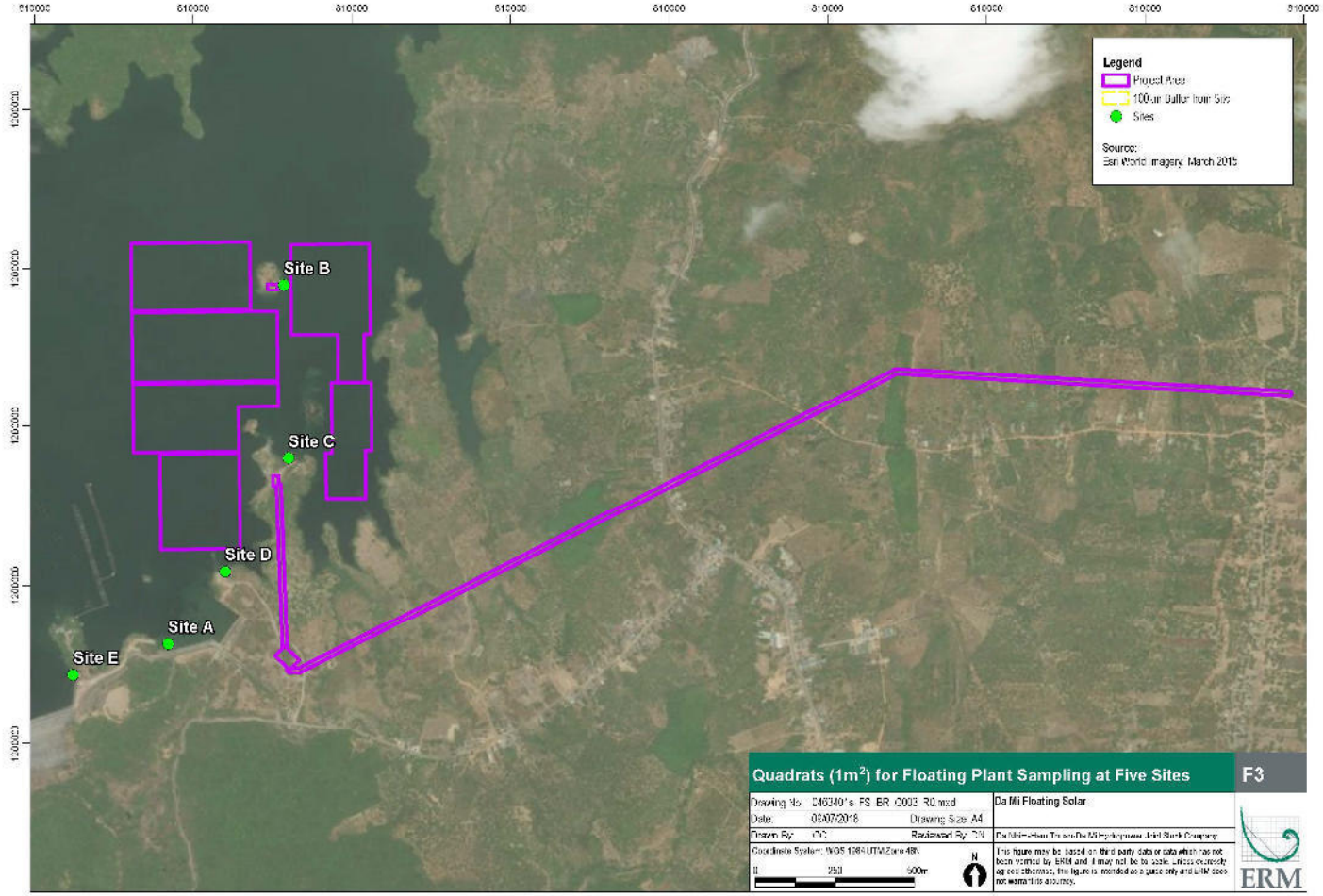
Surveys for floating plant, riparian flora, and vegetation were undertaken to identify the common and dominant species in each habitat type found within the Project Area, as well as to identify the presence of any protected or rare plant species. Representative areas of identified habitats within the Project Area were surveyed on foot and boat. All plant species encountered were identified and their relative abundance recorded in five nominal scales, namely; dominant (D), abundant (A), common (C), occupational (O), and rare (R) species. The locations of any plant species (including invasive alien species in Circular 22/2011/TT-BTNMT on Invasive Alien Species of Ministry of Natural Resources and Environment, 2011) of conservation interest observed, were also recorded.

For floating and riparian flora, five sites were chosen to set up three transects of 20 m length per site. Each transect ran from the current water level to 20 m from from lakeside. On each transect, five quadrats (1 m^2) (***Figure 3.6***) set up at the distances of 0 m, 5 m, 10 m, 15 m and 20 m from the bank. At each quadrat, the depth of water was measured. The species and the species coverage in each quadrat were also recorded.

[1] Melak et al (1979) Temporal Variability of Phytoplankton in Tropical Lakes, Oecologia Vol. 44, No. 1 (1979), pp. 1-7

Figure 3.6 1 m² Quadrat for Floating Plant Sampling

Figure 3.7 Transects for floating and riparian flora



The Pvs Area

All PVs will be located on the surface of Da Mi Lake at least 20 m from the lakeside. No aquatic vascular plants were recorded in areas with great depth, but some terrestrial and semi-aquatic species surrounding the lakeside were recorded. The submered and aquatic grass species are presented in ***Table 3.24*** and ***Table 3.25***.

Table 3.24 Abundance of Submerged and Aquatic Grass Species at Riparian Areas

Site	Species	1m	5m	10m	15m	20m
A	**Depth (m)**	**0.2**	**0.4**	**0.6**	**1.0**	**1.5**
	Cyperus polystachyos	8.33	2.50	0.33	-	-
	Limnophila chinensis	15.00	6.67	-	-	-
	Ludwigia adscendens	0.33	0.0	-	-	-
	Ludwigia hyssopifolia	1.67	0.0	-	-	-
	Mimosa pigra	-	1.67	-	-	-
	Monochoria vaginalis	1.67	0.0	-	-	-
	Nymphoides indicum	0.33	0.33	0.33	-	-
	Panicum paludosum	17.00	23.67	-	-	-
B	**Depth (m)**	**0.2**	**0.6**	**2.0**	**4.0**	**6.3**
	Cyperus polystachyos	10.00	-	-	-	-
	Mimosa pigra	10.00	-	-	-	-
	Nymphoides indicum	-	0.33	-	-	-
	Panicum paludosum	45.00	-	-	-	-
	Paspalum paspaloides	1.67	-	-	-	-
C	**Depth (m)**	**0.2**	**0.5**	**0.7**	**0.8**	**1.0**
	Leersia hexandra	16.67	10.00	-	-	-
	Ludwigia adscendens	0.33	-	-	-	-
	Mimosa pigra	53.33	16.67	-	-	-
	Nymphoides indicum		0.33	-	-	-
	Panicum paludosum	8.33	20.00	-	-	-
	Phragmites vallatoria	1.67	-	-	-	-
D	**Depth (m)**	**0.1**	**0.3**	**0.6**	**1.2**	**2.0**
	Cynodon dactylum	16.67	23.33	-	-	-
	Cyperus polystachyos	5.0		-	-	-
	Mimosa pigra	30.00	1.67	-	-	-
	Panicum paludosum	30.00	15.00	-	-	-
E	**Depth (m)**	**0.2**	**1.2**	**4.0**	**6.0**	**10.0**
	Ipomoea aquatica	3.33	-	-	-	-
	Mimosa pigra	26.67	-	-	-	-
	Monochoria vaginalis	3.33	1.67	-	-	-
	Nymphoides indicum	-	6.67	-	-	-
	Panicum paludosum	23.33	-	-	-	-
	Phragmites vallatoria	43.33	-	-	-	-

Table 3.25 Abundance of Submerged and Aquatic Grass Species in the Project Area of PVs Area

Site	Species	1m	5m	10m	15m	20m
A	**Depth (m)**	0.18	0.6	1.6	2.6	4.2
1	*Cynodon dactylum*	3.33	4.67			
2	*Cyperus polystachyos*	4.67	0.50	0.07	-	-
3	*Ipomoea aquatica*	0.67	-	-	-	-
4	*Leersia hexandra*	3.33	2.00	-	-	-
5	*Limnophila chinensis*	3.00	1.33	-	-	-

Site	Species	1m	5m	10m	15m	20m
6	*Ludwigia adscendens*	0.13	-	-	-	-
7	*Ludwigia hyssopifolia*	0.33	-	-	-	-
8	*Mimosa pigra*	24.00	4.00	-	-	-
9	*Monochoria vaginalis*	1.00	0.33	-	-	-
10	*Nymphoides indicum*	0.07	1.53	0.07	-	-
11	*Panicum paludosum*	24.67	11.67	-	-	-
12	*Paspalum paspaloides*	0.33	-	-	-	-
13	*Phragmites vallatoria*	9.0	-	-	-	-
	Total	**74.53**	**26.03**	**0.14**	**0**	**0**

Thirteeen (13) plant species were recorded at the Project Area, 11 of which were terrestrial and semi-aquatic species. Almost all of the species were common species in Vietnam. Some plants were terrestrial species growing at the lakeside and submerged by rising water levels. *Nymphoides indicum* (Thuy nu an) and *Monochoria vaginalis* (Rau mac) were the two aquatic species recorded at low abundances, and are common plants in Vietnam.

The invasive species *Mimosa pigra* (Mai duong) had a high recorded abundance (24.0). The management of this species at Da Mi Lake should be carried out to protect the ecosystem.

The majority of the species was present at 1 m and 5 m sections far from the current water level at the depths of 0.18 m and 0.6 m. At 10 m, 15 m and 20 m sections, no vascular plant species were recorded. The effect of the Da Mi PV Project on aquatic vascular plants is anticipated to be insignificant.

Flora Surrounding the PVs Area

In the terrestrial lakeside area surrounding the PVs area, 66 species belonging to 26 families were recorded (***Table 3.26***).

Table 3.26 Relative Abundance of Plant Species in the Area Surrounding the PVs Area

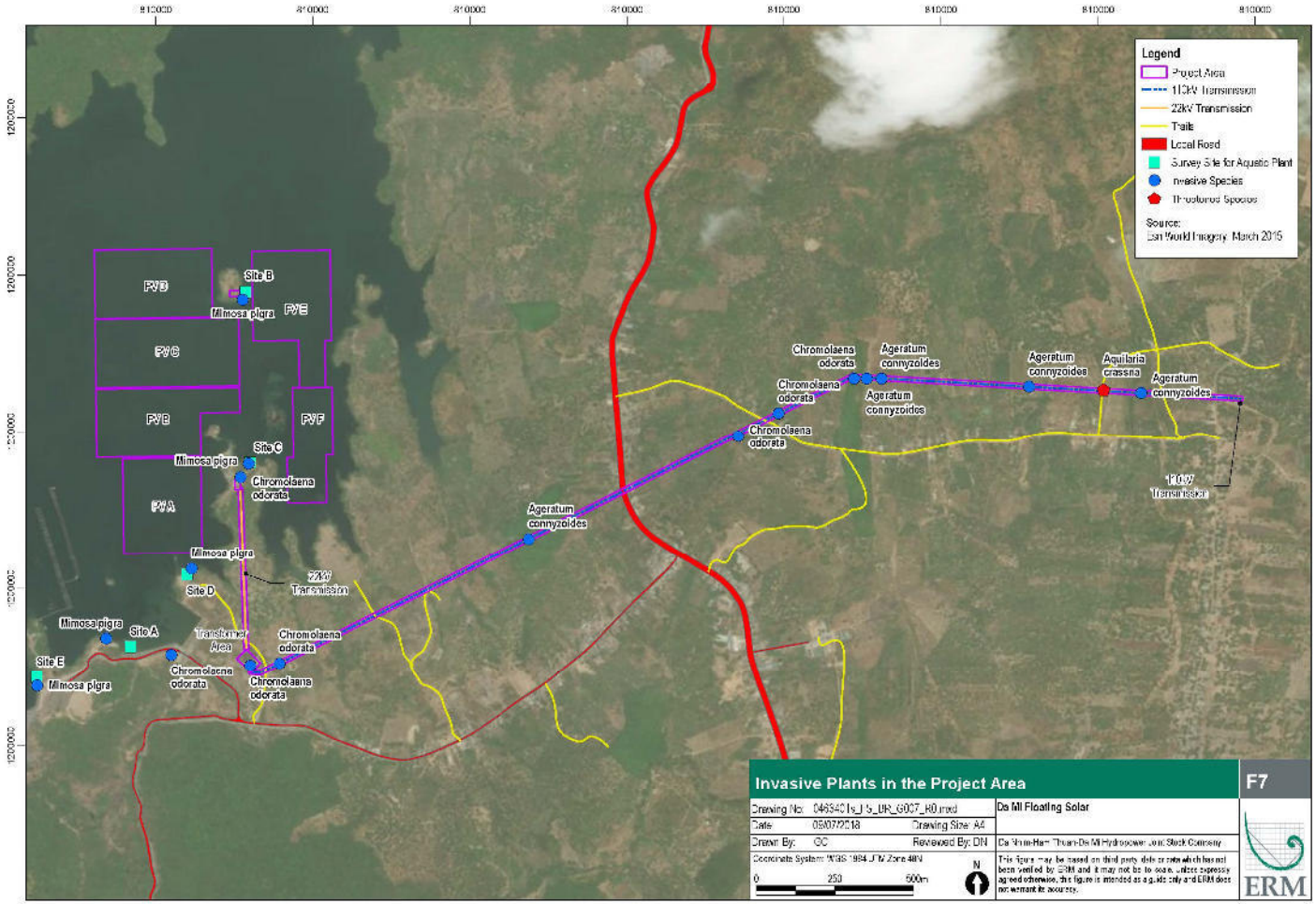
Relative Abundance	No. of Species	Percentage (%)
A	5	7.58
C	15	22.73
O	30	45.45
R	16	24.24
Total	66	

No species of conservation significance were recorded in the PVs area, according to the Vietnam Red Databook (2007) and the IUCN Red List of Threatened Species. However, the following invasive species occurred in the PVs area:

- *Mimosa pigra* (Mai duong): Abundant on lakeside (
- ***Figure 3.8***);
- *Ageratum connyzoides* (Cut lon): Abundant on gardens;
- *Chromolaena odorata* (Co hoi): Common on gardens and lakeside

Figure 3.8 Mimosa pigra observed in Project Area

Figure 3.9 Invasive Plants in the Project Area



Inverter A Area

The Inverter A area is approximately 0.055 ha, located on jackfruit and mango gardens. There were 14 species belonging to 6 families which were recorded in this area (***Table 3.27***).

Table 3.27 Relative Abundance of Plant Species in the Inverter A Area

Relative Abundance	No. of Species	Percentage (%)
A	1	7.14
C	4	28.57
O	8	57.14
R	1	7.14
Total	14	

No species of conservation significance, according to the Vietnam Red Databook (2007) and the IUCN Red List of Threatened Species, were recorded in this area. However, the following invasive species occurred in the Inverter A area:

- *Ageratum connyzoides (Cut lon): Common;*
- *Chromolaena odorata (Co hoi): Abundant.*

Inverter B Area

This area was approximately 0.06 ha, with about 50 wood trees with DBH from 20 cm – 45 cm and stand height of 12 m – 15 m. Dominant wood included *Bombax ceiba* (Gon rung), *Canarium album* (Tram trang), *Peltophorum dasyrrhachis* (Lim vang) and *Cratoxylum formosum* (Thanh nganh). There were 39 species belonging to 22 families recorded in this area (***Table 3.28***).

Table 3.28 Relative Abundance of Plant Species in the Inverter B Area

Relative Abundance	No. of Species	Percentage (%)
A	1	2.56
C	2	5.13
O	13	33.33
R	23	58.97
Total	39	

No species of conservation significance, according to the Vietnam Red Databook (2007) and the IUCN Red List of Threatened Species, were recorded in this area. However, the following invasive species occurred in the Inverter B area:

- *Mimosa pigra (Mai duong):* Common in water level surround the island;
- *Ageratum connyzoides (Cut lon):* Occasional on the island;
- *Chromolaena odorata (Co hoi):* Occasional on the island.

Transformer Area

This area was about 0.27 ha and located on grassland/bareland. The dominant grass was *Chromolaena odorata* (Co hoi) which covered about 30% of the Tranformer area (***Figure 3.10***).

Figure 3.10 Grassland in the Project Area

In this area, 15 species belonging to 7 families were recorded (***Table 3.29***).

Table 3.29 Relative Abundance of Plant Species in the Transformer Area

Relative Abundance	No. of Species	Percentage (%)
A	4	26.67
C	1	6.67
O	9	60.00
R	1	6.67
Total	15	

No species of conservation significance, according to the Vietnam Red Databook (2007) and the IUCN Red List of Threatened Species, were recorded in this area. However, the following invasive species occurred in the Transformer area: *Chromolaena odorata* (Co hoi) : Dominant in the Transformer area

Area of 15 m Width along the Transmission Line

There were 97 species belonging to 43 families recorded in this area (***Table 3.30***).

Table 3.30 ***Relative Abundance of Plant Species in the Area of 15 m Width along the Transmission Line***

Relative Abundance	No. of Species	Percentage (%)
A	8	8.25
C	22	22.68
O	33	34.02
R	34	35.05
Total	97	

Aquilaria crassna Pierre ex Lecomte (Do bau), a species listed as Endangered (EN) in the Vietnam Red Databook (2007) and Critically Endangered (CR) in the IUCN Red List of Threatened Species, was located in the coffee garden of the 110 kV transmission lines (11°14'59.33"N - 107°52'16.36"E) (***Figure 3.11***). Depite this, this species is a common tree in planting forests in Vietnam, especially in the North and Central Vietnam. Hence, there was no need to remove or replant this species in the Da Mi PV Project Area.

Figure 3.11 ***Aquilaria crassna in the Coffee Garden of the 110 kV Transmission Lines***

The following invasive species occurred in the Transmission Line area:

- *Ageratum connyzoides* (Cut lon): Dominant on rubber gardens;
- *Chromolaena odorata* (Co hoi): Abundant on gardens and grasslands;
- *Mimosa pigra* (Mai duong): Occasional grasslands.

Avifauna

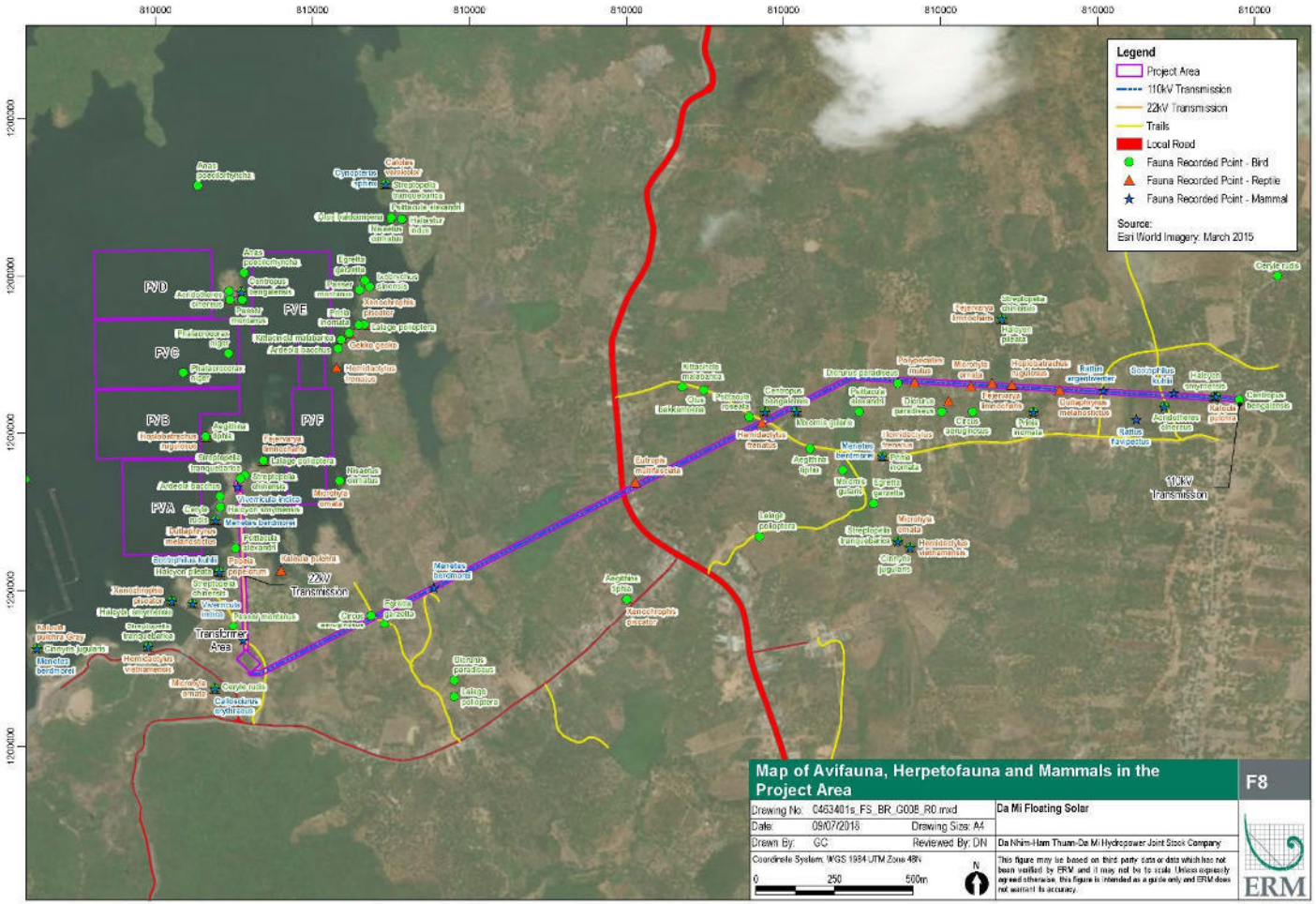
Bird communities in each habitat type recorded within the Project Area were surveyed on foot at dawn and dusk. Baseline surveys of bird populations (including invasive alien species in Circular 22/2011/TT-BTNMT on Invasive Alien Species of Ministry of Natural Resources and Environment, 2011) were

undertaken within each habitat type using quantitative survey methods (transect/point count method). Ten minutes was spent counting birds at each sampling point. All birds seen or heard within 50 m of the sampling transects/points were counted.

Signs of breeding (e.g. nests, recently fledged juveniles) within the Project Area were also recorded (Bibby et al. 2000). Observations were made using 8x binoculars and photographic records (The Canon 40D with 400 mm lens) were taken where possible. Bird species encountered outside counting points but within the Project Area were also recorded to produce a complete species list. The Point Counts (PCs) method were used to estimate relative abundance bird populations. The PCs were positioned along transects with 150 m interval distance due to open habitats in the Project Area. Two night time surveys for noctural birds were also undertaken on 1 June and 2 June 2018.

There were 26 bird species belonging to 17 families recorded in the Project Area. The list of bird species recorded within each habitat in this area is provided in **Annex I** and ***Figure 3.12***.

Figure 3.12 Locations of Avifauna, Herpetofauna and Mammals in the Project Area



The highest diversity of birds was observed in the Secondary Evergreen Forest habitat (20 species), followed the Gardens (18 species), Plantation Forests (13 species, Lake Corridors (13 species) and Residential Area (8 species) (***Table 3.31)***.

*Table 3.31 **Number of Bird Species by Habitat Type***

Habitat Type	No. of Species
Plantation Forests	13
Gardens	18
Residential Area	8
Secondary Evergreen Forest	20
Lake Corridors	13

The birds observed were common and widely distributed in both Highland Vietnam and elsewhere in Vietnam. The avifauna was dominated by resident species because the survey period did not coincide with the migratory season.

Only the White-throated kingfisher (*Halcyon smyrnensis*) had the widest distribution of any taxon collected in June 2018, as the species occurred in all habitats 5 habitats. The Eastern spotted dove (*Streptopelia chinensis*), Red turle dove (*Streptopelia tranquebarica*), Indochinese cuckooshrike (*Lalage polioptera*), Eurasian tree sparraw (*Passer montanus*) and Little egret (*Egretta garzetta*) were distributed widely in most sites. Of the 26 species, the Blossom-headed pararkeet (*Psittacula roseata*) was found at only one site (**Annex I**).

Mimosa pigra observed in Project Area was the most abundant species recorded were the White-throated kingfisher (*Halcyon smyrnensis*), Greater racquet-tailed drongo (*Dicrurus paradiseus*), Little cormorant (*Phalacrocorax niger*) and Red-breasted parakeet (*Psittacula alexandri*) (***Table 3.32***). Bird species with a high frequency of records included the Lesser coucal (*Centropus bengalensis*), Spotted dove (*Streptopelia chinensis*) and Eurasian tree sparrow (*Passer montanus*). The species observed in low frequency were the Red turtle dove (*Streptopelia tranquebarica*), Olive-Backed sunbird (*Cinnyris jugularis*), Pin-striped tit babber (*Mixornis gularis*), Chinese pond heron (*Ardeola bacchus*), Yellow bittern (*Ixobrychus sinensis*), Changeable hawk eagle (*Nisaetus cirrhatus*) and Blossom-headed parakeet (*Psittacula roseata*). Avifauna abundance at all habitats is shown in **Annex J**.

*Table 3.32 **Relative Abundance of Birds Recorded in the Project Area***

No.	Species	Habitats				
		Plantation Forests	Gardens	Residential Areas	Secondary Evergreen Forests	Lake Corridors
Bird Species with Highest Relative Abundance						
1	*Halcyon smyrnensis*	2	3	1	3	1
2	*Dicrurus paradiseus*	4	1	3	1	

No.	Species	Habitats				
		Plantation Forests	Gardens	Residential Areas	Secondary Evergreen Forests	Lake Corridors
Bird Species with Highest Relative Abundance						
3	*Phalacrocorax niger*				14	3
4	*Psittacula alexandri*	1	11			

The avifauna recorded in this area was relatively diverse in species composition. *Psittacula roseata* and *Psittacula alexandri* are two recorded species listed as Near Threatened (NT) according to the IUCN Red List of Threateaned Species. No important habitat such as breading habitat was identified within the project area for these species.

There were no recorded species listed in the Circular 22/2011/TT-BTNMT on Invasive Alien Species of Ministry of Natural Resources and Environment, 2011.

Herpetofauna

Surveys for aquatic reptiles, riparian reptiles and amphibians (including invasive alien species in Circular 22/2011/TT-BTNMT on Invasive Alien Species of Ministry of Natural Resources and Environment, 2011) were conducted through direct observation and active searching in potential hiding places such as among leaf litter, inside holes, and under stones, logs, water bodies and riparian flora within the Project Area.

Dip-netting was used to survey aquatic reptiles in streams and pools. During the surveys, all reptiles sighted and heard were recorded. The location of any observed species of conservation interest were also recorded.

Two night time surveys for nocturnal amphibians and reptiles were also undertaken on 1 June and 2 June 2018.

There were 15 herpetofauna species belonging to 10 families recorded in the Project Area by direct observation (11 species) and interviews with locals (4 species). They are species commonly found in Vietnam and are listed in **Annex K**.

The highest diversity of species was observed in Gardens (8 species) and Secondary Evergreen Forest (8 species), followed by Lake Corridors (7 species), Plantation Forests (6 species) and Residential Areas (4 species). Most herpetofauna species were recorded during night surveys. Some herpetofauna species observed in the Project Area are shown in ***Figure 3.13***.

Table 3.33 Number of Herpetofauna Species by Habitat Type

Habitat Type	No. of Species
Plantation Forests	6

Habitat Type	No. of Species
Gardens	8
Residential Area	4
Secondary Evergreen Forest	8
Lake Corridors	7

Calotes versicolor ***Hemidactylus vietnamensis***

Fejervarya limnocharis ***Microhyla ornata***

Figure 3.13 Some Herpetofauna Species Observed in the Project Area

The most abundant species observed in the Project Area were the Asian grass frog (*Fejervarya limnocharis*) and Black throated frog (*Microhyla ornata*). Herpetofauna species with a high record frequency included the Asian common toad (*Duttaphrynus melanostictus*) and Banded bullfrog (*Kaloula pulchra*). The Herpetofauna found in low abundance were the Green tree frog (*Dryophytes cinereus*) and Eastern garden lizard (*Calotes versicolor*).

Important and Invasive Species

Most recorded herpertofauna species in the Project Area were common species. Only the Tokay gecko (*Gekko gecko*) is listed as Vulnerable (VU) in the Vietnam Red Databook (2007). No observed species were listed in the Circular 22/2011/TT-BTNMT on Invasive Alien Species of Ministry of Natural Resources and Environment, 2011.

Mammals

The mammal surveys (including invasive alien species in Circular 22/2011/TT-BTNMT on Invasive Alien Species of Ministry of Natural Resources and Environment, 2011) were conducted covering each habitat type through active searching. As most mammals in the Project Area occur at low densities,

indicators of presence such as signs, tracks, faecal remains and burrows, and potential bat roost sites were actively searched for. Two night time surveys for nocturnal mammals were also undertaken on 1 June and 2 June 2018.

A total of 8 mammal species belonging to 5 families were recorded in the Project Area by direct observation (6 species) and interviews with locals (2 species). They are species commonly found in Vietnam and are listed in **Annex L**.

The highest mammal diversity was observed in Gardens (5 species), followed by Secondary Evergreen Forest (4 species), Plantation Forests (3 species), Lake Corridors (3 species) and Residential Area (2 species) (***Table 3.34***).

Table 3.34 Number of Mammal Species by Habitat Type

Habitat Type	No. of Species
Plantation Forests	3
Gardens	5
Residential Area	2
Secondary Evergreen Forest	4
Lake Corridors	3

Evening surveys recorded only rat and bat species with no signs of other animals. Generally, mice were abundant in the Project Area, and the presence of bats flying across the landsape was also observed.

The most abundant species were the Rice-field rat (*Rattus argentiventer*) and Lesser asiatic yellow bat (*Scotophilus kuhlii*). In general, the density of the mammal species was low as they are sentitive and tend to avoid areas with high human activity.

No mammal species observed in the Project Area are of conservation ssignificance according to the Vietnam Red Databook (2007) and IUCN Red List of Threatened Species. None of the species are listed in the Circular 22/2011/TT-BTNMT on Invasive Alien Species of Ministry of Natural Resources and Environment, 2011.

4 CRITICAL HABITAT

4.1 CRITICAL HABITAT SCREENING

Determination of Critical Habitat is a process that usually follows the assessment as to whether the habitat in question is either Natural or Modified. Natural habitats are generally of higher biodiversity value than Modified Habitats, although both can still support species that trigger Critical Habitat.

The determination of Critical Habitat is also not completely limited to Criteria 1-5 and other recognised high biodiversity values may also qualify for Critical Habitat designation which is carried out on a case by case basis.

Examples may include but not be limited to: areas of high scientific value; concentrations of Vulnerable species (under the IUCN Red List of Threatened Species) where there is uncertainty regarding their listing; and landscape and ecological processes (e.g. water catchment areas, areas which prevent flooding or fire).

The following Critical Habitat assessment utilises the assessment methodology as outlined in the IFC Performance Standard 6 and associated Guidance Note. The ADB SPS however has minor differences in terms of definitions and outcomes (in terms of requiring no-net-loss outcomes for Critical Habitat whilst PS6 requires a Net Gain). ERM has referred to the ADB SPS where relevant in the assessment.

4.2 DISCRETE MANAGEMENT UNIT

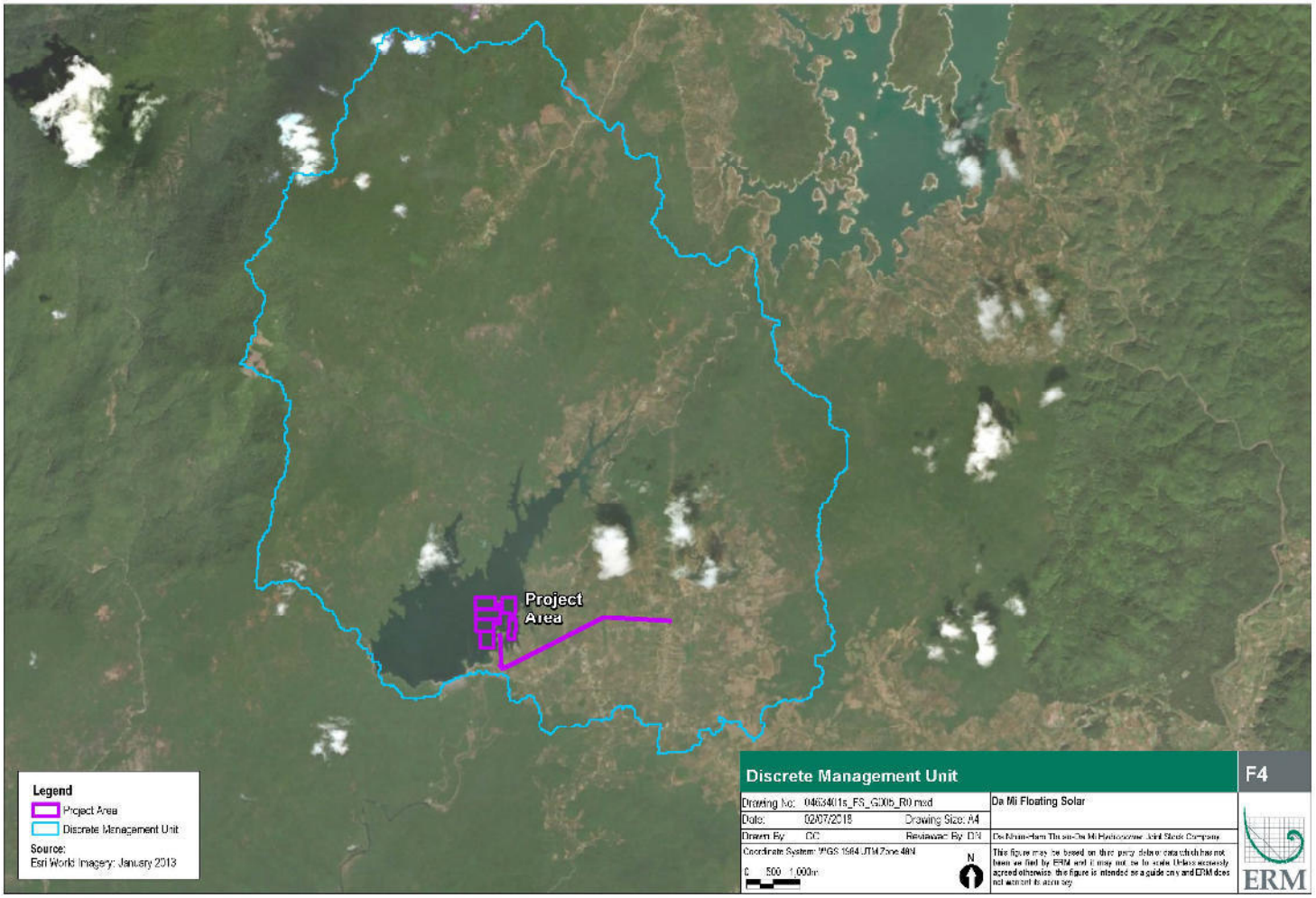
Based on IFC PS 6 Guidance Note 6, the project is required to 'determine a sensible ecological or political boundary that defines the area of habitat to be considered for the Critical Habitat assessment'. Termed as a Discrete Management Unit (DMU), this is an area with a 'definable boundary within which the biological communities and/or management issues have more in common with each other than they do with those in adjacent areas'. DMUs may hence be defined using ecological boundaries such as rivers and mountain ridges/valleys where wildlife is determined to be unable to cross, management boundaries such as a Protected Area, or an artificial barriers to movement such as roads and urban areas. DMUs do not imply management control or responsibility by the project, and often include areas outside of their control. The DMU also does not indicate project footprint or impacted area, and in most cases is larger than either of these. This ensures impacts on biodiversity values in the larger landscape are adequately considered.

For this project, the DMU has been defined as the watershed of Da Mi Lake upstream of the dam wall. The species assessed are generally wide ranging

(apart from endemic bird species). ERM has therefore estimated the likely ecological unit of the surrounding habitat based on the species that occur in the area, including migratory marine and terrestrial species that are wider ranging that are likely to inhabit the project area and immediate surrounds

The DMU for this project is outlined in ***Figure 4.1***.

Figure 4.1 Discrete Management Unit



4.3 *CRITERION FOR CRITICAL HABITAT*

The Critical Habitat assessment comprised an analysis of biodiversity values within the project area and area of influence, habitats of high biodiversity value, species of conservation concern and general flora and fauna assemblages. This involved GIS analysis; desk based data collection including a review of previous EIAs, and targeted field surveys at karst surface and cave habitats.

Critical Habitat criteria are defined in PS6 Guidance Note 6 (GN6), Paragraphs GN69 to 97. ***Table 4.1*** provides detail of the qualifying requirements for Criteria 1 to 3 (i.e. thresholds), while details of the likely qualifying interests for Criterion 4 and 5 will be defined based on research and expert opinion. The criteria listed have been used to complete this assessment. ERM has listed the ADB SPS critical habitat definition against the equivalent IFC PS6 criterion for comparative purposes.

The five criteria are 'triggers' in that if an area of habitat meets any one of the criteria, it will be considered Critical Habitat irrespective of failing to meet any other criterion(10). Therefore, Critical Habitat can be determined through a single criterion or where a habitat holds biodiversity meeting all five criteria. This approach is generally more cautious but is used more widely in conservation (11). Critical Habitat criteria therefore have two distinctive characteristics. First, components of biodiversity are essentially assigned to only two levels of conservation significance, those that trigger Critical Habitat and those that do not (Tier considerations being secondary to this primary Critical Habitat determination). Second, each criterion is applied separately and not in combination, meaning that the scores are not cumulative.

(10) The Biodiversity Consultancy (TBC) (2013) getting through PS6: Critical Habitat and its requirements. Case Studies from Guinea and Mongolia.Whitmore, T.C. (1984) Tropical Rain Forests of the Far East. Oxford University Press. Second Edition.

(11) McDonald-Madden, E. Gordon, A. Wintle, B. Walker, S. Grantham, H. Carvalho, S. Bottrill, M. Joseph, L. Ponce, R. Stewart, R. & Possingham, H. P. (2009). "True" Conservation Progress. Science 323: 43-44.

Table 4.1 Criteria Habitat Criteria

ADB SPS Equivalent Clause	IFC PS6 Criteria	Tier 1(1)	Tier 2(1)
Areas with high biodiversity value	No equivalent IFC PS6 Criteria. Includes: internationally recognised areas, Key Biodiversity Areas, Nationally Protected Areas or areas of high biodiversity significance outside the protected area system. It should be noted that Endemic Bird Areas are not recognised as an internationally recognised area and are considered as important for habitat-based bird conservation.		
Habitat required for the survival of critically endangered or endangered species	Criterion 1: Critically Endangered (CR) / Endangered (EN) species:	a) Habitat required to sustain ≥ 10 % of the global population of a CR or EN species /sub /species and where there known regular occurrences of the species and where habitat could be considered a discrete management unit for the species. b) Habitat with known, regular occurrences of CR or EN species where that habitat is one of 10 or fewer discrete management sites globally for that species.	c) Habitat that supports the regular occurrence of a single individual of a CR species and/or habitat containing regionally- important concentrations of Red-listed EN species where that habitat could be considered as a discrete management unit for the species/subspecies. d) Habitat of significant importance to CR/EN species that are wide-ranging and/or whose population distribution is not well understood and where the loss of such a habitat could potentially impact the long-term survivability of the species. e) As appropriate, habitat containing nationally/regionally important concentrations of an EN, CR or equivalent national/regional listing.
Areas having special significance for endemic or restricted-range species	Criterion 2: Habitat of significant importance to endemic and/or restricted-range species;	a) Habitat known to sustain ≥ 95 % of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species.	b) Habitat known to sustain ≥ 1 % but < 95 % of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgment.
Sites that are critical for the survival of migratory species	Criterion 3: Habitat supporting globally significant concentrations of migratory species and/or congregatory species;	(a) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 95 % of the global population of a migratory or congregatory species at any point of the species' lifecycle where that habitat could be considered a discrete management unit for that species.	(b) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 1 % but < 95 % of the global population of a migratory or congregatory species at any point of the species' lifecycle and where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgment. (c) For birds, habitat that meets BirdLife International's Criterion A4 for congregations and/or Ramsar Criteria 5 or 6 for Identifying Wetlands of International Importance.

ADB SPS Equivalent Clause	IFC PS6 Criteria	Tier 1(1)	Tier 2(1)
			(d) For species with large but clumped distributions, a provisional threshold is set at ≥ 5 % of the global population for both terrestrial and marine species. (e) Source sites that contribute ≥ 1 % of the global population of recruits.
As Above	Criterion 4: Highly threatened and/or unique ecosystems; and/or	Criterion 4 has no tiered system although recent publication (Keith et al, 2013) may introduce this. This criterion must include one of the following a) the ecosystem is at risk of significantly decreasing in area or quality; b) has a small spatial extent; and /or c) Contains unique assemblages of species including assemblages or concentrations of biome-restricted species. Highly threatened or unique ecosystems are defined by a combination of factors which may include long-term trend, rarity, ecological condition, and threat.	
	Criterion 5: Areas associated with key evolutionary processes	The criterion is defined by: a) the physical features of a landscape that might be associated with particular evolutionary processes; and/or b) Sub-populations of species that are phylogenetically or morphogenetically distinct and may be of special conservation concern given their distinct evolutionary history. The latter includes evolutionarily significant units and evolutionarily distinct and globally endangered species.	
Areas with unique assemblages of species or that are associated with key evolutionary processes or provide key ecosystem services	No equivalent IFC PS6 Criteria. Assessed in Ecosystem Services assessment using the World Resources Institute Guidelines		

Notes:
Under IFC PS6, there is no Tier system is in place for Criterion 4 and Criterion 5.
With regard to IFC PS6 Criterion 2, it should be noted that an endemic and restricted range species is defined by the IFC as one that possesses an extent of occurrence of 50,000 km2 (IFC pers. comms). Plant species may qualify as endemic if has ≥95% of its global range inside the country or region of analysis.

4.4 CRITICAL HABITAT CANDIDATE SPECIES

From the background assessment and results of the field baseline surveys, ERM has identified a number of Critical Habitat candidate species that require screening against the criterion contained in ***Table 4.1*** above. These species are shown in ***Table 4.2*** below.

Table 4.2 Critical Habitat Candidate Species

Taxonomic group	Species	Common name	IUCN Red List Category	Source	Critical Habitat Triggers
Amphibians	*Kalophrynus cryptophonus*		EN	IBAT	CR or EN species
Amphibians	*Rhacophorus helenae*		EN	IBAT	CR or EN species
Birds	*Emberiza aureola*	Yellow-breasted Bunting	CR	IBAT	CR or EN species
Birds	*Gracula robusta*	Nias Hill Myna	CR	IBAT	CR or EN species
Birds	*Gracula venerata*	Tenggara Hill Myna	EN	IBAT	CR or EN species
Birds	*Gyps bengalensis*	White-rumped Vulture	CR	IBAT	CR or EN species
Birds	*Rheinardia ocellata*	Crested argus	NT	WWF	Endemic
Birds	*Pavo muticus*	Green Peafowl	EN	IBAT	CR or EN species
Birds	*Sarcogyps calvus*	Red-headed Vulture	CR	IBAT	CR or EN species
Birds	*Sterna acuticauda*	Black-bellied Tern	EN	IBAT	CR or EN species
Birds	*Arborophila davidi*	Orange-necked Partridge	NT	EBA Trigger species	Endemic
Birds	*Polyplectron germaini*	Germain's Peacock-pheasant	NT	EBA Trigger species	Endemic
Birds	*Lophura edwardsi*	Edwards's pheasant	CR	WWF	Endemic/ CR or EN species
Birds	*Garrulax yersini*	Collared laughingthrush	EN	WWF	Endemic/ CR or EN species
Birds	*Garrulax ngoclinhensis*	Golden-winged laughingthrush	VU	WWF	Endemic
Birds	*Jabouilleia danjoui*	Short-tailed scimitar-babbler	NT	WWF	Endemic
Birds	*Mixornis kelleyi*	Grey-faced Tit-babbler	LC	EBA Trigger species	Endemic
Birds	*Actinodura sodangorum*	Black-crowned barwing	NT	WWF	Endemic

Taxonomic group	Species	Common name	IUCN Red List Category	Source	Critical Habitat Triggers
Birds	*Crocias langbianis*	Grey-crowned crocias	EN	WWF	Endemic/ CR or EN species
Birds	*Carduelis monguilloti*	Vietnamese greenfinch	LC	WWF	Endemic
Fishes	*Catlocarpio siamensis*	Giant Carp	CR	IBAT	CR or EN species
Fishes	*Pangasianodon hypophthalmus*	Striped Catfish	EN	IBAT	CR or EN species
Fishes	*Scleropages formosus*	Golden Dragon Fish	EN	IBAT	CR or EN species
Mammals	*Chrotogale owstoni*	Owston's Civet	EN	IBAT	CR or EN species
Mammals	*Rattus hoxaensis*		NA	WWF	Endemic
Mammals	*Rattus osgoodi*		LC	WWF	Endemic
Mammals	*Maxomys moi*		LC	WWF	Endemic
Mammals	*Dendrogale murina*		LC	WWF	Endemic
Mammals	*Hylobates gabriellae*	Yellow-cheeked gibbon	EN	WWF	Endemic/ CR or EN species
Mammals	*Manis javanica*	Sunda Pangolin	CR	IBAT	CR or EN species
Mammals	*Muntiacus vuquangensis*	Large-antlered Muntjac	CR	IBAT	CR or EN species
Mammals	*Nomascus gabriellae*	Red-cheeked Gibbon	EN	IBAT	CR or EN species
Mammals	*Pygathrix nigripes*	Black-shanked Douc Langur	EN	EBA Trigger species	Endemic/ CR or EN species
Mammals	*Pygathrix nemaeus*	Red-shanked douc	EN	WWF	Endemic/ CR or EN species
Mammals	*Trachypithecus germaini*	Indochinese Lutung	EN	IBAT	CR or EN species
Mammals	*Viverra megaspila*	Large-spotted Civet	EN	IBAT	CR or EN species
Mammals	*Capricornis sumatraensis*	Serow	VU	EBA Trigger species	Endemic
Mammals	*Nycticebus pygmaeus*	Pygmy Slow Loris	VU	EBA Trigger species	Endemic
Plants	*Magnolia cattienensis*		EN	IBAT	CR or EN species
Reptiles	*Crocodylus siamensis*	Siamese Crocodile	CR	IBAT	CR or EN species

4.5 CANDIDATE CRITICAL HABITAT SUMMARY

4.5.1 Critical Habitat Criterion 1-3

The results of the Critical Habitat screening assessment for species according to Criterion 1-3 is outlined in *Annex B*. No Critical Habitat species were identified from the screening assessment.

4.5.2 Critical Habitat Criterion 4

IFC PS6 describe this Criterion to be one of the following: ecosystem is at risk of significantly decreasing in area or quality; small spatial extent; and /or contains unique assemblages of species including assemblages or concentrations of biome-restricted species.

Highly threatened or unique ecosystems are defined by a combination of factors which may include long-term trend, rarity, ecological condition, and threat.

No Critical Habitats under Criterion 4 were identified from this assessment

4.5.3 Critical Habitat Criterion 5

Criterion 5 has no tiered system though IFC PS6 describes this Criterion to be one of the following: physical features of a landscape that might be associated with particular evolutionary processes (for example isolated areas, areas of high endemism, spatial heterogeneity, environmental gradients, edaphic interfaces, biological corridors or sites of demonstrated importance to climate change adaptation); and/or subpopulations of species that are phylogenetically or morphogenetically distinct and may be of special conservation concern given their distinct evolutionary history. The latter includes evolutionarily significant units and evolutionarily distinct and globally endangered species. There are no physical features within the AoI that are known to be associated with evolutionary processes.

4.6 ECOSYSTEM SERVICES

4.6.1 Defining Ecosystem Services

Ecosystem services are defined as the benefits that people, including businesses, derive from ecosystems (IFC 2012). These services are substantial and varied, underpinning basic human health and survival needs as well as supporting economics activities, the fulfillment of people's potential, and enjoyment of life.

In order to provide a uniform basis to assess the status of all major global habitat across all of the word's bioregions, the United Nation's Millennium Ecosystem Assessment (UN 2005) combine diverse Ecosystem Services typologies into a consistent classification scheme.

There are four categories of ecosystem services defined in Millennium Ecosystem Assessment as outlined in IFC Performance Standard 6:

Provisioning Services; these services that can be extracted from ecosystem to support human needs. This term is more or less synonymous with the term " **Ecosystem Goods**" that was used in some prior classification schemes, including such tangible assets as fresh water, food, fiber, timber and medicinal plants;

Regulating Services; the benefit obtained from an ecosystem's control of the natural environment, including of the regulation of surface water purification, carbon storage, and sequestration, climate regulation, protection from natural hazard, air quality, erosion and pests;

Cultural Services; non-material benefits including diverse aspect of aesthetic, spiritual, recreational, and others cultural value;

Supporting services; the natural process essential to the maintenance of the integrity, resilience, and functioning of ecosystem, thereby supporting the delivery of all other benefits. They include soil formation, nutrient cycling, and primary production.

4.6.2 Applicable Standards and Guidelines

The ADB SPS requires that ecosystem services are assessed when determining whether a project triggers the requirements for Critical Habitat. The definition of Critical Habitat under the SPS (Clause 151 of the ADB Source Book) specifically references ecosystem services as a component of Critical Habitat. Clause 183 of the ADB Source Book also identifies ecosystem services as a component necessary for assessment in relation to sustainable natural resource management (ADB 2012).

The International Finance Corporation's (IFC) performance standards require projects to assess and preserve the benefits from ecosystem services. The IFC also requires that the environmental and social risks and impacts identification process considers a project's dependence on ecosystem services. A fundamental component is to apply the mitigation hierarchy to determine measures to limit impacts on ecosystem services.

ERM has utilized the WRI Guidelines: *Weaving Ecosystem Service into Impact Assessment* to guide the approach used to assess ecosystem services in relation to the project. The ecosystem services review was undertaken following a five-stage approach (WRI 2014):

- ***Screening assessment*** to Identify Ecosystem Services that may occur within the study area;
- ***Data Collection and prioritization*** for 'screened in' Ecosystem Services;
- ***Scoping***; to refine the list of ecosystem services based on those identify in the study area and potentially impacted by the project;
- ***Prioritization*** to identify Ecosystem services importance to beneficiaries; and;
- ***Impact Assessment*** to identify the impacts to ecosystem services and their human beneficiaries as a result of the project

4.6.3 Ecosystem Services Baseline Assessment

Methods

Interviews with relevant stakeholders and government officers were conducted to collect relevant data regarding ecological services for the Project Area.

Results

The ecological services identified in the Project Area were fishing activities, aquaculture, payments for forest environment services, collection of firewood, bamboo exploitation and recreational fishing.

Fishing Activities

During the survey period, three fisherman at Da Mi Lake commented that there were about 5 or 6 professional fishing households who collect fish in the area using fishing nets. The usual catch ranges from 5 kg to 30 kg of fish per day, which consists of mainly the Nile tilapia (*Oreochromis niloticus*), Marble goby (*Oxyeleotris marmorata*) and occasionally sturgeons that are likely escapees from the nearby aquaculture area run by Tam Long Co. Ltd. Fishing farmers Mr. Vinh (32 years old), Mr. Lam (46 years old), and Mr. Ut (50 years old).

Figure 4.2 ***Fishermen at Da Mi Lake***

Aquaculture

At Da Mi Lake, the Tam Long Joint Stock Company runs aquaculture activities for the sturgeon of more than 14,000 m^2 of cages, producing hundreds of tons of commercial fish each year.

Figure 4.3 ***Sturgeon aquaculture at the Da Mi Lake***

Collection of Firewood

According to Mr. Phuoc (62 years old), there were about 10 households which collect firewood for fuel in the forest as Mr. Phuoc has purchased timber from farmers. Locals occasionally enter the forest to collect firewood by cutting trees as well.

Bamboo exploitation

During the survey, no bamboo collectors were observed in the forest. Forest rangers also did not respond to questions related to the issues of bamboo harvesting in the forest.

Local people reported that some people have harvested bamboo in the forest and soaked it in Da Mi Lake before selling the bamboo elsewhere.

Recreational Fishing

During the survey, approximately 15 – 20 people came to Da Mi Lake for recreational fishing activities each day. Mr. Anh, a ranger in the Da Mi ranger station said that no agency has announced the management of fishery resources in the lake at present. Rangers and local people only used boats to ferry fishermen to their desired locations with prices for 50,000 VND/person. Local people also said that there no agencies currently manage the recreational fishing activities at Da Mi Lake.

Figure 4.4 Recreational Fishing at Da Mi Lake

4.6.4 Ecosystem Services Screening Assessment

An ecosystem services screening assessment was undertaken to determine the likely ecosystem service values that could be potentially important to affected communities.

The scoping exercise was undertaken in order to refine the list of Ecosystem Services that:

- **Potential Beneficiaries**: Known and potential beneficiaries for a service were identified and where possible identifying people at the local, national, and / or global level;

- **Sources of Impact**: Potential sources of impact were considered based on the social data obtained for the site;

- **Project Dependence:** IFC PS-6 requires that the Ecosystem Services assessment take into consideration any services that the Project may rely upon during construction, operation and/or decommissioning. Therefore all services for which there is a potential project dependency were scoped into the prioritisation stage.

The goal of the scoping exercise was to identify a list of Ecosystem Services to be assessed during through the surveys.

This assessment was done using existing sources of data, including information gleaned during the scoping visit.

The results of the scoping assessment are contained in ***Table 4.3***.

Table 4.3 Ecosystem Services Screening Assessment

Ecosystem Service Type	Description, Examples	Current Known Ecosystem Services	Screened in?
Provisioning Services			
• Food: wild-caught fish and shellfish & aquaculture	• Fish caught for subsistence or commercial sale; Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of fresh- or salt-water confinement for harvesting	• Fish were caught within Da Mi Lake for local consumption. Fish were also grown in aquaculture ponds.	Yes
• Food: wild meat	• Animals hunted for primarily for food (recreational hunting covered under cultural services)	• Not identified	No
• Food: cultivated crops	• Annual and permanent crops grown for subsistence use and commercial sale	• Crops were identified within the Project Area and surrounds, including cashew nuts, rubber	Yes
• Food: herbs and plants	• Herbs and plants collected for food by local people	• Not identified	No
• Livestock farming	• Sedentary and nomadic livestock farming	• Not identified	No
• Biomass fuel	• Wood, dung and plant matter collected for charcoal, fuel	• Not identified	No
• Timber and wood products	• Wood collected for local use or for sale as timber, wood pulp and paper	• Not identified	No
• Non- Timber Forest Products (NTFP)	• Non-timber products collected from the forest. For example, cane, palm, straw, cotton, hemp, twine and rope, natural rubber	• Not identified	No
Regulating Services			
• Freshwater	• Freshwater for bathing, drinking, irrigation, laundry, household and industrial use	• Freshwater use was identified used for drinking and irrigation.	Yes
• Biochemical, natural medicines, pharmaceuticals	• Natural medicines, biocides, food additives, pharmaceuticals and other biological material for commercial or domestic use. For example, pelts, carved or decorative animal products, live animal trade	• Not identified	No
	• Genes and genetic information used for animal breeding, plant improvement, and biotechnology	• Not identified	No
• Ecosystem functions	• The influence ecosystems have on air quality by extracting chemicals from the atmosphere (i.e., serving as a "sink") or emitting chemicals to the atmosphere (i.e., serving as a "source")	• Not considered significant	No
	• Carbon sequestration (impacts on global climate change) regulation of temperature, shade air quality by vegetated areas	• Not considered significant	No
	• Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge	• Not considered significant	No
	• Role played by vegetation and bacteria in the filtration and decomposition of organic wastes and pollutants and the assimilation and detoxification of compounds.	• Not considered significant	No

Ecosystem Service Type	Description, Examples	Current Known Ecosystem Services	Screened in?
	• Role of natural habitats (e.g. wetlands, beaches, reefs) in protecting crops, buildings, recreation areas from waves, wind and flooding from coastal storms.	• Not considered significant	No
	• Regulation of fire frequency and intensity (e.g. dense forest can provide firebreaks)	• Not considered significant	No
	• Predators from forests, grassland areas, etc. may control pests attacking crops or livestock	• Not considered significant	No
	• Influence ecosystems have on the incidence and abundance of human pathogens	• Not considered significant	No
	• Role of vegetation in regulating erosion on slopes and riparian areas	• Not considered significant	No
	• Birds, insects and some small mammals pollinate certain flora species, including some agricultural crops	• Not considered significant	No
Cultural Services			
• Spiritual, religious or cultural value	• Natural spaces or species with spiritual, cultural or religious importance	• Not identified	Yes
	• Cultural value placed on traditional practices such as hunting, fishing, crafts and use of natural resources.	• Not identified	No
	• Use of natural spaces and resources for tourism and recreation (e.g. swimming, boating, hunting, bird-watching, fishing)	• Da Mi lake is used for recreation and swimming	Yes
	• Cultural value placed on the aesthetic value provided by landscapes, natural landmarks	• Not identified	No
	• Information derived from ecosystems used for intellectual development, culture, art, design, and innovation.	• Not identified	No
	• Ornamental resources	• Not identified	No
Existence Values			
• Non-use value of biodiversity (e.g. existence, bequest value)	• Species and areas valued globally as of high conservation value	• Not identified	Yes
	• Formation of biological material by plants through photosynthesis and nutrient assimilation.	• Not identified	No
	• Flow of nutrients (e.g., nitrogen, sulfur, phosphorus, carbon) through ecosystems.	• Not identified	No
	• Flow of water through ecosystems in its solid, liquid, or gaseous forms.	• Not identified	No
	• Natural soil-forming processes throughout vegetated areas.	• Not identified	No
	• Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances.	• Not identified	No

4.6.5 Ecosystem Services Prioritisation

The WRI guidelines and IFC PS6 requires that priority ecosystem services are identified, and impacts to those services are assessed (IFC 2012). The prioritization process is aimed at identifying those services for which Project impacts would be most likely to result in adverse impacts on project affected communities and other beneficiaries. Using the information collected through the baseline data collection and stakeholder engagement processes, Ecosystem Services were prioritized according to a priority matrix ranking two criteria:

- Importance of the ecosystem service to the beneficiary which considers the intensity of use, degree of dependence and the importance expressed by the project affected communities; and

- Irreplaceability of the ecosystem service, which refers to the availability of alternatives, the accessibility, cost and appetite for those alternatives as discussed with the beneficiary.

After compiling baseline information on the importance and irreplaceability of each service, these ratings were combined to assign a priority rating to the service grading from *Low* to *Major* as shown in the ecosystem service prioritization matrix in ***Table 4.4***.

Ecosystem services identified as *High* priority or *Major* priority were considered Priority Ecosystem Services. The weight given to each of these components varied slightly depending upon the service, but stakeholder values were given precedence over other criteria where the rating was not clear.

In addition to the above, according to the IFC definition of priority ecosystem services, all services for which project dependencies are identified are considered priority services. The importance and irreplaceability of services relied upon by the Project was assessed through the same prioritization process outlined above, with the Project filling the role of the beneficiary.

In addition to the prioritization exercise, the baseline data collection process provided the opportunity to collect information on the status, trends and sustainability of resource use as they pertain to the habitats and species that support Ecosystem Services. This information was gathered through secondary sources and field studies by the environment team and where appropriate through engagement with local stakeholders. This information is important for the assessment of impacts on Ecosystem Services and therefore on local people as the final receptors of these changes.

Table 4.5 outlines the beneficiaries, potential sources of impact and project dependence for each service, and whether the service was scoped into or out of the Ecosystem Services assessment.

This *section* provides an assessment of the potential Project impact to ecosystem services using the criteria provided.

Table 4.4 Ecosystem Service Prioritization Matrix

Importance to Beneficiaries		**Irreplaceability**		
		High	Moderate	Low
Low	The service is used and valued by parts of the community, but it is not important in maintaining quality of life or livelihoods of Project Affected Communities.	Low Priority	Low Priority	Moderate Priority
Medium	The service is readily used by some members of the Project Affected Communities for income or subsistence, but they are not dependent upon the service for their livelihoods, and not everyone utilises the service.	Low Priority	Moderate Priority	High Priority
High	The service is highly important in maintaining the livelihoods of the Project Affected Communities, and is used by most of the community regularly.	Moderate Priority	High Priority	Major Priority
Essential	The service is essential to maintain the health of the Project Affected Communities, and the service is used by all members of the community.	High Priority	Major Priority	Major Priority
Irreplaceability definition				
High	Many spatial alternatives exist that are readily available to the Project Affected Communities, and there are no major impediments to their usage.			
Moderate	Spatial alternatives exist but are either less accessible than the affected service, or there are other barriers to their use such as distance, cost and skills required to access the service.			
Low	There are few to no spatial alternatives available to the Project Affected Communities.			

Table 4.5 Results of Prioritization

Ecosystem Services	Trends and Sustainability	Beneficiaries	Importance to Beneficiaries	Irreplaceability	Potential Alternatives	Priority?
Provisioning Services						
• Food: wild-caught fish and shellfish & aquaculture	There is no current data available on the sustainability of the fishery.	Local people are the beneficiaries of the fishery.	It is likely that the fish caught are sold at local markets and used for consumption.	It is considered that fish caught can be replaced by alternate sources of protein. Income of local fishermen may be replaced by alternative work (if available)	Protein from other livestock. Alternative livelihoods for fishermen.	High Priority
• Food: cultivated crops	There is no current data on the crop yield or sustainability of agriculture within the AoI.	Local people are the beneficiaries of the agricultural produce, however some may be sold to other villages.	Cultivated crops are important to local people as a food source and also as income.	Cultivated land is considered irreplaceable, however the crops may be replaced by the purchasing of alternative food sources.	Alternative food sources may be purchased by local people.	Moderate Priority
Regulating Services						
• Freshwater	There is currently not current data on the availability of freshwater within the project area for local people.	Local people depend on freshwater for drinking and agricultural uses.	The local people depend on clean freshwater for use.	The availability of freshwater is irreplaceable.	Bottled or trucked water may be available for household use. There would be no replacement available for irrigation water.	High Priority
Cultural Services						
• Use of natural spaces and resources for tourism and recreation (e.g. swimming, boating, hunting, bird-watching, fishing)	Some local businesses have been created reliant on natural spaces.	Local people benefit through income sources.	The income sources derived from the businesses are important to local people.	The income sources are replaceable if alternative livelihoods are established.	Alternative businesses are available to replace the incomes if the service was lost.	Moderate Priority.

4.6.6 Priority Ecosystem Services

The following priority ecosystem services shown in ***Table 4.6*** have been identified and will be assessed against the impact assessment procedures.

Table 4.6 Priority ecosystem services

Provisioning Services
• Food: wild-caught fish and shellfish & aquaculture
• Food: cultivated crops
Regulating Services
• Freshwater
Cultural Services
• Use of natural spaces and resources for tourism and recreation (e.g. swimming, boating, hunting, bird-watching, fishing)

5.1 ASSESSMENT APPROACH AND CRITERIA

The legal framework of relevance to terrestrial and aquatic biodiversity is listed below:

- *ASEAN Agreement on the Conservation of Nature and Natural Resources, 1985;*
- *IFC PS6 Biodiversity Conservation and Sustainable Management of Living Natural Resources, 2012;*
- *ADB Safeguard Policy Statement – Environment Safeguard;*
- *World Bank IFC General EHS Guidelines, 2007;*
- *World Bank IFC EHS Guidelines for Electric Power Transmission and Distribution, 2007.*

The significance of the impacts has been assessed using the approach and methodology as described. The criteria for sensitivity to and magnitude of the impact to Terrestrial Biodiversity (Habitat & Species) are defined in ***Table 5.1*** to ***Table 5.4.***

Table 5.1 Sensitivity Criteria for Biodiversity - Habitat

Sensitivity	Definition
Low	• Habitats with no, or only a local designation/ recognition, habitats of significance for species listed as Least Concern (LC) on IUCN Red List of Threatened Species, habitats which are common and widespread within the region, or with low conservation interest based on expert opinion.
Medium	• Habitats within nationally designated or recognised areas, habitats of significant importance to globally Vulnerable (VU), Near Threatened (NT), or Data Deficient (DD) species, habitats of significant importance for nationally restricted range species, habitats supporting nationally significant concentrations of migratory species and/ or congregatory species, and low value habitats used by species of medium value.
High	• Habitats within internationally designated or recognised areas, habitats of significant importance to globally Critically Endangered (CR) or Endangered (EN) species, habitats of significant importance to endemic and/ or globally restricted-range species, habitats supporting globally significant concentrations of migratory species and/ or congregatory species, highly threatened and/ or unique ecosystems, areas associated with key evolutionary species, and low or medium value habitats used by high value species.

Source: ERM, 2012a

Table 5.2 Magnitude Criteria for Impacts to Biodiversity – Habitat

Magnitude	Definition
Negligible	• No existing habitat is affected
Small	• Affects only a small area of habitat, such that there is no loss of viability/ function of the habitat.
Medium	• Affects part of the habitat, but does not threaten the long term viability/ function of the habitat.
Large	• Affects the entire habitat, or a significant proportion of it, and the long term viability/ function of the habitat is threatened.

Source: ERM, 2012a

Table 5.3 Sensitivity Criteria for Biodiversity – Species

Sensitivity	Definition
Low	• Species and sub-species of LC on the IUCN Red List, or not meeting criteria for medium or high value.
Medium	• Species on IUCN Red List as VU, NT, or DD, species protected under national legislation, nationally restricted range species, nationally important numbers of migratory, or congregatory species, species not meeting criteria for high value, and species vital to the survival of a medium value species.
High	• Species on IUCN Red List as CR, or EN. Species having a globally restricted range (i.e. plants endemic to a site, or found globally at fewer than 10 sites, fauna having a distribution range (or globally breeding range for bird species) of less than 50,000 km^2), internationally important numbers of migratory, congregatory species, key evolutionary species, and species vital to the survival of a high value species.

Source: ERM, 2012a

Table 5.4 Magnitude Criteria for Impacts to Biodiversity – Species

Magnitude	Definition
Negligible	• No species is affected
Small	• Effect does not cause a substantial change in the population of the species, or other species dependent on it.
Medium	• Effect causes a substantial change in abundance and/ or reduction in distribution of a population over one, or more generations, but does not threaten the long term viability/ function of that population, or any population dependent on it.
Large	• Affects entire population, or a significant part of it causing a substantial decline in abundance and/ or change in and recovery of the population (or another dependent on it) is not possible either at all, or within several generations due to natural recruitment (reproduction, immigration from unaffected areas).

5.2 SCOPING OF LIKELY IMPACTS TO BIODIVERSITY VALUES

Table 5.5 broadly defines the types of threats to biodiversity values that have potential to occur from Projects.

Table 5.5 Typical Biodiversity Impact Types

S/N	Term	Description
1.	Loss of aquatic habitat	Permanent loss of aquatic habitat or species due to permanent or temporary site activities.
2.	Changes to aquatic habitat functionality	Changes to the physical and chemical dynamics of an aquatic environment that can result in modifications to the functionality of the habitat.
3.	Loss of terrestrial habitat	Permanent loss of terrestrial habitat or species due to permanent or temporary site activities.
4.	Disturbance or displacement of individuals • Light • Noise • vibration impacts	Temporary disturbance to, or displacement/exclusion of a species from foraging habitat due to construction activities, and operational and maintenance activities. Permanent impacts from light, noise and vibration sources on surrounding habitats during operation causing disturbance and displacement and changes in behaviour
5.	Barrier creation, fragmentation and edge effects	Permanent and temporary creation of barriers to the movements of animals, especially fish, but also mammals, reptiles and amphibians and invertebrates and plants with limited powers of dispersal. Fragmentation of habitat, or permanent /temporary severance of wildlife corridors between isolated habitats of importance for biodiversity. Impacts that occur when a habitat is exposed to a different adjacent habitat type or structure. These impacts can include increased risk of parasitism or disease, increased risk of predation, adverse microclimate conditions (including drying out and subsequent fire risk), and competition from invasive species
6.	Degradation of habitat • Dust • Water pollution • Invasive species	Disturbance or damage to adjacent habitat and species caused by changes in microclimate, vulnerability to predation and invasion and overall changes in conditions that can lead to a change in the community and its values for flora and fauna. This can include increased exposure to noise, light and dust. Introduction or spreading of alien species during the construction works.
7.	Mortality – vehicle strike, hunting, fishing and poaching	Mortality of individual fauna species as a result of vehicle or machinery strike or falling debris during clearing activities. Mortality to individual fauna species as a result of worker influx and hunting/poaching of extant fauna
8.	Impact to ecosystem services	Impacts to high and medium priority ecosystem services provided to local people, including provisioning, regulating and cultural services.

5.3 *LIKELY IMPACTS TO BIODIVERSITY VALUES DUE TO THE PROJECT*

The scoping and screening of potential Project impacts identified a number of Project aspects and activities that have potential to biodiversity values. Whilst the potential impacts relate to a combination of Project aspects/activities and biodiversity threats, they can be summarised into a number of key potential impacts according to the biodiversity threat type. These impacts can relate to habitat areas, specific species or both.

Project activities that may have an impact on terrestrial biodiversity during the construction and operation phases are outlined in ***Table 5.6*** below.

Table 5.6 Likely Impacts to Biodiversity Values

S/N	Term	Description
1.	Loss of aquatic habitat	Permanent loss of habitat from clearance and preparation for the construction of the floating solar facility and associated infrastructure. Loss of lake surface habitat for floating macrophytes and associated biota. Habitat loss for benthic species could occur as a result of anchoring the PV array
2.	Changes to aquatic habitat functionality	Changes in aquatic habitats due to altered light, evaporation and oxygen penetration at the lake surface due to the physical presence of the floating PV solar panels could impact aquatic biodiversity through a number of mechanisms, including shading and reduced oxygen exchange and evaporation.
3.	Loss of terrestrial habitat	Permanent loss of habitat from clearance and preparation for the construction of the transmission line and associated infrastructure.
4.	Barrier creation, degradation of habitat, fragmentation and edge effects	Fragmentation of habitats in terrestrial habitats during construction and operation from erection of barriers (fences), construction of the transmission line, roads, pipelines and habitat loss. Degradation of habitat due to the construction activities of floating solar facility and associated infrastructure including the access road, and transmission line
5.	Mortality – vehicle strike, hunting, fishing and poaching	Direct mortality to fauna and flora from: hunting, fishing and poaching from the workforce and local residents; and avifauna along the transmission line due to strike during operation
6.	Ecosystem Services	Direct impacts to high and medium ecosystem services, including the provision of freshwater, fisheries and ecosystem functions.

5.4 IMPACT DURATION FOR PROJECT PHASES

Table 5.7 scopes the impacts likely during the construction, operational and decommissioning phases of the Project. The impact assessment for these impact types are further assessed below.

Table 5.7 Scoping of Potential Impacts during Construction and Operational Phases

S/N	Type of Impact	Direct/ Indirect	Construction Phase	Operational Phase
1.	Loss of aquatic habitat	Direct	Yes	No
2.	Changes to aquatic habitat functionality	Indirect	No	Yes
3.	Loss of terrestrial habitat	Direct	Yes	Continuing from construction phase
4.	Barrier creation, degradation of habitat, fragmentation and edge effects	Direct	Yes	Continuing from construction phase
5.	Mortality – vehicle strike, hunting, fishing and poaching	Indirect	Yes	Continuing from construction phase

S/N	Type of Impact	Direct/ Indirect	Construction Phase	Operational Phase
6.	Mortality: Avifauna Infrastructure Strike with Tranmission Line	Direct	Yes	Continuing from construction phase
7.	Ecosystem Services	Indirect	Yes	Continuing from construction phase

Notes:

Yes: considered to be likely impacts during the phase

No: considered that there will be no impacts or negligible impacts during the phase

Continuing from construction/operation phase: the impact is likely to continue from the operation phase and the mitigations outlined are appropriate to manage impacts during construction and/or operational phase.

Reassessed for operational phase: the impact is likely to be different during the phase and hence is reassessed based on the likely impacts. Additional mitigations may be outlined to apply to this phase.

5.5 ASSESSMENT OF IMPACTS

This section discusses on the nature of impacts to biodiversity values at it relates to the characteristics of the Project Area as determined by assessing the impacts of the Project Description (*Section 1*). The information has been used to inform the evaluation of the significance of the impact in the impact assessment summary tables following each impact assessment type. Impact assessments have been undertaken for both the Construction Phase and Operation Phase.

ERM has utilised the mitigation hierarchy to outline avoidance, mitigation and compensation (offset) requirements as required by the ADB SPS and IFC PS6.

5.5.1 Assessment of Impacts – Loss of Aquatic Habitat

Description of Relevant Baseline Conditions

Habitat is important to support the lifecycles of aquatic fauna identified with the Project area. This includes aquatic habitat for breeding, foraging and roosting. Removal of the habitat reduces the habitat available to resident species and the ecological value of the area.

No surface macrophytes or assocated biota are present on the lake surface where the array if to be installed; therefore no loss of habitat is expected. No important benthic habitat or sessile benthic species are present; therefore loss of any small areas of lakebed habitat as a result of anchor placement are not deemed significant.

The biodiversity values identified within the aquatic ecosystem are considered low and of a highly impacted nature. The aquatic habitat identified within the Project area is considered to be Modified Habitat.

No aquatic species were identified that are considered to be Critical Habitat candidate species. Widely distributed species and species of economic value to local people were identified within the Lake. These are assessed separately in for ecosystem services at Section below. The area of the lake surface that will be covered by floating PV is 6.8%.

The area to be occupied by floating PV within Da Mi Lake is outlined in ***Table 5.8***.

Table 5.8 Area of Floating PV within Da Mi Lake

PV	Area (ha)
PV A	7.48
PV B	8.19
PV C	9.89
PV D	8.09
PV E	8.36
PV F	4.56
Total	**46.58**
Da Mi Lake Surface Area	**684.04**
PV Cover Percentage	**6.8%**

The proportion of the lake surface that will be impacted from the floating PV is 6.8% of the total lake surface (46.58ha/684.04ha).

Avoidance Measures Adopted

No additional avoidance measures are recommended.

Impact Assessment

The loss of habitat is not considered to be significant. The significance of impacts associated with aquatic biodiversity using the assessment of significance during construction activities are presented in ***Table 5.9.***

The sensitivity of Modified Habitats are considered to be **Low**. The magnitude of effect is likely to be **Small/Medium** as it will effect only a small area of habitat, but without the loss of viability/function of the habitat. The overall impact is therefore likely to be **Minor** for Modified Habitat before Mitigation Measures.

Table 5.9 Assessment of Impacts

Evaluation of Significance		Sensitivity/Vulnerability/ Importance of Resource/Receptor
		Modified Habitat
		Low
Magnitude of Impact	**Negligible**	Negligible
	Small	**Negligible**
	Medium	Minor
	Large	Moderate

Recommended Mitigation Measures

No additional Mitigation Measures are recommended.

5.5.2 Assessment of Impacts Changes to Aquatic Habitat Functionality

Desciption of relevant baseline conditions

The presence of infrastructure on the surface of a lake reduces the wavelengths of light which penetrate the surface of the lake which is used by submerged aquatic plants and phytoplankton. Any effect on phytoplankton could cascade to biota at other trophic levels, since they are the primary producers

A reduction in primary production in a lake with problematic levels of eutrophication could be seen as a positive impact; however in some circumstances an impact on the fisheries resource may be expected. In addition, phytoplankton species composition may be affected, with knock-on effects on other biodiversity.

Reduced light penetration is also expected to have the overall effect of reducing water body temperature, primarily by reducing the heating effect of the sun, making thermal stratification less likely and slowing the rate of water body processes such as productivity and the breakdown of organic compounds, which can also affect aquatic biota. Given the relatively high and stable atmospheric and lake temperatures in this part of Vietnam, this is considered unlikely to be significant.

Wind blowing over the surface of a water body results in oxygen exchange and any surface installation that covers the lake surface may interfere with this process, due to the presence of a physical barrier to gaseous exchange. The lack of mixing has the potential to increase the risk of stratification and harm aquatic biota, including through pollutant release from sediment due to lack of oxygen at depth. The presence of a physical barrier at the waterbody surface can also inhibit evaporation, reducing water loss. This issue however is unlikely to be significant given that the solar array is proposed within shallower bays on the

south-eastern side of the lake where exposure to the atmosphere and subsequent oxygenation of water is likely to be higher (compared to oxygenation and mixing with water at depth). Given the small percentage of the lake surface occupied by the floating solar array, and degree of mixing elsewhere in the lake, any significant impact on biota due to reduced oxygen exchange or evaporation appears unlikely.

The ecological productivity of Da Mi Lake is classified as eutrophic at all water depths (Trophic Status Index >50). The species of zooplankton and macroinvertebrates identified were representative of species that occur in nutrient rich conditions. Based on literature reviews, it is likely that sunlight availability is the limiting factor in terms of productivity of the lake. Given this, it is expected that productivity loss would occur immediately below the array. The impact may mean a reduction in algal productivity and hence a reduction in current eutrophic conditions. Given that the solar penetration is higher in summer months (April to August), the reduction in productivity will be more pronounced during this time.

An assessment of biomass derived from phytoplankton levels in the lake indicate that the lake is currently highly productive. The assessment has identified that a reduction of 50% of the estimated dry weight of phytoplankton in the lake would result in a dry weight of between 150 to 450 µg/l, which is twice the productive rate of compared reference tropical lakes.

Considering that fish communities feed on lower trophic levels (including phytoplanktono and zooplankton), a reduction in the available biomass for foraging may result in reductions in fish biomass within the lake. However, the estimated reduction in productivity within the lake is considered to remain higher than other comparible tropical lakes. Therefore it is likely that sufficient foraging resource (biomass) is available for high trophic levels, including fish, within the ecosystem.

The impact assessment has concluded that only a negligible effect on aquatic biota is expected as a result of the installation and operation of the floating solar array. Very little research has, however, been undertaken on the ecological impacts of such installations. The variety of impact mechanisms combined with their potentially conflicting outcomes means that making predictions is not straightforward. It is therefore recommended that precautionary post-deployment monitoring of the lake ecosystem takes place . This should include monitoring of trophic dynamics to assess the continued functioning of the ecosystem.

The significance of impacts associated with aquatic biodiversity using the assessment of significance during construction activities are presented in ***Table 5.10.***

The sensitivity of Modified Habitats are considered to be **Low**. The magnitude of effect is likely to be **Small/Medium** as it will effect only a small area of habitat, but without the loss of viability/function of the habitat. The overall impact is therefore likely to be **Minor** for Modified Habitat before Mitigation Measures.

Table 5.10 Assessment of Impacts

Evaluation of Significance		Sensitivity/Vulnerability/ Importance of Resource/Receptor
		Modified Habitat
		Low
Magnitude of Impact	**Negligible**	Negligible
	Small	Negligible
	Medium	**Minor**
	Large	Moderate

Recommended Mitigation Measures

It is recommend that the following mitigation measures be applied in relation to habitat impacts during construction:

- All floating PV panels are to be "glass on glass" transparent type to enable light penetration of the lake surface. A minimum spacing of 50cm is to be placed between panel arrays to increase light penetration between arrays during the daily movement of the sun. Arrays are to be placed at least 20cm above the lake surface to enable airflow and light penetration below the panels.

- Watershed management activities are to occur within the lake to reduce nutrient runoff entering the lake. A Watershed Management Plan is to be prepared that outlines the activities to reduce nutrient loads. The plan is to include:

    1. Working with government agencies and stakeholders to identifysources of nutrients entering waterways from land uses, including the use of fish meal, fertilisers, livestock and effluent systems (domestic and agricultural);

    2. Working with stakeholders to identify both educational and physical measures to alter practices that are contributing to nutrients entering the Lake;

    3. Identifying measures to reduce existing nutrient loads within the lake, including planting and harvesting of macrophytes.

    4. Monitoring activities to trigger adaptive management as required (See *Monitoring Measures* below.

Monitoring Measures

The following monitoring measures are recommended:

- Water quality and aquatic flora assessments are to occur on a weekly basis during construction. Oxygen levels and sampling of aquatic flora is to occur. If algal blooms are detected or the Lake is determined to be continualy eutrophic, additional mitigation measures are to be considered including: mechanical mixing devices; and oxygenation of the water column through installation of air pipelines.

- Quarterly monitoring of the biota at different trophic levels (phytoplankton, zooplankton, aquatic macroinvertebrates and fish) and depth profile physicochemistry during the operational phase to allow for the detection of effects and adaptive management measures if necessary. A monitoring plan has been attached at *Annex P*.

- Regular (weekly) checks during construction are to occur along all project boundaries to ensure compliance with clearing within marked boundaries;

- Records are to be kept and regularly reviewed (3 monthly) for implementation of the workforce training program for fauna/flora awareness;

- Records are to be kept and regularly reviewed (3 monthly) of all personnel entering and exiting the project area through checkpoints, including results of all random inspections undertaken for poached flora/fauna;

- A regular social engagement (12 monthly) survey is to occur to gauge the socialisation of conservation measures, including the coastal revegetation program.

Assessment of Residual Impact

In view of the implementation of mitigation measures, the residual impact is to reduce to **Negligible** for Modified Habitat.

5.5.3 Assessment of Impacts: Loss of terrestrial habitat

Description of Relevant Baseline Conditions

The transmission line for the project will pass through modified habitat. The transmission line length is 3.3km and the sub station will occupy 5000m^2 of land. Given that the spacing of the transmission towers is 100m, it is expected that 16 towers will be used along the length of the line. Given that the expected base for each tower is 100m^2, the total loss of terrestrial habitat due to the transmission line would be 3200m^2. The total loss of modified habitat is therefore estimated at 8200m^2.

The modified habitats present along the transmission line do not play host to threatened species. However, transmission lines may cause mortality to avifauna due to collision. This impact is assessed below in relation to potential mortality impacts.

Avoidance Measures Adopted

No additional avoidance measures are recommended.

Impact Assessment

The significance of impacts associated with the loss of terrestrial habitat during construction activities are discussed and presented in ***Table 5.11.***

The magnitude of effect due to loss of terrestrial habitat is **Medium** as the effect will not cause a substantial change in the population of the species present, or other species dependent on them during construction.

The overall magnitude of this impact is therefore **Minor** for Modified Habtiat.

Table 5.11 Assessment of Impacts

Evaluation of Significance		**Sensitivity/Vulnerability/ Importance of Resource/Receptor**
		Modified Habitat
		Low
Magnitude of Impact	**Negligible**	Negligible
	Small	**Negligible**
	Medium	Minor
	Large	Moderate

Mitigation Measures

The following mitigations are recommended in relation to managing habitats along the transmission line route:

- Clearing vegetation outside of designated areas will be prohibited for Project staff, workers, all contractors and personnel engaged in or associated with the Project;
- The Project owner shall provide training to staff and workers on all rules, regulations and information concerning restrictions related to unauthorised clearing of vegetation;
- The planned terrestrial vegetation clearance area for the construction works shall be clearly identified and marked to avoid accidental clearing;

- Use of the access road should be restricted to construction vehicles only. Checkpoints should be used to manage access and inspect vehicles for vegetation (including firewood) taken from the Project Area; and

- All land rehabilitation will be undertaken using native indigenous species. The area of landscaping within the Project area shall re-establish habitat values.

Monitoring Measures

No additional monitoring measures are considered necessary.

Significance of Residual Impact

In view of the implementation of mitigation measures, the residual impact is to remain as **Negligible** for terrestrial species considered as Least Concern on the IUCN Red List.

5.5.4 Assessment of Impacts – Temporary and Permanent Barrier Creation, Degradation of Habitat, Edge Effects and Fragmentation

Description of Relevant Baseline Information

Construction activities relating to linear infrastructure have potential to create a temporary barrier to fauna movement (for some fauna groups). This includes construction of the access roads, the transmission line and other infrastructure. Most other Project components are discrete areas that may be navigated around by fauna that may be moving through. The construction of access roads and transmission line will primarily be within Modified Habitat.

Temporary and permanent barrier creation will occur during construction. This will include the erection of fences and hoardings around construction sites, and also construction of linear infrastructure (such as the access road and transmission line). This may impact the movement of fauna within the landscape, particularly bird species.

Edge effects are an indirect impact of land clearing during construction and throughout operation and can have temporary and permanent impacts. Where vegetation clearing occurs, adjacent vegetation and habitats can be exposed to changes in noise, light (natural or artificial), dust, humidity and temperature factors as well as increased competition from predators and invasive species. The impact of edge effects to habitat value and forest composition has been widely recognised as a contributor to habitat degradation and impacts to biodiversity.

Modified Habitats surrounding the Project area may be temporarily impacted due to Project construction from dust and pollution. This will be most pronounced along the transmission line and road construction routes where

vehicle movements along dirt roads will likely increase dust impacts. The primary impact will be dust deposition on flora within close proximity of construction sites.

Fragmentation of habitats can occur where currently linked habitats are disconnected through the construction of Project components. Fragmentation reduces the continuity of habitat and hence the ability for fauna to move within and between habitats patches. Fragmentation of existing habitats within the project area is not considered to be a significant impact as the infrastructure design does not lead to isolation of habitat patches and is primarily within Modified Habitat.

A range of Project activities have the potential to lead to degradation of native flora and fauna habitats including excavation, construction, land clearing, spoil disposal, movement of vehicles, drilling, refuelling, hazardous materials storage and maintenance. In general the impacts will cause: dust; runoff; release of potential contaminants; and invasive species. Construction activities have been assessed for these impact types, including: construction of the access roads, erection of the power plant and construction of the transmission line and associated infrastructure.

Invasive species (flora and fauna) have the potential to be introduced or spread throughout the Project Area through increased movement of people, vehicles, machinery, vegetation and soil. An increase in the prevalence of weeds or other pests has the potential to reduce the quality of habitat for some native flora and fauna, including conservation significant species. Invasive flora species can rapidly germinate in disturbed areas whereby affecting the ability of native vegetation communities to re-establish. Invasive animals also have the potential to be introduced or increased in abundance. These animals may adversely impact native fauna as a result of increased competition for resources, predation or habitat degradation.

The introduction of invasive species onto the site can contribute to changes in species composition. The following invasive species were identified at the Project area (***Table 5.12***).

Table 5.12 Invasive Species Identified at the Project Area

No	Taxonomic group	Species	Habitat	Status	Location in Project Area
1	Mollusca	*Pomacea canaliculata*	Aquatic	Listed in Vietnam	Da Mi Lake
2	Plantae	*Mimosa pigra*	Aquatic	Listed in Vietnam	Da Mi Lake
3	Plantae	*Ageratum connyzoides*	Terrestrial	Listed in Vietnam	Gardens and lakeside
4	Plantae	*Chromolaena odorata*	Terrestrial	Listed in Vietnam	Gardens and lakeside

Avoidance Measures Adopted

Avoidance measures for temporary and permanent barrier creation, edge effects and fragmentation are not possible to be applied. The erection of barriers and fences is required in order to control access to the site for workers and local people.

Impact Assessment

The significance of impacts associated with terrestrial biodiversity during construction activities are discussed and presented in ***Table 5.13.***

The sensitivity of terrestrial species to disturbance and displacement is considered to be **Low** for all Least Concern, Near Threatened and Vulnerable species.

The magnitude of effect due to disturbance and displacement of terrestrial habitats is likely to be **Small** as the effect will not cause a substantial change in the population of the species present, or other species dependent on them during both construction.

The overall magnitude of this impact is therefore **Negligible** for Least Concern, Near Threatened and Vulnerable Species.

Table 5.13 Assessment of Impacts

Evaluation of Significance		**Sensitivity/Vulnerability/ Importance of Resource/Receptor**
		Modified Habitat
		Low
Magnitude of Impact	**Negligible**	Negligible
	Small	**Negligible**
	Medium	**Minor**
	Large	Moderate

Mitigation Measures

It is recommended that the following mitigation measures be applied in relation to habitat impacts during construction:

- The use of fencing and hoarding during construction is to be kept to a minimum around Project construction sites;
- Measures to control dust are to be utilised to limit generation of dust and hence deposition onto vegetation surrounding construction areas;

- All disturbed soil surfaces are to be rehabilitated and native flora species are to be planted within areas under the Projects control;

- Existing populations and the introduction of new invasive species into the Project Area. These measures are to be outlined in an Invasive Species Management Plan and include measures such as: The provenance of any fill material brought onto the site is to be checked regarding invasive species contamination; Vehicle wash down procedures are to be used to reduce the transmission of invasive species into and from the Project area(s); and

- Appropriate rehabilitation of disturbed areas using native vegetation is to occur to facilitate movement of fauna species.

Monitoring Measures

The following monitoring measures will be applied during construction:

- Records are to be kept and regularly reviewed (3 monthly basis) during construction on the application of the fencing and hoarding implementation;

- Regular inspections (weekly during construction) during the dry season to determine the level of dust deposition on vegetation surrounding the Project Area. Where excessive dust on vegetation is identified, and rain is not forecast within the next 5 days, vegetation should be washed using a water truck.

- Records are to be kept and regularly reviewed (3 monthly basis) on the planting of indigenous flora and fauna on disturbed areas; and

- Monitoring if rehabilitation success/failure is to occur on all replanting sites. Monitoring is to consist of regular inspections (3 monthly) to determine plant establishment. Where plant establishment is determined to have failed, reestablishment is to occur.

Significance of Residual Impact

In view of the implementation of mitigation measures, the residual impact is to remain as **Negligible** for terrestrial species considered as Least Concern, on the IUCN Red List.

5.5.5 *Assessment of Impacts - Mortality: Vehicle Strike, Hunting, fishing and poaching*

Description of Relevant Baseline Information

Mortality of individual fauna may occur during construction due to vehicle or machinery strike or falling debris during clearing activities; and worker influx and hunting/poaching of extant fauna.

During construction, vehicle and machinery use may strike fauna within the Project area, however this is likely to impact livestock rather than species of conservation concern.

Avoidance Measures Adopted

The following avoidance measure is recommended:

- Pre-construction with the local community on hunting/poaching activities is to occur according to the Community Engagement Program. The purpose of this approach is to inform and educate the community regarding conservation and identify alternative livelihoods for people reliant on the wildlife trade.

Impact Assessment

The potential impacts during construction will remain during operation.

The significance of impacts associated with terrestrial biodiversity during construction activities are discussed and presented in ***Table 5.14.***

The sensitivity of terrestrial species to fauna mortality from vehicle strike, hunting, fishing and poaching is considered to be **Low** for all Least Concern, Near Threatened and Vulnerable species.

The magnitude of effect due fauna mortality from vehicle strike, hunting, fishing and poaching is likely to be **Small** as the effect will not cause a substantial change in the population of the species present, or other species dependent on them during construction.

Table 5.14 Assessment of Impacts from Mortality: Vehicle Strike, Hunting, fishing and poaching

Evaluation of Significance		Sensitivity/Vulnerability/ Importance of Resource/Receptor
		Modified Habitat
		Low
Magnitude of Impact	**Negligible**	Negligible
	Small	**Negligible**
	Medium	Minor
	Large	Moderate

Mitigation Measures

It is recommended that the following mitigation measures be applied in relation to habitat impacts during construction:

- Hunting, fishing and poaching will be prohibited for Project staff, workers, all contractors and personnel engaged in or associated with the Project;
- The Project owner shall provide training to staff and workers on all rules, regulations and information concerning restrictions related to hunting, fishing and poaching, as well as the punishment that can expected if any staff or worker or other person associated with the Project violates rules and regulations; and
- All vehicles are to maintain a speed of a maximum of 40km/hr within work sites to reduce the risk of fauna strike.

Monitoring Measures

No additional monitoring measures are recommended.

Significance of Residual Impact

In view of the implementation of mitigation measures, the residual impact is to remain **Negligible** significance.

5.5.6 Assessment of Impacts - Degradation of Habitat during Operations Phase

Description of Relevant Baseline Information

Minor residual impacts for all construction phase impacts are likely remain during operation. Additional impacts due to degradation of habitat and

mortality are likely to be different during operation and hence are reassessed for operational phase impacts.

Degradation of habitat during operation will occur due to air, noise and water discharges into the environment.

Impacts due to air, noise and water emissions during operation can cause impacts to biodiversity values such as: deposition of particulates on vegetation; leaf necrosis; disturbance of fauna from close proximity to noise sources.

Compliance with relevant standards will reduce the impacts on biodiversity values from air, noise and water pollution.

Avoidance Measures Adopted

No additional avoidance measures are recommended.

Impact Assessment

The significance of impacts associated with terrestrial biodiversity during operation activities are discussed and presented in ***Table 5.15.***

The sensitivity of Modified Habitats are considered to be **Low**.

The magnitude of effect is likely to be small as the degradation of habitat will effect only a small area of habitat, but without the loss of viability/function of the habitat.

The overall magnitude of this impact is therefore **Minor** for Natural Habitat and **Negligible** for Modified Habitat before Mitigation Measures.

Table 5.15 Assessment of Impacts on Degradation of Habitat during Operations

Evaluation of Significance		**Sensitivity/Vulnerability/ Importance of Resource/Receptor**
		Modified Habitat
		Low
Magnitude of Impact	**Negligible**	Negligible
	Small	**Negligible**
	Medium	Minor
	Large	Moderate

Mitigation Measures

No additional measures are necessary than those outlined in the impacts to air, water and noise.

Monitoring Measures

No additional monitoring measures are recommended.

Significance of Residual Impact

In view of the implementation of mitigation measures, the residual impact is to remain **Minor** significance.

5.5.7 Assessment of Impacts - Mortality: Avifauna Infrastructure Strike with Tranmission Line

Description of Relevant Baseline Information

Impacts to fauna during operation may persist with potential impacts to infrastructure causing local mortality of individuals. This is most likely to occur with avifauna striking the transmission line during construction and operation.

Whilst no bat species were detected during surveys, it is likely that bats would forage over the rice paddies during dawn and dusk. Individuals may collide with the transmission line, causing mortality of individuals. Similarly, bird species may collide with the transmission line during flight.

Avoidance Measures Adopted

Avoidance measures for mortality: avifauna infrastructure strike are not possible to be applied. The design of the transmission line requires the erection of poles and wires that will be a risk to avifauna.

Impact Assessment

The sensitivity of terrestrial species to fauna mortality from avifauna strike with infrastructure is considered to be **Low** for all Least Concern, Near Threatened and Vulnerable species.

The magnitude of effect due fauna mortality from avifauna infrastructure strike is likely to be **Small** as the effect will not cause a substantial change in the population of the species present, or other species dependent on them during construction.

The overall magnitude of this impact is therefore **Negligible** for Least Concern, near Threatened and Vulnerable Species.

Table 5.16 Assessment of Impacts from Avifauna Infrastructure Strike

Evaluation of Significance		Sensitivity/Vulnerability/ Importance of Resource/Receptor
		Modified Habitat
		Low
Magnitude of Impact	**Negligible**	Negligible
	Small	**Negligible**
	Medium	Minor
	Large	Moderate

Mitigation Measures

It is recommended that the following mitigation measures be applied in relation to habitat impacts during construction:

- Use of bird deflectors on the length of the power line. The deflectors will increase line visibility by thickening the appearance of the line for easier detection by avifauna;
- Moveable markers of contrasting colours (e.g. black and white) that protrude above and below the line, and be placed 5-10 m apart;
- Removing the thin neutral or earth (shield) wire above the high voltage transmission lines where feasible, and where this is not possible, marking the line to make it more visible;
- Minimising the vertical spread of power lines. Having lines in a horizontal plane reduces collision risk;
- Habitat manipulation to influence flight activity and bird behaviour, e.g. tree lines under the high voltage lines to increase visibility;
- Insulating cables close to poles, at least 70 cm on both sides and around perching areas, and up to at least 140cm; and
- Hanging insulators under cross arms and poles, provided the distance between a likely perch (mainly the transmission tower crossarm) and the energised parts (conductors) is at least 70 cm.

Monitoring measures

The following monitoring measures are recommended:

- Regular inspections of the transmission line routes (3 monthly) during construction is to occur to identify any fauna mortality that has occurred. Where patterns in species mortality or conservation significant species are

identified, advice from a suitably qualified person should be sought to alter mitigation measures to reduce future potential impacts.

Significance of Residual Impact

In view of the implementation of mitigation measures, the residual impact remains of **Minor** significance.

5.5.8 Impact Assessment: Ecosystem Services

Relevant Baseline Information

The following priority ecosystem services shown in ***Table 5.17*** have been identified.

Table 5.17 Priority ecosystem services

Provisioning Services
• Food: wild-caught fish and shellfish & aquaculture
• Food: cultivated crops
Regulating Services
• Freshwater
Cultural Services
• Use of natural spaces and resources for tourism and recreation (e.g. swimming, boating, hunting, bird-watching, fishing)

The ecosystem services are considered to be medium priority. There are approximately 5 or 6 professional fishing households who collect fish in the area using fishing nets. Tam Long Joint Stock Company runs aquaculture activities for sturgeon of more than 14,000 m^2 of cages, producing hundreds of tons of commercial fish each year. Local people also use the lake for recreational fishing.

The Project area along the transmission line route is currently used for agriculture and market gardens. Approximately 8200m^2 of land will be lost for construction of the transmission line and substation.

A reduction in surface area of 6.8% available for fishing activities of the lake is not expected to lead to a significant reduction in fishing catch for recreational or commercial fishermen. The aquicultural activities are located approximately 500 metres from the proposed PV insallation. This commercial activity is considered to be self sustaining and is unlikely to be impacted due to the floating solar facilities.

Avoidance Measures Adopted

No additional avoidance measures are recommended.

Impact Assessment

The significance of impacts associated with ecosystem services during construction activities are discussed and presented in ***Table 5.18.***

The sensitivity of ecosystem services are considered to be **Low**.

The magnitude of effect is likely to be small. The overall magnitude of this impact is therefore **Negligible** before Mitigation Measures.

Table 5.18 Assessment of Impacts on Degradation of Habitat during Construction

Evaluation of Significance		**Sensitivity/Vulnerability/ Importance of Resource/Receptor**
		Modified Habitat
		Low
Magnitude of Impact	**Negligible**	Negligible
	Small	**Negligible**
	Medium	Minor
	Large	Moderate

Mitigation Measures

No additional mitigation measures are recommended, however measures may be triggered from montiring activities outlined below.

Monitoring Measures

The following monitoring measures will be applied during construction:

- Fish catches from fishermen should be monitered for at least 6 months following the installation of the solar facility.
- Based on the results of the monitoring, measures to supplement fishing activities may be considered.

Significance of Residual Impact

In view of the implementation of mitigation measures, the residual impact is to reduce to **Negligible** for ecosystem services.

5.5.9 Assessment of No-Net-Loss of Biodiversity Values

ERM has not identified significant residual impacts to biodiversity values that require compensation or offsetting. No impacts to Natural Habtiat were identified and Critical Habitat values were not identified within the Project

Area. There is therefore no requirement to consider an assessment of no-net-loss for this project.

Annex A

Singscore-Tolerance Scores For Macroinvertebrates In Singapore's Lotic Waters

Annex A SingScore-tolerance Scores for Macroinvertebrates in Singapore's Lotic Waters

Macroinvertebrates	SingScore-Tolerance Scores
Platyhelminthes	
Dugesiidae	3
Polychaeta	
Nereididae	6
Oligochaeta	
Tubificidae	2
Hirudinea	
Erpobdellidae	1
Glossiphoniidae	2
Haemadipsidae	5
Mollusca	
Ampullariidae	3
Ancylidae	1
Bithyniidae	3
Lymnaeida	1
Physidae	2
Planorbidae	2
Thiaridae	1
Crustacea	
Amphipoda	2
Atyidae	6
Copepoda	4
Isopoda	1
Ostracoda	3
Palaemonidae	7
Parathelphusidae	9
Odonata (Zygoptera)	
Amphipterygidae	10
Calopterygidae	8
Coenagrionidae	3
Euphaeidae	9
Platycnemididae	5
Platystictidae	8
Odonata (Anisoptera)	
Aeshnidae	9
Corduliidae	5
Gomphidae	8
Libellulidae	4
Ephemeroptera	
Baetidae	7
Caenidae	7
Heptageniidae	9
Leptophlebiidae	10
Plecoptera	
Leuctridae	10
Perlidae	9
Hemiptera	
Corixidae	10
Gerridae	5
Helotrephidae	4
Mesoveliidae	10
Naucoridae	7
Notonectidae	8
Veliidae	7
Megaloptera	
Sialidae	8
Trichoptera	
Calamoceratidae	9
Ecnomidae	6
Hydropsychidae	7
Hydroptilidae	6
Leptoceridae	7
Odontoceridae	10
Philopotamidae	8
Polycentropodidae	9
Lepidoptera	
Crambidae	5
Coleoptera	
Curculionidae	6
Dytiscidae	5
Hydraenidae	8
Hydrophilidae	6
Scirtidae	8
Diptera	
Athericidae	10
Canacidae	6
Ceratopogonidae	3
Chironomidae	2
Corethrellidae	10
Culicidae	1
Dolichopodidae	1
Empididae	4
Ephydridae	4
Muscidae	6
Psychodidae	2
Simuliidae	7
Syrphidae	4
Tipulidae	3
Collembola	5
Acari	4

Annex B

Species Composition Of Phytoplankton In The Project Area

Annex B Species Composition of Phytoplankton in the Project Area

No.	Scientific name	Sampling sites														
		BT01	**BT02**	**BT03**	**BT04**	**BT05**	**BT06**	**BT07**	**BT08**	**BT09**	**BT10**	**BT11**	**BT12**	**BT13**	**BT14**	**BT15**
	PHYLUM CYANOBACTERIA															
1	*Merismopedia glauca*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2	*Microcystis aeruginosa*		+		+	+		+		+	+	+	+	+		+
3	*Pseudanabaena schmidlei*		+	+	+	+	+	+	+			+	+		+	+
4	*Oscillatoria subbrevis*	+	+	+	+	+		+			+	+		+		+
5	*Oscillatoria limnetica*	+									+					
6	*Oscillatoria cf. tenuis*		+						+							
7	*Lyngbya limnetica*	+		+	+	+	+		+	+	+		+	+	+	+
8	*Lyngbya sp.*						+	+							+	+
	PHYLUM CHRYSOPHYTA															
9	*Aulacoseira granulata*	+										+				
10	*Synedra ulna*					+								+		+
11	*Eunotia elegans*	+	+	+	+	+	+	+		+	+	+		+	+	+
12	*Navicula phyllepta*	+	+			+		+	+		+	+	+			
13	*Gyrosigma cf. kuetzingii*														+	+
14	*Nitzschia filiformis*	+	+	+		+	+	+		+	+	+		+	+	
15	*Surirella biseriata*	+	+		+	+		+	+	+	+	+	+	+		
16	*Surirella elegans*			+	+		+		+	+			+	+	+	+
	PHYLUM CHLOROPHYTA															
17	*Eudorina elegans*				+					+				+	+	
18	*Pandorina morum*					+						+				
19	*Pediastrum duplex*		+							+						
20	*Pediastrum simplex*								+					+		
21	*Scenedesmus quadricauda*	+			+				+	+	+		+	+		+

No.	Scientific name	Sampling sites														
		BT01	**BT02**	**BT03**	**BT04**	**BT05**	**BT06**	**BT07**	**BT08**	**BT09**	**BT10**	**BT11**	**BT12**	**BT13**	**BT14**	**BT15**
22	*Ankistrodesmus falcatus*	+	+	+	+	+	+	+			+	+			+	+
23	*Closterium macilentum*		+	+	+	+	+	+	+	+		+	+		+	+
24	*Closterium acutum*	+		+	+		+		+	+	+	+	+	+	+	+
25	*Closterium macilentum*	+		+	+		+		+		+		+		+	+
26	*Staurastrum bigibbum*	+		+	+		+		+	+	+		+	+	+	+
27	*Cosmarium granatum*		+			+		+	+	+		+	+	+		
28	*Spirogyra ionia*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
29	*Oedogonium crispum*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	PHYLUM EUGLENOPHYTA															
30	*Euglena acus*		+				+	+						+		+
31	*Euglena oxyuris*	+				+							+			
32	*Euglena spirogyra*			+								+			+	
33	*Phacus curvicauda*				+		+	+	+	+		+	+	+	+	+
34	*Trachelomonas hispida*	+	+	+	+					+	+	+		+		+
	PHYLUM DINOPHYTA															
35	*Ceratium hirundinella*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
36	*Peridinium cf. cinctum*			+			+						+			
	Total species	**19**	**18**	**18**	**20**	**18**	**18**	**17**	**18**	**19**	**18**	**20**	**19**	**21**	**19**	**22**

Annex C

Quantity Of Phytoplankton In The Project Area

Annex C Quantity of Phytoplankton in the Project Area

No.	Scientific name	Sampling sites														
		BT01	**BT02**	**BT03**	**BT04**	**BT05**	**BT06**	**BT07**	**BT08**	**BT09**	**BT10**	**BT11**	**BT12**	**BT13**	**BT14**	**BT15**
	PHYLUM CYANOBACTERIA															
1	*Merismopedia glauca*	4370	3850	3780	4130	4240	3690	3830	3700	4080	3990	3890	3720	3940	3890	610
2	*Microcystis aeruginosa*		140		110	110		90		130	180	160	110	100		80
3	*Pseudanabaena schmidlei*		130		110	180	120	160	150			130	150		110	110
4	*Oscillatoria subbrevis*	80	90	80	70	70		110			120	90		90		70
5	*Lyngbya limnetica*	190		180	160	220	160		130	160	110			140	170	80
	PHYLUM CHRYSOPHYTA															
6	*Eunotia elegans*	170	150	210	190	190	230	230		190	210	140		130	170	100
7	*Navicula phyllepta*	60	70			60		50	70		50	90	60			
8	*Nitzschia filiformis*	70	60	70		40	40	60		30	70	40		50	60	
9	*Surirella biseriata*	40	40		30	30		40	30	50	20	50	50	30		
10	*Surirella elegans*			120	80		110		140	80			90	120	110	30
	PHYLUM CHLOROPHYTA															
11	*Scenedesmus quadricauda*	30			20				20	40	40		10	10		20
12	*Ankistrodesmus falcatus*	50	40	40	60	70	20	20			10	30			20	30
13	*Closterium macilentum*		70	60	30	10	30	10	30	20		10	40		30	10
14	*Closterium acutum*	20		20	10		20		50	40	10		10	30	20	20
15	*Closterium macilentum*	60		10	40		10		10		30		30		50	10
16	*Staurastrum bigibbum*	230		190	130		200		180	160	140		210	140	190	80
17	*Cosmarium granatum*		110			180		130	140	160		130	170	90		
18	*Spirogyra ionia*	1980	1820	1810	1760	2040	1800	1710	1830	1860	1800	1830	1760	1680	1770	1040
19	*Oedogonium crispum*	1400	1350	1320	1290	1260	1490	1460	1520	1360	1450	1490	1470	1390	1510	580
	PHYLUM EUGLENOPHYTA															
20	*Phacus curvicauda*				150		170	310	280	130		140	260	160	180	70
21	*Trachelomonas hispida*	310	340	280	270					230	270	310		230		130

No.	Scientific name	Sampling sites														
		BT01	**BT02**	**BT03**	**BT04**	**BT05**	**BT06**	**BT07**	**BT08**	**BT09**	**BT10**	**BT11**	**BT12**	**BT13**	**BT14**	**BT15**
	PHYLUM DINOPHYTA															
22	*Ceratium hirundinella*	10	30	10		10	20	20	10	30	10		40	10	30	
	Quantity (cells/liter)	**9070**	**8290**	**8180**	**8640**	**8710**	**8110**	**8230**	**8290**	**8750**	**8510**	**8530**	**8180**	**8340**	**8310**	**3070**

Annex D

Species Composition Of Zooplankton In The Project Area

Annex D Species Composition of Zooplankton in the Project Area

No.	Scientific names	Sampling sites														
		BT01	**BT02**	**BT03**	**BT04**	**BT05**	**BT06**	**BT07**	**BT08**	**BT09**	**BT10**	**BT11**	**BT12**	**BT13**	**BT14**	**BT15**
	PHYLUM ROTIFERA															
	CLASS EUROTOTARIA															
	Order PHILODINIDA															
	Family Philodinidae															
1	*Philodina roseola* Ehrenberg	+	+							+		+	+			
	Order PLOIMA															
	Family Trichoceridae															
2	*Trichocerca (Trichocerca) capucina* (W&Z)		+	+	+	+		+								+
	Family Synchaetidae															
3	*Polyarthera vulgaris* Carlin				+	+	+	+	+	+	+	+	+	+	+	
	Family Asplanchnidae															
4	*Asplanchna sieboldi* (Leydig)	+	+	+				+	+							+
	Family Brachionidae															
5	*Brachionus forficula* Wierzeski		+	+												
6	*Keratella cochlearis* (Gosse)					+			+							+
	Family Conochilidae															
7	*Conochiloides dossularis* (Hudson)	+				+	+									
	Order FLOCULARIACEAE															
	Family Filiniidae															
8	*Filinia longiseta* (Ehrenberg)	+	+	+	+		+		+			+	+	+		
9	*Tetramaastix opoliensis* Zacharias													+	+	+
	PHYLUM ARTHROPODA															
	CLASS CRUSTACEA															
	Order CLADOCERA															
	Family Bosminidae															

No.	Scientific names	Sampling sites														
		BT01	**BT02**	**BT03**	**BT04**	**BT05**	**BT06**	**BT07**	**BT08**	**BT09**	**BT10**	**BT11**	**BT12**	**BT13**	**BT14**	**BT15**
10	*Bosmina longirostris* (O. F. Muller)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Family Silidae															
11	*Diapanosoma excisum* Sars	+		+	+									+	+	
	Family Daphniidae															
12	*Ceriodaphnia rigaudi* Richard	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
13	*Moina dubia* de Guerne et Richard	+	+	+	+	+	+	+	+				+	+	+	
	Family Chydoridae															
14	*Chydorus sphaericus* O.F. Muller					+						+				
15	*Alona davidi* Richard												+			+
16	*Alona rectangula* Sars														+	+
	Order COPEPODA															
	Family Diaptomidae															
17	*Eodiaptomus leuckarti* (Claus)				+	+	+	+	+	+	+	+	+	+	+	+
	Family Cyclopida															
18	*Microcyclops varicans* (Sars)								+	+	+				+	+
19	*Thermocyclops hyalinus* (Rehberg)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

No.	Scientific names	Sampling sites														
		BT01	**BT02**	**BT03**	**BT04**	**BT05**	**BT06**	**BT07**	**BT08**	**BT09**	**BT10**	**BT11**	**BT12**	**BT13**	**BT14**	**BT15**
	Order OSTRACODA															
	Family Cypridae															
20	*Heterocypris anomala* Klie					+	+				+					
	LARVA															
21	Nauplius copepoda	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
22	Gastropoda							+	+			+	+	+		+
23	Bivalvia		+		+	+	+	+	+	+	+	+	+	+	+	+
24	Chironomidae	+	+	+			+			+	+		+			
	Total species	**11**	**12**	**11**	**11**	**13**	**12**	**11**	**13**	**10**	**10**	**11**	**13**	**12**	**12**	**14**

Annex E

Quantity Of Zooplankton In The Project Area

Annex E Quantity of Zooplankton in the Project Area

No.	Scientific names	Sampling sites														
		BT01	**BT02**	**BT03**	**BT04**	**BT05**	**BT06**	**BT07**	**BT08**	**BT09**	**BT10**	**BT11**	**BT12**	**BT13**	**BT14**	**BT15**
	PHYLUM ROTIFERA															
	CLASS EUROTOTARIA															
	Order PHILODINIDA															
	Family Philodinidae															
1	*Philodina roseola* Ehrenberg		2							1		2				
	Order PLOIMA															
	Family Trichoceridae															
2	*Trichocerca (Trichocerca) capucina* (W&Z)		2	2		1		3								2
	Family Synchaetidae															
3	*Polyarthera vulgaris* Carlin				8	7	7	9	6	7	6	9	9	8	7	
	Family Asplanchnidae															
4	*Asplanchna sieboldi* (Leydig)	5	1	3				3								2
	Family Brachionidae															
5	*Brachionus forficula* Wierzeski		6													
6	*Keratella cochlearis* (Gosse)					2			2							
	Family Conochilidae															
7	*Conochiloides dossularis* (Hudson)	2					1									
	Order FLOCULARIACEAE															
	Family Filiniidae															
8	*Filinia longiseta* (Ehrenberg)	9	7	10			2					1	4			
9	*Tetramaastix opoliensis* Zacharias													4	3	3
	PHYLUM ARTHROPODA															
	CLASS CRUSTACEA															
	Order CLADOCERA															
	Family Bosminidae															
10	*Bosmina longirostris* (O. F. Muller)	4	2		6	5	4	3	6	7	8	4	7	4	3	4

No.	Scientific names	Sampling sites														
		BT01	**BT02**	**BT03**	**BT04**	**BT05**	**BT06**	**BT07**	**BT08**	**BT09**	**BT10**	**BT11**	**BT12**	**BT13**	**BT14**	**BT15**
	Family Silidae	1														
11	*Diapanosoma excisum* Sars	1		2												
	Family Daphniidae															
12	*Ceriodaphnia rigaudi* Richard	48	33	31	13	4	3	4	7	4	3	5	3	3	4	4
13	*Moina dubia* de Guerne et Richard	4		1	1	2	1		3					1	1	
	Order COPEPODA															
	Family Diaptomidae															
14	*Eodiaptomus leuckarti* (Claus)				2	2	3	1	1	2	1		1	1	1	2
	Family Cyclopida															
15	*Microcyclops varicans* (Sars)								3	1						
16	*Thermocyclops hyalinus* (Rehberg)	2	1	3	3	1	5	6	1	6	6	5	3	7	5	3
	Order OSTRACODA															
	Family Cypridae															
17	*Heterocypris anomala* Klie					1					4					
	LARVA															
18	Nauplius copepoda	7	6	11	34	34	31	32	39	34	27	28	27	32	29	10
19	Bivalvia		1		2	3	1	1	1	2	1	2	2	2	3	2
	Quantity (individuals/sample)	**83**	**61**	**63**	**69**	**62**	**58**	**62**	**69**	**64**	**56**	**56**	**56**	**62**	**56**	**32**

Annex F

Species Composition And Quantity Of Macroinvertebrates In The Project Area

Annex F Species Composition and Quantity of Macroinvertebrates in the Project Area

No.	Scientific name	Sampling sites														
		BT01	BT02	BT03	BT04	BT05	BT06	BT07	BT08	BT09	BT10	BT11	BT12	BT13	BT14	BT15
	PHYLUM ANNELIDA															
	CLASS OLIGOCHAETA															
	Order HAPLOTAXIDA															
	Family Naididae															
1	*Pristina longiseta* Ehrenberg			2	1			2		2						
	PHYLUM MOLLUSCA															
	CLASS GASTROPODA															
	Order MESOGASTROPDA															
	Family Thiaridae															
2	*Sermyla tornatella* (Lea)								2		1	1	2		1	
	Family Viviparidae															
3	*Filopaludina (Filopaludina) sumatrensis* (Dunker)	3	2	5		1						1	2	1		
	Family Ampullaridae															
4	*Pomacea canaliculata* (Lamarck)													1	2	
	Order NEOGASTROPODA															
	Family Lymnaeidae															
5	*Lymnaea viridis* Qouy et Gaimard	1														2
	CLASS BIVALVIA															
	Order MYTILOIDA															
	Family Mytilidae															
6	*Limnoperna siamensis* (Morelet)	17	14	20	8	12	9	2		7	8	3	2	1	3	
	Order VENEROIDA															
	Family Corbiculidae															
7	*Corbicula lamarckiana* Prime				1		2					1	1	1		1
8	*Pomacea canaliculata (Lamarck)*				2		1	8	10		1	12	13	10	22	
9	*Corbicula tenuis* Clessin	3	2	2		1		1			2					3

No.	Scientific name	Sampling sites														
		BT01	**BT02**	**BT03**	**BT04**	**BT05**	**BT06**	**BT07**	**BT08**	**BT09**	**BT10**	**BT11**	**BT12**	**BT13**	**BT14**	**BT15**
10	*Corbicula cyreniformis* Prime					3	3		1	1		1	1	3	1	
	PHYLUM ARTHROPODA															
	CLASS CRUSTACEA															
	Other DECAPODA															
	Family Palaemonidae															
11	*Macrobrachium lanchesteri* (De Man)	1		1					1	2						
12	*Macrobrachium mekongense* Dang															1
	Family Parathelphusidae															
13	*Sayamia germaini* (Rathbun)	1	1													1
	CLASS INSECTA															
	Order EPHEMEROPTERA															
	Family Baetidae															
14	*Baetis* sp.	1	2	2												
	Family Heptageniidae															
16	*Heptagenia* sp.															3
	Family Leptoplebiidae															
17	*Paraleptophlebia* sp.															11
	Order ODONATA															
	Family Agrionidae															
18	*Enallagma deserti* (Selys)															6
	Family Gomphidae															
19	*Dromogomphus* sp.							1	1			1				2
	Order HEMIPTERA															
	Family Naucoridae															
20	*Naucoris* sp.	3	1	1											1	
	Family Nepidae															
21	*Ranatra chinensis* (Mayer)														1	1
22	*Laccotrephes japonensis* (Scott)													2	3	

No.	Scientific name	Sampling sites														
		BT01	**BT02**	**BT03**	**BT04**	**BT05**	**BT06**	**BT07**	**BT08**	**BT09**	**BT10**	**BT11**	**BT12**	**BT13**	**BT14**	**BT15**
	Family Aphelochidae															
23	*Aphelocheirus vittatus* Matsumura															3
	Order TRICHOPTERA															
	Family Rhyacophilidae															
24	*Rhyacophila* sp.															2
	Family Hydropsychidae															
25	*Macronema* sp.				1							1			3	5
	Order DIPTERA															
	Family Chironomidae															
26	*Ablabesmyia* sp.					2	1			2	3		1			2
27	*Polypedilum* sp.		2		1	1		1	2		1					
	Individuals/Sample	**30**	**24**	**33**	**14**	**20**	**16**	**15**	**17**	**14**	**16**	**21**	**22**	**19**	**37**	**43**
	No. species/Sample	**8**	**7**	**7**	**6**	**6**	**5**	**6**	**6**	**5**	**6**	**8**	**7**	**7**	**9**	**14**

Annex G

List Of Fish Recorded In The Project Area

Annex G List of Fish Recorded in the Project Area

No.	Scientific Name	Common Name	Family	Ordaer	Conservation Status			Remarks	Uses
					IUCN Red List	Vietnam Data RedBook	Relative Abundance		
1	*Notopterus notopterus* (Pallas)	Cá thát lát	Notopteridae	Osteoglossiformes	LC		O	Observed	Eaten
2	*Mastacembelus favus* Hora	Cá chạch bông	Mastacembelidae	Synbranchiformes	LC		O	Observed	Eaten
3	*Monopterus albus* (Zuiew)	Lươn đồng	Synbranchidae	Synbranchiformes	LC		O	Observed	Eaten
4	*Paralaubuca barroni* (Fowler)	Cá thiểu mại	Cyprinidae	Cypriniformes	LC		O	Observed	Eaten
5	*Rasbora argyrotaenia* (Bleeker)	Cá lòng tong đá	Cyprinidae	Cypriniformes	LC		A	Observed	Eaten
6	*Rasbora borapetensis* H. M. Smith	Cá đỏ đuôi	Cyprinidae	Cypriniformes	LC		O	Observed	Eaten
7	*Esomus longimanus* (Lunel)	Cá lòng tong	Cyprinidae	Cypriniformes	DD		A	Observed	Eaten
8	*Luciosoma setigerum* (C & V)	Cá mương nam	Cyprinidae	Cypriniformes	LC		O	Observed	Eaten
9	*Hampala macrolepidota* Kuhl & van Hasselt	Cá ngựa nam	Cyprinidae	Cypriniformes	LC		O	Interviewed	Eaten
10	*Barbonymus altus* (Gunther)	Cá hỗng nhau	Cyprinidae	Cypriniformes	LC		O	Interviewed	Eaten
11	*Barbonymus gonionotus* (Bleeker)	Cá mè vinh	Cyprinidae	Cypriniformes	LC		C	Observed	Commercial/Eaten
12	*Barbonymus schwanenfeldii* (Bleeker)	Cá he đỏ	Cyprinidae	Cypriniformes	LC		O	Observed	Eaten
13	*Puntioplites proctozystron* (Bleeker)	Cá dảnh	Cyprinidae	Cypriniformes	LC		O	Observed	Eaten
14	*Osteochilus prosemion* Fowler	Cá lúi	Cyprinidae	Cypriniformes	LC		O	Observed	Eaten
15	*Gyrinocheilus pennocki* (Fowler)	Cá bám đá	Gyrinocheilidae	Cypriniformes	LC		O	Observed	Eaten
16	*Botia beauforti* H. M. Smith	Cá heo chấm	Cobitidae	Cypriniformes	LC		O	Observed	Eaten
17	*Kryptopterus cryptopterus* (Bleeker)	Cá trèn đá	Siluridae	Siluriformes	LC		O	Interviewed	Eaten
18	*Mystus vittatus* (Bloch)	Cá chốt sọc	Bagridae	Siluriformes	LC		O	Observed	Eaten
19	*Mystus rhegma* Fowler	Cá chốt vạch	Bagridae	Siluriformes	LC		O	Observed	Eaten
20	*Hemibagrus wyckii* (Bleeker)	Cá lăng ki	Bagridae	Siluriformes	LC		O	Interviewed	Commercial/Eaten
21	*Zenarchopterus ectuntio* (Hamilton)	Cá lìm kìm sông	Zenarchopteridae	Beloniformes	LC		C	Observed	Eaten
22	*Oxyeleotris marmorata* (Bleeker)	Cá bống tượng	Eleotridae	Perciformes	LC		A	Observed	Commercial/Eaten
23	*Channa lucius* (Cuvier)	Cá tràu dày	Channidae	Perciformes	LC		O	Observed	Commercial/Eaten
24	*Channa gachua* (Hamilton)	Cá chành đục	Channidae	Perciformes	LC		O	Interviewed	Eaten

No.	Scientific Name	Common Name	Family	Ordaer	Conservation Status			Remarks	Uses
					IUCN Red List	Vietnam Data RedBook	Relative Abundance		
25	*Channa striata* (Bloch)	Cá lóc	Channidae	Perciformes	LC		C	Observed	Commercial/Eaten
26	Channa micropeltes (Cuvier)	Cá lóc bông	Channidae	Perciformes	LC		O	Interviewed	Commercial/Eaten
27	*Anabas testudineus* (Bloch)	Cá rô đồng	Anabantidae	Perciformes	DD		O	Interviewed	Eaten
28	*Oreochromis niloticus* (Linnaeus)	Cá rô phi rằn	Cichlidae	Perciformes	LC		D	Observed	Commercial/Eaten

Annex H

Fishing Activities Recorded In The Project Area

Annex H Fishing Activities Recorded in the Project Area

No.	Scientific Name	Common Name	Family	Ordaer	Number of catches		
					Mr. Vinh (Kg/day)	**Mr. Lam (Kg/day)**	**Mr. Ut (Kg/day)**
1	*Oxyeleotris marmorata* (Bleeker)	Cá bống tượng	Eleotridae	Perciformes	16.5 Kg	13.0 Kg	14.5 Kg
2	*Oreochromis niloticus* (Linnaeus)	Cá rô phi rằn	Cichlidae	Perciformes		0.8 Kg	0.7 Kg

Annex I

Avifauna Recorded In The Project Area

Annex I Avifauna Recorded in the Project Area

No.	Scientific Name	Common Name	Family	CONSERVATION STATUS		Abundance along Transect					Remarks
				IUCN Red List	Vietnam Data RedBook	Plantation Forests	Gardens	Residential Areas	Secondary Evergreen Forests	Lake Corridors	
1	*Centropus bengalensis* (Gmelin)	Bìm bịp nhỏ	Cuculidae	LC		+	+		+		Observed
2	*Streptopelia chinensis* (Scopoli)	Cu gáy	Cuculidae	LC		+	+	+	+		Observed
3	*Streptopelia tranquebarica* (Hermann)	Cu ngói	Cuculidae	LC		+	+		+	+	Observed
4	*Halcyon smyrnensis* (Linnaeus)	Sả đầu nâu	Alcedinidae	LC		+	+	+	+	+	Observed
5	*Halcyon pileata* (Boddaert)	Sả đầu đen	Alcedinidae	LC		+				+	Observed
6	*Ceryle rudis* Hartert	Bói cá nhỏ	Alcedinidae	LC			+		+	+	Observed
7	*Cinnyris jugularis* (Linnaeus)	Hút mật họng tím	Nectariniidae	LC		+	+		+		Observed
8	*Mixornis gularis* (Horsfield)	Chích chạch má vàng	Timalidae	LC		+	+	+			Observed
9	*Kittacincla malabarica* (Scopoli)	Chích chòe lửa	Muscicapidae	LC			+		+		Observed
10	*Prinia inornata* Sykes	Chiền chiện bụng hung	Cisticolidae	LC		+		+	+		Observed
11	*Aegithina tiphia* (Linnaeus)	Chim nghệ ngực vàng	Aegithinidae	LC			+	+		+	Observed
12	*Lalage polioptera* (Sharpe)	Phường chèo xám nhỏ	Campephagidae	LC			+	+	+	+	Observed

No.	Scientific Name	Common Name	Family	CONSERVATION STATUS		Abundance along Transect					Remarks
				IUCN Red List	Vietnam Data RedBook	Plantation Forests	Gardens	Residential Areas	Secondary Evergreen Forests	Lake Corridors	
13	*Dicrurus paradiseus* (Linnaeus)	Chèo bẻo đuôi chẻ	Dicruridae	LC		+	+	+	+		Observed
14	*Acridotheres cinereus* Bonaparte	Sáo mỏ vàng	Sturnidae	LC			+		+		Observed
15	Passer montanus (Linnaeus)	Sẻ	Passeridae	LC			+	+	+	+	Observed
16	Anas poecilorhyncha (Oates)	Vịt trời	Anatidae	LC					+	+	Observed
17	*Phalacrocorax niger* (Vieillot)	Cốc đen	Phalacrocoracidae	LC					+	+	Observed
18	*Ardeola bacchus* (Bonaparte)	Cò bợ	Ardeidae	LC		+				+	Observed
19	*Ixobrychus sinensis* (Gmelin)	Cò lửa lùn	Ardeidae	LC					+	+	Observed
20	*Egretta garzetta* (Linnaeus)	Cò trắng	Ardeidae	LC		+	+		+	+	Observed
21	*Circus aeruginosus* (Linnaeus)	Diều đầu trắng	Accipitridae	LC		+	+				Observed
22	*Haliastur indus* (Boddaert)	Diều lửa	Accipitridae	LC					+		Observed
23	*Nisaetus cirrhatus* (Gmelin)	Diều đầu nâu	Accipitridae	LC					+	+	Observed
24	*Otus bakkamoena* Pennant	Cú mèo khoang cổ	Strigidae	LC			+		+		Observed
25	*Psittacula roseata* Biswas	Vẹt đầu hồng	Psittacidae	NT			+				Observed
26	*Psittacula alexandri* (Linnaeus)	Vẹt ngực đỏ	Psittacidae	NT		+	+		+		Observed
						13	**18**	**8**	**20**	**13**	

Annex J

Avifauna Abundance In The Project Area

Annex J Avifauna Abundance in the Project Area

No.	Scientific Name	Common Name	Family	Abundance along Transect					Remarks
				Plantation Forests	Gardens	Residential Areas	Secondary Evergreen Forests	Lake Corridors	
1	*Centropus bengalensis* (Gmelin)	Bìm bịp nhỏ	Cuculidae		2		1		Observed
2	*Streptopelia chinensis* (Scopoli)	Cu gáy	Cuculidae		1	1	2		Observed
3	*Streptopelia tranquebarica* (Hermann)	Cu ngói	Cuculidae	1					Observed
4	*Halcyon smyrnensis* (Linnaeus)	Sả đầu nâu	Alcedinidae	2	3	1	3	1	Observed
5	*Ceryle rudis* Hartert	Bói cá nhỏ	Alcedinidae				1	1	Observed
6	*Cinnyris jugularis* (Linnaeus)	Hút mật họng tím	Nectariniidae		1				Observed
7	*Mixornis gularis* (Horsfield)	Chích chạch má vàng	Timalidae	1					Observed
8	*Prinia inornata* Sykes	Chiền chiện bụng hung	Cisticolidae				1		Observed
9	*Aegithina tiphia* (Linnaeus)	Chim nghệ ngực vàng	Aegithinidae			1			Observed
10	*Lalage polioptera* (Sharpe)	Phường chèo xám nhỏ	Campephagidae		1			1	Observed
11	*Dicrurus paradiseus* (Linnaeus)	Chèo bẻo đuôi chẻ	Dicruridae	4	1	3	1		Observed
12	*Acridotheres cinereus* Bonaparte	Sáo mỏ vàng	Sturnidae				1		Observed
13	Passer montanus (Linnaeus)	Sẻ	Passeridae		2	1			Observed
14	Anas poecilorhyncha (Oates)	Vịt trời	Anatidae				1	2	Observed

No.	Scientific Name	Common Name	Family	Abundance along Transect					Remarks
				Plantation Forests	Gardens	Residential Areas	Secondary Evergreen Forests	Lake Corridors	
15	*Phalacrocorax niger* (Vieillot)	Cốc đen	Phalacrocoracidae				14	3	Observed
16	*Ardeola bacchus* (Bonaparte)	Cò bợ	Ardeidae					1	Observed
17	*Ixobrychus sinensis* (Gmelin)	Cò lửa lùn	Ardeidae				1		Observed
18	*Egretta garzetta* (Linnaeus)	Cò trắng	Ardeidae	1			2	1	Observed
19	*Circus aeruginosus* (Linnaeus)	Diều đầu trắng	Accipitridae		2				Observed
20	*Nisaetus cirrhatus* (Gmelin)	Diều đầu nâu	Accipitridae				1		Observed
21	*Psittacula roseata* Biswas	Vẹt đầu hồng	Psittacidae				1		Observed
22	*Psittacula alexandri* (Linnaeus)	Vẹt ngực đỏ	Psittacidae	1	11				Observed

Annex K Herpetofauna Recorded in the Project Area

No.	Scientific Name	Common Name	Family	Conservation Status		Relative Abundance					Remarks
				IUCN Red List	Vietnam Data RedBook	Plantation Forests	Gardens	Residential Areas	Secondary Evergreen Forests	Lake Corridors	
1	*Duttaphrynus melanostictus* (Schneider)	Cóc nhà	Bufonidae	LC		2	1	1		1	Observed
2	*Hoplobatrachus rugulosus* (Wiegmann)	Ếch đồng	Dicroglossidae	LC			1		1	1	Observed
3	*Fejervarya limnocharis* (Gravenhorst)	Ngóe	Dicroglossidae	LC		1	3	2	2	2	Observed
4	*Dryophytes cinereus* (Schneider)	Ếch cây xanh	Hylidae	LC					1		Observed
5	*Microhyla ornata* (Duméril & Bibron)	Nhái bầu hoa	Microhylidae	LC		6	10		5	3	Observed
6	*Kaloula pulchra* Gray	Ễnh ương	Microhylidae	LC		1	2	1	1	1	Observed
7	*Polypedates mutus* (Smith)	Ếch cây mép trắng	Rhacophoridae	LC			1		1		Observed
8	*Eutropis multifasciata* (Kuhl)	Thằn lằn bóng	Scincidae	LC		1	1				Observed
9	*Calotes versicolor* (Daudin)	Nhông hàng rào	Agamidae	LC					1		Observed
10	*Hemidactylus frenatus* Schlegel in Duméril & Bibron	Thạch sùng	Gekkonidae	LC			1	4		1	Observed
11	*Hemidactylus vietnamensis* Darevsky, Kupriyanova & Roshchin	Thạch sùng	Gekkonidae	LC		1			1	1	Observed
12	*Gekko gecko* (Linnaeus)	Tắc kè	Gekkonidae	LC	VU	+	+		+		Interviewed

No.	Scientific Name	Common Name	Family	Conservation Status		Relative Abundance					Remarks
				IUCN Red List	Vietnam Data RedBook	Plantation Forests	Gardens	Residential Areas	Secondary Evergreen Forests	Lake Corridors	
13	*Xenochrophis piscator* (Schneider)	Rắn nước	Colubridae	LC			+	+	+	+	Interviewed
14	*Coelognathus radiatus* (Schlegel)	Rắn sọc dưa	Colubridae	LC			+		+		Interviewed
15	*Popeia popeiorum* (Smith)	Rắn lục miền Nam	Viperidae	LC		+	+		+	+	Interviewed

Annex L Mammals Recorded in the Project Area

No.	Scientific Name	Common Name	Family	Conservation Status		Relative Abundance					Remarks
				IUCN Red List	Vietnam Data RedBook	Plantation Forests	Gardens	Residential Areas	Secondary Evergreen Forests	Lake Corridors	
1	*Mus musculus* Linnaeus	Chuột nhắt nhà	Muridae	LC				1		2	Observed
2	*Rattus argentiventer* (Robinson & Kloss)	Chuột đồng	Muridae	LC		2	1		1	1	Observed
3	*Rattus flavipectus* (Milne-Edwards)	Chuột nhà	Muridae	LC			1	1			Observed
4	*Cynopterus sphinx* (Vahl)	Dơi chó ấn	Pteropodidae	LC		1	1		1		Observed
5	*Scotophilus kuhlii* (Leach)	Dơi nâu	Vespertilionidae	LC		1	3		1	1	Observed
6	*Callosciurus erythraeus* (Pallas)	Sóc mõm hung	Sciuridae	LC			1		2		Observed
7	*Menetes berdmorei* (Blyth)	Sóc vằn lưng	Sciuridae	LC		+	+	+	+	+	Interviewed
8	*Viverricula indica* (É. Geoffroy Saint-Hilaire)	Cầy hương	Viverridae	LC			+		+		Interviewed

Annex M Ecosystem Services in the Project Area

No.		Ecological Services		
1	**Fishing Activities**	Mr. Vinh	Mr. Lam	Mr. Ut
	Age	32	46	50
	Fishing gear	Fishing net	Fishing net	Fishing net
	Abundant species	Nile Tilapia, Marble goby	Nile Tilapia, Marble goby	Nile Tilapia, Marble goby
	Fish yield (kg/day)	5 - 30	5 - 30	5 - 30
	Prices (VND/kg)	Nile tilapia (30,000 – 50,000), Marble goby (100,000 – 150,000), Sturgeon (120,000 – 150,000)		
2	**Aquaculture**	Tam Long Joint Stock Company		
	Area of cage (m^2)	14,000		
	Species	Sturgeon		
	Prices (VND/kg)	220,000 - 250,000		
	Broodstock	It was imported from Russia		
3	**Payments for forest environment services**	Mr. Anh and other rangers	Ranger officers	Mr. Phuoc
	Career	Head of ranger station	Ranger station	Carpenter
	Understanding of the payments for forest environment services	Know a little about this service	Know a little about this service	No
	Cost and benefits or detail information	No	No	
4	**Collection of firewood**	Mr. Phuoc	Mr. Vinh	Mr. Lam
	Career	Carpenter	Fishermen	Fishermen
	Purposes	Bought the trash timber	Collect the firewood for fuel	Collect the firewood for fuel
5	**Bamboo exploitation**			
	During the survey, no bamboo collectors were found in the forest. The bamboo was soaked under the water of Da Mi Lake			

No.	Ecological Services			
6	**Recreational fishing**	Mr. Anh	Mr. Vinh	Mr. Lam
	Career	Head of ranger station	Fishermen	Fishermen
	Shipping services (VND/person)	50,000	50,000	50,000
	Management	There were no agencies currently managing the recreational fishing and fishing at Da Mi Lake.		

Annex N Critical Habitat Screening Assessment

Taxonomic group	Species	Common name	IUCN Red List Category	Source	Potential Critical Habitat Triggers	Detected during surveys	Species Information	Critical Habitat Rationale
Amphibians	*Kalophrynus cryptophonus*		EN	IBAT	CR or EN species	No	This species is currently known from between 247-800 m asl in the Southern Annamite Mountains in Loc Bao and Cat Tien National Park, Lam Dong Province, Viet Nam. The limits of the species' range are not known however it is likely to occur in Binh Phuoc, Dak Nong and Binh Thuan Provinces. Its estimated extent of occurrence is 5,438 km^2.	Habitat is likely present within the DMU, however the species was not detected during survey. The species is identified as a restricted range species. No historic records exist for the species within the DMU. It is not considered that the species triggers Critical Habitat under CR/EN species or endemic as the species is unlikely to occur within the DMU.
Amphibians	*Rhacophorus helenae*		EN	IBAT	CR or EN species	No	This species is known from two patches of forest in Binh Thuan and Dong Nai Provinces in southern Viet Nam. The two known localities are approximately 30 km apart. The extent of occurrence, has been estimated at 308 km^2.	Habitat is likely present within the DMU, however the species was not detected during survey. The species is identified as a restricted range species. No historic records exist for the species within the DMU. It is not considered that the species triggers Critical Habitat under CR/EN species or endemic as the species is unlikely to occur within the DMU.
Birds	*Emberiza aureola*	Yellow-breasted Bunting	CR	IBAT	CR or EN species/ migratory	No	This species is a winter migrant in SE Asia. The estimated extent of occurrence is 7,390,000km^2. The species winters in large flocks in cultivated areas, rice fields and grasslands, preferring scrubby dry-water rice fields for foraging and reedbeds for roosting. There are no current global estimates of	Habitat is likely present within the DMU, however the species was not detected during survey. The species is identified as a winter migratory species. No historic records exist for the species within the DMU. It is not considered that the species triggers Critical Habitat under CR/EN species or

Taxonomic group	Species	Common name	IUCN Red List Category	Source	Potential Critical Habitat Triggers	Detected during surveys	Species Information	Critical Habitat Rationale
							population size, however the global population has reported to have reduced dramatically since the 1990s.	migratory/congregatory criterion as the species is unlikely to occur within the DMU.
Birds	*Gracula robusta*	Nias Hill Myna	CR	IBAT	CR or EN species		Occurs in Indonesia. Considered out of range.	No assessed
Birds	*Gracula venerata*	Tenggara Hill Myna	EN	IBAT	CR or EN species		The global population size has been assessed to be less than 10,000 mature individuals. This species occurs in moist or semi-evergreen forest in lowlands, hills and mountains. The estimated extent of occurrence is 152,000km^2.	Habitat is likely present within the DMU. The species was not detected within the DMU. It is not considered that the species triggers Critical Habitat under CR/EN species criterion as the species is unlikely to occur within the DMU.
Birds	*Gyps bengalensis*	White-rumped Vulture	CR	IBAT	CR or EN species		The global population is estimated to fall within the band 2,500-9,999 mature individuals. The estimated extent of occurrence is 7,370,000km^2. The population close to the project area is in Cambodia and is restricted to the northern and eastern plains.	The species is highly unlikely to be present within the DMU given the distance from the extant population in Cambodia to the DMU. No individuals were identified during survey. Critical Habitat for globally CR/EN species would not be triggered.
Birds	*Rheinardia ocellata*	Crested argus	NT	WWF	Endemic		Remnant populations occur within Cambodia, Myanmar and Vietnam. The estimated extent of occurrence is 4,590,000km^2. Estimated population size is 15,000-30,000 individuals.	Habitat is likely present within the DMU, however the species was not detected during survey. The species is identified as a restricted range species however it has a large extent of occurance so this may be an error. No historic records exist for the species within the DMU. It is not considered that the species triggers Critical Habitat under endemic as the

Taxonomic group	Species	Common name	IUCN Red List Category	Source	Potential Critical Habitat Triggers	Detected during surveys	Species Information	Critical Habitat Rationale
								species is unlikely to occur within the DMU.
Birds	*Pavo muticus*	Green Peafowl	EN	IBAT	CR or EN species/ Endemic		Noted as having viable populations in west-central Vietnam. Estimated global population is 10,000-19,999 mature individuals. The estimated extent of occurrence is 4,590,000km^2.	Habitat is likely present within the DMU, however the species was not detected during survey. The species is identified as a restricted range species. No historic records exist for the species within the DMU. It is not considered that the species triggers Critical Habitat under CR/EN species or endemic as the species is unlikely to occur within the DMU.
Birds	*Sarcogyps calvus*	Red-headed Vulture	CR	IBAT	CR or EN species		The population close to the project area is in Cambodia and is restricted to the northern and eastern plains; with a minimum of only 47 individuals in 2010. Vagrants may sometimes stray into Vietnam.	The species is highly unlikely to visit the DMU given the distance from the extant population in Cambodia to the DMU. No individuals were identified during survey. Critical Habitat for globally CR/EN species would not be triggered.
Birds	*Sterna acuticauda*	Black-bellied Tern	EN	IBAT	CR or EN species		Considered probably extinct in Vietnam.	Not assessed
Birds	*Arborophila davidi*	Orange-necked Partridge	NT	EBA Trigger species	Endemic		The species is known from southern Vietnam and eastern Cambodia and has been recorded from Cat Tien National Park (NP), Dong Nai Protected Forest. The estimated extent of occurrence is 10,100km^2. Estimated population is 1,500-7,000 mature individuals.	

Taxonomic group	Species	Common name	IUCN Red List Category	Source	Potential Critical Habitat Triggers	Detected during surveys	Species Information	Critical Habitat Rationale
Birds	*Polyplectron germaini*	Germain's Peacock-pheasant	NT	EBA Trigger species	Endemic		The species is endemic to southern Indo-China, where it is known only from south Annam and Cochinchina, Vietnam. The estimated extent of occurrence is 60,900km^2. Estimated population is 6000-15,000 mature individuals.	The species does not meet the definition of endemic/restricted range (<50,000km^2). The species is therefore not considered to be a candidate for critical habitat as an endemic/restricted range species.
Birds	*Lophura edwardsi*	Edwards's pheasant	CR	WWF	Endemic/ CR or EN species		The species occurs over 18,000 km^2 and has been recorded from 6 to 10 locations in central Vietnam. Populations appear very small, fragmented and are suspected to be declining. It inhabits damp mountain forests up to an estimated 600 m, favouring thick underbrush and lianas. The population is only estimated at 50 - 249 mature individuals.	Habitat is likely present within the DMU, however the species was not detected during survey. The species is identified as a restricted range species. No historic records exist for the species within the DMU. It is not considered that the species triggers Critical Habitat under CR/EN species or endemic as the species is unlikely to occur within the DMU.
Birds	*Garrulax yersini*	Collared laughingthrush	EN	WWF	Endemic/ CR or EN species		Species is endemic to the Da Lat plateau in Vietnam. Considered that the DMU is out of range for the species	Not assessed.
Birds	*Garrulax ngoclinhensis*	Golden-winged laughingthrush	VU	WWF	Endemic		The species is only known from Mt Ngoc Linh and Mt Ngoc Boc on the Kon Tum plateau of central Vietnam. Considered that the DMU is out of range for the species	Not assessed.
Birds	*Jabouilleia danjoui*	Short-tailed scimitar-babbler	NT	WWF	Endemic		This species is known from east Tonkin, north, central and south Annam, Vietnam. . The estimated extent of occurrence is 310,000km^2. Estimated population is <20,000 mature individuals.	The species does not meet the definition of endemic/restricted range (<50,000km^2). The species is therefore not considered to be a candidate for critical habitat as an endemic/restricted range species.

Taxonomic group	Species	Common name	IUCN Red List Category	Source	Potential Critical Habitat Triggers	Detected during surveys	Species Information	Critical Habitat Rationale
Birds	*Mixornis kelleyi*	Grey-faced Tit-babbler	LC	EBA Trigger species	Endemic		This species may have a restricted range with an estimated extent of occurrence <20,000 km². The population of the species is unknown.	Habitat is likely present within the DMU, however the species was not detected during survey. The species is identified as a restricted range species. No historic records exist for the species within the DMU. It is not considered that the species triggers Critical Habitat as an endemic species as the species is unlikely to occur within the DMU.
Birds	*Actinodura sodangorum*	Black-crowned barwing	NT	WWF	Endemic		The species is currently known from just seven associated localities in Kontum province in the western highlands of Vietnam. The estimated population is 6,600-13,400 mature individuals. The estimated extent of occurrence <14,400 km².	Habitat is likely present within the DMU, however the species was not detected during survey. The species is identified as a restricted range species. No historic records exist for the species within the DMU. It is not considered that the species triggers Critical Habitat as an endemic species as the species is unlikely to occur within the DMU.
Birds	*Crocias langbianis*	Grey-crowned crocias	EN	WWF	Endemic/ CR or EN species		This species is known from only three sites in central Annam, Lam Dong and Dak Lak provinces on the Da Lat Plateau, Central Vietnam. Considered that the DMU is out of range for the species	Not assessed.
Birds	*Carduelis monguilloti*	Vietnamese greenfinch	LC	WWF	Endemic		The species is endemic to the Da Lat plateau of south Annam, Vietnam, where it is locally common. Considered that the DMU is out of range for the species	Not assessed

Taxonomic group	Species	Common name	IUCN Red List Category	Source	Potential Critical Habitat Triggers	Detected during surveys	Species Information	Critical Habitat Rationale
Fishes	*Catlocarpio siamensis*	Giant Carp	CR	IBAT	CR or EN species		The Giant Carp is recorded from larger rivers and floodplain areas in the Maeklong, Mekong and Chao Phraya basins in Thailand, Cambodia, Lao PDR and Viet Nam. Considered that the DMU is out of range for the species	Not assessed
Fishes	*Pangasianodon hypophthalmus*	Striped Catfish	EN	IBAT	CR or EN species		This species occurs in the Chao Phraya and middle-lower Mekong basins and is also reported from the Mae Khlong in Thailand. Considered that the DMU is out of range for the species	Not assessed
Fishes	*Scleropages formosus*	Golden Dragon Fish	EN	IBAT	CR or EN species		This species occurs in the Mekong basin in Viet Nam and Cambodia, southeastern Thailand. Considered that the DMU is out of range for the species	Not assessed
Mammals	*Chrotogale owstoni*	Owston's Civet	EN	IBAT	CR or EN species		The species is known to occur across a wide latitudinal range of both eastern Lao PDR and Viet Nam. No population estimates are available for the species. Its occurance in Vietnam is described as declining.	Habitat is likely present within the DMU. The species was not detected within the DMU. It is not considered that the species triggers Critical Habitat under CR/EN species criterion as the species is unlikely to occur within the DMU.
Mammals	*Rattus hoxaensis*		NA	WWF	Endemic		Endemic rat species occurring in Central Vietnam. Very little species specific information is available. It is described as restricted range. No population or range information is available for the species.	Habitat is likely present within the DMU, however the species was not detected during survey. The species is identified as a restricted range species. No historic records exist for the species within the DMU. It is not considered that the

Taxonomic group	Species	Common name	IUCN Red List Category	Source	Potential Critical Habitat Triggers	Detected during surveys	Species Information	Critical Habitat Rationale
								species triggers Critical Habitat as an endemic species as the species is unlikely to occur within the DMU.
Mammals	*Rattus osgoodi*		LC	WWF	Endemic		The extent of occurrence is probably less than 7,000 km². This species has been recorded from only two localities in Lam Dong province, southern Viet Nam. No population information is available on the species.	Habitat is likely present within the DMU, however the species was not detected during survey. The species is identified as a restricted range species. No historic records exist for the species within the DMU. It is not considered that the species triggers Critical Habitat as an endemic species as the species is unlikely to occur within the DMU.
Mammals	*Maxomys moi*		LC	WWF	Endemic		This species has been recorded from the highlands of southern Viet Nam and adjacent southern Lao PDR between 190 and 1,500 m. No estimated area of occurrence or species population information is available.	Habitat is likely present within the DMU, however the species was not detected during survey. The species is identified as a restricted range species. No historic records exist for the species within the DMU. It is not considered that the species triggers Critical Habitat as an endemic species as the species is unlikely to occur within the DMU.
Mammals	*Dendrogale murina*		LC	WWF	Endemic		The species' records include sightings in southern Viet Nam, south-east Thailand and probably Cambodia. Recent records show their range extending much further north in Viet Nam (at least to 17º20'N and probably to	Habitat is likely present within the DMU, however the species was not detected during survey. The species is identified as a restricted range species. No historic records exist for the species within the DMU. It is not considered that the

Taxonomic group	Species	Common name	IUCN Red List Category	Source	Potential Critical Habitat Triggers	Detected during surveys	Species Information	Critical Habitat Rationale
							21º27'N), into Lao PDR. No estimated area of occurrence or species population information is available.	species triggers Critical Habitat as an endemic species as the species is unlikely to occur within the DMU.
Mammals	*Hylobates gabriellae*	Yellow-cheeked gibbon	EN	WWF	Endemic/ CR or EN species		Species is located in southern Viet Nam, south of Bach Ma national park. No estimated area of occurrence or species population information is available.	Habitat is likely present within the DMU, however the species was not detected during survey. The species is identified as a restricted range species. No historic records exist for the species within the DMU. It is not considered that the species triggers Critical Habitat as an endemic species as the species is unlikely to occur within the DMU.
Mammals	*Manis javanica*	Sunda Pangolin	CR	IBAT	CR or EN species		The species is rare in central and southern Vietnam. The species exhibits habitat plasticity and can be found in primary and secondary forests, plantations, gardens and near human settlements. Main threats to this species are overexploitation for the international wildlife trade. There is a very large hunting pressure in Vietnam on this species.	Potential Critical Habitat for Criterion 1, Tier 2c, being habitat that supports the regular occurrence of a single individual of a CR species.
Mammals	*Muntiacus vuquangensis*	Large-antlered Muntjac	CR	IBAT	CR or EN species		The species occurs in Cambodia, Laos and Vietnam. Evidence for its presence comes mostly from the Annamite Mountain range. The species does not generally live above 900 m asl. The species faces	

Taxonomic group	Species	Common name	IUCN Red List Category	Source	Potential Critical Habitat Triggers	Detected during surveys	Species Information	Critical Habitat Rationale
							substantial population losses from very high hunting pressure. Key threats are hunting for bushmeat and antlers, habitat loss and degradation.	
Mammals	*Nomascus gabriellae*	Red-cheeked Gibbon	EN	IBAT	CR or EN species		Population of the species is considered extirpated within the Cat Tien National Park. No records of the species occur within the DMU and it is considered out of range.	Not assessed.
Mammals	*Pygathrix nigripes*	Black-shanked Douc Langur	EN	EBA Trigger species	Endemic/ CR or EN species		The species is found in north-eastern Cambodia and southern Viet Nam. This species has a fragmented distribution extending from Sa Tay district (Kon Tum Province) in the north to just south of Cat Tien National Park in the south. The population of the species is restricted to Nui Chua National Park (Ninh Thuan Province), which is estimated at 500-700 individuals. No records of the species occur within the DMU and it is considered out of range.	Not assessed.
Mammals	*Pygathrix nemaeus*	Red-shanked douc	EN	WWF	Endemic/ CR or EN species		This species range occurs in central Laos and northern central Vietnam. The species occurs in undisturbed primary and secondary evergreen, semi-evergreen broadleaf forests and limestone forests. There are at least 5 known localities in Vietnam	Not assessed.

Taxonomic group	Species	Common name	IUCN Red List Category	Source	Potential Critical Habitat Triggers	Detected during surveys	Species Information	Critical Habitat Rationale
							where this species has been found. No records of the species occur within the DMU and it is considered out of range.	
Mammals	*Trachypithecus germaini*	Indochinese Lutung	EN	IBAT	CR or EN species		The precise limits of distribution of this species are unclear. It is reliably recorded from Cambodia, Viet Nam, and from southern Lao PDR. This is a widespread but very rare species throughout most of its range with very few sitings in Vietnam. No records of the species occur within the DMU and it is considered out of range.	Not assessed.
Mammals	*Viverra megaspila*	Large-spotted Civet	EN	IBAT	CR or EN species		Considered extirpated within Vietnam.	Not assessed.
Mammals	*Capricornis sumatraensis*	Serow	VU	EBA Trigger species	Endemic		The species is native to Cambodia, Laos, Myanmar, Thailand and Viet Nam. Populations in the northern highlands of Vietnam are likely to be heavily depleted in number and fragmented, but are likely more numerous along the Annamite mountains. The species occurs in rugged limestone mountains and cliffs. In Vietnam, it is usually found above 1500m in steep montane scrub, evergreen hill forests, and grassland slopes.	Habitat is likely present within the DMU, however the species was not detected during survey. The species is identified as a restricted range species. No historic records exist for the species within the DMU. It is not considered that the species triggers Critical Habitat as an endemic species as the species is unlikely to occur within the DMU.
Mammals	*Nycticebus pygmaeus*	Pygmy Slow Loris	VU	EBA Trigger species	Endemic		This species is found east of the Mekong River in eastern Cambodia, southernmost China (southeastern Yunnan), Lao PDR,	Habitat is likely present within the DMU, however the species was not detected during survey. The species is identified as a restricted

Taxonomic group	Species	Common name	IUCN Red List Category	Source	Potential Critical Habitat Triggers	Detected during surveys	Species Information	Critical Habitat Rationale
							and Viet Nam. No estimated area of occurrence or species population information is available. The species is considered to be endemic.	range species. No historic records exist for the species within the DMU. It is not considered that the species triggers Critical Habitat as an endemic species as the species is unlikely to occur within the DMU.
Plants	*Magnolia cattienensis*		EN	IBAT	CR or EN species		The species is only found in the Cat Tien National Park in Viet Nam. No estimated area of occurrence or species population information is available. The species is considered to be endemic. Considered to be out of range for the DMU.	Not assessed.
Reptiles	*Crocodylus siamensis*	Siamese Crocodile	CR	IBAT	CR or EN species		Considered extirpated in Vietnam.	Not assessed.

Annex O Aquatic Survey Plan

The following requierments are to be applied on a three (3) monthly basis.

1. Collect water quality data from Da Mi Resrvoir (collected for the hydro-electric project at various locations within the lake). The results for BOD and COD are to be collected and analysed. The following thresholds are relevant to tropical lakes:

	Chl a	**TP**	**TN**	**NH4**	**BOD**	**COD**	**DO (% saturation**	**DO (% saturation**
	µg L^{-1}	µg P L^{-1}	µg N L-1	µg N L^{-1}	mg/L	mg/L	Lower limit	Upper limit
Threshold for tropical lakes	3	10	350	10	<15	<40	90	120

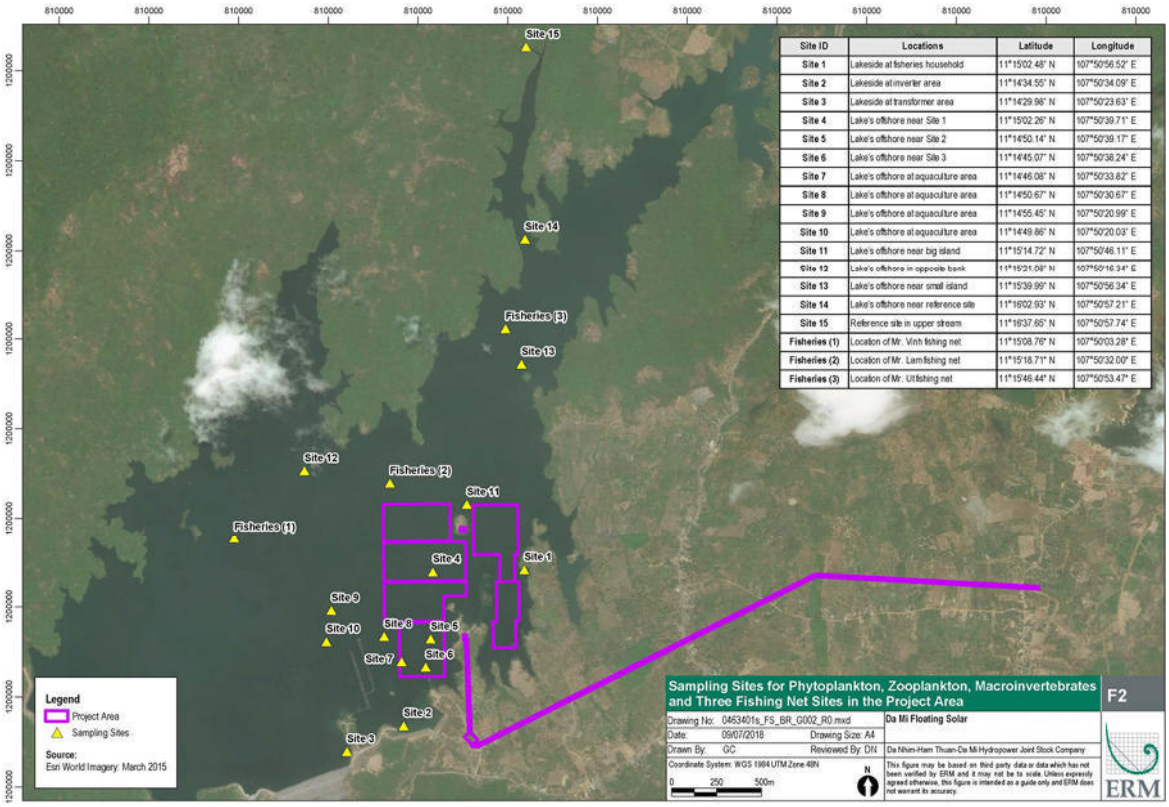
An annual assessment is to occur in relation the results of the water quality assessment in terms of meeting/exceeding the required standards.

2. Inspections and inerviews with fishermen are to occur to determine if any fish kills have occurred within the Lake. Where fish kills have been identified, they are to be investigated to determine the likely source. Fish kills may be caused from toxicants, disease or deoxygenated/eutrophic water. If deoxygenated water is the likely cause, measures are to be considerd to increase mixing within the lake.

3. Biota sampling at different trophic levels (phytoplankton, zooplankton, aquatic macroinvertebrates and fish) and depth profile using a secchi disk is to occur at the sampling lcoations shown below:

   The results are to be analysed to determine whether any significant changes in trophic levels are occurring within the lake during and following construction.

All sampling and assessment is to be completed by suitably qualified individuals.



Site ID	Locations	Latitude	Longitude
Site 1	Lakeside at fisheries household	11°15'02.48" N	107°50'56.52" E
Site 2	Lakeside at inverter area	11°14'34.55" N	107°50'34.09" E
Site 3	Lakeside at transformer area	11°14'29.98" N	107°50'23.63" E
Site 4	Lake's offshore near Site 1	11°15'02.26" N	107°50'39.71" E
Site 5	Lake's offshore near Site 2	11°14'50.14" N	107°50'39.17" E
Site 6	Lake's offshore near Site 3	11°14'45.07" N	107°50'38.24" E
Site 7	Lake's offshore at aquaculture area	11°14'46.08" N	107°50'33.82" E
Site 8	Lake's offshore at aquaculture area	11°14'50.67" N	107°50'30.67" E
Site 9	Lake's offshore at aquaculture area	11°14'55.45" N	107°50'20.99" E
Site 10	Lake's offshore at aquaculture area	11°14'49.86" N	107°50'20.03" E
Site 11	Lake's offshore near big island	11°15'14.72" N	107°50'46.11" E
Site 12	Lake's offshore in opposite bank	11°15'21.09" N	107°50'16.34" E
Site 13	Lake's offshore near small island	11°15'39.99" N	107°50'56.34" E
Site 14	Lake's offshore near reference site	11°16'02.93" N	107°50'57.21" E
Site 15	Reference site in upper stream	11°16'37.65" N	107°50'57.74" E
Fisheries (1)	Location of Mr. Vinh fishing net	11°15'08.76" N	107°50'03.28" E
Fisheries (2)	Location of Mr. Lam fishing net	11°15'18.71" N	107°50'32.00" E
Fisheries (3)	Location of Mr. Ut fishing net	11°15'46.44" N	107°50'53.47" E

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