**Environmental Impact** Assessment (EIA) for the **Deployment & Operation** of Floating Solar PV (FPV) Systems at Lower **Seletar Reservoir** 



This Non-Technical Summary presents a condensed summary of findings from the environmental baseline studies and impact assessment for the construction, operation, and maintenance of Floating Solar PV at Lower Seletar Reservoir.





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The Project aims to deploy a minimum **130 MWp** Floating Solar Photovoltaic (FPV) System in Lower Seletar Reservoir.

The proposed FPV will cover approximately 36% of the reservoir surface area. The design considers existing uses, users and avoids any disturbance. These activities include reservoir operations, recreational areas, and existing aeration and sampling points.



PUB, Singapore's national water agency, has engaged the following organisations for the Project:





**Design Engineering Consultant** 

### **Benefits of Project**

- The project will support the Energy Market Authority's goal of achieving at least 2 GWp of solar capacity by 2030 to meet Singapore's electricity needs.
- The use of solar panels also supports the clean energy transition and the Singapore Green Plan's targets

### **Reservoir-based Project Components**

#### **FPV Layout Considerations**

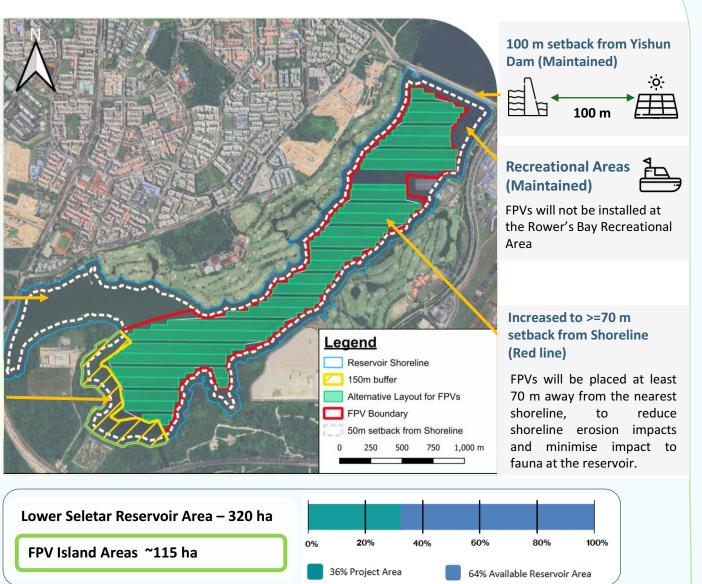
FPVs are broken up into smaller islands with 30 m corridors for vessel & SCDF emergency access



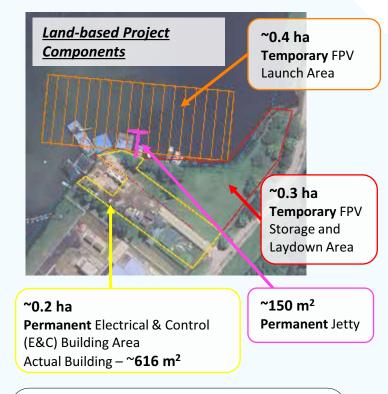


FPVs will not be installed at the Lower Seletar Reservoir Park Water Recreational Area

Up to 150 m buffer zone where high-level of bird activities were spotted



### **Land-based Project Components**



#### **Project timeline**

Construction to commence in 2026

**Expected completion in 2029 for operations** 

### **Activities Across Project Phases**

#### Construction



Site Preparation: Removal of Hydrilla Assembly and Launch of FPV Blocks





**Construction of launching platform** 



Piling works for over-water structures



**Commissioning & Testing** 



**Construction of land components** 

### **Operations & Maintenance**



**Drone technology for remote inspection** 



Cleaning and Visual inspection of PV panels. Inspection of all arrays



SCADA monitoring system to monitor and control the operation of the plant

### **Steps in EIA Process**







### 1 SCOPING

In May 2022, PUB engaged with Nature Groups on the scope of the EIA study for the Lower Seletar Reservoir FPV Deployment. Attendees highlighted that the deployment should not disrupt the ecological connectivity identified in NParks' Ecological Profiling Exercise (EPE) & to minimise impacts to habitats, where possible.

### 2

#### **BASELINE MONITORING**

Environmental baseline surveys were undertaken for the following aspects



### <u>IMPAC</u>

#### **IMPACT ASSESSMENT**

**Rapid Impact Assessment Matrix (RIAM)** was used to assess the potential environmental impacts of the Project. An environmental score was calculated using five criteria (importance, magnitude, permanence, recoverability, and cumulative). The five criteria were combined to create a quantitative score utilising a formula to determine the significance of impact.

Environmental Score (ES) = $\sum_{n} I_n * M_n * (P_n + R_n + C_n)$	
Environmental score (ES) = - 1/1 101/1 (1 /1 · 11/1 · C/I)	

RIAM Criteria	Description	
I	Importance of Receptor	
М	Magnitude	
Р	Permanence	
R	Recoverability	
С	Cumulative Impact	

Range	Description of Range Band
116 to 180	Major positive change / impact
81 to 115	Moderate positive change / impact
37 to 80	Minor positive change / impact
7 to 36	Slight positive impact
-6 to +6	No Impact / Status quo / Not Applicable
-7 to -36	Slight negative change / impact
-37 to -80	Minor negative change / impact
-81 to -115	Moderate negative change / impact
-116 to -180	Major negative change / impact

#### 4

#### **MITIGATION MEASURES & RECOMMENDATIONS (EMMP)**

### Mitigation Hierarchy



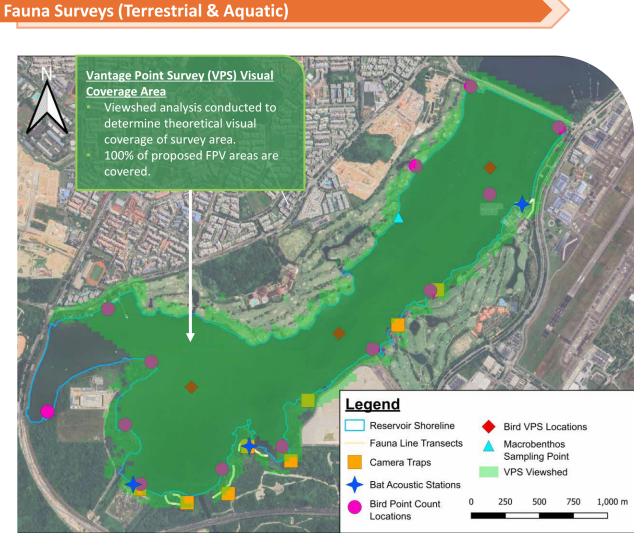
#### Monitoring Throughout Project Phases

Monitoring frequencies for various environmental aspects (i.e., biodiversity, physical environment) will be proposed for pre-, during-, and post-construction phases to ensure environmental compliance.

**EIA APPROACH &** 

**ASSESSMENT** 

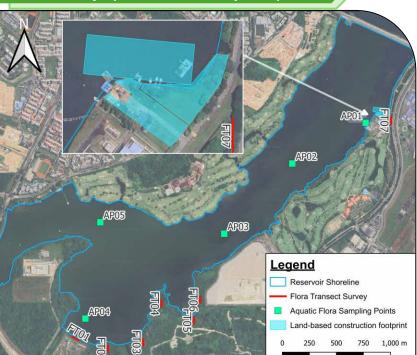
# Environmental Baseline Surveys (August 2023 to March 2024)



Survey Method (#)	Target Taxa	Survey Timing	Frequency (Duration)
Line Transect (4)	Birds, Non-volant Mammals & Herpetofauna	0700-1100 1930-2330	6 replicates per transect (monthly)
	Butterflies & Odonates	0900-1300	
	Bats	1900-2130	
Camera Trap (8)	Non-volant Mammals	24 hrs	6 months (continuous)
Stationary Acoustic Monitoring (3)	Bats	1930-2130	2 consecutive nights per station (monthly)
Point Count (13)	Birds	0700-1100	6 replicates per point
			Each replicate: 10 minute (monthly) = 13 hours total
Vantage Point (3)	Birds	0700-1000 1000-1300 1300-1600 1600-1900	2 replicates per 3- hour time-block, per point = 72 hours total
Colonizer cages (2)	Macrobenthos	N.A	2-time deployment for 4 weeks each

### **Environmental Baseline Surveys (August 2023 to March 2024)**

#### Flora Surveys (Terrestrial & Aquatic)



#### **Terrestrial Flora**

- One-time survey on seven,
   50 x 10 m belt transects
- 6 transects at the South forest, 1 transect near the land-based construction area
- All woody stems ≥ 30 cm girth measured and identified

#### **Aquatic Flora**

- 2 replicates per point at 5 sampling points
- Rake-harvest method in water column
- Samples tested for dry weight, Carbon, Nitrogen, Phosphorus, Potassium
- Aquatic plant biomass estimated from samples

### **Water & Sediment Quality**

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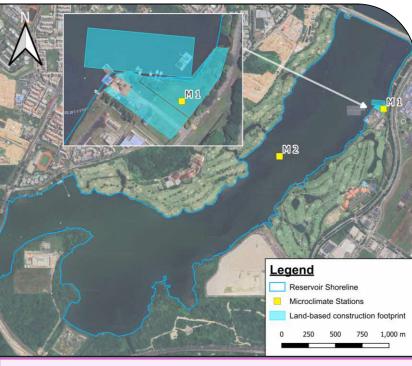
#### **Water Quality**

- Monthly sampling for 6 months
- Samples collected at middepth & 0.5 m above reservoir bed
- Analysed for 30+ parameters such as pH and Turbidity
- WQ evaluated against PUB's water quality criteria

#### Sediment

- One-time sampling
- Sample collected from the bottom of the reservoir
- Analysed for 20+ parameters such as total organic carbon
- Sediment evaluated against the Dutch Soil Remediation Circular 2013. Elutriate and porewater was evaluated against PUB's internal limits

### Meteorology

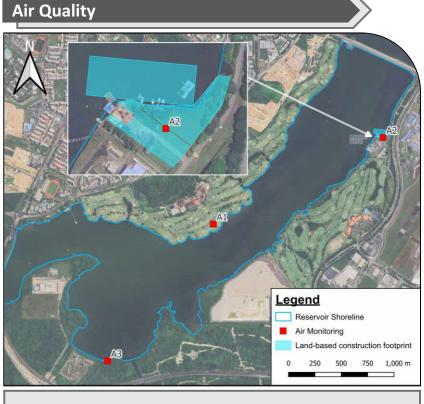


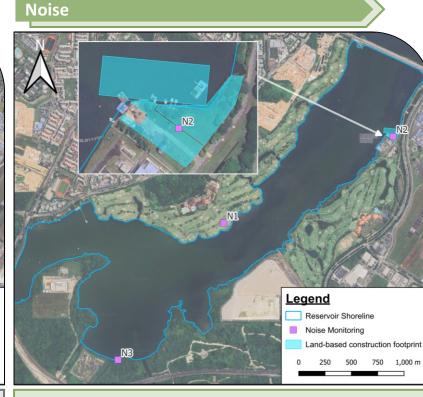
#### Meteorology

- 2 meteorology stations deployed 1 on land, 1 on the reservoir for continuous 6 months
- Parameters measured:
  - Air temperature
  - Relative humidity
  - Irradiance
  - Total accumulated rain
  - Atmospheric pressure
  - Wind speed & direction

## **Environmental Baseline Surveys (August 2023 to March 2024)**







#### Soil

- One-time sampling
- 20 parameters assessed
- Results compared to the Dutch Soil Remediation Circular 2013

#### **Air Quality**

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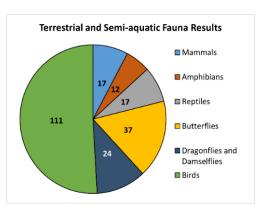
- One-time monitoring (7-day continuous)
- Parameters tested:
  - Sulfur Dioxide (SO<sub>2</sub>)
  - o Carbon Monoxide (CO)
  - Nitrogen Dioxide (NO<sub>2</sub>)
  - $PM_{2.5}$
  - $\circ$  PM<sub>10</sub>

#### Noise

- One-time monitoring (7-day continuous)
- Sound pressure level measured:
  - o LAeq 5mins
  - o LAeq 1hr
  - o LAeq 12 hrs
- Monitoring locations at receptors surrounding Lower Seletar Reservoir

## **FAUNA (TERRESTRIAL & AQUATIC): BASELINE FINDINGS**

### **Overall Fauna Assemblage**

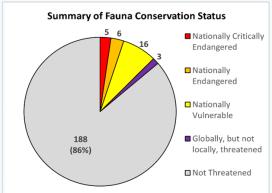


- fauna species 218 were recorded, of which 111 species were birds.
- Most of the fauna were found on the transects at the forested area along south-western end of the the outside reservoir. construction area.
- Surveys at the land-based construction area did not record high diversity relative other areas on the reservoir, with only 2 locally Significance Conservation (CS) mammals and 5 locally CS birds seen.

### **Conservation Significance (CS) Fauna Recorded**

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**ASSESSMENT** 



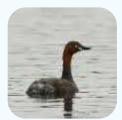
27 CS species recorded (SRBD3)



Cottom Pygmy Goose (CR)



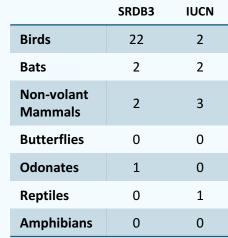
**Purple Heron** (EN)



Little Grebe (CR)



Little Tern (EN)



\* This table includes native species only



Otter (EN)



Grev-headed Fish Eagle (VU)



Common Kingfisher (VU)

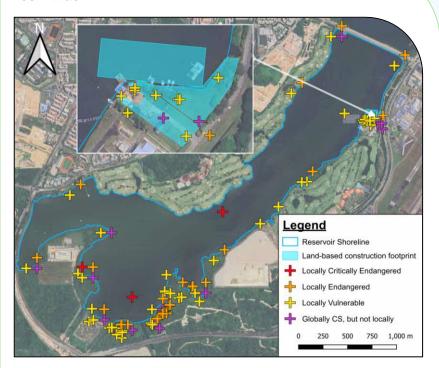


**Oriental Pratincole** (EN)

- Of the 27 CS species recorded, 19 species are expected to utilise the reservoir/shoreline habitat for foraging or other activities. These include the smooth-coated otter. insectivorous bats which may forage over the water's surface, dragonflies, waders, shorebirds, crakes, and raptors, among others.
- The five nationally critically endangered species are the little grebe, cotton pygmy goose, long-winged tomb bat, greater woolly horseshoe bat, and the Sunda pangolin.
- · Macrobenthos diversity was low, with one genus of decapod crustacean, one genus of insect, and four genera of molluscs found.
- Based on secondary data collected by PUB, none of the native fish, aquatic molluscs, and decapod crustacean were of conservation significance. Most of the fish found were non-native.

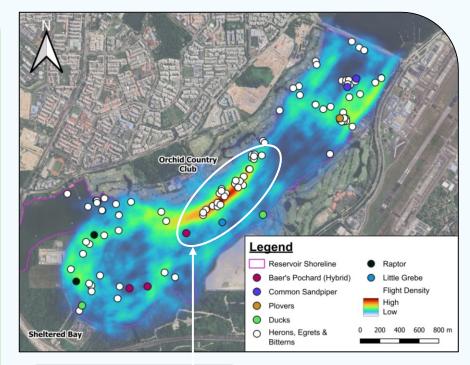
### **FAUNA (TERRESTRIAL & AQUATIC): BASELINE FINDINGS**

#### **CS Birds**



- □ 111 birds (67 native residents, 31 migrants/visitors, 13 non-native/origin uncertain)
- 22 locally conservation significant (2 CR, 5 EN, 15 VU)
- 1 globally conservation significant (Long-tailed Parakeet, IUCN: VU, SRDB3 NT)

#### **Spatial Utilisation & Foraging Observations**



High density of flights in this area are attributed mostly by herons and egrets on the hydrilla harvester and the floating pontoon with harvested hydrilla.



- Raptors: High intensity in the southwestern region of the reservoir near the sheltered bay, with a decrease in intensity observed towards the northeast. The high intensity correlates with raptors frequently soaring, thermalling, or landing in the trees at the reservoir edge.
- Herons & Egrets: Species were largely observed foraging on the harvested mounds of hydrilla on pontoons scattered throughout the reservoir and alongside the shoreline close to Orchid Country Club. Many were perched on the existing FPV array as well.
- Water birds: A number of rare waterbirds were observed during the baseline surveys. However, most observations were one-off sightings (except for the little grebe, *Tachybaptus ruficollis*), suggesting that the birds are transient and not residing/ overwintering at the reservoir and its surroundings.
- Terns: The little tern was recorded only once, seen hovering low over water at the sheltered bay, possibly foraging. The whiskered tern was sighted multiple times, skimming low over the reservoir surface and feeding at the sheltered bay area.

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# EIA APPROACH & ASSESSMENT

### FAUNA (TERRESTRIAL & AQUATIC): IMPACT ASSESSMENT

<u>Con</u>	<u>struction</u>			
S/N	Impacts	Pre-Mitigation Impact	Residual Impact	Degree of Impact
1	Noise disturbance from construction activities	Minor (-48)	Slight (-24)	
2	Light pollution from night works	Minor (-48)	Slight (-24)	
3	Disturbance to aquatic fauna due to increased traffic and water based construction	Minor (-48)	Slight (-24)	
4	Impact on reservoir habitat and fauna usage of the reservoir due to FPV coverage	Minor (-64)	Slight (-32)	
5	Habitat loss from land-based construction activities	Slight (-32)	Slight (-32)	SLIGHT
6	Roadkill and human-wildlife conflict	Slight (-24)	Slight (-24)	
7	Air quality impacts from construction activities	Slight (-24)	Slight (-24)	
8	Change in water quality	Slight (-24)	Slight (-12)	
		•		

### **Operations & Maintenance**

S/N	Impacts	Pre-Mitigation Impact	Residual Impact	Degree of Impact
1	Cascading effects of reduced light levels, plant and plankton biomass on aquatic fauna	Slight (-32)	Slight (-32)	SLIGHT
2	Long-term impact on reservoir habitat and fauna usage of the reservoir due to FPV coverage	Moderate (-96)	Minor (-64)	MINOR

#### **Mitigation Measures**

- Replant with native species to restore breeding and foraging habitats, especially for waterbirds
- Develop a Fauna Management and Wildlife Response Plan for handling fauna-related incidents to ensure fauna encountered can escape or be rescued/relocated.
- Avoid night work where possible. If not, develop a Light Management Plan to reduce light leakage and light pollution.
- Install temporary noise barriers around the construction site.
- Carry out anchoring and piling works with utmost consideration to minimize the disturbance of sediment. If water quality deterioration is observed, anchoring and piling works should slow down or cease.
- Plan cable laying work to avoid work correction and repeated disturbance at the reservoir bottom.
- Activate contingency response plan swiftly when water quality parameters exceed limits to enhance mixing and prevent anoxic conditions and aquatic fauna mortality.
- Redesign the floating panels arrays to allow a larger buffer area (150 m), avoiding hotspots and preserving food sources and habitat for birds, bats, and mammals.
- Where practicable, conduct vegetation clearance outside of the nesting period of native birds (February July).
- Develop a waste management plan to manage waste<sup>1</sup>. Meals should not be stored on site. Waste from meals should be thrown into monkey-proofed bins immediately after consumption, and removed from the site at the end of each working day.

<sup>&</sup>lt;sup>1</sup> Waste impact assessment is made available in the full EIA report

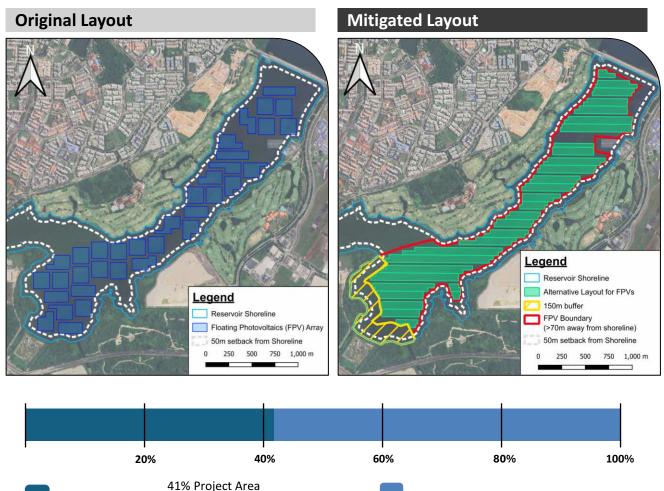
59% Available Reservoir Area

### FAUNA (TERRESTRIAL & AQUATIC): IMPACT ASSESSMENT

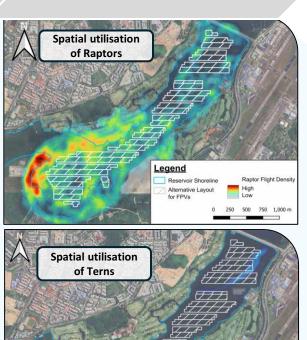
(Occupied by FPV, Ancillary Equipment & Water Corridor)

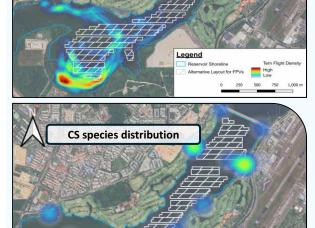
### **Mitigation Measures**

#### **FPV Layout**



- Based on the spatial utilization of birds of different species, it is observed that birds are mostly concentrated in the south and along reservoir shoreline. The FPVs were reorientated to avoid areas of high sensitivity and high bird usage. Thus, at the Southwestern part of the reservoir (sheltered bay), the buffer has been increased to up to 150 m instead of 50 m buffer per the original layout.
- The space between FPV islands can also be used for foraging.
- Certain birds (e.g. herons, bitterns) will be able to use FPV panels as perches to aid in hunting.





### FLORA (TERRESTRIAL & AQUATIC): BASELINE FINDINGS

### **Habitats**

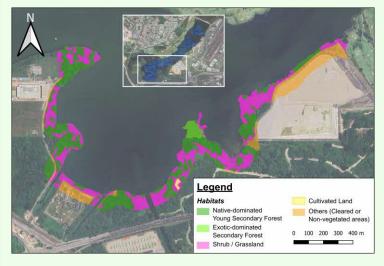
#### **Land-based Construction Area**



 Land-based area comprises of mostly planted vegetation



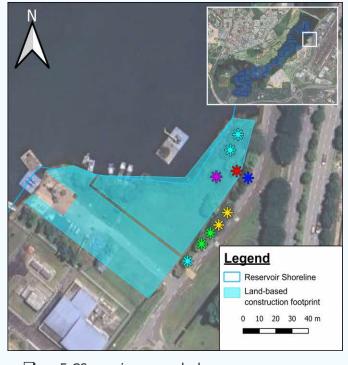
#### **Forested Area at South of Reservoir**



- Project will not encroach into forested areas
- Forested areas have generally sparse understory
- Some areas are dominated with Ficus macrocarpa (LC)



### **Conservation Significance Flora Recorded**



5 CS species recorded



Red Mempat Common Sterculia 🦥 Cratoxylum cochinchinense (EN) Sterculia parviflora (CR)



pterocarpum (CR)



Pink Mempat 🔆 Cratoxylum formosum (EN)



Sea Beam 🗱 Maranthes corymbosa (VU)

### FLORA (TERRESTRIAL & AQUATIC): BASELINE FINDINGS

### **Aquatic Flora Composition**

- Hydrilla verticillata (non-native) was observed in over 90% of the reservoir surface. No other aquatic flora species was found from the sampling.
- Biomass was calculated using rake-harvested samples from five designated points, measuring the wet mass of entire plant columns.
- Aquatic flora biomass was estimated to be 3,409 tonnes in average across the reservoir.





### **Aquatic Flora Nutrient Content**

Sampling Point	Wet Mass (g)	Dry Mass at 60°C (g)	Dry to Wet Mass Ratio	C (%)	N (%)	C:N Ratio	Total P (mg/kg)	K (mg/kg)
AP01	350	89.5	0.26	31.2	1.5	21.4	404.0	29,684
AP02	396	78.0	0.20	28.6	2.2	13.2	ND	25,821
AP03	388	71.2	0.18	27.9	2.1	13.4	ND	19,814
AP04	382	122.0	0.32	13.7	1.0	14.1	ND	15,659
AP05	512	97.5	0.19	10.4	0.7	15.3	29.1	16,407
Remarks:	ectable							

- not detectable

• Phosphorus (P) was very variable between samples, possibly due to H. verticillata sampled at different maturity / condition.

### FLORA (TERRESTRIAL & AQUATIC): IMPACT ASSESSMENT

Con	<u>struction</u>			
S/N	Impacts	Pre-Mitigation Impact	Residual Impact	Degree of Impact
1	Vegetation clearance and trimming due to land-based construction activities	Slight (-12)	Slight (-12)	
2	Impact from clearing for FPV deployment and shoreline construction work	Slight (-24)	Slight (-24)	SLIGHT
3	Water pollution from land & water-based construction activities	Slight (-12)	Slight (-12)	SLIGHT

**EIA APPROACH &** 

**ASSESSMENT** 

Ope	erations & Maintenance			
S/N	Impacts	Pre-Mitigation Impact	Residual Impact	Degree of Impact
1	Long-term impacts on flora due to changes in ambient environment	No Impact (0)	No Impact (0)	
				NO IMPACT

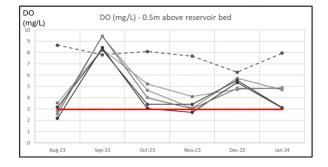
#### **Mitigation Measures**

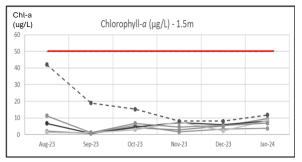
- Cables route should be routed to avoid trees where possible.
- Minimise trimming and removal of vegetation and keep it within the site boundaries.
- Replant with native species to restore breeding and foraging habitats in the operation & maintenance phase.
- Remove Hydrilla directly under the FPV footprint before the installation of FPVs. The time between hydrilla removal and FPV installation at their respective areas should be no more than one month, so that hydrilla regrowth at those areas is minimised.

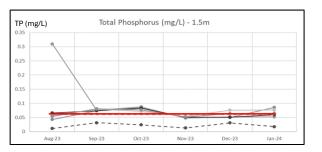
### WATER & SEDIMENT QUALITY: BASELINE FINDINGS

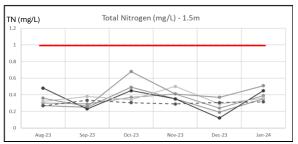
#### Water Quality (WQ) & Sediment Quality

- WQ baseline sampling results for all parameters, such as Dissolved Oxygen (DO), Total Organic Carbon (TOC), Total Nitrogen (TN), Ammonia (NH<sub>3</sub>), Total Phosphorus (TP), and Chlorophyll-*a* (Chl-*a*), generally met PUB's guidelines, with occasional spikes of TP.
- Sediment quality was under limits as prescribed by the Dutch Soil Remediation Circular 2013, at all points.









- Water quality criterion/ guideline
- Water quality monitoring results

### WATER & SEDIMENT QUALITY: WQ MODELLING

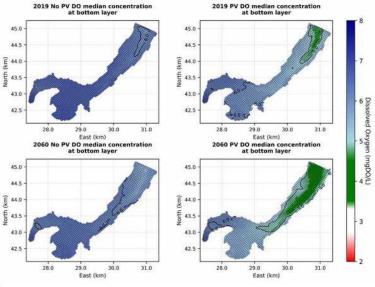
#### **Water Quality (WQ) Model**

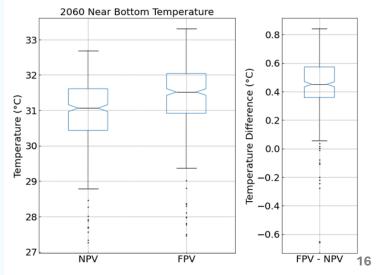
- Water quality modelling was carried out using a suite of calibrated catchment (SOBEK), hydrodynamic (Delft3D-FLOW), and water quality (Delft3D-WAQ) models.
- Assumed full surface coverage of 132 ha (vs. 105 ha without coverage of gaps between FPV).
  - Typical FPVs include gaps for maintenance and natural water-air exchange. Modelling water quality under FPV systems with no open space will likely predict reduced mixing, significant declines in light penetration, DO, phytoplankton biomass, potentially more significant temperature change, and nutrient accumulation.
- Model validated against PUB's 2019 in-reservoir water quality monitoring data.
- Modelled for 2019 and future climate conditions (2040, 2050, and 2060).

#### **WQ Model Findings**

With FPVs in place across all scenario years (2040, 2050, and 2060):

- Temperature
  - Bottom temperature over the whole reservoir increases by 0.28°C by 2019, to 0.45°C by 2060.
  - Bottom temperature increase potentially reduces bottom oxygen levels and increases nutrient release from sediments.
     However, WQ modelling shows bottom DO and other WQ parameters are within the guidelines with this increase in bottom temperature.
- DO
  - Modelled bottom DO satisfies criterion (>3 mg/L) for both
     2019 and future climate change scenarios up until 2060.
- Total Nitrogen (TN), Total Phosphorus (TP), and Ammonium (NH<sub>4</sub>)
  - o In 2019, there is a slight increase in TN and insignificant changes in TP and NH<sub>4</sub> with FPV. In 2060, FPV will slightly increase TN, TP, and NH<sub>4</sub>, but still within water quality guidelines.
- Chlorophyll-a (Chl-a) & Macrophytes
  - $\circ$  Chl- $\alpha$  slightly increases with FPV, but values are much lower than the guideline (<50 ug/L).
  - Macrophytes biomass decrease slightly (6%).





**EIA APPROACH &** 

**ASSESSMENT** 

### **WATER & SEDIMENT QUALITY: IMPACT ASSESSMENT**

Con	<u>struction</u>			
S/N	Impacts	Pre-Mitigation Impact	Residual Impact	Degree of Impact
1	Increased sedimentation from construction activities (i.e., anchoring, piling, shore erosion from increased boat movement etc.)	Minor (-48)	Slight (-24)	
2	Impact on water quality due to removal of Hydrilla for FPV construction	Minor (-72)	Minor (-48)	SLIGHT TO MINOR
<u>Ope</u>	rations & Maintenance			
S/N	Impacts	Pre-Mitigation Impact	Residual Impact	Degree of Impact
S/N 1	Impacts  Impact on water quality and biomass due to shading from FPV panels and associated environmental changes			

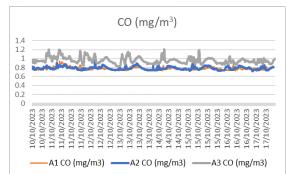
#### **Mitigation Measures**

- Ensure Earth Control Measures (ECM) meet the requirements cited in the Code of Practice on Surface Water Drainage, and comply with the Sewerage and Drainage Act.
- Install Total Suspended Solids (TSS) meters and CCTV cameras at the entrances to any public drains or discharge points on-site.
- Minimise erosion from soil stockpiles, exposed ground surfaces, and excavated areas by covering them with tarpaulin sheets or erosion control blankets.
- Plan cable laying work to avoid work correction and repeated disturbance at the reservoir bottom.
- Allow sufficient time for sinker placement works for careful implementation to minimize sediment disturbances.
- Carry out anchoring and piling works with utmost consideration to minimize sediment disturbance. Anchoring works should be spaced at adequate intervals if possible. Drilling rigs and other equipment are to be lowered slowly and not dragged along the substrate. Anchoring and piling works are to stop if water quality declines consistently.
- Install silt curtains around the location of water-based construction activities.
- Rerun the WQ models with the detailed design layout and reassess the impact on WQ.
- Deploy real-time sensors for water quality assessment to detect potential water quality issues early.
- Install engineering adaptation measures, e.g., aeration to increase DO if required. The locations of the aeration should be guided by the Environmental Monitoring and Management (EMMP) results.

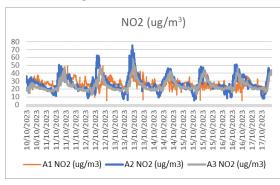
#### **AIR QUALITY: BASELINE FINDINGS**

- Concentrations of Carbon Monoxide (CO), Nitrogen Dioxide (NO<sub>2</sub>), and Sulfur Dioxide (SO<sub>2</sub>) are within Singapore's ambient air quality targets (SAAQT).
- Average Particulate Matter (PM) values are under SAAQT with limited period of exceedances, due to sampling occurring during an inter-boundary haze period where Pollution Standard Index (PSI) values for the same dates were in the "Moderate" band<sup>1</sup>).

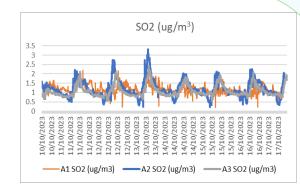
<sup>1</sup> According to the National Environment Agency (NEA)'s historical 24-hour PSI data



#### SAAQT: 30 mg/m<sup>3</sup>



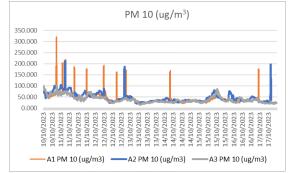
SAAQT: 200 ug/m<sup>3</sup>



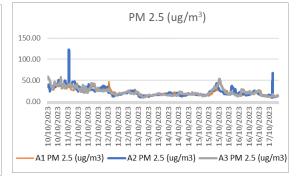
SAAQT: 50 ug/m<sup>3</sup>

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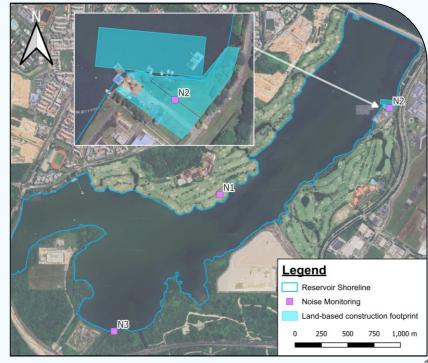


#### SAAQT: 50 ug/m<sup>3</sup>



SAAQT: 37.5 ug/m<sup>3</sup>

- **NOISE: BASELINE FINDINGS** 
  - Noise levels at all monitoring stations were under the National Environment Agency (NEA)'s limits.
  - N2 consistently had higher maximum and average calculated noise levels than N1 and N3, especially during the day.
  - This could be due to operational works in the area, as N2 is located near a launching point into Lower Seletar Reservoir. This could also be due to its proximity to the Lower Seletar Pumping Station, Seletar West Link road, and Seletar Airport.



### EMMP

### CONCLUSION

### AIR QUALITY: IMPACT ASSESSMENT

<u>struction</u>			
Impacts	Pre-Mitigation Impact	Residual Impact	Degree of Impact
Air pollution due to generation of dust from construction activities (and exhaust gas emissions from construction machinery and vehicles (e.g., excavators, generators, cranes, boats etc.)	No Impact (-6)	No Impact (-6)	NO IMPACT
rations & Maintenance			
Impacts	Pre-Mitigation Impact	Residual Impact	Degree of Impact
	Impacts  Air pollution due to generation of dust from construction activities (and exhaust gas emissions from construction machinery and vehicles (e.g., excavators, generators, cranes, boats etc.)  rations & Maintenance	Impacts  Pre-Mitigation Impact  Air pollution due to generation of dust from construction activities (and exhaust gas emissions from construction machinery and vehicles (e.g., excavators, generators, cranes, boats etc.)  Pre-Mitigation  Pre-Mitigation	Impacts  Pre-Mitigation Residual Impact  Air pollution due to generation of dust from construction activities (and exhaust gas emissions from construction machinery and vehicles (e.g., excavators, generators, cranes, boats etc.)  Pre-Mitigation Residual  No Impact (-6)  No Impact (-6)  Pre-Mitigation Residual

**EIA APPROACH &** 

**ASSESSMENT** 

#### **Mitigation Measures**

- Use hoardings at the construction site to minimize dust generation by attenuating wind forces.
- Set up a vehicle wheel washing bay within the work site as far as practicable to minimize dust leaving the construction boundary.
- Cover excess soil stockpiles with 100 % biodegradable, wildlife-friendly Earth Control Blankets (ECB), and promptly remove them from the work sites as soon as possible.
- Ensure that all vehicles are compliant with the Environmental Protection and Management (Vehicular Emissions) Regulations, and are regularly serviced to minimize smoke and dust exhaust emissions.

### NOISE: IMPACT ASSESSMENT

Con	<u>struction</u>			
S/N	Impacts	Pre-Mitigation Impact	Residual Impact	Degree of Impact
1	Noise disturbance from construction activities and operation of construction vehicles and machinery (receptors >100m away from source)	No Impact (-6)	No Impact (-6)	NO IMPACT
2	Noise disturbance from construction activities and operation of construction vehicles and machinery (receptors <100m away from source)	Slight (-12)	No Impact (-6)	NO IMPACT
Ope	rations & Maintenance			
S/N	Impacts	Pre-Mitigation Impact	Residual Impact	Degree of Impact
1	Noise disturbances from motorboats and vehicles	No Impact (-6)	No Impact (-6)	NO IMPACT

#### **Mitigation Measures**

- Development of a Noise Management Plan (NMP) prior to commencement of construction activities.
- Install temporary noise barriers surrounding the construction site and use of portable acoustic blankets around noisy stationary machinery such as gen-sets.
- Fully switch off vehicles, motorboats, and machinery when not in use and are regularly and properly maintained to reduce unnecessary noise.

#### **SOIL: BASELINE FINDINGS**

• Soil quality for all parameters were under limits as prescribed by the Dutch Soil Remediation Circular 2013, at all points.

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**ASSESSMENT** 

• The results indicate that the baseline soil quality at this area is safe for human exposure and should have minimal or negligible negative impacts to the biodiversity in the area.

#### **SOIL: IMPACT ASSESSMENT**

Construction S/N Impacts					
	S/N	Impacts	Pre-Mitigation Impact	Residual Impact	Degree of Impact
	1	Impact on receptors (i.e., land-based construction area, Lower Seletar reservoir bank) due to soil erosion from construction	Slight (-24)	Slight (-16)	
		works			SLIGHT

<u>Ope</u>	rations & Maintenance			
S/N	Impacts	Pre-Mitigation Impact	Residual Impact	Degree of Impact
1	Impact on receptors due to soil erosion from boat usage	No Impact (0)	No Impact (0)	NO IMPACT

#### **Mitigation Measures**

- Use earth control blankets on excavated soil areas and exposed ground, and stand by earth blankets on site in case of rain during land-construction works.
- Install silt fences or sediment traps along the perimeter of the land-construction works.
- Provide bank protection immediately if bank erosions occur.
- · Schedule towing and construction activities strategically to minimise movements around the Project site.
- Plan the construction of the jetty and the launching platform to minimize disturbance to the shoreline.

### **Environmental Management and Monitoring Plan (EMMP)**

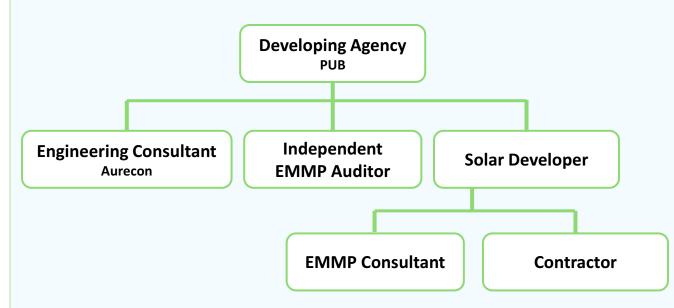
### **Objectives**

- To establish a monitoring mechanism to ensure that environmental impacts are mitigated effectively and in a timely manner.
- To ensure that roles, responsibilities, and monitoring frequencies are clearly defined and assigned to concerned team members on the ground so that mitigation measures are implemented as planned.
- To ensure regular monitoring happens and any gaps identified during monitoring are reported, and corrective actions are taken to prevent environmental damage to assets and environmentally sensitive receptors.
- To ensure that good environmental management practices and mitigation measures recommended by the Environmental Impact Assessment (EIA) Report are adequately implemented.
- To monitor the performance and effectiveness of the implemented mitigation measures.
- To ensure compliance with regulatory requirements.
- To provide regular documentation on the environmental performance of the Project to PUB and other government and technical agencies as required.

### **Monitoring Throughout Project**

The EMMP that will be implemented during the construction and operation & maintenance phases of the Project.

#### **EMMP Roles**



### **EMMP Monitoring (Construction)**

Environmental Aspect	Proposed Monitoring	PIC / Frequency		
Fauna	<ul> <li>Visual site inspections to ensure no non-compliances</li> <li>Visual inspections on a portion of Seletar Club Road leading to the site to monitor for roadkill</li> </ul>	<ul> <li>Contractor (Environmental Control Officer (ECO)) / Daily</li> <li>EMMP Consultant / Monthly</li> </ul>		
Flora	<ul> <li>Flora inspection (up to 15 m from the worksite)</li> <li>Visual monitoring of aquatic flora</li> <li>Monitoring of retained trees, and flora within the project boundary, both terrestrial and aquatic</li> </ul>	<ul> <li>Contractor (ECO) / Daily</li> <li>EMMP Consultant / Monthly</li> <li>Arborist/ Monthly</li> </ul>		
Surface Water Quality	<ul> <li>Install real-time monitoring equipment to ensure silty water is not discharged out from ECM per PUB requirements (CCTV inclusive of Silt Imagery Detection System at every discharge point onsite and near the entrance to any public drains)</li> <li>Visual site inspection to ensure ECM is properly operated and maintained</li> <li>Visual site inspections to identify any construction activities that may be affecting water quality during land-based construction activities</li> <li>Grab sampling and laboratory analysis for TSS at all ECM discharge locations</li> </ul>	<ul> <li>Contractor / Daily, continuous</li> <li>Contractor (ECO) / Daily</li> <li>EMMP Consultant / Fortnightly</li> <li>EMMP Consultant / Monthly</li> </ul>		
Water Quality	<ul> <li>In-situ turbidity monitoring using handheld meter in the immediate surrounding of piling, drilling and anchoring works in the reservoir</li> <li>Real-time monitoring using water quality online profilers to measure temperature, pH, Conductivity, Turbidity, DO, Chl-a</li> <li>Profilers should be coupled with an alert system to trigger alerts through SMS or email when any water quality parameters have exceeded threshold limits</li> <li>In-situ and ex-situ grab sampling from mid-depth and 0.5 m above the reservoir bed. Ex-situ parameters (non-exhaustive) includes (DO, TOC, DOC, pH, Turbidity, Conductivity, Chl-a, TN, TP, N, P, Al, As, Cu, Pb, Fe, Mn, Ammonia (as N), and Chloride)</li> </ul>	<ul> <li>Contractor (ECO) / Daily</li> <li>Contractor / Daily, continuous</li> <li>EMMP Consultant / monthly &amp; quarterly</li> </ul>		
Air Quality & Noise	<ul> <li>Visual site inspections on vehicle and equipment emissions ensuring no non-compliances</li> <li>EMMP Consultant to conduct site inspections to ensure environmental mitigation measures have been effectively implemented by the Contractor</li> </ul>	<ul><li>Contractor (ECO) / Daily</li><li>EMMP Consultant / Monthly</li></ul>		
Soil	<ul> <li>Visual site inspections at the reservoir bank to report on and rectify and soil erosion issues</li> <li>EMMP Consultant to conduct site inspections to ensure environmental mitigation measures have been effectively implemented by the Contractor</li> </ul>	<ul><li>Contractor (ECO) / Daily</li><li>EMMP Consultant / Monthly</li></ul>		

### **EMMP Monitoring (Construction) – Fauna Surveys**

Monitoring	Number of Monitoring Points/Location	Location	Target Taxa	Frequency	PIC
Point Count	13	Same as EIA	Birds	<ul><li>One-time (pre-construction)</li><li>Monthly (construction)</li></ul>	
Vantage Point Survey	3	Same as EIA		Total of 72 hours per point (construction)	ЕММР
Line Transect	2 transects	Around land-based construction area	<ul> <li>One-time (pre-construction)</li> <li>Birds, Mammals, Herpetofauna</li> <li>Monthly (construction)</li> </ul>		Consultant
Camera Trap	3	On FPVs	Mammals	<ul><li>One-month (pre-construction)</li><li>Monthly (construction)</li></ul>	

### **EMMP Monitoring (Operation & Maintenance)**

Environmental Aspect	Proposed Monitoring	Person-in-Charge / Frequency
Fauna	Visual monitoring for fauna presence and fatality	<ul> <li>Solar Developer/ During Maintenance Trips</li> </ul>
Flora	Visual monitoring of aquatic flora	<ul> <li>Solar Developer/ During Maintenance Trips</li> </ul>
Surface Water Quality	<ul> <li>As the construction would have ceased and surface water quality is no longer affected, no monitoring was required.</li> </ul>	Not Applicable
	Visual inspection of water quality during maintenance trips	Solar Developer / Daily
Water Quality	<ul> <li>Profilers should be coupled with an alert system to trigger alerts through SMS or email when any water quality parameters have exceeded threshold limits</li> </ul>	Solar Developer / Daily, Continuous
,	• In-situ and ex-situ grab sampling from mid-depth and 0.5 m above the reservoir bed. Ex-situ parameters (non-exhaustive) includes (DO, TOC, DOC, pH, Turbidity, Conductivity, Chl-a, TN, TP, N, P, Al, As, Cu, Pb, Fe, Mn, Ammonia (as N), and Chloride)	<ul> <li>EMMP Consultant / Monthly &amp; Quarterly</li> </ul>
Air Quality & Noise	As the construction would have ceased, no monitoring is proposed for air quality and noise	Not Applicable
Soil	As there is no impact on soil during O&M phase, no monitoring is proposed for soil	Not Applicable

### Fauna Surveys

Monitoring	Number of Monitoring Points/Location	Location	Target Taxa		Frequency	Person-in-Charge	
Point Count	13	Same as EIA  Same as EIA		•	Monthly		
Vantage Point Survey	3			•	Total of 72 hours per point annually	EMMP Consultant	
Camera Trap	3	On FPVs	Mammals	•	Monthly		

- In general, the Construction and Operation & Maintenance Phases of the Project do not cause significant negative impact, and the impacts are mainly No to Minor Negative impacts.
- With the implementation of the recommended mitigation measures and the EMMP, the Project's impact is minimised.
- Continuous monitoring and adaptive management strategies should be employed to ensure minimal environmental impact and compliance with regulatory requirements.
- Biodiversity near the Project can potentially be enhanced by selectively planting indigenous flora around the reservoir and along its banks, as the surrounding land is mainly used for recreation and golf courses. This can be achieved through collaboration with various landowners surrounding the reservoir and by engaging URA/MND to promote the adoption of biodiversity enhancement initiatives within their development. This supports Singapore's long-term plan and strategy for stewarding nature and heritage in the country.

### **Summary of Impact Assessment**

**ASSESSMENT** 

	CONSTRUCTION PHASE				OPERATIONS & MAINTENANCE PHASE			
Environmental Category	Pre-Mitigation Impact		Residual Impact (with mitigation)		Pre-Mitigation Impact		Residual Impact (with mitigation)	
BIODIVERSITY (FLORA)	SLIGHT		SLIGHT		NO IMPACT		NO IMPACT	
BIODIVERSITY (FAUNA)	SLIGHT TO MINOR		SLIGHT		SLIGHT TO MODERATE		SLIGHT TO MINOR	
WATER QUALITY	MINOR		SLIGHT TO MINOR		MINOR		MINOR	
AIR QUALITY	NO IMPACT		NO IMPACT		NO IMPACT		NO IMPACT	
NOISE	NO IMPACT TO SLIGHT		NO IMPACT		NO IMPACT		NO IMPACT	
SOIL	SLIGHT		SLIGHT		NO IMPACT		NO IMPACT	
WASTE	SLIGHT		NO IMPACT TO SLIGHT		MINOR		MINOR	