REVIEW OF APPLICATION FOR LIHI CERTIFICATION
OF THE
MA'AN HYDROPOWER STATION

Dajia River
Heping District, Taichung City

December 9, 2025
Maryalice Fischer, Certification Program Director

Table of Contents

1. Introduction

Taiwan Power Company (Taipower or Applicant), the Taiwanese government-owned electricity company, requested a LIHI review of the 133.47-MW Ma'an Hydropower Station (Project), located 36.86 km above the Taiwan Strait estuary on the Dajia River. The Project is within the Heping District of Taichung City,[1] in central-west Taiwan (Figure 1).

The Dajia River is bordered by the Daan River to the north and the Wu River to the south, making it the third-largest river basin in Taiwan. The river originates from Nanhu Mountain (elevation 3,742 m) in the Central Mountain Range and Xueshan Main Peak (elevation 3,886 m) in the Xueshan Range. Its major tributaries include Qijiawan River, Nanhu River, Hehuan River, Zhile River, and Zhongke River. The entire basin is almost entirely within Taichung City, and the river flows into the Taiwan Strait between the Daan and Qingshui districts. The mainstem is 124.2 km long, with a basin area of 1,235.7 km^2.

The Ma'an Project is the fifth downstream project in a cascade of hydroelectric facilities on the Dajia River (the Dajia River Project) and is the newest development on the river having been completed in 1998. A sixth project, the Sheliao powerhouse (owned by Taipower) and the Shigang dam (not owned by Taipower) is located downstream of Ma'an, 22.15 km above the estuary and it is the first dam on the river (Figure 2). It is owned and operated by the Central Region of Taiwan's Water Resources Agency.

[1] In Taiwan, the term city is similar to a typical county in the US.

Figure 1. General Project Location

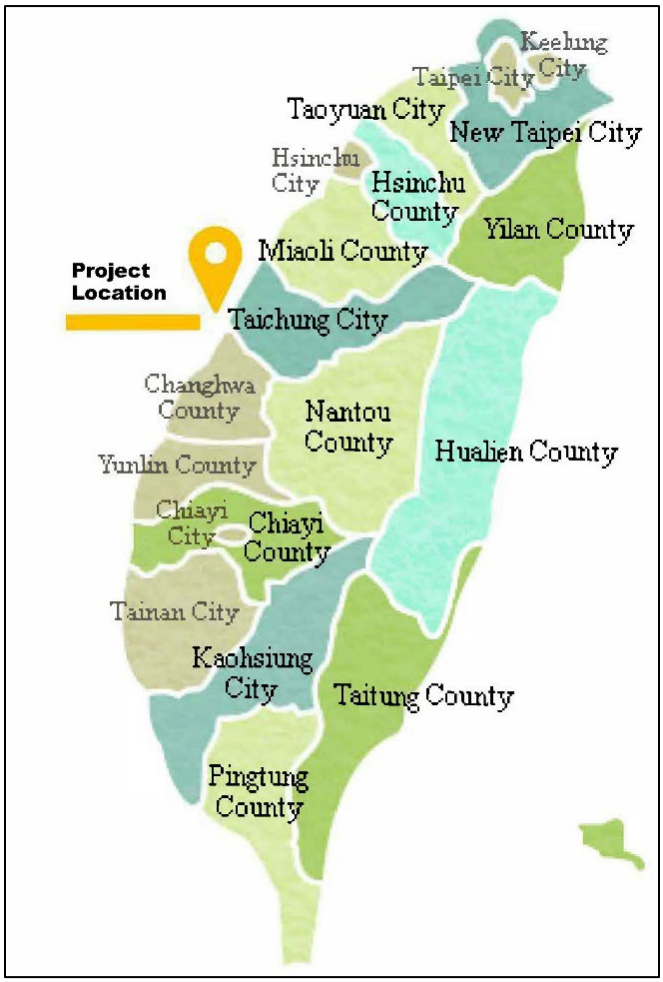
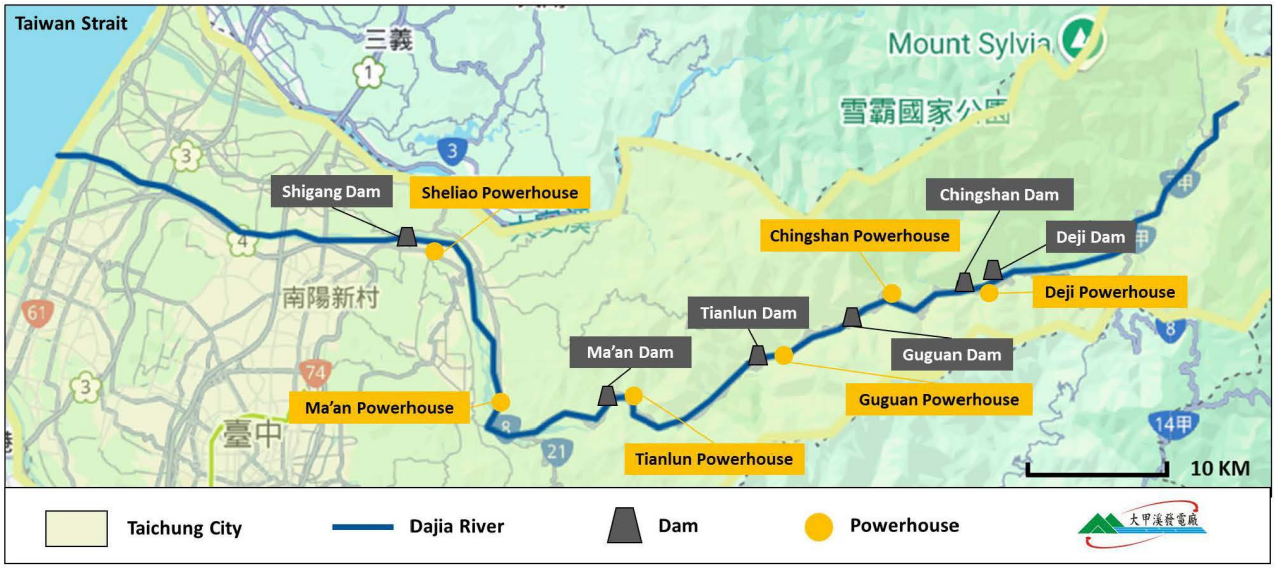


Figure 2. Dajia River Hydro Facilities



2. Purpose and Scope of the LIHI Review

This review was conducted in conjunction with a Hydropower Sustainability Alliance (HSA) certification assessment of the Project. HSA is a globally applicable standard (though not currently certifying hydro projects in the US without LIHI), while LIHI only certifies projects in the US. This review of a non-US project is a pilot program initiated under a LIHI-HSA Memorandum of Understanding with a goal to assess the feasibility of dual certification for hydropower projects under each organization's certification processes and standards.

This review evaluated the Project's compliance with the current LIHI criteria and standards within the context of the Taiwan regulatory, environmental, and cultural framework. This evaluation included the reviewer's observations during HSA's onsite assessment; interviews with key Taiwan Power staff, resource and regulatory agencies, local residents and interested parties; the LIHI application and supporting documents provided by the Applicant and other publicly available information; and responses to the reviewer's questions provided by the Applicant.

The primary difficulty encountered in this review was that many supplemental documents were only provided in Mandarin Chinese, and most could not be machine translated since they were scanned documents. Some documents were able to be translated, and a few (or excerpts of larger documents) were provided in English by the Applicant. As a result, this review may not be as comprehensive as it would be for a US project. However, the reviewer determined that sufficient evidence was provided to complete this review.

Public notice of the review report was made on September 17, 2025 on the Taipower, HSA, and LIHI websites as well as to LIHI's email list, and the agency and interested party contacts provided by the Applicant. This is the first LIHI review of a non-US project and was conducted under the 2025 LIHI Handbook Revision 2.06 with a formal LIHI application submitted by the Applicant. We are using this experience to identify whether non-US projects could satisfy the LIHI criteria and standards, and to solicit feedback on the possibility of dual certification with HSA. The 60-day public comment period closed on November 17, 2025 and two comments were received and are posted on the LIHI website. Comments were welcomed on the following topics: 1) the Ma'an Project application, 2) the process of this certification review, 3) dual certification with HSA. Neither comment letter resulted in changes from the draft report.

3. Facilities and Operations

Construction of the Ma'an dam was completed in March of 1998. It is 16.3 meters (m) high and 229.5 m long and 4.5 m wide, with the dam crest at 550 m elevation above sea level. The left dam section is 102 m long with no gates. The right section of the dam is controlled by nine arc-shaped spill gates, each 10.0 m wide by 6.7 m tall and two sediment flushing gates, each 4.5 m wide by 5 m tall (Figure 3). Two fishways are located side by side on the right end of the dam.

The primary fishway is a pool and weir type and the secondary fishway is a Denil type. The use of both is intended to accommodate the passage of different fish species and sizes (Figure 4).

Figure 3. Ma'an Dam and Spillways from Downstream Side

Figure 4. Ma'an Dam Fishways – Denil (at left) and Pool/Weir (at right)

The dam creates an impoundment with a surface area of 19.9 hectares (49 acres) and a length of 900 m from the tailrace of the upstream Tianlun power station to the Ma'an dam. The minimum water level is 547.0 m elevation with a normal operating range from 550.0 to 553.4 m. The impoundment has an effective storage capacity of 575,000 m^3 (466 acre-feet). The dam creates a bypassed reach of the river approximately 11.19 km (6.95 miles) long.

Water is conveyed from the dam to the powerhouse via a headwater tunnel approximately 7,485 m (4.6 miles) long to an open-top surge tank 69.14 m tall by 15 m diameter (Figure 5).

The surge tank discharges to the underground penstock which is approximately 385.14 m (1,264 ft) long.

The powerhouse (see cover photo) contains two vertical Francis units, each with a capacity of 66.735 MW for a total installed capacity of 133.47 MW. The Project has an average annual generation of 324,131 MWh.

Figure 5. Ma'an Surge Tank

The tailrace system consists of two tunnels, each 49.6 m long with a circular cross-section and an inner diameter of 4.0 m. It includes two straight-lift type tailrace gates, each measuring 4.0 m wide by 4.0 m high. The tailrace discharges via a series of gates to an "adjustment pond" (Figure 6). The adjustment pond serves to regulate outflow from the powerhouse and smooth flows downstream for public water supply. The pond is sectioned into two by differing elevations. It was constructed as part of the upstream Tianlun Project but later incorporated into the Ma'an Project at the time of Ma'an dam construction.

The upper pond has a volume of 550,000 m^3 (445 acre-feet) and the lower pond has a volume of 290,000 m^3 (235 acre-feet). The adjustment pond regulates the powerhouse discharge into the downstream river reach and modulates the flows arriving at the downstream Shigang dam which was built from 1974 to 1977 for flood control, municipal water supply, and irrigation.

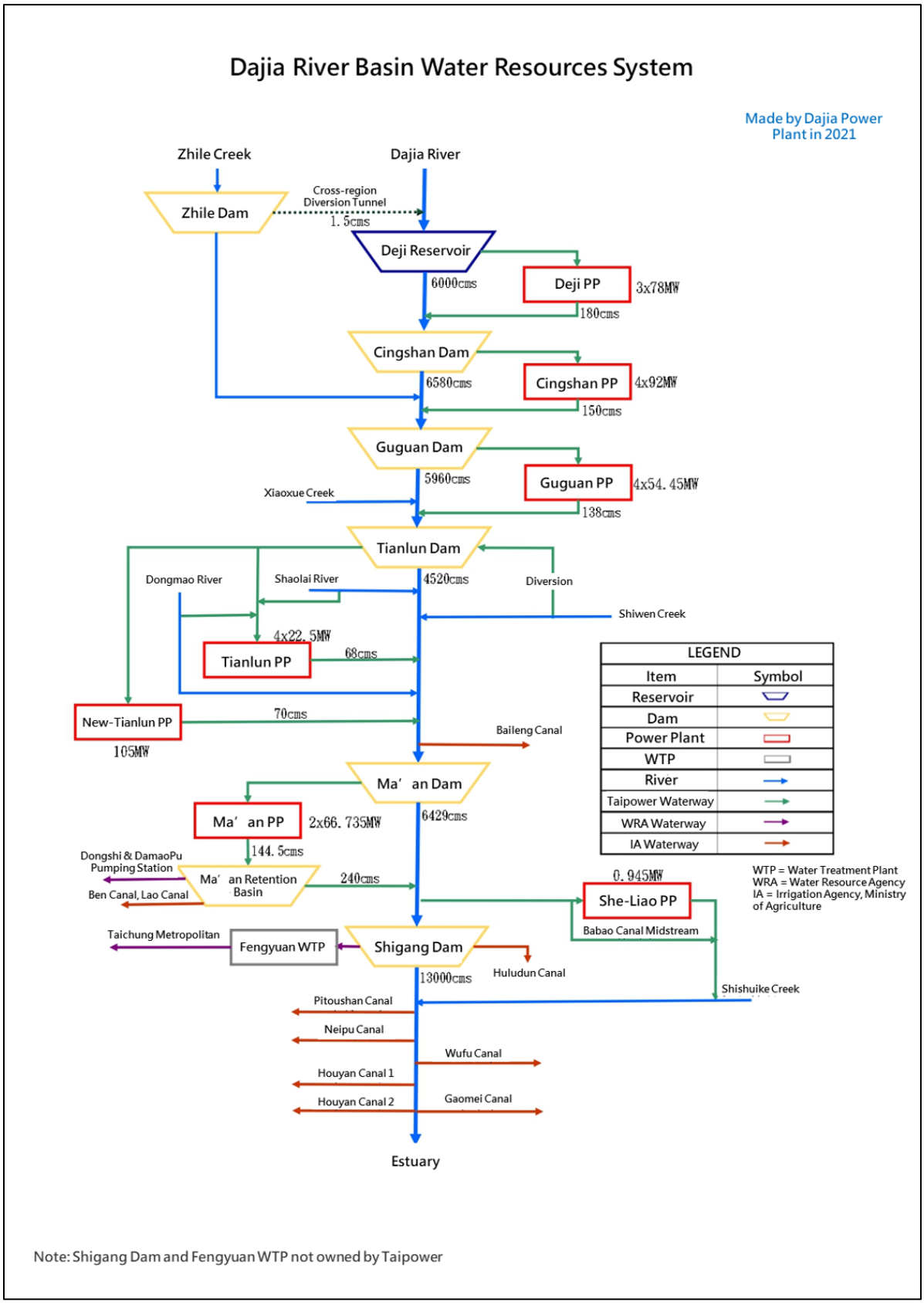
Figure 6. Ma'an Adjustment Pond and Discharge from Pond to River (at lower right)

The Project also includes an outdoor switchyard, a floating solar photovoltaic system installed on the lower adjustment pond (Figure 6), and public facilities (see Sections 6.G and 6.H below for details).

The Project is operated in a coordinated manner with the upstream and downstream developments for flood control, hydropower, irrigation, and municipal uses (Figure 7). Operations are remotely controlled from the Tianlun control center, although local control is possible if needed from within the Ma'an powerhouse.

Generation operations at Ma'an depend on the season. During the wet season (May – September) generation can be continuous. In the dry season generation is typically ramped up to full capacity during the evening peak period with the adjustment pond attenuating the outflow into the Dajia River downstream. Outside of peak hours, generation and discharge from the adjustment pond is kept stable.

Figure 7. Dajia River Basin Operational Schematic



4. Regulatory Framework

The Project is regulated by various Taiwan governmental agencies. Operations are governed by the Energy Administration (EA) of the Ministry of Economic Affairs (MOEA) which oversees the electricity industry in Taiwan. According to Article 17 of the Taiwan Electricity Act, a license is initially valid for 20 years and may be extended, with each extension valid for an additional 10 years. The original license was issued in 1948 (for the entire Dajia River Project) and expired in 1968. It has been extended every 10 years since. Accordingly, the current extension remains valid until 2028.

An environmental impact assessment (EIA)[2] was conducted at the time of Ma'an Project construction and was approved by the Taiwan Ministry of Environment. The approval included various protection, mitigation, and enhancement measures proposed or required at that time.

Rivers in Taiwan are regulated by the Water Resources Agency (WRA) of the MOEA. The Water Act and the Special Statute for the Comprehensive Management of River Basins guide the scope of river management including the agency's responsibilities for planning and implementing river improvement projects, delineating and adjusting river zones, designating gravel extraction areas, developing environmental management plans, maintaining flood control structures, conducting river patrols and enforcement, processing river use applications and associated fees, acquiring land for river projects, managing flood response and emergency repairs, and overseeing related administrative affairs.

The Project is subject to other regulatory requirements as well. The Taiwan Ministry of Environment regulates water quality; the Ministry of Agriculture regulates fisheries, forests, wildlife and biodiversity; the Ministry of Interior regulates land management; and the Ministry of Culture and the Council of Indigenous Peoples oversee cultural and historical matters. Specific requirements include:

Flow Regimes

- Directions for the Operation of Ma'an Dam Reservoir
- Regulations on the Operation of Sluice Gates of Ma'an Dam Reservoir

Water Quality

- Surface Water Classification and Water Quality Standards
- Water Pollution Control Act
- Regulations for the Establishment and Monitoring of Surface Water Quality Monitoring Stations

Shoreline, Watershed Protection, and Recreational Resources

- Storage Area of the Ma'an Dam Reservoir and Its Application Permit Matters

[2] Ma'an Hydropower Project Environmental Impact Assessment Report, 1988.

Threatened and Endangered Species

- Article 78 of the Cultural Heritage Preservation Act
- Article 17-1 of the Forestry Act
- National Park Law
- Article 40 of the Wetland Conservation Act
- Act on Wildlife Conservation

Cultural and Historic Resources

- Regulations for the Delimitation of Indigenous Peoples' Land or Tribal Areas
- Cultural Heritage Preservation Act

5. Zones of Effect

The Applicant selected three Zones of Effect (ZoEs). ZoE 1 is the 900-m-long impoundment, ZoE 2 is the 11.9-km bypassed reach, and ZoE 3 is the powerhouse tailrace. This review finds that Zone 3 should be extended approximately 15.8 km to include the adjustment ponds and the downstream reach to Shigang dam although it does not change the criteria evaluation in that zone.

The Applicant selected the standards listed in Table 1 for each ZoE and criterion. This review finds that different standards are more appropriate for some criteria, as highlighted in **red** in the table. These are discussed in Section 6 below.

Table 1 – Applicant Selected Standards and LIHI Reviewer Recommended Changes

Zone:		**1: Impoundment**	**2: Bypassed Reach**	**3. Downstream Reach**
River Mile at upper and lower extent of Zone:		49.05 – 50.027 km	37.86 – 49.05 km	37.86 – **22.06** km
Criterion		**Standard Selected**		
A	Flow Regimes	2, ~~PLUS~~	2	1
B	Water Quality	2	2	2
C	Upstream Fish Passage	1, ~~PLUS~~	~~1,~~ **2**	~~1,~~ **2**
D	Downstream Fish Passage	~~1,~~ **2**	~~1,~~ **2**	1
E	Shorelines and Watershed	1	1	1
F	Threatened and Endangered Species	~~2~~, **4**	~~2~~, **4**	~~2~~, **4**
G	Cultural and Historic Resources	2	~~1,~~ **2**	1
H	Recreational, Public, and Traditional Cultural Access	2, PLUS	~~1,~~ **3**	2

6. Detailed Criteria Review

A. Flow Regimes

Goal: *The flow regimes in riverine reaches that are affected by the facility support habitat and other conditions suitable for healthy fish and wildlife resources.*

Assessment of Criterion: The Applicant selected Standard A-2, Resource Agency and Tribal Government Recommendations for ZoE 1 and ZoE 2. Standard A-1, Not Applicable/De Minimis Effect was selected for ZoE 3. The reviewer agrees with these selections.

Discussion: Project operations are coordinated with the other hydro projects on the river and are regulated by the MOEA under the "Directions for the Operation of Ma'an Dam Reservoir" which was most recently amended on January 17, 2024. The document regulates water diversions from the Dajia River by the Ma'an reservoir for water supply and coordination with downstream water use projects. The document specifies required reservoir water levels, and inflow and outflow under various operational conditions:

- Typhoon Season (July to September): When typhoons are common, the upstream water typically has high turbidity, which can compromise the safe operation of the generators. Power generation is suspended during this period and the reservoir level is proactively lowered in advance of predicted storms to provide flood control capacity.

- Dam Maintenance Period: Maintenance typically occurs during the non-flood season. During this time, the reservoir water level may be reduced as necessary, but water conveyance through the spillways and fishways continues as usual.

- Dredging Operations: When dredging is required, the designated dredging area may be dewatered, but the rest of the reservoir maintains a certain water level. For example, dredging work in May requires the water level to be temporarily lowered to 551.5 m (compared to the normal level of 553.5 m).

The Project is also subject to "Regulations on the Operation of Sluice Gates of Ma'an Dam Reservoir" also issued by the MOEA, which regulates the operations of spillway gates, sediment flushing gates, and the power intake, river outlet and fishway gates. Spillway gates are normally kept closed but if needed to reduce the reservoir level for gate or dam maintenance, under high flows, or for sediment flushing, the gates are ramped open one at a time by 10 cm every 10 minutes until reaching 50 cm. The sediment flushing gates are opened when sediment in front of the intake accumulates more than 1.5 m which can interfere with power generation. The power intake, outlet and fishway gates are normally kept open except in flood situations or other emergencies.

Inflow to the reservoir consists of flows discharged from the upstream Tianlun Project as well as tributary inflows (see Figure 7). The reservoir is continuously monitored via a Programmable

Logic Control (PLC) system for inflow, water level, and outflow. Water releases to the downstream reach are also monitored and determined by a Water Source Allocation Team (under the Central Region of the WRA), which are based on downstream water demands as projected by the downstream Shigang dam operator on a 10-day basis.

The bypassed reach is regulated and managed by the Third River Management Branch of the WRA which oversees this river section except for matters related to water allocation coordination efforts. Flows into the bypassed reach are a function of the minimum releases through the Ma'an dam fishways, discharges from Tianlun dam, and inflows from several tributaries.

The Applicant indicated that during the initial design phase of the Ma'an Project, Japan's hydroelectric development practices were used to determine an appropriate ecological base flow for the bypassed reach. According to the Applicant, that general regional guideline[3] specified 0.1 to 0.3 cms of flow per 100 km^2 of catchment area.[4] The catchment area is approximately 916 km^2 resulting in a calculated ecological base flow of 2.7 cms. After consultation with the Taichung City Dajia River Ecological Environment Protection Association and local conservation interests, the flow was set slightly higher than the calculated flow and is maintained at 3 cms (105.9 cubic feet/second) continually discharged through the fishways.

This flow regime was designed to protect aquatic species in the bypassed reach and maintain a continuous wetted reach along river right during the dry season which widens to encompass more of the riverbed during the wet season (Figures 8 and 9).

Figure 8. Upper End of Ma'an Bypassed Reach (left in dry season, right in wet season).

Image source: Investigation of Current Status of Dajia River Report, 2013

[3] Similar in nature to the US Fish and Wildlife Service New England Flow Policy or the Tenant Method.
[4] The Japanese flow guideline was 0-30% of average annual flow at a 95% frequency.

Figure 9. Lower End of Ma'an Bypassed Reach

Image source: Ministry of Environment https://wq.moenv.gov.tw/EWQP/en/EnvWaterMonitoring/River.aspx

In ecological surveys conducted from 2018 to 2020, the area downstream of Ma'an dam recorded the highest number of aquatic species in the river relative to other river segments[5] including fish, shrimp, crabs, and mollusks which indicates that the minimum flow regime is sufficient to support aquatic habitat suitable for healthy fish and wildlife resources for the species that are present. In a 2021 Ministry of Environment inspection, the agency recommended continuing to release the minimum flow of water "required to maintain the ecology."[6] This indicates that the agency remains satisfied with the level of minimum flow provided.

However, no flow studies have been conducted in the bypassed reach to confirm that the minimum flow was or now remains adequate to maintain habitat for fish, particularly the protected species (see Section 6.F below) and other aquatic species that are present at the Project. Therefore, this review finds that the Project conditionally satisfies the flow regimes criterion with a recommended condition that the Applicant consult with resource agencies and experts, and initiate studies if needed to confirm that the minimum flow is sufficiently protective.

[5] Chapter 3, Dajia River Power Plant Ecological Co-prosperity Project Report, 2024-2025.
[6] Confidential inspection report provided to LIHI by Taipower.

The Applicant also requested a PLUS award based on their voluntary adoption of the "Other Effective Area-Based Conservation Measures" (OECMs) approach, as recommended by the International Union for Conservation of Nature (IUCN)[7], to ensure long-term ecological management.

OECMs are geographically defined areas distinct from formal protected areas but are managed in ways that yield positive, sustained, and long-term outcomes for biodiversity conservation, including associated ecosystem functions and services and where applicable, cultural, spiritual, socio-economic, and other locally significant values. The OECM project targets designating over 30% of the Dajia River Project area as a conservation zone, aligning with the global "30x30" initiative. That initiative's aim is to conserve 30% of terrestrial, inland water, coastal and marine areas by 2030, "through ecologically representative, well-connected and equitably governed systems of protected areas and other effective area-based conservation measures, recognizing indigenous and traditional territories."[8]

According to Taipower, their 1 to 5-year goals under the OECM include the following:

- Maintain the reservoir capacity of the Ma'an dam, with an annual sediment removal target of 120,000 cubic meters.
- Continue the release of native fish fry, to be carried out once every two years.
- Maintain the functionality of the riverine ecological corridor, providing suitable habitats and breeding environments for fish, while enhancing ecological connectivity and stability with ecological monitoring conducted quarterly during sediment removal operations.
- Encourage local community participation in environmental and ecological conservation efforts, enhance residents' recognition of the power plant, and increase their willingness to engage; including scholarships provided once a year.
- Continuously review and revise management goals and strategies as needed.

The 6 to 10-year goals include the following:

- Adjust the volume of sediment removal annually based on the results of sedimentation surveys.
- Modify the species and quantity of fish fry released based on fish monitoring outcomes.
- Continue to maintain the ecological connectivity and stability of the riverine corridor.
- Continue to promote initiatives such as the "Caring Breakfast Program," "Moonlight Angels," community-based environmental education, and the OECM.
- Continue evaluating the effectiveness of conservation measures and revise management goals and strategies accordingly.

[7] IUCN: https://iucn.org/our-work/topic/effective-protected-areas/our-philosophy-protected-and-conserved-areas/oecms

[8] See https://www.worldwildlife.org/publications/30x30-a-guide-to-inclusive-equitable-and-effective-implementation-of-target-3-of-the-kunming-montreal-global-biodiversity-framework

Some of these goals are already part of normal Project operations (e.g., sediment removal and monitoring) and others are too vague to evaluate here. It is also not clear that Taipower has fully implemented the OECM program although a management plan is in place. Therefore, the PLUS standard is not met at this time.

B. Water Quality

Goal: *Water quality is protected in waterbodies directly affected by the facility, including downstream reaches, bypassed reaches, and impoundments above dams and diversions*.

Assessment of Criterion: The Applicant selected Standard B-2, Resource Agency and Tribal Government Recommendations for all ZoEs. The reviewer agrees with this selection.

Discussion: Waters in Taiwan are regulated by the Ministry of Environment under the Surface Water Classification and Water Quality Standards, the Water Pollution Control Act, and the Regulations for the Establishment and Monitoring of Surface Water Quality Monitoring Stations.

Taiwan has instituted water quality standards for drinking and surface water and water quality data is publicly available. According to the most recent data[9], the Dajia River at Longanda Bridge located in the bypassed reach just upstream of the powerhouse tailrace is a Class B water, suitable for public water supply after treatment, aquaculture, industrial purposes, and environmental conservation. This reach is considered "moderately polluted" based on April 2025 monthly monitoring. A relative "river pollution index"[10] (RPI) value is calculated from four parameters - dissolved oxygen (DO), biochemical oxygen demand (BOD), total suspended solids (SS) and ammonia nitrogen (NH-3N).

Figure 10 shows the last five years of data for those parameters in the lower bypassed reach about 10 km downstream of Ma'an dam. Figure 11 shows data for the same parameters at a location about 7.8 km upstream of Ma'an dam and illustrates varying values but similar trends overall, although that monitoring station is considered only "mildly polluted" based on its RPI value in April 2025.

In both figures, DO levels have consistently met standards[11] while BOD tends to spike in the dry winter months, SS is typically low but can spike occasionally likely due to rain events and sediment runoff, and NH-3N varies throughout the year. BOD represents the amount of organic matter which can be decomposed by aquatic organisms. It also indirectly represents the degree of organic pollution of the water. NH-3N concentrations result from decomposition of feces and animal and plant remains.

[9] https://wq.moenv.gov.tw/EWQP/en/EnvWaterMonitoring/River.aspx
[10] https://wq.moenv.gov.tw/EWQP/en/Encyclopedia/NounDefinition/Pedia_37.aspx
[11] Based on minimum point values in the online tool.

Figure 10. Bypassed Reach Water Quality Monitoring Results – June 2020 through April 2025

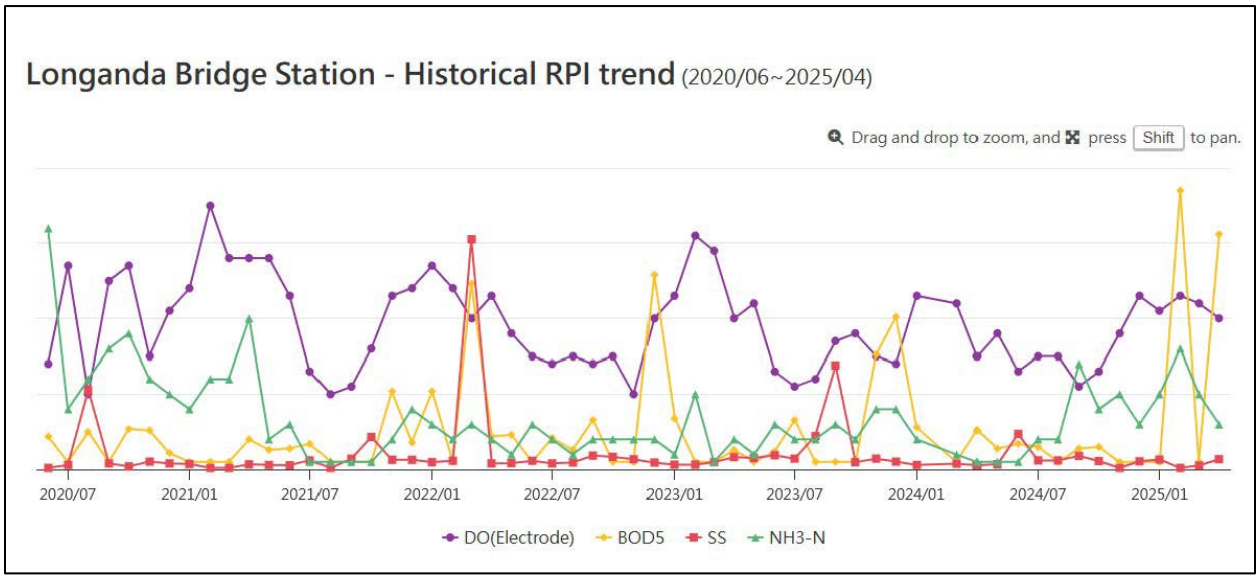
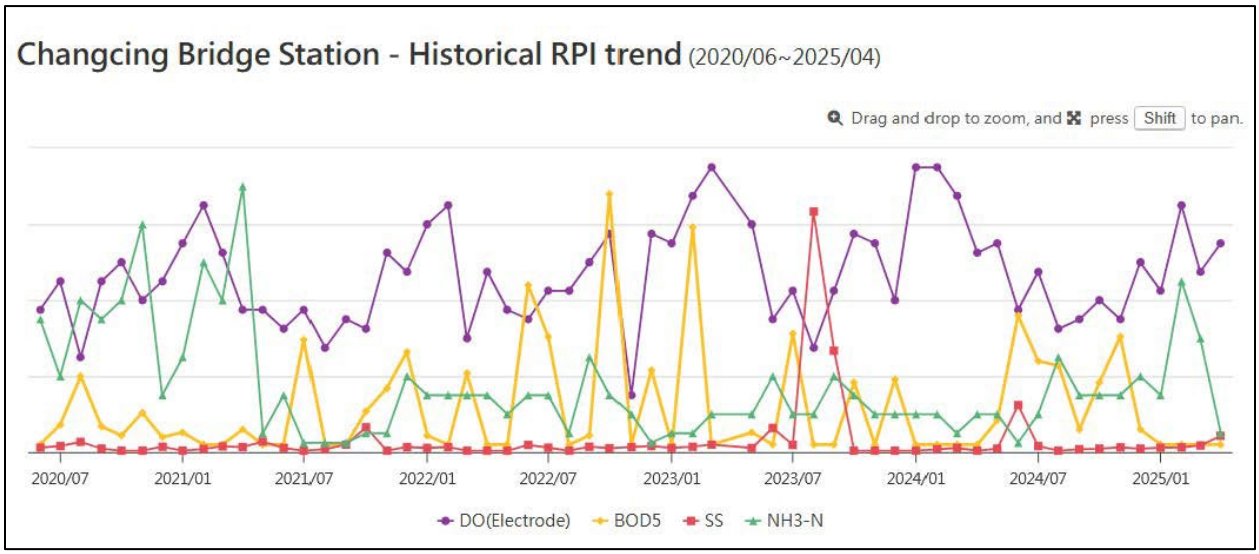


Image source: Ministry of Environment https://wq.moenv.gov.tw/EWQP/en/EnvWaterMonitoring/River.aspx

Figure 11. Upstream Reach Water Quality Monitoring Results – June 2020 through April 2025



Taipower also measures water quality in the Ma'an adjustment pond (ZoE 3) on a quarterly basis. Data included in the LIHI application show similar results to those above.

One major issue in the Dajia River is sedimentation. The sediment load is high due to the overall steep topography in the upper reaches, local geology, earthquakes and landslides, and heavy precipitation including typhoons. Following the 1999 earthquake (9-21 earthquake) which resulted in landslides into the river and typhoons in 2001 and 2004, several of the power stations along the Dajia River (although not the Ma'an Project) were damaged by debris, and major rehabilitation projects were conducted.

Sedimentation causes a loss of reservoir storage volume and creates backwater effects, potentially affecting the intake of the Ma'an power station and the tailrace of the upstream Tianlun power station to which the Ma'an reservoir backwaters.

Taipower is required to manage sediment accumulation in the reservoir and maintain sediment transport in the river through regular sluicing operations during the wet season and dredging operations in the dry season. Dredging operations are conducted under a regulatory permit each year and comply with standard operating procedures provided by WRA which include measures to ensure worker and public safety, limit air emissions from dust and equipment, and manage sediment removal to ensure compliance with water pollution control regulations. The removed sediment is tested for heavy metals to ensure that regulatory limits are not exceeded and then much of it is sold for use in construction materials.

The reservoir is dredged to maintain storage at approximately 75% of the original volume and the adjustment pond is dredged to maintain approximately 90% of the original volume. The finer sediment from the adjustment pond is placed back in the riverbed downstream.

Sediment management and removal in the downstream reach is the responsibility of the WRA's Third River Management Branch.

The average residence times of water in the Ma'an reservoir (estimated at 4.1 hours) and in the adjustment pond (estimated at 1.4 hours)[12] are short and as a result, the Project is unlikely to have any noticeable influence on overall river water quality.

This review finds that the Project is in compliance with applicable water quality standards, operates to effectively manage sediment, and is unlikely to negatively affect water quality in the river. Therefore, the Project satisfies the water quality criterion.

C. Upstream Fish Passage

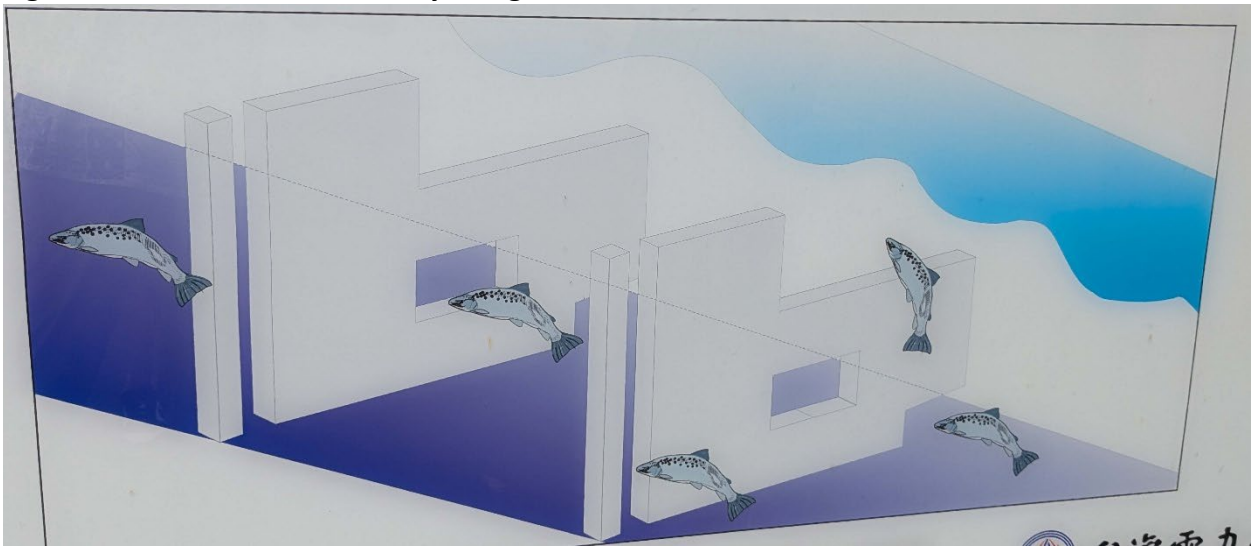
Goal: *The facility allows for the safe, timely, and effective upstream passage of migratory fish. This criterion is intended to ensure that migratory species can successfully complete their life cycles and maintain healthy populations in areas affected by the facility.*

Assessment of Criterion: The Applicant selected Standard C-1, Not Applicable/De Minimis Effect in all ZoEs. The reviewer finds that Standard C-1 is appropriate in the impoundment given that once above the dam there are no Ma'an facility-related barriers to further upstream migration. The reviewer finds that Standard C-2, Resource Agency and Tribal Government Recommendations, is more appropriate for ZoE 2 and ZoE 3, the bypass and downstream reaches through which fish move on their way upstream.

[12] According to the HSA assessment report.

Discussion: As noted in Section 3 and Figure 4 above, the Project includes two fishways, a main pool and weir fishway which is 144 m long, and an auxiliary Denil fishway which is 77 m long. Each weir in the pool and weir fishway has openings at the top, middle, bottom right, and along the left edge which allow fish of different species, sizes, and swimming abilities to ascend through the opening most appropriate for them (Figure 12). The main fishway is equipped with a viewing window and underwater video camera. The auxiliary fishway also has video cameras. However, due to high bubble density in the water caused by flow conditions at the fishway inlet gate, video quality is relatively low.[13]

Figure 12. Pool and Weir Fishway Design



Upstream fish passage was required at the time that the Environmental Impact Assessment (EIA) for the Ma'an Project was submitted to the Environmental Protection Administration (EPA), now the Ministry of Environment, for review in 1988. Scholars, experts, and the Dajia River Ecological Environment Conservation Association (formerly the Dongshi District Ecological Environment Protection Association) required that a fishway be constructed at Ma'an dam to allow fish to migrate upstream.[14] Therefore, Standard C-2 is appropriate for ZoEs 2 and 3.

Migratory species in the Dajia River include the catadromous Japanese eel (*Anguilla japonica*), that has only been recorded downstream of the Shigang dam[15], giant mottled eel (*Anguilla marmorata)* with rare observations at the Ma'an auxiliary fishway, and ayu sweetfish *(Plecoglossus altivelis*) which is considered an exotic, amphidromous[16] species but is also known to remain in freshwater for its entire lifecycle.

Other species present in the Project area upstream or downstream of Ma'an dam include some

[13] Chapter 5, Dajia River Power Plant Ecological Co-prosperity Project Report, 2024-2025.
[14] Chapter 5, Dajia River Power Plant Ecological Co-prosperity Project Report, 2024-2025.
[15] According to Professor Ching-Hsien Tseng of National Tsing Hua University, consultant to Taipower.
[16] Amphidromous refers to fish born in freshwater/estuaries which then drift into the ocean as larvae before migrating back into freshwater to grow into adults and spawn.

protected species (see Section 6.F below), some exotic or introduced species, some that are known to migrate, and some that are not. Due to periodic typhoons and water variability between wet and dry seasons, most fish species have adapted to the background variability in flow and may even require certain levels of variability to meet their life-history requirements.[17]

Species listed below[18] are based on surveys conducted throughout the river in 1983-1987, 2009-2010, 2018-2020, and 2024 as well as Ma'an dam fishway observations. The species most commonly observed in the fishways are in bold text and species that are known to migrate are underlined:[19]

Amblycipitidae Family (torrent catfish)

- Formosa torrent ("trooent" according to Taipower) catfish *(Liobagrus formosanus*)

Anguillidae Family

- Japanese eel (*Anguilla japonica*)
- Giant mottled eel or marbled eel (*Anguilla marmorata*)

Bagridae Family (catfish)

- Taiwan bagrid catfish (*Tachysurus brevianalis*)
- *Pseudobagrus adiposalis* (No English common name found)

Balitoridae family (loaches)

- tasseled-mouth loach (*Formosania lacustre*)
- **hillstream loach or Taiwam rheophilic loach (*Hemimyzon formosanus*)**
- Pulin river loach (*Sinogastromyzon puliensis*)

Cyprinidae Family (carps, minnows), including subfamilies

- **Taiwan banded barb (*Acrossocheilus paradoxus*)**
- Taiwan ku fish (*Onychostoma alticorpus*)
- Taiwan horse mouth (*Candidia barbata*)
- **Taiwan shovel-jaw carp (*Onychostoma barbatulum*)**
- **Taiwan chub (aka Taiwan zacco, Taiwan creek chub or Taiwan predaceous chub (*Opsariichthys pachycephalus*)**
- highbody longnose gudgeon (*Microphysogobio alticorpus*)
- shortnose gudgeon (*microphysogobio brevirostris*)
- topmouth gudgeon or stone moroko (*Pseudorasbora parva*)
- Holland's carp (*Spinibarbus hollandi*)

[17] Tsai, W. P., Chang, F. J., & Herricks, E. E. (2016). Exploring the ecological response of fish to flow regime by soft computing techniques. *Ecological Engineering*, *87*, 9-19. http://hyinfo.bse.ntu.edu.tw/WRHS/%E6%9C%9F%E5%88%8A/periodical.pdf/2016/1-s2.0-S0925857415302767-main.pdf

[18] Information provided by Professor Ching-Hsien Tseng of National Tsing Hua University, consultant to Taipower.

[19] Chapter 5, Dajia River Power Plant Ecological Co-prosperity Project Report, 2024-2025.

- goldfish (*Carassius auratus*)
- barbel steed (*Hemibarbus labeo*)
- sharpbelly (*Hemiculter leucisculus*)
- Siberian spiny loach (*Cobitis sinensis*)
- *Distoechodon compressus* (No English common name found)

Gobiidae Family (gobies)

- **candidus goby or Mingtan goby (*Rhinogobius candidianus*)**

Exotic Species

- ayu sweetfish *(Plecoglossus altivelis*)
- hybrid tilapia (*Oreochromis mossambicus*)
- redbelly tilapia (*Coptodon zillii*)

Fish populations are monitored by electrofishing upstream and downstream of the dam every 10 years with results indicating that the population and species diversity have improved over time. However, some non-native species, including a species of invasive Asian carp, have also been introduced. Experimental trap and truck operations of the native Taiwan shovel-jaw carp *(Onychostoma barbatulum)* are conducted at the upstream Tianlun dam which does not have fish passage. The native (and endangered in Taiwan) giant mottled eel also known as marbled eel (*Anguilla marmorata*) has been introduced in the upstream reaches to serve as a predator for the non-native species.

Since the fishways were originally constructed, the riverbed has changed as a result of the 1999 earthquake, associated landslides, and subsequent typhoons. Taipower conducted fishway effectiveness evaluations in 2004, 2009, and 2013. In 2016, the original designer and a fisheries expert[20] conducted additional investigations and repairs were made that significantly improved the fishway's effectiveness in supporting fish migration.[21]

In 2023, Taipower collaborated again with experts in fishway ecological design to conduct further investigations, focusing on the hydraulic conditions at the entrance of the main fishway. A detailed hydraulic analysis and preliminary modifications were also carried out for the auxiliary Denil fishway. The results showed that although the flow rate in the main fishway was slightly high, it did not prevent fish from swimming upstream to the entrance and the main fishway now meets hydraulic conditions suitable for aquatic species.[22]

According to Taipower, the functionality of the auxiliary fishway was successfully restored by adjusting the elevation difference between the entrance, three resting pools, and the downstream section of the main fishway which had precluded some fish from entering the

[20] Professor Shunroku Nakamura of Toyohashi University of Technology, and Professor Ching-Hsien Tseng of National Tsing Hua University.
[21] Chapter 5, Dajia River Power Plant Ecological Co-prosperity Project Report, 2024-2025.
[22] Chapter 5, Dajia River Power Plant Ecological Co-prosperity Project Report, 2024-2025.

auxiliary fishway. As part of *Phase II of the Overall Ecological Conservation Plan for the Dajia River Basin (2018–2020)*, surveillance cameras were installed at the main fishway's observation window to monitor fish activity in order to assess the effectiveness of the improvements. Additionally, artificial intelligence technology is being introduced to aid in identifying fish species in the fishway. This work is ongoing at this time and effectiveness has not yet been fully assessed.

This review finds that the Project conditionally satisfies the upstream fish passage criterion, with a recommended condition that the Applicant complete the current and planned improvements and subsequently confirm that the fishways are effective. The Applicant requested a PLUS award based on the 2016 fishway optimization work as an adaptive management measure, but this review finds that the improvements made at that time do not rise to the level of the PLUS standard since it remains unclear if the fishways are effective.

D. Downstream Fish Passage

Goal: *The facility allows for the safe, timely, and effective downstream passage of migratory fish. For riverine (resident) fish, including resident potamodromous fish, the facility minimizes loss of fish from impoundments and upstream river reaches affected by facility operations. Migratory species can successfully complete their life cycles and maintain healthy populations in the areas affected by the facility.*

Assessment of Criterion: The Applicant selected Standard D-1, Not Applicable/De Minimis Effect in all ZoEs. The reviewer finds that Standard D-1 is appropriate in the downstream reach since once a fish has passed downstream of a dam or bypassed reach there are no Ma'an facility-related barriers to further downstream migration. The reviewer finds that Standard D-2, Resource Agency and Tribal Government Recommendations, is more appropriate for ZoE 1 and ZoE 2.

Discussion: The fishways were required as part of Project development, thus Standard D-2 is appropriate for ZoEs 1 and 2. The fishways were designed to be bidirectional, supporting downstream passage as well as upstream passage. Species that are or may be present in the Project area are listed in Section 5.C above. Most of these species are small and many do not require passage to complete their lifecycles.

The area downstream of Ma'an Dam recorded the highest number of species in surveys, whereas the hydro projects upstream of Ma'an dam where there are no fish passage facilities have fewer recorded species. Fish populations between the different dam sites have gradually stabilized in those different reaches (presumably after dam building and riverbed changes due to the earthquake and periodic typhoons).[23] The number and composition of species observed directly upstream and downstream of Ma'an dam are similar, indicating that fish can move

[23] Chapter 5, Dajia River Power Plant Ecological Co-prosperity Project Report, 2024-2025.

through the Project. Fish surveys throughout the river continue to be conducted on a periodic basis.

Taipower reported that the intake trashracks have clear spacing of 10 cm (4 inches) which would preclude impingement on the racks for most fish. Small fish could pass through the racks and become entrained in the turbines. The intake was reportedly designed to account for the average cruising speed of local fish which typically ranges from 0.8 to 1.0 m/s, while their escape speed typically ranges from 1.0 to 2.0 m/s. The designed flow velocity at the water inlet is 1.2 m/s but velocity is purposely kept below 1.0 m/s (at slightly less than 9 m/s) to allow fish to effectively avoid the intake.[24]

Many, but not all fish species at the Project are small and could potentially pass unharmed through the turbines if they did enter through the trash racks, but Francis turbines often produce high levels of fish injury and mortality. The turbines each have 17 blades and rotational speeds up to 257 rpm which could be a concern for out-migrating adult eels, although there have only been anecdotal observations of eels at the Ma'an Project. Adult eels are large and strong enough swimmers to potentially avoid the turbine intakes given the low approach velocity and the alternative attraction flow at the fishway, but any eels that did become entrained would be likely to suffer severe injury or mortality.

No entrainment, downstream passage survival, or downstream passage effectiveness studies have been requested or required by the regulatory agencies and no studies have been conducted. Given this lack of information, it is unclear whether flows in the bypassed reach (see Section 6.A) and/or the fishway design and operation are adequate to ensure that downstream migrating fish, particularly protected species (see Section 6.F), are adequately protected.

Therefore, this review finds that the Project conditionally satisfies the downstream passage criterion, with a recommended condition that the Applicant consult with resource agencies and experts and conduct any studies needed to confirm that downstream passage is safe, timely, and effective.

E. Shorelines and Watershed

Goal: *The facility has demonstrated that sufficient action has been taken to protect, mitigate or enhance the condition of soils, vegetation, and ecosystem functions on shoreline and watershed lands associated with the facility.*

Assessment of Criterion: The Applicant selected Standard E-1, Not Applicable/De Minimis Effect in all ZoEs. The reviewer agrees with this selection.

Discussion: The watershed area at the dam is 916.4 km² (353 square miles), accounting for approximately 74.17% of the total drainage area of the Dajia River which is approximately 142

[24] Based on Taipower's responses to reviewer questions.

km (88 miles) long. The Ma'an Project encompasses about 59 hectares of land and water (146 acres). The dam area covers 47% of that area and includes land at the reservoir's full pond elevation, its backwaters, the impoundment area, and facilities. The upper and lower adjustment ponds, their backwaters, impoundment area, and related facilities span the remaining 53% of the Project lands.

There are no protected lands or lands of ecological significance within the immediate Project area, but there are several protected areas along the river including Shei-Pa National Park located upstream, water source protection areas, and potable water protection zones that have been established by government agencies.

Land use around the Project consists primarily of orchards, grasslands and areas of shrubs such as willow, and a small amount of forest along the steeper slopes. Terrestrial species in the Project area include small mammals (e.g., squirrels, rats, and monkeys). Numerous bird species are also present, both migratory and resident. Islands in the reservoir and adjustment pond are home to colonies of egrets.

Taipower has conducted ecological surveys and implemented conservation work along the Dajia river, including at the Ma'an development through two projects - the "Dajia River Basin Overall Ecological Conservation Plan" in two phases (until 2020), and the "Ecological Co-Prosperity Project" (since 2024), in collaboration with partners such as universities.

The Project has taken sufficient action to protect, mitigate or enhance the condition of soils, vegetation, and ecosystem functions based on the ecological surveys and ongoing conservation work, and therefore satisfies this criterion.

F. Threatened and Endangered Species

Goal: *The facility does not negatively impact federal or state listed species, or tribal trust species.*

Assessment of Criterion: The Applicant selected Standard F-2, Finding of No Negative Effect for all ZoEs. The reviewer finds that Standard F-4, Acceptable Mitigation is more appropriate in all ZoEs.

Discussion: The Formosan torrent (or "trooent") catfish (*Liobagrus formosanus),* Pulin river loach (*Sinogastromyzon puliensi*), and Taiwan chub (*Opsariichthys pachycephalus*) are listed under the Taiwan Wildlife Conservation Act as protected fish species.[25] These species have been observed both above and below Ma'an dam indicating that they are able to utilize the fishways. All are small fish (3 – 6 inches in length) and prefer water that is fast-flowing, shallow, cool, and well oxygenated. There do not appear to be specific recovery plans for these species

[25] Chapter 5, Dajia River Power Plant Ecological Co-prosperity Project Report, 2024-2025.

(Standard F-3) nor is it clear that the Project has no effect on them (Standard F-2). Given upstream fish passage availability and ongoing improvements to the fishway, the facility is implementing measures recommended to mitigate impacts on these species (Standard F-4), an effort that is still in progress.

Rare bird species that may be present at the Project include crested serpent eagle *(Spilornis cheela)*, thick-billed green pigeon *(Treron curvirostra)*, yellow-browed warbler *(Phylloscopus inornatus)*, collared scops owl *(Otus lettia)*, Oriental turtle dove *(Streptopelia orientalis)*, and mountain scops-owl *(Otus spilocephalus)*.[26] Given the small project footprint, protection of lands at the impoundment, and little need for tree cutting, it is unlikely that the Project adversely affects these species.

Terrestrial plant surveys conducted in 2020 found no species listed as rare or valuable plants under the Cultural Heritage Preservation Act.[27]

This review finds that the Project is working to avoid or minimize the facility-related impact on fish species and conditionally satisfies this criterion. However, a separate condition is not recommended since the recommended conditions related to the flows and upstream and downstream passage criteria should provide the requisite information to confirm that these species are adequately protected.

G. Cultural and Historic Resources

Goal: *The facility does not adversely impact cultural or historic resources associated with the facility's lands and waters, including archaeological sites, historic era sites, traditional cultural landscapes, traditional cultural properties, and other tribal trust resources.*

Assessment of Criterion: The Applicant selected Standard G-2, Approved Plan for ZoE 1 and Standard G-1, Not Applicable/De Minimis Effect for ZoEs 2 and 3. The reviewer finds that Standard G-2 is also more appropriate in ZoE 2.

Discussion: The Project area has been inhabited for approximately 3,000 years and is partially located within the traditional territory of the Nanshi Tribe of the Atayal people in ZoE 1 and part of ZoE 2. The Atayal people began migrating into the area during the Qing Dynasty (about 200 years ago).[28] They originally resided in the northern part of the central mountains of Taiwan but during Japanese occupation (1895-1945), the Japanese government forced the Atayal communities to move from the mountains to lower ground and nearer the coast where they could be more easily controlled.[29]

[26] Ma'an Hydropower Project Environmental Impact Assessment Report, 1988.
[27] Chapter 5, Dajia River Power Plant Ecological Co-prosperity Project Report, 2024-2025.
[28] Ma'an Hydropower Project Environmental Impact Assessment Report, 1988.
[29] https://ehrafworldcultures.yale.edu/cultures/ad08/summary

The Council of Indigenous Peoples in Taiwan promulgated the “Regulations for the Delimitation of Indigenous Peoples’ Land or Tribal Areas”. These regulations define "Indigenous Traditional Territory" as public lands including areas used for traditional rituals, ancestral sacred grounds, tribal settlements, hunting grounds, cultivated land, or other locations identifiable based on indigenous cultural practices and customary usage. Several other laws protect indigenous rights and interests.[30]

The 1988 Ma’an Project EIA described prehistoric sites, former indigenous settlements and locations of significant events, and historical sites in the Project vicinity. These sites were identified based on literature reviews, two archaeological field surveys, and interviews with elders in the Project area. Some of these areas, mostly ruins, exist on lands currently in use for orchards, other agriculture, or forest. Some are located near the Project’s original construction activities and minor impacts on them were likely at the time of construction. Current operations of the Project are now unlikely to adversely affect these resources. The primary ground-disturbing activity is annual removal of sediment from within the riverbed and not in adjacent riparian areas.

Interviews were held with local community members (including members of the Nanshi Tribe, local residents, and representatives from local government, businesses and education) as part of the onsite HSA assessment, all of whom were supportive of the Project and Taipower. The company appears to maintain good relations with and respects the culture of the Atayal people, including by supporting traditional cultural activities and elevating their cultural history (see Section 6.H below).

Taipower operates under the Taiwan Electricity Act and the Management Guidelines for the Electricity Development Assistance Fund to assist municipal government or county (city) government in promoting development of electric power and improving relations with local communities.[31] As a whole, the company’s fund amounted to approximately $103 million US in 2022.[32] A committee of representatives from local government agencies, experts, and community members review and approve project applications for funding of amounts allocated to the local community.

Taipower also operates under its internal Cultural Heritage Asset Preservation Operation Guidelines which serves to ensure preservation of the company’s own historical and cultural assets including documents, materials, and memories. The company published a summary of the Dajia River’s hydroelectric development history and its company’s cultural history in 2016. To preserve historical and cultural heritage, the Dajia River Power system as a whole

[30] According to the HSA assessment these laws include: Constitutional Amendments on Indigenous representation in the Legislative Assembly, protection of language and culture and political participation (2000); the Indigenous Peoples Basic Law (2005); the Education Act for Indigenous Peoples (2004); the Status Act for Indigenous Peoples (2001); the Regulations regarding Recognition of Indigenous Peoples (2002); the Name Act (2003); and the Indigenous Languages Development Act (2017).
[31] Article 65 of the Electricity Act https://law.moea.gov.tw/EngLawContent.aspx?lan=E&id=10666
[32] Taipower 2023 Sustainability Report https://hc1.taipower.com.tw/mag/Sustainability_en/2023sustainability.pdf

established the Baileng Dajia River Electricity Heritage Museum, located near the upstream Tianlun development, which houses a collection of artifacts and materials related to the river's hydroelectric development history.

This review finds that the Project has at most, a de minimis effect on cultural heritage and resources and Taipower has taken positive steps to preserve and protect such resources and maintain positive relationships with the local indigenous community. Therefore, the Project satisfies this criterion.

H. Recreational, Public, and Traditional Cultural Access

Goal: *The facility accommodates recreational activities on lands and waters controlled by the facility; and provides recreational, public, and traditional cultural access to its associated lands and waters without fee or charge.*

Assessment of Criterion: The Applicant selected Standard H-2, Resource Agency and Tribal Government Recommendations for ZoEs 1 and 3, and Standard H-1, Not Applicable/De Minimis Effect for ZoE 2. The reviewer finds that Standard H-3, Assured Accessibility and Use is more appropriate for ZoE 2.

Discussion: Lands around ZoE 1 and ZoE 3 are regulated as restricted activity areas by the MOEA under an order entitled "Storage Area of the Ma'an Dam Reservoir and its Application Permit Matters". The restricted activity zones are designated primarily to protect human safety by preventing access near the dam gates and water supply facilities.

In ZoE 2, the bypassed reach, access is not restricted (thus Standard H-3 applies) but Taipower indicates that in practice, there is a height difference of approximately 3 to 4 meters between the road and the riverbank, making access difficult.

At the dam, public facilities include the Ma'an Ecological Park (Figure 13) which includes an observation deck overlooking the reservoir; dynamic and static educational displays about the river, ecological aspects, and hydroelectricity; a pavilion with benches and native trees identified on plaques; a spotting glass to view egrets on the island in the reservoir; a public viewing window for the fishway; a model of a turbine; and a large ecological mosaic wall at the dam that is based on a student drawing that won a Taipower sponsored children's painting contest (Figure 14).

Taipower also conducts energy education including a 3-course program:

- Hydropower Voyage: 2.5 hours course on principle of hydropower generation;
- Check out Renewable energy: 3-hour course on the principles of renewable energy such as wind power, hydropower, solar power and fuel cells; and
- Ma'an Ecological Tours which consists of a 4-hour guided tour of the Ma'an Ecological Park.

Figure 13. Ecological Park Overview

Figure 14. Mosaic Wall at Ma'an Ecological Park

This review finds that the Project provides recreational, public and traditional cultural access where it is safe to do so without fee or charge and therefore satisfies this criterion. The Applicant also requested a PLUS award for ZoE 1, since the Ma'an Project has been certified as an Environmental Education Facility and Venue by the National Environmental Research Academy within the Ministry of Environment. This achievement, in addition to the significant educational and recreational opportunities described above, satisfies the PLUS standard for this criterion.

7. Conclusions and Recommendation

This evaluation included the reviewer's observations during HSA's onsite assessment; interviews with key Taiwan Power staff, resource and regulatory agencies, local residents and other interested parties; the LIHI application and supporting documents provided by the Applicant and other publicly available information; and responses to the reviewer's questions provided by the Applicant.

Based on the information, Taipower staff from senior management to front-line workers fully understand and embrace their environmental and social obligations and continually strive to improve conditions and minimize or mitigate Ma'an Project impacts on the river and the local community. As such, this review finds that the Project conditionally satisfies the LIHI criteria and it could be certified for a 13-year term, including the PLUS award for the Recreational, Public, and Traditional Cultural Access criterion, with the following three recommended conditions:

Condition 1: Within 6 months, the Facility Owner must initiate consultation with appropriate regulatory agencies and recognized experts on whether the existing bypass minimum flow regime is adequate to protect fish including protected species, other aquatic species, and their habitats under current ecological flow guidelines applicable to the Project. In annual compliance submittals to LIHI, the Facility Owner must provide status updates on consultation, any agreements made, and any related studies that are conducted until it is confirmed that the current flow regime or any modified flow regime is sufficiently protective. Sufficient progress toward satisfying the condition must be demonstrated in each annual compliance submittal. LIHI reserves the right to modify or add conditions, or to suspend or revoke the LIHI Certification if LIHI determines that sufficient progress is not being made over time.

Condition 2: In annual compliance submittals to LIHI, the Facility Owner must report on the status of implementation of current and future modifications to the fishways, and the status of any effectiveness evaluations; and must provide the results of any effectiveness studies that are conducted. Sufficient progress toward satisfying the condition must be demonstrated in each annual compliance submittal. LIHI reserves the right to modify or add conditions, or to suspend or revoke the LIHI Certification if LIHI determines that sufficient progress is not being made over time.

Condition 3: Within 6 months, the Facility Owner must initiate consultation with appropriate regulatory agencies and recognized experts on the need for additional investigation of downstream passage effectiveness. In annual compliance submittals to LIHI, the Facility Owner must provide status updates on consultation, any agreements made, any passage modifications, and any related studies that are conducted until it is confirmed that the downstream passage is sufficiently protective for all fish including protected species and eels. Sufficient progress toward satisfying the condition must be demonstrated in each annual compliance submittal. LIHI reserves the right to modify or add conditions, or to suspend or revoke the LIHI Certification if LIHI determines that sufficient progress is not being made over time.