Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

Cambodia aims to realize a balanced supply of fisheries products both from capture fisheries and aquaculture to secure a total quantitative target from the sea. The issues identified in each sector are protection of natural resource and conservation of environment in the capture fisheries sector, and promotion and development of aquaculture business in the aquaculture sector. The supply of marine aquaculture seeds in Cambodia is as mentioned above dependent on capture from natural water or importation from foreign countries, which is causing problems like outbreaks of disease in cultured organisms and pressure to the natural resources. The Cambodian Fisheries Administration assessed that the stable supply of healthy aquaculture seeds is indispensible to the marine aquaculture development and formulated a plan to develop, extend and promote the hatchery technology and the actual seed production of aquaculture species including *Lates calicarifer*, groupers and prawns. The promotion of artificial aquaculture seed production is also expected to contribute for the reduction of pressure to the coastal fisheries resources and thereby for protection of the resources and conservation of the environment.

This Project is for construction of Marine Aquaculture Development Centre (MADeC) which will be established as the core facility for development of marine aquaculture in Cambodia through implementation of research & development activities and provision of education & extension services. This Project is formulated taking the following three activities prioritized as the short term objectives for the MADeC into consideration:

Development of marine aquaculture technology and distribution of aquaculture seeds to fishers

Provision of training and education for extension of aquaculture technology

Monitoring of aquaculture environment

The Project is made of the following components of facility construction and equipment supply.

Facility to be constructed:

1. Research and administration building	2. Brood stock building
3. Hatchery and breeding building	4. Crustacea building
5. Machine building	6. Electricity substation
7. Security guard house	8. Outdoor live feed culture tank
9. Outdoor rearing pond	10. Seawater intake facility
11. Effluent treatment facility	

Equipment to be supplied

1.Education and training equipment	2.Experiment and research equipment
3.Rearing equipment	

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design policy

The basic design policy in respect to the basic design of the works under the Requested Japanese Assistance are as listed below.

1)The three main components indispensible for the operation of the Marine Aquaculture Development Centre of Cambodia government, namely, 1) development of marine aquaculture technology and distribution of aquaculture seeds to the operators, 2) implementation of training and education programs for extension of aquaculture technology and capacity building of the aquaculture stakeholders, 3) monitoring of aquaculture environment, are accounted to be the subjects of this Japanese cooperation program.

2)The Project adopts multi-species and multipurpose designs for the Project components, especially for facility like aquaculture tanks.

3)The Project will be designed with sufficient attention given to the control and prevention of disease outbreaks.

4)The results of the environmental survey around the Project site shall be reflected in the Project design.

5)The Project designing will be made with special consideration on easiness in operation and maintenance as well as reduction in operational cost.

(1) Policy on the natural environmental conditions

The Project adopts the following basic policies upon reflection of the results of natural environmental survey.

1)The Project facility being under hot and moist tropical monsoon climatic condition should be designed in consideration of applications of natural ventilation, shading from direct sunlight, etc.

2)The Project site being located at seashore is affected from sea breeze. The Project designing should consider applications of rustproof measures for the facility.

3)The Project will adopt a design that drains the rainfall on the Project premises naturally and efficiently toward the sea.

4)The Project will consider the prevention of costal pollution by the effluents from the aquaculture facility and domestic wastewaters.

5)Designing of underwater facilities like seawater intake piping should be made carefully in consideration of the effects of littoral drifting and wave dynamics as well as conservation of the natural environment at the same time.

The design values of natural environmental conditions assumed for the construction of the Project facility based on the natural environmental survey are as shown in Table 5

Table 5 Values of natural environmental conditions applied for designing of the Project facility

Item	Design value	Source
Air temperature	Maximum: 35.1 ^{o}C, Minimum: 18.6 ^{o}C	Existing climatic records from 2003 to 2008
Rainfall	Maximum daily rainfall: 203.8 mm, Maximum annual rainfall: 4064.8 mm	Existing climatic records from 2003 to 2008
Wind pressure	Wind speed: 21.5 m/sec	Existing climatic records from 2003 to 2008
Seismic force	Horizontal seismic coefficient: 0	Not recorded

(2) Policy on environmental and social consideration

1） Development plans around the project site

Development plan of Shihanoukville port

In Shihanookville port area near the Project site, “The Study on the Master Plan for Maritime and Port Sectors in the Kingdom of Cambodia” has been carried out by JICA in 2007 partly aiming at examination of future development of Shihanookville port and based on this master planning study, construction of oil base and multipurpose terminal is now being examined assuming the Japanese yen loan. In principle, the Project shall continue exchange of information with other development projects near the site particularly for the port-related ones and elaborate common understandings.

Establishment of Special Economic Zone (SEZ)

A special economic zone (SEZ) is proposed at the east side of existing Shihanookville port, and the foundation work is to be started from June 2009. There were 4-5 residents who refused relocation, and among those, two households opposed to the relocation plan strongly and it took about 2 years to compromise about compensation conditions from them. Concerning the relocation of residents in this Project, it is necessary to monitor continuously correspondence of the Cambodian side before and after the start of construction.

(3) Procedures of environmental and social consideration

In Cambodia, the Sub-Decree indicates the necessity of EIA for buildings having more than 12 m in height or architectural area of 8000m^2. The planned facilities are smaller than those criteria. Whereas, considering that the Project is implemented by the scheme of Japanese Grant Aid, environmental evaluation had already been carried out at the level of Initial Environmental Evaluation (IEE) in the preliminary study. In this B/D study an additional stakeholder meeting was held and opinions of residents and other stakeholders have been compiled. In conclusion, environmental and social consideration for the Project would be appropriate and sufficient.

(4) Treatment of discharge water and solid wastes

Regarding discharge water and solid wastes from MADeC, it is necessary to introduce measures to accomplish the criteria shown in the Sub-Decree on Water Pollution Control (1990) and Sub-Decree on Solid Waste Management (1999) of the Ministry of Environment. There is a regulation of total emission, which is to be applied for specific industrial factories discharging water more than 10m^3/day, and those factries require notification to the Ministry. However, aquaculture facilities like those in the Project are not specified in the list of factories that shall obey the total emission regulation. Therefore, from the aspect of proper management of seed production facilities, special attention shall be paid for water parameters about eutrophication such as BOD and COD.

(5) Policy on construction and procurement

1)Construction standards

The design of the Project facility will be made in compliant to the standards listed in Table 2-2. There is no legal construction standard similar to Japanese Building Standard Law in Cambodia although there are regulations on construction permits. This Project therefore will apply Building Standard Law and structure standards of Japan for the designing of the facility.

Table 6 Design standards for the Project facility

Item	Standards complied
Construction	Japanese Building Standard Law
Structure	Japanese Building Standard Law (“*Nihon Kenchiku Kijyun Hou*”) and Japanese structural design standards (“*Nihon Kentikugakkai Kaku Kouzou Sekkei Kijyun*”)
Equipment	Cambodian effluent standard and construction permit acts

2)Sources for the construction materials

The Project will primarily source the construction materials through local procurements. However, most construction materials except some such as concrete aggregates, timbers, and bricks are actually imported from the neighbouring countries. For the following reasons, the Project considers to procure steel beams and plumbing materials in Japan or in the neighbouring countries.

1.Prefabricated steel beams made locally are unreliable in material quality and fabrication precision. Good quality materials are difficult to obtain locally.

2.Galvanized floor gratings are difficult to obtain in local procurements,

3.Plastic pipes, plastic valves, and FRP tanks are the main materials that determine the basic quality of Project. The quality problems in strength and precision expected in the locally available products may cause troubles in the facility operations.

3)Procurement of equipment

There is no highly sophisticated instalment in the requested equipment. Specifications of the Project equipment will be determined in consideration of the following criteria.

1.Easy to use and durable

2.Easy to maintain without application of special techniques

3.Resistant to rusting for the equipment used with seawater

(6) Policy on utilization of local contractors

The Project will adopt popular specifications and commonly practiced construction methods in Cambodia for formulation of the construction plan as much as possible so that the local contractors can be hired for the construction works.

(7) Policy on the operation and maintenance capacity building for the implementation agency

Marine Aquaculture Development Centre is under the direct control of the Director of Fisheries Administrasion, not belonging to the Aquaculture Division. The Director who is immediately responsible for securing of the operational budget for the Centre is planning to make a special budgetary arrangement to supplement for the anticipated shortage of operational funds in the initial phase of the Centre. Fisheries Administration also intends to set up an operational

committee for the Centre for smooth and efficient operation in cooperation with various donor agencies. Nevertheless, they do not have actual experience in operation of marine aquaculture centre such as this Project facility. From the technical and operational view point, therefore, it is necessary to provide technical assistances in operation and maintenance of the facility. The detail of the technical assistance is described in the section of “Soft Component” appearing later in this document.

(7) Policy on setting scales and grades for the facilities and equipment

1)Principal setting policy

The followings are the principal policies for setting scales and grades of the facilities and equipment of this Project.

1.Adopt simple design placing importance on the functionality of facility and equipment

2.Make comprehensive assessment considering factors including safety, durability, easiness in operation and maintenance, and economy for the determination of grades of the Project facilities and equipment using the similar existing facilities in Cambodia as references.

3.Incorporate the standard design and grade commonly observed in Cambodia in the structure of the Project facilities and in the specifications of equipment.

2)Determination of scale and grade for the Project components

A.Research and Administration Building

Scale and grade of the offices and rooms in Research and Administration Building will be determined based on the Japanese standards for office space for newly operational general government offices and “Kensetu Sekkei Siryou Shusei (compilation of architectural designs)” by Architectural Institute of Japan, while also considering the examples in general offices and in IFReDI.

The relative space ratios applied for the offices in the Research and Administration Building based on the examples for small public offices at prefectural level in the Japanese Standards are as show in the following table.

Table 7 Relative space ratios applied for the offices in this Project

Director	10
Deputy director	5
Head of division	2.5
Head of section	1.8
Regular staff	1

Rooms on Ground Floor (1F)

1)Administration and General Affairs Division Room

Design policy

The design of this room will be determined based on examples in the Japanese standards mentioned above as well as examples in general offices and in IFReDI in Cambodia.

The designed total staff number in this room will be four being comprised of one division head, one section head and two regular staffs.

Scale and grade

Office space: 3.36 m^2/person × 2.5 (division head) × 1 person
+ 3.63 m^2/person × 1.8 (section head) × 1 person
+ 3.36 m^2/person × 1 (regular staff) × 2 persons
= 22.698 m^2

Business machine space (shelves, copy and facsimile machines, etc.):
5 m × 1.5 m = 7.5 m^2

Access passages:(22.689 m^2 + 7.5 m^2) × 30% = 9.11m^2

Total space:39.30 m^2 → actual space 39.28 m^2 (cf. Plain View of Research and Administration Building)

2)Seed Production Division Room

Design policy

The design of this room will be determined based on examples in the Japanese standards mentioned above as well as examples in general offices and in IFReDI in Cambodia.

The designed total staff number in this room will be seven being comprised of one section head and six regular staffs.

Scale and grade

3.36 m^2/person × 1.8 (section head) × 1 person
+ 3.36 m^2/person × 1 (regular staff) × 6 persons
= 28.314 m^2 → actual space 30.45 m^2

3)Feed Production Division Room

Design policy

The design of this room will be determined based on examples in the Japanese standards mentioned above as well as examples in general offices and in IFReDI in Cambodia.

The total designed staff number in this room will be five being comprised of one section head and four regular staffs.

Scale and grade

3.36 m^2/person × 1.8 (section head) × 1 person
+ 3.36 m^2/person × 1 (regular staff) × 4 persons
= 21.045 m^2 → actual space 24.0 m^2

4)Feed Nutrition Research Laboratory

Design policy

Feed Nutrition Research Laboratory is a room where test feed productions are carried out as the main activity. The laboratory room will be designed to install equipment and facility for the feed production such refrigerator, chopper, mixer, granulator, weighing balance, and draft chamber.

The total space for installing the designed equipment will be 36.0 m^2.

5)Water Quality Analysis Laboratory

Design policy

Water Quality Analysis Laboratory is a room where analyses of sea water sample is carried out. In addition, the room will be used to store and maintain the stock cultures of

plankton strains and also to prepare initial and secondary cultures for mass cultivation. This room will be therefore designed as a wet laboratory equipped with multiple water quality analysers, temperature and illumination controlled incubators, and seawater and air supply systems.

The total area required for installation of these instruments and facilities will be 36 m^2.

6)Aquaculture Division Room

Design policy

The design of this room will be determined based on examples in the Japanese standards as well as examples in general offices and in IFReDI in Cambodia.

The total designed staff number in this room will be five being comprised of one section head and four regular staffs.

Scale and grade

3.36 m^2/person × 1.8 (section head) × 1 person
+ 3.36 m^2/person × 1 (regular staff) × 4 persons
= 21.045 m^2 → actual space 24.0 m^2

7)Aquatic Organisms Pathological Laboratory

Design policy

This is a laboratory for carrying out examination and research on fish pathology and disease control, and to be installed with the equipment necessary for PCR method and electrophoresis. The laboratory will also equip with incubators and microscopes for culture, observation and isolation of microorganisms. In addition, this laboratory will accommodate two independent aseptic rooms. The reason for installing two independent aseptic rooms is to separate a room for treating pathogenic organisms from another room for non-pathogenic activities like preparation of culture media. The aseptic rooms will be designed to have an entrance chamber for changing cloths, a pass box for receiving samples and an aseptic chamber with a clean bench for the ascetic operations. The total space of the room will be determined based on the dimensions of installed equipment and laboratory tables.

The design space for the aseptic rooms will be 10.71 m^2 and that for aquatic pathological laboratory is 43.89 m^2.

8)Washing and Sterilization Room

Design policy

This is a room for washing and drying of laboratory glassware and metal wares, and also for sterilization of glassware, metal wares and culture media.

Scale and grade

18.00 m^2

9)Aquatic Pathology Division Room

Design policy

The design of this room will be determined based on examples in the Japanese standards as well as examples in general offices and in IFReDI in Cambodia.

The designed total staff number in this room will be six being comprised of one section head and five regular staffs.

Scale and grade

3.36 m^2/person × 1.8 (section head) × 1 person
+ 3.36 m^2/person × 1 (regular staff) × 5 persons
= 24.687 m^2 → actual space 23.40 m^2

10)Aquaculture Technical Development Division Room

Design policy

The design of this room will be determined based on examples in the Japanese standards as well as examples in general offices and in IFReDI in Cambodia.

The total designed staff number in this room will be five being comprised of one section head and four regular staffs.

Scale and grade

3.36 m^2/person × 1.8 (section head) × 1 person
+ 3.36 m^2/person × 1 (regular officer) × 4 persons
= 21.054 m^2 → actual space 25.2 m^2

11)Toilet

Design policy

The appropriate scale and specification will be determined based on the number of users.

Scale and grade

Designed total number of users: 32 persons (male 1: female 1)

Men's toilet: toilet bowl 1, urinary basin 2, washbasin 2 → total space 19.20 m^2

Women's toilet: toilet bowl 2, washbasin 2→ total space 16.50 m^2

12)Night Duty Rooms

Design policy

The Project facility requires 24-hour monitoring due to its fundamental nature, and therefore, requires two night duty rooms. The design will be determined based on examples in "Kentiku Sekkei Shiryo Shusei (compilations of architectural designs of Japan)".

Scale and grade

Night duty room No.1: 12.16 m^2

Night duty room No.2: 12.50 m^2

13)Kitchen

Design policy

The kitchen equipment is composed of sink, water heater, refrigerator, and cupboards. The design will be determined considering the equipment composition and the common examples in Cambodia.

Scale and grade

The kitchen space will be determined based on the arrangement of the planned equipment. = = 6.82 m^2

Rooms on First Floor (2F)

1)Director's Room

Design policy

The design of director's room will be determined based on the reference values in the Japanese standard for office space for newly operational public offices and "Keichiku Seekei Siryou Syusei (compilation of architectural design)" by Architectural Institute of Japan and examples of Cambodian offices for Greater Class civil servant and the director's room of IFReDI (5 m × 8 m = 40 m^2).

Scale and grade

3.36 m^2/person × 10 (director) × 1 person
= 36.3 m^2 → actual space 39.54 m^2

2)Deputy Director's Room 1, 2, and 3

Design policy

The design of deputy director's rooms will be determined based on the reference values in the Japanese standard for office space for newly operational public offices and "Keichiku Seekei Siryou Syusei (compilation of architectural design)" by Architectural Institute of Japan and appropriate examples of Cambodian offices and the deputy director's room of IFReDI (4 m × 5 m = 20 m^2).

Scale and grade

3.36 m^2/person × 5 (deputy director) × 1 person = 18.15 m^2

The actual space is determined as 18.00 m^2 taking the example of IFReDI and pillar span of the building .

3)Training and Extension Division Room

Design policy

The design of room for the training and extension division will be determined based on the reference values in the Japanese standard for office space for newly operational public offices and "Keichiku Seekei Siryou Syusei (compilation of architectural design)" by Architectural Institute of Japan and appropriate examples of Cambodian offices and office rooms of IFReDI. The total designed staff number in this room will be five being comprised of one section head and four regular officers.

Scale and grade

3.36 m^2/person × 1.8 (section head) × 1 person
+ 3.36 m^2/person × 1 (regular officer) × 4 persons
= 21.054 m^2 → actual space 24.0 m^2

4)Meeting Room

Design policy

The meeting room will be used for regular meetings and communication among the staffs up to approximately 20 persons. The design will be determined based on examples

in “Kenchiku Sekkei Siryou Syusei (compilation of architectural designs of Japan)” by Architectural Institute of Japan.

Scale and grade

$2.5m^2$/person × 20 persons = 50 m^2

The actual design is determined considering the desk arrangement.

→ Actual space 49.20 m^2

5)Library

Design policy

The design of laboratory will be determined assuming 1/3 of the researchers use it at a time.

Space and grade

The scale of library will be calculated based on the reference values in “Kenchiku Sekkei Siryou Syusei (compilation of architectural designs of Japan)” by Architectural Institute of Japan.

Assuming the library has enough space (1.5 allowance rate) for storage of 5000 books on elevated bookshelves and reading space for 9 persons at a time using reading desks with 4 chairs, the required space will be as follows.

(5000 books ÷ 220 books/m^2) + (9 persons ÷ 0.55 person/m^2) = 39.10 m^2

→ actual space 42.00 m^2 (because of the pillar span)

6)Specimen Room

Design policy

The design will be determined by reference to the existing specimen room of the Centre (approximately 9 m × 6 m = 54 m^2)

Scale and grade

→ 18.90 m^2

7)Meeting Hall

Design policy

The meeting hall will have enough space for holding general meetings with attendance

of all 40 staff and also for holding regularly seminars and training courses with participants of up to 50 persons including the Centre staff. The design will be determined by reference to “Kenchiku Sekkei Siryou Shusei (compilation of architectural designs of Japan)”.

Scale and grade

2.5 m^2/person × 50 persons = 125 m^2

The actual design will be determined considering the desk arrangement.

→ actual space 109.20 m^2

8)Kitchen

Design policy

The kitchen equipment will be composed of sink, water heater, refrigerator, and cupboards. The design will be determined considering the common utilization in Cambodia, and the equipment composition.

Scale and grade

The kitchen space is determined based on the arrangement of the planned equipment.

2 m × 3 m = 6.0 m^2 → actual space 6.0 m^2

9)Toilet

Design policy

The appropriate scale and specification will be determined based on the number of users.

Scale and grade

Expected total number of users: 10 staffs + 50 seminar participants (male 2: female 1)

Men’s toilet: toilet bowl 2, urinary basin 3, washbasin 2 → total space 19.20 m^2

Women’s toilet: toilet bowl 2, washbasin 2 → total space 16.50 m^2

B.Seawater Intake Facilities

The designing of this facility will be explained in detail in Section 2-2-2 Seawater Intake Plan appearing later in this document.

C.Seawater Filtration and Distribution Facilities

1)Filtration facility

The Centre adopts a seawater intake system with underwater filter chambers to collect filtered seawater at the underwater intake point. Therefore, it is not necessary to install a large-scale filtration facility on ground.

2)Facility for distribution of seawater

The seawater collected through the seawater intake system is designed to be pumped up to an elevated seawater storing tank, and then distributed from there through the three distribution systems; 1) to Hatchery & Breeding Building, 2) to Crustacean Building, and 3) to the outdoor earthen ponds. For anti-rusting, the water distribution pump must be for seawater application protected in a plastic casing. The distribution systems to Hatchery & Breeding Building and Crustacean Building will be equipped with ultraviolet sterilization apparatuses.

D.Freshwater Distribution Facility

The Centre will require freshwater in a total volume for 37 staff (100 litres × 37 person) and 20 training participants (100 litres × 20 persons) and for aquaculture activities (15 m^3/day). The required freshwater for the people will be supplied by the city water supply system, while the freshwater for the aquaculture activity is planned to be supplied from the stored rainwater.

E.Effluent Treatment Facility

The aquaculture effluent from the Project facilities will be removed for the solid matters first in sedimentation tanks. The clear upper portion only will be then treated for reduction of BOD in a purification tank and the treated water will be finally discharged.

F.Brood Stock Building

Brood Stock Maturation Tanks

Design policy

The brood stock maturation tanks will be made of concrete and set in an arrangement of close positions for efficient operation as well as for cost reduction. The shape of the tanks will be circular or octagonal with a cone-shaped bottom like a mortal for easy

removal of uneaten feeds and faecal matters.

Installation of copper ion generators will be considered for prevention of parasitic and other diseases to the brood fish. The Project will also consider introduction of ozone generators for washing and sterilization of fertilized eggs.

Scale and grade

The total number of breed stock maturation tanks will be four of which one is a backup tank used for transfer of brood fish. The capacity of each tank will be 4 tons with 1.8 m height. The tank will be filled with water from a point on the upper rim of side wall, and drained from the bottom centre through a pipe. The water will flow over the end of a stand pipe electing outside of the tank wall. The colour of the inside wall will be determined after consultation with the Cambodian staffs. The tank wall will be coated with flexible epoxy resin FRP linings for water proofing.

G.Hatchery and Breeding Building

1)Fry rearing tanks (hatchlings to 30 mm size fry)

Design policy

The fry rearing tanks will be set in a compact arrangement for operation efficiency. The tanks will be made of FRP material which is lighter than concrete and therefore convenient for possible future rearrangement of the tank locations. The FRP tanks will be in a circular shape with a mortal-like bottom in shape for easy cleaning for uneaten feeds and faecal matters. The height of tanks will be set at a level not interrupting the aquaculture operations.

Scale and grade

Each FRP tanks will have a capacity of 4 tons with 1 m height. Total number of tanks to be installed will be 20. The tank will be filled with water from a point on the upper rim of tank wall and drained from the bottom centre through as drain pipe. The water will flow over the end of a stand pipe electing outside of the tank. The colour of the inside wall will be decided after consulting with the Cambodian staffs. There is no water leakage risk from the FRP material tanks.

2)Fingerling rearing tanks (30 to 80 mm fingerlings)

Design policy

The fingerling rearing tanks will be set in a compact arrangement for efficient operation. The tanks will be made of concrete for reduction in the construction cost. The shape of

tanks will be circular or octagonal with a mortal-like bottom in shape for easy removal of uneaten feeds and faecal matters. The height of tank will be set at a level not interrupting the aquaculture operations.

Scale and grade

The total number of tanks will be 4. Capacity of each tank will be 30 tons with 1.2 m height. The tank will be filled wit water from a point on upper rim of the tank wall and drained from the bottom centre through a drain pipe. The water flows over the end of stand pipe electing outside of the tank wall. The inside colour of the tank will be determined after consultation with the Cambodian staffs. The tank will be water-proofed with flexible epoxy resin FRP linings.

H.Crustacean Building

1)Brood Stock Rearing Tank

Design policy

The tanks will be set in a compact arrangement for efficient operation. The tanks will be made of FRP material which is lighter than concrete and convenient for possible future rearrangement of the tank locations. The FRP tanks will be in a rectangular shape with rounded corners for prevention of uneaten feed accumulation and dead water pockets at the corners. The height of tanks will be set at a level not interrupting the operations.

Scale and grade

The total number of tanks will be 4. Capacity of each tank will be 2 tons with 1 m wall height. The tank will be filled with water from a point on the upper rim of the tank wall, and drained at the bottom centre through a drain pipe. The water flows over the end of a stand pipe electing outside of the tank wall. The colour on the inside wall will be determined after consultation with the Cambodian staffs. The tank is leakage-free as it is made of FRP material.

2)Prawn larvae rearing tank

Design policy

The tanks will be made of concrete in a circular or octagonal shape with mortal-like bottom in shape for easy removal of uneaten feeds and faecal matters. The height of tank wall will be set at a level not interrupting the operations.

Scale and grade

The total number of tanks will be 2. Capacity of each tank will be 50 tons with 1.5 m wall height. The tank will be filled with water from a point on the upper rim of the tank wall, and drained at the bottom centre through a drain pipe. The water flows over the end of a stand pipe electing outside of the tank wall. The colour on the inside wall will be determined after consultation with the Cambodian staffs. The tank will be considered for water-proofing with a flexible epoxy-resin FRP linings.

I.Outdoor ponds and tanks

1)Outdoor rearing ponds

The outdoor earthen ponds suitable for rearing of sea bass fingerlings (30 mm to 80 mm) will be included in the Project facility for demonstration of aquaculture practices.

Design policy

The ground level at the Project site is too low to drain the outdoor ponds completely. Therefore, the Project will consider for filling soil to raise the ground the level high enough for complete drainage and sun-drying of the pond bottom. There will be poles around the pond for hooking shading net (expecting 90% shading) to avoid strong direct sunlight.

Scale and grade

There will be 2 ponds, and each pond will have a surface area of 300 m^2 and 2 m depth. The sidewalls of pond will be made of concrete and stone masonry with appropriate treatments applied for water proofing and weathering resistance.

2) Outdoor live feed culture tank

The Project will construct outdoor tanks to be used for culturing of live feed organisms for aquaculture seed production (marine chlorella or *Nannochloropsis oculata*, and others).

Design policy

Concrete tanks suitable for cultivation of phytoplankton to be used for growing rotifers will be constructed. In order for minimizing the risk of cultivation collapses, there will be multiple tanks constructed rather than one big tank to produce the required quantity of plankton. The concrete tank will be coated with epoxy resin FRP linings for prevention of cracking, water proofing, and increased durability.

Scale and grade

There will be 3 tanks. Each tank will have 35 ton capacity with 0.8 m depth. Air stones are installed on the bottom at 1 piece/m^2 for aeration and agitation of water for facilitation of the photosynthetic activity. The bottom of tanks will be sloping slightly for easy drainage.

J.Machine Building

1)Seawater intake pump room

There will be two sets of pumping system with 2 pumps in each set. The capacity of pumps will be explained in a latter section of “Seawater Intake System”.

2)Blower room

There will be a total of 4 air supply systems that supply compressed air to; 1) Brood Stock & Maturation Building, 2) Crustacean Building, 3) Hatchery & Seed Production Building, and 4) Microalgae cultivation tanks.

3)Worker room

There will be a room for maintenance workers for resting and preparation.

4)Elevated water storage tanks

There will be elevated storage tanks for seawater to supply by gravity to the culture facilities. There will be also other elevated tanks of 25 m^3 capacity for backwashing the underwater filtration chambers. In addition, there will be elevated tanks for storage of freshwater.

K. Electricity Substation

1)Electrical switchboard room

The 220-V public electricity will be received at this room and transformed to specified voltages for distribution to the facilities.

2)Generator house

There will be a room where generators will be installed for emergency use during the

blackout period of the public electric power supply.

L.Security Guard House

Design policy

A guard house will be build near the main gate for full-time guarding by 2 persons. The guard house will be composed of office, resting room and toilet.

Scale and grade

Office:	$3.93\ m^2 \times 2 = 8.89\ m^2$	$\rightarrow 7.50\ m^2$
Resting room:		$\rightarrow 15.00\ m^2$
Toilet:		$\rightarrow 5.00\ m^2$

(8) Policy on construction method, procurement of construction machinery and construction period

1) Most of the construction machinery required for the facility construction in this Project are available in Cambodia, and therefore, the necessary machines will be obtained primarily through local procurements. Nevertheless, the workboat for marine construction for installation of intake pipes has to be obtained from Japan or neighbouring countries.

2) The implementation schedule should be made with ample time allowances for transportation of imported materials.

2-2-2 Basic Plan

2-2-2-1 Seed production plan

The main activity that will be carried out using the facility to be constructed in this Project is production and distribution of aquaculture seeds. The annual demand for sea bass fingerlings in Cambodia was estimated at about 800,000 to 1,000,000 by the survey conducted in the 1st Basic Design Study of this Project. The design capacity of the Project facility for fingerling production and distribution is set at about 40 to 50 % of this estimated annual demand which is a level that MADeC would become able to produce and sell eventually in about 5 years. Needless to say, it is ideal to become able to supply 100 % of the estimated demand. However, considering the fact that the Project facility is the first marine aquaculture centre in Cambodia and little experience and knowledge in this area has been accumulated in the country, the target of sea bass fingerling production by the Project is appropriate to be set at about 400,000 per year.

In respect to black tiger prawn which is identified as a target species that the Centre aim to be able to do mass production in the medium to long terms, the design capacity of the Project facility is set at a level that enables the Centre to carry out basic experimental-scale seed productions. Assuming the Centre repeats the experimental-scale seed production three times in a year and produces 150 – 200,000 larvae per time, the seed production capacity of the facility is set at 50,000 larvae in a year, which are enough to be stocked in about 0.75 – 1 ha of aquaculture ponds at a traditional stocking density (20 ind/m^2). In respect to giant river prawn which requires brackish water at an early stage of the life cycle, the Project facility is designed to play a complementary role of the freshwater aquaculture centre at Bati. The seed production activity of giant river prawn at the Project facility is then designed to be carried out using the same facility for the seed production of black tiger prawn.

There are possibilities for seed production of other species at MADeC in the future in addition to these particular target species mentioned above as well as possibilities of expansions in capacity and function in the fingerling production activities of the Centre. Taking the future expansion possibilities into consideration, the Project facilities are designed to have a characteristic of multi-purpose use in some items like water tanks.

(1)Fingerling production of sea bass

1)Design policy

- Consider the possibility of future conversion of target species to others,
- Make the facility capable to manage the fingerling production procedure by pair of brood fish and its offspring in one unit for prevention of infectious disease outbreak,

•Ensures a reliable fingerling production through stable supply of live feeds though systematic culture process of rotifers and chlorella

2)Production target

•400,000 fingerlings/year

•3 production cycles/year, 133,000 fingerlings per production cycle

•Body length of produced fingerlings: 8 cm (3 inch size)

3)Production system

Brood fish rearing

•Spawning and egg collection is basically by application of artificial fertilization technique

•Brood fish stock: made of 30 males and 30 females or total 60 fish including candidates for future use. Use 10 brood fish per spawning in each sex selected from the brood fish stock.

•Rearing density: 1.5 kg/m^3, 4 kg per brood fish

•Capacity of brood fish rearing tanks: 60 fish × 4 kg ÷ 1.5 kg = 160 m^3

Including one additional tank for transfer of brood fish,
4 tanks of 50 m^3 capacity are required.
6 m diameter × 1.8 m height (circular or octagonal design)

•Required quantity of water: exchange rate 2 cycles/day

50 m^3 × 4 tanks × 2 cycles = 400 m^3/day

Fry nursery (hatch-out larvae to 30 mm size fry)

•Number of 30 mm fry produced in each production cycle

400,000 fingerling/year ÷ 3 production cycles ÷ 0.9 survival rate = 148,000 fry

•Rearing density: 3000 fry/m^3

•Capacity of rearing tanks 148,000 fry ÷ 3000 fry/m^3 = 50 m^3

4 m^3/tank × 20 tanks = 80 m^3 (FRP tanks, 2.4 m diameter × 0.9 m height)

•Required quantity of water: total volume required for the 20 tanks is 80 m^3

Exchange rate: 2 cycles/day

80 m^3 × 2 cycles = 160 m^3/day

Fingerling nursery (30 mm fry to 80 mm fingerlings)

The following four options (*a*, *b*, *c*, and *d* options) are compared for selecting the best method for rearing sea bass from 30 mm fry to 80 mm fingerlings. The Project facility is designed based on the *d* option.

Option a: Outdoor ponds only

Rearing the fry in *hapa* (net cages suspended in water) set in outdoor earthen ponds

- Rearing density: 300 fry/m^3
- Total capacity of hapa: 134,000 fry ÷ 300 fry = 446 m^3
- Net cage: 3 m × 3 m × 1.2 m (10.8 m^3)
- Number of net cage required: 446 m^3 ÷ 10.8 m^3 = 42 sets
- Earthen ponds: 345 m^3 in capacity and 1.5 m in depth, 3 ponds

  Each pond can set up to 15 net cage
- Required quantity of water: exchange rate 1.5 cycle/day

  345 m^3 × 1.5 cycle × 3 ponds = 1,552 m^3/day

Option b: Indoor tanks and one outdoor pond for demonstration

- Stocking density: 500 fry/m^3 in indoor rearing tank
- Capacity of indoor rearing tank: 6 m diameter × 1.0 m height = 28 m^3, 8 tanks (total volume 224 m^3)
- Required quantity of water: exchange rate 2 cycle/day

  For indoor rearing tank: 224 m^3 × 2 cycles/day = 448 m^3
  For one earthen pond: 1552 m^3 ÷ 3 = 517 m^3

  …… Total 965 m^3

Option c: Indoor tanks only

- Rearing density: 500 fry/m^3 in indoor fry rearing tank
- Capacity of indoor rearing tank:

  Total indoor tank capacity: 134,000 fry ÷ 500 fry/m^3 = 268 m^3

Capacity additional to larvae rearing = 268 m^3 – 80 m^3 = 188 m^3

6 m diameter × 1.0 m height = 28 m^3, 8 tanks

•Required quantity of water: exchange rate 2 cycle/day

(80 m^3 + 224 m^3) × 2 cycles/day = 608 m^3/day

<u>Option d: Indoor tanks and two outdoor ponds for demonstration</u>

•Rearing density: 500 fry/m^3 in indoor fry rearing tanks

•Capacity of indoor rearing tank: 6 m diameter × 1.0 m depth = 28 m^3, 4 tanks (concrete circular tanks)

•Required quantity of water: exchange rate 2 cycle/day

For indoor tanks: 112 m^3 × 2 cycles/day = 224 m^3/day

For two outdoor ponds: 1552 m^3 ÷ 3 × 2 = 1035 m^3/day

…..… Total 1259 m^3/day

Table 8 Maximum seawater requirement for fingerling production of sea bass Unit: m^3/day

Option in fingerling production system	Brood fish rearing	Fry nursery (hatch-out to 30 mm length)	Fingerling nursery (30 mm to 80 mm length)	Total
Option a: outdoor ponds only	400	160	1,552	2,112
Option b: indoor tanks and one outdoor pond	400	160	965	1,525
Option c: indoor tanks only	400	160	608	1,168
Option d: indoor tanks and two outdoor ponds	400	160	1,259	1,819

(2)Seed production of black tiger prawn

Production target: 500,000 post larvae

Rearing density: 5000 larvae/m^3

6 m × 6 m × 1.5 m, 2 tanks (100 m^3)

Water exchange rate: 2 cycle/day

Brood stock rearing: 2 m^3 capacity tank, 4 pieces

Seawater requirement:Brood stock rearing 2 m^3 × 4 tanks × 2 cycle/day = 16 m^3

Larvae rearing 50 m^3 × 2 tanks × 2 cycle/day =200 m^3----------Total 216 m^3

(3) Live feed culture plan

(1)Rotifer culture

Required rotifer quantity for sea bass nursery

(200,000 fish × 20,000 ind./fish)400 million ind./day

Culture method: Extensive continuous culture that complements the flaw of increasing environmental resistance in the traditional batch culture technique

Productivity: 50 million ind./m^3/day

Capacity of culture vessels:

Total capacity 400 million ind./50 million individuals = 8 m^3/day

Culture tanks2 m × 2 m × 1 m (4 m^3), 2 tanks

Harvest tanks2 m × 2 m × 1 m (4 m^3), 2 tanks

(2)Microalgae culture

The microalgae culture system increase the density of marine chlorella from 5 million cells/ml to 20 million cells/ml to apply the produced chlorella for the rotifer culture and also for control of culture environment in the fingerling rearing tanks.

Total quantity of microalgae required for sea bass fingerling production:

8 m^3/day + 8 m^3/day= 16 m^3/day

The culture period of microalgae is about 7 days and therefore the total volume of required culture vessels is at least 112 m^3.

8 m × 5 m × 0.8 (effective depth), 4 tanks = 128 m^3

Microalgae are the most fundamental live feeds for marine seed productions and thus the capacity of culture system should be set with ample allowances.

(4) Seawater requirement

The table shown below compares the total requirements of seawater for the seed production system including the requirement for prawn and live feed culture with the four options of sea bass fingerling production systems (*a*, *b*, *c*, and *d*) mentioned earlier.

Table 9 Comparison of total quantities of seawater required for the seed production systems with four options of sea bass fingerling production systems unit: m^3/day

		Option a	*Option b*	*Option c*	***Option d***
Fingerling production of sea bass	Brood stock culture	400	400	400	400
	Larvae rearing (up to 30 mm)	160	160	160	160
	Fry nursery (up to 80 mm)	1552	965	608	1259
Prawn culture	Brood stock culture	16			
	Seed production	200			
Live feeds culture	Rotifer culture	10			
	Microalgae culture	20			
Total	Daily requirements (hourly requirements)	2358 (98)	1771 (74)	1414 (59)	2065 (86)

* *Option a*: Use only outdoor earthen ponds (3 ponds) for fingerling production of sea bass
Option b: Use indoor tanks and one outdoor ponds for fingerling production of sea bass
Option c: Use only indoor tanks for fingerling production of sea bass
***Option d*: Use indoor tanks and two outdoor ponds for fingerling production of sea bass**

This Project adopts the option d (indoor tanks and 2 outdoor ponds) for the project designing.

Extra system allowance: 2065 m^3 × 15% = 309 m^3/day (for future expansion etc.)

Total seawater intake volume: 2065 m^3 + 309 m^3 = 2374 m^3/day (98.9 m^3/hour)

The design volume of seawater intake for the facility is then set at 100 m^3/hour.

(5) Freshwater requirement for the culture facility

Live feed culture:4.0 m^3/day (for microalgae culture)

For cleaning:0.2 m^3/day

Total 4.2 m^3/day

2-2-2-2 Seawater Intake Plan

(1) Design of Seawater Intake Facility

1) Design Policy

Securing stable supply of high quality seawater is extremely important for rearing marine organisms. It is possible to waste all the achievements accumulated in the long-term at once upon a single failure incident in the seawater intake facility. This Project will therefore design the seawater intake facility most suitable for the hydrographical and environmental conditions with the following principal design

criteria.

1)The intake facility should be able to supply stable and sufficient seawater into the long future

2)The seawater should be taken from an area where the water is clean without pollution. Filtration should be considered depending on the quality of source water and the selected intake method.

3)Water should be collected from the middle or bottom layer to ensure the stable temperature variation throughout the year.

4)The intake facility should be easy in operation and low in operational cost.

5)A backup system should be considered for un-interrupted seawater supply during the time of maintenance work and possible mechanical failure of the main system.

2) There are various methods of water intake system available depending on purpose, scale, and environmental conditions. The methods that are used now can be categorized into three types; 1) vertical pumping, 2) submerged filtration, and 3) seawater well. The last option is found not to be applicable at the site for this Project because there is no highly permeable sand layer that enables to supply seawater at a discharge more than 100 m^3/hour based on the boring survey carried out in the Basic Design Survey of this Project which found the site geological layers are basically made of impermeable bedrock and high-density geologic strata.

Therefore, the appropriate method for this Project will be selected by comparing the remaining two methods, 1) vertical pumping intake system and 2) submerged filtration intake system, in respects to principal characteristics in the methods, tidal difference, bottom substrate, water quality at the intake point, operation and maintenance method, and cost of construction, as shown in the table below. The conditions for the comparison are as follows;

- Quantity of intake water: 100 m^3/hour (based on the seed production plan of this Project)
- Bottom geologic feature: Sand or bedrock layer is exposed up to 200 m from the beach, and silt layer of 0.5 – 1.2 m depth is covering on bedrock more than 200 m from the beach, based on the survey in the Basic Design Study,
- Water quality: Use BOD measured from the surface and bottom at the intake point as an index for water quality

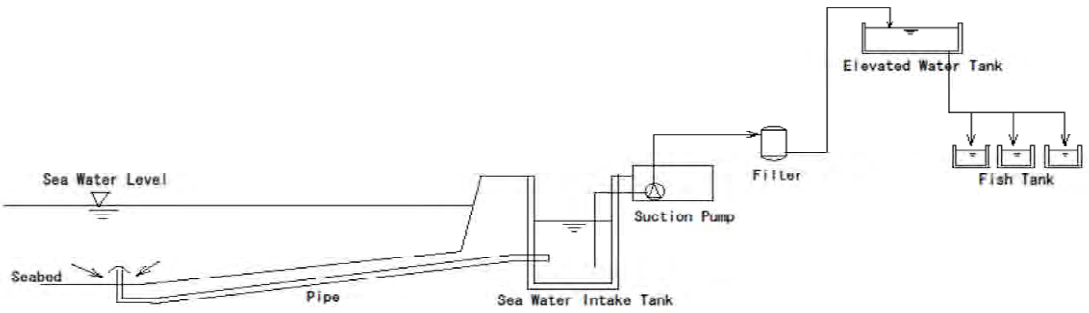


Figure 1 Vertical Pumping Intake System

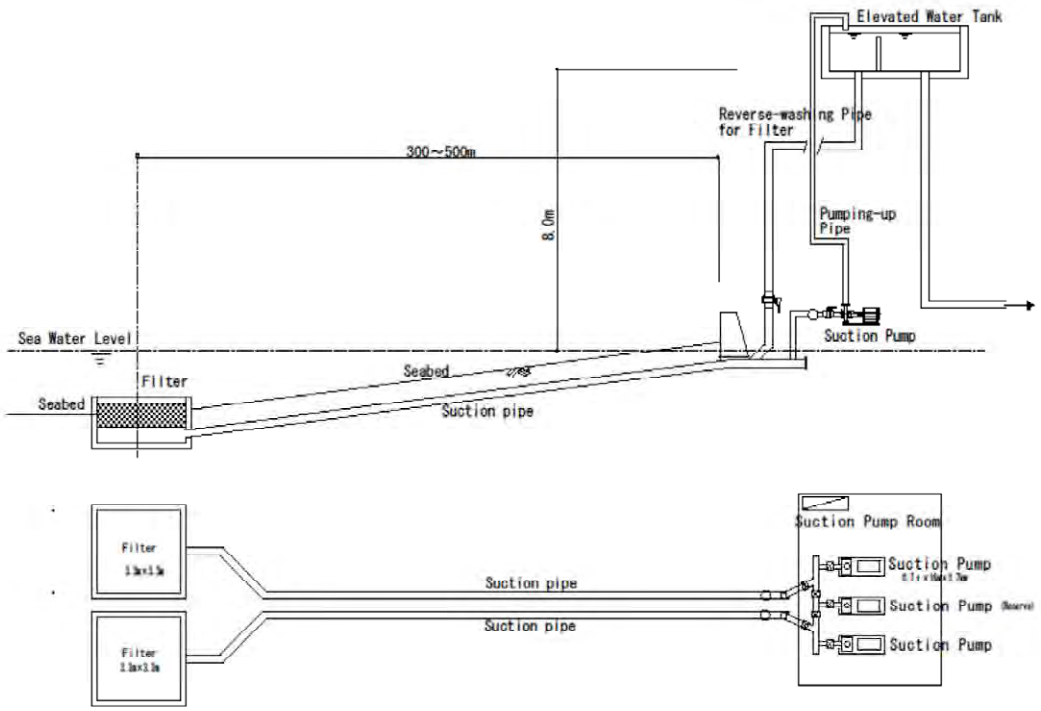


Figure 2 Submerged Filtration Intake System

(2) Comparison of seawater intake facility

Table 9 Comparison of seawater intake systems for the Project site

Water Intake method	Vertical pumping intake system	**Submerged filtration system (1) 2 intake pipe lines**	Submerged filtration system (2) 3 intake pipe lines
Water quality	Necessary to construct a sump and a ground filtration system as the water collected by this system directly from sea often contains sand and other particles	No attachment of shells and other bio-fouling inside of the intake pipes is expected as the water collected by this method is filtered at the intake point.	No attachment of shells and other bio-fouling inside of the intake pipe is expected as the water collected by this method is filtered at the intake point.
	○	○	○
Installation depth	Approximately 4.0 m Ideally 5 m. But difficult to install at a deeper position because of poor bottom substrate condition. Installation at a shallower location may result in unstable water quality of the collected seawater.	Approximately 4.0 – 5.0m Ideally 5 m to avoid drifting of the filtration sand particles. But installing at 4 m is still acceptable with a special countermeasure for the silt layer.	Approximately 4.0 – 5.0m Ideally 5 m to avoid drifting of the filtration sand particles. But installing at 4 m is still acceptable with a special countermeasure for the silt layer.
	△	△	△
Stability in intake quantity	Periodical cleaning of the intake pipe line for sand and befouling with polyethylene pigs is necessary for stable water collection.	Stable water collection is possible with periodic backwashing of the filtration system. Diameter of intake pipe line is primarily determined by the required water quantity for the backwashing process.	Same as submerged filtration system (1)
	△	△	△
Length and nominal diameter of intake pipe line	Main line Length: 295 m Diameter: 300 mm × 1 Sub line Length: 220 m Diameter: 150 mm × 1	Length: 295 m Diameter: 200 mm × 2	Length: 295 – 468 m Diameter: 200 mm × 3
	○	○	○
Requirement for sump	Necessary to build in the land area	Not necessary	Not necessary
	×	○	○

Requirement for ground filtration system	Necessary. Backwashing system and settlement tank are also required.	Not necessary	Not necessary
	×	○	○
Construction and installation easiness	Underwater pipe installation is relatively easy, especially at the intake end. Construction of a sump and laying pipe line in the land area is difficult.	Installation of submerged filtration system is not difficult as it is prefabricated on ground. Pipe laying work is easy as the installation level can be raised to +1.75 m by using combination of suction pump and self-priming pump.	Same as submerged filtration system (1)
	△	○	△
Inspection and maintenance	No complicated inspection is required as the water automatically drains to the sump. It is necessary to clean inside of the intake pipe by inserting polyethylene pigs into the pipe line for 1–2 times in a year.	When the sand filtration media are drifted off, it has to be refilled. Regular inspection by divers is necessary about once a year.	Same as submerged filtration system (1)
Operational cost	Divers' inspection: required Intake pipe cleaning: required Sump cleaning: required Maintenance of filtration system: required	Divers' inspection: required Intake pipe cleaning: not required Sump cleaning: not required Maintenance of filtration system: not required	Divers' inspection: required Intake pipe cleaning: not required Sump cleaning: not required Maintenance of filtration system: not required
	×	○	○
Construction cost	Marine work: Low Sump construction: High Filter construction: High Pump installation: High	Marine work: Middle Sump construction: Nil Filter construction: Nil Pump installation: Nil	Marine work: High Sump construction: Nil Filter construction: Nil Pump installation: Nil
	○	○	×
Overall Evaluation	△		×

Based on the evaluation above, the submerged filtration system (1) is the best method for the Project.

(3) Design of Submerged Filtration Water Intake System

1) Brief description of submerged filtration water intake system

The submerged filtration water intake system is a method of seawater collection that draws seawater from a sand filtration chamber installed on the bottom of the sea. Because the seawater is filtered at the pipe end intake point, this method has an advantage of little biofouling to be developed inside of the intake pipe and thus enabling application of smaller pipe diameter. When the intake pipe gets clogged, backwashing can clean the pipe. It is not necessary to build a sump and filtration device in the land area in this water intake system, and therefore the land space can be used efficiently. The construction cost is not different from that for the vertical pumping system because of the dominance of the ground filter and sump in the design. The maintenance cost is also low. This method is concluded as the appropriate method for the Project.

2) Water intake position

The submerged filtration system for this Project will use sand particles of 1mm diameter for forming the sand filtration media. It is important that the sand particles are not drifted away by the wave and current forces. The 50-year wave height projected by the port and harbour authority near the site is 2.6 m. Based on the fact that the resident houses in the Project site have not experienced any damage for more than 30 years as well as the observed sediment condition in the area, the design wave height for this project is considered to be appropriate to set at 80 % of the projected 50-year value, or 2.0 m. This Project considers the following two options for the position of the water intake and the intake pipe route.

A-Route Plan

This is a plan to set the water intake point at a sufficiently deep position where no special countermeasure is necessary for prevention of sand drifting at the filtration chamber. The distance from the shoreline to the intake point is approximately 430 m in this plan. Advantage of this plan is the simple filtration structure and easiness in maintenance of the intake system. However, this plan may have a risk of sinking down for the filtration chamber into the silt layer which covers the bottom around the intake position at a depth of 2.5 m or more. In addition, the filtration efficiency may have been affected by the bottom sediments.The condition for the sand particles of 1.0 mm in diameter not drifting away from a position can be calculated as follows.

Offshore wave height (H_0)= 2.0 m

Wave period (T_0)= $3.86\sqrt{H_0}$= 5.4 sec

Wave length (L0)= 1.56×5.4^2 = 45 m

Y_1 = 1.16

h_1 / L_0 = 0.1

$h_1 = 0.1 \times 45$ = 4.5 m

Therefore, the sand particles of 1.0 mm in diameter would not been drifted away from where the depth of water is more than 4.5 m.

In this plan, the pipe line needs to be routed avoiding the underwater hills and depressions which are forming a complex bottom configuration in the site area. This plan requires a study on the bottom and sediment conditions along the pipe installation route, especially on the depth of silt layer at the water intake position.

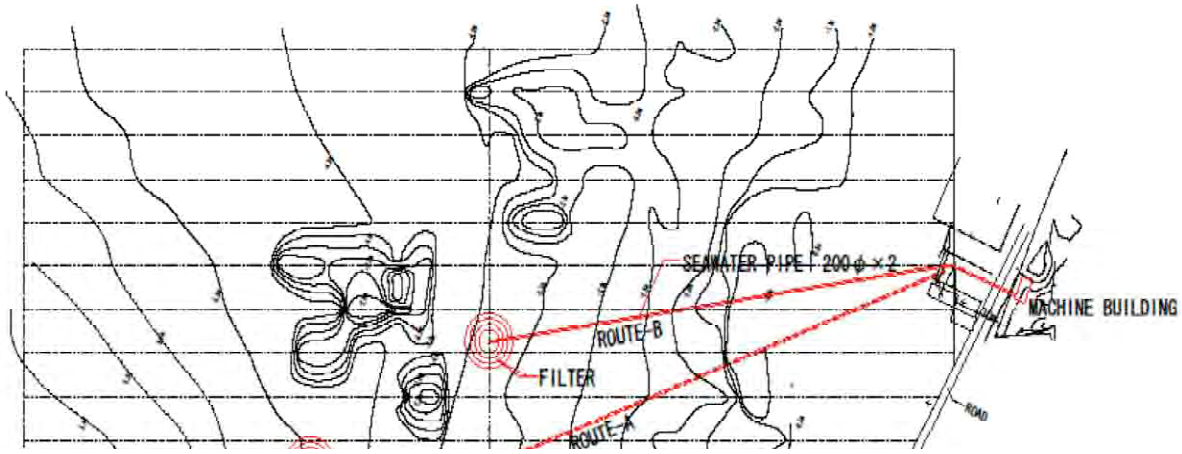


Figure 3 Planed Water intake positions and pipe installation routes (A and B plan)

B-Route Plan

In this plan, the filtration chamber is covered to prevent drifting away of sand particles and sucking of sediments around. It is necessary to install the chamber in a low profile without projecting much from the bottom of the sea as the water is shallower at the intake point in this plan. This plan also requires more frequent inspections for the condition of sand in the filtration chamber than the A-route plan.

3) Design conditions for the submerged filtration

The total water intake requirement is 100 ton/hr including the quantity for backwashing.

The submerged filtration chamber is designed based on the following specific filtration requirements.

- Length of intake pipe line: 295 to 465 m
- Filtration capacity per m^2: 3 to 4 $m^3/m^2/hr$
- Discharge rate of backwashing water: 1 $m^3/m^2/hr$
- Velocity of backwashing water: 15 m/hr or faster
- Interval between backwashing operations: 6.0 to 24 hr
- Diameter of supporting gravels in the filtration chamber: 25 to 40 mm

- Diameter of filtration sand: 1.0 mm
- Depth of filtration sand layer: 60 cm
- Number of filtration chambers: 2 sets

4) Backwashing frequency and time

The backwashing operation will be repeated every 6 to 24 hours depending on the quality of the source water. The backwashing duration, which is determined by the backwashing water quantity and the water speed, is set at 10 minutes during which the water intake operation must halt. The pressure necessary for effective backwashing is created by lifting water to elevated reservoir tanks. The water level in the elevated reservoir tank for supplying water for rearing organisms will fall lower during the backwashing period because of the discontinued water intake operation. The water level in the reservoir tanks must recover to the normal level before the next backwashing process.

5) Diameter of intake pipe

The diameter of intake pipe is determined depending on the highest discharge rate for the pipe which occurs during the backwashing process. The filtered water stored in the elevated water tank for backwashing flows down through the pipe during the backwashing process. The pipe diameter is determined so that the total water head loss during the backwashing operation is kept to be less than 10 m considering the level of elevated storage tank.

- Backwashing duration:10 min/time
- Water head loss:Less than 10.0 m
- Material and type of pipe:Polyethylene, WE pipe (with weight)
- Number of intake pipe line:2 lines or more

The following tables compare parameters required for determination of the intake pipe diameter among four selected options (Case 1 to 4) with different filter dimensions and number of filtration chamber.

Table 10 Comparison of parameters for filtration chamber

Optional scenario		Case 1	**Case 2**	Case 3	Case 4
Total length (m) of pipe line		295	295	295	468
Number of filter chamber		2 sets	2 sets	2 sets	2 sets
Item	Unit				
Design water intake requirement	ton/hr	100	100	100	100
Number of filtration chambers	number	2	2	3	2
Water intake requirement per filtration chamber	ton/hr	50.0	50.0	33.3	50.0
Filtration velocity	m/hr	3	4	3	4
Filtration area per unit of filter chamber	m^2	16.7	12.5	11.1	12.5
Dimensions of the filtration chamber	m	4.1×4.1	3.5×3.5	3.3×3.3	3.5×3.5
Backwashing discharge rate per m^2 of filter media	ton/m^2/time	1	1	1	1
Total dischare for backwashing operation per filtration chamber	ton/hr	16.7	12.5	11.1	12.5
Duration of backwashing operation	min	3.5	3	3.5	3.5
Total discharge by backwashing operation per minute	ton/min	4.8	4.2	3.2	3.6
ditto (per hour) to be used for pipe diameter calculation	ton/hr	285.7	250.0	190.5	214.3
Backwashing velocity at filter media	m/hr	17.1	20.0	17.1	17.1
(Intake quantity)					
Duration for backwashing operation (water intake shut-down period)	min	10	10	10	10
Intake water loss during the backwashing operation	ton	8.3	8.3	8.3	8.3
Total volume for backwashing operation (backwashing loss)	ton	16.7	12.5	11.1	12.5
Intake loss + backwashing loss	ton	20.0	20.8	16.7	20.8
Recovery time (backwashing interval)	hr	6.0	6.0	6.0	6.0
Additional discharge required for recovery due to backwashing	ton/hr	4.2	3.5	2.8	3.5
Total load (backwashing + normal operation) per intake pipe line	ton/hr	54.2	53.5	36.1	53.5
ditto (per min)	ton/min	0.9	0.9	0.6	0.9

The plumbing material used is polyethylene WE pipe.

Table 11 Water head loss and velocity in intake pipe by optional scenario

Optional scenario	Case 1	**Case 2**	Case 3	Case 4
Intake pipe condition	200 mm diameter × 2 pipe line, 2 sets of filtration chambers	200 mm diameter × 2 pipe line, 2 sets of filtration chambers	200 mm diameter × 3 pipe line, 3 sets of filtration chambers	200 mm diameter × 2 pipe line, 2 sets of filtration chambers
Water head loss during the backwashing operation (m)	9.7	7.6	4.6	9.0
Velocity inside the intake pipe (m/sec)	2.3	2.0	1.5	1.7

▲
The case selected

Table 12 Comparison of water head loss and velocity with various pipe diameters during the backwashing operation in **Case 2**

Selected
▼

Nominal diameter	mm	100	125	150	**200**	250	300	350	400	450	500
Diameter (Di)	m	0.1	0.125	0.15	0.21	0.26	0.3	0.33	0.39	0.43	0.48
Water head loss (h)	m	280.7	94.6	38.9	7.5	2.6	1.3	0.8	0.3	0.2	0.1
Velocity (V)	m/sec	8.9	5.6	3.9	2.0	1.3	0.9	0.8	0.5	0.4	0.3

Table 13 Comparison of water head loss and velocity with various pipe diameters during the normal water intake operation

Selected
▼

Nominal diameter	mm	100	125	150	**200**	250	300	350	400	450	500
Diameter (Di)	m	0.1	0.125	0.15	0.21	0.26	0.3	0.33	0.39	0.43	0.48
Water head loss (h)	m	17.0	5.7	2.3	0.4	0.1	0.08	0.05	0.02	0.01	0.008
Velocity (V)	m/sec	1.9	1.2	0.8	0.4	0.29	0.21	0.18	0.12	0.10	0.085

Based on the investigation as shown above, the optional scenario of **Case 2** using 2 sets of filtration chambers and 2 pipe lines of 200 mm nominal diameter offers the best conditions in dimensions of the filtration chamber, water head loss, and inside pipe velocity for the Project site situation. This Project will therefore adopt this option. The optional scenario Case 3 with 3 filtration chambers results in somewhat lower operational cost because of the lower intake water requirement, but it is not selected because the construction cost will increase greatly.

2-2-2-3 Layout Plan

(1) Location of the Project site

The Project site is located at the north end of Sihanouk commercial port. The east side faces an arterial road and the north side faces a street leading to the breakwater of the commercial port. There are existing facilities of Fisheries Administration, official and private houses scattering inside the Project site. The north eastern corner of the site is occupied by private houses and shops. On the seaside (west side), there exist fishers' houses and landing places adjoining to the site. These fishers on daily bases pass through the Project premises, and there is a passage formed on the southern side of the site. There are some houses and a beach on the northern side of the street leading to the breakwater. There are fisheries related factories on the south side of the site.

Figure 4 Location of the Project site

(2) Land utilization and facility layout plan

The Project designing in respect to land utilization and facility layout will be carried out giving priority to the following points.

1)A passage for the fishermen living in the west side of the Project site will be secured and an effort will be made as much as possible to minimize eviction and removal of facilities and private houses existing in the site. The Project site is located on a ground ascending gently up from the south side passage to the north side beach. Land along the south side border of the site will be reserved for a passage accessing to the houses and the landing sites located on the

west side of the Project site as well as for relocation of the existing official residences. Construction of facility will be avoided and reserved for future use in the low-laying south-western corner of the site.

2)The west side of the Project site is a commercial port, and therefore, the Project must take seawater for the facility and discharge the effluent from the north side sea. The water intake and discharge facilities will be laid out accordingly. Supply of sea water will be made by gravity minimizing use of mechanical energy as much as possible taking the advantage of existing slope in the site. Consequently, the machinery like seawater intake pump and blowers will be placed in a compact layout in the north side. Such compact layout will be beneficial also in terms of the facility maintenance. Over the machinery, elevated water storage tanks will be built so that the water flows down by gravity to the rearing facilities. The intake water pipes as well as the effluent discharge pipes will be designed to pass under the street leading to the breakwater with sufficient reinforcement. The sea side parts of these pipes will be laid under the ground considering the levels of intake point at sea and the tidal variation.

3)The Project facility will be designed in consideration of the electricity supply condition in the area. The electric power need to be taken in to the site from a point opposite to the existing main gate. Consequently, an electrical substation will be built beside the road. Generator sets will be installed in the substation.

4)The existing MADeC administration building will remain under the current plan. If the existing building is converted to other facility like an accommodation building, the construction work must be done with sufficient care for handling of asbestos used in the existing building.

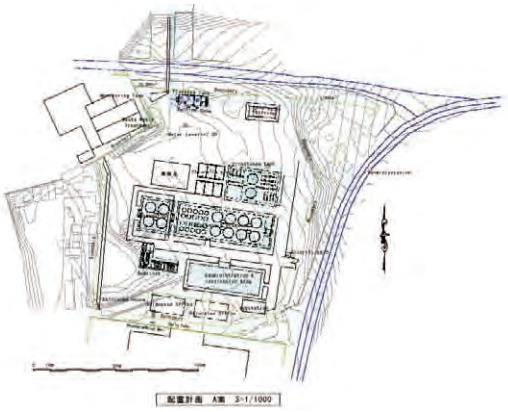
(3) Facility layout plan options

1)Layout Plan A

In this plan, the project facilities will be arranged parallel to the east-west axial. The Research and Administration Building will be laid in the southern side, while the aquaculture and rearing facilities will be laid in the northern side. This arrangement has an advantage of keeping the aquaculture and rearing facilities away from the possible external influences, and also making it possible to match the drainage slope along with the ground gradient. However, there may be necessary to use mechanical power for drainage from the aquaculture facilities located in the low-laying southern side area. This option allows reserving an area on the north side of the Centre for future facility expansion without much complication in designing of the supply and drainage systems.

2)Layout Plan B

This plan keeps the existing layout axial which angles 45^{o} from the east-west line, and arranges the Project facilities along with contour lines. The main internal road will run towards north-western direction from the new gate which will be constructed near the existing gate. The Research and Administration Building will be laid in the lower western side, while the aquaculture facilities will be laid in the higher eastern side. Because of the higher elevation of the aquaculture facilities, this arrangement has an advantage in setting the drain and supply levels for the aquaculture water as well as installation for the pipe lines. Although there will be little area that can be reserved for the future expansion in this plan, some area on the south-western corner of the Centre is still available.



1) Layout Plan A

2) Layout Plan B

(4) Comparison of facility layout plan options

The layout plan B has more advantages than the plan B in term of land utilization, utilization of ground slope, condition of draining system, and location of gate as shown in the tale below. This Project, therefore, adopts the Layout Plan B and designs the facilities accordingly.

Table 12 Comparison of Layout Plan A and Layout Plan B

	Layout Plan A	**Layout Plan B**	Evaluation
Land utilization	Some facilities have to be built in the low-laying west side area. Land on the north side can be reserved for future facility expansion with easy drainage designing.	The low-laying west side area can be reserved for future expansion.	Plan B
Utilization of ground slope	The buildings have to be laid crossing the contour lines, resulting in a sloping approach from one building to another.	The buildings are laid along the contour lines. Approaches to the buildings will have little slope.	Plan B
Condition in drainage system	There will be relatively large vertical distance in the drainage system for the aquaculture facilities. Pumping may be necessary to drain from some facilities located in the low land area.	The drainage pipe line can be laid to flow water down naturally by gravity to the sedimentation tank.	Plan B
Location of gate	A new gate will be built on the north of the existing gate. The distance from the outside arterial road to the gate becomes longer and the slope of internal road near the gate becomes steep.	New gate will be built very close the existing gate.	Plan B
Natural lighting to the buildings	Light intensity will be different between the north and the south sides of the building, although this effect may not be much because the sun rises high at the site located in a low altitude site. Consideration has to be made for shading from the intense direct sunlight on the south side of building.	Light intensity will be similar in all sides of the buildings because they are arranged 45^{o} angled from the east-west axial as same as the existing buildings. There should be consideration to avoid the effect of direct sun light.	No apparent difference

2-2-2-4 Architectural Plan

(1) Floor Plan

1) Research and administration building

The rooms in the Administration and Research Building will be arranged considering efficiency and convenience in the Project operation and administration as well as reduction in the construction cost. This building will be composed of rooms for the administration division, 5 research divisions, the extension and training division for dissemination of the established achievements, a meeting room for internal communication, a meeting hall for communication with external parties, a library, and other smaller rooms. The room for the administration division will be placed at the position facing to the entrance on the ground floor for convenience in reception of visitors. Laboratories and examination rooms will be laid also on the ground floor considering the convenience in carrying the samples and data into the building. The rooms for the various research divisions will be built also on the ground floor for convenience in communication among the divisions. In addition, the ground floor will have night duty rooms for researchers. The rooms for the director and deputy directors, meeting room and meeting hall, and the room for the training and extension division will be laid upstairs. This building which is the central facility of this research institution will be built near the gate in consideration of accessibility for visitors.

2) Brood stock building

This facility will be composed of 4 sets of circular concrete tanks in dimensions of 6 m diameter and 1.8 m depth for rearing sea bass.

3) Hatchery and breeding building

This building will be composed of a room for rearing hatch-out larvae and fry equipped with 20 sets of FRP circular tanks ($4m^3$ capacity, 2.4m diameter and 0.9m depth), a room for rearing later stage fry and fingerlings equipped with 4 concrete tanks (28 m^3 capacity, 6m diameter and 1m depth), a supply room, and a data recording room. There will be a storage room for equipment and materials attached to this building.

4) Crustacean building

This building will be designed to contain aquaculture tanks in various sizes for rearing black tiger prawn and giant river prawn (concrete tanks: $50m^3$ capacity, 6m square, 1.5m depth; FRP tanks, 3×1.45m, 0.8m depth, 4 sets), a room for rotifer culture, a room for artemia culture, and a data recoding room.

5) Machine building

This building will be made up of a room for water intake pumps, a room for blowers, a

workers' resting room, and roof-top spaces for installing various water tanks including storage tanks for backwashing water for the submerged filtration chambers, storage tanks for rearing organisms, and storage tanks for clean freshwater. The level of the roof-top space will be determined based on the piping routes.

6) Electricity substation

It will be composed of a room where public electric power is taken in and transformed for internal distribution and a room for installation of generator sets.

(2) Elevation Plan

The elevation plan for the Project facilities will be made in considerations of 1) setting the reference ground level (GL) of each building according to the existing ground level, 2) rationale and economy in water supply and drainage system which is the key determination factor for aquaculture facility, and 3) effects from the intense direct sunlight and the strong monsoon rainfall. The floor level of each aquaculture facility will be determined based on the drainage level that enables natural flow by gravity.

1) Research and administration building

This main building of the MADeC will be designed to have rooms with large internal air mass for alleviating heat by natural air flow, and the entrance hall with vaulted ceiling that gives an impression of open environment. Ceilings in corridors, research rooms and laboratories will be raised high enough to contain large air mass for reducing the load to the air conditioning systems. This building will have long appentices supported by outer poles for blocking the direct sunlight.

The reference ground level (GL) for this building is set at +3.2 m and Floor Level (FL) of the ground floor is set +3.80 m. The floor heights for the ground floor and the first floor are 4.2 m and 3.8 m, respectively. The ceiling height is 3.2 m above the floor in the rooms.

2) Brood stock building

The floor level of this building will be set carefully taking the appropriate drainage level for gravity flow into consideration. GL and FL are set at +3.40 m and +4.7 m, respectively with sufficient distance in-between for drainage piping. The floor height of the building is set at 3.5 m.

3) Hatchery and breeding building

The floor level of this building will be set carefully taking the appropriate drainage level for gravity flow into consideration. GL and FL are set at +3.20 m and +3.85 m, respectively with

sufficient distance in-between for drainage piping. The floor height of the building is set at 3.5 m.

4) Crustacea building

The floor level of this building will be set carefully taking the appropriate drainage level for gravity flow into consideration. GL and FL are set at +3.70 m and +4.30 m, respectively with sufficient distance in-between for drainage piping. The floor height of the building is set at 3.5 m.

5) Machine building

The floor level of this building will be set carefully in consideration of the pumping capacities of seawater intake pumps. The level of storage tanks for backwashing seawater will be set at a level sufficient to give necessary pressure. The level of freshwater storage tank for supplying drinking water is also determined in the same manner. Plumbing system will be carefully designed taking piping resistance and other factors into consideration.

6) Electricity Substation

The floor height of this building will be determined based on the height of the high-voltage switch board and the height of generator sets.

(3) Structural Plan

The buildings in this Project will be designed in a rahmen reinforced concrete structure with brick masonry curtain walls, which is seen commonly in Cambodia. For roof framing, however, steel frame trusses will be used.

(4) Finishing Plan

The finishing plan for internal and external of buildings and facilities are shown in following tables.

Table 15　External Finishing Plan

Building	Finishing
RESEARCH AND MINISTRATION BLDG.	Roof & Eaves: Steel truss structure & light-weight C-type steel Purline, Cement boned wood-flake board t=18mm, Asphalt roofing sheet (self- bonded), Ceramic-tile roofing Flat Roof: RC, Water-proofing sheet, Cover mortar
	Canopy: RC, Water-proofing sheet
	External Wall: Brick wall, Mortar brush finish acrylic resin painting Partial: Ventilating cement block facing
	Column, Beam: RC, Mortar brush finish acrylic resin painting
	Baseboard: RC, Silane-type water repellent solvent
	Doors & windows: Alminum frame sash, Wooden door
	Porch: Ceramic tile(non-slip type)
	Steps: Ceramic tile(non-slip type)
BRODSTCK BLDG., HACHERY & BREEDING BLDG., CRUSTACEA BLDG.	Roof & Eaves: Steel truss structure & light-weight C-type steel Purline, Cement boned wood-flake board t=18mm, Asphalt roofing sheet (self- bonded), Formed galvanized sheet iron (polyester resin coated)t=0.5mm batten seam
	External Wall: Brick wall, Mortar brush finish acrylic resin painting
	Column, Beam: RC, Mortar brush finish acrylic resin painting
	Baseboard: RC, Silane-type water repellent solvent
	Doors & windows: Alminum frame sash, Steel frame door
	Steps: RC trowel finish, Epoxy penetrate-type floor-hardener
MACHINE BLDG., ELECTRICITY SUB STATION, SECURITY GUARD HOUSE	Roof: RC, Water-proofing sheet
	External Wall: Brick wall, Mortar brush finish acrylic resin painting
	Column, Beam: RC, Mortar brush finish acrylic resin painting
	Baseboard: RC, Silane-type water repellent solvent
	Doors & windows: Alminum frame sash & door, Steel frame door
	Steps: RC trowel finish, Epoxy penetrate-type floor-hardener

Table 16　Internal Finishing Plan(1)

Building	Room	Finishing		
		Floor	Wall	Ceiling
RESEARCH AND MINISTRATI ON BLDG.	・Feed nutrition lab., ・analysis lab. Of water quolity, ・wash & sterization room, ・aquatic animal hea -lth lab., ・specimen room	Floor:Epoxy res -in Plinth : Hardwood H=75 OS	Mortar AEP	Gypsum plaster board with fiberglass t=12
	・Adominiration divisi -on room, ・seed production div -ision room, ・feed production div -ision room, ・stock enhancement te -chnology development Division room, ・aquaculture technolo -gy development divis -ion room, ・aquatic animal Health division room, ・training & informati -on division room ・director room ・deputy director room ・library ・meeting room ・night duty room	Floor : PVC tile Plinth : Hardwood H=75 OS	Mortar AEP	Gypsum plaster board with fiberglass t=12
	・Conference room	Floor : Ceramic tile Plinth : Granite stone H=75	Granite stone H=0 ～ 1500mm AEP	Gypsum plaster board with fiberglass t=12
	・Entrance hall ・corridor	Floor : Ceramic tile Plinth : Granite stone H=75	Mortar AEP	Gypsum plaster board with fiberglass t=12
	・Pantry	Floor : Ceramic tile Plinth : Hardwood H=75 OS	Mortar AEP	Fiber cement board t=6 VP
	・Wc	Ceramic tile	Ceramic tile	Fiber cement board t=6 VP
	・Store	Floor : Floor ha -rdener Plinth: Mortar H=100	Mortar AEP	Fiber cement board t=6 VP

Table 17　Internal Finishing Plan（2）

Building	Room	Finishing		
		Floor	Wall	Ceiling
RESEARCH AND MINISTRATIO N BLDG.	・Fish tank room	Floor: Epoxy res -in Plinth : Rounded corner, Epoxy resin H=300	Mortar AEP	Roof back side
HATCHERY & BREEEDING BLDG.	・Hachery tank room	Floor: Epoxy res -in Plinth : Rounded corner, Epoxy resin H=300	Mortar AEP	Roof back side
	・Rearing tank room ・storage ・corridor Recording room			Fiber cement board t=6 VP
	・Wc	Ceramic tile	Ceramic tile	Fiber cement board t=6 VP
	・Storage for outdoor equipment	Floor: RC trowel finish, Epoxy penetrate-type floor-hardener Plinth : Mortar pointing,Silane -type water rep -ellent solvent H=100	Mortar AEP	Roof back side
CRUSTACEA BLDG.	・Tank room ・propagation room ・storage	Floor: Epoxy res -in Plinth : Rounded corner, Epoxy resin H=300	Mortar AEP	Roof back side
	・Recording room			Fiber cement board t=6 VP
MACHINE BLDG.	・Suction pump room ・blower pump room	Floor: Cinder co -ncrete t=470mm , Mortar trowel floor hardener Plinth: Mortar pointing H=100 mm	Mortar AEP	Cement boned wood-flake board
	・Worker room ・work shop			Fiber cement board t=6 VP
ELECTRICITY SUBSTATION	・Transformer room ・generator room	Floor: Floor ha -rdener Plinth: Mortar pointing H=100	Mortar AEP	Cement boned wood-flake board
SECURITY GUARD HOUSE	・Staff room ・restroom	Floor: Floor ha -rdener Plinth : Hardwood H=75 OS	Mortar EP	Gypsum plaster board with fiberglass t=12
	・Wc	Ceramic tile	Ceramic tile	Fiber cement board t=6 VP
INTERNAL & EXTERNAL FISH TANKS		RC Trowel finish, Epoxy-resin FRP lining (1 ply) water proofing		

(5) Facility Plan

1)Seawater supply facility plan

The intake water pump will lift seawater from the submerged filtration chamber to the elevated seawater storage. Then, the collected seawater will be supplied to respective facilities through four piping systems; 1) to Brood Stock & Maturation Building and Hatchery & Breeding Building, 2) to Crustacean Building, 3) to outdoor fishponds and phytoplankton propagation tanks (total three piping systems for aquaculture facilities), and 4) Research and Administration Building.

The seawater to be supplied to the Brood Stock & Maturation Building will be treated by a cupper ion generator. The seawater to be supplied to the Hatchery & Breeding Building will be treated by an ozone generator (for washing eggs) and an ultraviolet sterilizer. The seawater to be supplied to the Crustacean Building will be treated by an ultraviolet sterilizer.

2)Freshwater supply facility plan

Water for domestic use in the Project site will be collected in a reservoir from the main public water line and pumped up to the elevated freshwater storage, and then delivered to the various Project facilities like Administration and Research Building, the accommodation building for research and education activity, the guard house, and other buildings for drinking and cleaning purposes.

3)Drainage plan

The discharges from the aquaculture facilities of the Project site will be collected first to sedimentation tanks where solid substances like faecal matters are removed by sedimentation, and then the clear supernatant only will be discharged. The domestic wastewater and sewage will be treated within the Project site according to the WHO standard using septic tanks as there is no public sewage system installed in the area. They are collected in septic tanks for separation into solid and supernatant portions. The solid portion will be removed manually and the supernatant portion will be joined to the drainage for the aquaculture discharge to enter eventually into the sedimentation tanks.

4)Aeration facility plan

The compressed air from blowers in Machine Room will be supplied to aquaculture facilities through four aeration pipe lines; 1) to Brood Stock Building and Hatchery & Breeding Building, 2) to Crustacean Building, 3) to outdoor ponds and phytoplankton culture tanks and

4) to Research and administration building .

5)Air conditioning and ventilation equipment plan

Research laboratories, offices, and meeting rooms in the Research & Administration Building will be air-conditioned with split type air conditioners. Rooms without air-conditioning will be supplied ceiling fans for natural ventilation controlled by opening of the windows. The guard house will be supplied also with ceiling fans for natural ventilation. The rooms without windows and the rooms in which odours or heat could be generated will be equipped with exhausted fans for mechanical ventilation. The rooms installed with aquaculture tanks, the Machine Room &Elevated Tank Building and the Electrical Substation will be equipped with the mechanical ventilation equipment.

6)Electric equipment plan

1. Electrical substation equipment

The existing transformer that receives 8 MW power of 22 kV in three phase 4 core cable is located across the road on the front side of the site promises. It is said to be possible to get 380/220V, 300kVA power supply, the required power supply for the Project facilities. However, it would not be reliable if the surrounding area is developed in future. Therefore, construction of a separate power substation is included in the Project to receive the 22kV, 300 kVA high voltage power directly and transform it down to 380/220V necessary for motor, lighting and wall outlets power sources. The installation of 22kV underground power cable up to the Electrical Substation is responsible to the Cambodian side.

2. Generator equipment

The public power supply condition in the project site area is not reliable. There are quite a lot of power failures occurring in the area. Because the aquaculture operation cannot be interrupted during the blackout time, installation of diesel engine generator sets is included in the Project.

3. Main distribution system

The low-voltage electricity will be supplied from the switch board in the Electrical Substation to distribution boards, power control boards, and built-in switches. The power distribution system is designed rationally so that an electrical accident in a zone does not

affect the other zone. Electrical wiring will be done with cross-liked polyethylene cables sheathed in plastic pipes in principle.

4. Distribution to power equipment

Electric power supplies to pumps, air-conditioning facilities, sterilization facilities, etc. will be done from appropriate distribution boards and power control boards. Wiring will be in principle made with cross-liked polyethylene cables sheathed in plastic pipes.

5. Wall outlets

Power supply will be made to general wall outlets and special outlets for aquaculture machinery. The outlet type is C-type round pin plug. Wiring will be done with PVC cables sheathed in plastic pipes if they are laid in the concrete structure or in the brick walls. The PVC cables sheathed in plastic pipe or VV-F cables will be used for wiring behind the ceilings.

6. Lighting system

Lighting in the Project facilities will be made primarily with fluorescent tubes. Surface mounting type fluorescent ceiling lights with acrylic cover will be used in the rooms for research activities, desk works, and administration works. Waterproof type fluorescent lights with acrylic cover will be used in the rooms for aquaculture activities. Appropriate lights will be selected for other rooms considering easiness in maintenance and repair as well as possible damages from salt water as the site is located on the seashore. Wiring will be done with PVC cables sheathed in plastic pipes if they are laid in the concrete structure or in the brick walls. The PVC cables sheathed in plastic pipe or VV-F cables will be used for wiring behind the ceilings or in the steel beam roof truss.

The following list shows the lighting standard in different type of rooms.

Rooms for aquaculture activities	300 lx (floor level)
Rooms for research and study works	500 lx (desktop level)
Offices and rooms for administration	400 lx (desktop level)
Auxiliary rooms	200 lx (floor level)
Toilets and storages	150 lx (floor level)

Corridors	70 lx (floor level)

Outdoor lights will be placed at appropriate places for increased security at night.

7. Lightening protection apparatus

The site is located considered in high thunder area. The device protecting from lightening will be installed to protect the important core facility such as air blower system, water supply system and experimental equipment etc. .

8. Solar power equipment

Application of solar energy generation would be advantageous for the facilities that consume relatively small electricity on regular bases. In the following section, an application of solar energy generation system for the aeration blower which has to be made by 24-hour fulltime bases is examined. The blower suitable for this Project requires 18 kW when it starts but consumes only 6 kW during the normal operation. In the following cost analysis, it is assumed that the blower starts using public electricity and thereafter operates with the power from an 8-kW solar power generation system.

Cost for the solar energy generation system:

1) Solar panel (Japanese price)	¥5,513,000 (200W ¥137,000 × 40 panels, case ¥33,000)
2) Transformer (Japanese price)	¥590,000 (4.0kw ¥295,000 × 2 sets)
3) Buttery (Japanese price)	¥1,175,780 (258Ah(24hr), ¥225,2260 × 3 sets, charge controller (max. 80A) ¥500,000)
Total cost	¥7,278,780

Assuming the serviceable lives for the solar panel, transformer, and battery are 10 years, 10 years, and 3 years, respectively, the total annual service cost for the solar energy generation system without considering installation and depreciation costs is;

¥5,513,000/10 + ¥590,000/10 + ¥1,175,780/3 = ¥1,002,227.

On the other hand, the total annual electricity charge using the public electricity supply required for operation of the blower would be;

6 kW × 24 hr × 365 days × ¥17/kwhr = ¥893,520.

Based on the above examination, the annual operational cost for the aeration blower is ¥1,002,227 when the solar energy generation system is used, and ¥893,520 when public electricity is used. It is clear that the application of solar power generation system is not advantageous in terms of operational cost. Therefore, it is concluded that solar power generation system is not included in this Project facility.

(6) Exterior plan

1)Pavement in the Project site

In consideration of future expansion possibility, pavement in the Project site premises will be provided only on the passages connecting the facilities and on the parking spaces.

2)Drainage slope in the Project site

The ground surface in the Project site will be made to have a slight gradient for natural drainage for surface runoff water downward from the main road side to the beach side.

3)Fence and gate

The construction and installation of fence surrounding the Project site and gate is the responsibility of the Cambodian side and shall be carried out with their cost.

2-2-2-5 Equipment Plan

(1) Review on the requested equipment

Necessity and appropriateness of the equipment requested by the Cambodian authority were comprehensively evaluated according to the objectives, functions, planned activities, and operation and maintenance capacity of Marine Aquaculture Development Centre (MADeC) which were clarified by the field survey in the Basic Design Study. The equipment to be supplied in this Project should serve for the role, function and planned activities of the divisions of MADeC (Training and Extension Division, Seed Production Division, Aquaculture Technology Development Division, Feed Production Division, Aquatic Disease Control Division, and Stock Enhancement Division). They must be consisted with the facility construction plan, too. Results of the review on each of the requested equipment are presented in the attached document “Review on the Requested Equipment”.

(2) Criteria for selecting the equipment

1) Purpose of use

○: Basic equipment whose function matches with the activities planned in MADeC

×: Equipment whose function does not match with the activities planned in MADeC

2) Necessity

○: Equipment indispensible for the activities planned in MADeC

×: Equipment not necessary for the activities planned in MADeC

3) Technical and operational capacity

○: Equipment appropriate, or expected to be appropriate after short-term training, to the technical level of personnel and to the institutional capacity of MADeC

×: Equipment not appropriate, or not expected to become appropriate after short-term training, to the technical levels of personnel and to the institutional capacity of MADeC

4) Operation and maintenance system

○: Equipment that is easy in operation and maintenance for the personnel and for the institutional capacity of MADeC, as well as in the availability of required consumables and spare parts

×: Equipment that is difficult in operation and maintenance for the personnel and for the institutional capacity of MADeC, as well as in the availability of required consumables and spare parts

5)Operational cost

○: Equipment that is low in operational and maintenance cost, and whose inclusion into the Project is not expected to cause high budgetary strain for the Cambodian side

×: Equipment that is high in operational and maintenance cost, and whose inclusion into the Project is expected to cause high budget strain for the Cambodian side

6) Overall elevation

○: Equipment that is concluded as appropriate and selected for the Project

×: Equipment that is not included in the Project

(5) Summary of Project equipment and the installation plan

The equipment that will be procured in this Project are appropriate for the objective, function and the planned activities of the various divisions of MADeC (Seed Production Division, Aquaculture Technology Development Division, Aquatic Disease Control Division, Stock Enhancement Division, and Training and Extension Division), and also are in consistent to the facility construction plan of this Project.

Those items which are marked with "○" n the table of "Review on the Requested Equipment" in the attached document will be procured in this Project. Numbers of the selected Project equipment summarized by category are shown below in Table 2-15. There are 71 items evaluated as appropriate for this Project, which were selected from the requested 161 items.

Table 18 Numbers by category of selected and requested items of Project equipment

Category	Equipment	Number of requested items	Number of selected items
A Education and training equipment	Items for desk study	1	1
	Items for transportation of participants	1	0
B Experiment and research equipment	Feed development division	39	13
	Aquatic disease control division, bacterial work	14	6
	Aquatic disease control division, pathological work	20	3
	Aquatic disease control division, viral work	30	18
	Aquaculture technology development	41	16
C Rearing equipment	Transportation and maintenance equipment	11	10
	Rearing tanks and other aquaculture equipment	4	4
Total		161	71

Main specification and number of each of the equipment to be procured in this Project is shown in the attached document.

(4) Purpose of use and necessary quantity of the equipment

1)Education and training equipment

Purpose of use

These are the equipment necessary for extension and training activities on fingerling production technology, rearing technology, etc. There were 5 requested items, of which only

one item (projector) was selected as appropriate.

2)Experiment and research equipment

Purpose of use

• Feed development equipment

Development of mass production technology of chlorella, rotifer and daphnia as live feed organisms is a very important aspect for the Project. Those items necessary for establishment of the mass production technology suitable for the site condition as well as those items required for cultivation of the stock seeds should be included in the Project equipment list. In addition, equipment used for production of artificial feeds suitable for the brood fish rearing and grow-out cultivation will be included.

• Aquatic disease control equipment

It is important for the Project to take measures for fish disease that often occurs inhe fingerling production process and in the grow-out production system. Equipment required for fish disease diagnosis, pathological examination for brood fish and fingerlings, characterization of disease agent, health examination for aquaculture seeds, and DNA analysis will be included in the Project equipment list. There should be a facility for prevention of internal transmission of disease agents as the disease samples will be brought from outside.

• Water quality analysis equipment

These are the equipment for monitoring water quality in the Centre and in the area where private aquaculture operations are carried out. It will include samplers and analytical instalments for water, bottom sediment, current, etc. Equipment used on board will be of portable and multi-item analysis type which is easy in operation.

Scale and quantity of equipment

The specifications of PCR system will be determined based on the expected number of examination. For other equipment, quantity will be determined based on the expected frequency of use, time of use and required capacity for each item. Quantity of equipment like autoclave, distilled water production device, and microscopes will be set according to the requirement estimated assuming shared utilizations among different divisions.

3)Aquaculture rearing equipment

Purpose of use

Aquaculture tanks except concrete-made tanks will be included in the equipment list. They will be small sized FRP or polycarbonate tanks for fry and fingerling rearing, live feed culture, and rearing of crustacean organisms, as well as the equipment necessary for operation and maintenance of these tanks. There will be also equipment necessary for transportation of produced fingerlings to the open-stocking points and to the private aquaculture operators.

Scale and quantity of equipment

The scale and quantity of equipment will be determined based on the aquaculture seed production plan.

(5) Description of the main equipment

1)PCR system

As intensity of aquaculture production increased, outbreak of fish diseases especially viral diseases becomes an increasingly serous threat to the aquaculture operations. In this Project, it is inevitable to depend for the aquaculture brood stock (including prawn) on the collection from natural wild stocks or on the importation from overseas. The diseases examining capacity for these wild or imported organisms will affect the performance in the fingerling production activities. This disease examination activity should be in operation as soon as the Project facility starts working.

Accordingly, making early diagnoses for the brood stocks and the fingerlings for vial diseases using PCR method is imperative for prevention of mass mortality. This Project therefore will include the equipment necessary for operation of PCR method and related equipment.

2)Clean bench

This is the equipment for carrying out laboratory operations in aseptic condition. Each aseptic room will have one clean bench, for separating the one which will be used in dealing with pathological materials and the other which will be used in dealing with non-pathological materials. The type of clean bench selected as appropriate for this Project will be equipped with an ultraviolet sterilization light and a gas burner for flame sterilization. It will be in a standard size of approximately 120 cm width.

3)Plankton incubator

Phytoplankton incubators suitable for stock culture of microalgae equipped with illumination device will be procured. One set for stock culture of phytoplankton (marine and freshwater chlorella) and anoone set for zooplankton (rotifers etc.) will be installed. These incubators will have a capacity of holding 8 culture flasks of 5 litre capacity or 24 flasks of 1 litre capacity (total capacity approximately 200 litre of culture media volume).

4)Multipurpose boat

A work boat will be included in the Project equipment mainly for inspection and maintenance of the underwater intake pipe lines. A minimum of 6 persons composed of two divers, one watchman, one boat operator, and 2 work assistants, are necessary for the pipe inspection work. In addition to the personnel, the boat should have sufficient space for storing necessary equipment and materials like diving equipment, tools, and sand as filtration media. Therefore, a FRP boat with outboard engine in 6 to 7 meters in total length will be appropriate for the purpose. The capacity of outboard engine of 40 to 75 Hp is sufficient as the work area is within 500 m from the shore and the condition is usually calm. The auxiliary equipment necessary for the work boat are outboard engine, anchor, life jacket, etc.

5)Aquaculture seeds transportation vehicle

The aquaculture seeds organisms produced by this Project will be distributed to small-scale aquaculture operators by the Centre staff. For this activity, a truck equipped with a live fish transportation tank is included in the Project equipment list. The vehicle will be equipped with oxygen diffusing device (oxygen cylinder, regulator, and diffuser) and simple live fish tanks. The equipment commonly seen in Japan like water cooling system and protein skimmer are not necessary as the transportation distance is short and the fish will be always defecated before the transportation operation.

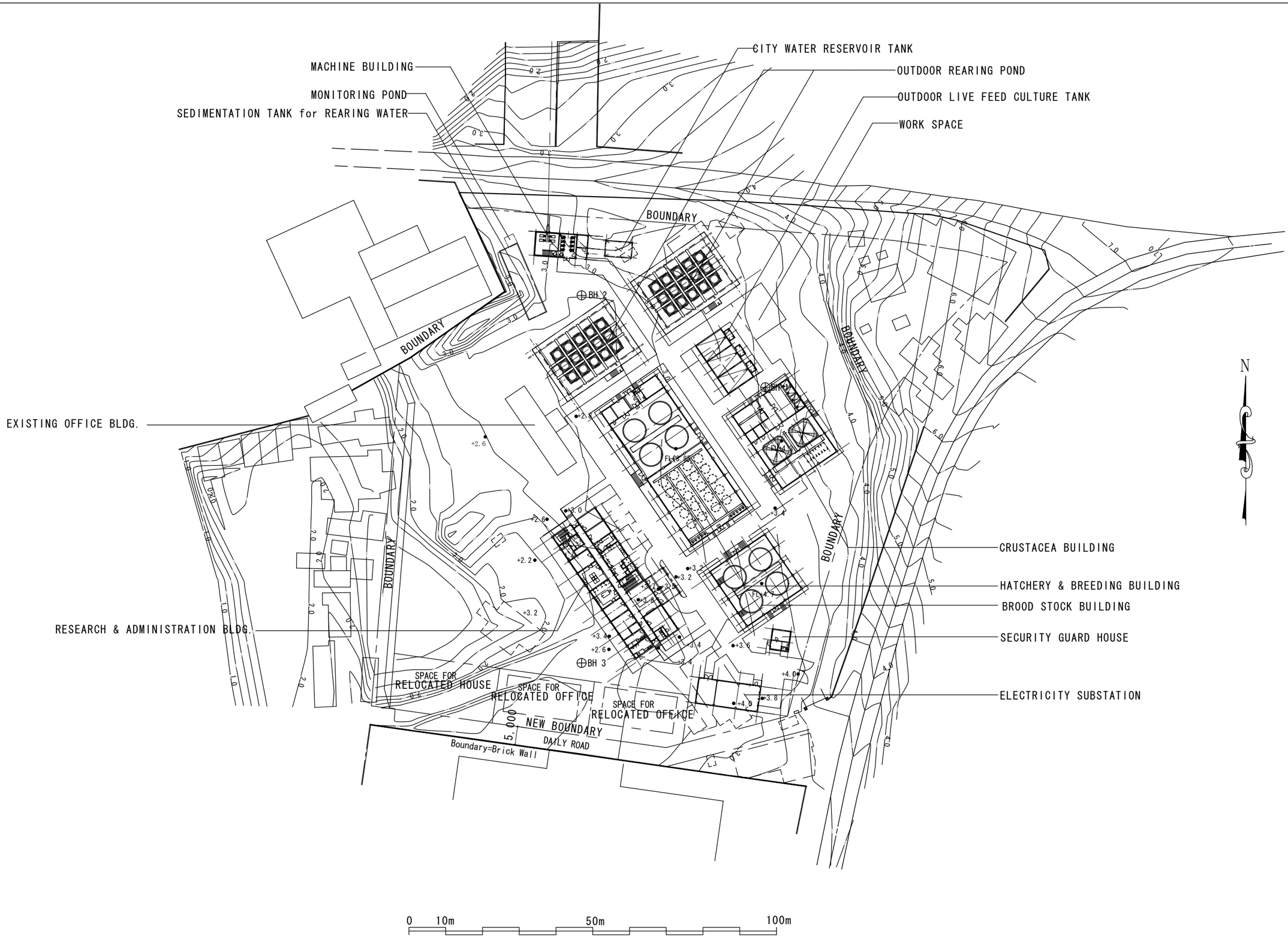
A simple live fish transportation tank with 1 ton capacity will be selected as appropriate to be used with the vehicle. It is possible to transport approximately 5000 fingerlings of sea bass in one set of this tank. The fingerling production program is designed to produce 148,000 fish of sea bass per production cycle. It is desirable to distribute these fingerlings separately by sizes in a time span of about one month.

6)FRP tanks

This Project will include a least necessary number of fixed concrete tanks which is difficult to relocate. Considering possible expansion of the facility in future, the Project in stead uses various plastic tanks (FRP or polycarbonate material) which can be rearranged according to the needs. Plastic tanks are also resistant to rusting problem. The following types of FRP tanks will be included as already mentioned in the fingerling production plan.

Main application	Capacity	Shape	Quantity
Larvae and fry rearing (hatch-out larvae to 30 mm fry)	4 tons	Circle	20
Black tiger prawn brood stock rearing	2 tons	Square	4
Artemia incubation	1 ton	Circle	4
Artemia incubation (polycarbonate tank)	0.1 ton	Circle	10

2-2-3 Basic Design Drawing



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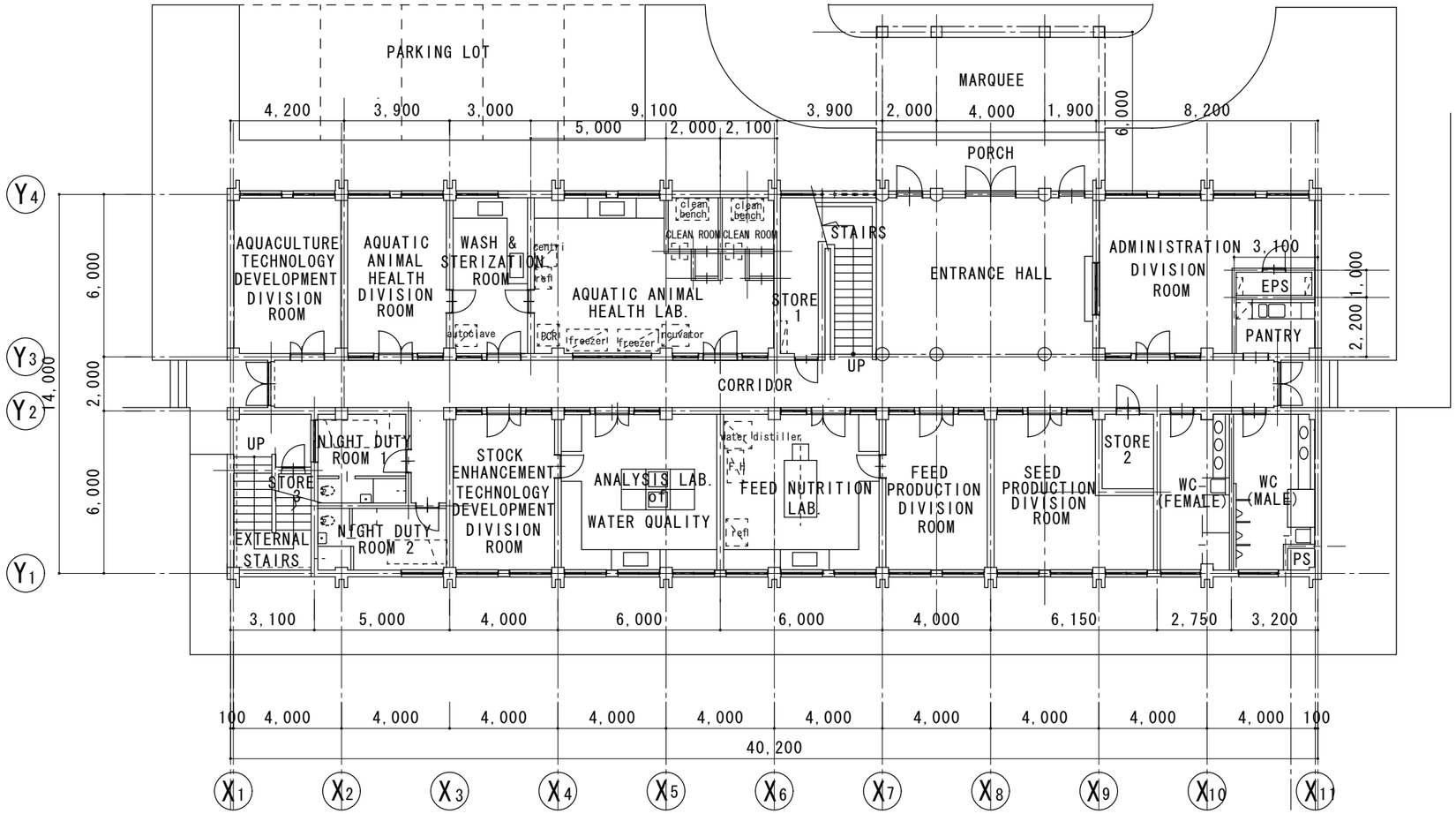
URL:http://www.fuyokaiyo.co.jp , Email:fuyo_web@fuyokaiyo.co.jp

PROJECT TITLE :
THE PROJECT FOR CONSTRUCTION OF MARINE AQUACULTURE DEVELOPMENT CENTRE

DRAWING TITLE :
SITE PLAN

DRAWN BY :	APPROVED BY:
CHECKED BY :	DATE :
SCALE : 1/1000	DWG No: A-01



GROUND FLOOR PLAN

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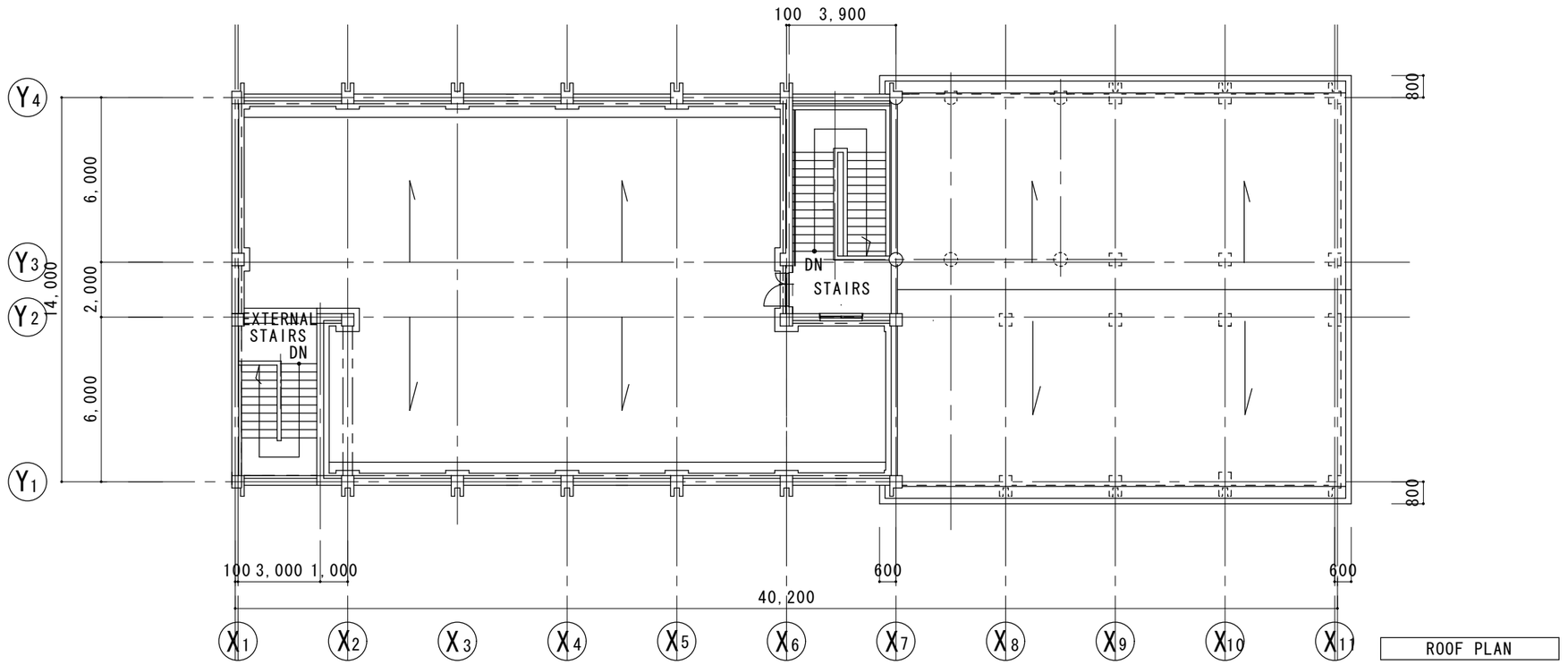
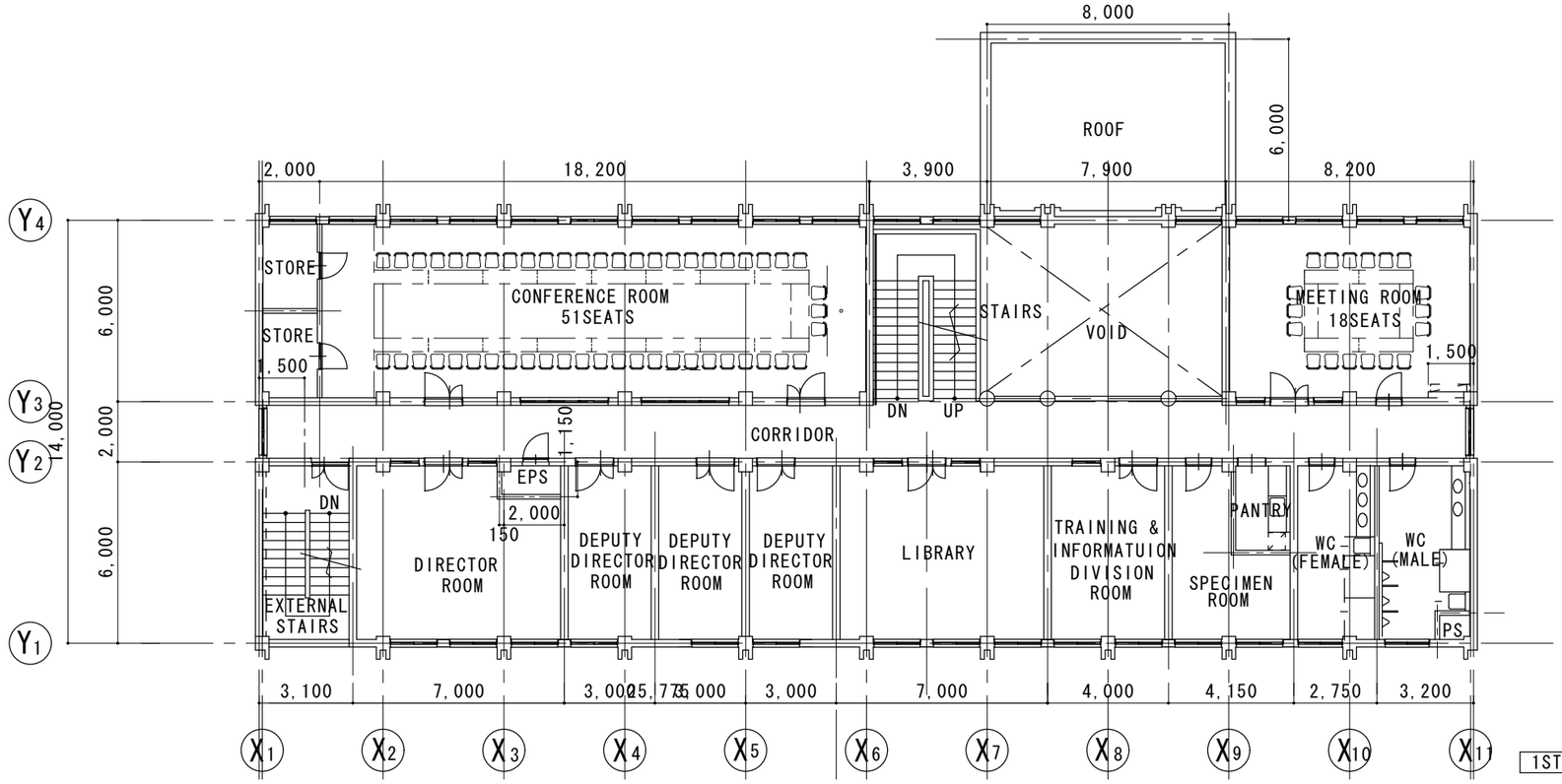
PROJECT TITLE :
THE PROJECT FOR CONSTRUCTION OF MARINE AQUACULTURE DEVELOPMENT CENTRE

DRAWING TITLE :
RESEARCH & ADMINISTRATION BLDG.
GROUND FLOOR PLAN

DRAWN BY :	APPROVED BY:
CHECKED BY :	DATE :
SCALE : 1/200	DWG No: A-02



ROOF PLAN



1ST FLOOR PLAN

FISHERIES ADMINISTRATION
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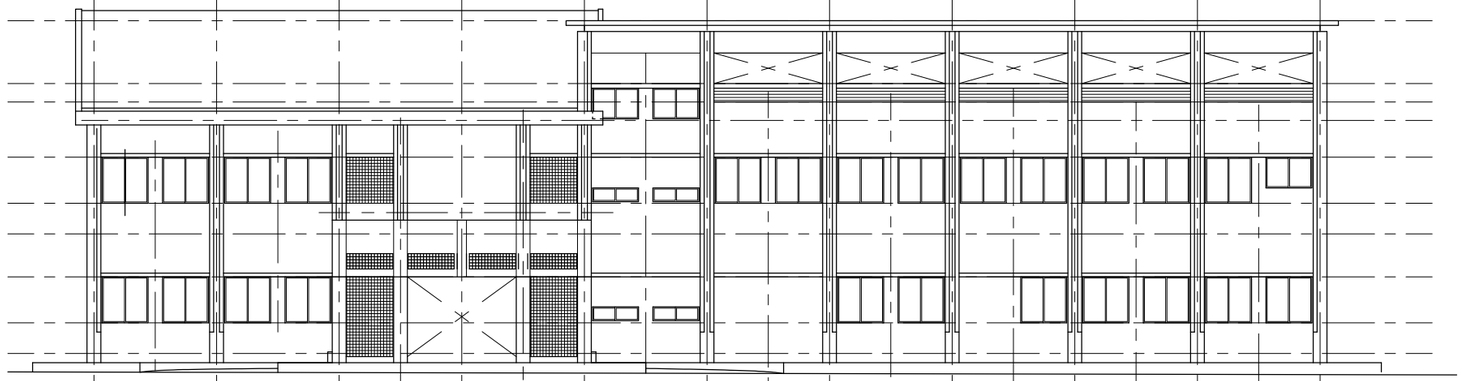
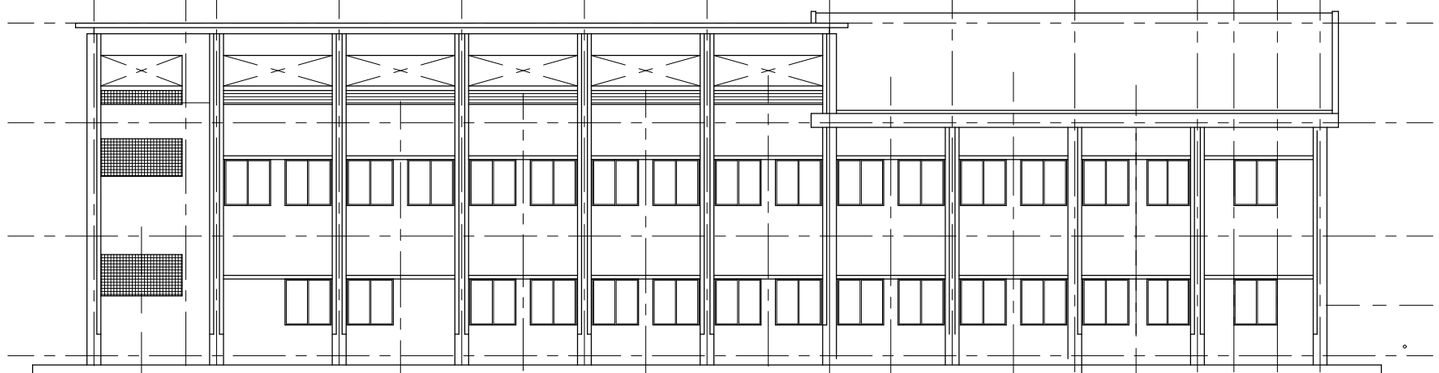
PROJECT TITLE :
THE PROJECT FOR CONSTRUCTION OF
MARINE AQUACULTURE DEVELOPMENT CENTRE

DRAWING TITLE :
RESEARCH & ADMINISTRATION BLDG.
1ST FLOOR PLAN, ROOF PLAN

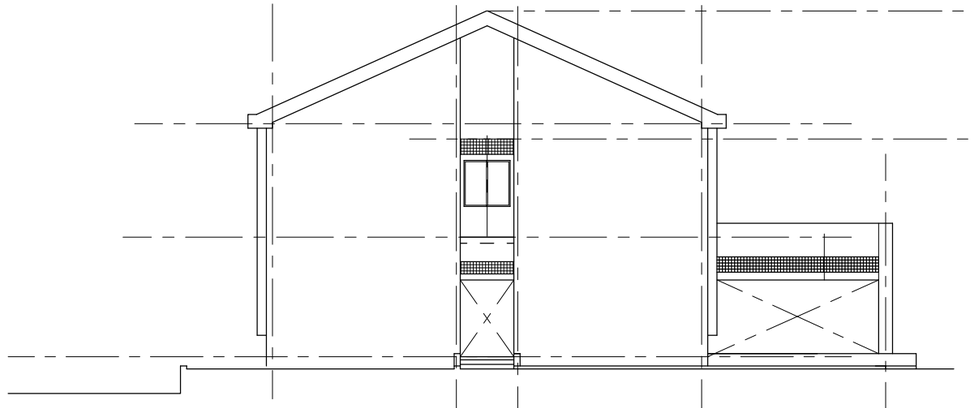
DRAWN BY :	APPROVED BY:
CHECKED BY :	DATE :
SCALE : 1/200	DWG No: A-03



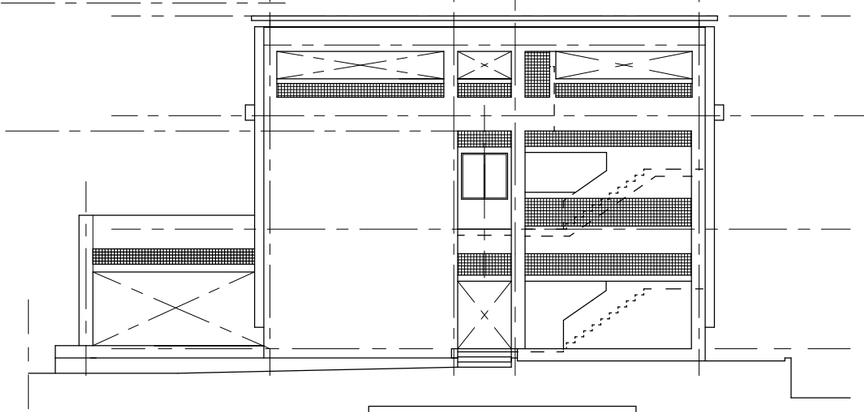
NOPRTH ELEVATION



SOUTH ELEVATION



EAST ELEVATION



WEST ELEVATION

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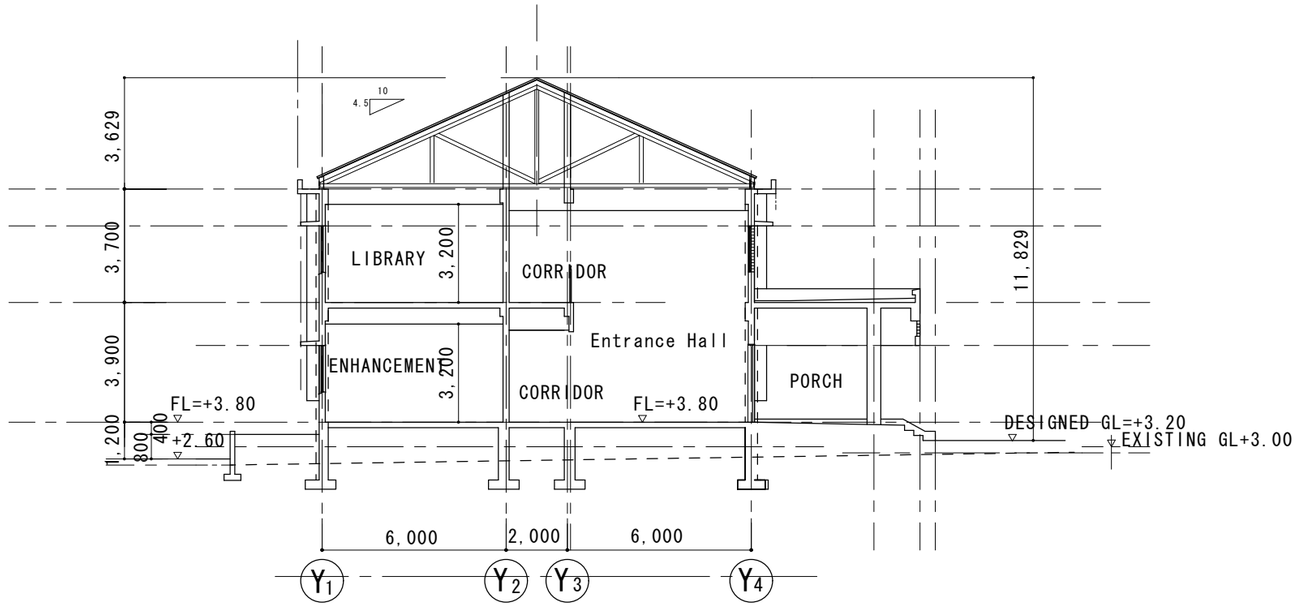
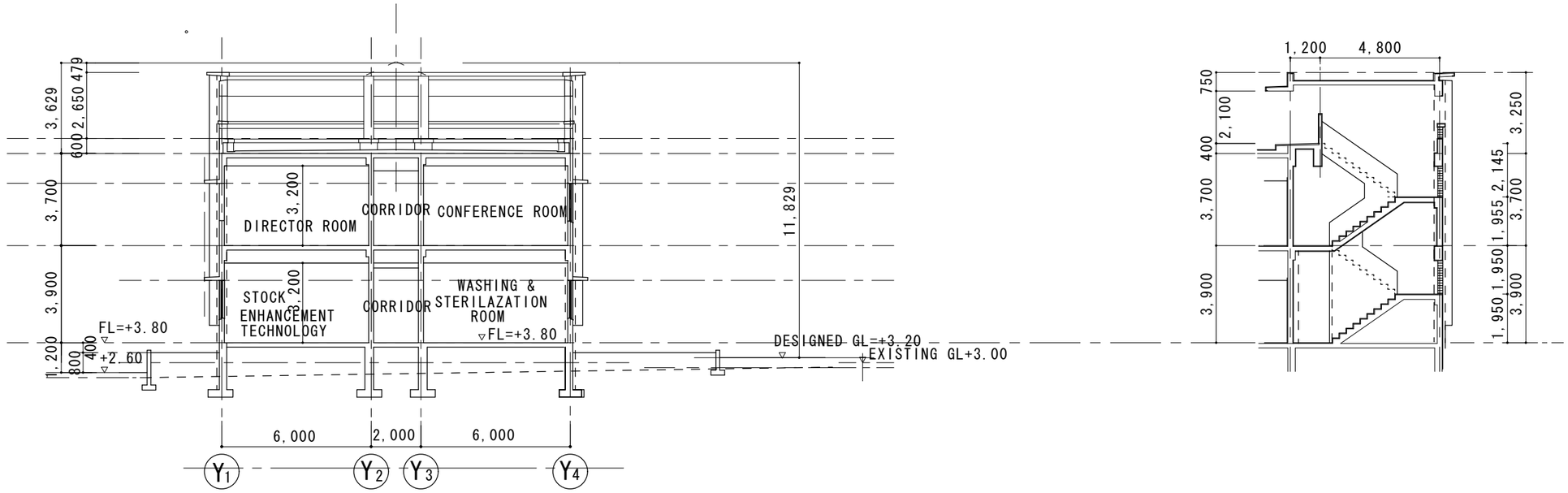
PROJECT TITLE :
THE PROJECT FOR CONSTRUCTION OF
MARINE AQUACULTURE DEVELOPMENT CENTRE

DRAWING TITLE :
RESEARCH & ADMINISTRATION BLDG.
ELEVATION

DRAWN BY :	APPROVED BY:
CHECKED BY :	DATE :
SCALE : 1/200	DWG No: A-04



SECTION A



SECTION B

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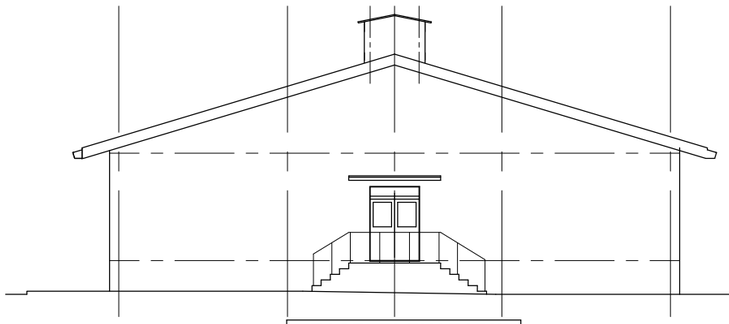
PROJECT TITLE :
THE PROJECT FOR CONSTRUCTION OF MARINE AQUACULTURE DEVELOPMENT CENTRE

DRAWING TITLE :
RESEARCH & ADMINISTRATION BLDG.
SECTION

DRAWN BY :
CHECKED BY :
SCALE : 1/200
APPROVED BY:
DATE :
DWG No: A-05

NORTH ELEVATION



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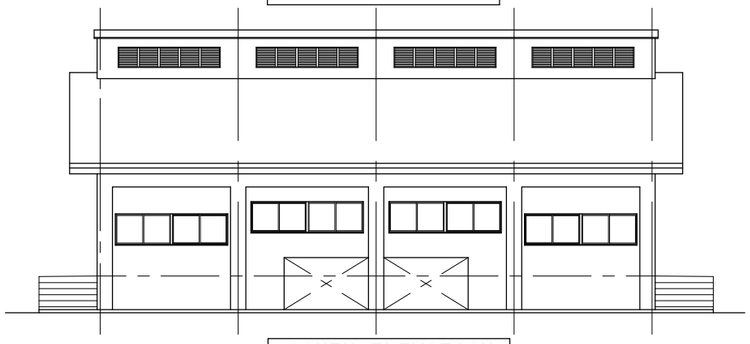
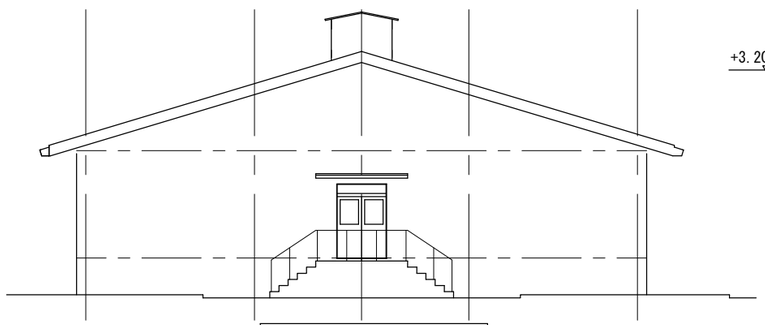
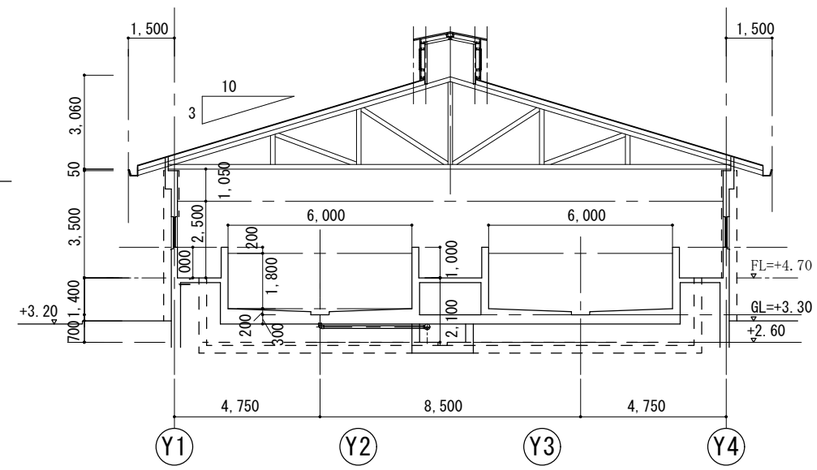


SOUTH ELEVATION



WEST ELEVATION



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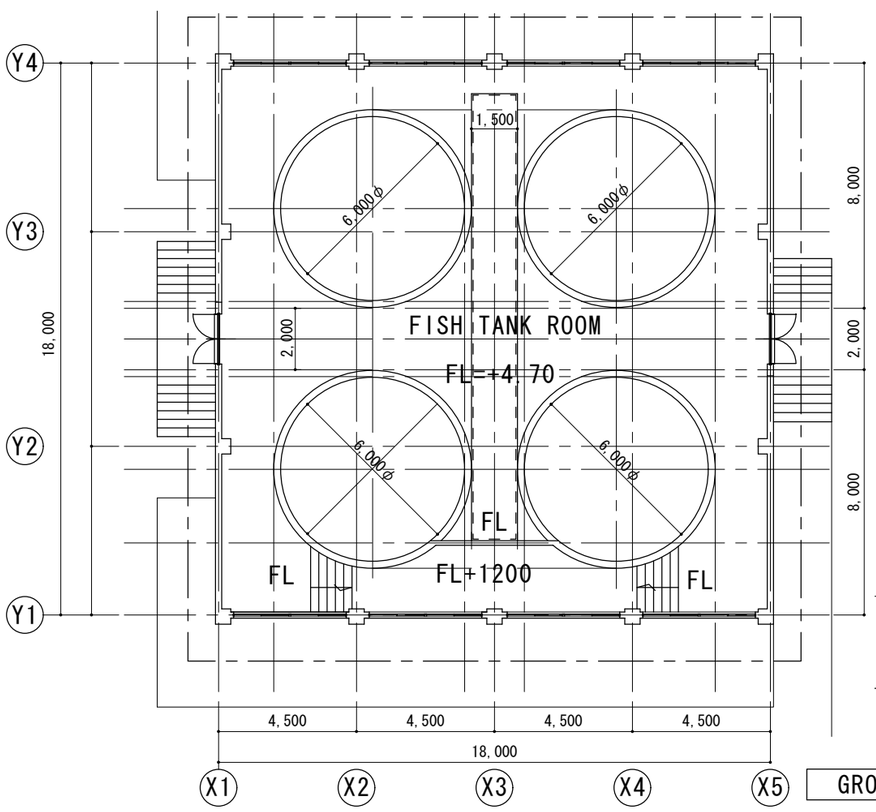
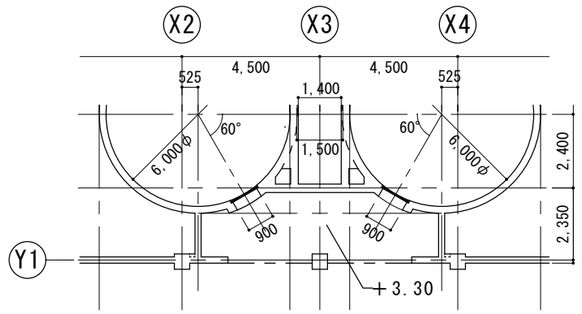
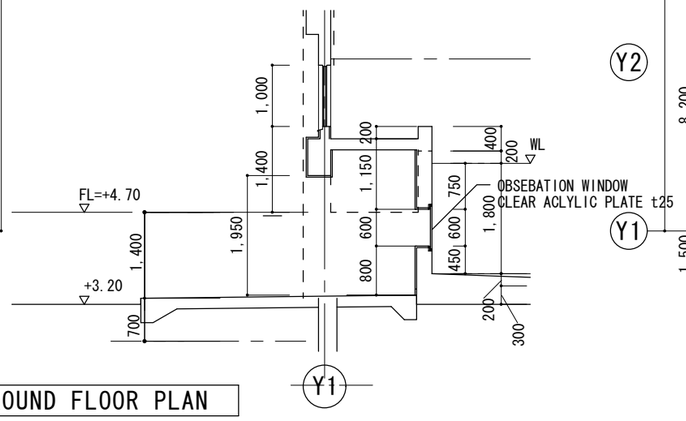
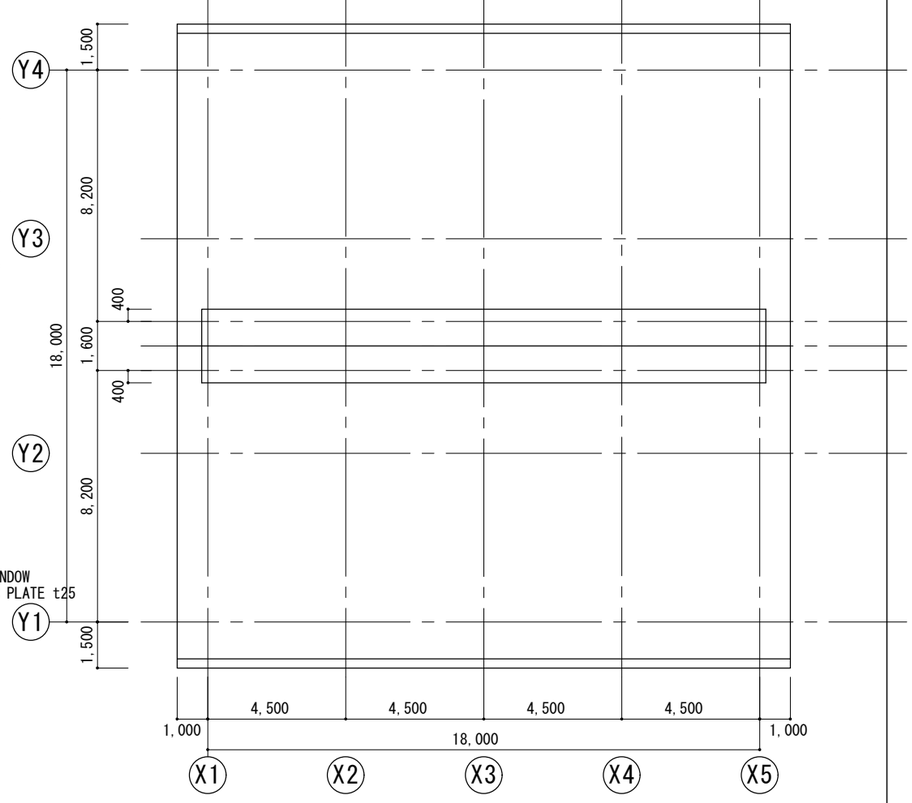


GROUND FLOOR PLAN



OBSEVATION WINDOW





ROOF PLAN

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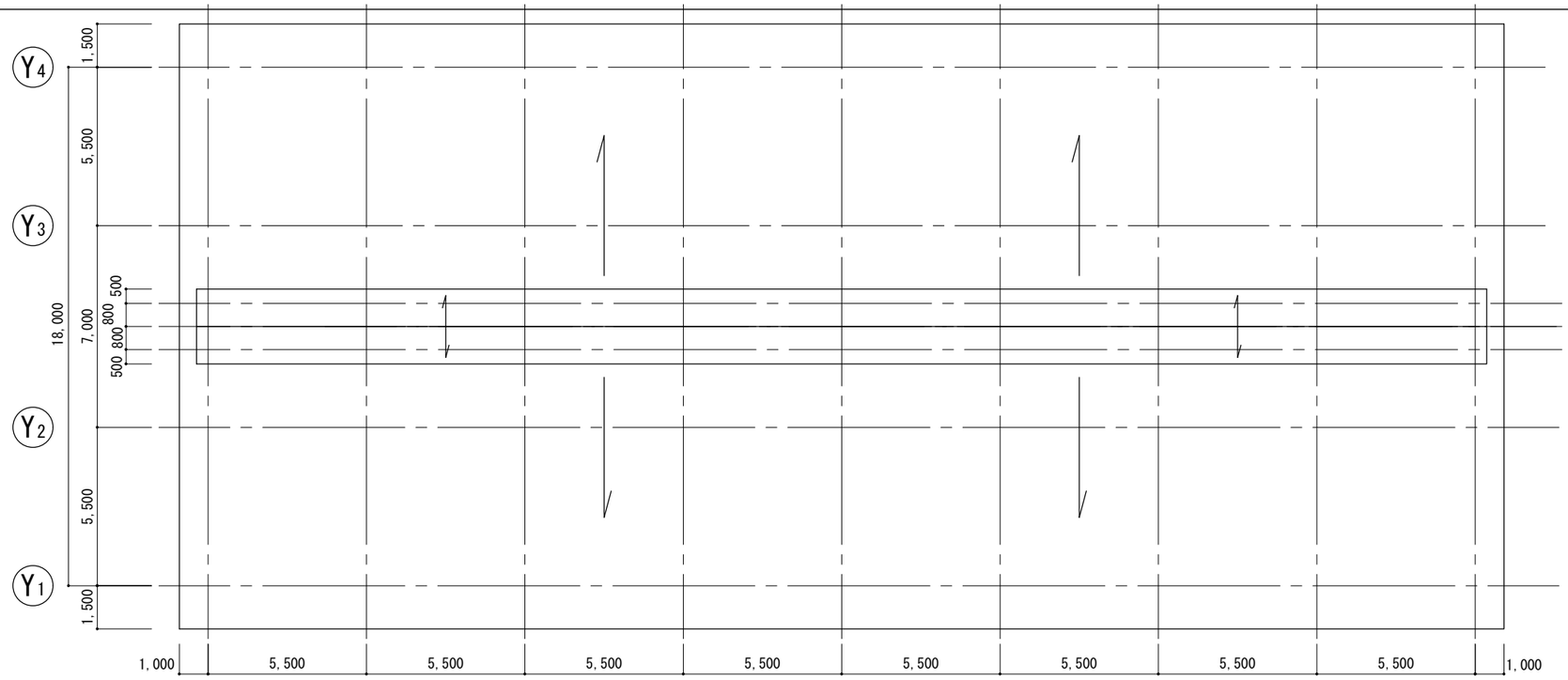
URL:http://www.fuyokaiyo.co.jp , Email:fuyo_web@fuyokaiyo.co.jp

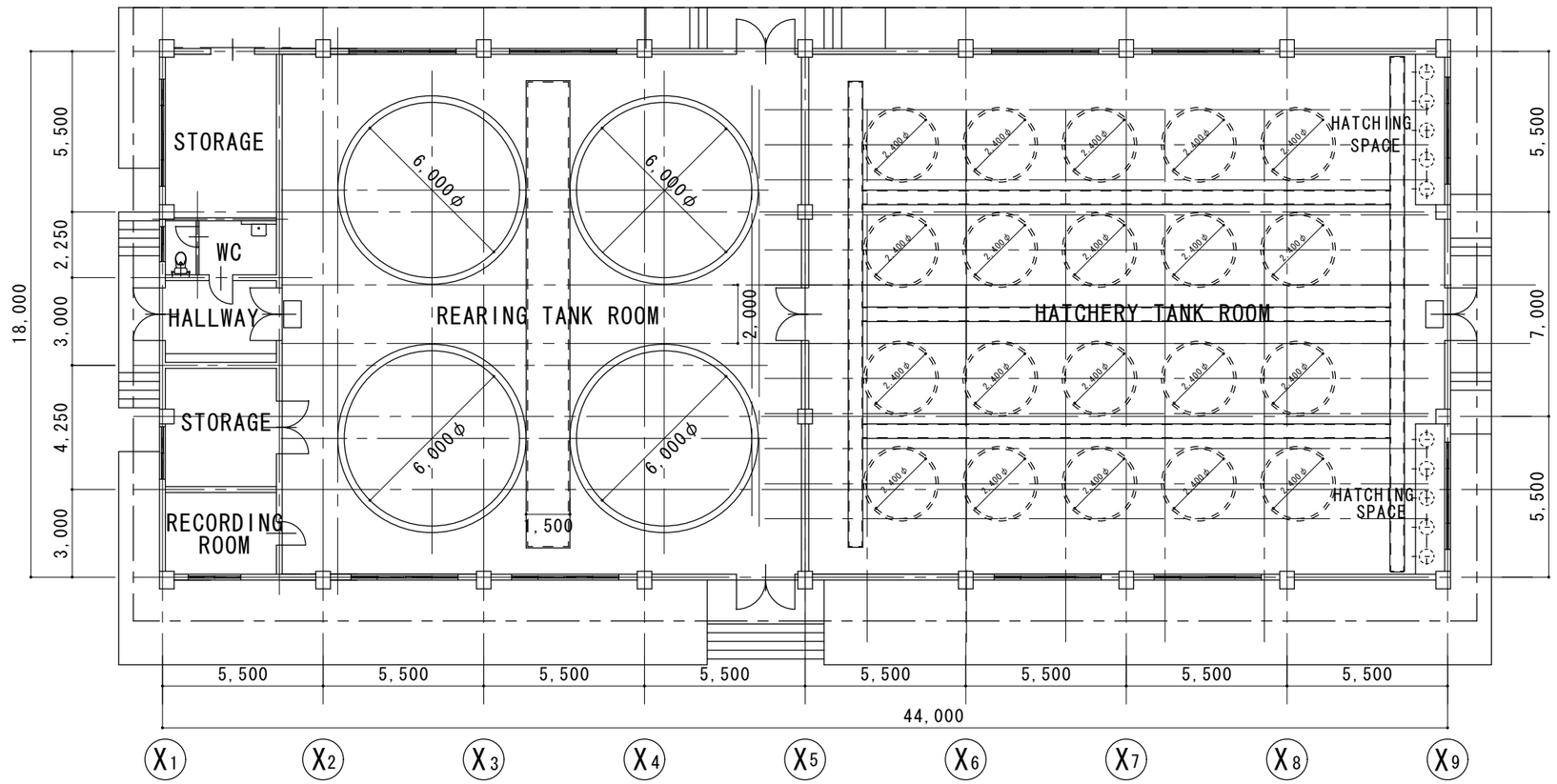
PROJECT TITLE :
THE PROJECT FOR CONSTRUCTION OF MARINE AQUACULTURE DEVELOPMENT CENTRE

DRAWING TITLE :
BROOD STOCK BUILDING
PLAN, ELEVATION, SECTION

DRAWN BY :	APPROVED BY:
CHECKED BY :	DATE :
SCALE : 1/200	DWG No: A-06



ROOF PLAN



GROUND FLOOR PLAN

FISHERIES ADMINISTRATION
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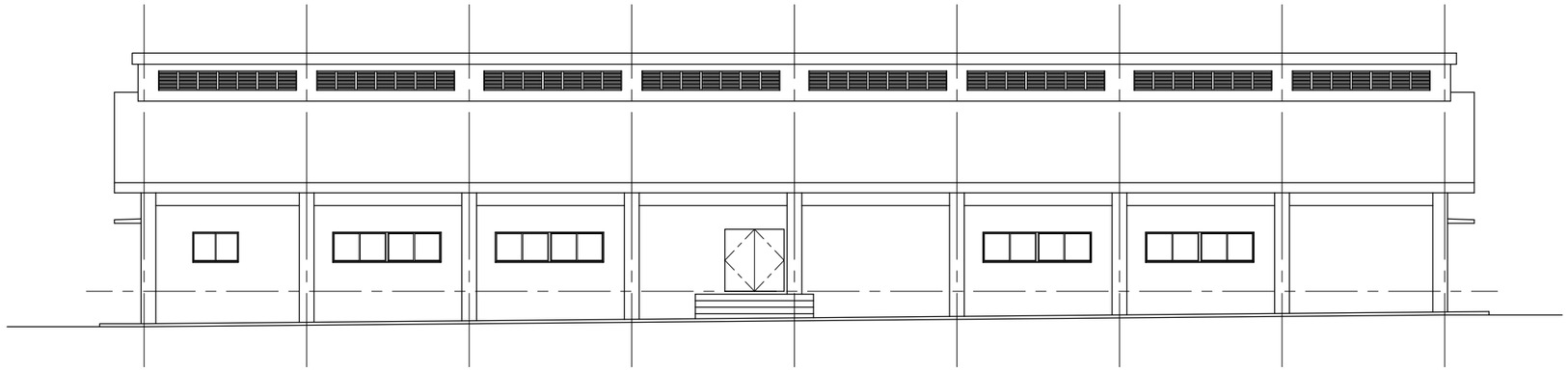
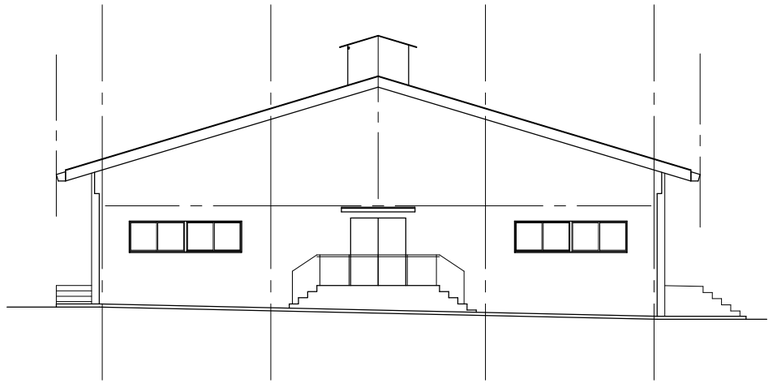
PROJECT TITLE :
THE PROJECT FOR CONSTRUCTION OF MARINE AQUACULTURE DEVELOPMENT CENTRE

DRAWING TITLE :
HATCHERY & BREEDING BLDG.
GROUND FLOOR PLAN, ROOF PLAN

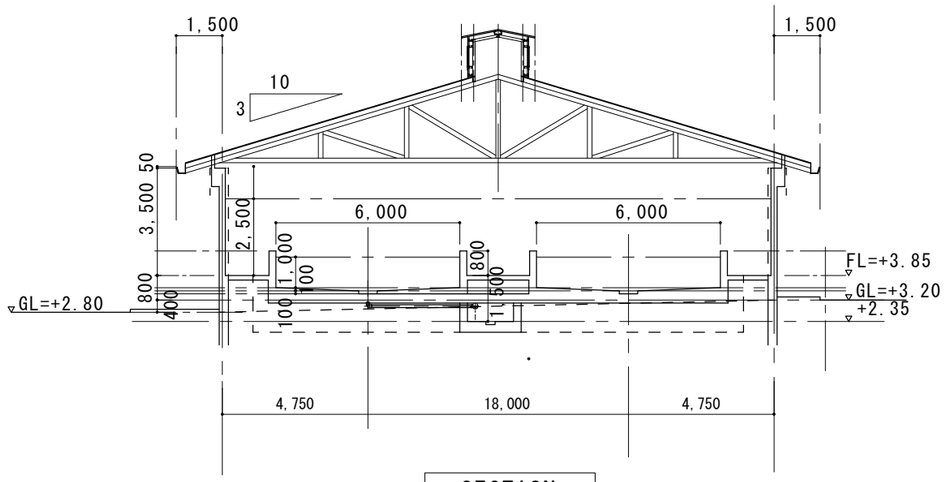
DRAWN BY :	APPROVED BY:
CHECKED BY :	DATE :
SCALE : 1/200	DWG No: A-07



SOUTH ELEVATION

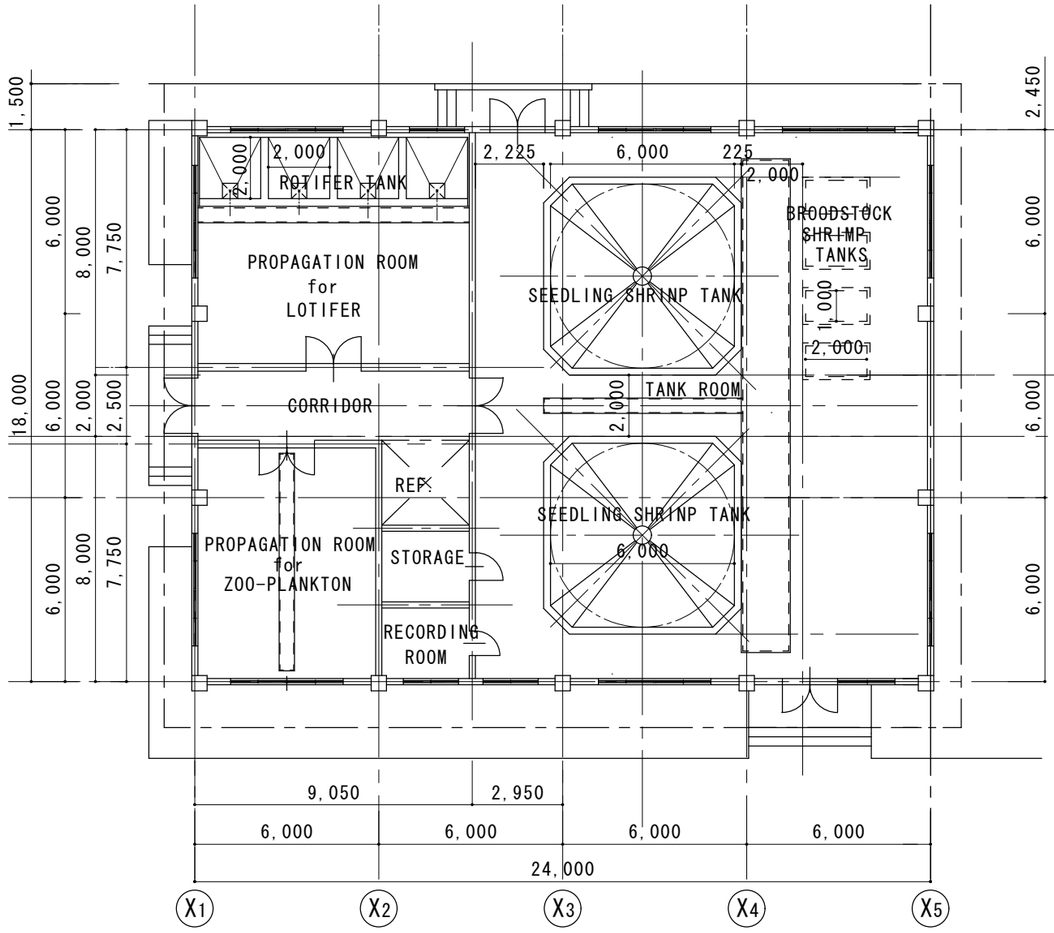


WEST ELEVATION

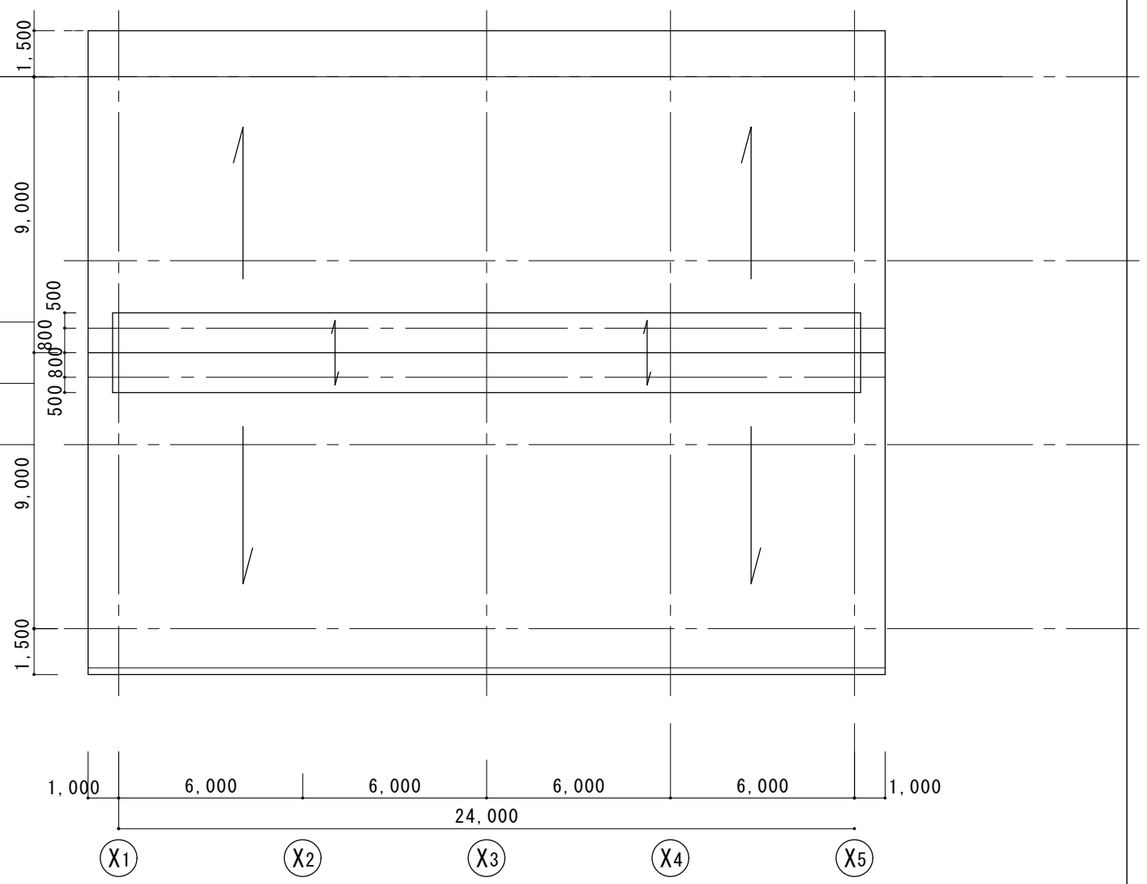


SECTION

FISHERIES ADMINISTRATION MINISTORY OF AGRICULTURE, FORESTRY AND FISHERIES THE KINGDOM OF CAMBODIA	OAFIC OVERSEAS AGRO-FISHERIES CONSULTANTS CO., LTD. KANDA 4TH AMELEX BLDG. 2F, 2-13 KANDA TSUKASAMACHI, CHIYODA-KU, TOKYO 101-0048 JAPAN TEL: +81-5281-1071 FAX: +81-5281-1072 http://www.oafic.co.jp	FUYO OCEAN DEVELOPMENT & ENGINEERING CO.,LTD 3-15-7 KURAMAE TAITO-KU TOKYO 111-0051,JAPAN TEL:+81-3-5820-1181, FAX:+81-5820-1225 URL:http://www.fuyokaiyo.co.jp , Email:fuyo_web@fuyokaiyo.co.jp	PROJECT TITLE : THE PROJECT FOR CONSTRUCTION OF MARINE AQUACULTURE DEVELOPMENT CENTRE	DRAWING TITLE : HATCHERY & BREEDING BLDG. ELEVATION, SECTION	DRAWN BY : CHECKED BY : SCALE : 1/200 APPROVED BY: DATE : DWG No: A-08

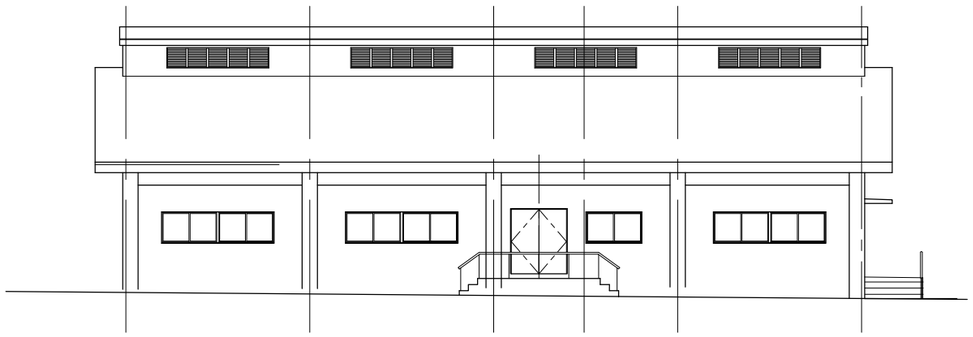


GROUND FLOOR PLAN

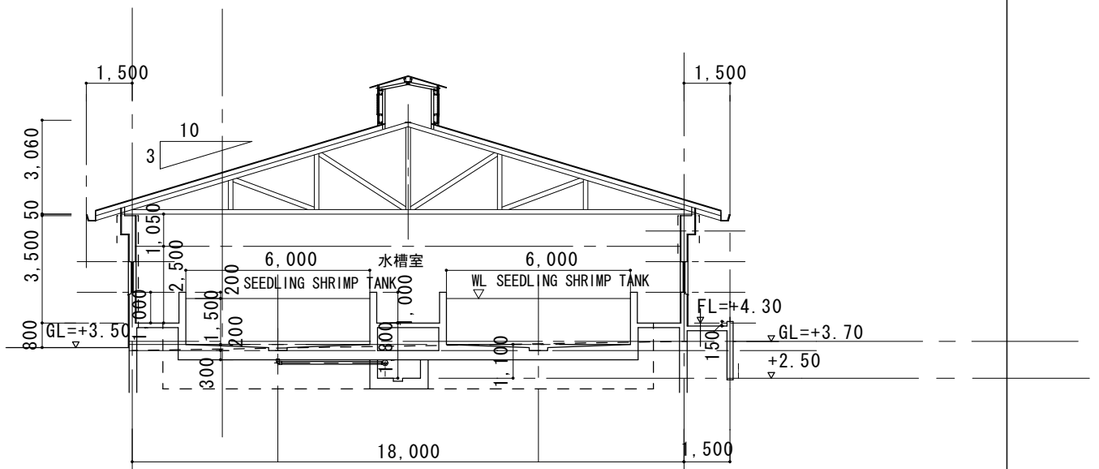


ROOF PLAN

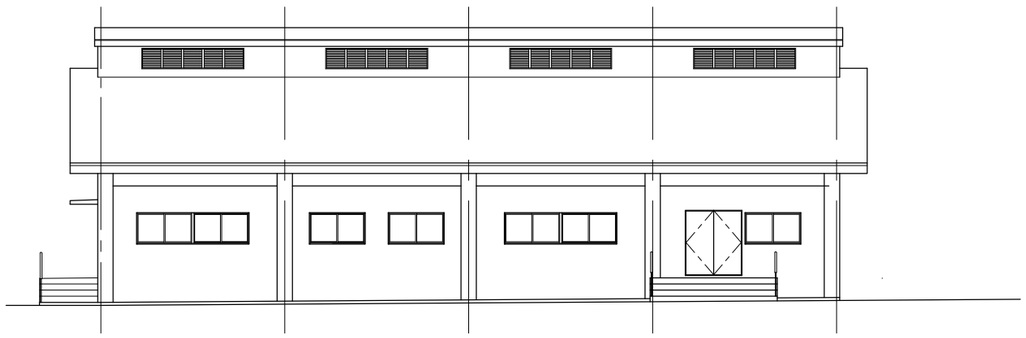
FISHERIES ADMINISTRATION MINISTORY OF AGRICULTURE, FORESTRY AND FISHERIES THE KINGDOM OF CAMBODIA	OAFIC OVERSEAS AGRO-FISHERIES CONSULTANTS CO., LTD. KANDA 4TH AMELEX BLDG. 2F, 2-13 KANDA TSUKASAMACHI, CHIYODA-KU, TOKYO 101-0048 JAPAN TEL: +81-5281-1071 FAX: +81-5281-1072 http://www.oafic.co.jp	FUYO OCEAN DEVELOPMENT & ENGINEERING CO.,LTD 3-15-7 KURAMAE TAITO-KU TOKYO 111-0051,JAPAN TEL:+81-3-5820-1181, FAX:+81-5820-1225 URL:http://www.fuyokaiyo.co.jp , Email:fuyo_web@fuyokaiyo.co.jp	PROJECT TITLE : THE PROJECT FOR CONSTRUCTION OF MARINE AQUACULTURE DEVELOPMENT CENTRE	DRAWING TITLE : CRUSTACEA BLDG. GROUND FLOOR PLAN, ROOF PLAN	DRAWN BY : CHECKED BY : SCALE : 1/200 APPROVED BY: DATE : DWG No: A-09



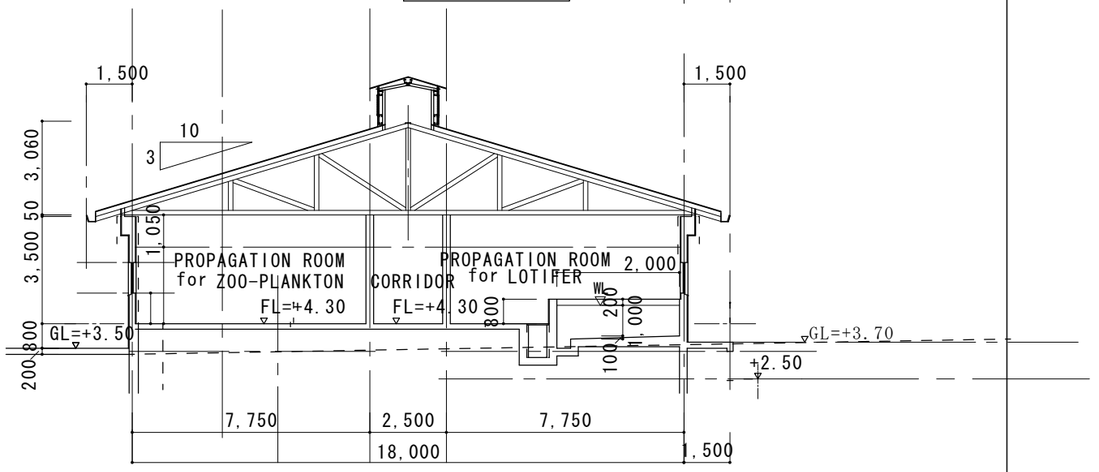
NORTH ELEVATION



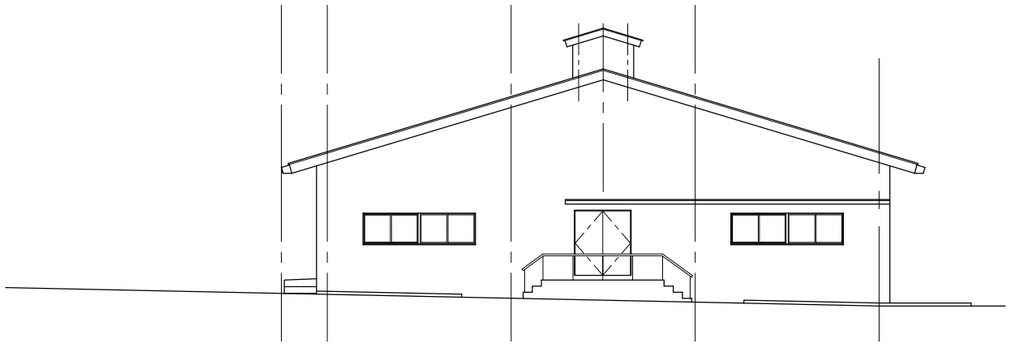
SECTION A



SOUTH ELEVATION



SECTION B



WEST ELEVATION

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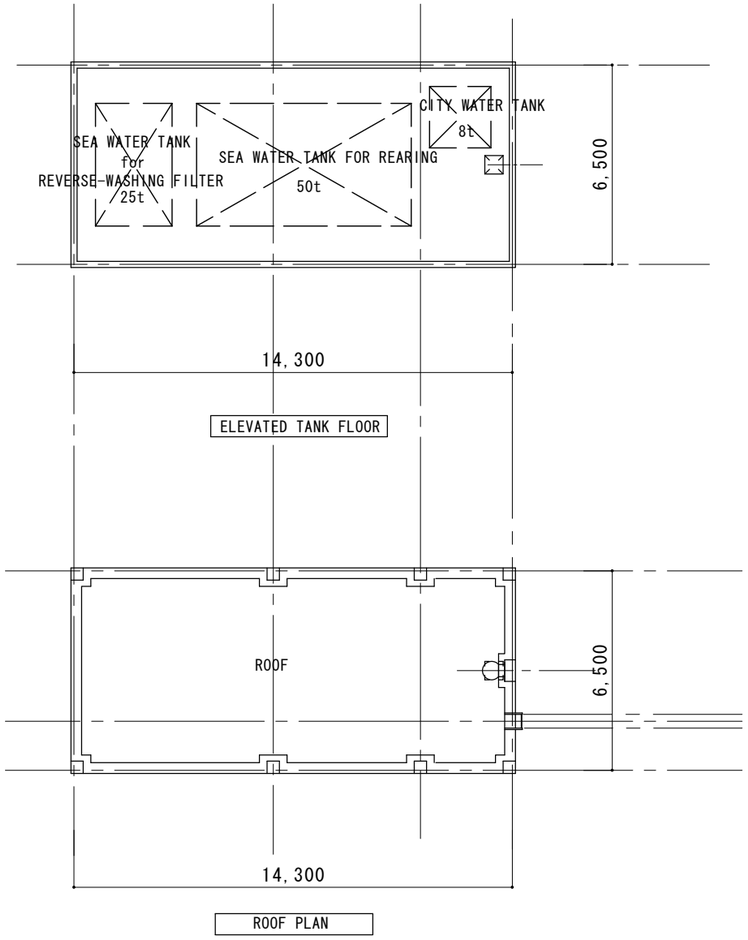
PROJECT TITLE :
THE PROJECT FOR CONSTRUCTION OF
MARINE AQUACULTURE DEVELOPMENT CENTRE

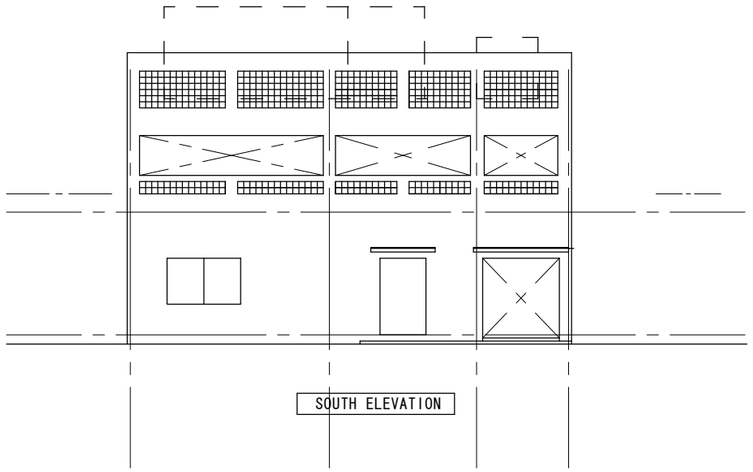
DRAWING TITLE :
CRUSTACEA BLDG.
ELEVATION, SECTION

DRAWN BY :	APPROVED BY:
CHECKED BY :	DATE :
SCALE : 1/200	DWG No: A-10

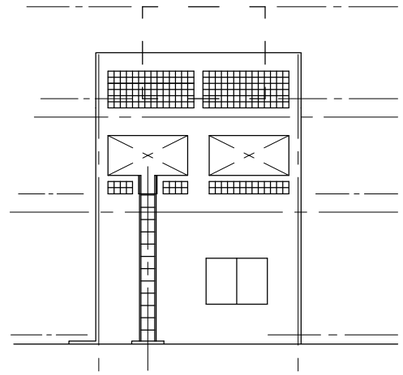


ELEVATED TANK FLOOR

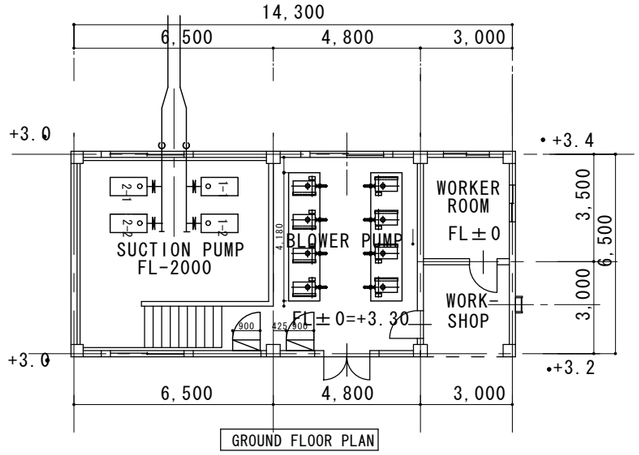
ROOF PLAN



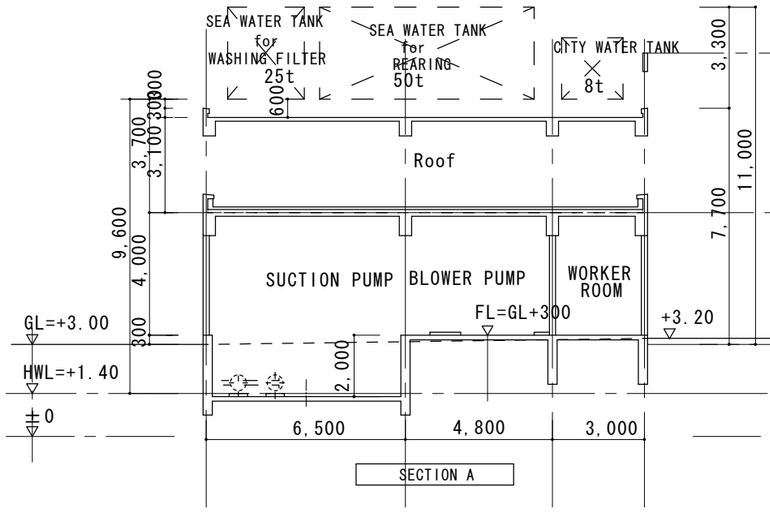
SOUTH ELEVATION



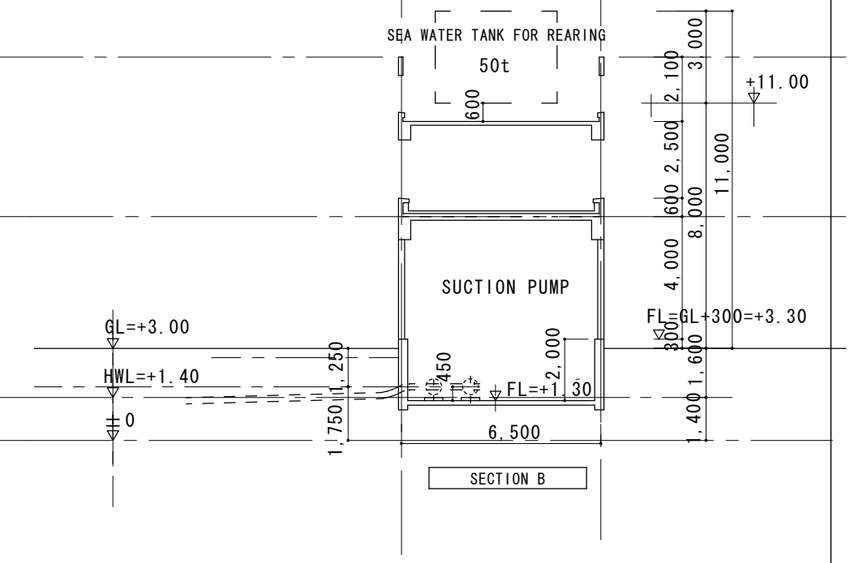
EAST ELEVATION



GROUND FLOOR PLAN



SECTION A



SECTION B

FISHERIES ADMINISTRATION
MINISTORY OF AGRICULTURE,
FORESTRY AND FISHERIES
THE KINGDOM OF CAMBODIA

OAFIC OVERSEAS AGRO-FISHERIES CONSULTANTS CO., LTD.
KANDA 4TH AMELEX BLDG. 2F, 2-13 KANDA TSUKASAMACHI, CHIYODA-KU, TOKYO 101-0048 JAPAN
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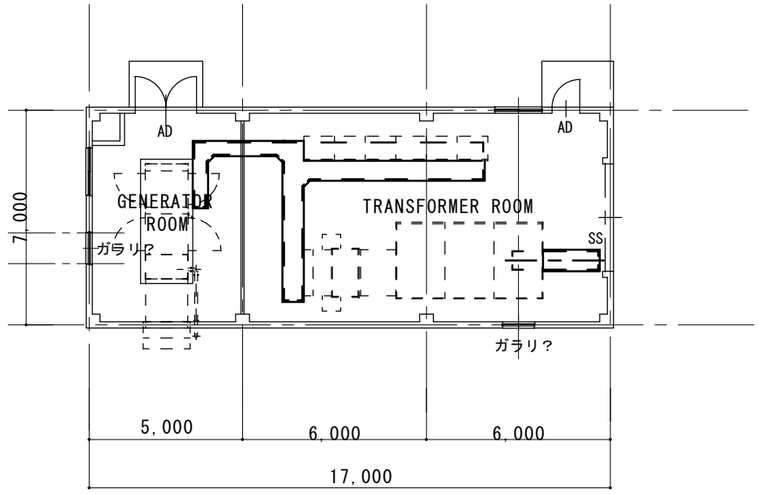
TEL:+81-3-5820-1181, FAX:+81-5820-1225
URL:http://www.fuyokaiyo.co.jp , Email:fuyo_web@fuyokaiyo.co.jp

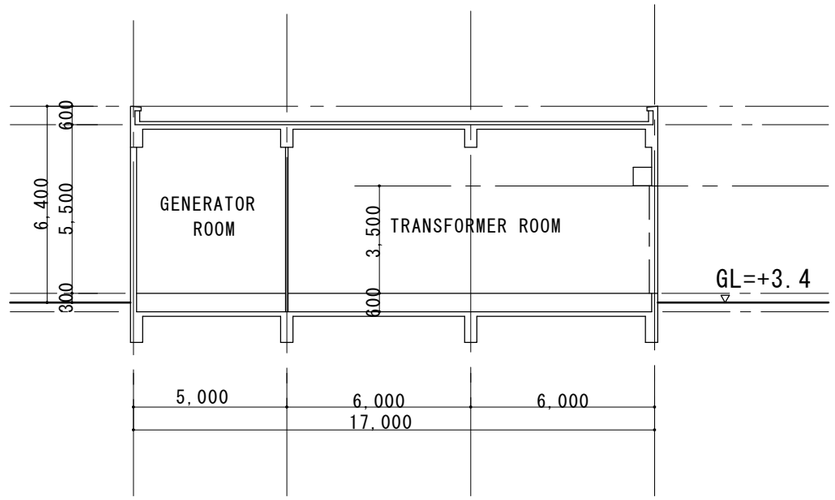
PROJECT TITLE :
THE PROJECT FOR CONSTRUCTION OF MARINE AQUACULTURE DEVELOPMENT CENTRE

DRAWING TITLE :
MACHINE BUILDING
GROUND FLOOR PLAN, ROOF PLAN
ELEVATION, SECTION

DRAWN BY :	APPROVED BY:
CHECKED BY :	DATE :
SCALE : 1/200	DWG No: A-11



GROUND FLOOR PLAN



SECTION

FISHERIES ADMINISTRATION
MINISTORY OF AGRICULTURE,
FORESTRY AND FISHERIES
THE KINGDOM OF CAMBODIA

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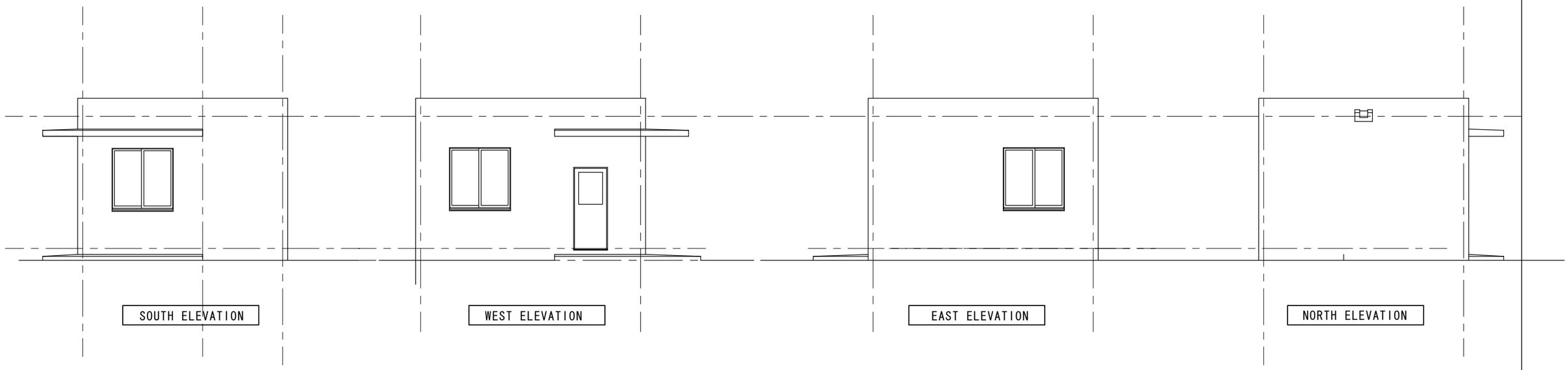
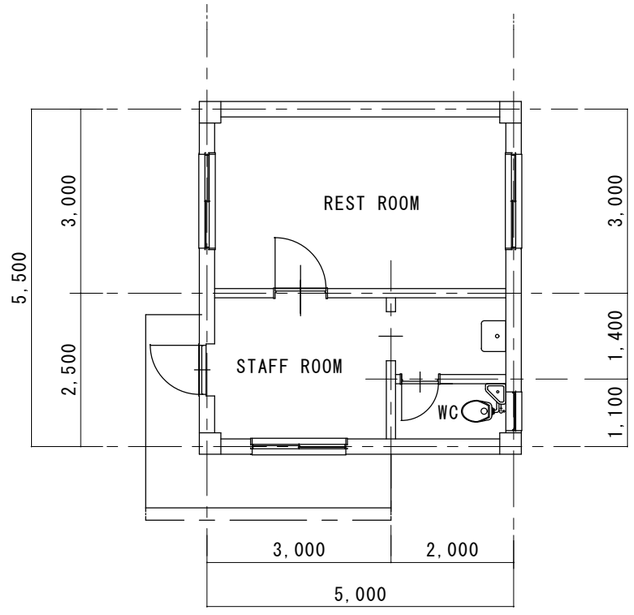
URL:http://www.fuyokaiyo.co.jp , Email:fuyo_web@fuyokaiyo.co.jp

PROJECT TITLE :
THE PROJECT FOR CONSTRUCTION OF MARINE AQUACULTURE DEVELOPMENT CENTRE

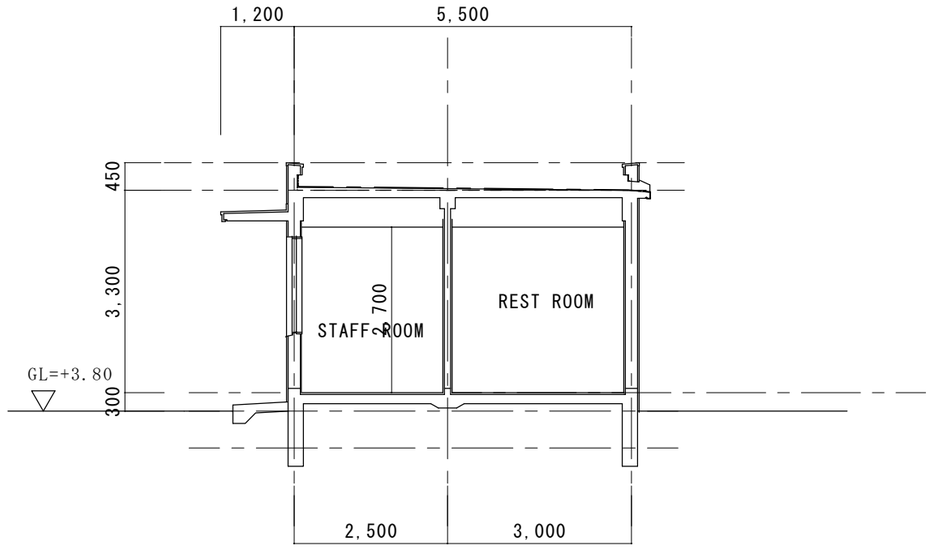
DRAWING TITLE :
ELECTRICITY SUBSTATION
GROUND FLOOR PLAN
SECTION

DRAWN BY :	APPROVED BY:
CHECKED BY :	DATE :
SCALE : 1/200	DWG No: A-12





GROUND FLOOR PLAN



SECTION

FISHERIES ADMINISTRATION
MINISTORY OF AGRICULTURE,
FORESTRY AND FISHERIES
THE KINGDOM OF CAMBODIA

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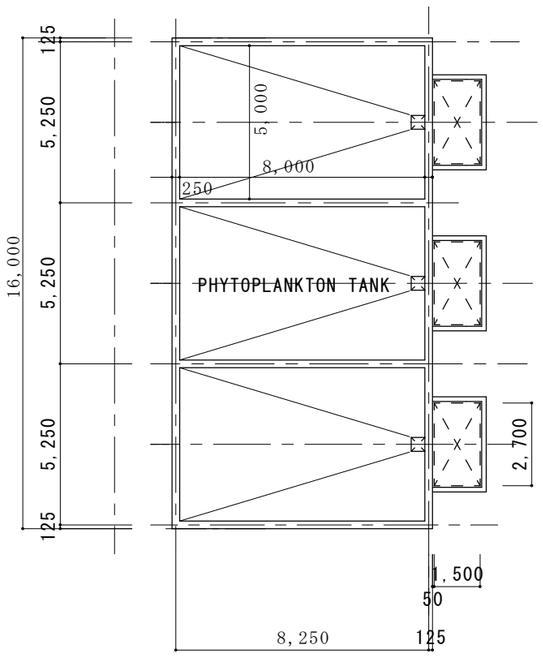
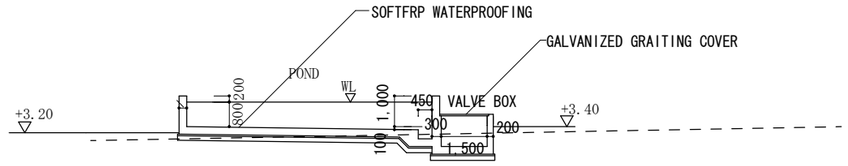
PROJECT TITLE :
THE PROJECT FOR CONSTRUCTION OF
MARINE AQUACULTURE DEVELOPMENT CENTRE

DRAWING TITLE :
SECURITY GUARD HOUSE
PLAN, ELEVATION, SECTION

DRAWN BY :	APPROVED BY:
CHECKED BY :	DATE :
SCALE : 1/100	DWG No: A-13

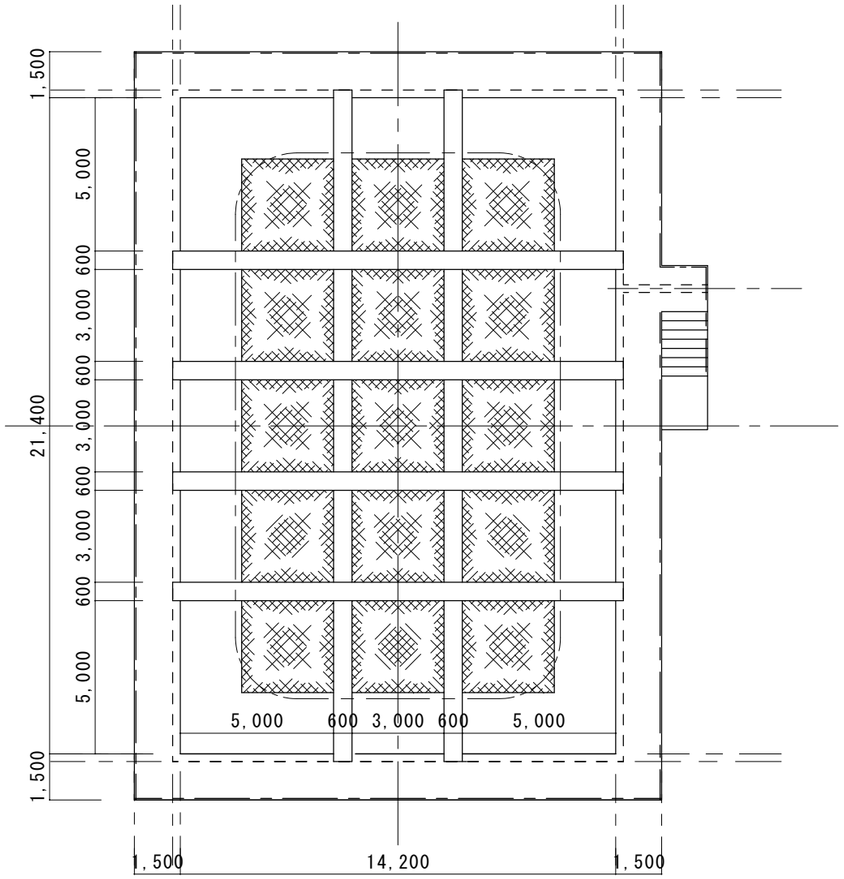


PLAN

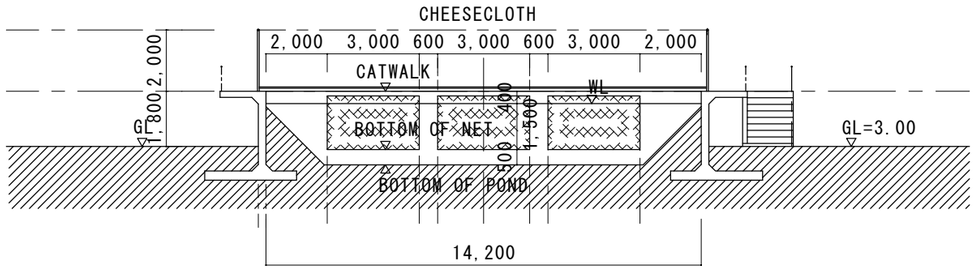


SECTION

FISHERIES ADMINISTRATION MINISTORY OF AGRICULTURE, FORESTRY AND FISHERIES THE KINGDOM OF CAMBODIA	OAFIC OVERSEAS AGRO-FISHERIES CONSULTANTS CO., LTD. KANDA 4TH AMELEX BLDG. 2F, 2-13 KANDA TSUKASAMACHI, CHIYODA-KU, TOKYO 101-0048 JAPAN TEL: +81-5281-1071 FAX: +81-5281-1072 http://www.oafic.co.jp	FUYO OCEAN DEVELOPMENT & ENGINEERING CO.,LTD 3-15-7 KURAMAE TAITO-KU TOKYO 111-0051,JAPAN TEL:+81-3-5820-1181, FAX:+81-5820-1225 URL:http://www.fuyokaiyo.co.jp , Email:fuyo_web@fuyokaiyo.co.jp	PROJECT TITLE : THE PROJECT FOR CONSTRUCTION OF MARINE AQUACULTURE DEVELOPMENT CENTRE	DRAWING TITLE : OUTDOOR LIVE FEED CULTURE TANK PLAN, SECTION	DRAWN BY : CHECKED BY : SCALE : 1/200 APPROVED BY: DATE : DWG No: A-14



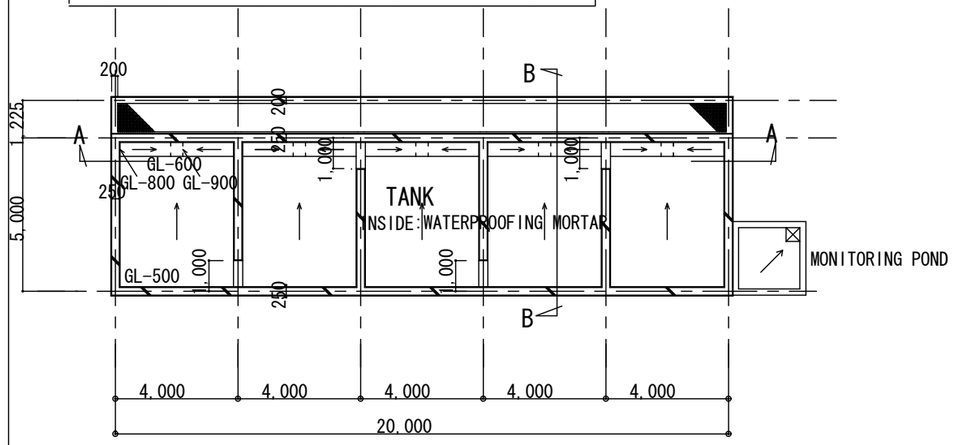
GROUND PLAN



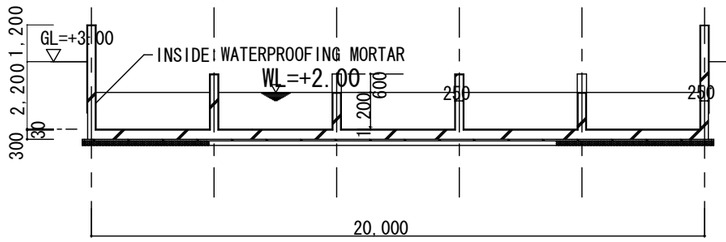
SECTION

FISHERIES ADMINISTRATION MINISTORY OF AGRICULTURE, FORESTRY AND FISHERIES THE KINGDOM OF CAMBODIA	OAFIC OVERSEAS AGRO-FISHERIES CONSULTANTS CO., LTD. KANDA 4TH AMELEX BLDG. 2F, 2-13 KANDA TSUKASAMACHI, CHIYODA-KU, TOKYO 101-0048 JAPAN TEL: +81-5281-1071 FAX: +81-5281-1072 http://www.oafic.co.jp	FUYO OCEAN DEVELOPMENT & ENGINEERING CO.,LTD 3-15-7 KURAMAE TAITO-KU TOKYO 111-0051,JAPAN TEL:+81-3-5820-1181, FAX:+81-5820-1225 URL:http://www.fuyokaiyo.co.jp , Email:fuyo_web@fuyokaiyo.co.jp	PROJECT TITLE : THE PROJECT FOR CONSTRUCTION OF MARINE AQUACULTURE DEVELOPMENT CENTRE	DRAWING TITLE : OUTDOOR REARING POND PLAN, SECTION	DRAWN BY : CHECKED BY : SCALE : 1/200 APPROVED BY: DATE : DWG No: A-15

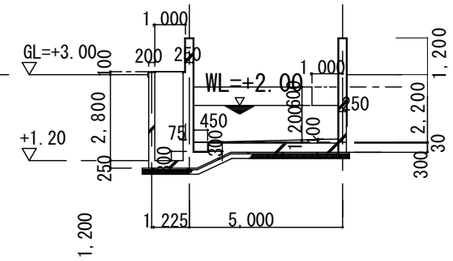
SEDIMETATION TANK of REARING WATER



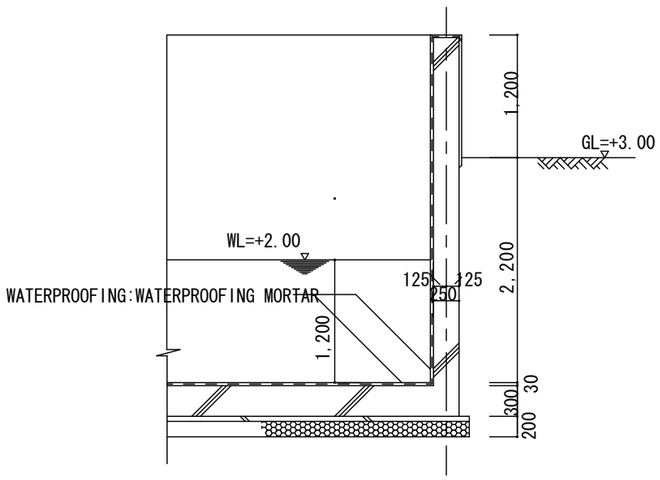
PLAN S=1/200



SECTION A-A S=1/200

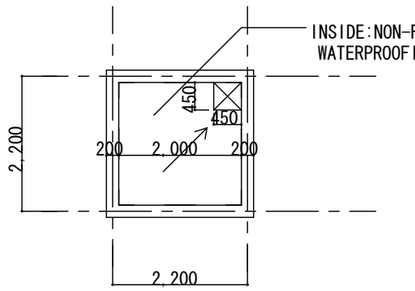


SECTION B-B S=1/200

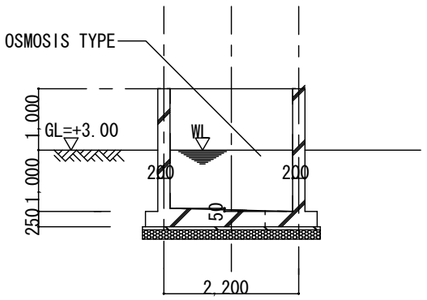


DETAIL S:1/60

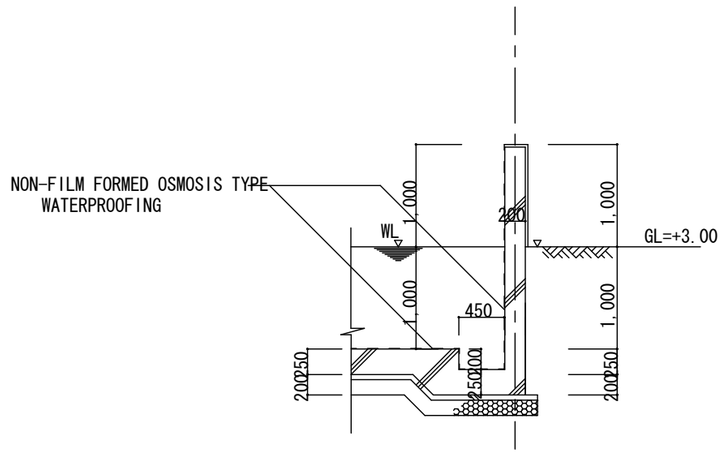
MONITORING POND



PLAN S:1/100



SECTION S:1/100



DETAIL S:1/60

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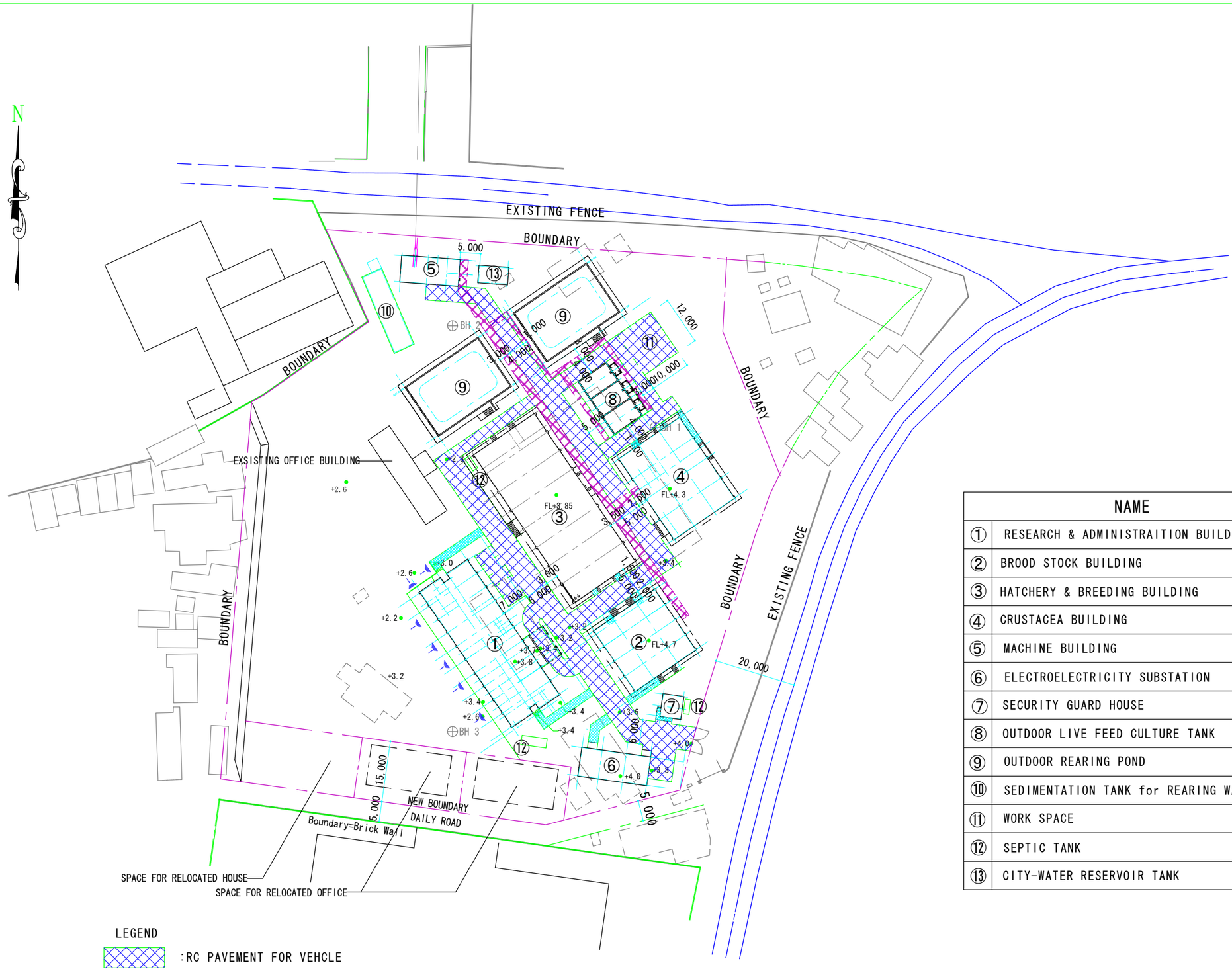
URL:http://www.fuyokaiyo.co.jp , Email:fuyo_web@fuyokaiyo.co.jp

PROJECT TITLE :
THE PROJECT FOR CONSTRUCTION OF MARINE AQUACULTURE DEVELOPMENT CENTRE

DRAWING TITLE :
SEDIMENTATION TANK for REARING WATER MONITORING TANK
PLAN, SECTION, DETAIL

DRAWN BY :	APPROVED BY:
CHECKED BY :	DATE :
SCALE : 1/200	DWG No: A-16



NAME	
①	RESEARCH & ADMINISTRAITION BUILDING
②	BROOD STOCK BUILDING
③	HATCHERY & BREEDING BUILDING
④	CRUSTACEA BUILDING
⑤	MACHINE BUILDING
⑥	ELECTROELECTRICITY SUBSTATION
⑦	SECURITY GUARD HOUSE
⑧	OUTDOOR LIVE FEED CULTURE TANK
⑨	OUTDOOR REARING POND
⑩	SEDIMENTATION TANK for REARING WATER
⑪	WORK SPACE
⑫	SEPTIC TANK
⑬	CITY-WATER RESERVOIR TANK

LEGEND

:RC PAVEMENT FOR VEHCLE

:RC PAVEMENT FOR WALKER

:CULVERT

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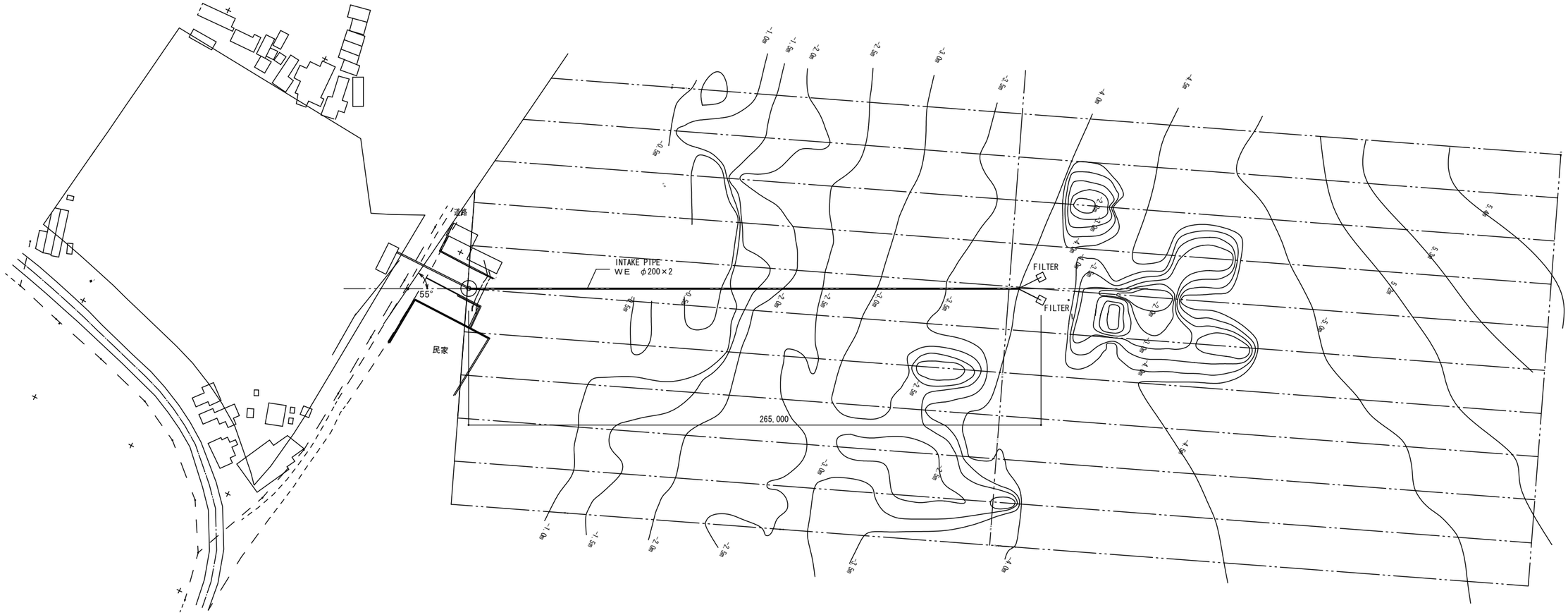
PROJECT TITLE :
THE PROJECT FOR CONSTRUCTION OF MARINE AQUACULTURE DEVELOPMENT CENTRE

DRAWING TITLE :
EXTERNAL PLANNING

DRAWN BY :
CHECKED BY :
SCALE : 1/1000
APPROVED BY:
DATE :
DWG No: A-17



FISHERIES ADMINISTRATION
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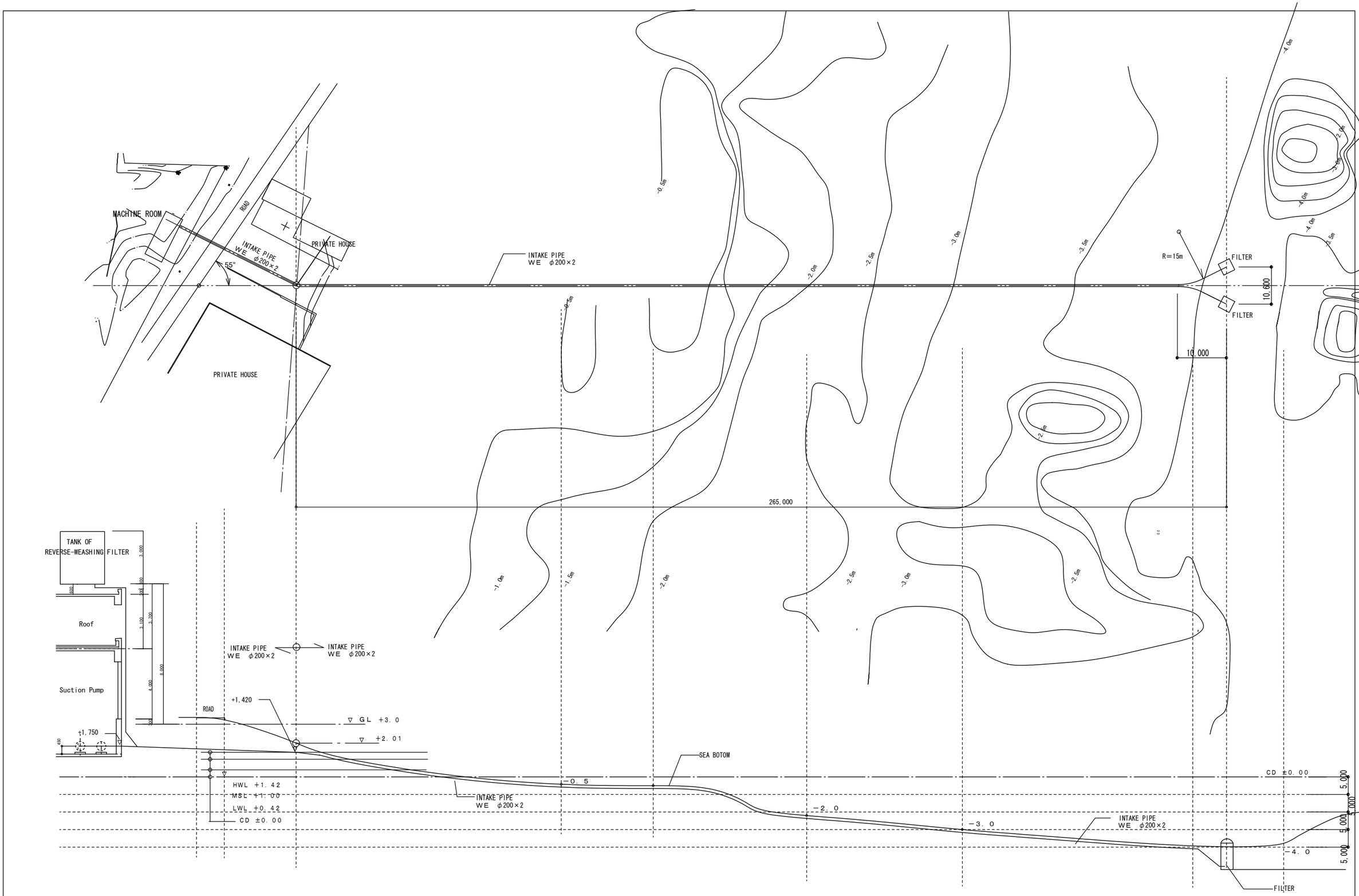
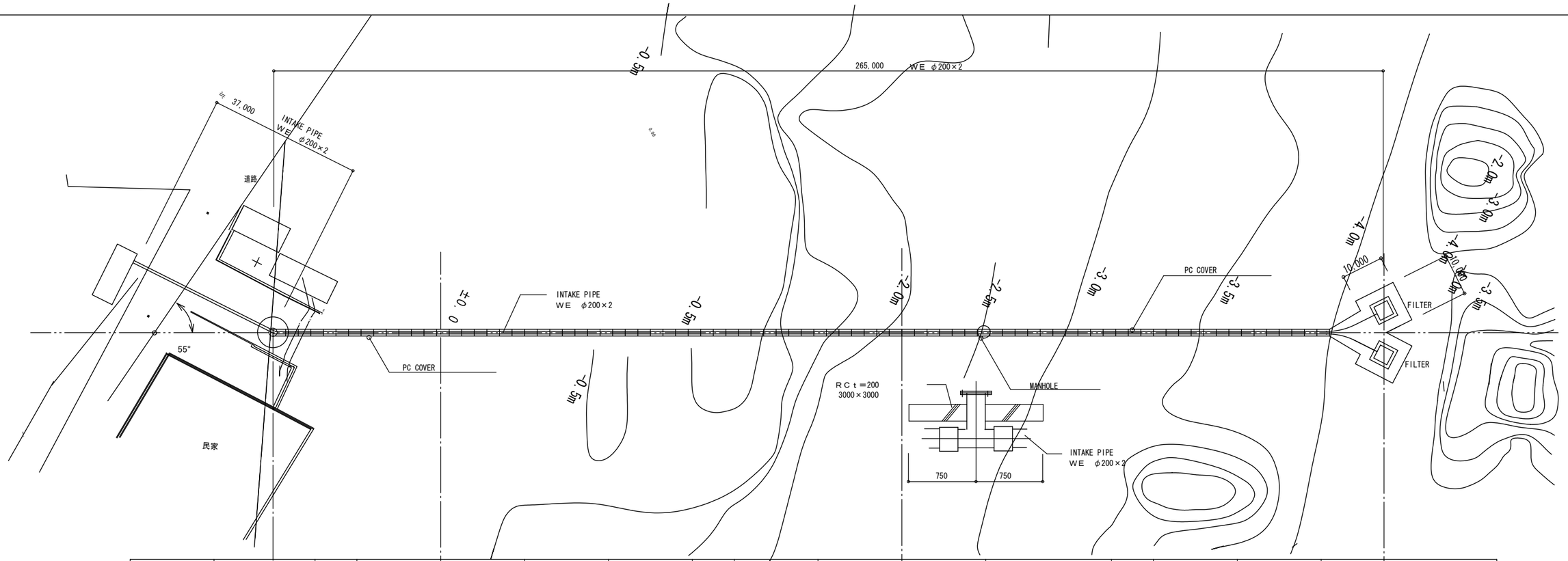
PROJECT TITLE :
THE PROJECT FOR CONSTRUCTION OF
MARINE AQUACULTURE DEVELOPMENT CENTRE

DRAWING TITLE :
SEAWATER INTAKE SYSTEM
GENERAL SITE PLAN

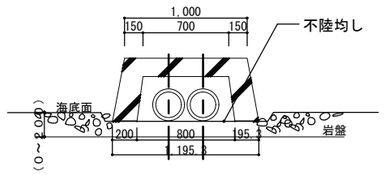
DRAWN BY :	APPROVED BY:
CHECKED BY :	DATE :
SCALE : 1/2000	DWG No: C-01



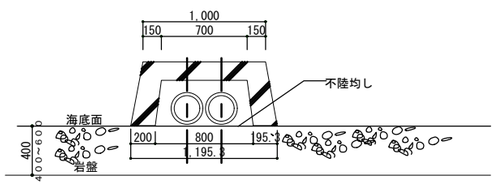
FISHERIES ADMINISTRATION MINISTORY OF AGRICULTURE, FORESTRY AND FISHERIES THE KINGDOM OF CAMBODIA	OAFIC OVERSEAS AGRO-FISHERIES CONSULTANTS CO., LTD. KANDA 4TH AMELEX BLDG. 2F, 2-13 KANDA TSUKASAMACHI, CHIYODA-KU, TOKYO 101-0048 JAPAN TEL: +81-5281-1071 FAX: +81-5281-1072 http://www.oafic.co.jp	FUYO OCEAN DEVELOPMENT & ENGINEERING CO.,LTD 3-15-7 KURAMAE TAITO-KU TOKYO 111-0051,JAPAN TEL:+81-3-5820-1181, FAX:+81-5820-1225 URL:http://www.fuyokaiyo.co.jp , Email:fuyo_web@fuyokaiyo.co.jp	PROJECT TITLE : THE PROJECT FOR CONSTRUCTION OF MARINE AQUACULTURE DEVELOPMENT CENTRE	DRAWING TITLE : SEAWATER INTAKE SYSTEM SEACTION OF INTAKE PIPE LINE	DRAWN BY : CHECKED BY : SCALE : 1/200 APPROVED BY: DATE : DWG No: C-02



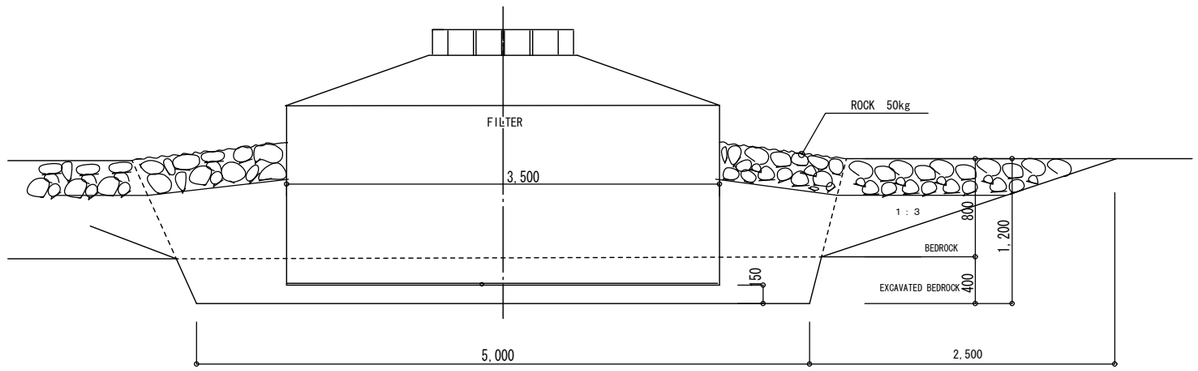
側　点	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
追加距離　(m)	0	10	20	40	60	80	100	110	130	150	170	200	210	230	250	265
地盤高　(m)	+2.01	+1.2	+0.7	0.0	−0.1	−0.5	−0.5	−0.5	−1.3	−2.1	−2.5	−3.2	−3.3	−3.7	−3.9	−4.2
堆積厚　(m)	0	0.2	0.2	0.1	0.3	0.0	0.3	0.4	0.4	0.4	0.5	0.0	0.5	0.5	0.6	0.8
計画管底高　(m)	+1.2	+1.0	+0.5	−0.1	−0.4	−0.5	−0.8	−0.9	−1.7	−2.5	−3.0	−3.2	−3.8	−4.2	−4.5	−5.0
掘削高　(m)	0.81	0.2	0.2	0.1	0.3	0.0	0.3	0.4	0.4	0.4	0.5	0.0	0.5	0.5	0.6	0.8



1～10　SECTION　S=1/50



10～15　SECTION　S=1/50



EXCAVATED SECTION FOR FILTER　S=1/50

FISHERIES ADMINISTRATION
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THE KINGDOM OF CAMBODIA

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PROJECT TITLE :
THE PROJECT FOR CONSTRUCTION OF MARINE AQUACULTURE DEVELOPMENT CENTRE

DRAWING TITLE :
SEAWATER INTAKE SYSTEM
SECTION OF FILTER & INTAKE PIPE

DRAWN BY :	APPROVED BY:
CHECKED BY :	DATE :
SCALE : 1/1000	DWG No: C-03

2-2-4 Implementation Plan

2-2-4-1 Implementation and procurement Policies

This Project will be implemented by means of Japan's Grant Aid which is provided by the Japanese government. Fisheries Administration, Ministry of Agriculture, Forestry and Fisheries, the Cambodian implementation agency of the Project, is responsible for overall supervision, acquisition of necessary approvals and permits, and coordination among relevant authorities and stakeholders. After the completion of the facility, Marine Aquaculture Development Centre (MADeC) will operate and maintain the facility while Fisheries Administration will support the Project activities through operational auditing of MADeC and other appropriate means.

The construction work must be implemented in consistence with the following basic policies.

(1) In consideration of the time constraint by Japan's Grant Aid that the construction of Project facility must be completed within a specified period of time, formulate appropriate plans for construction method, procurement for construction material, construction schedule and quality control, and carry out the facility construction under adequate supervision.

(2) Make necessary efforts for conservation of nearby promises and natural environment

(3) Maintain close relation and sufficient communication with respective authorities and relevant stakeholders of the recipient government at every step of the construction in order to avoid procedural mistakes

(4) Select equipment and facilities which are easy in spare part's availability and maintenance

(5) Respect the custom, tradition and culture of the recipient country in the implementation of construction work and labour management

(6) Utilize local contractors to a fullest extent for the construction because their construction techniques and labour quality are at a satisfactory level

(7) Take sufficient measures for security for the personnel involved in the project.

2-2-4-2 Implementation and Procurement Conditions

(1) The project site is located in a busy area with heavy vehicle and pedestrian traffic. As such it may be necessary to take special measures such as designating the construction site as an off-limit zone during the construction period.

(2) It is necessary to take appropriate a measure for prevention of soil and dust scattering to the neighbouring premises.

(3) For the environmental conservation, it is necessary to take a necessary measure for avoiding pollution of coastal water due to the construction of marine equipment.

(4) It is important to formulate a work plan that takes hygiene and health of the workers into consideration as the construction has to be carried out under severe tropical climate condition

(5) Majority of the construction materials will be procured though transportation by sea. A simple

mistake in procurement would be possible to cause a considerable delay in the overall construction schedule. It is, therefore, important to formulate and implement a well-thought-out procurement plan.

2-2-4-3 Scope of Works

The respective responsibilities for the Project implementation by the Japanese and Cambodian authorities under the framework of Japan's Grant Aid are as shown bellow. Each side will carry out the specified obligations with their own financial expenses.

1) Obligations of the Cambodian side

(1) Acquisition of the construction site and removal of existing buildings, facilities and any other obstruction for the construction in the Project site.

(2) Supply of water and electricity to the specified positions in the construction site.

(3) Provision of telephone line which will be necessary at the Research and administration building

(4) Construction and installation of necessary fences and gates as well as provision of the necessary planting

(5) Acquisition of land for temporary storage of the equipment and materials for the Project and a field office for the construction supervision

(6) Procurement of office furniture to be provided to the Research and administration building

2) Obligations of the Japanese side

(1) Construction of the Research and administration building and aquaculture facilities including a Brood stock building, Hatchery and Crustacea building.

(2) Installation of marine water supply system, freshwater supply system, water sterilisation system, filtration system, water storage tanks, and sedimentation tanks.

(3) Installation of live feed culture facility

(4) Provision of education and training equipment, rearing equipment, and experiment and research equipment

(5) Provision of implementation design, bidding assistance, construction supervision and consultation on Soft Component (Technical Assistance).

(5)Provision of all materials and labour necessary for the construction and installation works that are responsible by the Japanese part.

(6) Provision of insurance costs for marine and inland transportation of imported materials and equipment necessary for the construction and installation works responsible by the Japanese part

2-2-4-4 Consultant Supervision

(1) In respect for supervision for executions of the construction plan and the procurement plan which will be implemented under the framework of Japan's Grant Aid, the Consultant will make full effort to implement the required constructions smoothly from first to last attaining respective required qualities, and thus to be able to handover the completed facilities to the recipient government on time.

(2) The Consultant will carry out appropriate supervision of the Project implementation by inspecting carefully construction details, schedule, quality control plan and other documents to be provided by the contractor in consistent with the designing of the Project

(3) The Consultant will maintain close communications with relevant Cambodian authorities, Japanese Embassy in Cambodia, JICA Cambodia office, and the contractors.

(4) The Consultant will prepare appropriate plans for equipment, vehicle and office required for supervision of the Project implementation. It will also prepare appropriate plans for applications for formalities, its timing and means pertinent to the quality control.

(5) In respect to the human resource plan, the Consultant will carefully consider on the necessary technical levels, positioning, required number, and compositions required for realising proper operation of the Project.

2-2-4-5 Quality Control Plan

The Project ensures quality control based on the following points, paying special attention to the building's structural frames which determine the fundamental performance of the facilities such as durability and reliability.

(1) The Contractor will prepare a construction plan that specifies construction method, schedule, and quality control means for approval by the Consultant prior to the commencement of respective construction components.

(2) The quality control for steel beams and steel bars will be ensured based on the inspection certificates provided by the manufactures.

(3) The quality control for cement material will be ensured based on the inspection certificates provided by the manufactures.

(4) The quality of concrete will be confirmed by collecting the quality data of produced concrete every day of the casting.

2-2-4-6 Procurement Plan

(1) Construction materials and machinery

Common construction materials except some that have special requirements are available within Cambodia and thus it is possible to obtain them locally. For some special materials which are either difficult to obtain locally, unreliable for delivery because of importation of goods, or unreliable in quality will be procured from Japan or neighbouring countries. Table able blow shows the procurement sources for the construction materials.

Table 19 Procurement sources for the construction materials

Materials	Procurement Sources		Reasons for determination
	Cambodia	Japan or neighbouring countries	
Aggregates, sand, cement	○		Locally available material have sufficient quality required for this Project
Bricks	○		ditto
Mould form materials	○		ditto
Steel bars	○		ditto
Steel beams		○	Difficult to obtain materials that have sufficient quality required for this Project
Wood building materials	○		Locally available material have sufficient quality required for this Project
Roofing materials	○		ditto
Tiles	○		ditto
Paints	○		ditto
Aluminium window frames and doors	○		ditto
Lighting fixtures	○		ditto
Sea water intake facility	○		ditto
Portable water supply and drain facilities	○	○	For some materials, goods available in Cambodia do not satisfy the required quality specified for this Project
Air conditioning and ventilation facilities	○		Locally available material have sufficient quality required for this Project
Land construction machinery	○		ditto
Marine construction machinery		○	Difficult to obtain machinery that have sufficient quality required for this Project

(2) Equipment

There is no Cambodian made measuring instrument, FRP tank, and plumbing materials such as water control valves. The measuring instruments that are currently used in aquaculture research are products made in USA, England, Italia or Japan. Use of Japanese instruments is not expected to cause any maintenance problem as there are several local shops dealing with Japanese products.

Most FRP tanks and plumbing materials used in Cambodia are imported products made originally in Thailand which often are low in material strength due to thin wall thickness. In addition, procurement of plumbing materials assured for research quality is difficult in Cambodia because there is no research facility that uses marine water in the country. These conditions obligate the Project to use Japanese plumbing materials for the construction.

Transportation of materials imported from Japan is easy because the construction site is located near Sihanoukville Port. The arterial roads are also well structured and maintained for logistic distribution.

2-2-4-7 Initial Testing and Operation Guidance Plan

The facilities and equipment systems, which would require initial testing by specialists, are listed below. During the construction period, the contractors must make the smooth transfer of technical knowledge and skills by providing specialists from the implementing and operating agencies with basic information about the devices that are required for the initial testing. The contractors must also provide guidance on how to operate each equipment system during test runs at the time of handing them over to the implementing operating agencies.

Table 20 Initial testing and operation guidance plan

Equipment/Facilities	Details of Initial Testing/Operation Guidance	Time
Power distribution	Operation of the incoming panels and emergency generator switches, plus their maintenance	During the construction and when handed over
Low current facilities	Maintenance of the lights and other common devices	When handed over
Sea water intake system	Operation and management of the sea water pump, reverse washing system	During the construction and when handed over
Aquaculture system	Operation and management of the sea water distribution system, air blower system and seawater sterilization system	
Waste water treatment	i) Operation and management of the drainage pump and blower ii) Cleaning and maintenance of the sediment tank	During the construction and when handed over
Air-conditioning	Basic operation	When handed over

2-2-4-8 Soft Component (Technical Assistance) Plan

Marine Aquaculture Development Centre (MADeC) is the first research and technical development institute for marine aquaculture in Cambodia. It will contribute for the development of marine aquaculture in Cambodia by carrying out basic research for marine aquaculture technical development as well as production and distribution of aquaculture seeds.

The core staffs expected to be stationed to the Centre are equipped with basic knowledge and techniques on marine aquaculture technology as they have been trained trough participation in marine aquaculture training courses at Southeast Asian Fisheries Development Center (SEAFDEC) in Philippines or other similar institutions in Vietnam and Thailand. Although the fingerling production of marine species is somewhat more complicated, its fundamental procedural flow does not differ from that for freshwater species which are widespread in Cambodia. Therefore, it is considered that those core staffs become capable to operate the facility in the long and medium terms. However, none of them has actual working experience in fingerling production of marine species at a practical scale. Consequently, there are some uncertainties remaining on operation of the Centre in the period right after the hand-over of the facility. Especially for the fingerling production of *Lates calicarifer*, MADeC has to start virtually from scratch from collection and management of brood fish and culture of live feed organisms. Technical assistance through an On-The-Job form to be provided during the initial phase of facility operation is expected to minimize the operational uncertainty.

Despite that it is confirmed in the Minute that Fisheries Administration will strengthen the institutional capacity of MADeC by providing the necessary budget and human resources in stages, it has yet to formulate the work programs including research contents, annual fingerling production and distribution targets, and extension activities. Preparation of an inventory for the supplied equipment is also an important work for proper operation and maintenance of the facility.

In consideration of the situations explained above, provision of technical assistance by Japanese consultants who understand well the background of the Project

Soft Component (Technical Assistance) will be planned as On-The-Job technical assistance by Japanese consultants and starting from the time around the facility hand-over is considered effective in realization of the objectives of this Grant Aid project. The category of the Soft Component (Technical Assistance) are Operation and maintenance of facility and Fingerling Production Technic of *Lates calicarifer* , its activity are as follows.

(1) Operation and maintenance of facility (1.5MM)

1) Preparation of MADeC work plan (draft) for the first year

The consultant will assist the counterpart staffs to prepare the work plan for the first year for MADeC.

2) Preparation of inventory of the facility and equipment

The consultant will prepare an installation plan for the supplied equipment and also an inventory for the equipment. The consultant will also train the counterpart staffs on registration and management system of the equipment using the inventory to develop a appropriate operation and maintenance system for the facility.

3) Workshop on operation and maintenance of the facility

Workshops will be held with participants including the MADeC staffs who are planned to be increased step by step, officers from Aquaculture Division of Fisheries Administration, and innovative aquaculture producers to discuss on various operational issues of MADeC such as human resources requirement, research and technical development activities, and schedule for fingerling production. Holding such workshops several times repeatedly is expected to facilitate the sharing of information among stakeholders, and therefore, to improve the operation of MADeC to be more practical with appointments of appropriate personnel and allotting proper budgets.

4) Survey on the possible buyers of the produced fingerlings

The produced fingerlings will be sold to fingerling distributors at the Centre as well as to small-scale aquaculture producers by delivering them using the supplied equipment (pick-up truck etc.). Although the general situation of coastal aquaculture operators were studies in the Basic Design Study of this project, it is necessary to carry out another detail survey for assessing the demand on the aquaculture seedlings for formulation of a strategic distribution plan of the produced aquaculture seeds. The consultant will assist the Cambodian staffs for conducting a survey to produce a list of aquaculture producers in order to assess their fingerling demands.

(2) Fingerling Production Techniques on *Lates calicarifer* (total 1.5MM)

1) Survey on the possible sources of brood fish collection and support for the procurement

The consultant will conduct a survey on the possible sources where brood fish of *Lates*

calicarifer are available and support the actual procurement activity by MADeC. There are two types of potential sources for the brood fish collection; cage culture producers in Cambodia and fingerling suppliers in Thailand. The consultant will prepare a procurement plan after comparing quality of brood fish, availability, means for transportation, and the cost between these two types of potential sources. Although the actual procurement must be carried out by MADeC, the consultant will assist their activities for the live fish transportation though technical advices. The consultant will also assist them for checking infectious diseases like viral nervous necrosis (VNN) using the supplied equipment.

2) Review on reproduction biology of *Lates calicarifer* and study on existing fingerling production manuals of similar species

To review existing literatures on basic biology of *Lates calicarifer* in particular on the reproduction biology including process of sexual maturation, spawning behaviour, spawning period, spawning pattern, fecundity, food and feeding habit of hatchlings and fingerlings, and to explain systematically the reproduction biology of the species to the Cambodian staffs.

There are several fingerling production manuals of *Lates calicarifer* that were already published by SEAFDEC Aquaculture Department and other institutions. The consultant will collect these manuals and other latest information on the fingerling production techniques of similar species and evaluate the techniques in order for assessing the possibility of applying them at MADeC.

3) Preparation of fingerling production manual for MADeC

Based on the review and study explained above, the consultant will prepare a draft version of fingerling production manual of *Lates calicarifer* specially adjusted for the MADeC facilities. The manual should be practical and user-friendly with plenty of illustrations and charts for ease of understanding by the Cambodian staffs who will try full-scale fingerling production first time at the Centre.

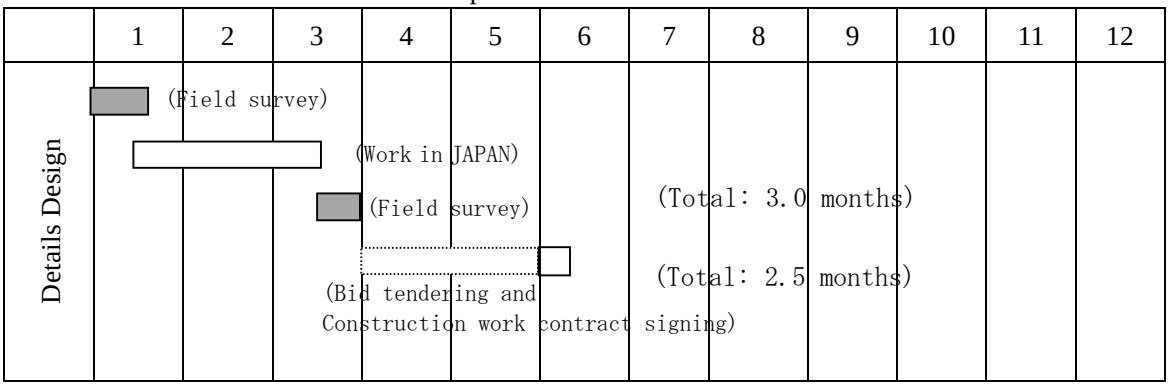
The prepared draft manual will be evaluated through the demonstration process explained below and finalized as an output of the ProJect, Fingerling Production Manual of *Lates calicarifer* of MADeC (ver. 1).

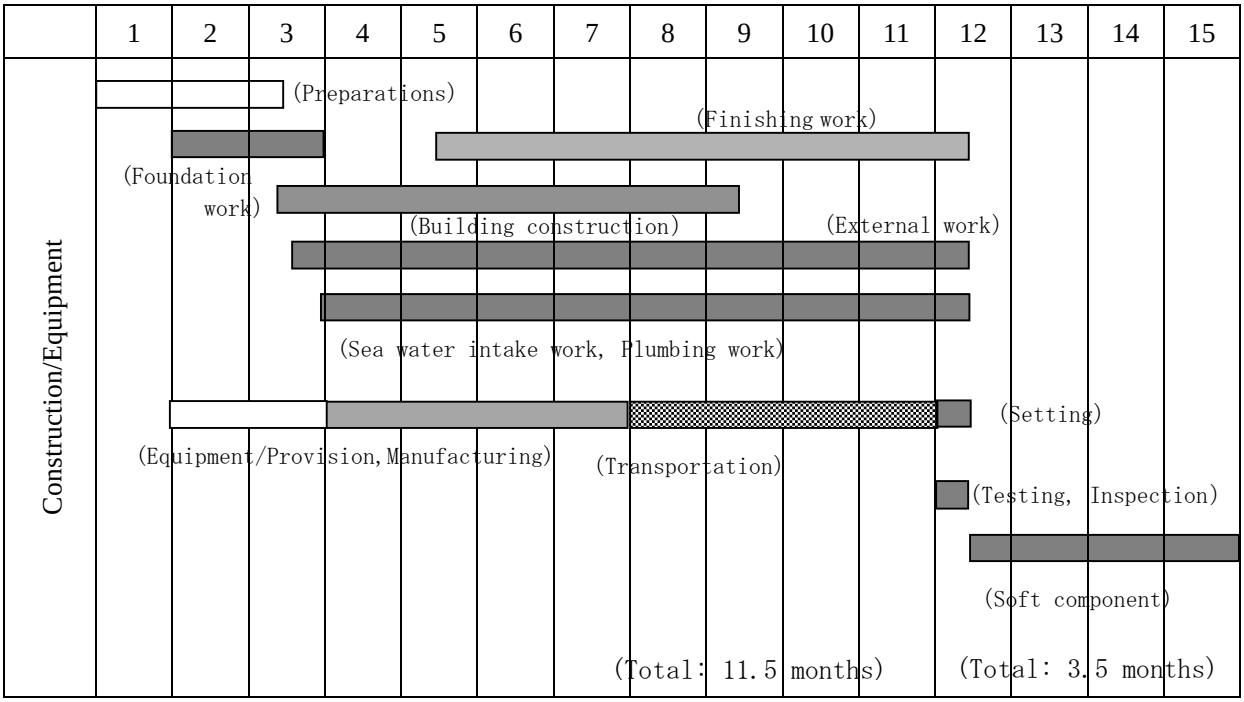
This first version of manual which will be prepared for the first year operation by inexperienced staffs should be revised within one to two years with practical issues raised and improvements made during the initial phase of operation of the Centre.

2-2-4-9 Implementation and Procurement Schedule

It is estimated that implementation of this project will take 3.0 months for execution design down to detail facilities designing, and acquisition of approval on tender documents, 2.5 months for the subsequent bit tendering and construction work contract signing, and 11.5 month for the acquisition of approval on drawings, construction work and inspection after the contract with contractor. Soft components will take 3.5 months after completion of construction. Table 2-18 shows the implementation schedule of this Project.

Table 21 Implementation and Procurement Schedule





2-3 Obligations of Recipient Country

i) Securing of the Project site, reclamation of the land, demolition and removal of the existing facilities and obstacles for the facility construction, and disposal of litters.

ii) Acquisition of all approvals and permits necessary for implementation of the Project and construction of the facility required by law in Cambodian

iii) Prompt conclusion of the Banking Arrangement and issuing of Authorization to Pay required for the implementation of the Project

iv) Securing of swift customs clearance and tax exemption arrangements necessary for implementation of the Project and construction of the facility

v) Arrangement of exemptions from all tax and any other surcharges that would be levied on Japanese workers and Japanese corporations rendering the construction work, equipment procurement, and services that are related to the Project in Cambodia

vi) Issuing of entry and stay permits required for implementation of the Project to the Japanese personnel

vii) Securing of land sufficient for temporary storage of construction materials and equipment as well as for field offices required for the construction of the facility of the Project

viii) Arrangement for keeping outsiders off the construction site during the construction period

ix) Construction and installation of fences, gates, and other similar structures that need to be build and installed around the construction site of the Project

x) Procurement of office equipment, telephone and internet communication equipment, office furniture and other similar equipment that are to be installed in the Administration and Research building and other facilities.

xi) Provision of portable water and public electricity to the specified points in the Project sites

xii) Payment of all financial costs that are not included in the Japanese Grand Aid but required for implementation of the Project

2-4 Project Operation Plan

(1) Operational Arrangement for the Project

There are three principal roles or functions of the facility constructed by this Project; namely, 1) development of marine aquaculture technology and production and distribution of seeds to aquaculture producers, 2) education and training for the extension of marine aquaculture technology, and 3) monitoring of marine environment for sustainable aquaculture development. In addition, the medium and long term functions and activities of MADeC include conservation and sustainable utilization of fisheries resources through open-stocking & stock enhancement activities, research on selective breeding for establishment of superior progeny that promote efficient aquaculture, and research on artificial fish feed development.

1)Securing of Operational Budget

MADeC is a public institution that belongs to the Fisheries Administration of the Ministry of Agriculture, Forestry and Fisheries, and therefore, securing of the operational budget for the facility is in principle responsible by the Fisheries Administration. Nevertheless, it is planned that the Centre should generate a part of income from the activities for operational expenses. As such, MADeC has to charge a price for the aquaculture seedlings to be distributed from the Centre despite it is a public institution. An important point is that the seedlings should be healthier yet the price should be same or slightly lower than those that are currently distributed in the market. Fisheries Administration will make a special budgetary arrangement for the initial 5 year during which the Centre's revenue base would be unreliable due to the technical difficulties in the fingerling production and distribution activates.

2)Cooperation with Coastal Provinces and other Provinces

MADeC plans to make special arrangements with the fisheries administration cantonments of target provinces, which are Sihanoukville, Koh Kong, Kampot and Kep Provinces, and other provinces, for fingerling distribution, training implementation, and establishment of monitoring system of aquaculture environment. These provincial fisheries cantonments are responsible for attending the requests from the aquaculture operators such as provisions of technical assistances and fish disease examinations. It has been, however, difficult to meet their expectations because there was no facility with appropriate equipment that could deal with the needs of these aquaculture operators. Implementation of this Project is expected to establish MADeC as a technical core for the marine aquaculture development system and to facilitate the capacity building of provincial fisheries officers through training programs, and thereby improve the condition for promoting the extension of marine aquaculture in the region. The works to be carried out by those trained provincial fisheries administration cantonment officers in extension and sensitization of marine aquaculture development in respective provinces using the improved facility of the Centre will further promote the marine

aquaculture development through the strengthened extension system.

3)Cooperation with NCSC and PWG

On the implementation of marine aquaculture development programs using the facility of MADeC, sufficient attention will be paid for not causing any negative impact on the surrounding environment condition but provide positive contributions to the community-based development through a cooperative working arrangement with National Coastal Steering Committee (NCSC) and Provincial Working Group (PWG).

NCSC is a committee established by a prime ministerial decree in 2001 for economic development, environmental protection in coastal region and improvement of living standard of coastal population. It is formed with governors of coastal provinces, senior representatives from relevant central government offices including Ministry of Agriculture, Forestry and Fisheries, Ministry of Environment, and Ministry of Public Works and Transportation. Implementation of this Project was reported to a regular meeting of NCSC and will be informed properly on the future activities.

PWG is also a committee established by a prime ministerial decree and formed with representatives from environmental departments, rural development departments, agriculture departments, forestry administration cantonments and fisheries administration cantonments, police, navy, other relevant offices, NGOs and other district level stakeholders of the respective coastal provinces. The function of PWG is coordination among stakeholders for implementations of various projects in the region and environmental conservation at provincial and district levels. Community-based marine aquaculture activities are often implemented in consultation and cooperation with PWG according as needed bases.

(2)Organization for operation and maintenance of the facility

Fisheries Administration has a human resources plan for MADeC as shown in Table 22. Officers having experiences in marine aquaculture research, education, and training in overseas countries will in principle form the core staff. Personnel transfers to MADeC will be arranged from IFReDI and the Sihanoukville Fisheries Administration Cantonment as well as from Koh Kong and Kampot Fisheries Administration Cantonments. In addition, the Fisheries Administration is planning to appoint the officers who are currently learning abroad to MADeC and also to employ fresh graduates from Royal University of Agriculture, Prek Leap National School of Agriculture, and Kampong Cham National School of Agriculture. The institutions shown in bracket in the column of recruitment sources in the table indicate expected potential institutions from which the required personnel are planned to be obtained.

Table22　Human Resources Plan for Marine Aquaculture Development Centre

Division		Number		Recruitment sources	Work description
		Stuff	Worker		
Administration Department					
	Director	1		IFReDI	Overall administration
	Deputy Director	1	-	Sihanoukville Fisheries Administration Canthonment	Assistant administration responsible for divisions of fingerling production, aquaculture development, and feed production
	Deputy Director	1	-	Sihanoukville Fisheries Administration Canthonment	Assistant administration responsible for divisions of aquatic disease control, and stock enhancement
	Deputy Director	1	-	Fisheries Administration	Assistant administration responsible for divisions of general affairs, engineering, training and extension
General Affairs Division	General affairs	2	-	(Fisheries Administration)	General affairs
	Accounting	1	-	(SV Fisheries Administration Cantonment)	Accounting
	Engineering	1	1	(new recruit)	Facility maintenance and engineering
Technical and Research Department					
Seed production Division	Seed production technology	3	1	(KP Fisheries Administration Cantonment)	Seed production of aquatic organisms
	Brood stock rearing research	2	-	(SV Fisheries Administration Cantonment)	Brood fish rearing
	Aquaculture seed distribution	2	-	(KK Fisheries Administration Cantonment)	Distribution of aquaculture seeds
Aquaculture Technique Development Division	Aquaculture production technology	3	1	(SV Fisheries Administration Cantonment)	Development of aquaculture production technology
	Reproduction technology	1	-	(new recruit)	Development of complete lifecycle culture system and recirculation aquaculture system
	Genetics and breeding research	1	-	(new recruit)	Research on fish genetics and selective breeding
Feed Production Division	Live feed production	3	1	(SV Fisheries Administration Cantonment)	Control and production of live feed organisms
	Artificial feed	1	-	(new recruit)	Research on artificial feeds
	Fish nutrition research	1	-	(new recruit)	Nutritional analysis of aquatic feeds
Disease Control Division	Pathology	3	-	(IFReDI)	Disease diagnosis and pathological research
	Disease control	3	-	(new recruit)	Treatment and control of aquatic diseases and immunological research
Stock enhancement Division	Open-stocking and stock-enhancement technology	1	-	(new recruit)	Research on open-stocking and stock-enhancement technology
	Environment	3	-	(Fisheries Administration)	Monitoring on aquaculture environment
	Biodiversity	1	-	(new recruit)	Research on biodiversity
Training and Extension Division	Training Plan	3	-	(Fisheries Administration)	Planning and coordination for seminar, training and technical extension
	Collaborative research coordination	2	-	(Fisheries Administration)	Coordination for collaborative research with domestic and international institutions
Total staff: 41 (Greater class officers: 4 and staff: 37), and current staff: 5					

* SV: Sihanoukville, KP: Kampot, KK: Koh Kong.

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation

Project cost bone by the Cambodian side is estimated to be 18,000 US dollar, showing in below the contents of the Project cost.

1) Removal of the existing buildings and arrangement of a relocation site	USD 5,000.-
2) Power/water supply/telephone line	USD 2,000.-
3) Gate, fence surrounding project site (appx 425m)	USD 4,500.-
4) General furniture and Banking Arrangement etc,	USD 6,500.-

2-5-2 Operation and Maintenance Cost

To secure the long-term sustainable management of this Project, it is requested to allocate appropriate depreciation expense and prepare necessary savings for implementation and renovation of facilities and/or equipments as shown in Table 5-1. The Fisheries Administration shall secure the extra budget for the operation of MADeC up to USD80,000.- per year for 5 years from 2011.

In addition, since the facilities are located in a coastland, periodic maintenance and repainting are essential for exposed part of steel made materials of the structure, mortar surface of the building and roof surfaces where sunlight directly strikes.

Table 23 Cost estimation for facilities maintenance

Facility	Years of service	Cost estimation for replacement (USD)
Sea water intake pump, sea water supply pump, air blower	6 -10years	100,000
Repainting of the steel structure or part of the building	4 -10years	30,000
Repainting of the mortar surface	7-10 years	17,000
Repainting or maintenance of the top-coat of the roof	10 years	15,000

Remark: An operating time is very limited for the emergency power generator, it is unnecessary to include in the depreciation items.

2-6 Other Relevant issue

The project site has big scale ware house which should be removed before the Project construction start.

The land preparation for the Project construction shall be begin as soon as possible after E/N and G/A between Japan and Cambodia.

Chapter 3 Project Evaluation and Recommendation

3-1 Project Effect

Implementation of the components of this Project is expected to manifest its benefits as shown in the following table. Expected number of sea bass fingerlings produced, number of the extension and training courses and the rate of artificially produced seeds to wild seeds of sea bass are used in the table as appropriate indicators to quantitatively assess the benefits of this Project.

In the field survey on marine aquaculture situation conducted during the first phase of Basic Design Study, we asked the current and previous marine aquaculture farmers in the coastal provinces about their operation and problems, and also on the distribution of aquaculture seeds using a formatted interview sheet. We also conducted a survey on the current situation and trend on the consumption of marine fish in the major consuming cities, Sihanoukville and Phnum Penh. Based on these surveys, it is revealed that the demand of sea bass fingerlings in the country is 800,000 to one million per annum. And from this estimate, it is considered to be appropriate to set the short-term fingerling production and distribution target for sea bass from the MADeC at 400,000 or 50% of the estimated domestic demand. In regards to the training programs at MADeC, the related activities had just started and the first course on fish disease (demonstration of simple disease examination methods) completed in 2008. There are requests from the fishers for seminars on more advanced and practical disease examination methods and prevention of infectious diseases and trainings on aquaculture rearing techniques. MADeC is planning to conduct about 10 courses of trainings and seminars annually from 2011 after the completion of the facility

Current situation and problems	Countermeasures taken by this Project	Direct benefits and extent of improvements	Indirect benefits and extent of improvements
There is no facility and equipment for carrying out experiment, research and technical development. Therefore, it is not possible to realize the stable supply of aquaculture seeds, development of appropriate aquaculture technology and extension of the techniques.	Construction of Marine Aquaculture Development Centre and supply of necessary equipment	1.Production of 400,000 fingerlings of sea bass become possible 2.Training on aquaculture techniques and infectious disease are conducted 10 times a year 3.Appropriate aquaculture technique is developed and technical manuals on fingerling production of sea bass and others are prepared.	1.Supply of healthy fingerlings improves the survival of aquaculture fish 2.Risk of infectious disease introduction is minimized 3.Fishing pressure to natural fisheries resources is reduced by use of hatchery produced fingerlings 4.Monitoring on water quality and bottom condition improves aquaculture environment and improve its sustainability 5.Contribution to the improvement in economic status of aquaculture farmers is expected 6.Contribution to the stable supply of marine fisheries products is expected.

3-2 Recommendations

The following recommendations are made for smooth and effective implementation of the Project.

Securing of the operational budgets

Despite the fact that MADeC is a research and development institute in its fundamental nature, it is designed to produce revenues from the operation in this Project. Nevertheless, it is difficult to achieve financial feasibility in the first three years of the operation when the centre expects to make revenues only from fingerlings sales. The Cambodian government therefore needs to take and implement appropriate budgetary measures for the operation on the centre in the initial period.

Inspection and maintenance of machinery

Establishment of the operation and maintenance system by securing of trained maintenance personnel for the pumps and electric equipment is an important factor for trouble-free operation of the MADeC facilities. Especially, the maintenance program for the seawater intake equipment which is the fundamental infrastructure of the centre must be operated reliably with appropriate maintenance plan.

Capacity building for research personnel

Technical and staff exchange programs between MADeC and fisheries research institutes of neighbouring countries like Vietnam, Malaysia, Thailand, Indonesia, etc. should be enhanced for improving the efficiency of research activities. Acquirements of aquaculture technology and research results through interactions with Southeast Asian Fisheries Development Centre (SEAFDEC) and other international institutions are expected to increase the operating effectiveness. In the future, MACDeC should not only receive the benefits through the exchange programs but also become able to give actively the own techniques and research results achieved by the staffs to the other countries as the regional and international contributions.

Conservation of aquatic environment

The Cambodian Government and the relevant ministries need to pay sufficient attentions on the conservation of coastal aquatic environment in the Sihanoukville area as it contains tourist attractions with precious beaches. Continuous monitoring of aquaculture environment is important not only from the view point of tourism development but also from the view point of aquaculture industrial development as it contribute for appropriate aquaculture operations and sustainable marine aquaculture development.

Financial support to the aquaculture fishers

The aquaculture fishers are the end beneficiaries of the techniques developed at the MADeC. Therefore, it

is desirable to provide necessary financial supports to the aquaculture fishers with establishment of soft loan programs so that they can apply the developed techniques for realization of the aquaculture development.

Establishment of aquatic disease control and prevention system

Examination of viral diseases for fingerlings, disease diagnosis for brood fish as well as young fish, and control of fish disease in general are important for securing the sustainability in marine aquaculture development. Establishment of monitoring and prevention system for infectious diseases are especially vital since they could cause significant damage to the aquaculture industry.