**PROJECT DESCRIPTION FOR PUBLIC SCOPING**

**PROJECT FACT SHEET**

| | |
|---|---|
| **Project Name** | **Proposed Angat Water Transmission Improvement (AWTIP) – Tunnel 5 Project** |
| **Project Location** | **Barangays Bigte, San Mateo and San Lorenzo, Municipality of Norzagaray, Province of Bulacan** |
| **Project Type** | **Tunnel** |
| **Project Area** | **6.43 km length** |
| **ECC Application** | **EPRMP** |
| **Project Proponent** | **Metropolitan Waterworks and Sewerage System (MWSS)** |
| **Proponent Address** | **4th Floor, Administration Building, MWSS Complex, 489 Katipunan Avenue, Balara, Quezon City** |
| **Authorized Representative**<br>**Designation**<br>**Contact Details** | **Leonor C. Cleofas, CESO IV**<br>**Administrator**<br>**Engr. Patrick James B. Dizon**<br>**Manager – Angat / Ipo Operation Management Division**<br>**+63 8922 – 2969 / dcc@mwss.gov.ph/ patrick.dizon@mwss.gov.ph** |
| **Project Implementor** | **Common Purpose Facilities (CPF)** |
| **Authorized Representatives** | **Engr. Cristotel D. Corrales – Project Manager (Maynilad)**<br>**Engr. Julius Edgar B. San Juan – Project Manager (MWCI)** |

### 1.1 Project Background

The Metropolitan Waterworks and Sewerage System (MWSS) is a Philippine government-owned and controlled corporation established in 1971 to provide water supply and sewerage and sanitation services to Metro Manila, Bulacan, portion of Cavite and Rizal provinces.

In 1997, it awarded two concession contracts to private firms for water distribution and wastewater management. MWSS retained responsibility for raw water supply. The concessionaires are Manila Water Company Incorporated (MWCI) and Maynilad Water Services Incorporated (MWSI). Privatizing the distribution services significantly improved the delivery of water supply services.

With the concessionaries' expanding coverage, demand has increased to about 40 cubic meters per second (3.4 million cubic meters per day). Until recently, the water gained through the concessionaires' nonrevenue water reduction programs could meet the increased demand.

Recognizing the Angat system's critical importance to uninterrupted water supply to Metro Manila, the MWSS prioritized the construction of a new aqueduct, which was completed in 2012. The full capacity of this aqueduct can only be achieved if a new tunnel is constructed to feed raw water into it. This will also substantially reduce the risk of full or partial water supply disruption.

In addition to the recently constructed Tunnel 4, a new tunnel (Tunnel 5) is urgently required to continuously mitigate the risk of a partial or total disruption of water supply to Metro Manila. The new tunnel will increase system capacity and will enable the system's full design capacity to be augmented and allowing the upstream tunnels downstream aqueducts to be sequentially closed, inspected, and rehabilitated or decommissioned.

The proposed Angat Water Transmission Improvement (AWTIP) Tunnel 5 Project is parallel to the Tunnel 4 Project covered by ECC No. ECC-CO-1508-0022 issued on 07 April 2017 (copy of the ECC is herein attached as Annex A) as shown in ***(Figure 1.1).***

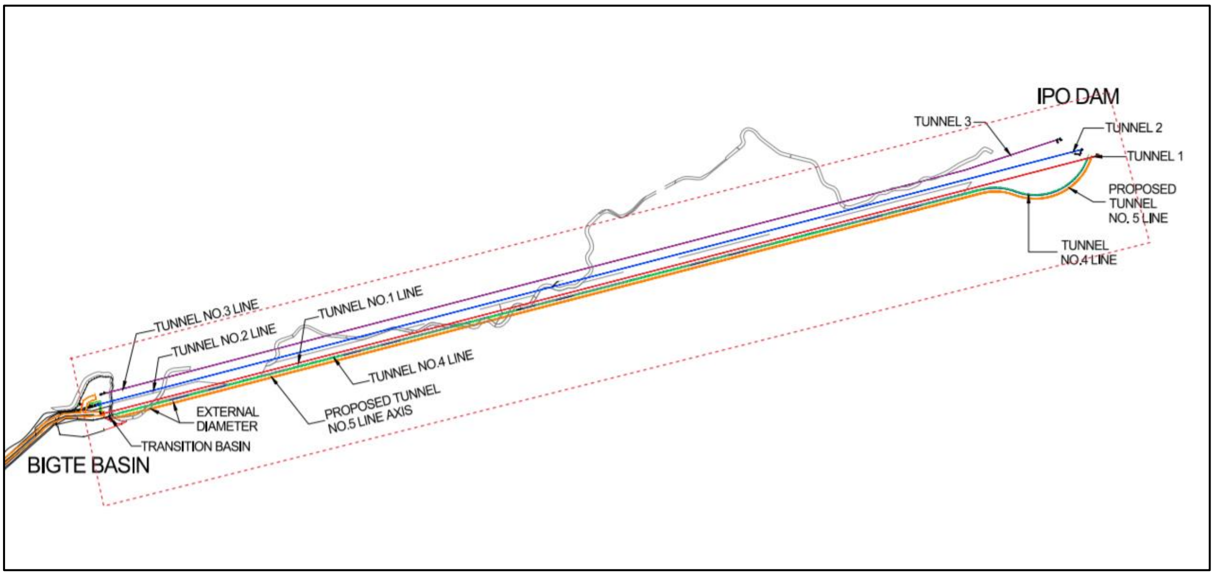



**Figure 1.1: Project Alignment** (Source: Proponent)

The Tunnel 4 was completed on June 2020, including all the component structures. The proposed Tunnel 5 has similar component structures to Tunnel 4 including the Specification. Its conceptual alignment is more or less 15 meters away from the center line alignment of Tunnel 4.

The purpose of constructing Tunnel 5 is to ensure and maintain uninterrupted supply of raw water during maintenance or repair of existing structure/structures of the delivery system of raw water from the Ipo reservoir.

### 1.2 Project Location and Area

The proposed project is located at Barangays Bigte, San Mateo and San Lorenzo, Municipality of Norzagaray, Province of Bulacan ***(Figures 1.2 and 1.3).***

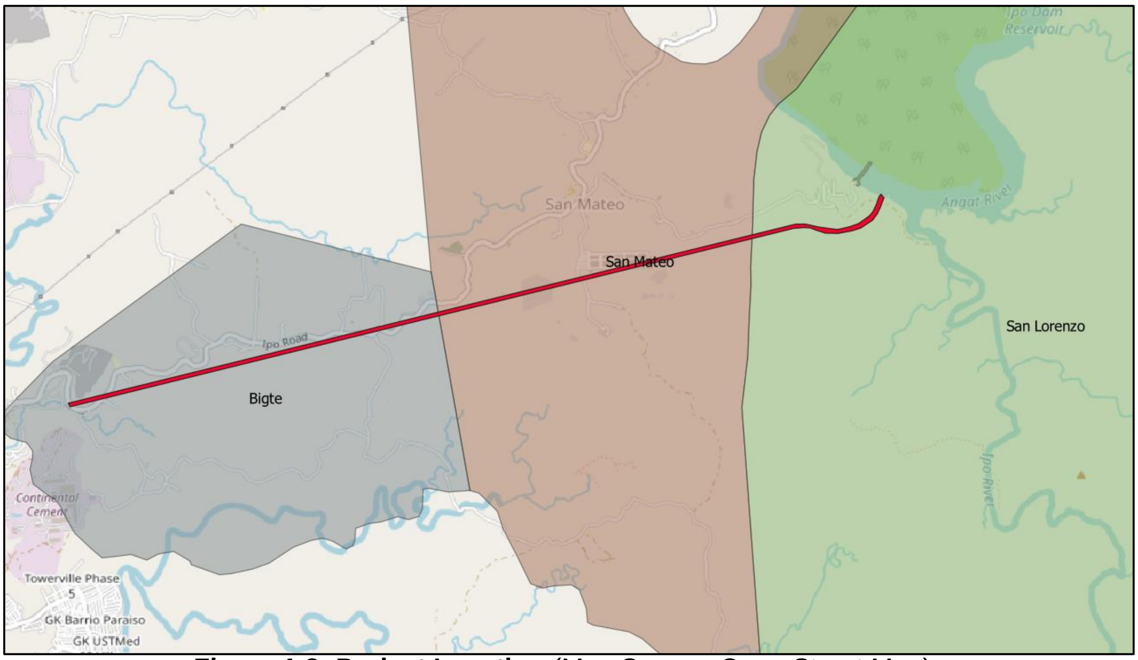



**Figure 1.2: Project Location** (Map Source: Open Street Map)

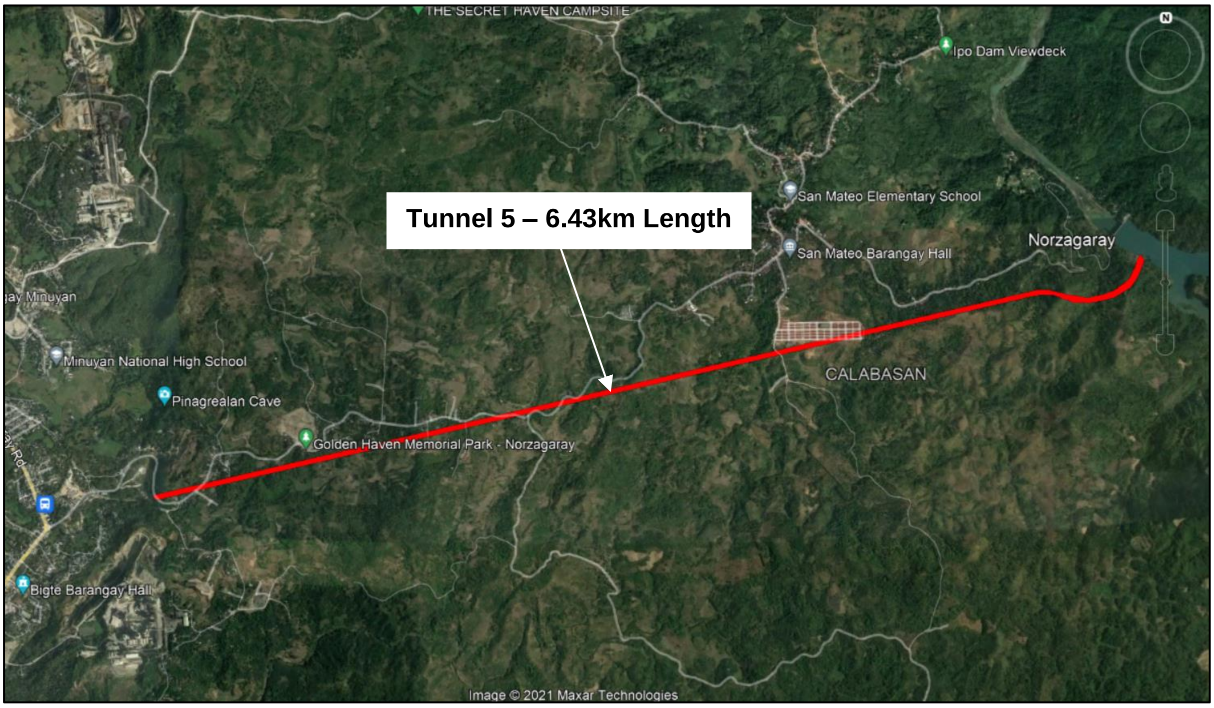



**Figure 1.3: Project Location** *(Map Source: Google Earth)*

### 1.2.1 Direct and Indirect Impact Areas

The Direct Impact Area is the entirety of the location where the Tunnel 5 project will be constructed within the MWSS right-of-way (ROW). On the other hand, the Indirect Impact Area is the 1km zone from the periphery of the Direct Impact Area. This area includes the nearest cluster of communities, major thoroughfares, etc., which will be indirectly disturbed by the proposed development. **Figure 1.3** shows the identified impact areas.

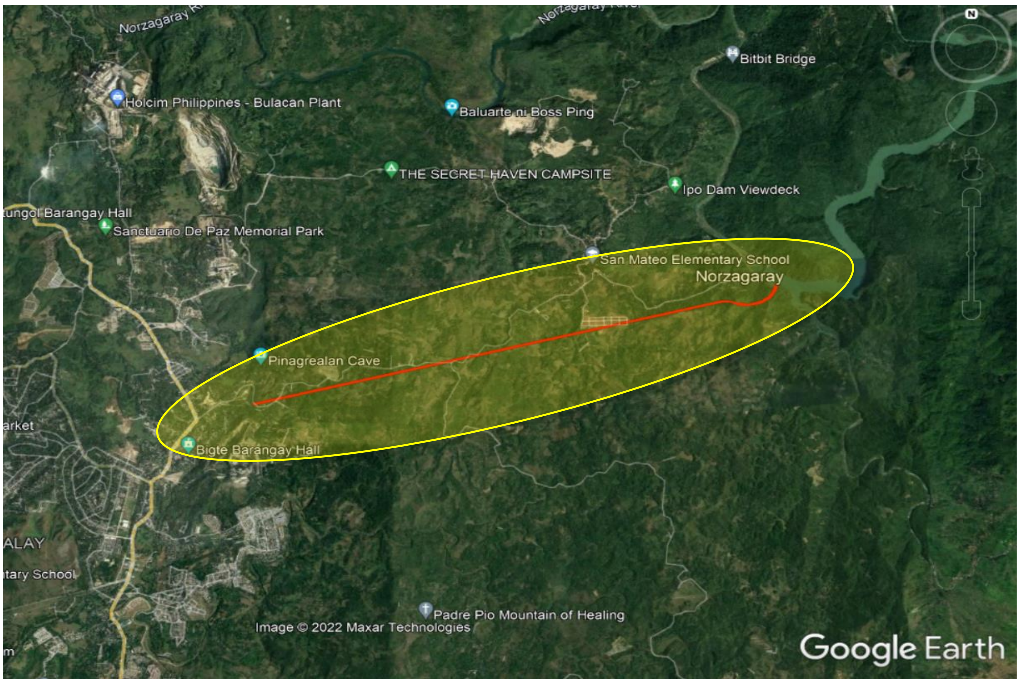



**Figure 1.4: Direct Impact Area (Red) Indirect Impact Area (Yellow)** *(Map Source: Google Earth)*

## 1.3 Project Rationale

The Project aims to deliver additional 19 cubic meter per second (minimum) from Ipo Dam Reservoir to La Mesa Portal and increase operational efficiency and capability of raw water conveyance system as well as operational flexibility during maintenance works and project implementation at the existing Tunnels and Aqueduct to maintain continuous operation.

## 1.4 Project Alternatives

### 1.4.1 Facility Siting

The project site was chosen mainly because of its strategic location since it is located adjacent to the existing tunnel 4 in which future interconnection for a new conveyance channel at Brgy. Bigte will be constructed.

### 1.4.2 No Project Option

If the project will not push through or implemented, the main impact would be on the social aspect. The proposed construction of tunnel 5 is urgently required to continuously mitigate the risk of a partial or disruption of water supply to Metro Manila, Bulacan and Cavite.

## 1.5 Project Components

The project components are listed in **Table 1.1a and Table 1.1b.**

**Table 1.1a Comparative Matrix of Tunnel 4 and Tunnel 5**

| COMPONENTS | SPECIFICATION | DIMENSIONS | MINIMUM CAPACITY (cu. m/sec) | STATUS | REMARKS |
|---|---|---|---|---|---|
| **TUNNEL 4** | | | | | |
| INLET<br>OUTLET<br>TRANSITION BASIN<br>INTERCONNECTION CHANNEL<br>LENGTH, m.<br>INSIDE DIA., m. | Concrete<br>Concrete<br>Concrete<br>Concrete | Indicated In As-Built Drawings<br><br>6,454.77<br>3.2 | 19<br>-do-<br>-do-<br>-do- | Existing<br>Existing<br>Existing<br>Existing | Completed on June 2020 |
| **TUNNEL 5** | | | | | |
| INLET<br>OUTLET<br>TRANSITION BASIN<br>INTERCONNECTION CHANNEL<br>LENGTH, m.<br>INSIDE DIA., m. | Concrete<br>Concrete<br>Concrete<br>Concrete | To be firmed up in the Detailed Design Stage<br><br>-do-<br>-do- | 19<br>-do-<br>-do-<br>-do- | Design Ongoing | Location of Inlet and Outlet are more or less 15 m. from the structures of Tunnel 4 |

**Table 1.1b: Project Components**

| Covered ECC No.<br>ECC CO-1508-0022 | Additional Components to be Covered by this Application |
|---|---|
| Tunnel 4 (6.4 km length) | Tunnel 5 (6.43 km length) |
| Intake Structure | Intake Structure at Ipo reservoir |
| Outlet Structure | Transition Basins |

| Covered ECC No.<br>ECC CO-1508-0022 | Additional Components to be Covered by this Application |
|---|---|
| Channel | Interconnection of the new Tunnel 4 conveyance channel at Bigte |
| Fencing of ROW | Stub out for the future Aqueduct 7 (AQ7) |
| Contractor's Work Area | Contractor's Work Area |
| Temporary Soil Disposal Sites | Temporary Soil Disposal Sites |



| Area A = 12,500 sqm. | Area B = 1,500 sqm. | Area C = 20,000 sqm. |
|---|---|---|
| • Gantry Crane<br>• Parking Area<br>• Material Storage / Stockpile Areas<br>• TBM Maintenance Workshop<br>• Warehouse | • Communication House<br>• Axial Fan Ventilation Facilities<br>• Air Compressor<br>• Mortar Mixer<br>• TBM Back-up System | • Site Office Accommodation<br>• Covid-19 Quarantine Facilities<br>• Segment Fabrication Plant and Batching Plant Area |


**Figure 1.5 Site Facilities Plan**

The Tunnel 4 industrial area will be the same area to be used by Tunnel 5 for the tunnel boring machine (TBM) and back up equipment assembly site. The Tunnel 5 Contractor's offices, living quarters, concrete segment lining fabrication plant and concrete batching plant will be located 3 km. away from Bigte Outlet site at Barangay Minuyan, Norzagaray, Bulacan.

Referring to the attached schematic diagram of the proposed Tunnel 5 Transition Basin Interconnection, a concrete channel will be constructed from the Stub Out at the Transition Basin of Tunnel 5 and will be connected to Tunnel 4 . A control gate will be installed at the Stub Out structure.

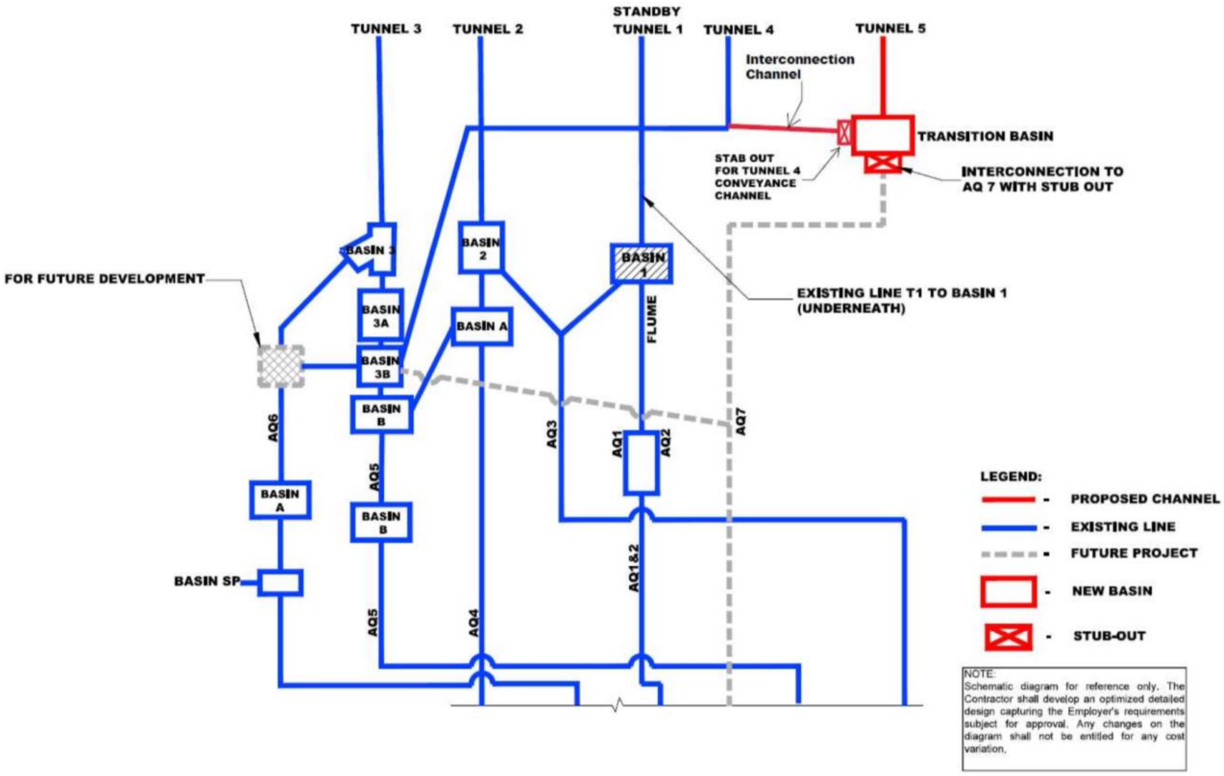



**Figure 1.6 Schematic Diagram of the Proposed Tunnel 5 Transition Basin Connection**

### 1.5.1 Energy / Power Supply

A 34.5kV Electrical Post/Overhead line on the industrial area is available on site and the electric supply for tunnel no.5 construction is from the said electrical post/overhead line and connected to the opposite

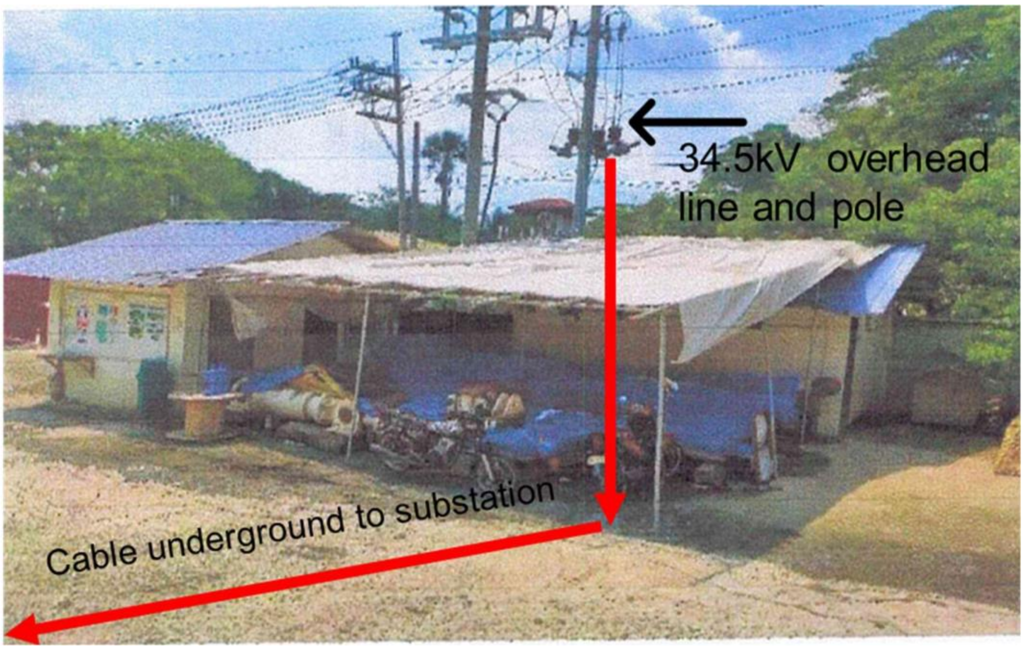



**Figure 1.7: Electrical Cable Layout**

TBM industrial area substation through buried high-voltage cable from the grid connection circuit breaker. A substation will be set up with switchgear, transformer cabinet, metering cabinet and other equipment. Electric supply system shall ensure construction safety and minimum requirements for construction lighting, drainage and ventilation during power grid outage. Two (2) 400KW diesel generator will be utilized in site as emergency backup power for construction lighting,ventilation and drainage in case the power supply is not sufficient.

Electrical Supply for TBM

The power supply for TBM and its backup system is to be provided by a 20KV high-voltage cable from themain substation in the industrial area, and transfer 20kv to 690V and 440V for equipment, which is connected to the TBM tail cable through a switch cabinet. The high voltage cable is laid on the left side of the tunnel wall, and the optical cable is also laid at the same height.

Electrical Supply for Ventilation System, Water Supply and Other Equipment in Construction Area

Power for primary ventilation system, water supply & drainage, lighting and other equipment at construction area, with a total load of about 475 KW. Is to be drawn from the 440V low-voltage power supply of the substation in the industrial area. To ensure the normal operation of ventilation, water supply equipment and lighting equipment, two diesel generators will be use in case the electrical supply for the substation is not sufficient.

Electrical Supply for Industrial Area

In the industrial area there some equipment and tools needed an electric power supply such as plants, cutter shops, tool shops and warehouses and other electrical equipment, totaling about 150KW, and the power supply is to be drawn from the 440V low-voltage power of the industrial area substation.

Power for Segment Plant

The segment plant uses electricity equipment needed electricity such as concrete batching plant, reinforced bar processing equipment, segment precast, transportation and maintenance equipment, etc. The electricity load will be about 400KW, because the plant is far away from the industrial substation, the power supply is to be connected to a 33/0.4kV, 630kVA transformer with overhead steel-core aluminum strand, and then distributed to each power point.

Power for Contractor’s Site Office & Quarters

The electricity used by the contractor's office and quarters will be mainly for office, accommodation, canteen and other electricity-using equipment, with an electricity load of about 150kW. In order to ensure the reliable and smooth electricity consumption of the segment plant, the electricity for site office & quarters is to be taken separately from the substation in the industrial area.

Lighting for Tunnel Construction

The lighting in the tunnel adopts three-phase five-lines power supply, the power supply is to be taken from the substation in the industrial area, the wire adopts BLV-50mm$^2$ flame retardant insulated wire, the lighting wire bracket is to be installed in the right side of the tunnel wall in the middle position, the lightingsupply voltage should not be more than 24V in the place of wet and easy to touch the electrically charged body.

In order to ensure that there will be enough illumination in the tunnel, the SD2 type tunnel waterproof explosion-proof energy-saving lamp with high luminous flux and energy saving will be used. Each lamp has a power of 2×28W, an illumination of 150LX and a protection level of IP65, which can meet the requirements of the tunnel environment. The lamps are fixed in the middle part of the tunnel with a spacing of 15m.

In the event of a sudden power failure or outage, the emergency generator installed in the backup will automatically start in 1 minute to provide power for the TBM's own emergency lighting and safety equipment. The emergency lighting uses emergency lighting with a discharge time of not less than 30 minutes to ensure safety.

### 1.5.2 Water Supply

The construction water supply of this project mainly includes water for production, water for contractor's site office & quarters and water for firefighting. The water consumption quantities are as follows

**Table 1.2: Water consumption of Tunnel No. 5 Construction**

| NO. | Water consumption Area | Quantity $m^3/d$ | Remarks |
|---|---|---|---|
| | Water supply for TBM | 600 | Including cooling water for equipment |
| | Segment plant | 200 | |
| | Contractor's site office & quarters | 170 | |
| | Water supply for industrial area | 50 | |
| Total | | 870 | |

The water for TBM excavation is to be taken from the nearby aqueduct or basin, a steel high level pool is built at a higher location of the tunnel No.5 outlet, with a capacity of about 60 $m^3$. Primary pumping station (with a head of about 20m) will be set nearby the aqueduct to have variable frequency constant pressure water supply to be used. Water level sensor will be set in the high-level pool to control the on and off of the primary pumping station. Two (2) pumps will be arranged in the primary pumping station, usually one is for daily use, and the other one is for backup. In case of large supply of water, two (2) pumps will be used to supply water to the high-level pool.

The TBM water supply pipeline is to be fixed along one side of the tunnel, with a suspended installation, taken from the reservoir outside the tunnel, with two $100m^3/h$-20m-50kw pumps in the high-level pool,one used and one backup, and laying DN150 steel pipes, connected by quick coupling pipe hoops, extending to the TBM clean water tank for TBM boring, and grouting water supply. A gate valve is to be set at the outlet of the high-level pool, and additional gate valves are to be added every 1000m for maintenance and overhaul.

The water supply for the segment prefabrication plant and contractor's site office and quarters will be supplied by a well drilling near the fabrication and pass purification treatment before using.

## 1.6 Process / Technology

### 1.6.1 Tunnel Portal and Outlet Construction Methodology

The construction of the tunnel portal may be summarized in the flowchart shown below.

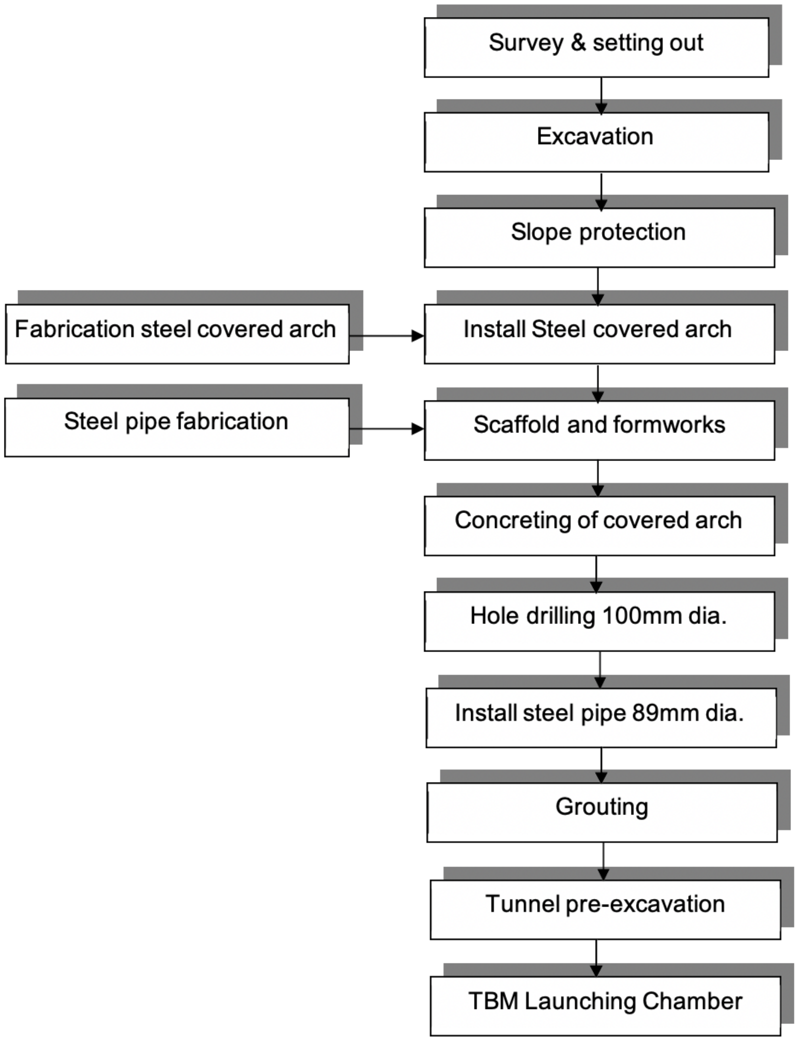



**Figure 1.8: Sequence of Tunnel No. 5 Outlet Portal Construction Activity**

A. Excavation Methodology - For both intake and outlet portal, the excavation will be executed by means of hydraulic backhoe assistby road header mounted on hydraulic backhoe and wheeled loader. Surface excavation of solid rock or for the big size boulders, hydraulic Breaker with Model 300 series Backhoe will be used. Removal of the excavated material will be removed at the same time as the excavation proceeds. Necessary tests will be conducted to determine its suitability. Unsuitable or surplus materials will be disposed at the designated disposal area.

B. Slope Protection

B.1 Two kinds of Slope Protections will be implemented:

B.1.1 For soil and Weak/fracture rock

Horizontal drill holes will be done with a diameter of 50mm, and a depth of 6.0 m, after the drilling, PVC drainpipe will be installed in the drill holes as shown on the ***Figure 1.9***. This will serve as the horizontal drains of the slope.

Concrete Cut off ditch will be constructed on the top of the cut slope, the dimension will be 500mm x 500 mm, also a strip drain shall be put (150mm x150mm) behind the layer of shotcrete and the soil. Weepholes with a diameter of 45 mm shall be installed with a spacing of 3 m to allow further drainingon the slope.
The berm will have a slope of 3% in the uphill direction to divert water accumulation at the base of the berm or in the discharge drain itself. A lined discharge drain will be constructed at the base of each berm for diverting or removing the water.

**Figure 1.9: Anchor bar with wire mesh and PVC horizontal drains**

B.1.2 For sound rock

Installation of spot bolting shall be done Φ36 with 6 m long grouted bars with a capacity of at 400 kN each. Position and specifications for spot bolting will be defined according to actual geotechnical conditions at site.

The berm will have a slope of 3% in the uphill direction to divert water accumulation at the base of the berm or in the discharge drain itself. A lined discharge drain will be constructed at the base of each berm for diverting or removing the water.

B.1.3 Provision of Drain Holes

Holes for installation of the rock bolts will be drilled with the YT-28 drilling machine. Insertion of dowels will be done in manual and grouting shall be done by means of a grouting machine. Grouting mix will be composed of water, cement, and admixture. Shotcrete will be applied by means of a shotcrete machine, the concrete mix use in shotcrete will be mixed in batching plant and transported by transit mixer truck.

Drilled holes will be cleaned by air compressor prior to the installation of the bolts/nails. Tensioning or stressing of rock bolts will be done immediately after the installation, by means of calibrated torque wrenches. Nuts and threads should always be well lubricated and maintained, all materials will be stored inside closed storage room or containers to prevent damages.

**Figure 1.10: Detail of cut off ditch**

B.1.4 Grouting **-** Grouting will be done by means of grouting machine. The grouting machine can be used specifically in narrow holes. Unless otherwise specified and/or directed/approved the following materials specification can be used, the size of the sand for grouting should be less than 2.5mm, the cement is AASHTO M 240 Portland cement.

The maximum water/cement ratio allowed for the grout will be 1:2 or instructed by the Engineer due to actual condition at site. The grout will be reaching the strength of 50KN in 30 minutes and 80KN in 60 minutes. The following cement grout characteristics:

- Concrete grout shall be non-shrink.
- High early strength.
- High strength.

To ensure a full-length contact between the grout and the rock bolts and soil nails, grouting should always start from the bottom of the holes. Each working site should have a grouting machine and a portable grouting cement mixer, to guarantee a safe but quick execution of the works. Spot testing on the installed rock bolts/soil nails shall be done prior to the start of the excavation. Pull-out tests for Rock bolts/soil nails will be done by means of a test jack which operated by a manual pump. Installation and testing procedures shall be done in accordance with the requirements and specifications of the project.

**Figure 1.11 – Actual Grouting Procedure**

A. Covered Concrete Arc Construction

B. Launching of Tunnel Boring Machine (TBM) Chamber
   D.1 Excavation of Launching Chamber
   D.2 Installation of Steel Rib
   D.3 Installation of Anchor Bolt and Wire Mesh
   D.4 Shotcreting
   D.5 Bottom Slab Launching

### 1.6.2 TBM Excavation of Tunnel 5

#### 1.6.2.1 Preparation of TBM and Auxiliary System

A. Construction Preparation

- The Electric power supply of TBM shall be independent from transformers of the Industrial Area (Area A) and Fabrication Area (Area C).
- Check the data and results of the gas monitoring system and fire monitoring system to Determine whether the TBM is ready for boring operations.
- Make sure of all light and sound indicating components are working properly.
- All speed knobs shall be in the zero position.
- Check the hydraulic oil level, lubricating oil level, and add oil immediately if necessary.

- Make sure that the water supply system and ventilation system are working normal.
- Turn on the control power of the TBM and start the hydraulic pump station, secondary ventilation system, and the TBM's own water feeding pump. Depending on the construction conditions, determine whether to start the drainage pump.
- Make sure that the belt conveyor is on the normal working mode, the extension of ventilation tube, water pipes and electricity cable is ready.
- Check the instruments for measuring the tunnel axis are working properly and provide the correct position and guidance parameters for TBM boring.
- Geological Prediction is used to forecast the surrounding rocks, by using advanced driller to detect the geological condition of surrounding rocks within 30 meters ahead, so we can obtain more accurately parameters of surrounding rock class, length of fault zone, degree of fracture, fracture water situation, etc., providing a basis for the selection of construction measures or mode for the next excavation.
- According to the position of the TBM provided by the measuring system, the position of the TBM should be checked regularly to ensure that the direction of excavation is within the tolerance in regards of horizontal, vertical and circumferential survey.

B. Steps of the excavation cycle

- Make sure that the belt conveyer is already working, and the mucking material wagon is ready and in place.
- Turn on all the acoustic and electrical alarm system in each part of the TBM to find out that the TBM is ready to work.
- Start the inverter drive motor.
- Start the lubrication system of the main bearing and the lubrication system of each relative moving part. Make sure that all the lubrication system is working properly.
- In order to make sure that the rotating torque of the cutter can be reliably transferred to the support shield, the torque cylinder should tightly hold on to the support beam. After the completion of those above steps, adjust the cutter speed to the pre-selected speed and start the duster at the sametime.
- Check the cutterhead against the working face. The appropriate advance speed selected for excavation will be set after making sure the cutterhead has been tightened against the tunnel working face and the water spraying system is started to work. When the tunnel excavation is in the soft soil, do not spray water to avoid the destabilization of the soil layer.
- Monitor the changes of various parameters and the condition of mucking material during TBM excavation. Parameters of TBM excavation can be set depending on the condition of surrounding rocks. Parameters of TBM excavation are the cutter speed, thrust force, motor frequency, thrust speed belt conveyor speed, etc.
- After the completion of tunneling, stop the advancing and set the cutterhead back about 3 to 5cm, and also stop the spraying, cutter rotation, drive motor and belt conveyer at the same time.
- Extend the front shield hydraulic support mechanism tightly, the main thrust cylinder drags the support shield forward and backup into place to complete the step change, repeat the boring preparation work and prepare to start the next excavation. When the single shield working mode is used, the forward movement of the support shield and the backup is completed by the joint action of the main thrust cylinder and the auxiliary thrust cylinder.

#### 1.6.2.2 Operating Mode of the TBM

Double shield tunneling mode will be adopted if the surrounding rock meets the requirements of double shield tunneling mode. Tunneling and segment installation, pea gravel backfilling, grouting and railway extension will be done simultaneously; if the surrounding rock condition is poor and cannot meet the conditions of double shield tunneling mode, single shield tunneling mode will be adopted, and the tunneling construction and segment installation cannot be done simultaneously. Only when completion of the segment installation, the auxiliary thrust cylinder will extend on the installed segments, and then push cutterhead forward to complete a cycle of boring, after completion of boring,then installation of segment.

In the process of Tunnel No.5 excavation, it is necessary to make accurate judgment on the condition of the surrounding rocks of the tunnel working face, judgement can be based on the geological investigation, mucking material, previous sequence tunneling parameters, and the results of Tunnel Geological Prediction. After considering all the information, the corresponding tunneling mode and tunneling parameters will be selected.

A. Double shield tunneling mode

The TBM adopts the double shield tunneling mode when passing through the rock class of Q1, Q2 and Q3. While the main thrust cylinder pushes the cutter boring the tunnel, the segment is installed in the tail shield under the protection of the tail shield. After the tunneling completes a stroke of 1.5m, the stabilizer in the front shield extends on the rock and the gripper shoes is retracted, while the main thrust cylinder is retracted, the auxiliary thrust cylinder pushes the support shield and the telescopic shield moving forward at the same time, so that the supporting shield moves forward and leaves a space for installing the segment in the end of the shield. The segments will be assembled inside the tail shield and the main thrust cylinder retract into place, then the gripper shoes extends and regrip on the tunnel rock wall, and the stabilizer retracts, the beginning of the next cycle.

Step 1: Extend the gripper shoes and retract the front stabilizer

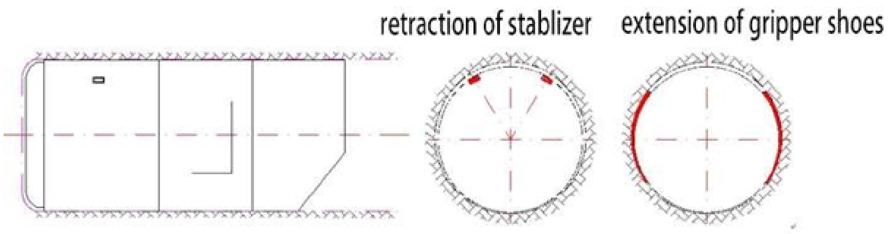



*Figure 1.11-1 preparation of excavation*

Step 2: Start of excavation

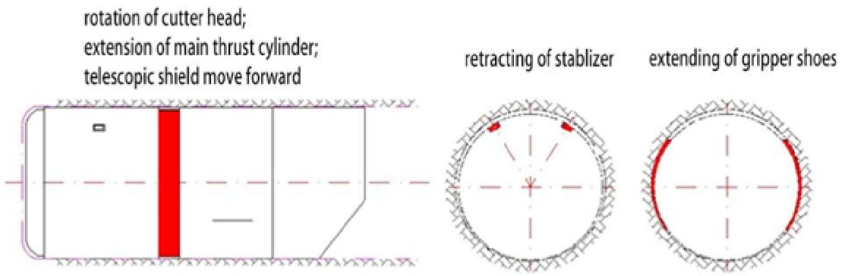



*Figure 1.11-2 start of excavation*

The main thrust system starts to advance, and the cutter rotates, and when completion of the boring stroke, the front stabilizer is extended, and the gripper shoe is retracted.

Step 3: Step changing (regripping)

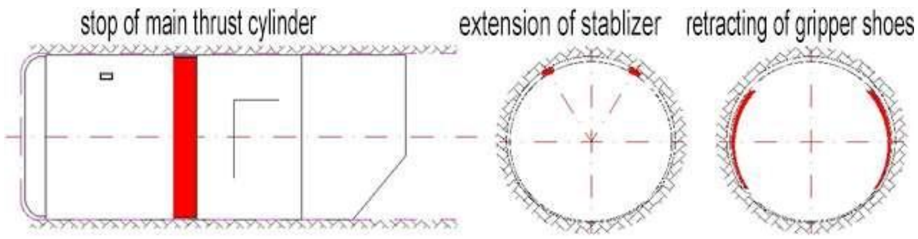



*Figure 1.11-3 regripping*

After the boring stroke is completed, extend the front stabilizer, retract the gripper shoes for step change, retract the main thrust cylinder, move the support shield forward and then extend the grippershoes for the next boring cycle.

Step 4: Support shield moving

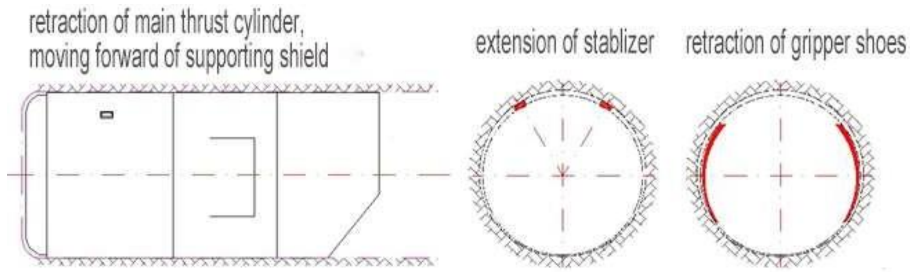



*Figure 1.11-4 moving forward of supporting shield*

Retract the main thrust cylinder, move the support shield forward, and then extend the gripper shoesfor the next boring cycle.

In this double shield tunneling mode, segment assembly can be done simultaneous during excavation. The mucking material is conveyed out of the tunnel via the host belt conveyor and the rear belt conveyor in backup into the mucking material transport wagon.

Single shield tunneling mode

When passing through the broken surrounding rocks and fault zone of Q4 and Q5, the gripper shoes cannot provide sufficient tunneling thrust, single shield tunneling mode can also be used, with the gripper shoe and telescopic shield retracted and the auxiliary cylinder using the reaction force of the propped pipe piece to push the TBM forward.

Step 1: Preparation of excavation

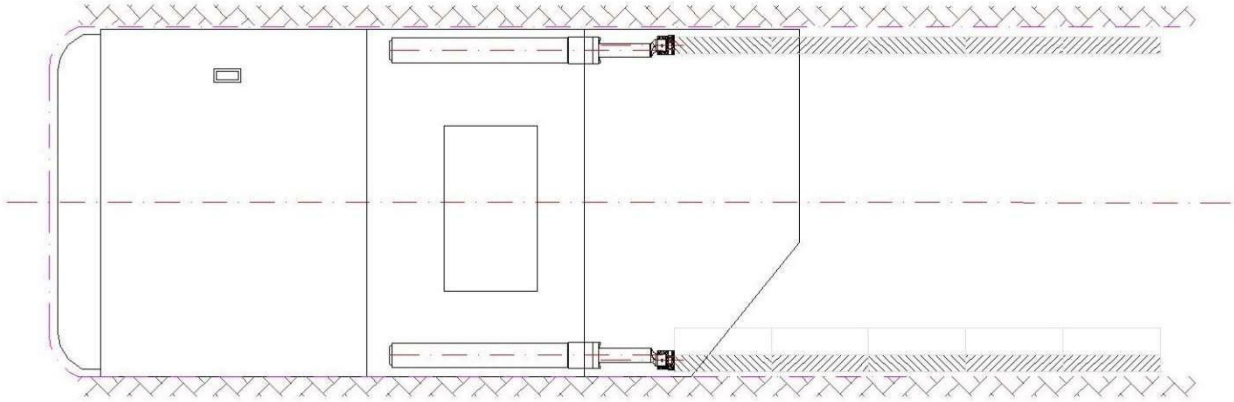


*Figure 1.11-5 preparation of excavation*

Retracting the gripper shoes and the front stabilizer assisted by the auxiliary thrust cylinder by extending in which it is directly supported by the installed tunnel lining concrete segment.

The cutter rotates and the auxiliary thrust system starts to advance; the shield body moves forward.

Step 2: Start of Excavation

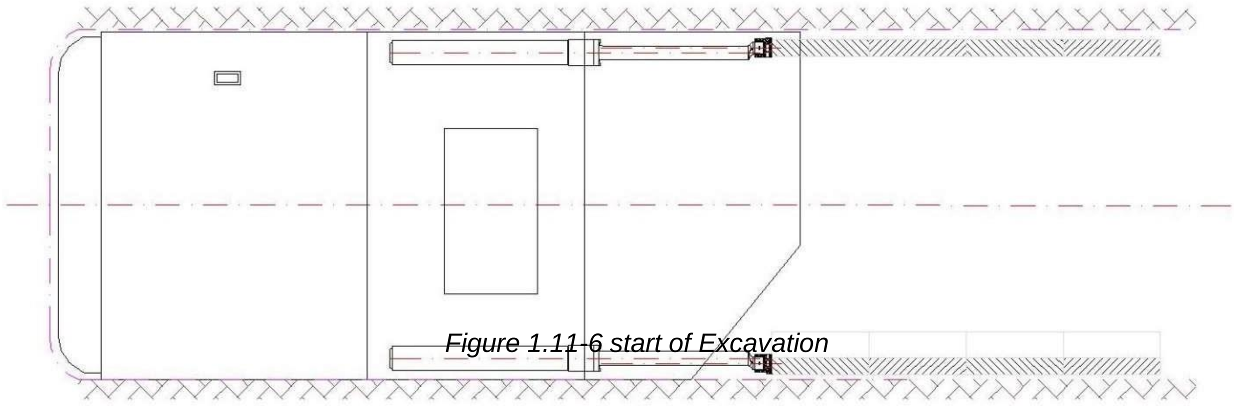


*Figure 1.11-6 start of Excavation*

Rotation of the cutterhead will start while auxiliary thrust cylinder is extending and pushing the shield.

After the boring stroke is completed, the cutter stops rotating, the auxiliary thrust cylinder is retracted and the segment is installed.

Step 3: Change step for the next cycle

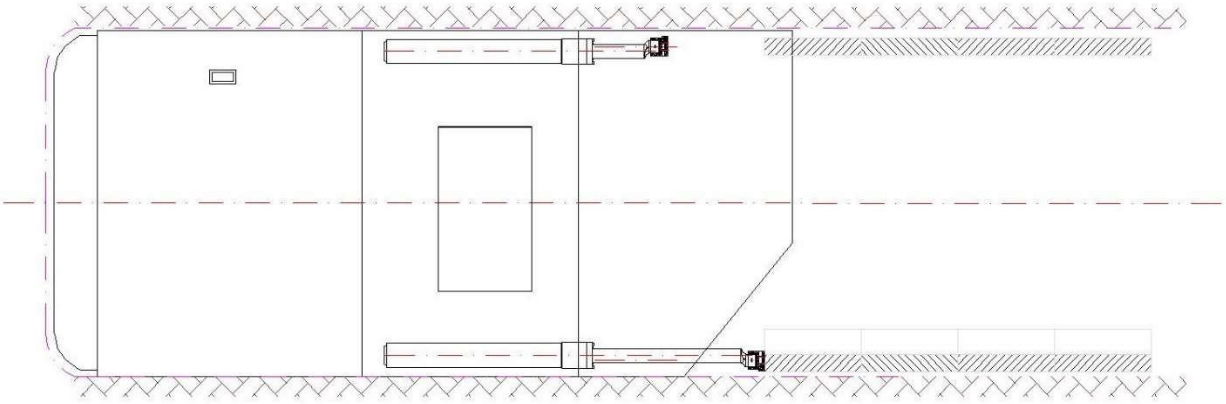


*Figure 1.11-7 step changing*

After the excavation stroke is completed, the cutterhead will stop rotating, while the auxiliary thrust cylinder is retracted tunnel concrete lining the segment will installed; after installation of tunnel concrete lining segments, the cutter rotates and proceeds to the next boring cycle; in single shield boring mode, the TBM uses the auxiliary thrust system to transfer the reaction force of the thrust required for boring to the lined precast segment to achieve boring, which cannot be lined with precastsegment in the process of boring. The efficiency of single shield tunnelling is lower than that of doubleshield mode.

#### 1.6.2.3 Measurement of the Tunnel Axis

The measurement in the tunnel carries out a three-grade measurement system. The first grade of control in the tunnel is measured once every 1000 meters, the second grade is measured once around 500 meters, and third grade measurement is extension measurement of the centerline and level within 500 meters.

The TBM laser guidance system sends the TBM attitude data to the TBM operation system uninterruptedly through the control terminal. The TBM operator adjusts the TBM attitude to keep it inthe correct position based on the detailed deviation between the TBM axis and the tunnel design axis provided by the guidance system.

The laser guidance system of TBM measures the deviation of the TBM position by the laser from the laser total station mounted on the tunnel sidewall behind the TBM.

The laser total station is fixed to the tunnel wall and connected to the control unit in the operator's room through an interface unit, while the laser azimuth and inclination angles are automatically enteredby the system.

The laser is directed to the target unit mounted on the TBM, and the target unit measures the angle between the laser beam and the target unit axis in the horizontal and plumb planes, the position of the laser beam on the target unit screen (X, Y), the left and right lateral roll angle of the target unit, and the distance from the total station to the target unit screen measured by the prism in the target unit in conjunction with the total station. All these data are transmitted to the main computer of the control unit through the connection cable. Based on the tunnel design axis data and laser latitude and longitude measurement data input to the control unit, and taking into account the installation error between the main axis of the target unit and the main axis of the TBM (this error is measured by conventional methods and input from the control unit), the X,Y difference between the center of the TBM cutter andthe design tunnel axis is calculated, and the TBM operator It is based on these data so that the TBM operator could control the attitude of the TBM.

| Automatic guidance system | Unit | Qty | Remarks |
|---|---|---|---|
| Laser total station | Set | 1 | LEICA TS15 |
| Electronic target | pcs | 1 | |
| industrial computer | set | 1 | Siemens 15‘‘ |
| software | set | 1 | Windows 7 |
| data acquisition unit | set | 1 | |

As the TBM continues to advance, the connection cable between the control unit and the laser total station is also releasing until the distance between the two reaches its maximum, at which point the laser total station and the interface unit should be re-installed forward.

On the computer, the data is displayed to monitor the position of the TBM, and record all data.

Mitigation Measures and Intervention during TBM Excavation throughFault and Weak Zones

As stated in the Concept Design report (see Geotechnical analysis and investigations programs), some fault zones can be foreseen along the alignment of the New Tunnel No. 5 and adverse conditions, with occurrence of water ingress and instability at the tunnel face, are to be expected along these tunnel sections. The position, geometry and geotechnical features will be addressed during the Final Design stage and shall be confirmed by means of the additional geotechnical investigations during excavation.

Some of the TBM specifications, such as conicity, overcut and values of TBM normal and unlocking thrust, may allow to reduce impact of squeezing conditions to avoid TBM jamming. Nevertheless, additional unfavorable rock mass conditions which may require additional interventions shall be foreseen, as described below:

- Severe squeezing conditions: as pointed out in the Concept Design Report, the technical specifications of the TBM may allow avoiding TBM jamming in converging ground. Nevertheless, in case of extremely poor geotechnical features of the ground, the load on the lining could lead to localized disturbance on the segments. In order to ensure long term stability of the lining, intervention measures may be applied as deemed necessary: drainage, ground treatment as well as fore poling from TBM.
- Water inrush/flowing ground: possible high-rate water inflows can be expected when excavating in rock with high permeability values, such as fault zones. In those sections where such

conditions are expected, intervention measures shall include systematic drainage in advance of the tunnel face (eventually by mean of Blow Out Preventer in case high water pressure is expected), ground treatment by means of consolidation grouting; execution of fore poling from the TBM can also beadopted as additional measures.

Based on these considerations, three main intervention measures can be suggested, as described below. The suggested position for the different type of intervention is illustrated in a graphical way on the Geotechnical Profile.

Intervention measure Type A - Drainage and Dewatering
Intervention measures Type B - Consolidating Grouting
Intervention measures Type C - Fore Poling

**1.6.3 Segment Installation and Backfilling**

Tunnel lining with segmental rings behind TBMs are reinforced concrete elements and must be installed properly according to the project specification and standard. In tunnelling, the determination of loads during ring erection, advance of the TBM, earth pressure and bedding of the articulated ring is difficult. The ring model and the design input values must be studied carefully according to the parameters of the surrounding soil.

The term segment refers to the precast reinforced concrete segment used to constitute the tunnel lining. The inner diameter of the ring is 4300 mm, the outer diameter is 4800mm, the thickness is 250mm, and the width of the ring is 1400mm.

**1.6.3.1. Segment Installation**

A. Inspection

- Check the correct type of ring segment with proper sequence ordered by the engineer.
- Check if there are any damages, arris defect, off-clip, or cracks in the segments surface during the segment transportation.
- Check the seals, water stop, rubber sheets, etc. have bulging, swelling, fracture, or breakage, and whether the water stop have partially failed.
- Check the connecting bolts, washers, bolt hole sealing gaskets, and lifting hole seals are complete and intact.
- Check the installation tools (air wrench, box wrench, hammer) are complete, and whether the air duct is in good condition.

B. Installation

- Clean the accumulated water and sludge in the shield.
- The segment erector operator and bolt installation personnel shall be in position.
- Install the invert segment (A) and connect the longitudinal bolts in time.
- Install the remaining segments from sides to crown. Connect and tighten the longitudinal bolts
- along with the installation of each segment.
- Install the remaining segments from sides to crown. Connect and tighten the longitudinal bolts along with the installation of each segment.
- When installing the crown segment (segment K), first put the segment at the 2/3 of the remained gap then insert it radially, and push it slowly and longitudinally while adjusting the position.
- After all the segments of the entire ring are installed, fasten all the bolts with an air wrench.
- Tighten all erection hole seals and plugs.

- The cylinders in the auxiliary thrust system extend and thus dragging whole back-up systemforward.
- After completing the previous work, the TBM can continue the next excavation circulation.
- After the segment gets out of the shield tail, re-tighten all longitudinal bolts with an air wrench intime and starts backfilling.

The TBM excavation and segment installation will be doing it at the same time, which is enabled by the main thrust cylinder system pushing on the extended gripper shoes and tail shield skin covering the segment installation area.

It takes about 20 minutes to install an entire ring of segments, which will not affect the TBM expected production.

C. Supplemental Work of Segment Installation

C.1 Connector installation

The joint connection of each segment ring includes the circular seam connecting bolts (M22) and the longitudinal seam connecting bolts (M22). When the segments are installed into a ring, the connecting bolts shall be preliminarily tightened, and then tightened again once get exposed out of the tail shield skin. Before the subsequent excavation and segment installation, the segment bolts in the adjacent 3 rings are inspected and re-tightened.

- Requirements for re-tightening of longitudinal and circumferential bolts during installation:
- After the segments have been installed into a ring, tighten the circumferential bolts, and re-tighten them when the ring is pushed out of the shield tail for 10 rings.
- After the segments have been installed into a ring, all the longitudinal bolts must be tightened. After the next excavation cycle of the TBM, the longitudinal bolts should be re-tightened before the next segment ring installation.

C.2 Jointing and Sealing Mortar

The flatness of the inner/intrados surface of the segment shall meet the requirements of segment production accuracy. In addition, Special CK mortar should be used for the longitudinal joints of the segments and the dovetail grooves in the ring joints. The jointing surface shall also be smoothed.

The mix rate of the special CK micro-expansion mortar for sealing 14 mounting holes per segment ring and 1 crown mid hole shall be determined by field tests.

The hard grout remaining on the inner/intrados surface of the segment during construction shall be removed, and then the surface shall be polished and smoothed.

1.6.3.2 Pea Gravel Backfilling and Grouting

A. Pea Gravel Backfilling

Pea gravel backfilling is to fill pea gravel in the annular space between the ring segment and the surrounding tunnel wall. And the grouting is to inject cement slurry to make the pre-compressed layerand the segment into a whole. This pre-compressed layer not only bears and transmits the pressure of the tunnel wall. In addition, it can also stabilize the structure of the installed segments and has an anti-seepage effect together with the ring segment during tunnel's operation. The specific procedures are as follows.

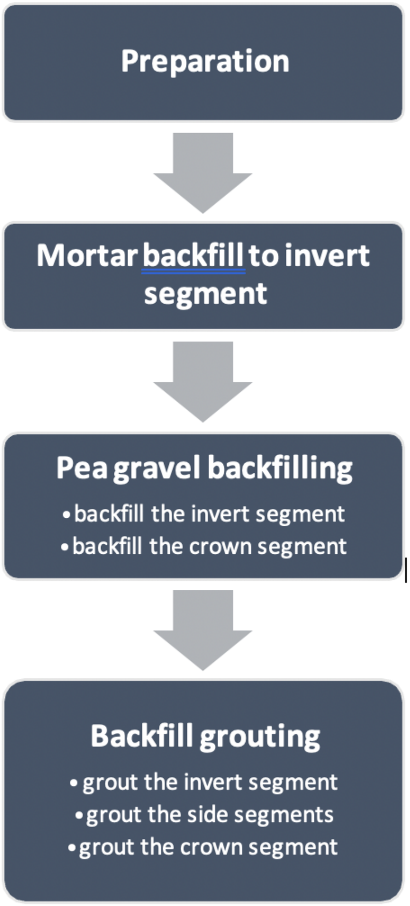



**Figure 1.12: General backfilling procedures**

B. Grouting

- The backfill grouting can be conducted after the pea gravel backfilling is completed.
- The cement grout is mixed on-site in the mixing tank located in the TBM back-up system.
- The backfill grouting is carried out at a distance of 30 to 50m from the tail shield. The grouting procedure is the same as that of the pea gravel backfilling and must keep up with the TBM's excavation.
- The grouting system has 2-unit high-speed mixers and mixing tanks. The cement and water are mixed by weight and controlled by an electronic scale. The cement grout after accurate proportioning enters the mixer for mixing. Water reducing agent (1.2 of the weight of cement %) is manually added to the mixer to make the cement grout meet the requirements of low viscosity and high permeability.
- The grout is pumped into the interstices of the pea gravel through a circulating system, which is connected to the plug in the grouting hole through a long straight pipe. Because the density of the pea gravel at the invert grouting hole is the highest, the density at the crown hole is relatively low, and the grout at the crown hole is relatively easy to move.
- Grouting process: The grouting starts from the invert hole and ends when the grout is overflowing through the adjacent holes (or the higher holes of the same ring or the lower holes of other rings), and then the grouting holes are switched to the higher one. In this way, the interstices of the pea.

- Under the specified required pressure (approximately 0.2MPa to 0.3MPa), until the grouting hole stops absorbing, another 5 minutes will be maintained until the grouting process will finishes.
- In order to fully backfill the spaces or voids, a special hydraulic system platform is constructed for supplemental grout for tunnel sections that are not fully filled during the "normal" grouting process.
- During grouting, the monitor of the grouting equipment can display data such as grouting time, pressure and grouting volume. As the grouting of each grouting hole is completed, these data will be recorded and printed out as part of the contractor's daily grouting work report and archived for future reference.
- Measures for non-usual situation: grouting work must be conducted continuously. If the process is interrupted somehow, the following measures shall be applied: grouting should be resumed as soon as possible. If the interruption takes more than 30 minutes, try to remove and clean the previous grout to the original hole depth and resume grouting. If this grouting hole still does not absorb grout, another hole shall be drilled and then re-grouted.
- Hole sealing: After the grouting finished to its initial set, the water and dirt in the hole shall be removed, and the hole should be sealed and smoothed with special CK micro-expansion mortar.

### 1.6.4 Precast Tunnel Lining Concrete Segment Fabrication

The Fabrication is located at Bigte, Norzagaray and named as Area C initially for tender purpose. The precast concrete lining segment works adopt automated production line system, the system includes the following activities: steel bar fabrication, concrete batching, formworks or steel mold, curing of concrete lining segment by steam tunnel curing, de-molding, segment storage etc.

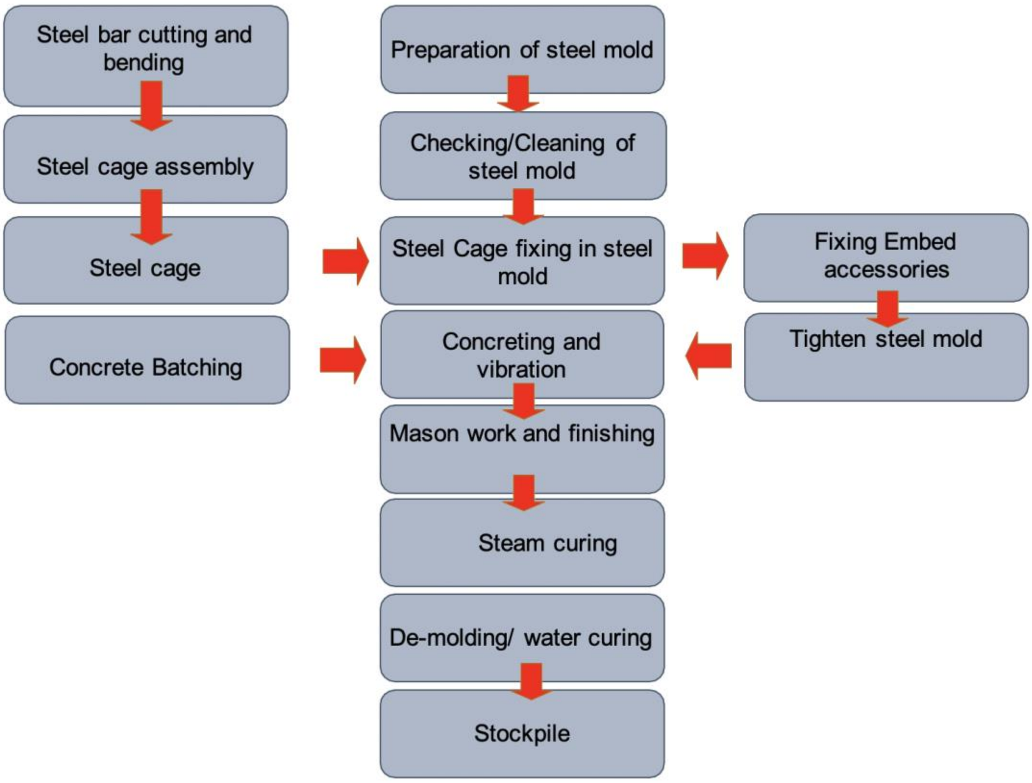



**Figure 1.13: Sequence of fabrication of precast concrete lining segment**

### 1.6.5 Intake / Inlet Construction

Stage 1

- Layout the TBM dismantling area and Inlet Structure.
- Layout the excavation line of Tunnel No. 5 inlet with two stages, first stage will be the excavation for the concrete retaining wall for inlet structure, second stage will be the excavation for the inner portion of TBM dismantle chamber

Stage 2

- Micro piles shall be installed on the tunnel face to stabilize the soil before removing the slope protection retaining wall
- Cut the existing concrete slab using the concrete cutter, during the cutting procedure always check the cutting is in the layout line
- Removing existing Structure

Stage 3 - Slope Protection Construction: Anchoring and construct beam slope to prevent the erosion of thesoil

Stage 4

- First stage excavation using the road header mounted on the hydraulic Backhoe and trencher machine equipment.
- The excavation shall be divided into two stage, first stage will be for the temporary concrete retaining wall of the inlet structure. Excavation will be done by the road header mounted on the hydraulic backhoe for the rock soil and excavation for the soil will be done by the trencher machine equipment. The width is 800mm, the excavation will be continued until reach the bottom elevation of 94.5 m.
- Construction of access going to Tunnel No. 4

Stage 5

- Rebar Fabrication
- Rebar cage for the retaining wall of the inlet structure will be fabricated on the working platform near the Tunnel No.5 inlet.
- Rebar Installation by means of crane
- After the Rebar cage was fabricated and properly checked, the rebar cage will be lifted by a crane and installed on the excavated portion of intake.
- Concrete Pouring
- After checking the rebar properly installed and fixed, pour concrete mix by the concrete pump

Stage 6

- Second stage excavation
- If the concrete pass the required strength, second stage of excavation on the inner portion of the TBM dismantle chamber will be done using the hydraulic excavator. This area will be served as the dismantling area for the TBM
- Bottom Slab for inlet structure Construction
- Rebar installation for the bottom slab will be installed and fixed properly, pour concrete after checking rebar is complete and make sure that rebar was no movement and displacement

Stage 7

- Dismantling of the TBM cutterhead, lifting with mobile crane positioned on the working platformat 103.50 and transport back through the tunnel or alternatively hoisted up to be loaded on truck.
- Transportation of the TBM backup outside the tunnel to the opposite direction of the excavation of the TBM

Stage 8
- Formworks
- Rebar
- Concreting
- Sluice Gates
- Slope protection

Stage 9
- Intake works - finishes.
- Demolish Existing Diaphragm Wall and temporary retaining wall.
- Execution of rip-rap layer to protect the intake foundation structures.
- Log Boom Installation

### 1.7 Project Size

The proposed Tunnel 5 Project is 6.43 kilometers long and 4.2m diameters wide which will traverse barangays Bigte, San Mateo and San Lorenzo. With a design capacity of 19 $m^3$ or 1,700 mld.

### 1.8 Description of Project Phases and Corresponding Timeframes

Project implementation is divided into four major phases: (1) pre-construction phase; (2) construction phase; (3) operational phase; and (4) abandonment phase. The first two are also considered pre-operational phases. Construction shall commence after the issuance of all necessary permits including the Environmental Compliance Certificate (ECC) for the project. The operational phase shall start as soon as the facility and its supporting facilities have been completed, established and passed the preliminary testing.

#### 1.8.1 Pre- Construction Phase

In this phase, all necessary permits from the LGUs and concerned government agencies will be secured prior to commencement of any project activities. Comprehensive works will also be required to finalize the plan and design methodology of the proposed project. The number of workers during pre-construction phase may vary depending on the requirements but most of which are heavy machinery operators or truck drivers.  The work required will be subcontracted, with a condition that the priority will be given to the qualified workers in the host municipality.  The project proponent will coordinate with the LGU for proper identification of the qualified residents in the municipality.

#### 1.8.2 Construction / Development Phase

Procured under a Design and Build Contract - new tunnel approximately 6.43 kilometers (km.) long. Works consist of:
- Intake structure at Ipo reservoir;
- Slope stabilization at intake structure;
- Tunnel works;
- Transition basins at Bigte;
- Interconnection of the new Tunnel 4 conveyance channel at Bigte;
- Provision of stub out to the future aqueduct 7 (AQ7); and,
- Slope stabilization at outlet structure.
- Interconnection of BNAQ7 to Tunnel 5 Project

Target completion by Second Quarter of 2024.

#### 1.8.2.1 Construction of Support Facilities

A. Construction of Temporary Site Facilities (Area C) – all temporary site facilities shall conform to all applicable standards and codes set down by the government for this purpose, including the sanitary requirements of the Department of health (DOH). These shall include:
- Field Offices
- Warehouse, Fabrication and Motorpool areas
- Water and Power Supply
- Accommodation and Quarantine Facilities
- Parking Spaces
- Security facilities and services
- Sanitary and Safety facilities
- Clinic

B. Construction of the Industrial Area (Area A) – this area will be dedicated to industrial activities and will be located at a 12,500 sqm area, west of the proposed Tunnel 5. This area shall have the following facilities:

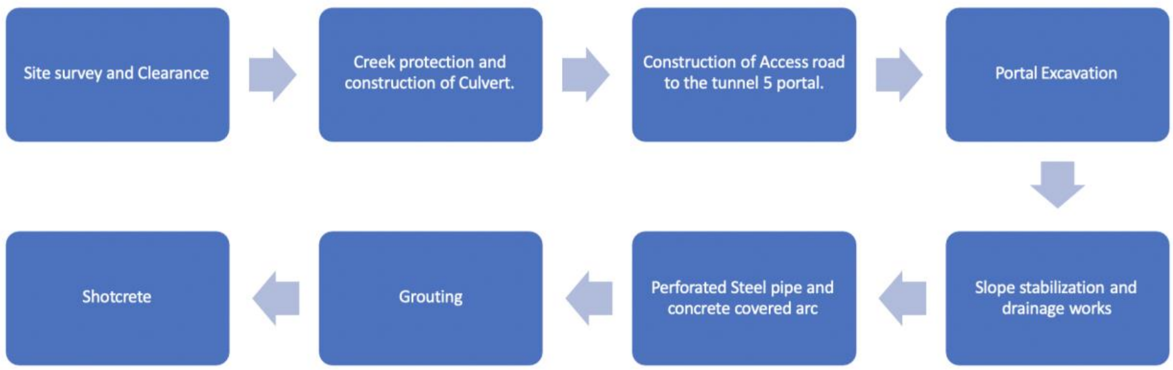
- Security and fencing.
- Electrical Substation with diesel generator.
- Fuel Station/tank.
- Temporary Storage area for prefabricated segments.
- Gantry Crane for prefabricated segments.
- Pea-Gravel Hopper.
- Cement bulk.
- General Warehouse.
- Sedimentation tank for sewage water from tunnel construction
- Parking area for vehicles and Equipment.
- Material storage/Stockpile areas.
- TBM cutter library and maintenance Workshop.

C. Preparation and Setting up of the Construction Area (Area B) – An area approximately 1,500 sqm., will be allocated for outlet portal construction area for the tunnel's construction activities. To enable excavation works done by TBM, the outlet portal construction area locates at level +92.50 mapproximately. A concrete TBM platform and access road will be constructed to connect the existingroad. When constructing the TBM platform and access road, the creek nearby will be protected throughthe construction of Concrete box culvert and maintained. The construction area connects the industrial area by two parallel rails with a gauge about 900mm and a distance about 450m.TBM will be assembled and launched at the outlet portal construction area, and along the rail the back-up will be mounted.

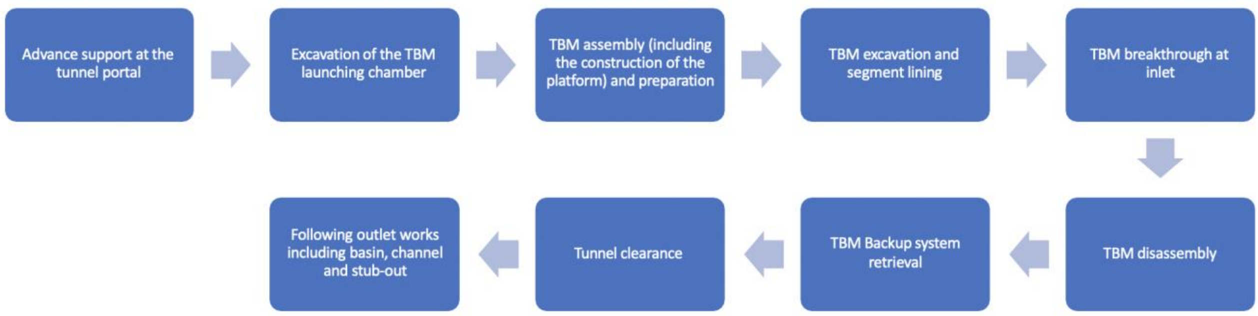
#### 1.8.2.2 Tunnel Construction

The construction process is summarized in the following process charts. The detailed discussion is found in the preceding section, Section 1.6 (Process and Technology)

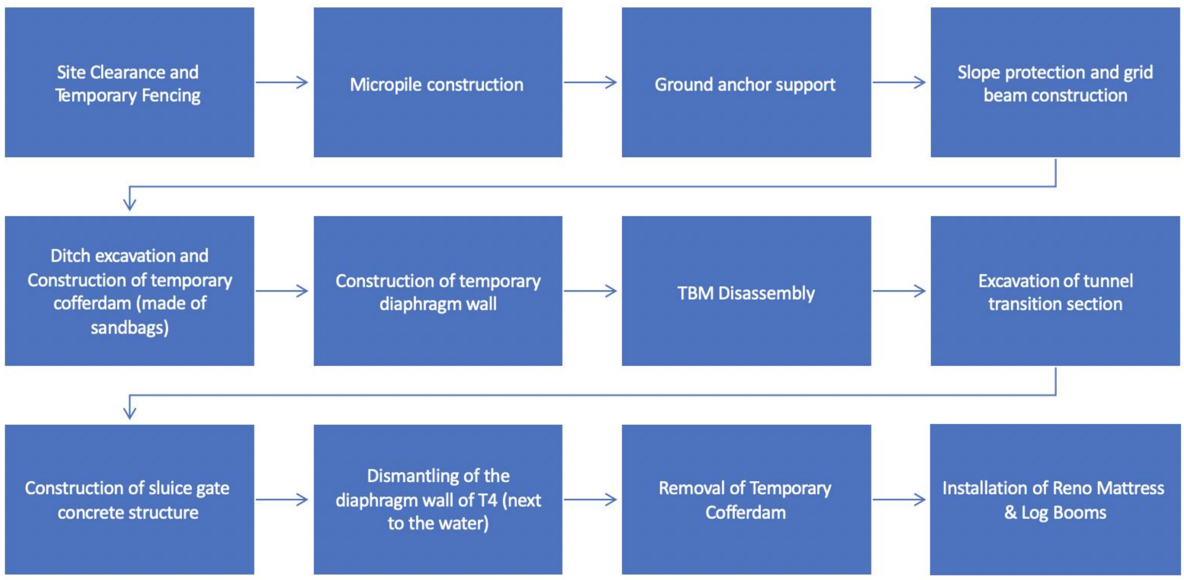
A. Tunnel Portal and Outlet Works




B. Tunnel Boring / Excavation by the Use of Tunnel Boring Machine (TBM)




C. Tunnel Inlet Works



D. Commissioning

Phase 1 - Pre-Commissioning Test

Pre-commissioning is a process where all equipment and components are already installed, pre-commissioned, tested and functional. Corresponding documents can be found as an Appendix A to this plan.

- Installation Checklists
  All equipment, component and materials shall be inspected for workmanship and to ensure that no damage was done during installation or construction.

- Electrical System Tests
  Electrical & earthing system shall be inspected for proper connections and terminations. And various tests shall be conducted to ensure compliance to Institution of Electrical Engineers' Wiring Regulations.

- Equipment Functionality Tests
  All equipment shall be pre-tested and dry-run conducted.

- Leakage Tests
  Shall be conducted to Tunnel, Stoplogs & Sluice Gates to warrant that contractrequirement were met.

Phase 2 – Commissioning Test

Commissioning Test shall only commence once all the conditions specified on the Pre-commission Test are satisfied. Commissioning Test is a process where overall system shall be subjected to simulation to actual operating conditions. Corresponding documents can be found as an Appendix B to this plan;

- System Functionality Test and Procedure
  The whole system shall be tested and shall be subjected to partial, full-load,emergency and shutdown conditions.

- Wear Testing Checklist
  All equipment shall be monitored for excessive noise, vibrations, early sign of wearand tear.

- Water Tightness Test
  Shall be conducted to the Conveyance Channel.

- Sluice Gates Isolation Tests
  Inlet Sluice Gates shall be isolated to demonstrate the maintainability of the gates.

  The whole system shall be subjected to continuous testing for Thirty (30) Days to demonstrate and to ensure that the work meets both Operational and Performance Criteria. Corresponding documents can be found as an Appendix C to this plan;

- Performance Testing Checklists
  Whole system shall be operated continuously for thirty (30) days and shall be monitored for reliability, functionality and performance.

- Training Plan
  Training shall be conducted to ensure that the end user operations personnel are capable of operating the system.

### 1.8.3 Operational Phase

The operations and maintenance of Tunnel 5 will be managed by the MWSS with its implementing partner, the Common Purpose Facilities (CPF), guided by an Operation and Maintenance which contains the following:

1. Minimum Organizational Structure for the Water Supply System Operator
2. Staffing plans including staff capacity requirements and job descriptions
3. Permits and Regulations
4. Water Supply Infrastructure and Equipment in Ipo Dam and Bigte Basin
5. Tools and Spare Parts
6. Water Supply Operation including goals/targets, activities, schedules, activities, etc.
7. Preventive/Regular Maintenance of the Water Supply System
8. Emergency Operation
9. Reporting
10. Monitoring and Evaluation including performance indicators
11. Training Requirements

Tunnel 5 will be equipped with the following major equipment:

1. Sluice gate in the interconnection to aqueduct 7 (AQ-7)
2. Sluice gate in intake facility
3. Moveable cleaning machine
4. Stoplogs and lifting beam
5. Flow measurement and control system

#### A. Tunnel Operation

The proposed Tunnel 5 intends to deliver raw water from Ipo reservoir to the outlet transition basin located at Bigte, Norzagaray, Bulacan. A brief description of its operation is described below:

1. To draw water from the Ipo Reservoir, the sluice gate will be opened gradually. Opening of sluice gate will be automated. Manual operation is also included in the gate operation system.
2. To control the inflow of water into the tunnel, the sluice gate opening can be lowered or raised. Graduated rod extension of the screw lifting mechanism will indicate the sluice gate opening.
3. From the intake, the water will flow down to the outlet transition basin as shown on ***Figure 1.14***.
4. To control water releases to the interconnection channel and aqueduct 7, sliding gates that will be installed in the transition basin stub out will be operated. See ***Figure 1.15***.

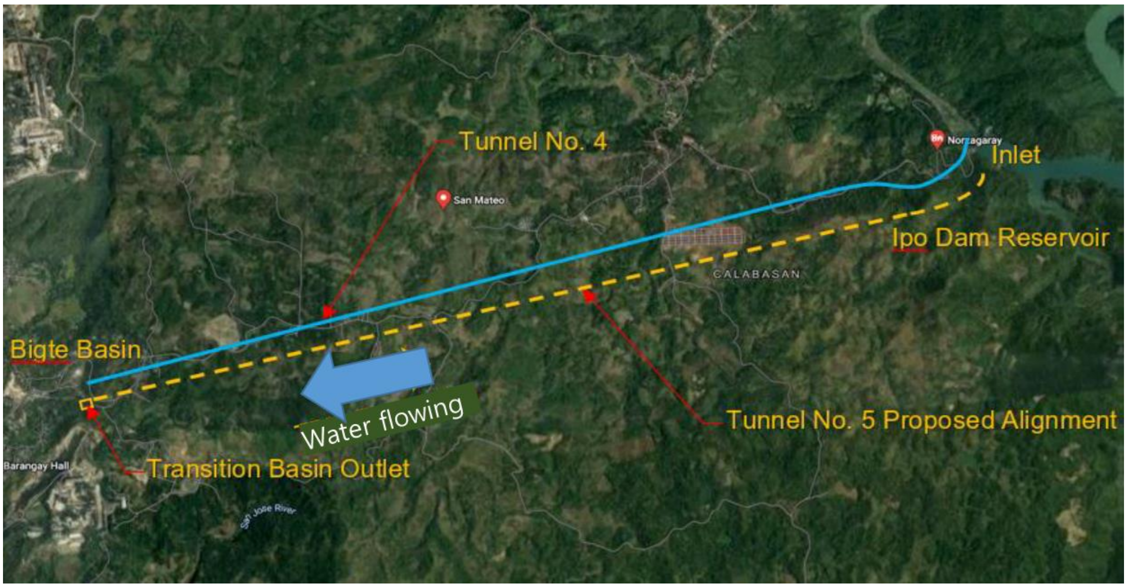



**Figure 1.14: Water flowing from inlet to Bigte Basin**

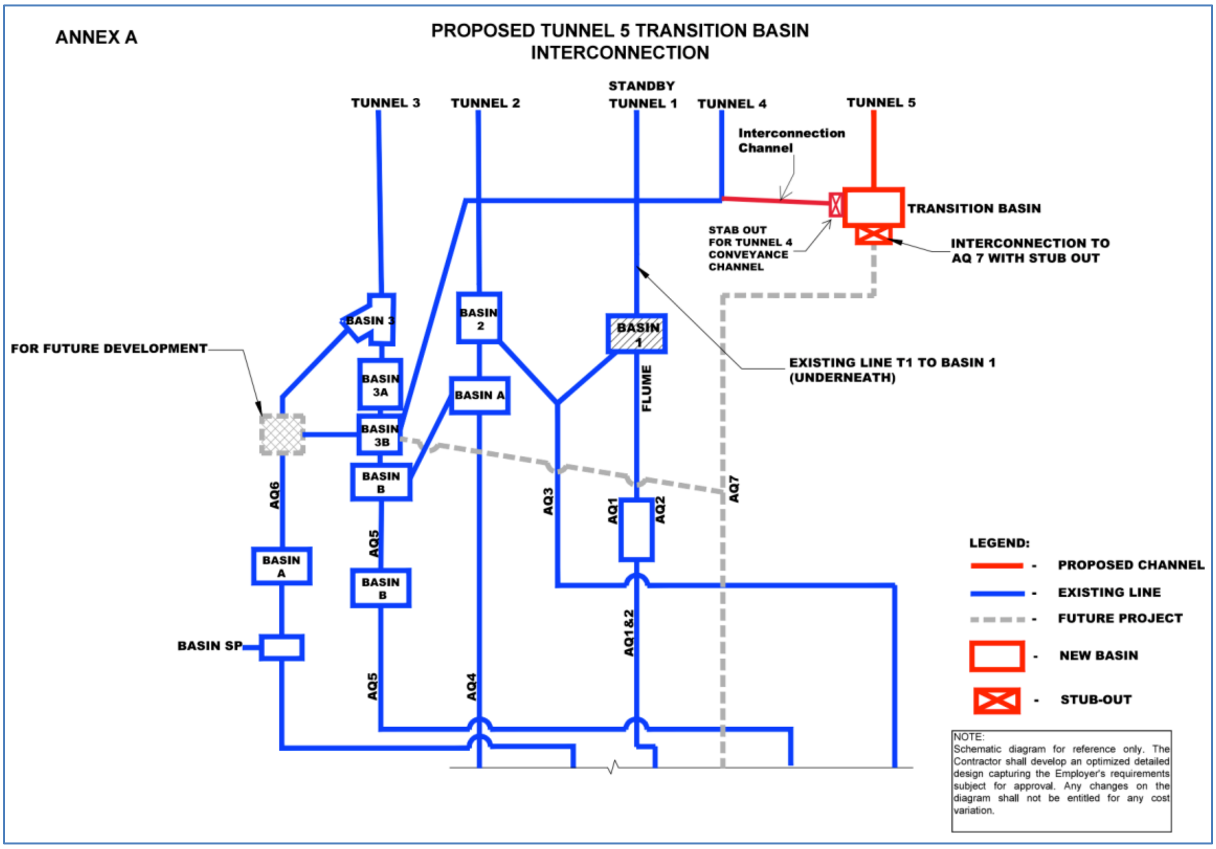



**Figure 1.15: Proposed Intersection Tunnel 5 and AQ-7**

*Operation and Maintenance Plan*

Timely maintenance will assure that a dam and reservoir would remain in good working condition and will prevent more harmful conditions from developing. Individual maintenance tasks should be noted, with a description of the area where the maintenance is to be performed, the schedule for performing the tasks, and reporting procedures.

Typical routine maintenance tasks performed at most electro-mechanical equipment include:

1. Intake facilities: Tunnel Structure, Trash rack, Stop-logs, Sluice gate, Actuator, Log boom
2. Outlet facilities:  Tunnel Structure, Transition Basin, Flow measurement

Other maintenance works that may need to be performed in protected slope and embankment to its design section, seepage problems, erosion, displaced riprap, cracking in embankment, etc. ***Figure 1.16*** provides the intake layout below:

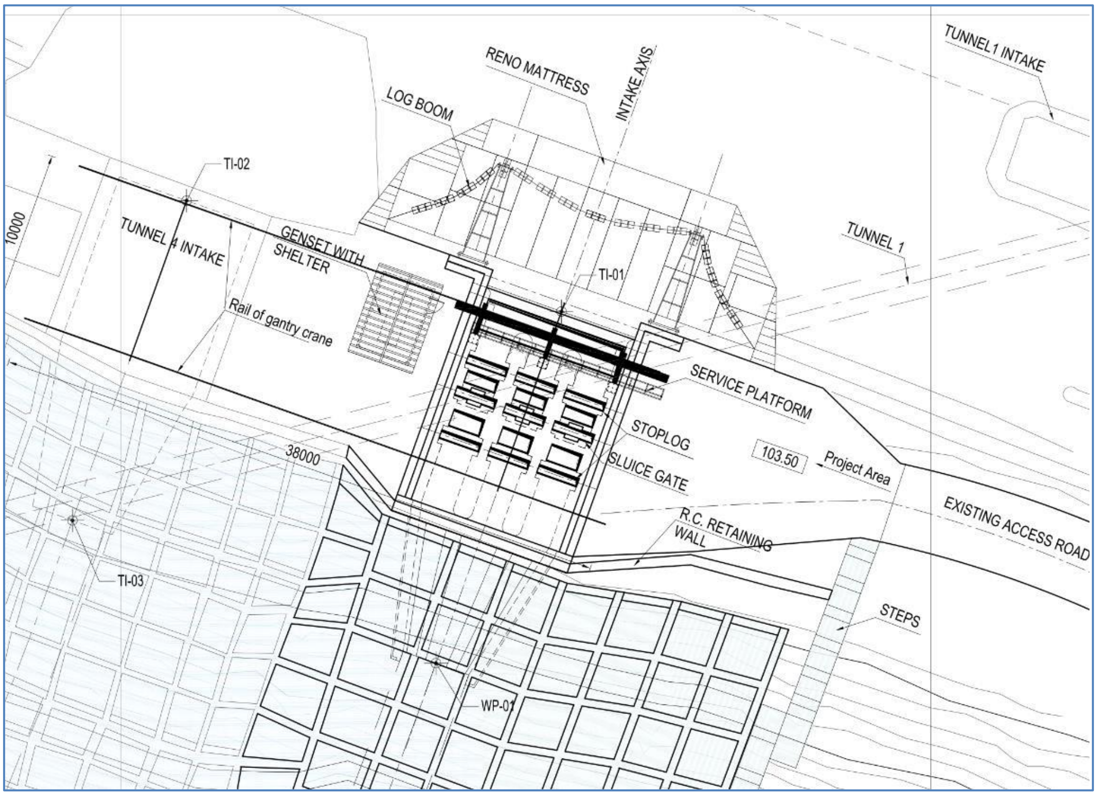



**Figure 1.16: Intake layout**

**B. Operation Process for Inspection and Maintenance**

1. Trash Rack Cleaning. Installed Trash Rack at the upstream of Stoplog will be cleaned mechanically. Trash Rack cleaner will be designed and installed by CWE and Operational Manual will be provided.
2. Stop Log will be used during inspection and maintenance of sluice gate. The Stop Log will be lowered and raised by movable hoisting cable installed in a stationary gantry crane.
3. Inspection and Maintenance of Stop Log will be done when they are and stacked up in designated location.
4. Inspection and maintenance of the tunnel, structures at the Bigte outlet and stub out gates will be maintained by closing intake sluice gate at the Ipo reservoir.
5. Equipment/Mechanical and Electrical maintenance shall be maintained following instruction manuals of every supplier/manufacturer including the frequency of periodic maintenance period.
6. The tunnel will be designed with 100-year life, the design life of Ipo intake structure, Bigte outlet structures and transition basin is 75 years and the frequency of inspection and maintenance will be determined and will be set by CPF/MWSS.

### 1.8.4 Abandonment Phase

There are no plans to abandon the project once operational. In the event, however, of a forced closure, the proponent will submit an Abandonment Plan to the EMB one year prior to abandonment of the project. The proponent will adhere to the policies of the EMB and other government agencies with regard to the decommissioning of the project. During abandonment, the proponent will ensure that all environmental mitigating measures will be adopted and followed to minimize negative impact to the environment.

## 1.9 Manpower

The proposed project is expected to generate jobs and livelihood to the host community, the proponent is committed to provide equal opportunities for employment to the host barangays and municipality as well as its neighboring communities. Initially, the Proponent has estimated their manpower utilization as shown in ***Table 1.3***.

### 1.9.1 Hiring Policy

It shall be the policy of the proponent to hire qualified local applicants based on the following order of priority:

- First Priority: Residents within the primary impact areas;
- Second Priority: Residents within the secondary impact areas; and
- Third Priority: Resident of Barangays adjacent to the secondary impact areas.

## 1.10 Indicative Project Investment Cost

The project as estimated represents a significant level of investment, with capital expenditure in the order of Php 3,200,000,000. The capital expenditure associated with this project relates to all necessary planning and approvals, development of the site and construction of related infrastructures. This investment will generate considerable long-term economic benefits on a local, regional and even on a national scale.

## Table 1.3: Manpower Utilization

**Design and Build of the Angat Water Transmission Improvement Project (Tunnel 5)**

**Monthly Manpower Utilization Schedule**

| No. | Description | Year | Year 1 | | | | | | | | | | | | Year 2 | | | | | | | | | | | | Year 3 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
| | | Day | 30 | 60 | 90 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | 360 | 390 | 420 | 450 | 480 | 510 | 540 | 570 | 600 | 630 | 660 | 690 | 720 | 750 | 780 | 810 | 840 | 870 | 900 | 930 | 960 | 972 |
| 1 | Project Manager | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | Project Program Manager | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3 | Quality Control Manager | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **II. DESIGN** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Technical Manager | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | Deputy Technical Manager | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | Civil/Structural Engineer(Design Manager) | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | Civil/Structural Engineer | | 3 | 3 | 3 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | Tunnel Specialist | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | Geotechnical Engineer | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | Chief Surveyor | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | Geodetic engineer | | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | E and M Manager | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | Electrical Engineer | | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | Mechanical Engineer | | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | Hydraulic Engineer | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | Social Safeguard Specialist | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | Social and Gender Specialist | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | Environment Specialist | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | Architect Designer | | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | Asistant engineer | | 4 | 4 | 4 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 21 | CAD Operator | | 6 | 6 | 6 | 6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **III. CONSTRUCTION** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 | Construction Manager | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 23 | Deputy Construction Manager | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 24 | Technical Manager | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 25 | Deputy Technical Manager | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 26 | Safety Manager | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 27 | Civil/Structural Engineer(Design Manager) | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 28 | Civil/Structural Engineer | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 29 | HSE Officer | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 30 | Civil/Structural Engineer(Tunnel Construction) | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 31 | Tunnel Senior Engineer | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 32 | Chief Surveyor | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| No. | Description | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Year | Year 1 | | | | | | | | | | | | Year 2 | | | | | | | | | | | | Year 3 | | | | | | | | |
| | | Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
| | | Day | 30 | 60 | 90 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | 360 | 390 | 420 | 450 | 480 | 510 | 540 | 570 | 600 | 630 | 660 | 690 | 720 | 750 | 780 | 810 | 840 | 870 | 900 | 930 | 960 | 972 |
| 33 | Geodetic engineer | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 2 | 2 | 2 | 0 | 0 | 0 |
| 34 | Geotechnical Engineer | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 35 | Plant and Equipment Manager | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 36 | E and M Manager | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 37 | Electrical Engineer | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 38 | Mechanical Engineer | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 39 | Environment Specialist | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 40 | Hydraulic Engineer | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 41 | Social Safeguard Specialist | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 42 | Social and Gender Specialist | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 43 | CAD Operator | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 44 | Foreman | | 2 | 2 | 6 | 6 | 8 | 8 | 8 | 8 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 8 | 8 | 8 | 8 | 8 | 6 | 6 | 6 | 6 | 4 | 4 | 4 | 2 |
| **IV.SKILLED POSITIONS** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 45 | TBM Manager | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | |
| 46 | Segment Plant Manager | | | | | | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | |
| 47 | Eletrician | | | | | | 2 | 6 | 10 | 10 | 10 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | | | | | | | | | | | | | |
| 48 | Mechanic | | | | | | 2 | 6 | 6 | 12 | 12 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | | | | | | | | | | | | | |
| 49 | Welder | | 6 | 12 | 12 | 12 | 28 | 28 | 28 | 28 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 20 | 20 | 10 | 10 | 10 | 6 | 6 | 6 | 6 | 4 | 4 | 2 | 2 | 2 | 2 |
| 50 | Kettleman | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | |
| 51 | Heavy Equipment Operator | | | 2 | 2 | 2 | 4 | 6 | 8 | 8 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 4 | 8 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 2 | 2 | 2 | 1 |
| 52 | Light Equipment Operator | | 4 | 4 | 6 | 6 | 6 | 6 | 10 | 10 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 10 | 10 | 10 | 10 | 8 | 8 | 8 | 6 | 6 | 6 | 4 | 4 | 4 |
| 53 | Segment Erector Operator | | | | | | | | 2 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | | | | | | | | | | | | | |
| 54 | Heavy Truck Driver | | 2 | 4 | 4 | 4 | 4 | 4 | 10 | 10 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 10 | 10 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 2 | 2 |
| 55 | Batching plant Operator | | | | | | | | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | | | | | | | | | | | | | |
| 56 | Senior TBM Operator | | | | | | | | 1 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | | | | | | | | | | | | |
| 57 | TBM Operator | | | | | | | | 4 | 6 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 8 | | | | | | | | | | | | |
| 58 | Locomotive Driver | | | | | | | | | 3 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | | | | | | | | | | | | | |
| 59 | Laboratory Aide | | | | 2 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 60 | Survey aide | | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 61 | Painter | | | | | | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 |
| 62 | Driver | | 4 | 4 | 6 | 6 | 6 | 8 | 8 | 10 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 8 | 8 | 8 | 8 | 4 |
| 63 | Tireman | | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 |
| 64 | Nurse | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 65 | Skilled Laborer | | 4 | 6 | 6 | 6 | 14 | 14 | 20 | 20 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 35 | 35 | 20 | 20 | 20 | 15 | 15 | 15 | 15 | 15 | 15 | 10 | 5 |
| **V. NON-SKILLED POSITIONS** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 66 | Laborer | | 15 | 15 | 15 | 15 | 44 | 44 | 44 | 44 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 60 | 60 | 60 | 60 | 60 | 60 | 50 | 50 | 50 | 40 | 40 | 20 | 10 |
| | **Total** | | 90 | 102 | 112 | 112 | 160 | 172 | 211 | 225 | 311 | 308 | 308 | 308 | 308 | 308 | 308 | 308 | 308 | 308 | 298 | 298 | 204 | 190 | 171 | 167 | 165 | 160 | 150 | 144 | 142 | 124 | 120 | 90 | 67 |

**SCHEDULE A** : Additional Requirements for the Conduct of Public Scoping for the Proposed Angat Water Transmission Improvement Project (AWTIP) – Construction of Tunnel 5 to be located in Barangays Bigte, San Mateo, and San Lorenzo, Norzagaray, Bulacan

**Item 1.a - COMPARATIVE MATRIX OF TUNNEL 4 TO TUNNEL 5**

| COMPONENTS | SPECIFICATION | DIMENSIONS | MINIMUM CAPACITY (cu. m/sec) | STATUS | REMARKS |
|---|---|---|---|---|---|
| **TUNNEL 4** | | | | | |
| 1. INLET<br>2. OUTLET<br>3. TRANSITION BASIN<br>4. INTERCONNECTION CHANNEL<br>LENGTH, m.<br>INSIDE DIA., m. | Concrete<br>Concrete<br>Concrete<br>Concrete | Indicated In As-Built Drawings<br><br>6,454.77<br>3.2 | 19<br>-do-<br>-do-<br>-do- | Existing<br>Existing<br>Existing<br>Existing | Completed on June 2020 |
| **TUNNEL 5** | | | | | |
| 1. INLET<br>2. OUTLET<br>3. TRANSITION BASIN<br>**4.** INTERCONNECTION CHANNEL<br>LENGTH, m.<br>INSIDE DIA., m. | Concrete<br>Concrete<br>Concrete<br>Concrete | To be firmed up in the Detailed Design Stage<br><br>-do-<br>-do- | 19<br>-do-<br>-do-<br>-do- | Design Ongoing | Location of Inlet and Outlet are more or less 15 m. from the structures of Tunnel 4 |

**Item 1.b - ADDITIONAL PROJECT BACKGROUND DISSCUSSION**

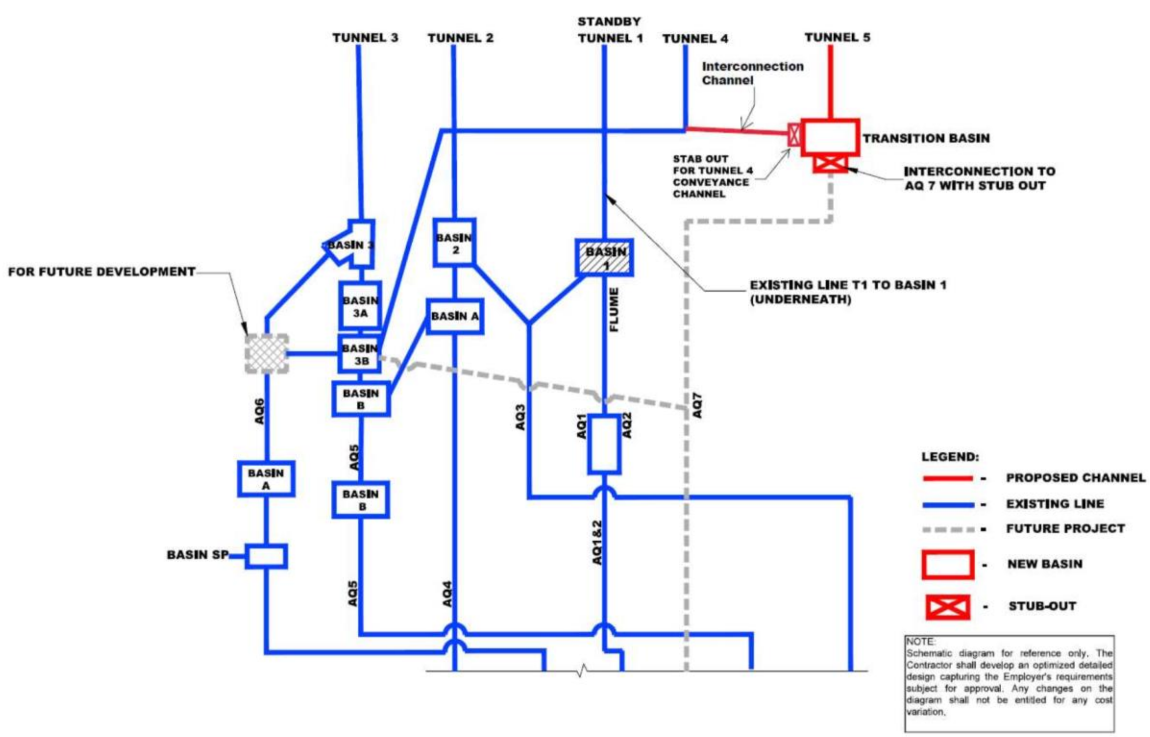
1. The Tunnel 4 was completed on June 2020, including all the component structures. The proposed Tunnel 5 has similar component structures to Tunnel 4 including the Specification. Its conceptual alignment is more or less 15 meters away from the center line alignment of Tunnel 4.

2. The purpose of constructing Tunnel 5 is to ensure and maintain uninterrupted supply of raw water during maintenance or repair of existing structure/structures of the delivery system of raw water from the Ipo reservoir.

**Item 1.c - ADDITIONAL INFORMATION ON THE INTERCONNECTION OF TUNNEL 4 AND TUNNEL 5**

1. Referring to the attached schematic diagram of the proposed Tunnel 5 Transition Basin Interconnection, a concrete channel will be constructed from the Stub Out at the Transition Basin of Tunnel 5 and will be connected to Tunnel 4 . A control gate will be installed at the Stub Out structure.

**Figure 1. Proposed Tunnel 5 Transition Basin Interconnection**




Source: Annex A. WS 19 CPF 12, Employer's Requirement for the Design and Build (D&B) of the Proposed Angat Water Transmission Improvement Project (Tunnel 5), page 162.

2. Another Stub Out will be provided at the Transition Basin for releases of water flow to AQ 7.

**Item 1.d - CLARIFICATION ON THE USE OF CONSTRUCTION AREA**

The Tunnel 4 industrial area will be the same area to be used by Tunnel 5 for the tunnel boring machine (TBM) and back up equipment assembly site. The Tunnel 5 Contractor's offices, living quarters, concrete segment lining fabrication plant and concrete batching plant will be located 3 km. away from Bigte Outlet site at Barangay Minuyan, Norzagaray, Bulacan.

**Item 1.e – Geotagged Photos**