

# Expansion of Mengkuang Dam Pulau Pinang Malaysia

By

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## 1 Background

The state of Pulau Pinang or Penang is a well known international tourist centre with a multi racial population of approximately 1.5 million. It has the second largest industrial area in Malaysia. With the rapid socio-economic development, it has become a major challenge for the Government to provide reliable and sufficient raw water source to meet the potable water demand in the state in tandem with the planned development.



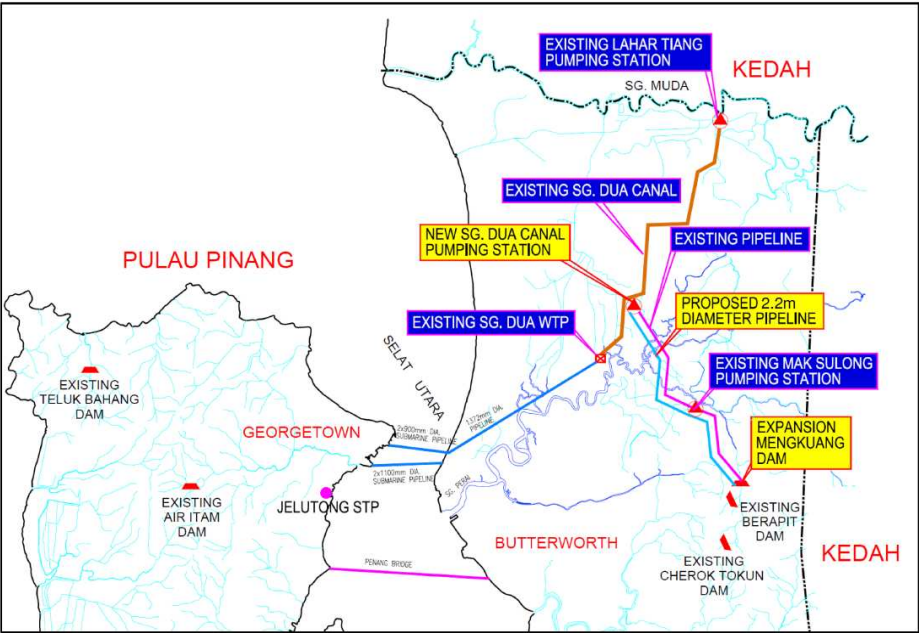
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Sg Dua Water Treatment Plant situated in Seberang Perai is the largest water treatment plant in Penang. It provides approximately 80% of the total potable water supply in Penang. The plant obtains the raw water from Sg Muda via Sg Dua Canal. During drought season, the river yield is insufficient to cater for the total water abstraction for domestic, industrial and agricultural irrigation supply.

The existing Mengkuang Dam which was completed in year 1983 has a storage capacity of 22 million cubic meter. It supplies raw water to Sg Dua Water Treatment Plant during drought season to make up for the shortfall in raw water supply from Sg Muda.



Mengkuang Pumped Storage Scheme



View of Existing Dam Embankment

With the rapid increase in water demand in Penang, the raw water supply from the existing Mengkuang Dam is insufficient to meet the expected rise in raw water demand from SgDua Water Treatment Plant. The Mengkuang Dam which is the main water supply source is the last major storage site with potential for expansion.



View of Existing Dam Crest



View of Existing Mengkuang Dam Storage Reservoir

In view of that, under the 10<sup>th</sup> Malaysian Plan, the Federal Government has approved the Mengkuang Dam Expansion Project. The objective is to increase the storage capacity from 22 million cubic meter to 73.5 million cubic meter and to increase the water conveyance capacity from the dam to Sg Dua Canal from the present 300 MLD to 1000 MLD for supply to Sg Dua Water Treatment Plant.

## **2 Scope of Project**

This Mengkuang Dam Expansion Project will be constructed in two (2) phases as follows:

### **Phase 1 Construction of Dam and Associated Works**

### **Phase 2 Construction of Raw Water Transfer Pipeline and Pump Station**

Phase 1 consists of the construction of a new dam with dam crest 2km in length and heightening of the existing dam with total cost of RM607 million. Phase 2 consists of 2.2m diameter raw water conveying main 13km in length and construction of pumping station. Phase 2 is presently at the preparation of tender document stage. The estimated cost for Phase 2 is RM400 million. The key design parameters of the project are summarized in Table 1. (Refer to page 13/19 and page 14/19)

#### **2.1. Construction Contract for Phase 1 Works**

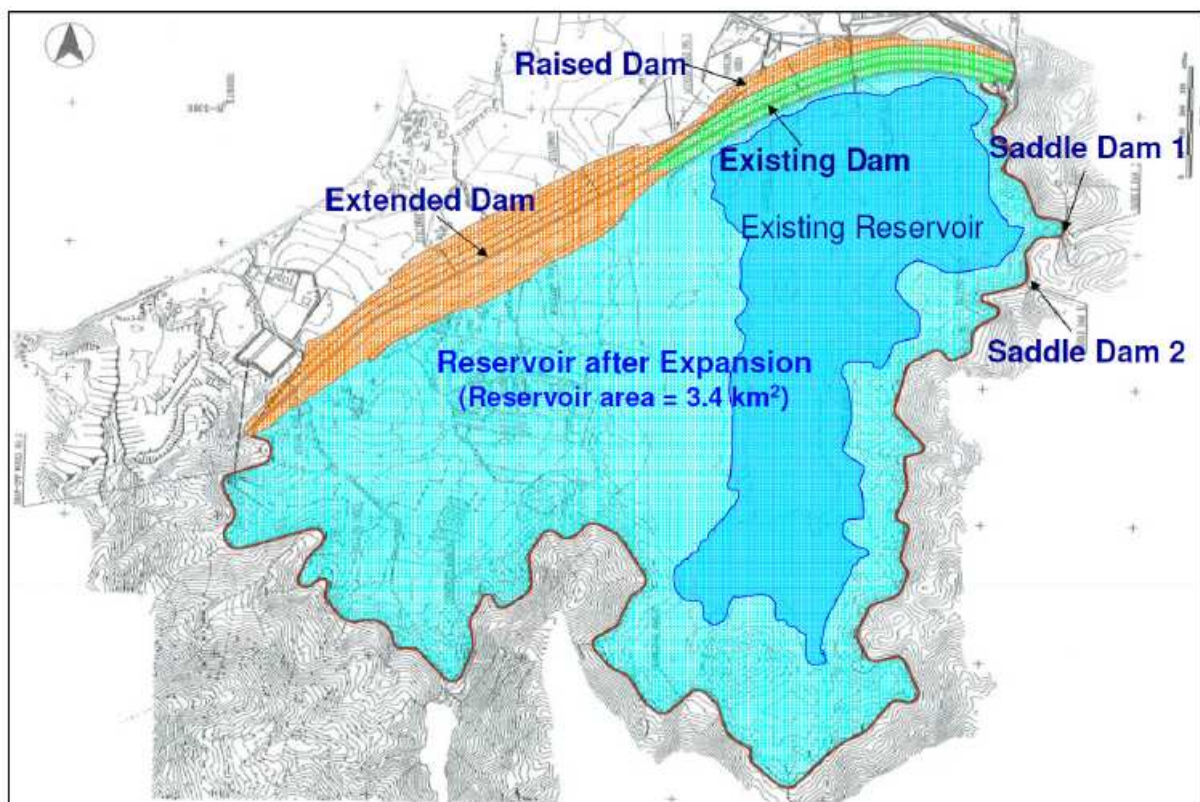
The implementation of this project is based on the partnership between the Government of Malaysia and the Government of The Republic of China. On the 2<sup>nd</sup> of June 2011, the Federal Government had issued the Letter of Acceptance (LOA) to China International Water and Electric (M) Sdn. Bhd, (CWEM) for the Phase 1 physical construction works.

The date of site possession was fixed on 1<sup>st</sup> August 2011 and the date of completion is 31<sup>st</sup> July 2016 with the construction period of 60 months. This project involves heightening of the existing dam by 11m and construction of a new dam of 2km in length at left valley. The existing and new dam are of earthfill type. The earthfill materials required for the construction

of this project is estimated to be 8 million cubic meter.

The salient point of this project is that the impounded water in the existing dam must always be available as and when required. It means that raw water supply from Mengkuang Dam must not be interrupted throughout the construction period of the dam.

Upon completion of the Mengkuang Dam expansion, storage of the existing dam and storage at the left valley will be merged to form a unified reservoir with inundated area of 3.4 square kilometer.

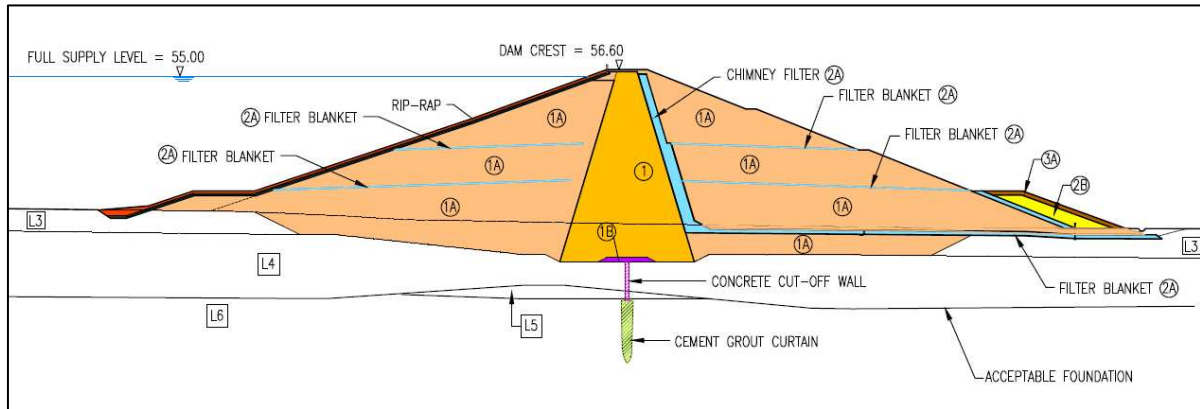


Reservoir Surface Area Upon Completion of Dam Expansion

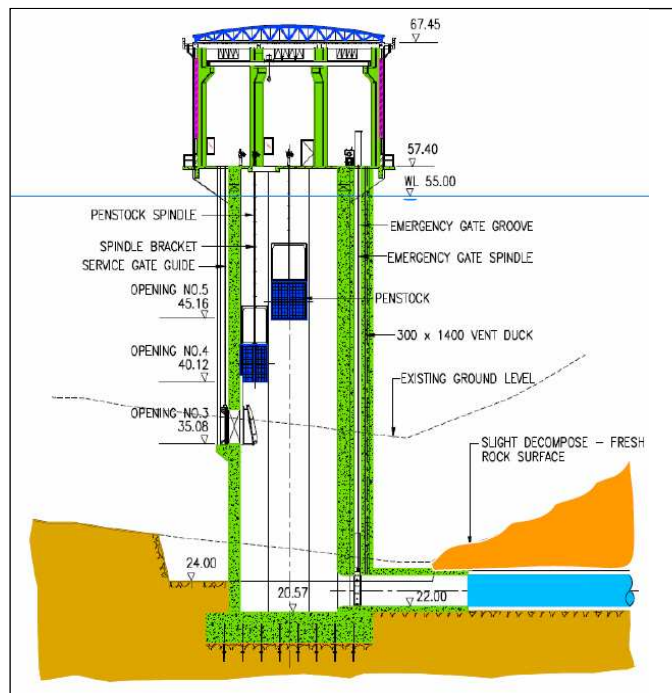
2.1.1 Expansion of Storage Area at Left Valley and associated works.

(1) Construction of New Dam Embankment at Left Valley (47m high, 2km in length).

Cross Sectional View of New Dam Embankment At left Valley

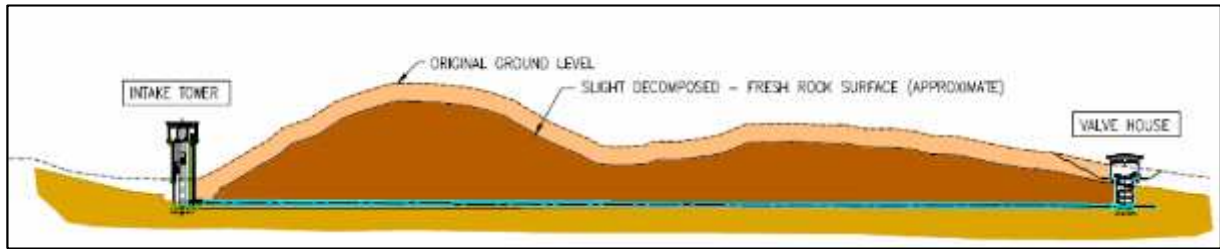


(2) Construction of Draw-off Tower No. 2



Cross Sectional View of Draw-off Tower No. 2

### (3) Construction of Draw-off cum Diversion Tunnel



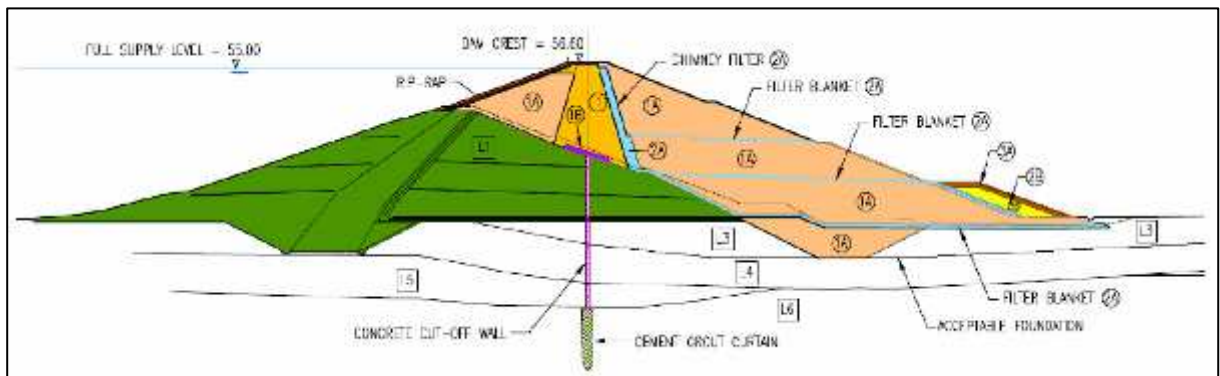
Cross Sectional View of Draw-off Tunnel

### (4) Construction of Valve House No. 2

(5) Laying of 2.2m diameter Mild Steel Pipe (2km in length) from Valve House No. 2 to connect with existing raw water pipeline.

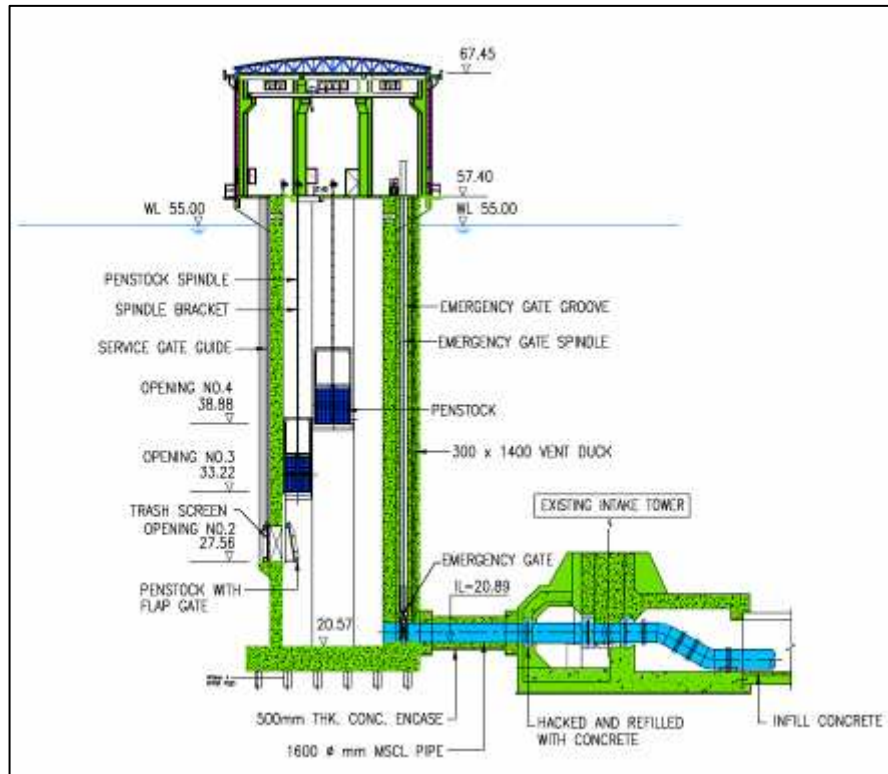
## 2.1.2 Expansion of storage at Existing dam and Associated Works

### (1) Heightening the existing dam embankment ( by 11m high and 1km in length)



Cross Sectional View of Heightened Existing Dam

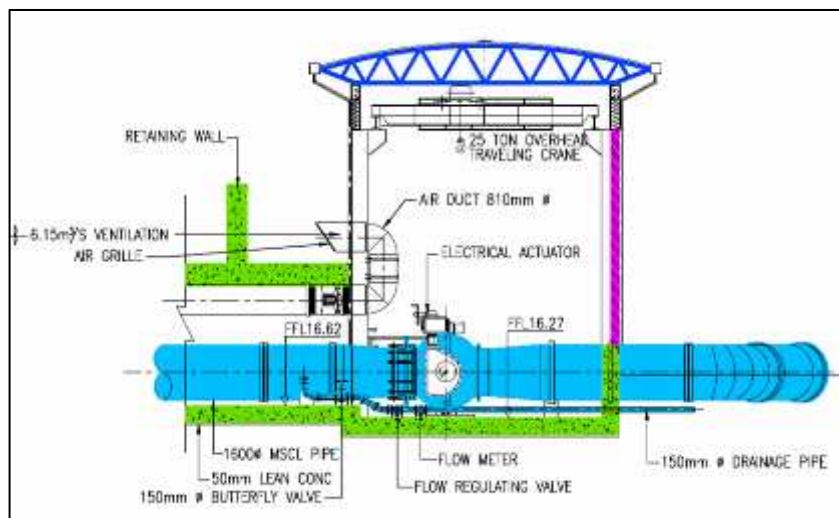
(2) Construction of new Draw-off Tower No.1



Cross Sectional View of Draw-off Tower No.1

(3) Strengthen and extend the existing draw-off culvert

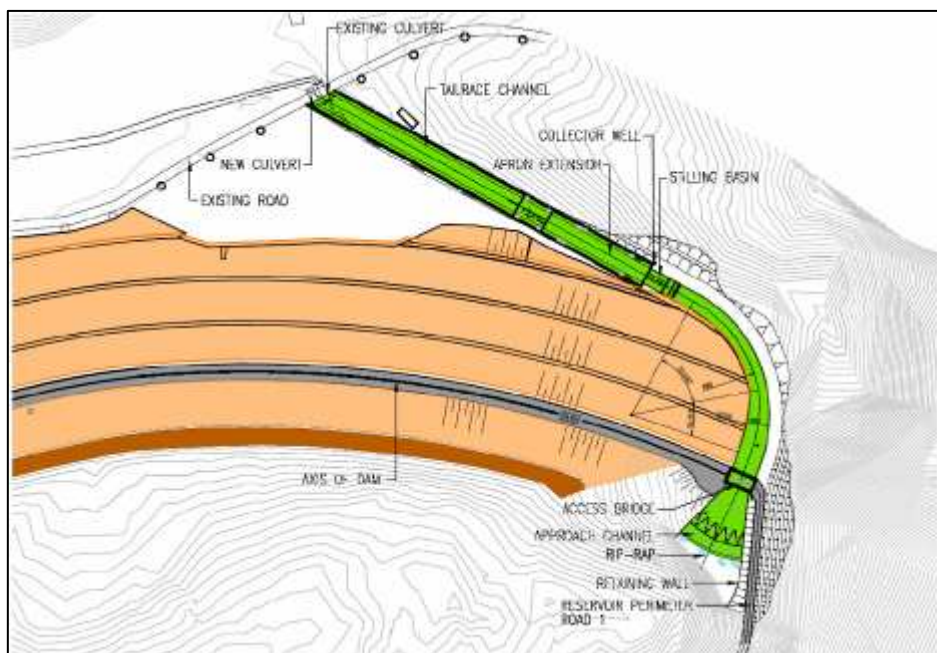
(4) Construction of Valve House No.1



Cross Sectional View of Valve House No.1

### (5) Construction of Labyrinth Spillway

The original design of the spillway which is of linear type has been changed to Labyrinth type similar to the Putrajaya Dam which is the first of its kind constructed in Malaysia. This type of spillway does not need a wide surface for the same flow, as such this design has saved the construction cost and also improves the dam safety level.



Labyrinth Spillway and Outlet Structure



View of the Labyrinth Spillway at Putrajaya Dam

### 2.1.3 Other Works

- (1) Construction of two Saddle Dams
- (2) Construction of reservoir perimeter road 8km in length
- (3) Construction of emergency water drawdown structure at Sg Kulim (at Mak Sulong Pumping Station).
- (4) Construction of balancing channel at ridge between existing reservoir and new reservoir at left valley

## 2.2 Phase 2 Components

Raw water conveyance and pumping station components:-

- (1) Sg Dua Intake
- (2) Pumping station at Sg Dua Canal (pump capacity of 440 MLD)
- (3) Installation of raw water conveyor pipe of 2.2m diameter, 13km in length

The conveyor pipe will act as:

- i Raw Water Conveyor from Sg. Dua Canal to Mengkuang Dam

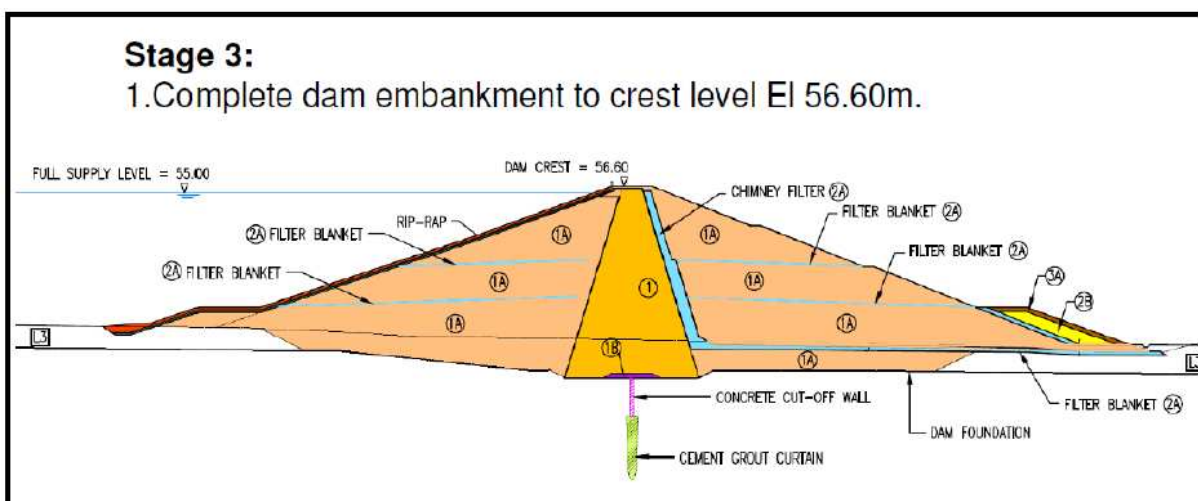
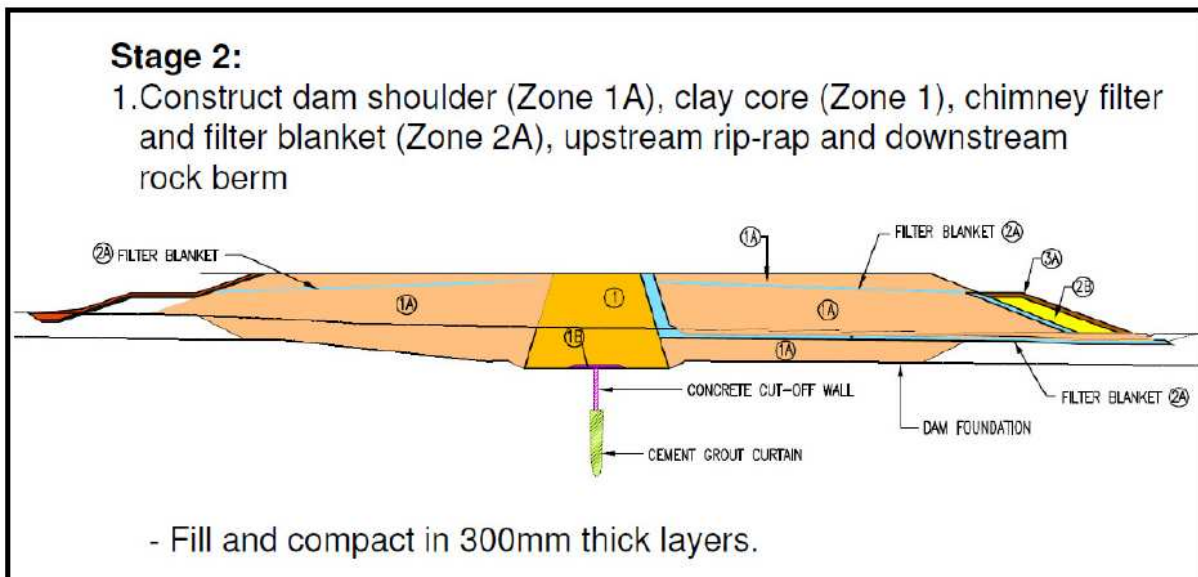
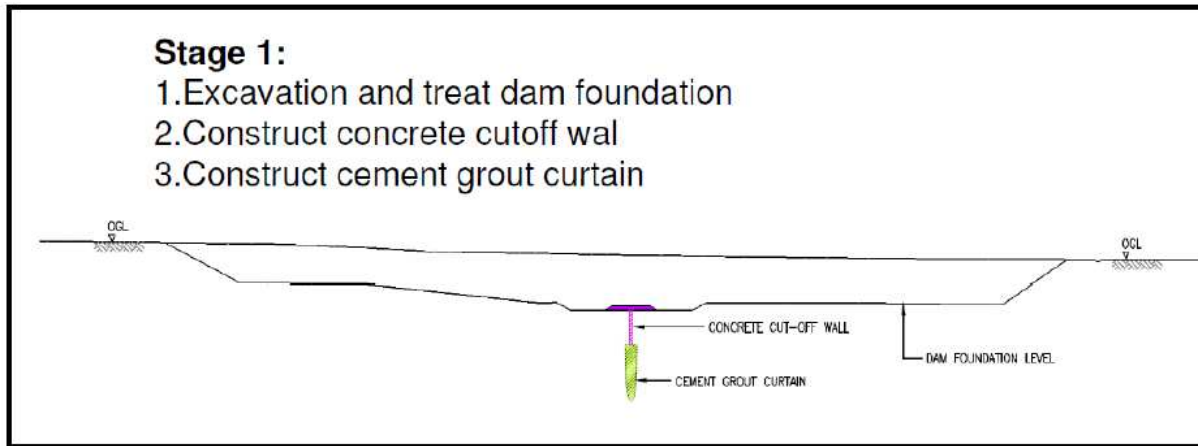
Raw water pumping station at Sg. Dua Canal will utilize the conveyor pipe to pump raw water from Sg. Muda to Mengkuang Dam during rainy season for storage. The designed capacity of the pumping station is 440 MLD.

- ii Raw Water Conveyor from Mengkuang Dam to Sg. Dua Canal

The raw water conveyor will also be used to release raw water from the impounding storage of Mengkuang Dam back to Sg. Dua Canal during drought season at the rate of 1000 MLD.

### 3. Construction Sequence at Phase Works

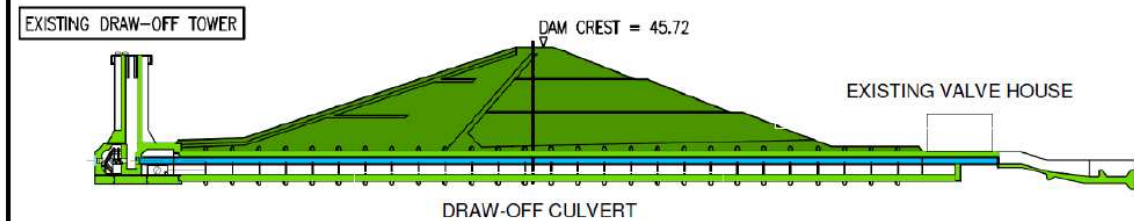
#### 3.1 Construction of new dam embankment and associated works.



### 3.2 Heightening of the existing Mengkuang Dam and associated works

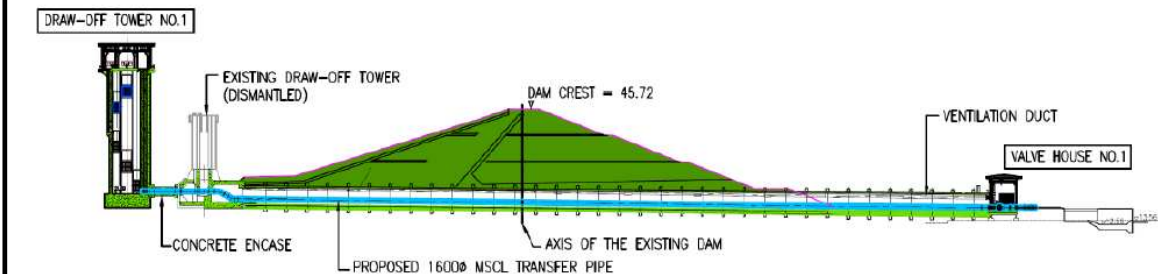
#### Stage 1:

1. Transfer reservoir water to new reservoir.
2. Construct temporary cofferdam and river diversion works.
3. Dismantle spillway pipe and outlet pipe inside culvert.
4. Demolish existing Draw-off Tower and Valve House.



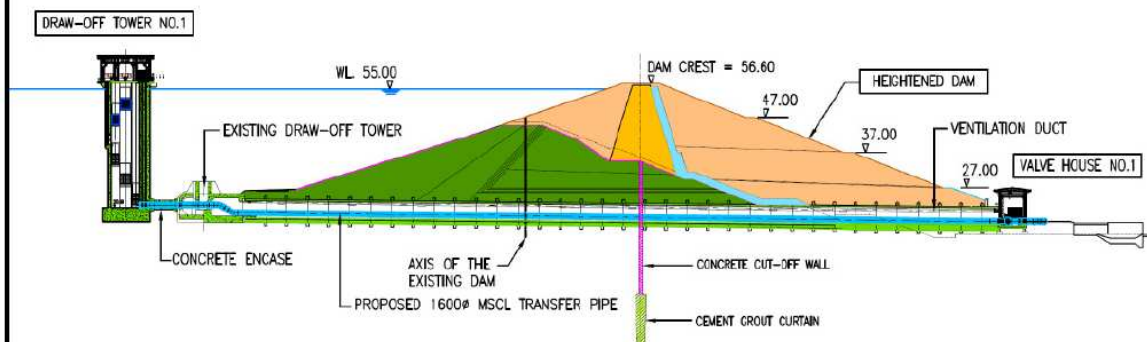
#### Stage 2:

1. Strengthen existing Draw-off Culvert.
2. Construct Draw-off Tower No.1.
3. Excavate and treat dam foundation.
4. Extend Draw-off Culvert and construct Valve House 1.



#### Stage 3:

1. Construct concrete cut-off wall.
2. Construct cement grout curtain.
3. Heighten existing dam.



**Table 1 - Main Parameters of the Project Components**

The main parameter of the project components is summarized as follows:-

Phase 1: Construction of Dam and Associated Works

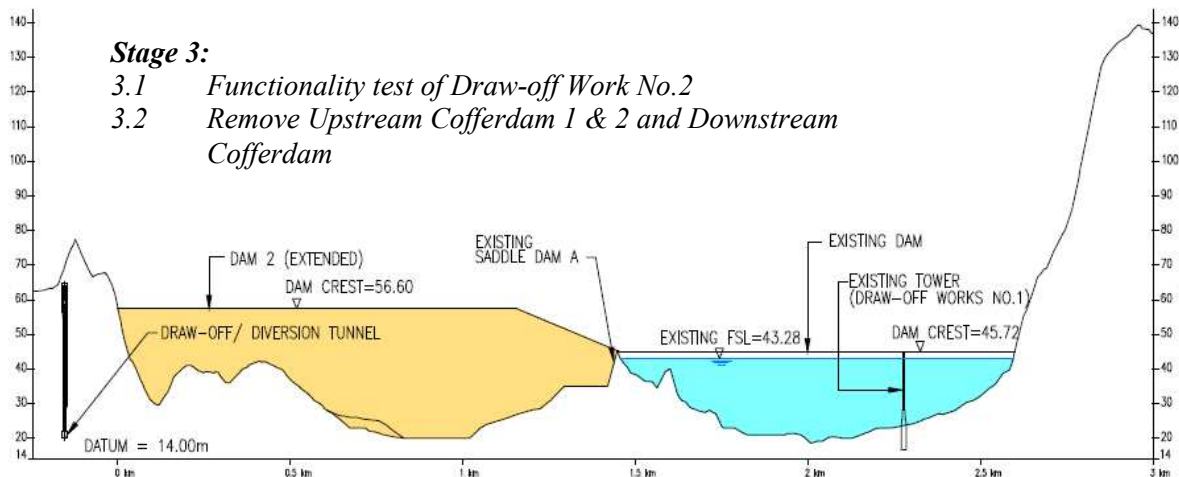
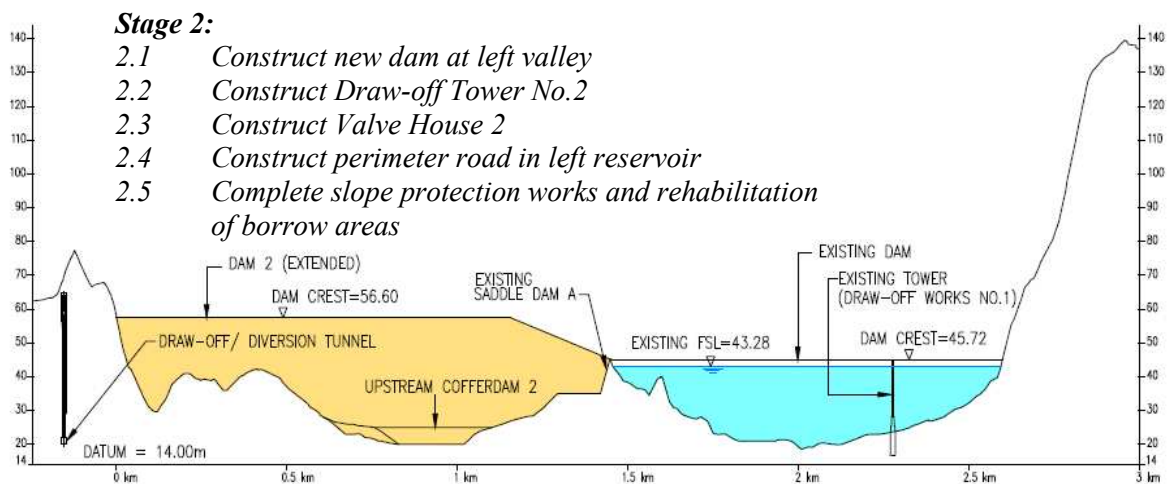
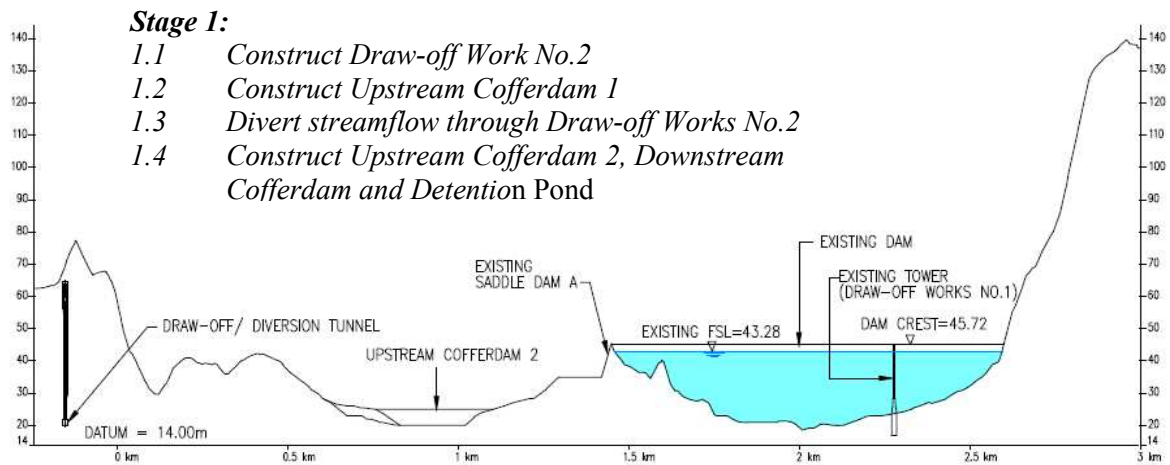
Storage	Full supply level (FSL)	El 55.00m
	Active storage volume	73.5x10 <sup>6</sup> m <sup>3</sup>
	Maximum reservoir area at FSL	3.4km <sup>2</sup>
Heightening of Existing Dam	Type of embankment	Semi-homogenous earthfill
	Dam crest Maximum height	El 56.60m 11m (from existing dam crest)
	Length of dam crest	1km
New Dam (Left Valley)	Type of embankment	Semi-homogenous earthfill
	Dam crest Maximum height	El 56.60m 47m (from existing site)
	Length of dam crest	2km
Catchment Area		11km <sup>2</sup>
Draw-off Tower 1 & 2	Tower type	Wet
	Design flow	1000 million litre per day
	Diameter	3m
Draw-off/Diversion Tunnel	Length	500m
	Type	Segmental culvert
	Diameter of conveyor pipe	1.6m
Draw-off Culvert	Length	210m
Valve House 1	Type	Exposed
Valve House 2	Type	Underground
Connecting Pipe from Valve House 2 to Existing Pipe	Type	Mild Steel
	Diameter	2.2m
	Length	2km
Spillway	Type	Labyrinth spillway
	Width	30m
Reservoir Rim Road	Length	8km
	Width	3m
Emergency Discharge Structure	Location	Sg Kulim (adjacent to Mak Sulong pumping station)

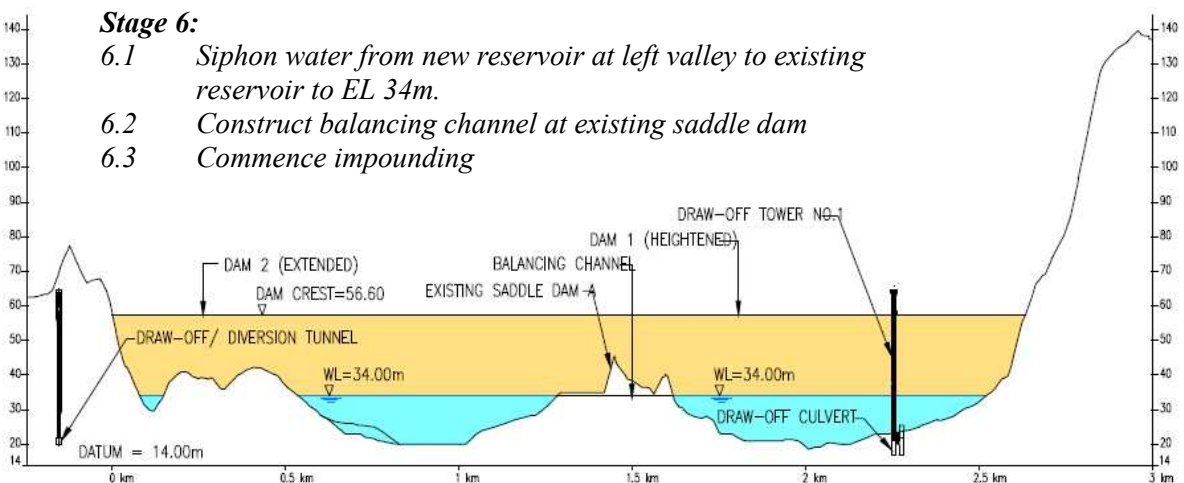
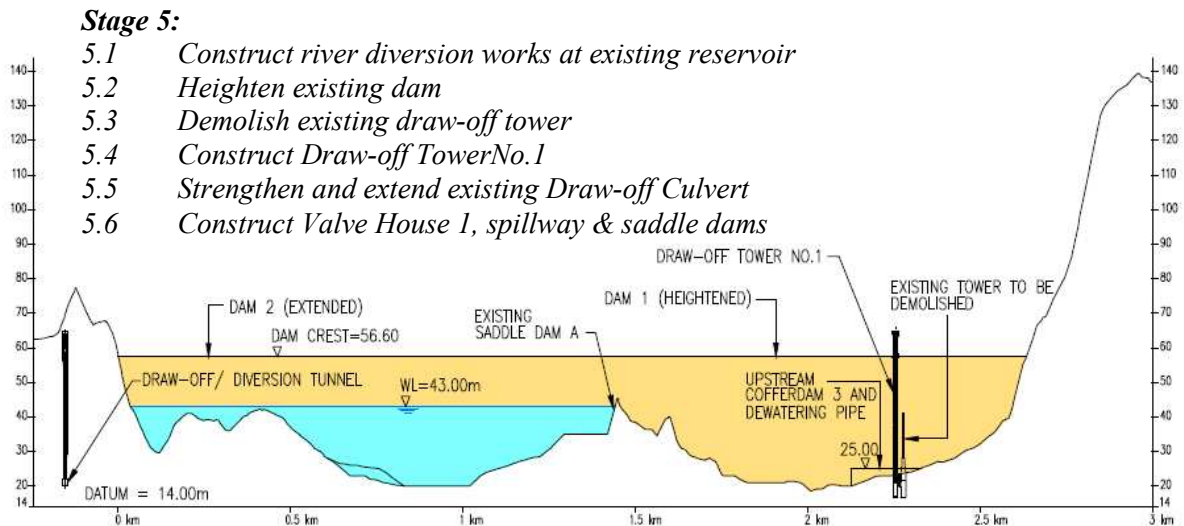
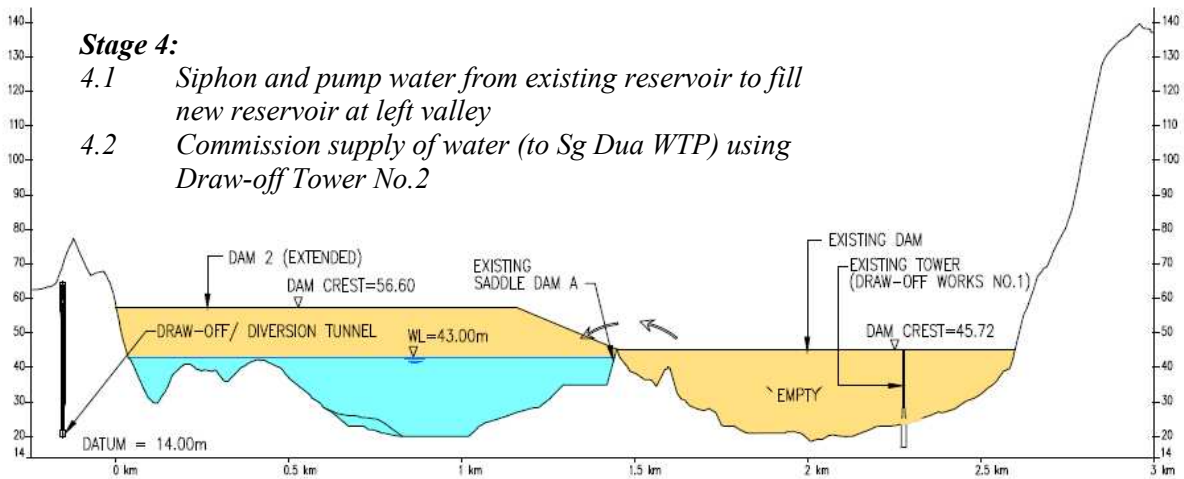
Phase 2: Construction of Raw Water Transfer Pipe Complete with Pumping Station

River Intake	Location No. of bays	Sg Dua canal 4
New Pumping Station	Location No. of pump sets Pumping head Capacity of pump	Sg Dua canal 4 55m 440 million liter per day
Existing Pumping Station	Location No. of pump sets Pumping head Capacity of pump	Sg Kulim 6 25.6m 209 million liter per day
Raw Water Transfer Pipe	Type Diameter Length	Mild steel 2.2m 13km

## 4 Stages of Dam Construction

The sequences of the dam construction are as per the following figures:

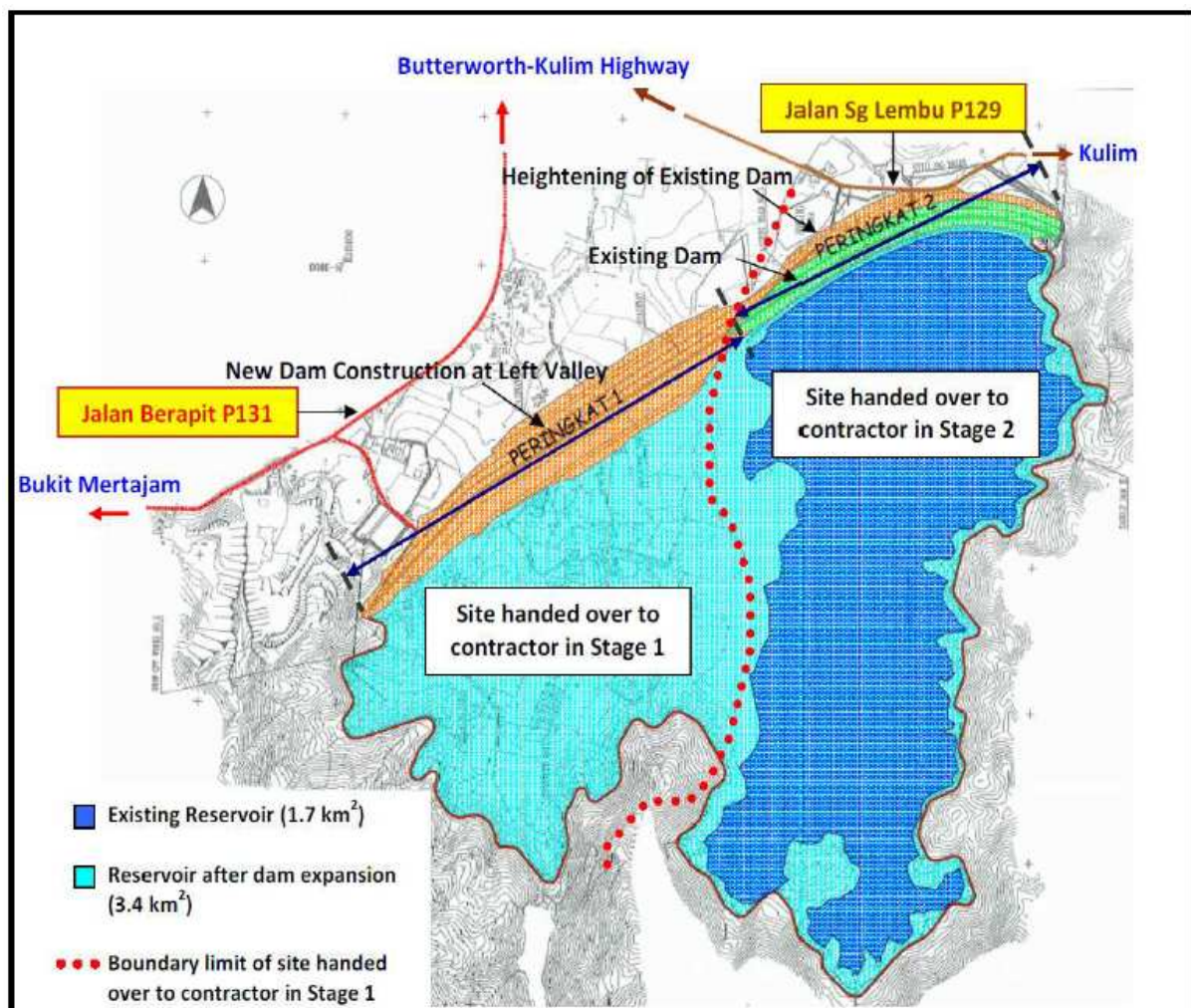




## 5 Staging of Site Possession

Mengkuang dam is currently being used for recreational activities. During construction the dam will not be closed to the public and the expansion works will continue without affecting visitors and nearby resident recreational activities. A section of the dam can still be used and site possession for the construction of the dam will be carried out in two stages.

Stage 1 is from 1<sup>st</sup> August 2011 to 31<sup>st</sup> January 2014 (30 months). During this stage the construction site for new dam (left valley) is handed over to contractor for the construction works of new dam, whereas the existing dam site is still under responsibility and surveillance of the operator. Stage 2 is from 1<sup>st</sup> February 2014 to 31<sup>st</sup> July 2016 (30 months). During this stage the existing dam site is handed over to contractor and closed for public for the heightening works of existing dam (Refer figure below).



## **6 Value Management**

The value management laboratory (VM Lab) for the Mengkuang Dam Expansion Project had been conducted from 10<sup>th</sup> to 19<sup>th</sup> January 2011 to ensure the objective of the project is achieved with optimum design and cost.

Several project components have been identified for modification which resulted in cost saving of about RM30 million without compromising the performance and original objectives of the project.

## **7 Impact of Project**

With the implementation of the Mengkuang Dam Expansion Project, shortage of water resource in Pulau Pinang which impedes the socio-economic development would be avoided. Upon completion of the dam expansion by year 2016, storage capacity of Mengkuang Dam will be increased to 73.5 million cubic meter from the present 22 million cubic meter and the raw water conveying capacity will also be increased to 1000 million litre per day from the present 300 million litre per day.

With the expansion of the dam and construction of raw water conveying works complete with pumping station, raw water supply to Sg. Dua Water Treatment Plant is envisaged be able to meet the water demand in the state of Pulau Pinang up to horizon year of 2020.

The construction of this project will stimulate the local economy especially at the area of Seberang Perai and Bukit Mertajam. It is anticipated that more than 90% of the construction material will be sourced locally which includes earthfill material (8 million cubic meter) crushed aggregate (300,000 cubic meter), rip-rap, sand, pebble, cement, steel reinforcement and mild steel pipe. In addition, it will provide the opportunity to the sub-contractors, manufacturers, suppliers, canteen operators and other service providers to participate in the project.

This project will also create jobs opportunity for individual involves in the

construction industry, whereby it is estimated that 500 workers consist of professional, sub-professional from different trades, i.e. Construction Manager, Inspector of Works, Engineers, Technicians, Safety Official, Welders, Quarry Operators, General Workers, Plant Operators, Laboratory Technicians, Skilled and Semi-skilled Workers will be involved during construction.

The involvement of local subcontractor in this project would facilitate transfer of construction technology which will enhance the experience and capability of the local contractor in the construction of dam.

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