20 Groundwater Simulation Analysis

20-1 Purpose of analysis and modeling approach

(1) Purpose of groundwater analysis

The NDGRs are set to be located 140 meters downstream of the existing regulators, while their ponding area will spread further down towards the residential area. The canal water level will increase by 2.7m[1] once NDGRs are operational. After construction, upstream of NDGRs, the water level will stay at 46.3m FWL, which is 0.3m higher than the current level.

Hydro-geologically, in some places, the canal water infiltrates the groundwater body, while in others, groundwater gushes out into the canals[2]. This phenomenon may be affected by the water head balance between canal water and groundwater. In general, changes in groundwater level take place seven days after changes in canal water level[3].

Improvement works have been implemented over the years as countermeasures against seepage from canals and related rises in groundwater level. These improvements are: (1) the extension of the Ibrahimia canal apron, (2) sheet piling, (3) protection of the canal bed in past constructions (DGRs in 1872, Abo Gabal intake in 1935), (4) and repair works (Ibrahimia canal in 1962). However, due to sewage effluence caused by recent urbanization, the groundwater level has been rising year after year. In fact, the foot of the canal banks and the basements of houses located near the DGRs, have shown signs of seepage.

In addition to this, the construction of NDGRs will result in a rise in canal water level, thereby increasing the groundwater level towards the center of Dirout city and its public facilities, such as mosques, stations, and highways, as well as its many private facilities such as shops, markets, and houses. The worst-case scenario includes serious direct damage to their structures, the floating of buildings, and the deterioration of structure foundations.

The aim of a groundwater simulation analysis is to predict and infer groundwater behavior after NDGRs construction, and to evaluate its environmental impact, and provide data that is useful in deciding on the necessity and scale of mitigation measures.

(2) Approaches for groundwater simulation analysis

In the case of groundwater simulation analysis with the purpose of developing an alternative design for groundwater insulation works and local seepage control, the model grid should be at least 1m. As regional hydro-geological information is scant, the model should cover as wide an area as possible to maintain model accuracy. Ideally, a broad model area with fine gridding (in 3D) is required to fulfill both purposes. However, in such a model, enormous amounts of input data and

[1]Annual lowest level of canal water observed was EL 43.7 in Ibrahimia canal from September 2015 to October 2016 not counting the winter-closure period (January to February 2015). When compared to the 46.3m of FWL after NDGRs construction, the difference is 2.7m.

[2]From the water level records measured at canal gauges and groundwater monitoring wells, it is considered that canal water flows (recharges) to groundwater body in the summer (high water season), while in the winter (low water level season), groundwater flows back (discharges) to canals.

[3]Aquifers in the Dirout area are regarded as “confined or semi-confined (multilayered) aquifer[s]” composed of a coning silty-clay surficial layer and permeable layers of sandy and gravely sediment. The changes in canal water level are therefore translated into pressure on groundwater.

complicated calculation processes are required to run the data continuously being produced with every calibration-trial and case simulation. This may become an obstacle to the analysis, so to overcome it, two different models should be prepared to ensure work efficiency and model accuracy in the study. These are shown as follows.

Regional model (larger model): covers the center of Dirout city surrounded by DGRs and NDGRs capable of dealing with regional groundwater flow.

Detailed model (sub-region/portion model): covers site of NDGRs and applies specific seepage analyses to design groundwater control works of NDGRs.

In the first stage of the analysis, the regional model is constructed with the necessary calibrations using monitoring records to evaluate groundwater flow near the NDGRs and the surrounding area. The detailed model is then upgraded from the regional model, and refined to use grids small enough to evaluate an alternative groundwater control plan. To this end, MODFLOW USG (ver3, 2015)[4] is applied with a refined Quadtree grid[5]. The work steps of modeling are shown in Figure 20-1.1.

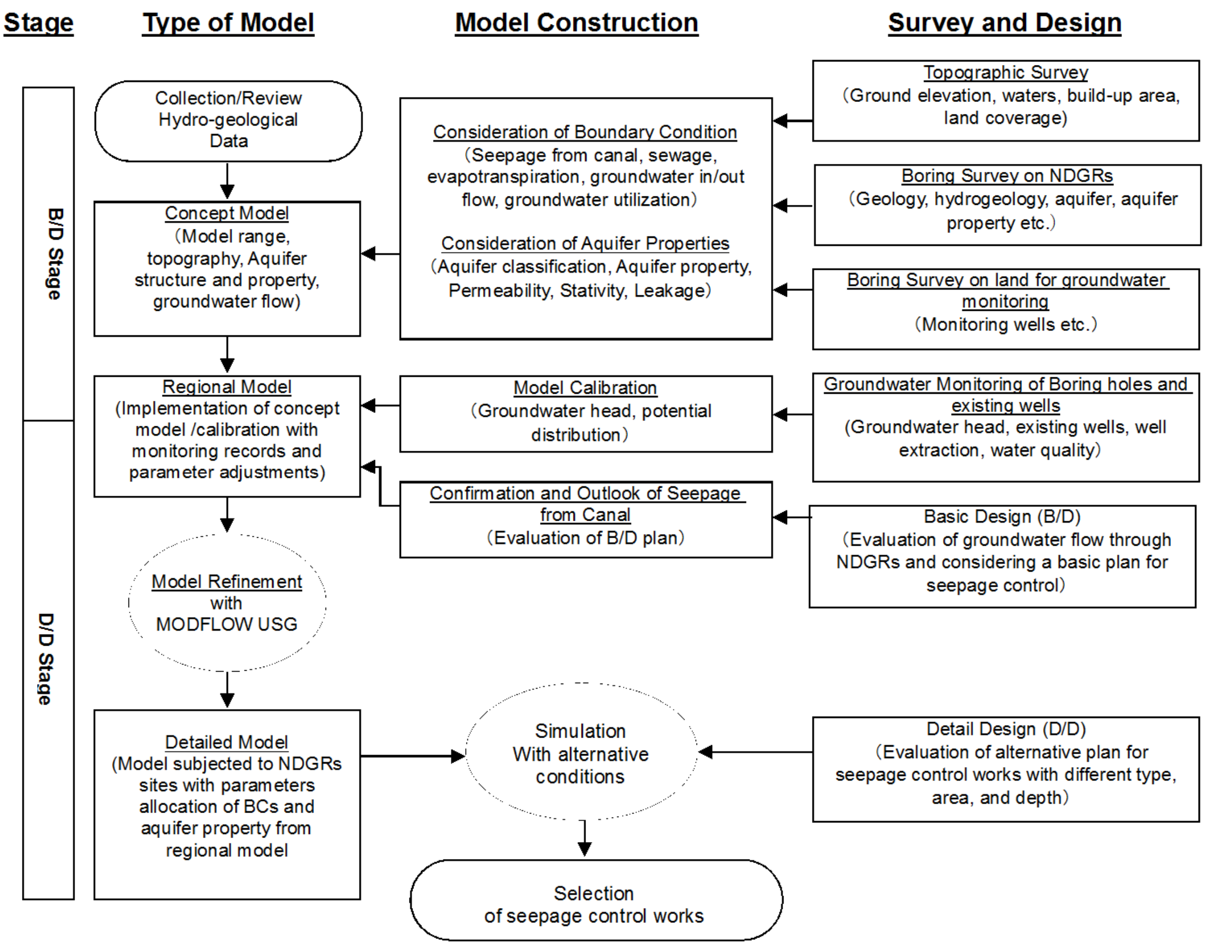


Figure 20-1.1 Approach for groundwater simulation analysis

[4] MODFLOW-USG: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation (http://water.usgs.gov/ogw/mfusg/)
[5] "Quadtree" is a refining method which modifies the normal grid (uniformed spacing structured grid) into a fine and unstructured grid, capable of detailed control of in/output of model.

20-2 Preparation of regional model

The regional model was constructed with due consideration of (1) groundwater recharge from the surface and groundwater flow in/out, and (2) the capacity of the groundwater reservoir underneath the study area.

In the following subsections, the main components of the model construction are described: (1) analysis area (model range), (2) design of FDM grid, (3) boundary conditions (BCs), and (4) hydro-geological properties.

(1) Analysis area (model range)

The piling-up of thick clay material is observed at 20m depth downstream of the Abo Gabal regulator, extending to the Irad Delgaw canal and further down to the left bank of the Bahr Yusef canal. With the exception of piling-up clay, Neo-Nile deposits are layered with horizontal homogeneity extending over the Dirout area. Restricted by this layered structure, groundwater flows outwards from the channels.

Relying on an empirical formula, groundwater inflow from the canals is supposed to be 300m to 350m (Kusakin, 1953).

Due to the lack of available hydrological data in the peripheral vicinity of the model, and to maintain model reliability, influenced area should be covered by a sufficient margin.

Adding a 200m buffer zone to the 300m inference area, the recharge zone in the analysis is a total of 500m away from the canal. Furthermore, at a canal width of 300m and a total area of 1,300m × 1,300m is properly required for the groundwater modeling analysis.

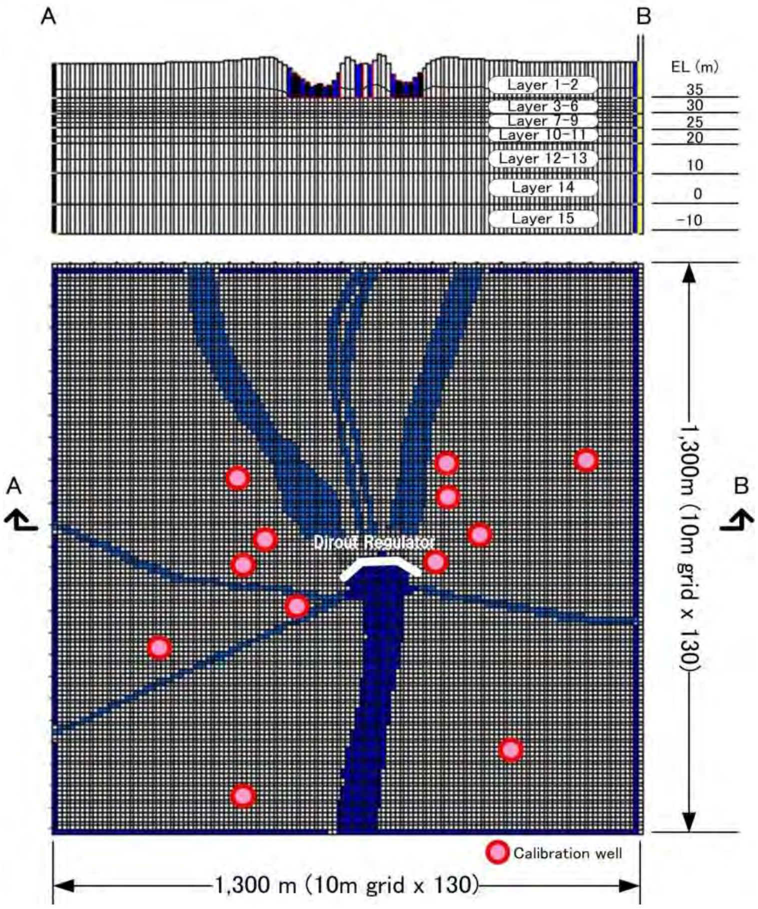


Figure 20-2.1 Model grid (regional model)

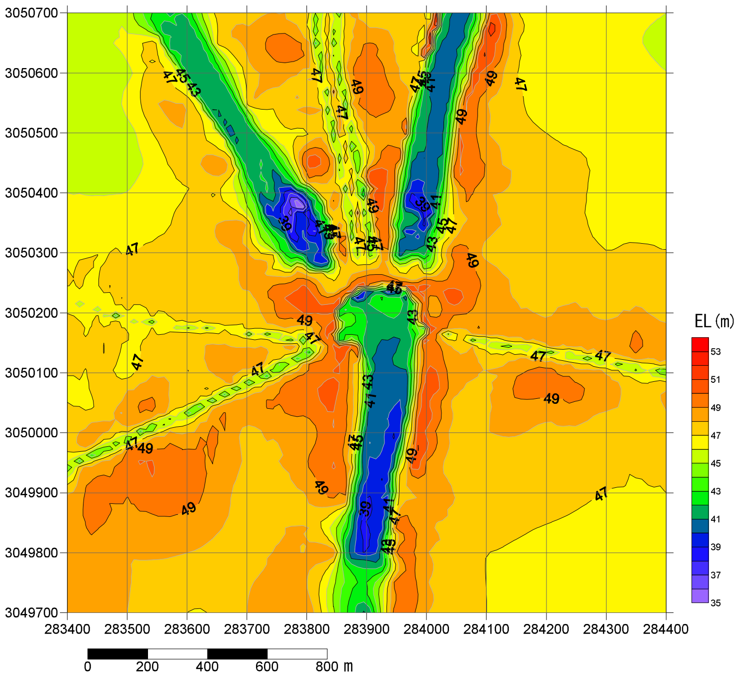


Figure 20-2.2 Ground elevation of model area

As for the depth covered by the analysis, at least 50m of clearance is required for comparing the design of the cut-off plate and bearing pile (see Figure 20-2.1).

(2) Design of FDM grid

In accordance with the purpose of the regional model, grid size is refined to 10m in plane (x, y) for whole model range (1,300m×1,300m). While at depth (z), 15 layers are applied from the ground level to EL -10m. There are 253,500 grids in total (130 in E-W direction × 130 in N-S direction × 15 layers in depth).

(3) Boundary conditions (BCs)

The center of Dirout is located on the embankment area, and is 3 or 4m higher than the surrounding farmland. The farmland extends along model borders and shows EL.46m to EL.47m, while the area adjoining the DGRs is EL.50m high (see Figure 20-2.2). The groundwater level (or head) is observed to be in the range of 1.5 to 8.5m below the ground surface.

Since the Dirout area suffers arid climate characterized by very little rainfall throughout the year, the canals leakage to the aquifer is the main source of groundwater. Thus, the gradients of groundwater heads decline from the city center (of regarded area from canals) towards the model borders.

Regarding the groundwater usage in the study area, the groundwater is utilized as the supplemental water resources for daily human activity. In fact, according to the inventory survey it was found that eight wells exist along the Abo Gabal canal in the study area.

Taking hydro-geological condition of this range into account, three boundary conditions are assigned to the regional model as shown in Table 20-2.1 and Figure 20-2.3.

Table 20-2.1 Boundary conditions (BCs) of groundwater model

Type of BCs	Description	MODFLOW Package
Head-dependent flux boundaries between canal bottom and aquifer	In the canal, flow of water into or out of aquifer is dependent on difference between canal water level and groundwater head. If canal water level is higher than groundwater head, then the canal moves water to the aquifer.	River package (RIV)
Specified flux boundary to individual pumping wells	At pumping wells, a specified amount is extracted from the aquifers. In the model, observed values from five wells are given and extracted from sandy layers.	Well package (WEL)
Specified head boundary between model area and its outside.	Along model margin, flow of water from/out of model area is dependent on the difference between specified head and groundwater head in the model.	Time-Variant Specified-Head package (CHD)

When calculating the amount of seepage from canals (groundwater recharge and outflow), the canals are first divided into eight sections: upstream and downstream of Ibrahimia canal, Bahr Yusef, Abo Gabal, Irad Delgaw, Sahelyia, Diroutiah, and Badraman canals. Then, head-dependent flux boundaries that consider canal conditions are drawn, and seepage is then calculated from: (1)

the given values of canal water level, (2) permeability and thickness of channel-bed sediments, and (3) the width and length of channels.

As for groundwater extraction, a specified flux boundary is adopted with the daily rate and screen position taken from the well inventory survey conducted in April 2016.

The exchange amount of water flowing in/out of model range is calculated with specified head boundary taken from the groundwater potential distribution based on the groundwater monitoring carried out at each step of the calculation.

Figure 20-2.3 Boundary condition (MODFLOW PACKAGE)

(4) Model property

Input data for model property is obtained through an analysis of hydrostratigraphy of the model area, involving both the surficial layer (recharging zone: unsaturated zone) and the aquifer (saturated zone). The characteristics of the unsaturated and saturated zones are described in the following subsections.

Figure 20-2.4 Land cover classification

1) Hydrostratigraphy

Non-marine alluvial and Pleistocene deposits are within the model range. In the boring survey (30m in depth), the grading structure is observed through beds and geologic members. The upper layer (about 10m thick) is composed of silty clay, but further down, it gradually changes into sandy facies with gravel, and further still it turns into coarse sand with granular gravel or pebble, and finally into boring holes (EL.19m to EL.25m) at the very bottom.

This strata correlates to flood deposits during the past climate change after Middle Pleistocene (40,000 years ago) and broadly covers the Nile Valley lowlands. It is generally referred to as 'Neo-Nile deposit' and is more thickly distributed along the Nile main channel and thins out the further it gets away from it. From the boring survey, the layers have been found to thicken on the right bank of the Ibrahimia canal, the side closer side to Nile main channel, and slightly thin out on the left bank of the Bahr Yusef canal. The strata are also grouped into four layers; Nc, Nm, Ns, and Ng, which are horizontally consistent with the model range.

Hydro-geological properties are classified into: (1) groundwater recharge at ground surface, (2) aquifer properties controlling groundwater flow, and (3) artificial underground structure.

a) Properties of unsaturated zone (Groundwater recharge and evapotranspiration)

In the model range, the surficial to unsaturated zone is about 10m thick, and consists of impervious silty-clay. Due to scant rainfall, natural recharge has hardly taken place in the model range. Thus, groundwater recharge occurs exclusively by canal water leakage, sewage, the water supply network, and surplus water from the irrigation field.

In Dirout city, the water supply system is constructed by the main stream of the Nile river and a 50 litre/day/cap[6] of water is provided for 25,000 people within the model area (1,300m × 1,300m=169ha)[7]. Actually, 1,250 m^3/day of water is utilized in the model range, and 90% of it was discharged as sweage in the area.

However, some sewage is collected by tank truck, due to the insufficient capacity of sewage treatment in Dirout city. Most sewage waste is disposed of in the surficial to unsaturated zone through sewage inlets and the infiltration holes of individual residences and multi-apartment buildings.

In the open spaces, playground, park, etc., the direct evaporation from shallow aquifer is supposed to take place in the dry sunny season. In addition, some groundwater is lost through transpiration and as a result of the trees planted along the roadsides and in the park.

In the farmland located outside the built-up area, irrigation water is supplied all year long, hence some water is consumed by the crops and what remains is recharged to shallow aquifer.

According to land cover classification, the recharge/evaporation zone properties are classified into three types, and their respective potentials are shown in Figure 20-2.4.

b) Property of saturated zone (aquifer property)

In the model range, there is aquifer in the deposits of thick Neo-Nile alluvium. The layer facies are characterized by cohesive silt (Nc) on the upper horizon, changing to coarser sediments of silt

[6] According to International Development Research Center (2007), design water supply amount is 52 lit/day/cap. If a leakage rate of 32% is applied, the amount of water supply is estimated to be 78 lit/day/cap.

[7] Population living in model range is estimated based on the Dirout city population of 72,856（492ha）sourced from National Information Center (2006).

(Nm), sand (Ns), and granular gravel (Ng) respectively toward the lower horizon. Hydraulically, aquifers are classified by permeability and storativity. The layers are horizontally homogeneous, each layer's properties remaining consistent.

In the area from the Abo Gabal regulator to the Bahr Yusef canal, thick fill materials (F) pile up on the clay (Nc) and silt (Nm) layer. These act as an aquiclude covering a sandy layer on the lower horizon of the Neo-nile deposit. This hydro-geological structure confines the groundwater in the model range. Regarding the aquifer condition, upper layers (F and Nc) act as 'confining layers', while the lower layers (Nm, Ns, and Ng) are the 'confined layers' of the model.

The permeability of each layer is accounted for based on observation records. In the field survey, 30 permeability tests of the NDGRs' foundation have been conducted so far. Of all the values, the range of $k=1.8\times10^{-5}$ to 1.6×10^{-3}cm/sec and the median value of 1.9×10^{-4} cm/sec[8] are shown in Figure 20-2.5.

As for the respective layers, fill deposit (F) is $k=2.2\times10^{-4}$ cm/sec in median value, $k=5.6\times10^{-5}$ cm/sec of Nc, $k=4.2\times10^{-4}$ cm/sec of Nm, $k=4.2\times10^{-4}$ cm/sec of Ns, and $k=2.7\times10^{-5}$ cm/sec of Ng layer are as shown in Figure 20-2.6.

The permeability coefficient of each layer and the value corresponding to the depth-zone are used to provide an initial value of the regional model[9] (see Table 20-2.2).

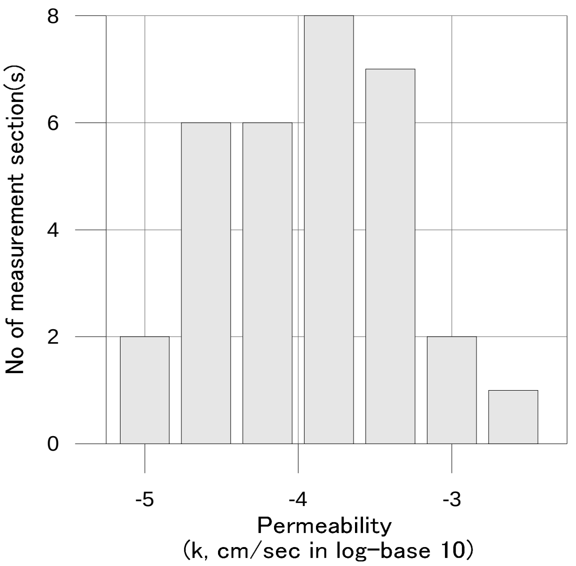


Figure 20-2.5 Distribution of observed permeability

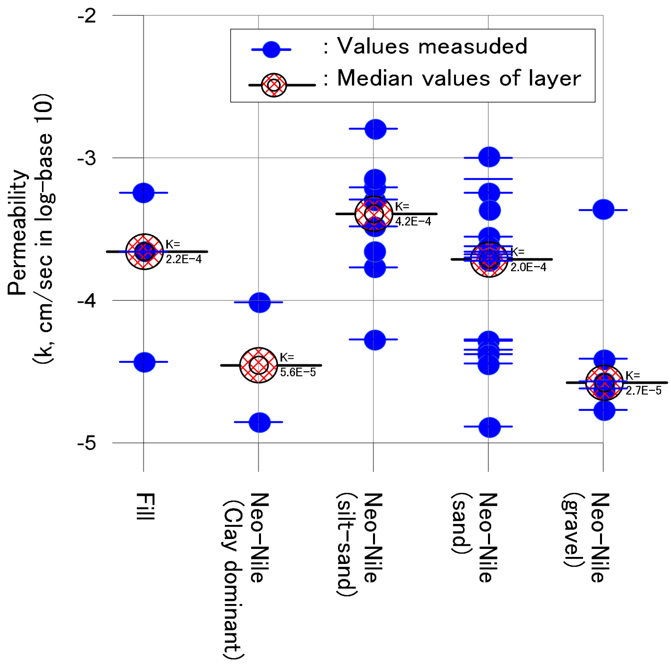


Figure 20-2.6 Permeability of each layer

8 Median value of permeability coefficient (1.9×10-4 cm/sec) is regarded as a common value of 'unconsolidated sand with silt and finer layer' (e.g. k=10-5~1.6×10-2 is given by Freeza R.A. and Cherry (1979).
9 Specific yield and storage have not been observed by field survey, so a value corresponding to layer faces is allocated to respective depths (model layer) and specified area (coverage of impervious fill).

Table 20-2.2 Average permeability by depth

Layer No.	Symbol	Type of Aquifer	EL(m)	Permeability*1			Storage Coef.*2	
				Horizontal (x,y)		Vertical (z)	Spec. Yield	Spec. Storage
				$k_{x,y}$ (cm/sec)	$k_{x,y}$ (m/day)	k_z (m/day)		
Fill (Silt/Clay/sand)	F	Unconfined (confining)	0~30m	2.7.E-05	0.03	0.03	0.03	-
1 (Silt～Clay)	Nc		0~35m	4.2.E-04	0.37	0.07	0.05	-
2 (Sand, loose, fine)	Nm	Confined	35m~30m	1.2.E-03	1.06	0.21	0.1	0.001
3 (Sand, medium)	Ns		30m~25m	3.2.E-04	0.28	0.06		
4 (Sand, medium)	Ns		25m~20m	2.7.E-04	0.24	0.05		
5 (Sand, dense, coarse)	Ng		20m~10m	4.5.E-04	0.39	0.08		
6 (Sand, dense, coarse)	Ng		10m~0m					
7 (Sand, dense, coarse)	Ng		0m~-10m					

* 1: Permeability test did not consider horizontal and vertical direction, observed value is thus regarded as horizontal permeability, and 1/5 of horizontal permeability is set as vertical permeability for the model's initial value.
* 2: Storage coefficient was not obtained by field test, and the value corresponding to facies is thus initially applied in the model.

c) Underground structure

In the construction of DGRs, some countermeasures against canal seepage must be taken at the very foundation. In 1962, improvement works were undertaken due to the rise in the water level upstream of the DGRs. These improvements included the extension of the Ibrahimia canal apron, wooden driven sheet piles, and canal bed protection works. However, no detailed records of the locations or extent of those works exists today. Thus, based on the monitored water heads and their distributions, the model assumed the construction range of the cut-off plate (the impervious wall lining) was installed on the Sahelyia, Ibrahimia, Abo Gabal, and Irad Delgaw regulators, until the depth of EL.35m.

(5) Assigned conditions to the model

The boundary conditions are arranged and classified for the concept model and then transferred into a GIS data set and assigned to the model under a specified format of [10]MODFLOW 2000 package. The applied packages are shown in Table 20-2.3.

[10]MODFLOW is the modular finite difference flow model developed by USGS. One of the features of MODFLOW is its available source code (free code). Given its transparency, and the data density of this project, the use of MODFLOW is superior in terms of accuracy and efficiency for the study to FEM.

Table 20-2.3 Boundary condition and MODFLOW package

Boundary Condition (BCs)	Location	Type	MODFLOW package
Boundary between model area and outside (groundwater in/out flow)	Model margin	Constant head boundary	Time-Variant Specified-Head package (CHD)
Boundary between canal bottom and aquifer (seepage/groundwater inflow)	Waters of canals	Head-depend ent flux boundaries	River package (RIV)
Wells (groundwater extraction from aquifer)	Well points	Constant flux boundaries	Well package (WEL)
Property (Pros)	Location	Type	MODFLOW package
Recharge (discharge sewage to aquifer)	City/built-up area	Constant flux boundaries	The recharge package (RCH)
Evapotranspiration (direct evaporation to groundwater)	open spaces etc.	- do -	Evapotranspiration package (EVT)
Evapotranspiration (Evapotranspiration from irrigation area)	Irrigation farmland	- do -	Evapotranspiration package (EVT)

(6) Calibrating data

The model calibration was made with monitoring records (groundwater head) of 13 wells (see Figure 20-2.7). Monitoring began in September 2015, and minimum value was observed to be EL.41.55m while maximum value was EL.44.22m. The difference between them is over 2.7m (see Figure 20-2.8). The shallowest depth was observed in the summer (high water period) to be 1.75m at BH-N13.

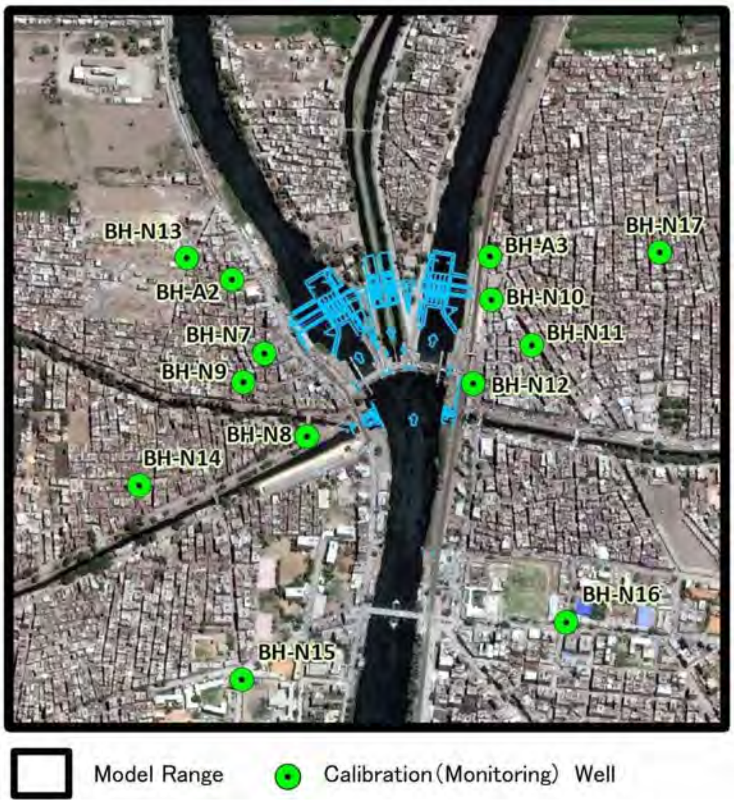


Figure 20-2.7 Calibration Point (Monitoring well)

The groundwater infiltration along canals increases during the high water period from June to August. For the purpose of groundwater modeling, and evaluating groundwater interference caused by NDGRs, the highest water level shall be applied for model calibration in the interest of safety.

In the period from September 2015 to February 2017, the target period disregarded was that from 20 June 2015 to 27 July 2016 (see Table 20-2.4 and Figure 20-2.8). For calibration records, the data for 13 selected monitoring wells on 27 July 2016 was collected and appropriately allocated to model layers with due reference to screen depth (see Table 20-2.5).

Table 20-2.4 Maximum/Minimum groundwater head and depth (Sep 2015 to Feb 2017)

Piezometers	Max. Depth (m)	Min. WL (EL.m)	date	Min. Depth (m)	Max. WL (EL.m)	date
BH-N7	5.38	41.93	18/1/2017	3.17	44.14	27/7/2016
BH-N8	5.62	41.93	18/1/2017	3.46	44.09	17/8/2016
BH-N9	5.06	41.88	18/1/2017	2.83	44.11	27/7/2016
BH-N10	6.88	41.88	18/1/2017	4.56	44.20	27/7/2016
BH-N11	5.64	41.89	18/1/2017	3.34	44.19	27/7/2016
BH-N12	8.82	41.90	18/1/2017	6.54	44.18	27/7/2016
BH-N13	3.93	42.02	18/1/2017	1.75	44.20	27/7/2016
BH-N14	4.81	42.03	18/1/2017	2.77	44.07	17/8/2016
BH-N15	4.96	41.84	18/1/2017	2.90	43.90	10/8/2016
BH-N16	4.78	41.55	18/1/2017	2.60	43.71	10/8/2016
BH-N17	4.83	41.66	18/1/2017	2.47	44.02	27/7/2016
BH-A2	5.00	42.00	18/1/2017	2.83	44.17	27/7/2016
BH-A3	7.56	41.83	18/1/2017	5.17	44.22	27/7/2016

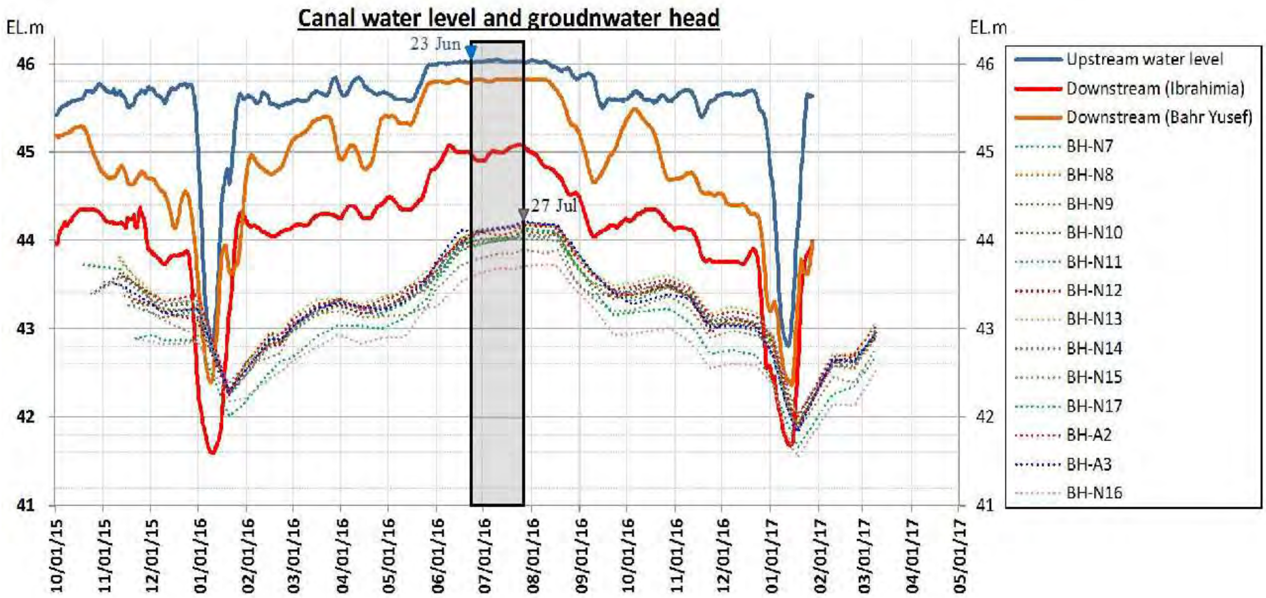


Figure 20-2.8 Change in groundwater head and canal water level (Sep 2015 to Feb 2017)

Table 20-2.5 Calibration data (record of 13 monitoring wells on 27 July 2016)

No		Location			Groundwater Head	
	Monitoring Hole	X (UTM36, m)	Y (UTM36, m)	Z (EL.m)	Measurement Value (EL.m)	Model Layer
1	BH-N7	283664	3050278	47.308	44.14	2
2	BH-N8	283741	3050126	47.509	44.08	2
3	BH-N9	283626	3050225	47.110	44.11	2
4	BH-N10	284076	3050375	48.835	44.20	1
5	BH-N11	284150	3050292	47.615	44.19	2
6	BH-N12	284043	3050222	50.913	44.18	1
7	BH-A2	283606	3050413	46.997	43.17	2
8	BH-A3	284074	3050454	49.593	44.22	1
9	BH-N13	283523	3050452	45.885	44.20	3
10	BH-N14	283437	3050038	46.841	44.06	3
11	BH-N15	283623	3049686	46.769	43.90	3
12	BH-N16	284212	3049791	46.530	43.71	3
13	BH-N17	284383	3050462	46.670	44.02	3

(7) Model calibration

For the automatic calibration, the observed permeability of the Nc to Nm layer was used as an initial value[11]. At thresholds, initial values were adjusted to minimize residual error between the observed and calculated values. Calibration results are shown in Table 20-2.6.

Table 20-2.6 Calibration summary for aquifer coefficients

Calibration Points			Groundwater Head（ELm)		
No.	Monitoring Hole	Model Layer	①Observed	②Calculation	③Residual
			27/July/2016	By Case 10	Dif=①-②
1	BH-N7	2	44.14	44.18	-0.04
2	BH-N8	2	44.08	44.09	-0.01
3	BH-N9	2	44.11	44.07	0.04
4	BH-N10	1	44.2	44.10	0.10
5	BH-N11	2	44.19	44.20	-0.01
6	BH-N12	1	44.18	44.11	0.07
7	BH-A2	2	44.17	44.27	-0.10
8	BH-A3	1	44.22	44.15	0.07
9	BH-N13	3	44.2	44.09	0.11
10	BH-N14	3	44.06	44.02	0.04
11	BH-N15	3	43.9	43.94	-0.04
12	BH-N16	3	43.71	43.79	-0.08
13	BH-N17	3	44.02	43.96	0.06
				Average	0.02

11Model calibration was made mainly using Parameter Estimation and Uncertainty Analysis: PEST (http://wi.water.usgs.gov/models/pestplusplus/) and with 0.2~5.0 x observation value of thresholds.

Table 20-2.7 Comparison between observation records and calculation values

Layer No.	Symbol	Type of Aquifer	Depth		Permeability (Initial /before calibration.)		Permeability (calibrated)			Storativity (calibrated)	
			EL(m)		Horizontal（Kx,y)		Horizontal（Kx,y)		Vertical（Kz)	Specific Yield	Specific Storage
			top	bottom	cm/sec	m/day	cm/sec	m/day	m/day		
1-5	F	Un-Con.	GL	30.0	2.7.E-05	0.03	2.9.E-05	0.03	0.025	0.03	-
1	Nc	confining	GL	36.0	4.2.E-04	0.37	5.6.E-05	0.05	0.035	0.05	-
2	Nc/m	Confined	36.0	35.0	1.2.E-03	1.06	1.2.E-03	1.06	0.182	0.1	0.001
3	Nm		35.0	33.8			1.2.E-03	1.06	0.182		
4	Nm		33.8	32.5			1.2.E-03	1.06	0.182		
5	Nm		32.5	31.3			1.2.E-03	1.06	0.182		
6	Nm		31.3	30.0			1.7.E-04	0.15	0.065		
7	Ns		30.0	28.8	3.2.E-04	0.28	1.7.E-04	0.15	0.065		
8	Ns		28.8	27.5			1.7.E-04	0.15	0.065		
9	Ns		27.5	25.0			4.6.E-04	0.40	0.08		
10	Ns		25.0	22.5	2.7.E-04	0.24	4.6.E-04	0.40	0.08		
11	Ns		22.5	20.0			9.3.E-04	0.80	0.16		
12	Ng		20.0	15.0	4.5.E-04	0.39	9.3.E-04	0.80	0.16		
13	Ng		15.0	10.0			9.3.E-04	0.80	0.16		
14	Ng		100	0.0			9.3.E-04	0.80	0.16		
15	Ng		0.0	-10			9.3.E-04	0.80	0.16		

The calibrated aquifer coefficient is only slightly different from the initial value, in particular, the aquifer coefficient of the Nm layer of loose fine sand located just below the regulator. Seepage flow is not changed and remains at observation values.

The calculation results are acceptably different from observation values, less than 2cm on average at 13 calibration points, with variations of 1cm to 11cm. The model can reproduce groundwater flow and head in the vicinity of NDGRs. The model parameters are fixed and the current conditions of groundwater head and flow flux are recalculated in case of 27 July 2016 (see Figure 20-2.9 of case 10 of current model[12]).

The results shown are those of the monitoring survey. That is, groundwater flows down to model borders in response to rise in canal water level, and disturbances are found as a result of the minor variation of local rises and depressions influenced by partial recharge and evapotranspiration caused by sewage disposal, pumpage and so on.

12 Due to the unavailability of annual highest level of groundwater in the B/D stage, the previous model (case 0) was constructed with the data from 09 Dec 2015, before the 2015 winter closure. In the D/D stage, annual highest data from 27 July 2016 was applied to the current model as case 10.

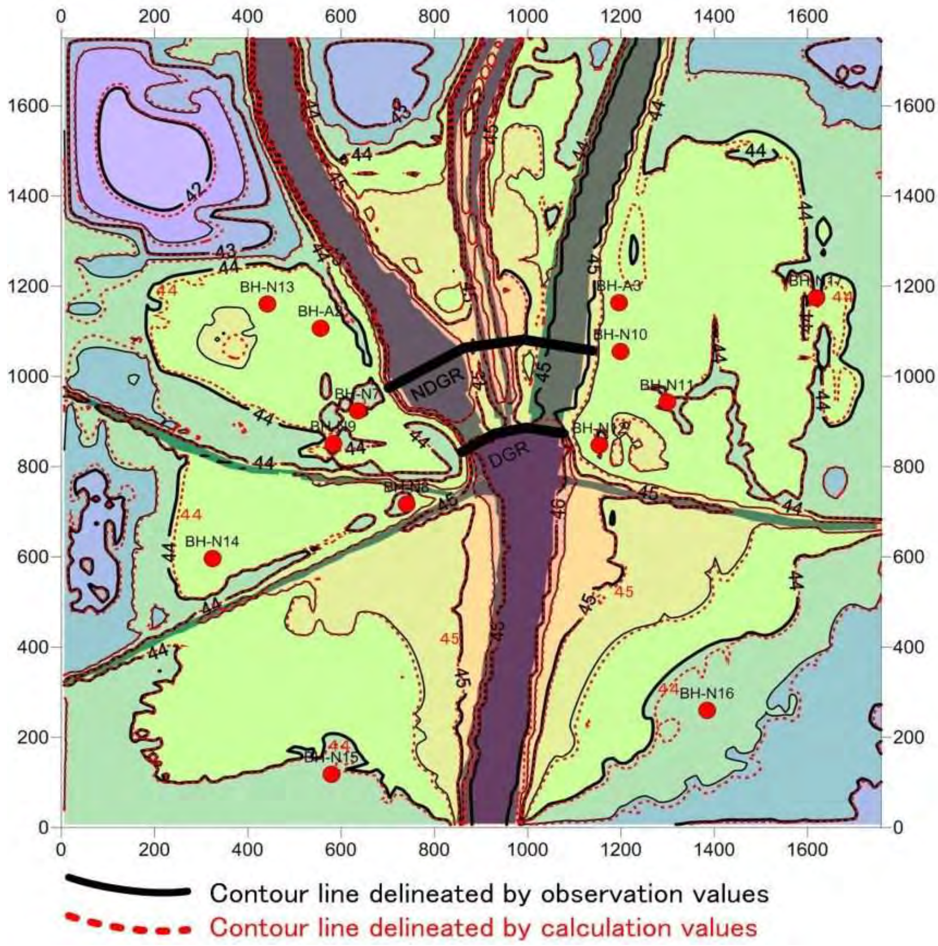


Figure 20-2.9 Comparison between observation and calculation values

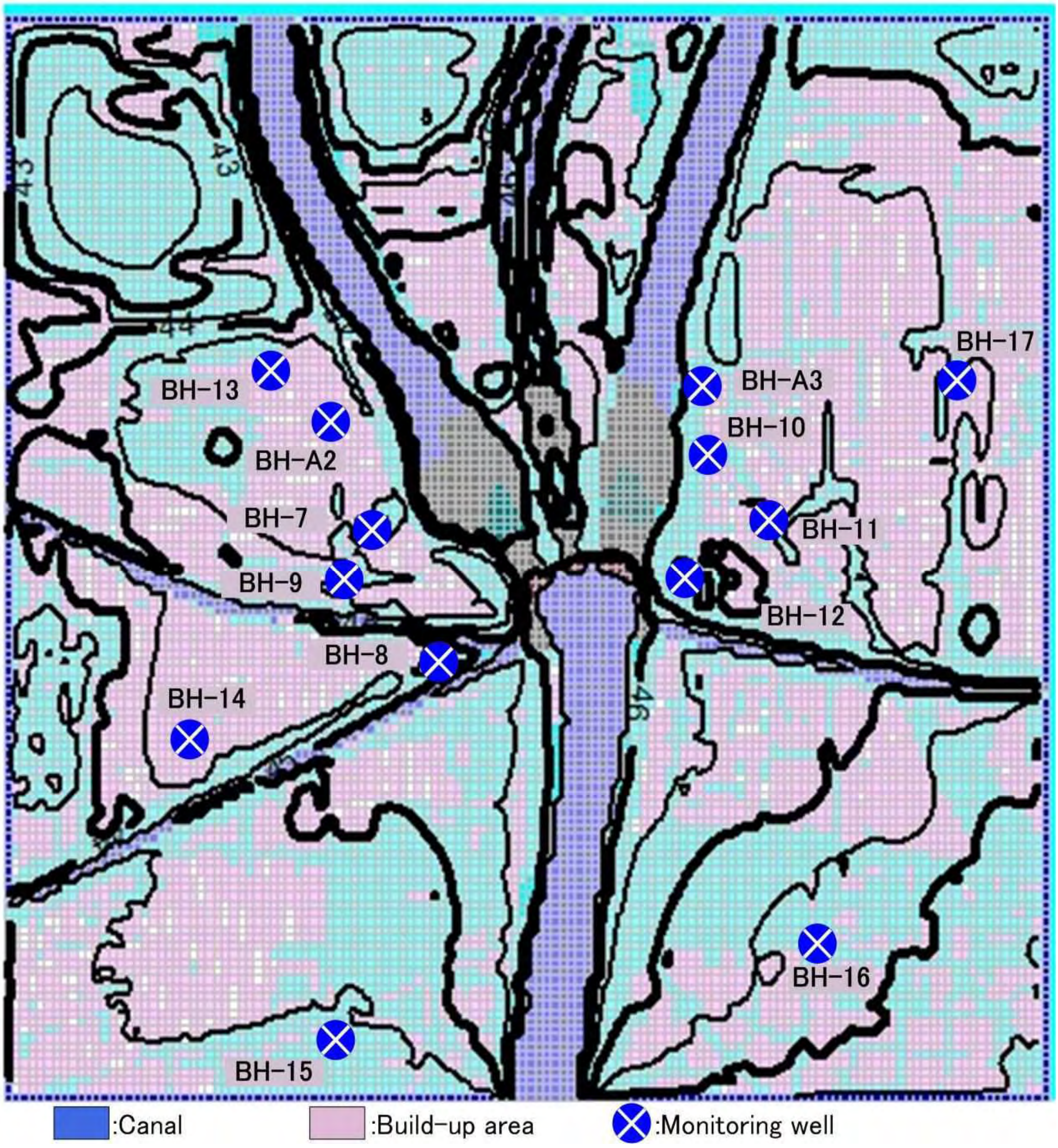


Figure 20-2.10 Contour map of groundwater head
(case 10, current model on 27 July 2016)

20-3 Preparation of detail model

For the purpose of groundwater modeling, which predicts groundwater interference after NDGRs construction, a regional model needed to be re-constructed to achieve a more precise simulation. The alternative study for groundwater control works covers the embankment, steel sheet piles, and so on. The detailed model has a small grid size capable of presenting the different dimensions of alignment and depth. The detailed model is therefore rebuilt from a refined regional model on an unstructured grid. In the following subsection, the process of making the detailed model is described.

(1) Grid refining

The construction area of NDGRs is subjected to grid refining. Using the Quadtree method on a 10m regional grid, a subdivision of 1/2 (5m), 1/4 (2.5m), and up to 1/8 (1.25m) are added on in order. In the last division, the total grid number reaches 531,735 (35,449 grids x 15 layers). The gridding structure of the detailed model is shown in Figure 20-3.1.

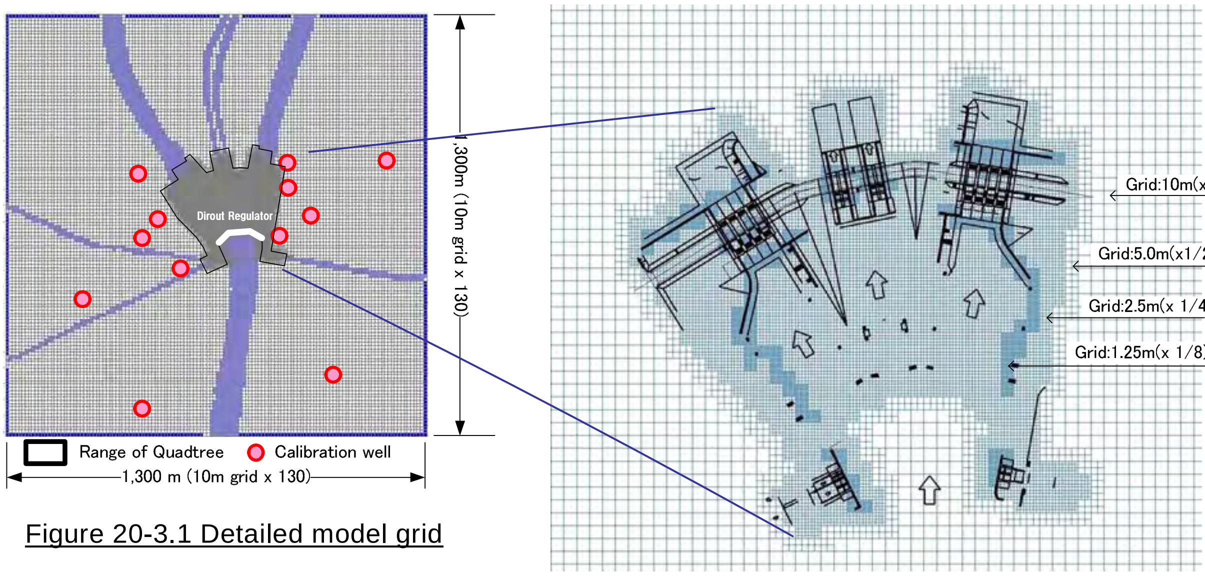


Figure 20-3.1 Detailed model grid

(2) Confirmation of model reliability (case 10 current condition)

The current groundwater status on 27 July 2016 of annual maximum water level is reproduced by the detailed model. In Figure 20-3.2, the distribution of groundwater head and flux are shown. Groundwater flowing east and west originated from DGRs (as a recharge source) with minor disturbances reflected on the pathways to model edges. An exchange of water at surface/groundwater systems, such as inflow of sewage, and loss by evaporation, are assumed through the distribution of groundwater head and flux.

The hydraulic gradient is 1/750 at the east (Ibrahimia) side and 1/600 at the west (Bahr Yusef) side. Due to the impervious silty clay overlain on the Irad Delgaw canals to the left bank of Bahr Yusef canal, the Bahr Yusef side shows a steeper hydraulic gradient than the Ibrahimia side. The water mass-balance in model range indicates 984m^3/day of infiltration from canals as shown in Table 20-3.1.

Table 20-3.1 Summary of mass water balance in the model area (case 10, current condition)

Boundary Condition	Inflow		Outflow		Balance		Remarks
	m^3/day	mm/day	m^3/day	mm/day	m^3/day	mm/day	
Canal	985	0.58	1	0	984	0.58	In/outflow, canals
Model boundary	147	0.09	403	0.24	-256	-0.15	In/outflow, model range
Recharge /evapotranspiration	435	0.26	1118	0.66	-683	-0.4	Inflow of sewage/ evapotranspiration
Well extraction	-		45	0.03	45	0.03	Pump up from well
Total	1567	0.93	1567	0.93	0	0)	-

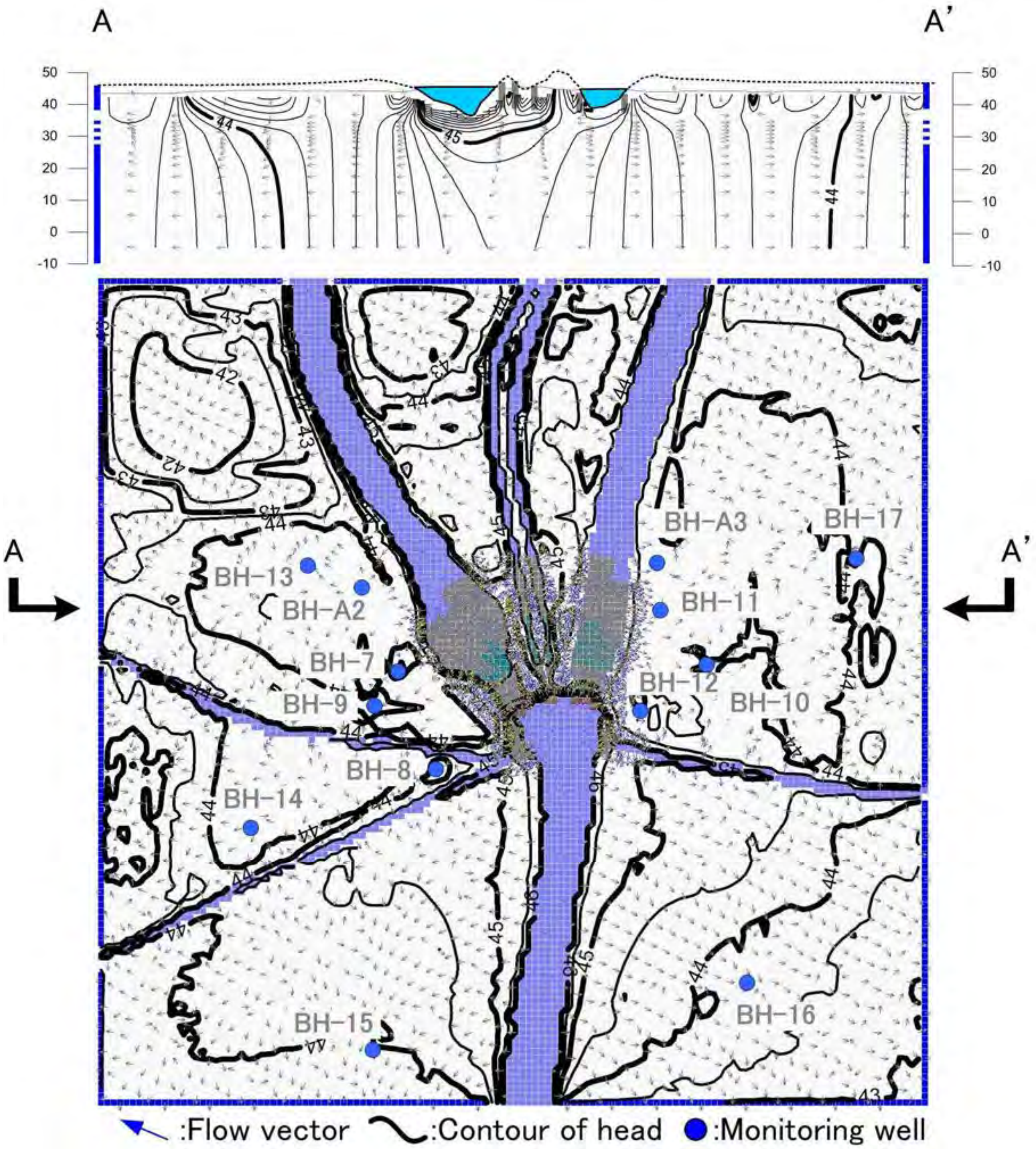


Figure 20-3.2 Groundwater head and flow vector (case 10)

20-4 Simulation study (Case 11, 12, and 13)

In the detailed analysis, case simulations are subjected to additional evaluation of seepage control in conjunction with embankments and steel sheet piles and so on. Simulations determine the acceptable measurements of components, areas, alignments, and amounts. Potential alternatives and their components and various configurations, may contribute to groundwater fluxes; causing seepage in unexpected directions and reducing groundwater inference. Groundwater simulations of selected alternatives are carried out as shown in the following subsections.

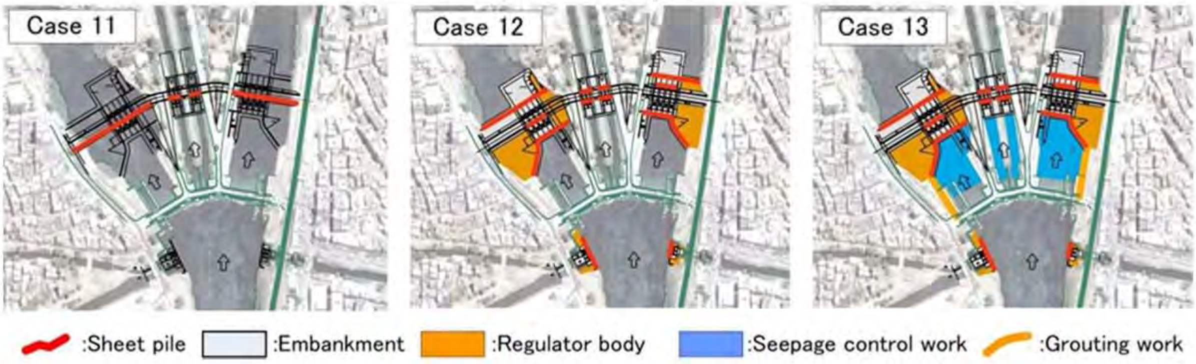
(1) Case condition

The full water level of Ibrahimia canal is planned as EL.46.3m (FWL) to simulate substantial influence by the NDGRs construction. Embankments and sheet pilings in revetment, bed protection works, and others are also included in simulations, with four cases shown in Table 20-4.1.

Table 20-4.1 Conditions of simulation cases

Case	Condition					Remarks
	Canal water level	Sheet Pile	Embankment	Seepage control work	Grouting	
Case 10	Current	×	×	×	×	Current status model (June-July/2016)
Case 11	Plan	○	×	×	×	Sheet pile/cut-off wall along axis
Case 12	-do-	○	○	×	×	D/D plan (sheet pile, Regulator, embankment)
Case 13	-do-	○	○	○	○	D/D plan + seepage control for channel bed, grouting

Alternative layout of seepage control works



Note: Permeability is given as

Sheet pile: $k=2.3 \times 10^{-5}$ cm/sec x 1.25m thickness of wall (1 grid)

Canal water inflow via embankment/regulator/foundation:
$k=1.15 \times 10^{-6}$ cm/sec x canal sediment thickness

Seepage control works: $k=1.15 \times 10^{-5}$ cm/sec x canal sediment thickness overlain aquifers

Grouting:: $k=1.15 \times 10^{-5}$ cm/sec x 1.25 thickness of wall (1 grid)

(2) Result of simulation

The simulated groundwater head and flux of cases 11, 12, and 13 are delineated in in Figures 20-4.1, 20-4.2, and 20-4.3 respectively. Even though groundwater seepage is found in parts of Abo Gabal and Irad Delgaw, their main directions (vectors) are seen as aligning outwards of (toward the east and west) the main canals of Bahr Yusef and Ibrahimia.

The velocity of groundwater flow, is not so fast, with a range of 0.001～0.4 m/day, an avarege of 0.01m/day (about 4m/year). In the E-W section, groundwater is recharged from the bottom of the canals and flows outside along layered aquifers, and the runoff in the model margin flows horizontally and slightly downhill.

a) Case 11

Case 11 is prepared with a cut-off wall (or sheet piles) penetrating up to EL.25m along NDGRs' axis. In the A-A' section of groundwater, the equi-contour line moves downward and increases seepage amount from the canals in comparison with current seepage level (case 10). Groundwater is acted on by confined pressure from the impervious clay layer (Nc layer) overlain, and groundwater head extends outside with almost same potential from top to bottom horizon.

b) Case 12

Case 12 is prepared under the same conditions as the ongoing bank protection works designed in D/D stage, which are composed of steel sheet piles along regulator axes, upstream and downstream of regulators, and embankments on both banks (see chapter 13). The penetration depth of sheet piles is planned at EL.25m maximum at the upstream alignment, and EL.29m～EL.41m at the downstream alignment. There are 31 piling sections classified into eight depths (EL.25m～EL.41m). In the model, respective depths are given corresponding model layers.

In the section along regulator axis (A-A'), groundwater flow is defined by canal section, and seepage amount is controlled at half of that in case 11.

c) Case 13

Case 13 is prepared as case 12 plus two additional features for bank protection: grouting and seepage protection. Grouting is planned along both banks of NDGRs and seepage protection is planned on the canal floor between NDGRs and DGRs. Both aim to close the gaps in the impervious areas of the DGRs and NDGRs against infiltration.

In case 13, groundwater inference area is deduced, but its effect is much less than that in case 12.

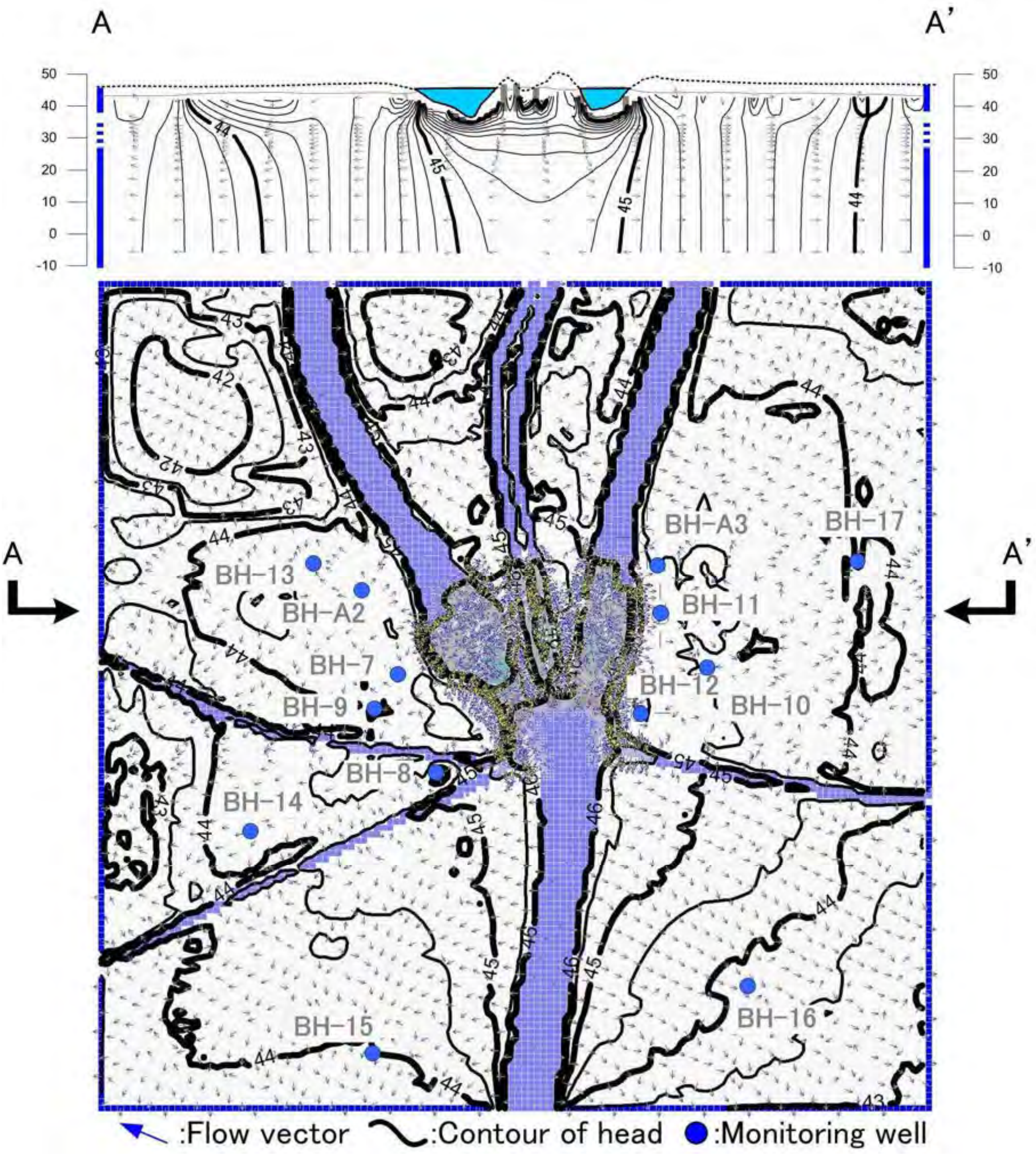


Figure 20-4.1 Groundwater head and flow vector (case 11)

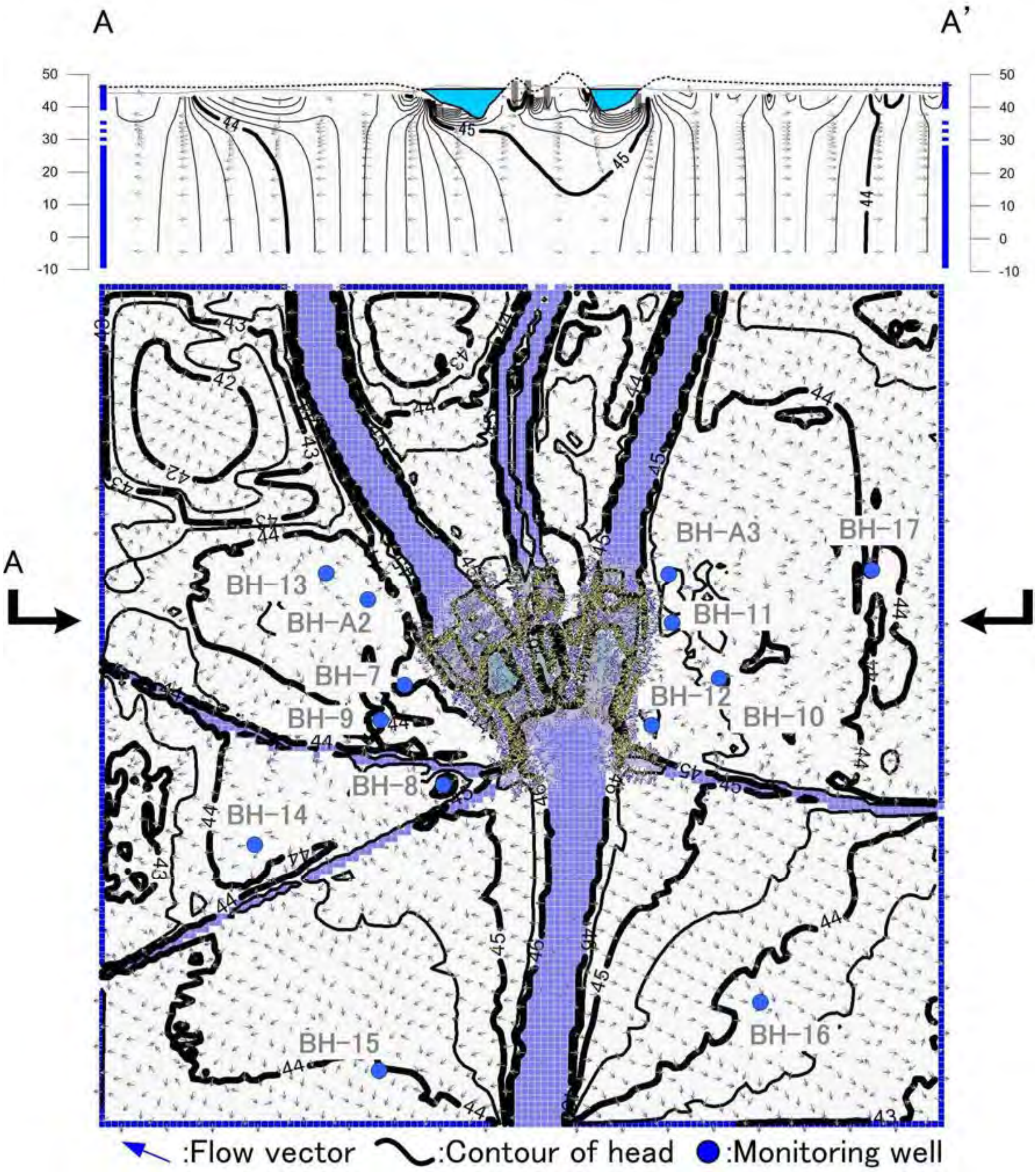


Figure 20-4.2 Groundwater head and flow vector (case 12)

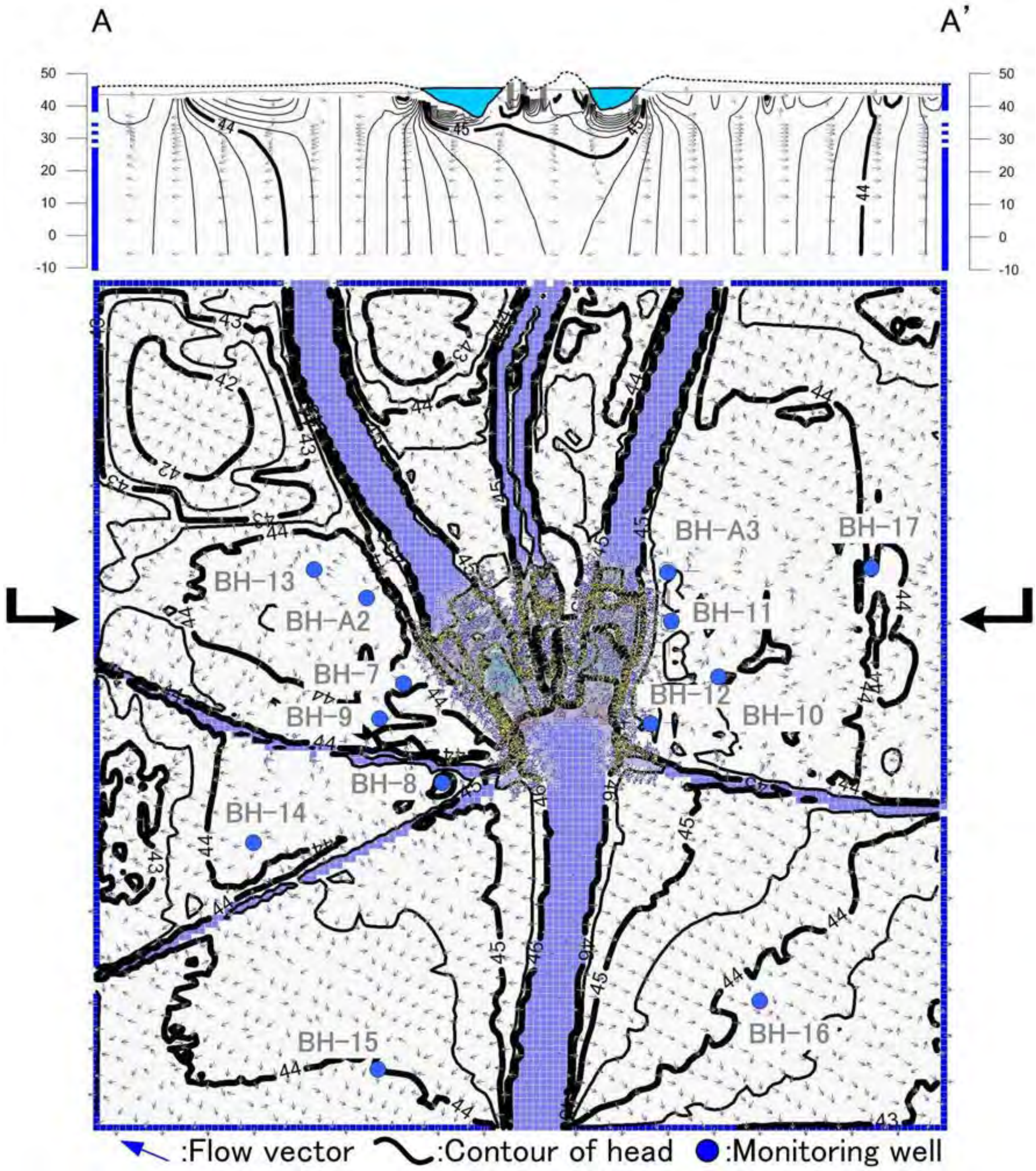


Figure 20-4.3 Groundwater head and flow vector (case 13)

20-5 Evaluation of seepage control works

(1) Groundwater rise and interference

In simulation cases 11, 12, and 13 after NDGRs construction, the rise in canal water is given as 1.3m higher than before construction at Ibrahimia canal, and 0.52m higher than before construction at Bahr Yusef canal (case 10). In the following subsections, groundwater rise and its inference is described for respective cases.

a) Case 11

In response to the canal water rise in case 11, groundwater head rises up to 0.5m on the Ibrahimia side and its influence extends with a radius of 400m from the edge of the canal water at Ibrahimia and 350m on the Bahr Yusef side. In Figure 20-5.1, the groundwater rise caused by canal water is shown as the difference between current conditions in case 10 and case 11.

Although estimated groundwater head in case 11 does not exceed ground surface, it reaches 1.25m at the shallowest point of the model range in the northwest. This depth may soak the ground surface through capillary action[13]. Areas adjoined to the canal banks, including blocks populated with shops, the railway station, mosques, and residential buildings with basements and structures on street corners are at particular risk of contact with groundwater.

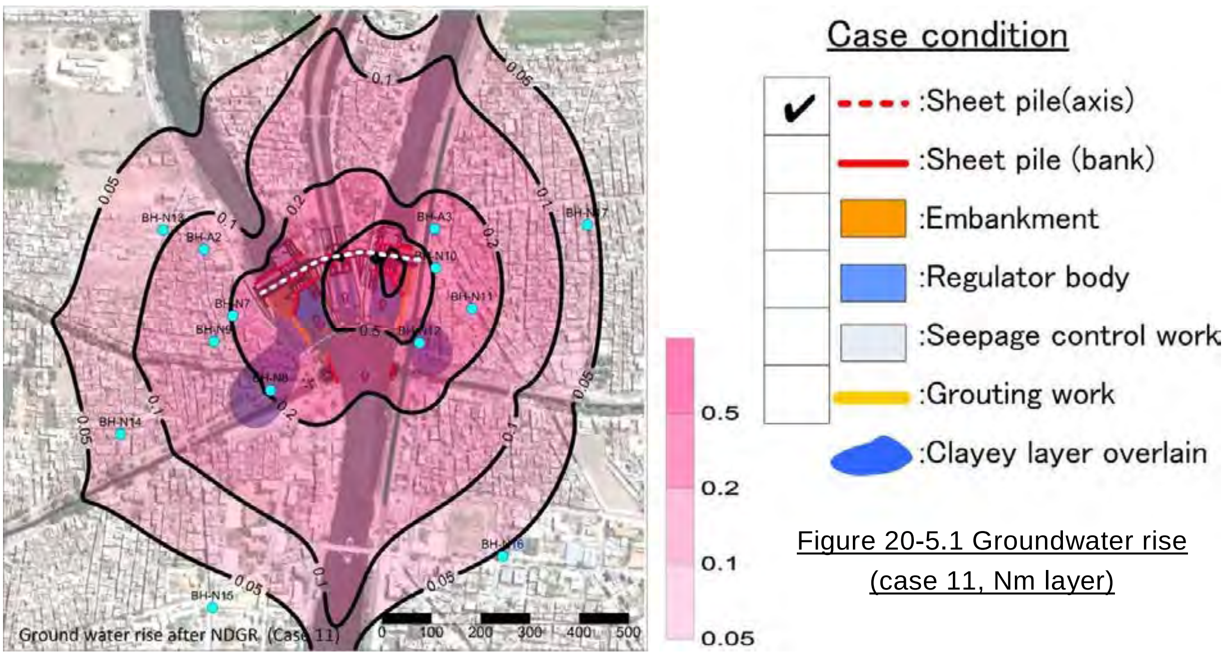


Figure 20-5.1 Groundwater rise (case 11, Nm layer)

b) Case 12

Case 12 is calculated under the condition of bank protection works designed in D/D and has enough impact on groundwater to reduce seepage by almost half of what is exhibited in case 11. In

[13] Most of the model area is covered by clay or silt, and the silt layer exhibits soaked ground. The theoretical value of capillary rise is 150～375cm, and wet zone may exist when the groundwater head becomes shallower than 300cm in depth according to the inventory survey.

Figure 20-5.2, the rise in groundwater (calculated as the difference in groundwater head between current condition case 10 and case 12) is shown on a contour map.

Bank protection works achieved with piling works and embankments control seepage and limit a rise in groundwater to 0.3m, and interference (of 5cm of groundwater rise) to 300m. Seepage is particularly reduced on the Bahr Yusef side through sheet piling which penetrates to the impervious horizon of the Bahr Yusef regulator’s foundation.

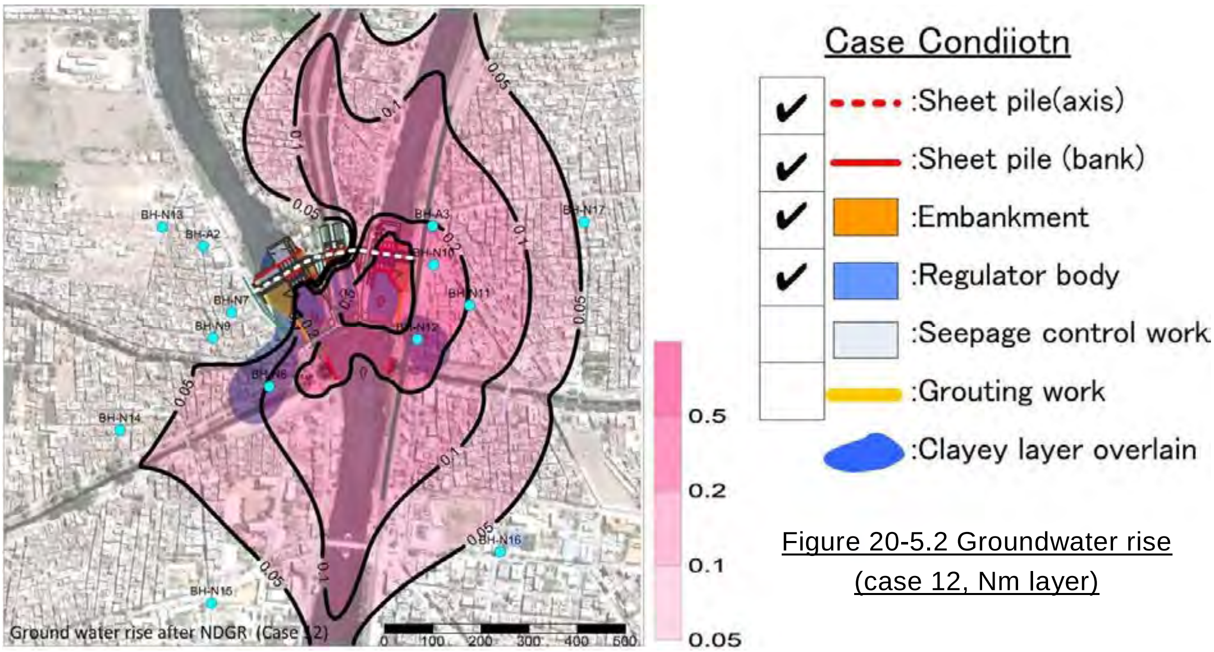


Figure 20-5.2 Groundwater rise (case 12, Nm layer)

c) Case 13

Case 13 is applied to evaluate the impact of grouting work on banks and canal bed seepage control. Therefore, model conditions and impervious properties[14] on canal floor are applied to grouting alignments.

The simulation shows that the impact of these additional works is limited and not much different from those of case 12. The range of the groundwater rise is slightly reduced and its interference range still extends to 300m, same as in case 12. The calculation results of the rise in groundwater (calculated as the difference in groundwater head between current condition case 10 and case 12) is shown in Figure 20-5.3.

[14] Improvement target of grouting is set as 1x10^{-5}cm/sec since grouting section is mainly composed of sandy foundation. The canal floor is also subjected to same condition of permeability.

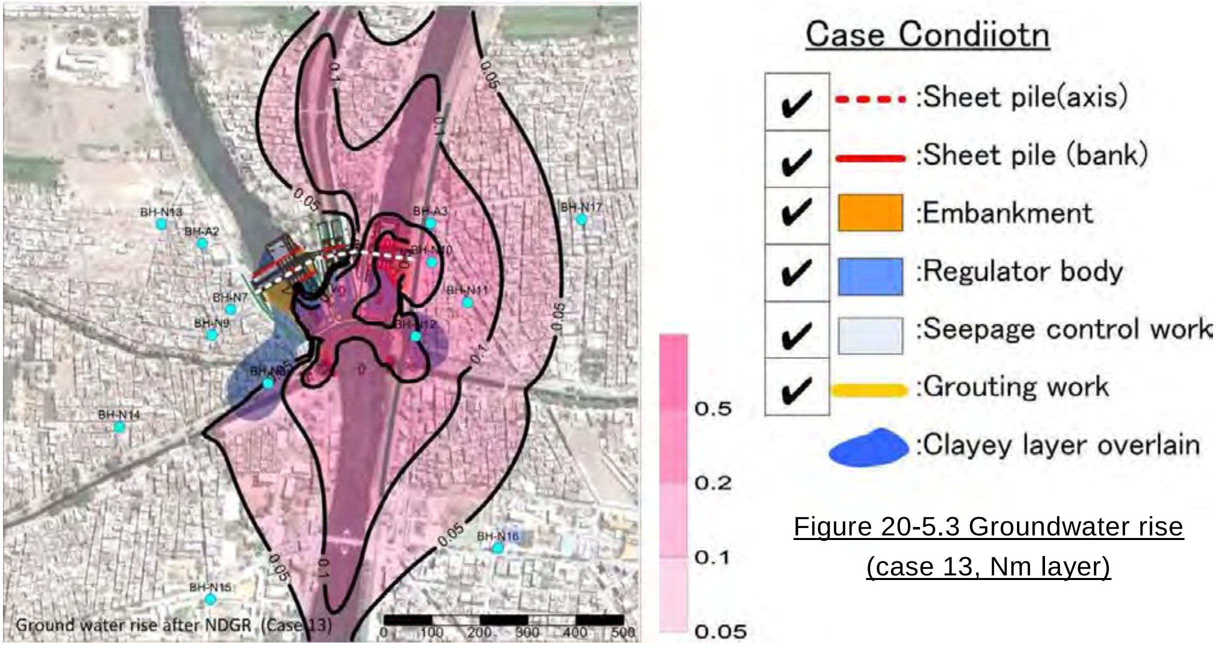


Figure 20-5.3 Groundwater rise (case 13, Nm layer)

(2) Comparison of seepage control works

The comparison Table 20-5.1 evaluates these two alternate plans; case 12 (bank protection work with steel sheet pile) and case 13 (case 12 plus grouting and seepage control on canal floor).

Table 20-5.1 Comparison of the seepage control works

Case	Feature of construction works			Effectiveness		
	Additional works	Reliability for quality	Temporary works	Groundwater rise	Inference area	Seepage amount
Case 12 bank protection	None ○ Done as bank protection	Certain ○ Sheet pile, embankment	None ○ Done as bank protection	0.09 m Avg. for model area	300m (RB) 270m (LB)	39m^3/day Avg. from all canals
Case 13 bank protection/ grouting/ seepage control	Necessary × (grouting, seepage control for channel beds)	Uncertain △ (difficult target)	Necessary × Expanding construction yard	0.06m Average for model area	300m (RB) 290m (LB)	33m^3/day Avg. from all canals

Case 13 presents obstacles to the course of NDGRs construction. Practically, grouting work has to be carried out after regulator construction to ensure sufficient workspace for construction. Also, earth works on the canal floor require temporary bypassing work before construction. The cost of construction therefore increases, and the construction period is extended.

Even if the works required in case 13 were completed, seepage control is much more effective in case 12. As for the differences in the results between case 12 and case 13; groundwater rise difference is only 0.03m, and difference in groundwater inference distance is 30m maximum and seepage amount is $6m^3$/day. Case 13 is therefore considered an ineffective plan due to the high cost of construction.

Although case 12 was solely designed for bank protection work, it also functions as groundwater control (water rise can be suppressed by a maximum of 0.3m), and restricts the expansion of risk to foundational and underground structures[15] to less than 3% (see Figure 20-5.4).

From both an environmental and an economical perspective, analysis shows that case 12 is the most feasible.

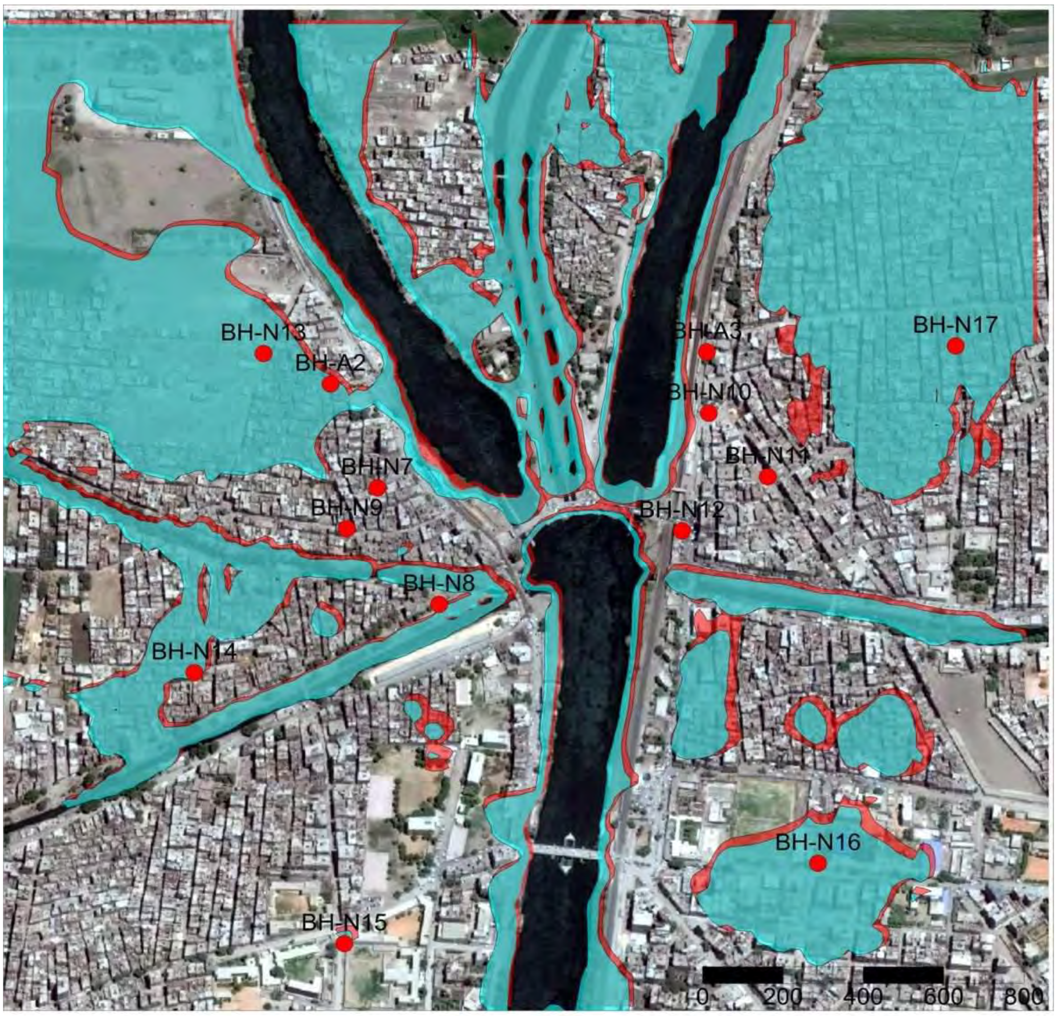
(3) Groundwater depth after NDGRs construction in case 12

In Dirout city, wet ground is caused by leakages from water supply pipes and sewage inlets. However, it may also be indirectly facilitated by the rise in groundwater due to inflow from canals and sewage water. In Dirout city, the underground structures of the most recent buildings are built 3m from the surface to avoid the harmful effects of shallow groundwater. Alternately, if groundwater level is kept deeper than GL -3m[16], negative environmental impacts can be evaded.

To check spatial distribution and risk inclination after the construction of the NDGRs (case 12), risk area is calculated with management depth, defined as GL-3m, as shown in Figure 20-5.4. Risk areas are spread widely at the low plains around NDGRs. In Figure 20-5.4 ‘blue’ indicates a risk area in the current condition (case 10), while ‘red’ indicates an expanding area after NDGRs’ construction (case 12). However, these risks only present themselves from June to August, the season with the highest water levels. As there are multiple factors influencing these phenomena, groundwater monitoring is to be continued with the purpose of facilitating impact mitigation projects, such as a public sewage system and so on.

[15] The drawing shows a risk area for groundwater obstacle due to shallow groundwater head which is less than marginal depth (3m from GL) at highest season. The ‘blue’ areas are the current risk area (case 10), while ‘red’ shows an expanding risk area after NDGRs construction (case 12).

[16] In general, management depth for underground facility is set as GL-3m to keep enough distance for controlling the groundwater rise by soil capillary action, and successive leaching.



Area of shallow groundwater area (GW depth is shallower than 3m from GL)

: Current condition calculated by Case 10 based on 2016 July observation record

: Future condition calculated by Case 12 after NDGR with bank protection works

Figure 20-5.4 Area of shallow groundwater head (less than 3m from GL)

Volume II　　WATER MANAGEMENT SYSTEM

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Volume II–WATER MANAGEMENT SYSTEM

1. Integrated Water Management System

1-1 Background of integrated water management system

The DGRs distribute 9.6 billion m^3 of irrigation water per year from the Nile River to approximately 600,000 hectares of land via the Ibrahimia canal. The water is distributed to the beneficiary areas by seven canals originating at the group of regulators. Of the seven canals branching from the group of regulators, the Bahr Yusef and Ibrahimia canals are 300km long, and as such are the main canals. Bahr Yusef canal has four regulators (Lahoun, Mazoura, Sakoula, and Dahab) installed with grant aid from Japan, and were upgraded between 1995 and 2010.

The DGRs were built in 1872, and the hydraulic functions of the facilities have declined significantly since then due to age. If the group of regulators is upgraded to enable them to fulfill their essential hydraulic functions, water can be properly distributed to the seven canals. The integrated operation of the group of regulators and the four regulators already installed will improve irrigation in the middle reaches of the Nile, leading to efficient water resource management in the area. Integrated operation and management of the group of regulators and the major regulators, will allow for appropriate water distribution in five governorates (Assiut, Giza, Beni Suef, Fayoum, and Minia).

Water management in the covered 600,000 hectares, is managed by the General Directorate for Water Distribution (GDWD) in Assiut. This authority manages the DGRs and the regulators on the canals that are located on the governorate boundaries. GDWD in Assiut monitors the regulator gates and instructions on gate operation through the General Directorates of Irrigations (GDIs). GDI monitor and instruct the gate operation to the intermediate regulators (not on the governorate boundaries) and the branch canals for water distribution.

To ensure proper water distribution to the canals, upgrading the DGRs is vital to stabilize the water level in the canals, with the aim of diverting the water taken in at the Ibrahimia Head regulators in the seven directions with prescribed amounts. Water management is particularly important in stabilizing water levels at canals over 300km long (Bahr Yusef and Ibrahimia canal), and diverting the prescribed amounts of water to the branch canals upstream of the regulators.

Furthermore, in order to let the diverted water from the main canals to the branch canals reach to the end fields, it is important to eliminate sediment blockage to the flow in the branch canals, and to let even the minor irrigation facilities give adequate hydraulic functions. However, the deteriorated minor irrigation facilities and gates do not adequately fulfill their hydraulic roles, resulting in defective canals and irrigation facilities and causing water shortages at the fringes of the beneficiary areas.

To ensure proper water management from the main canals to the ends of the branch canals across a huge beneficiary area of approximately 600,000 hectares , it is important to break down the issues and clearly define the steps necessary for: (1) upgrading the main regulators on the main canals, (2) introducing a water management system capable of providing centralized wide reaching water management, and (3) upgrading the facilities to restore the hydraulic function of the canals and minor irrigation facilities.

Downstream water level control system has generally been used to manage gate operation of regulators in Egypt until now. Therefore, introducing a new water management method that maintains stable water levels upstream and stable water distribution with an over-flow type gate, will require a trial period and technical assistance. Considering these changes, the following steps can promote fair water distribution in the areas concerned.

Step 1:

- Construction of new DGRs
- Introduction of an integrated water management system

Step 2:

- Technical assistance and aid for Integrated water management system

Step 3:

- Upgrading narrowed canal sections and minor irrigation structures to ensure proper water distribution

1-2 Concept of integrated water management system

In order to distribute the diverted irrigation water to the beneficiary areas fairly and properly, an integrated water distribution system should be established to monitor irrigation water diversion and formulate a proper water diversion plan. The objectives of the integrated water distribution system are the monitoring of water diversion and the evaluation of flow situation at (1) the new DGRs, (2) regulators along the Bahr Yusef canal and the Ibrahimia canal, and (3) intake facilities of branch canals, in order to formulate a real-time water distribution plan.

These things are realized by introducing unified management of the water distribution status at each monitoring location utilizing the telemeter system through flexible water management, rational water distribution based on the balance of supply and demand of water volume and fair water distribution management. The concept of the integrated water management system to be introduced in the study is consistent with that of the Central Directorate for Telemetry. With reference to the points above mentioned, the concept of the water management system will be established by introducing instruments and equipment that realize fairness, reliability, and flexibility of the system.

Table 1-2.1 Basic concepts of water management system

Description	Expected Accomplishment
Fairness	-Fair water distribution management under the prescribed amounts of water
Reliability	-Effective water distribution management reflecting the arrival time of supply -Appropriate water distribution based on the cropping schedule -Effective water distribution due to the reduction of management loss
Flexibility	-Water management corresponding to a future’s change of cropping pattern -Flexible water management based on the balance between demand and supply

In order to realize the integrated water management system, it is important point that not only installation of water distribution equipment but also human resource development for operating these equipment. Since the operation and maintenance manual for water distribution instruments will be prepared in the study, it will be utilized for future human resource development through the Technical Cooperation Project, and as such must establish the following basic functions.

Table 1-2.2 Three basic functions of the project

Item	Contents
Real-time Water management	Real-time monitoring of water supply situation in NDGR, discharge situation of each regulator in canal and the main branch canal intake.
Water Balance Management	Realization of unified monitoring of the discharge at the regulators and branch canal intake. And that the water balance can be confirmed at the central monitoring room by comparing "difference discharge between upstream and downstream regulator" and "demand amount multiplied by unit water requirement and served area".
PDCA Cyclic management	Formulate an improved cycle: Plan, Do, Check, and Act of water distribution system cycle. Proper water distribution and the rapid improvement of evaluation results based on real time discharge data are expected.

2 Current Situation of Water Distribution System

2-1 Regulators along main canals

The locations and names of the regulators on Bahr Yusef canal and Ibrahimia canal are shown in Figure 2-1.1 and Table 2-1.1. There are four regulators on Bahr Yusef canal and eight on Ibrahimia canal.

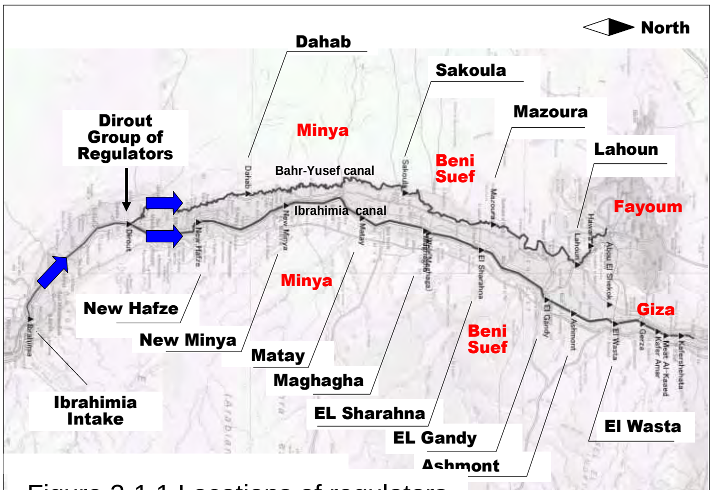


Figure 2-1.1 Locations of regulators

The role of the regulators on the governorate boundaries is to send the obligatory discharge to the governorate downstream. These play an important role in water management on the long main canals. The role of the other regulators except on governorate boundaries is to maintain water level at the main canals and stabilize diversion to the branch canals. At the regulators located on governorate boundaries, an H-Q curve is created on the downstream side of the regulator.

Table 2-1.1 Regulators along the main canals

Name of Canal	Regulator	Location	District Boundary	Gate Type		
				(1)	(2)	(3)
Bahr Yusef canal	Dahab regulator	Minia		+		
	Sakoula regulator	Minia	Beni Suef	+		
	Mazoura regulator	Beni Suef		+		
	Lahoun regulators	Beni Suef	Fayoum	+		
Ibrahimia canal	New Hafez regulator	Minia			+	
	New Minia regulator	Minia			+	
	Matay regulator	Minia			+	
	Maghagha regulator	Minia	Beni Suef		+	

	El Sharahna regulator	Beni Suef				+
	El Gandy regulator	Beni Suef				+
	Ashmont regulator	Beni Suef				+
	EL Wasta regulator	Beni Suef	Giza			+

Note: Gate Type (1) is double leaf gate, (2) is chain type, (3) is Fahmy Henien gate

Source: JICA Study Team (2015)

Double leaf gate	Chain type gate	F.H.(Fahmy Henien) gate

Figure 2-1.2 Regulators' gate type

Regarding the water level condition of each regulator, the water level status at the time of F/S, which became the background of implementation of the Project, is shown in Figure 2-1.3.

The regulator's gate operation aims to maintain a consistent water level downstream of the regulators along the Bahr Yusef and Ibrahimia canals. The typical fluctuations of water level at some regulators are shown in Figure 2-1.3 as an example. At Sakoula and Mazoura regulators, upstream water level is maintained in order to distribute water from the main canal to the branch canals. However, keeping the water level stable except summer months has become impossible. As for the regulators along the Ibrahimia canal, the upstream water level at the New Hafze Regulator is maintained high enough for reliable diversion to the Serry canal located upstream of the New Hafze Regulator.

As for the other regulators along the Ibrahimia canal, there is no major difference in the water level between the upstream and the downstream, as shown in the following figure (Matay regulator).

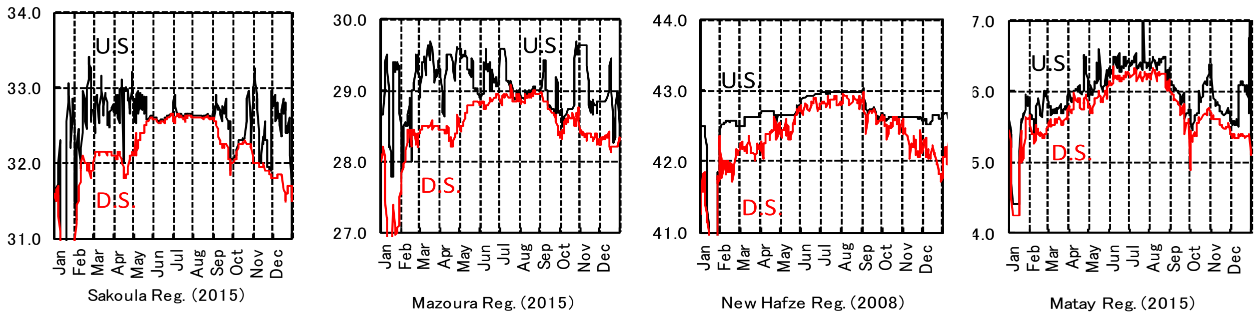


Figure 2-1.3 Record of U/S and D/S water levels at regulators along Bahr Yusef and Ibrahimia canals

Based on the current situation above mentioned, the challenges and measures for better water management along the main canals are shown in Table 2-1.2.

Through interviews with the GDWD in Assiut and GDIs, some of the regulators along the main canals are operated to maintain upstream water level for the branch canal intakes.

On the other hand, other regulators especially those located along the Ibrahimia canal are operated to maintain downstream water level. As will be described later, the GDWD in Assiut is located far from the actual operation sites. Therefore, the GDWD in Assiut could not monitor the gate operation status of the branch canal, such as whether or not the appropriate amount of water is distributed to the branch canal. And interviewing through this survey, there are subsequent concerns regarding excessive intake from the branch canal intake on the upstream side. For implementing appropriate water distribution, it is GDIs that operate the regulator along the main canal directly, and the GDWD in Assiut is the only institution that monitors the status of water distribution.

Table 2-1.2 Challenges and future countermeasures for main canals

Location	Challenges	Countermeasures
Regulators along Bahr Yusef canal	Lacking gate operator monitoring and follow up activities causes big water level fluctuations at regulator upstream	Operational guidance of gate to stabilize the upstream water level, and supervise branch canal's intake
Regulators along Ibrahimia canal	Because the difference between upstream and downstream water levels at regulator is small, the water intake to branch canal is not stable except at New Hafez regulator	Operational guidance for regulator's gate operation along main canal, and supervision of branch canal's intake

2-2 Small scale irrigation facilities (branch canal intake)

Under the current water management system, the roll of regulators located on the governorate boundaries is to discharge the proper amount of water to the downstream governorates. However, the quantities demanded for irrigation covered by each regulator are not distributed evenly to the branch canals.

In order to establish a proper water management system, it is important to take proper amount of water from the main canals to the branch canal and to operate the gates based on planned or actual demand. However, some of the gears of intake gates in the branch canals have broken (caused by deterioration and the theft of gear parts). As a result, the GDIs in charge of the gates operate the intake gates using a makeshift temporary steel frame attached to a mobile hoist or lifts up the gates by backhoe to divert water to the branch canals. There are some spots on the branch canals where the flow capability declines due to sediment accumulation and discarded rubbish. In the future, measures will be taken to ensure proper water distribution to the branch canals, such as installing water gauges that enable remote checking of flow conditions of the branch canals.

West Hafez Ganabia intake	El Mansour intake	Secondary canal after intake gate
		
The gear was broken. The gate is lifted and operated by chain crane and temporary steel frame.	The gear was broken. Lifting up the gates by backhoe as a temporary measure to divert water to the branch canal.	The flow capability declines due to sediment accumulation and discarded rubbish at the head of branch canal.

Figure 2-2.1 Gates with non-operational hoist and condition of branch canal

Table 2-2.1 Challenges and future countermeasures for minor irrigation facilities

Irrigation facilities	Challenges	Countermeasures
Branch canal's intake	The gate has not been operated, partially because some gears have been broken and others stolen. Irrigation district staff operates the gate by temporary mobile crane.	Replacement of the gate by Irrigation Directorate
Canals	Cross section of canal has been narrowed by sedimentation of soil and garbage, and water flow has been obstructed by sediment soil. On the other hand, there are some branch canals where the cross sections are over dredged.	Reshaping of the branch canals cross section by Irrigation Directorate.

2-3 Current situation of gates on branch canals

The field survey of the branch canal intake on the Bahr Yusef and Ibrahimia canals had carried out. The purpose of the survey was to clarify the current condition of the branch canal's intake. The branch canals surveyed were selected based on selection criteria described in section 3

In addition, the Minia and Beni Suef directorates had also implemented the current gate conditions of the branch canal's intake. These data were compared with the field survey result by D/D consultant and updated in accordance with that of the D/D consultant.

According to the survey by the D/D consultant, deterioration is progressing with fifteen gates and it is judged that all gates are in need of rehabilitation work for smooth and timely gate operation. The evaluations are shown in Table 2-3.1. In the column "defect condition," "A" means the stuck F.H. gate with gear trouble, and "B" means that the gate is operated by a temporary mobile hoist.

The rightmost column in Table 2-3.1 shows the relationships of the selected 128 minor structures that were inspected during the feasibility study of Dirout Group of Regulators in 2010. "-" in the column means that the target branch canals to be monitored in this NDGRs project are not included in the selected irrigation facilities at F/S which need rehabilitation.

During F/S study stage, the selected 128 minor structure had been prioritized for rehabilitation and those rehabilitation works would have been implemented by RGBS, however, the rehabilitation works are still under consideration at the moment. D/D consultant proposes to take up the following 15 intakes for reconstruction because they are important for the appropriate distribution of irrigation water from the main canal to the branch canal.

Table 2-3.1 Gate conditions at branch canal's intake

Name of Main Canal	Name of Branch Canal	Gate Type	Condition (Data from Directorate) 1: good 2: need maintenance	Condition (Inspection) 1: good 2: need maintenance	Defect condition	Selected 128 Minor structure
Bahr Yusef canal	Manshat EL-Dahab	F.H.	1	2	A	-
	El-Hareka	F.H.	1	2	A	-
	El-Sabaa	F.H.	1	2	A	-
	Quftan	F.H.	2	2	A	-
	Wesh El-Bab	F.H.	n/a	2	A	-
	El Giza	D.L.	n/a	1	-	-
	Hassan Wasef	D.L.	n/a	1	-	-
	New Kamdeer P.S.	Pump	n/a	1	-	-
	New Terfa P.S.	Pump	n/a	1	-	-
	Old Terfa P.S.	Pump	n/a	1	-	-
	Old Sakoula P.S.	Pump	n/a	1	-	-
	Mazoura P.S.(2)	Pump	n/a	1	-	-
Ibrahimia canal	Irad El Maharak	F.H.	n/a	2	A	-
	El Kosia	F.H.	n/a	2	A	-
	East Hafez	F.H.(with crane)	1	2	B	-
	West Hafez	F.H.(with crane)	2	2	B	-
	Adkak	F.H.(with crane)	1	2	B	-
	Gendia	F.H.(with crane)	2	2	B	-
	EL Soultany	F.H.	2	2	A	-
	Tansa	F.H.	1	1	-	-
	EL Azhary	F.H.	2	2	A	-
	Bosh	F.H.	2	2	A	-
	El Mansour	F.H.	2	2	A	-
	Serry Weir	Weir	-	-	-	-
	Maghagha Weir	Weir	-	-	-	-
	Abo Shosha Weir	Weir	-	-	-	-
	Bani Hader Weir	Weir	-	-	-	-

F.H. Fahmy Henien gate
D.L.: Double leaf gate
F.H. (with crane): The gate which is lifted up by chain crane.

2-4 Water management and distribution at DGRs

According to the interview with the CDWD during the F/S stage in 2010, water management and distribution for each governorate are based on the Agreement of Water Distribution approved by the governorates in 2002. However, it is clarified that this Agreement has not been taken into account for recent years. The water distribution is evaluated based on the data recorded by CDWD. Table 2-4.1 and Table 2-4.2 show the distributed amount of water and intake ratios from Bahr Yusef and Ibrahimia canals.

Table 2-4.1 Distributed water amount (average from 2010 to 2014)

Distributed Area		Discharge (MCM) *	Ratio (%)
Ibrahimia Head regulator		8,969	100%
	Bahr Yusef at DGR	4,566	51%
	Ibrahimia at DGR	3,399	38%

Source: CDWD's daily recorded data arranged by JICA Survey Team

*: Total discharge from February to November during 2010-2014

Table 2-4.2 Distributed water amount at Bahr Yusef and Ibrahimia canals (DGRs, average from 2010 to 2014)

No	Directorate	Bahr Yusef canal			Ibrahimia canal		
		Discharge (MCM) *		Ratio (%)	Discharge (MCM) *		Ratio (%)
DGR		4,566		100%	3,399		100%
	Minia	(1)	808	18%	(5)	1,871	55%
	Beni Suef	(2)	601	13%	(6)	1,528	45%
	Fayoum	(3)	2,493	55%			
	Giza	(4)	664	15%			

Source: CDWD's daily recorded data arranged by JICA Survey Team

*: Total discharge of February to November during 2010 – 2014

(1)= 4,566MCM (Discharge at DGR)-3,758MCM (Sakoula)

(2) = 3,758MCM (Sakoula)-1,461MCM (Lahoun)-1,032MCM (Hassan Wasef)

(3) =1,461MCM (Lahoun)+1,032MCM (Hassan Wasef), (4) = 664MCM (Giza Intake)

(5) = 3,399MCM (Discharge at DGR)-1,528MCM (Maghagha Weir)

(6) = 1,528MCM (Maghagha Weir) for Beni Suef and Giza

2-5 Irrigation system schematic diagram

In order to grasp the water distribution condition on the branch canals, a review was made on the command area of each branch canal surveyed during the F/S stage. The irrigation system schematic diagram is shown in the appendix.

2-6 Changes in water level of Lake Quarun

Figure 2-6.1 shows the record of water level of Lake Quarun in Fayoum Governorate. The lake is situated at the end of Bahr Yusef canal and the canal is only the lake's water source. Therefore, the cause of lake's water level rise are thought to be due to ineffective discharge from Bahr Yusef canal.

According to the water level data from 2010 through 2011 the rise in water level was temporarily curbed. However, since 2012 the level has begun to rise again. As there are hotels on the shore of Lake Quarun, water level rise should be avoided. In order to curb the rise, it is necessary to reduce ineffective discharge from Bahr Yusef canal and to use irrigation water more effectively.

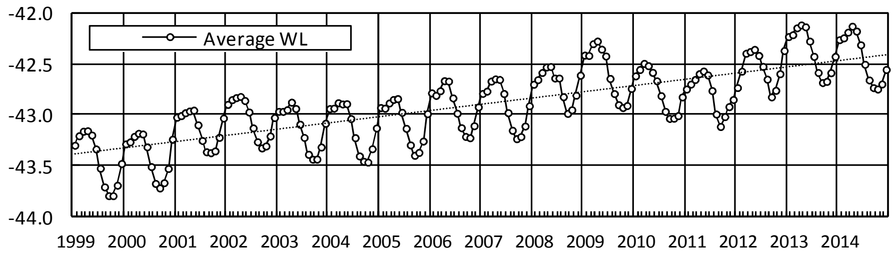


Figure 2-6.1 Water level changes of Lake Quarun

Quarun Lake Water Level Monitoring Facility

Figure 2-6.2 Lake Quarun and water level monitoring facility

2-7 Telemetry system

(1) MWRI"s Policy of telemetry system

The CDT of MWRI has implemented a telemetry system since 2009. The purpose of the telemetry system is to "transmit water level data at regulators, pump status, discharge data and meteorological data to the departments and agencies concerned with water distribution in real-time" and to "evaluate distribution to each governorate." The system aims to compare actual and planned water distribution in each governorate according to CDT policy, and to set up the system to adjust the water distribution in each canal based on the monitoring data. The main function of supervisory in the telemetry system is located in the CDT as the main station. At present, 219 gauging stations have been established. The equipment of the gauging station is composed with a water level sensor, a data logger with RTU, a GPRS modem, a solar panel, a charging controller and battery. The water level, voltage, and temperature data are transmitted to the main server every hour and then automatically sent to the GDWD and the GDI in each governorate in hourly text-typed e-mails. The water level data is also sent to the MWRI. In the future, MWRI plans to (1) increase the number of gauging stations to 450 with it's five year plan, (2) add discharge and flow velocity data to the transmitted water data, and (3) upgrade the system capable of optimizing water distribution to each governorate by evaluating the water balance between supply and demand.

The outline of the telemetry project (the water management system diagram formulated by the CDT) is shown in Figure 2-7.1.

The vast quantity of data collected through the telemetry monitoring equipment should be taken into a system as simple as possible. This should enable non-professional persons to grasp changes in water levels and other conditions easily.

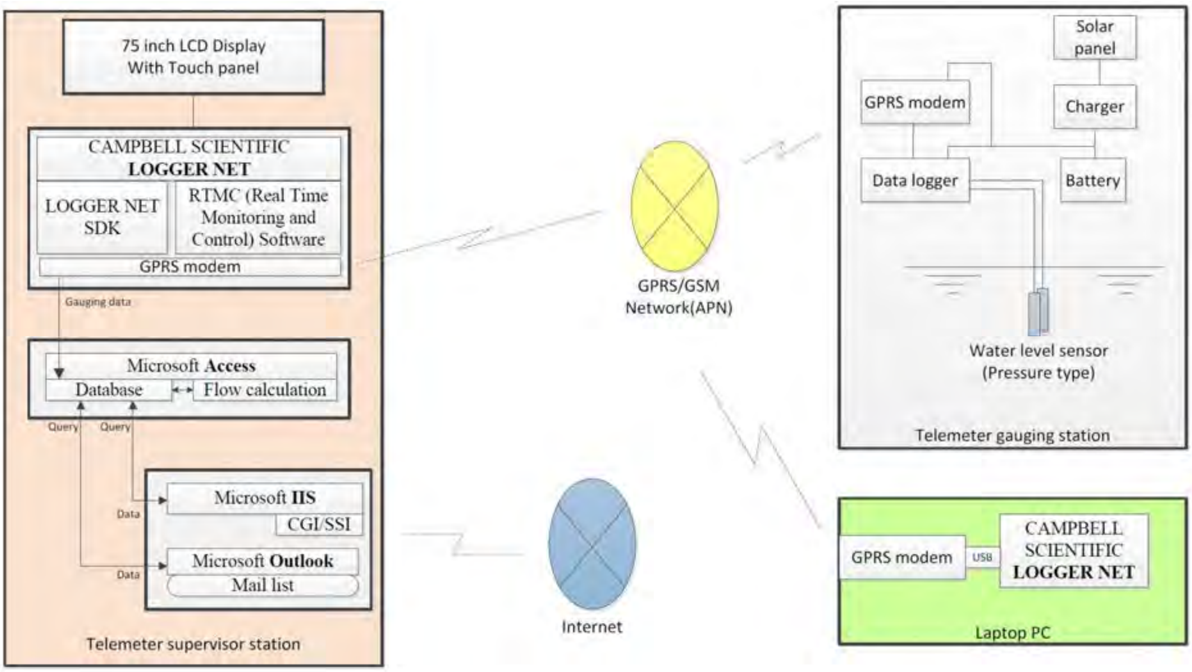


Figure 2-7.1 Schematic diagram of existing water monitoring system

Telemetry system in Cairo

Schematic Diagram of Dirout Area

Figure 2-7.2 Existing telemetry system, CDT in MWRI

(2) Telemetry sites in the project area

CDT has laid out the telemetry system in the project area. Table 2-7.1 indicates the names of telemetry sites which have been installed by CDT. Eleven sites have the H-Q curve equation for converting discharge based on downstream water level

Table 2-7.1 Current conditions of telemetry sites in the project area

Irrigation facilities			Name of the target facilities	Water Level		H-Q Curve	Number	
				Up	Dw		WL	H-Q
Dirout group of regulators			Bahr Yusef regulator	+	+	+	2	2
			Ibrahimia regulator	+	+	+		
Regulator	Bahr Yusef canal		Dahab regulator	+	+		6	3
			Sakoula regulator	+	+	+		
			Mazoura regulator	+	+			
			Lahoun regulator	+	+	+		
			Abo El Shekok regulator	+	+	+		
			Regulator km39	+	+			
	Ibrahimia canal		New Hafze regulator	+	+		1	0
Branch canal	Bahr Yusef canal	Intake	El Giza	+	+	+	1	1
		Weir	Hassan Wasef Weir	+	+	+	1	1
	Ibrahimia canal	Weir	Maghagha Weir	+	+	+	1	1
Ibrahimia main canal			Ibrahimia Head regulator	+	+	+	1	1
Lake			Quarun Lake	+			1	0
Total							14	9

Source: Central Directorate for Telemetry

2-8 Current monitoring and operating system

(1) Current method of water management

The current water management method is the same as that of generally used in Egypt, and local expertise on water management has accumulated for many years. On the other hand, it has become difficult to respond flexibly to the current water demand, caused by the diversification of farmland operation, and for real-time adjustment of water distribution based on the demand, for effective use of water resources and swift mobility for necessities in the ages

In addition, the demand for visual water distribution management has been raised with the increase of demand and interest of farmers and a strong need for an equal and appropriate water distribution system that responds to water demands in real time. This can be made possible with the development of highly-extensible and low-cost telemetry stations set up by MWRI.

(2) Organization responsible for water management system

The organization mentioned below is served for the monitoring of (1) water levels at the regulators along the main canal in the project area, and (2) the operation of regulator gates.

i) General Directorate for Water Distribution (GDWD) in Assiut

ii) General Directorates for Irrigation (GDIs) in Assiut, East Minia, West Minia, Beni Suef, Fayoum, and Giza

iii) Gate operators of each regulator

Figure 2-8.1 shows the instruction flowchart on gate operation of each responsible organization. Also, Table 2-8.1 shows the monitoring items at each regulator and the responsible organization of each regulator.

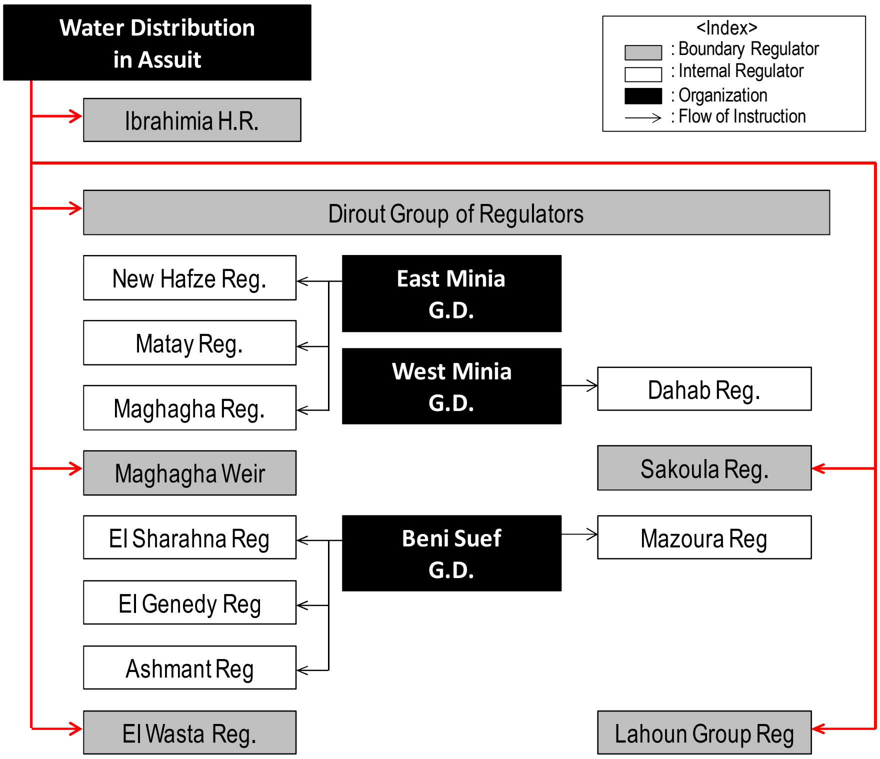


Figure 2-8.1 Organizations chart for the management of each regulator and gate operation

Table 2-8.1 Monitored items and organization responsible for the operation at each regulator

		Monitoring		Instruction Organization			
		Water Level	Dis-charge	WD in Assuit	East Minia	West Minia	Beni Suef
Ibrahimia Head Regulator		+	+	+			
Dirout Group of Regulator		+	+	+			
Bahr Yusef	Dahab	+				+	
	Sakoula	+	+	+			
	Mazoura	+					+
	Lahoun group	+	+	+			
Ibrahimia	New Hafze	+			+		
	Matay	+			+		
	Maghagha	+			+		
	Maghagha Weir	+	+	+			
	El Sharahna						+
	El Gendy						+
	Ashmant						+

As shown in Table 2-8.1, GDWD in Assiut is responsible for water distribution in the project area. The regulators between the governorates are monitored by the telemetry system and data are transmitted to the CDWD, the GDWD in Assiut, and the GDIs on time. At the other regulators on the main canals, Bahari, i.e. the gate operator, reads the water levels upstream and downstream of the regulators three times a day, and reports to the GDIs via mobile phone. After receiving the reports from the gate operators, GDIs informs the GDWD in Assiut of the water level data via mobile phone. Then, the GDWD issues instructions on the water level settings only on the downstream side of the regulators at the governorate boundaries (boundary regulators) to GDIs and the gate operators of these regulators adjust the gates in accordance with the instructions

GDIs decide on the water levels at the intermediate regulators (not on governorate boundaries) independently, and issue instructions to the gate operators. Observed water level data is converted to discharge (by H-Q curves) only at the boundary regulators along the Ibrahimia and Bahr Yusef canals. GDWD in Assiut prepares and maintains these H-Q curves.

GDWD in Assiut and GDIs in the governorates in the project area are the organizations directly involved in water distribution. On the other hand, CDT is responsible for the measurement and centralized monitoring of water levels at major regulators along the main canals, HAD, Lake Quarun, pump stations, main drain outlet, and some online discharge measurement facilities. The water level readings made by the CDT help check the water levels observed by GDWD, which are used to generate instructions on regulator gate operation.

Table 2-8.2 Challenges and countermeasures in the water management system

Item	Challenges	Countermeasures
Water level	The routine water distribution process is that the gate operator for the non-governing regulators reads the water levels observed by staff, then gauges and informs Water Distribution in Assiut by mobile phone. Therefore, it is not possible to rapidly evaluate and judge water distribution based on water level data because of the time gate operator takes to inform Water Distribution in Assiut by mobile phone of hand copied data.	The pressure-type water level sensor will be installed in each regulator to observe water levels in real time, and transmit the observed data to a water monitoring system at one site.
Instructions on water distribution	Water Distribution in Assiut does not decide on all water distribution in the project area. Only the regulators located on the border between districts is operated by Water Distribution. Therefore, it isn't possible to confirm the state of distributed water at one site because the regulators that are not on a border are operated at a local irrigation district level.	A new water distribution inspectorate will be established so that the instructions and judgment of equal water distribution will be evaluated by one organization.
Feedback for monitoring	The observed water level data is transmitted to the Water Distribution in Assiut three times a day. Therefore Water Distribution does not know the water level immediately after the operation of the gate, or whether the gate obeyed the instruction from Water Distribution.	For gathering a wide range of scattered water level data at one monitoring site, equipment must be installed to transmit, gather, record, visualize, evaluate, and store data at a central monitoring

	Water level data is transferred by voice through mobile phones and is then recorded by hand at Water Distribution. Therefore, it takes time to evaluate the distributed water situation and errors are likely when recording and transmitting data. In addition, evaluations cannot be made by visual charts and graphs.	house.

2-9 Current water management administration with the organization chart

The water management system consists of the above-mentioned three major organizations: 1) GDWD, 2) GDIs, and 3) gate operator (see Figure 2-8.1). Information on water level operation is centrally collected at GDWD in Assiut. However, because the operation of the intermediate regulators are managed by the GDIs of respective governorates, it is not possible for GDWD in Assiut or the GDIs of other governorates to verify whether the water levels in the main canals in the governorate concerned are being appropriately managed. Therefore, suspicions regarding water distribution may arise between GDWD in Assiut and the GDIs.

As mentioned above, the water level data monitored by the CDT is used as reference data to indicate water distribution instructions by GDWD in Assiut. Three different types of water level gauges shown in Figure 2-9.1, are used for monitoring of water levels at the regulators.

Because the water levels in canals are measured by the CDT in accordance with MWRI policy, the water level data obtained at these stations are utilized by GDWD as reference only. The water levels are also monitored at the gate control houses at regulators along Bahr Yusef canal. However, these water level data are not utilized to decide water distribution.

One of the issues of the water level monitoring equipment related to the regulators along the Bahar Yusef canal is the lack of maintenance of the water level sensor and the lack of instruction on the gate operation from GDWD and GDIs. Daily maintenance of the water level sensor is important from the viewpoint of sustainability utilization of these equipments. The responsible organization for the maintenance of these equipments is IIS. Figures 2-9.2 and 2-9.3 show the outline of the water level monitoring system introduced by the CDT.

Water Level gauging staff
(New Minia regulator)

Data transfer by telemetry
(Dahab regulator)

Dahab control house
(Dahab regulator)

Figure 2-9.1 Existing water level monitoring system

(left: a station at the Water Distribution, center: a station of the CDT, right: IIS)

Table 2-9.1 Issues and countermeasures in the design of the water management organization

Item	Design problem	Countermeasure
Ensuring that water level observation is monitored by each organization individually.	Water Distribution in Assiut is monitored on a marble water level meter indicating the same water level data monitored by CDT. However, GDWD's monitored data is recorded manually. And furthermore, the water level monitoring equipment is poorly maintained.	Integration of water level for monitoring and evaluating by a unified set of water level data.

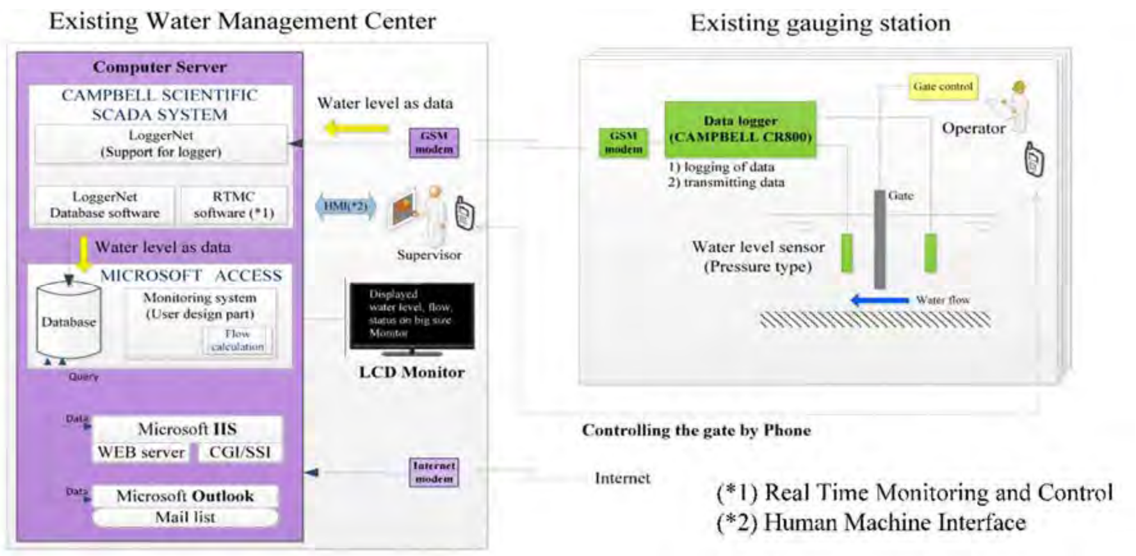


Figure 2-9.2 Diagram of water management system of the CDT

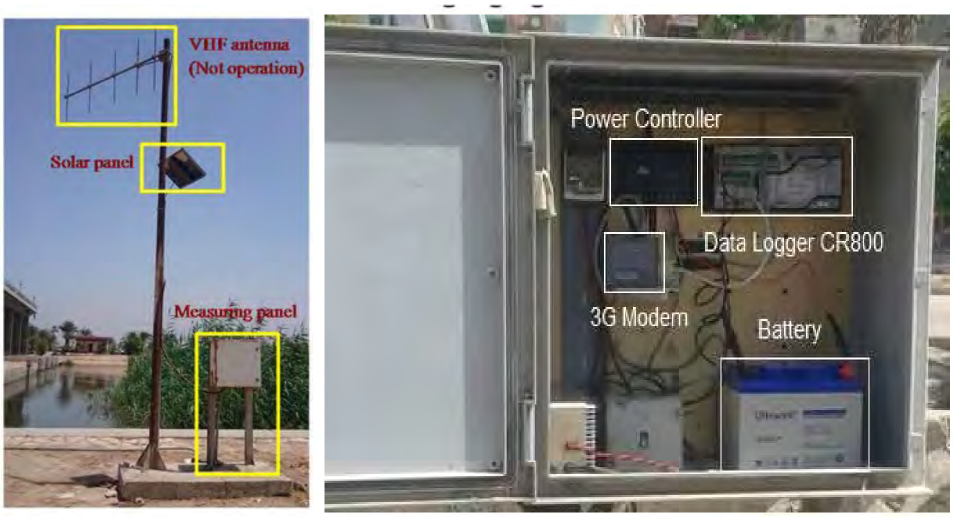


Figure2-9.3 Water level data transmission system developed by the CDT

3. Formulation of Integrated Water Management System

3-1 Setting up integrated water management system

(1) Effectiveness of the integrated water management system

Each facility in the irrigation system consists of water diversion facilities, regulators, main canals, intakes for branch canals, branch canals, farm land and drainage canals. In order to efficiently distribute water to 600,000ha-irrigation area in accordance with irrigation system requirements, each facility must fulfill its function satisfactorily. The scope of integrated water management system shall include not only the four regulators on the Bahr Yusef canal constructed through the grant aid from Japan, but also the irrigation facilities on the main canals under the supervision of the GDWD in Assiut of MWRI and that of GDIs. The irrigated area of the the main canal of the Project is a large area of 600,000 ha and the extension of the main canal is as long as 300 km. Therefore, it is indispensable to construct a system capable of unified monitoring of the water distribution status from the remote area. The following factors are considered as the necessity of introducing the water management system.

- Correction of the disparity in water distribution among the governorates
- Implementation of water distribution without surplus or shortage which is actually allocated based on the amount of water supplied data from the Ibrahimia head Regulator
- Efficient use of irrigation water by eliminating ineffective discharge
- Stabilization of water levels in the main canals
- Improvement of the transparency of the water distribution system
- Improvement of the safety of the system
- Utilization of collected data through upgrading of the management system

In view of the characteristics of each project area, the effect through the introduction of an integrated water management system is listed below.

- <u>Rational water distribution</u>

  The following items are expected; (1) the discharge in the main canals at the regulators, (2) the amounts of water distributed for irrigation between the regulators, (3) appropriate water distribution without surplus or shortage, and (4) equitable distribution of water in accordance with the agreement on water rights of each governorate in the area. The water allocation should be appropriately allocated by each weir based on the amount of water actually supplied from Ibrahimia. This leads to fair water management.

- <u>Better understanding of the water distribution</u>

  Using a system of centralized monitoring of water distribution and a visual display of water levels at multiple locations, enables anyone to confirm actual water distribution and the state of water distribution. An integrated water management system with a visual display function allows governorates with conflicting water usage interests to verify that the limited water supplied to the irrigation system is distributed equitably among them, hence the introduction of the system is expected to improve transparency of water distribution.

・Timely instructions on water distribution

This system allows for the centralized collection of monitoring data and the use of this data to guide instructions for water distribution to a wide area. This function of the system is expected to support the person in charge of water distribution in deciding on which water distribution instructions to issue

・Improvement of operation/maintenance of the irrigation facilities

As the system monitors water levels at the major irrigation facilities scattered over a wide area, abnormal water level data detected by the system show the identification of malfunction facilities and inappropriate water distribution. Therefore, this function is expected to enable timely and improved operation/maintenance of the irrigation facilities.

(2) Target facilities to be covered with integrated water management system

In order to distribute effectively the limited water resources in a large irrigation area, an integrated water management system that enables centralized management of irrigation facilities scattered across the region is necessary. The system to be introduced in the project area is for the monitoring of the irrigation facilities along the main canals, which are the mainstay of the economic activities in the area.

The target facility in water management covers the beginning facility of the main canal such as head regulator, the important facility for management along the main canal, and the branch canal intake with the large amount of water distribution from the main canal to the branch canal. In this area, targeted facilities are selected according to the following policies.

i) Regulators

Ibrahimia Head Regulator, New Dirout group of regulators, regulators on the Bahr Yusef canal and the Ibrahimia canal

ii) Intakes for major branch canals

The Technical Guidelines for the Water Management and Controlling Systems (Ministry of Agriculture, Forestry and Fisheries of Japan, 2013) indicate as a method of determining the target facilities for monitoring in a branch canal intake by using a distributed water amount grasping rate. In this method, in the case of the large and small branch canal intakes are irregularly scattered at locations, the range of the management target is selected based on the one with the larger amount of water distribution from the main canal to the branch canal. It is generally considered that the grasping rate of the targeted facilities is about 70 to 80% of the total amount of discharge. In this Project, the grasping rate of the monitoring facilities is set at 80%, and facilities that exceed 10,000 feddans are also monitored. Because the amount of distributed water into each branch canal is considered to be proportional to the size of the command area for each branch canal in the Project area, the branch canals to be monitored by the monitoring system are selected based on the size of the command areas.

In the F / S stage, the selection of the top 80% of the monitoring target was examined in the Bahr Yusef canal and Ibrahimia canal, respectively. However, in this D/D stage, facilities that are included in the grasping ratio of 80% of the beneficiary area of the Ibrahimia Head Regulator (1,565,100 fed) were selected as irrigation facilities to be monitored. Through this review, a branch canal intake with a larger command area will be added to the targeted monitoring facilities, which will contribute to grasping the water distribution status more widely.

In F/S, the top 80% of the branch canals in the irrigation areas of the Bahr Yusef and Ibrahimia canals were selected for monitoring. Meanwhile, in the D/D, the selection of the top 80% was made from the entire 1,565,100 feddans irrigated by the water diverted by the Ibrahimia Head regulator. This re-selection not only resulted in the inclusion of branch canals with larger beneficiary areas in the system, but was also expected to improve the monitoring of water distribution.

Table 3-1.1 Criteria for the selection of branch canals to be monitored

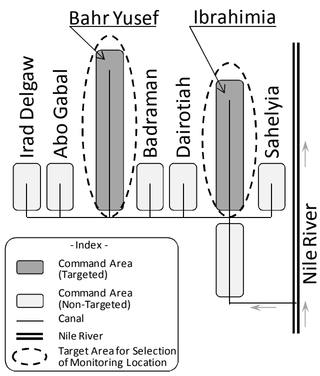
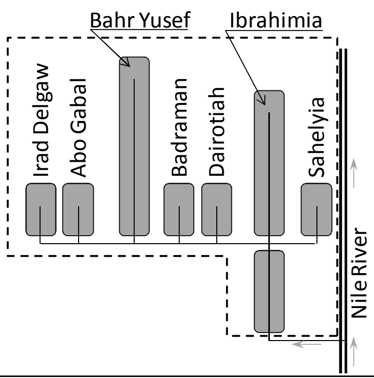
F/S	D/D
The range of the top 80% of the grasp rate was carried out for each of the Bahr Yusef canal (808,000 fed) and Ibrahimia canal (576,700 fed). - Grasp rate of more than 80% along the Bahr Yusef canal - Grasp rate of more than 80% on the Ibrahimia canal	The range of the top 80% of the grasp rate was carried out for all beneficiary area (1,565,100 fed). - Grasp rate of more than 80% for whole area
	

Table 3-1.1 shows the result of comparing the numbers at measuring points in F/S and D/D. At the time of reselecting the branch canals to be monitored, (1) the beneficiary area of the Bhbashen branch canal was revised from 23,000 feddans in F/S to 2,300 feddans in D/D, and (2) the beneficiary areas of the five small regulators in the DGRs was included in the beneficiary area used in the selected 80% of branch canals.

In addition to the size of irrigated areas selected, it is also necessary to evaluate the importance of irrigation facilities from the viewpoint of water management. In consultation with GDWD, the inclusion of an irrigation facility that was considered important to the water management of the facilities was selected for monitoring. Table 3-1.2 and Figure 3-1.1 show the facilities to be monitored. A comparison table showing the difference in the facilities selected for the monitoring in this survey and those in F/S are shown in the appendix.

Table 3-1.2 Facilities targeted for monitoring (1/2)

<table>
<tr><th colspan="3">Irrigation facilities</th><th colspan="2">Name of the Target facilities</th><th>No.</th></tr>
<tr><td rowspan="2">Regulator</td><td colspan="2">Bahr Yusef canal</td><td>Dahab Regulator
Sakoula Regulator
Mazoura Regulator</td><td>Lahoun Regulator
Abo El Shekok Regulator
Regulator km39</td><td>6</td></tr>
<tr><td colspan="2">Ibrahimia canal</td><td>New Hafze Regulator
Matay Regulator
Maghagha Regulator</td><td>Sharahna Regulator
El Gandy Regulator
Ashmont Regulator</td><td>6</td></tr>
<tr><td rowspan="5">Branch canal</td><td rowspan="3">Bahr Yusef canal</td><td>Intake</td><td>Manshat EL Dahab
El Hareka
El Sabaa</td><td>Quftan
Wesh El-Bab
EL-Giza</td><td>6</td></tr>
<tr><td>Weir</td><td>Hassan Wasef Weir</td><td></td><td>1</td></tr>
<tr><td>Pump</td><td>New Kamdeer P.S.
New Terfa P.S.
Old Terfa P.S.</td><td>Old Sakoula P.S.
Mazoura P.S.(2)</td><td>5</td></tr>
<tr><td rowspan="2">Ibrahimia canal</td><td>Intake</td><td>Irad El Maharak
El Kosia
East Hafze
West Hafze
Adkak</td><td>Gendia
Abo Shosha
EL Soultany
Tansa
El Mansour</td><td>10</td></tr>
<tr><td>Weir</td><td>Serry Weir</td><td>Maghagha Weir</td><td>2</td></tr>
<tr><td colspan="3">Ibrahimia main canal</td><td colspan="2">Ibrahimia Head Regulator</td><td>1</td></tr>
<tr><td colspan="3">Lake</td><td colspan="2">Quarun Lake</td><td>1</td></tr>
<tr><td colspan="5">Total</td><td>38</td></tr>
</table>

Table 3-1.3 Facilities targeted for monitoring (2/2)

<table>
<tr><th>Irrigation facilities</th><th colspan="2">Name of the Target facilities</th><th>No.</th></tr>
<tr><td>Dirout Group of Regulators</td><td>Bahr Yusef Regulator
Ibrahimia Regulator
Irad Delgaw Regulator
Abo Gabal Regulator</td><td>Badraman Regulator
Dairotiah Regulator
Sahelyia Regulator</td><td>7</td></tr>
<tr><td colspan="3">Total</td><td>7</td></tr>
</table>

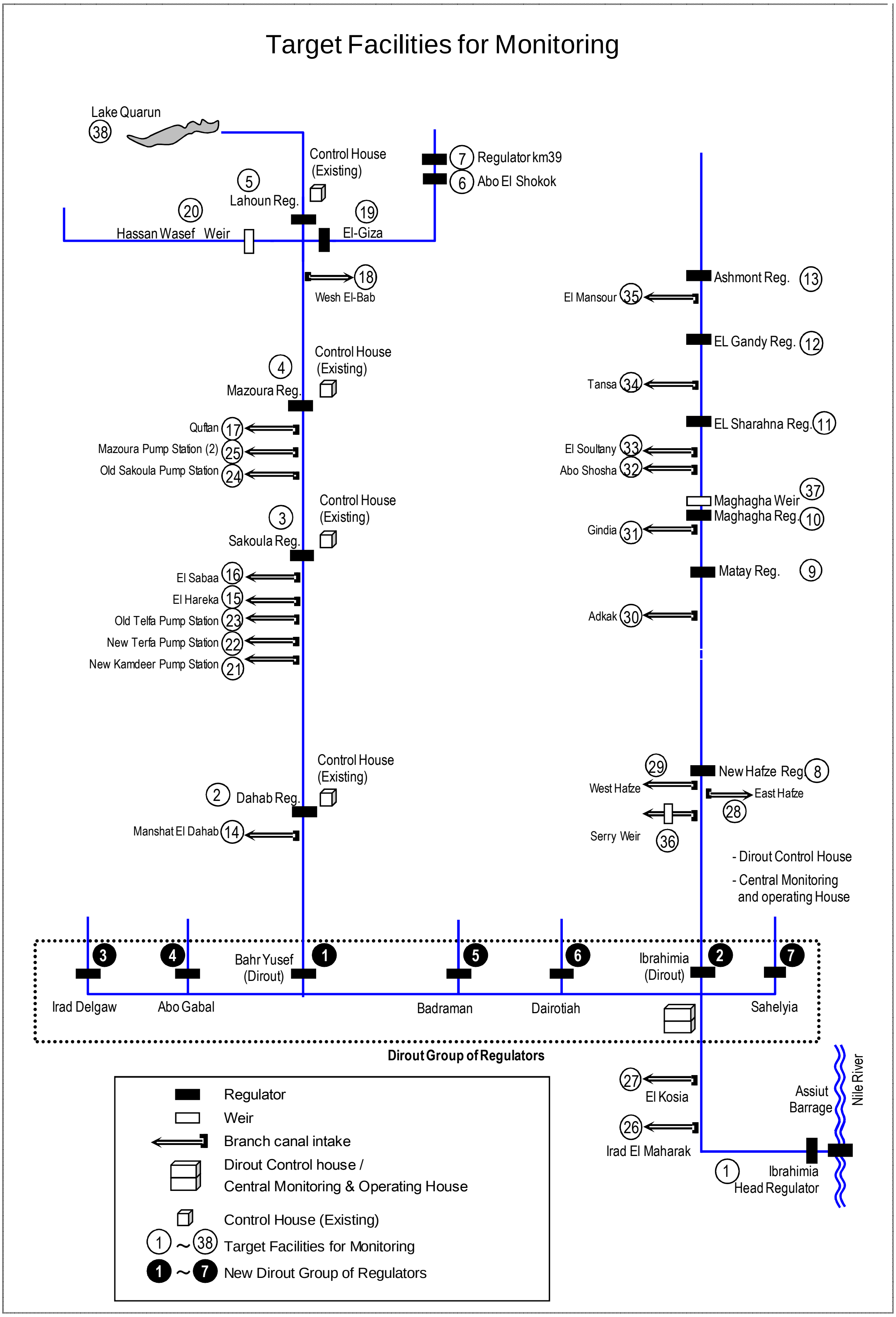


Figure 3-1.1 Schematic diagram of the facilities to be monitored in water management system

(3) Plan for the central monitoring and operating house

The development of the telemetry system has progressed significantly since F/S stagein 2010. The establishment of a central monitoring house in Beni Suef Governorate was recommended during F/S stage. The establishment of a central house in Minia Governorate and in Dirout was discussed during B/D stage. The realization of equitable water distribution requires the establishment of an “independent organization” that is not influenced by the requests of governorates for water distribution, and so there is a plan to establish a Central Monitoring and Operating House.

The D/D consultant recommends that the Central Monitoring and Operating House be responsible for unbiased distribution of water beyond governorate boundaries. And in the near future, the consultant also considers it important to develop the Central House into a highly sophisticated facility that, for example, performs water distribution based on forecasts of the size of irrigation areas and cropping patterns that are made using satellite imagery. MWRI can use this data to develop new farmlands and achieve the effective water distribution that their policies stipulate. For the development of such a facility, the consultant recommends the establishment of the Central House in an area where specialists in irrigation engineering, agriculture, and communication will be available.

In B/D, a plan to construct the Central Monitoring and Operating House in Dirout, adjacent to the NDGRs Control House or Irrigation District office was discussed within the framework of the activities of the water management working group. RGBS finally recommended and confirmed that Central Monitoring and Operating House will be constructed together with NDGRs control house in Dirout together with NDGRs control house.

(4) New categorization of monitoring and operating levels

Classifications pertaining to monitoring and controlling focus mainly on (1) what kind of information shall be measured, monitored, and operated at each irrigation facility and (2) how various collected information shall be classified, stored, and processed, and (3) how processed information shall be displayed, recorded, and controlled. The recommendation for categorizing monitoring level is described in Table 3-1.4 with the “Target facilities for integrated water management system” mentioned above.

As shown in Table 3-1.4, the gates of regulators in the project area shall not be controlled remotely from the Central Monitoring and Operating House. Only water levels shall be monitored remotely as planned in F/S stage, and the gates shall be operated onsite by a gate operator. The reason for not implementing the remote control is that, if the gate of a regulator is operated from a location 100-300kms from the regulator, opportunities for confirming the safety of the gate operation and the early detection of malfunction in the event of signs of abnormality during gate operation will be lost. Discussions in the water management working group concluded that telecontrol of the gates was not recommended from a safety perspective, or in the interest of promoting daily inspection and maintenance of the facilities.

Table 3-1.4 Study on the monitoring and operational level

				Current Situation		Current Function			Target of Supervisoriy Facilities		On-site	Control Room (Regulator along Bahr Yusef)						Central Monitoring House					
									Current State	Plan	On-site	Contorol			Supervisory			Control			Supervisory		
				Water Level Monitoring	Discharge Observation	Water Distribution between each District Level	Intake for Secondary Canal	Water level Adjustment along Main Canal	Appropriate Water Distribution along the Main Canal (Bahr Yusef Canal)	Appropriate Water Distribution for Main Canal and Major Secondary Canal	Manual Operation	Manual Operation	Manual Control with Preset Values	Automatic Control	Gate Status	Water Level	Discharge Observation	Manual Operation	Manual Control with Preset Values	Automatic Control	Gate Status	Water Level (US & DS)	Discharge Observation
Ibrahimia Head Regulator				○	○				○	○	○	○			○	○	○					○	○
Dirout Group of Regulators				○	○	○		○	○	○	○	○			○	○	○					○	○
Bahr Yusef Canal	Regulator	Dahab		○				○		○	○	○			○	○	○					○	○
		Sakoula		○	○	○		○	○	○	○	○			○	○	○					○	○
		Mazoura		○				○		○	○	○			○	○	○					○	○
		Lahoun	Lahouh	○	○	○		○	○	○	○	○			○	○	○					○	○
			Hassan Wasef	○	○					○	○	○			○	○	○					○	○
			El-Giza	○	○					○	○	○			○	○	○					○	○
	Branch Canal Intake	Intake(1)					○			○	○											○	
		Intake(2)					○			○	○											○	
		·					○			○	○											○	
		·					○			○	○											○	
		·					○			○	○											○	
		Intake(10)					○			○	○											○	
Ibrahimia Canal	Regulator	Hafze		○				○		○	○					○						○	
		New Minia		○				○		○	○												
		Matay		○				○		○	○											○	○
		Maghagha		○	○	○		○	○	○	○					○	○					○	○
		El Sharahna						○		○	○											○	○
		El Gandy						○		○	○											○	○
		Ashmont						○		○	○											○	○
		El Wasta		○	○	○		○	○	○	○					○	○						
	Branch Canal Intake	Intake(1)					○			○	○											○	
		Intake(2)					○			○	○											○	
		·					○			○	○											○	
		·					○			○	○											○	
		·					○			○	○											○	
		Intake(14)					○			○	○											○	
Quarun Lake				○					○	○						○						○	

Tables 3-1.5 and 3-1.6 show the monitoring and controlling levels of the Central Monitoring and Operating House and the regulators along the Bahr Yusef and Ibrahimia canals, respectively. In addition to its remote monitoring function, the Central Monitoring and Operating House shall be equipped with a calculation function that allows it to evaluate water balance by comparing the supply and demand for discharge. This calculation function is a tool intended to support the person in charge of decision-making regarding water distribution.

Table 3-1.5 Study on the management levels at regulators

	Monitoring				Recording			Operation/Control				Data Processing		
	Onsite Operation	Display Panel	Mini-Graphic Panel	CRT Display	Daily Log Recording	Analog Recorder	Recording (Printer)	Manual Operation from Operation room	Onsite Manual Operation	Manual Control with Preset Values	Automatic Control	Supervisory and Warning Processing	Calculation Processing	Forecasting Processing
B	○				○			○	○			○		
I	○				○				○			○		

B：Regulators along Bahr Yusef canal
I：Regulators along Ibrahimia canal

Table 3-1.6 Study on the management level at the central monitoring center

	Supervisory			Recording		Operation/Control			Data Processing		
	Display Panel	Mini-Graphic Panel	CRT Display	Analog Recorder	Recording (Printer)	Remote Control	Manual Control with Preset Values	Automatic Control	Supervisory and Warning Processing	Calculation Processing	Forecasting Processing
Central Monitoring and Operating House	○		○		○				○	○	

(5) New water management organization

The establishment of a new organization consisting of representatives from the governorates impacted by the project areas is recommended to ensure an appropriate integrated water management system after the construction of the new DGRs. Figure 3-1.2 shows the planned composition of this new organization. GDWD approved the establishment of this new organization in the consultation at the B/D stage.

Figure 3-1.3 shows a conceptual diagram of the new water management system.

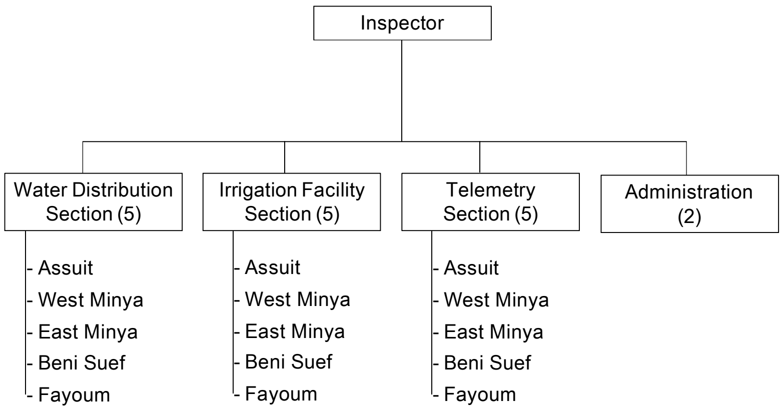


Figure 3-1.2 New organization for the integrated water management

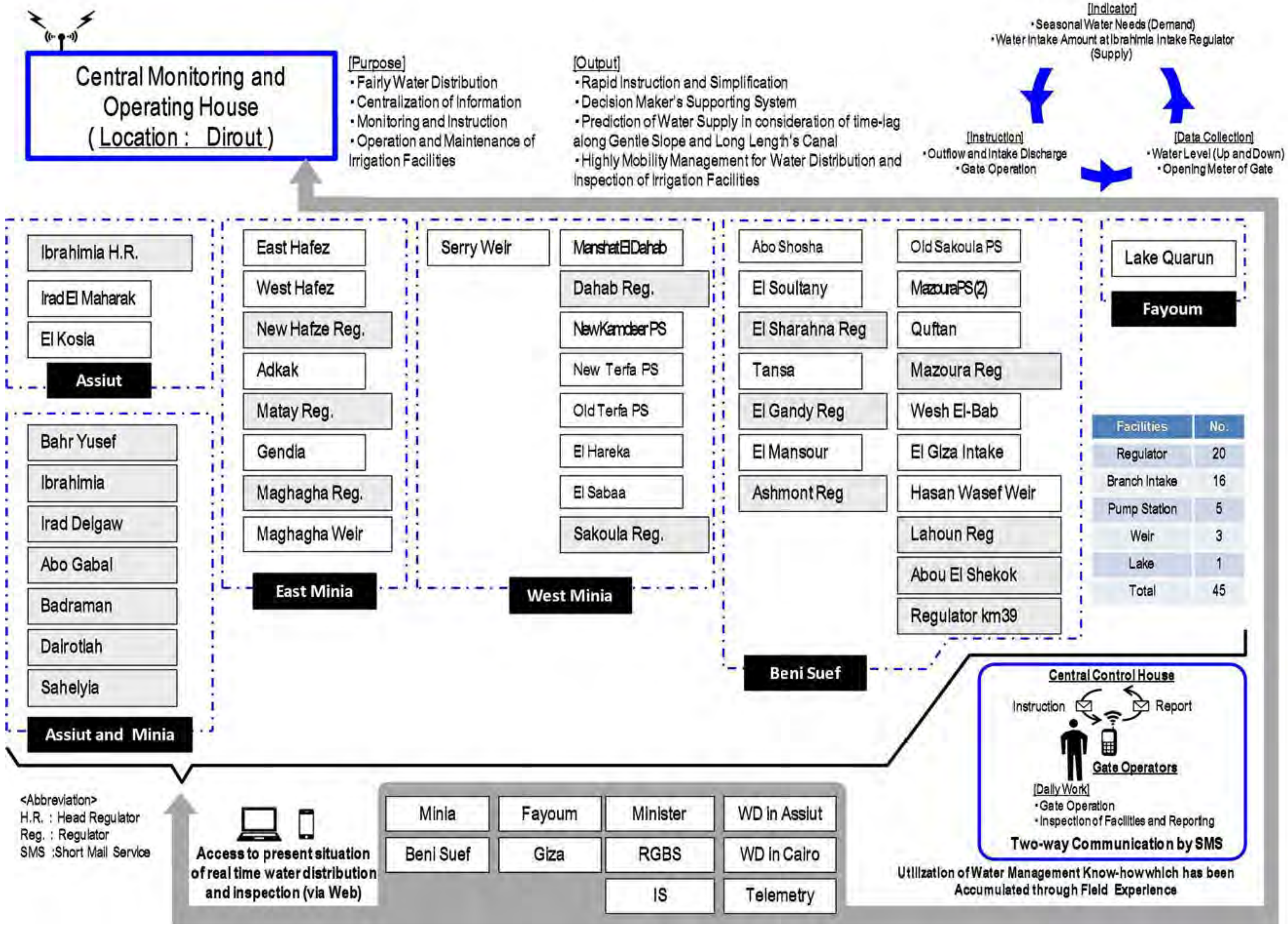


Figure 3-1.3 Hierarchic diagram for the integrated water management system

3-2 New centralized management system

As mentioned above, the water levels measured downstream of the regulators is the only data that GDWD in Assiut uses as an indicator of real-time water level for the gate operation of water distribution in the project area.

Remote monitoring of water level developed by the telemetry engineers and promoted by the CDT is expected to be utilized in the future following its wide dissemination because of its high expansibility and technical simplicity.

Therefore, the CDT-based monitoring system shall be used continuously for the remote monitoring of the water levels at the regulators in the main canals, at the intakes of the branch canals, and for data processing that converts water levels into flow rate.

In an interview at MWRI, it became clear that the CDT had developed a remote water level monitoring system to simplify the collection of water levels, pump status, meteorological data, and so on. MWRI is aware of the need for specialized technologies for the development of a system that can convert water level data into discharge, and determine the amount of water to be distributed to each irrigation canal by comparing the discharge and the water supply.

It was therefore decided that it was important to develop a system that assisted persons in charge of water distribution in the new organization, while continuing to make use of the monitoring system developed by the CDT. Figures 3-2.1 and 3-2.2 show the data flow in the integrated water management system proposed for the project concerned. The concept of water balance monitoring will continue to be discussed with CDWD.

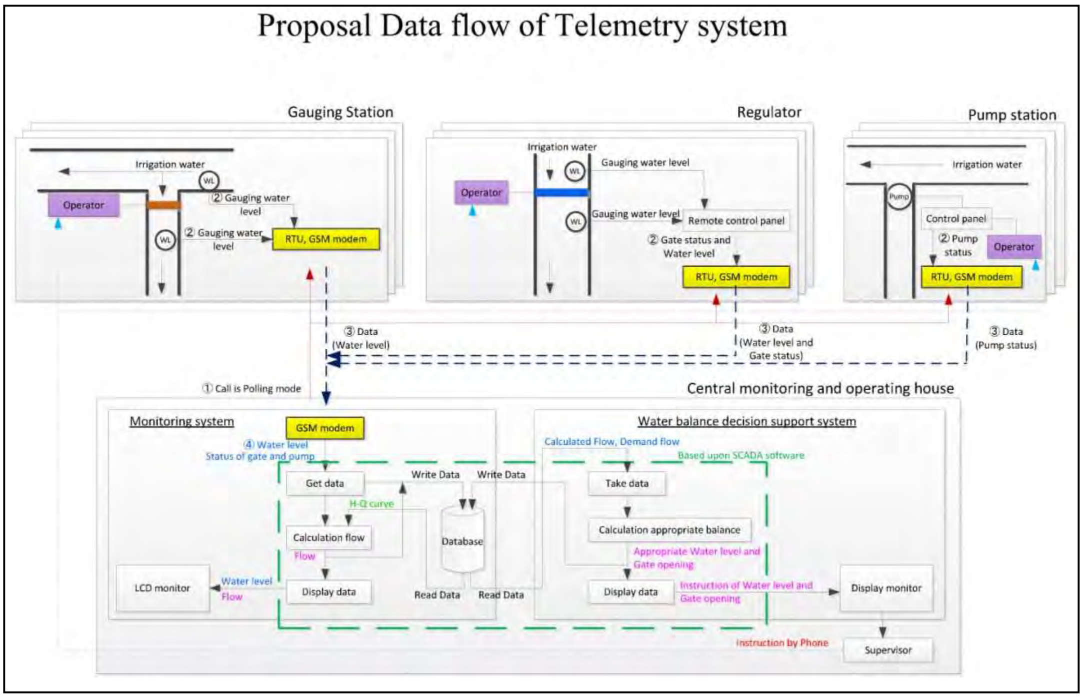


Figure 3-2.1 Data flow in the integrated water management system

The following steps show the data flow for measuring water level, and for collecting, transmitting, calculating, storing, and evaluating data. These steps are formulated based on the monitoring software which matches that of the existing telemetry system assembled by CDT.

1) Polling from the central monitoring house to the irrigation facilities to connect with central monitoring house and irrigation facilities such as regulators and branch canal intakes,
2) Gauging upstream and downstream water levels using pressure-type water level gauge at each irrigation facility,
3) Transmitting data from irrigation facilities to the central monitoring house via GPRS communication module,
4) Receiving water level data from irrigation facilities to the central monitoring house via GPRS communication module and storing the received data in the database server,
5) Calculating discharge at each regulator using H-Q curve which is saved on database server,
6) Storing the calculated discharge data onto database server,
7) Displaying water level data at each irrigation facility on an LCD monitor,
8) Reading the discharge data from upstream and downstream regulators, and requesting data from database server,
9) Comparing the difference in discharge between upstream and downstream regulators and requesting data from each regulator,
10) Calculating the appropriate amount of water for effective distribution and correct water level, and relaying gate operations from the central monitoring house to each gate operator onsite.

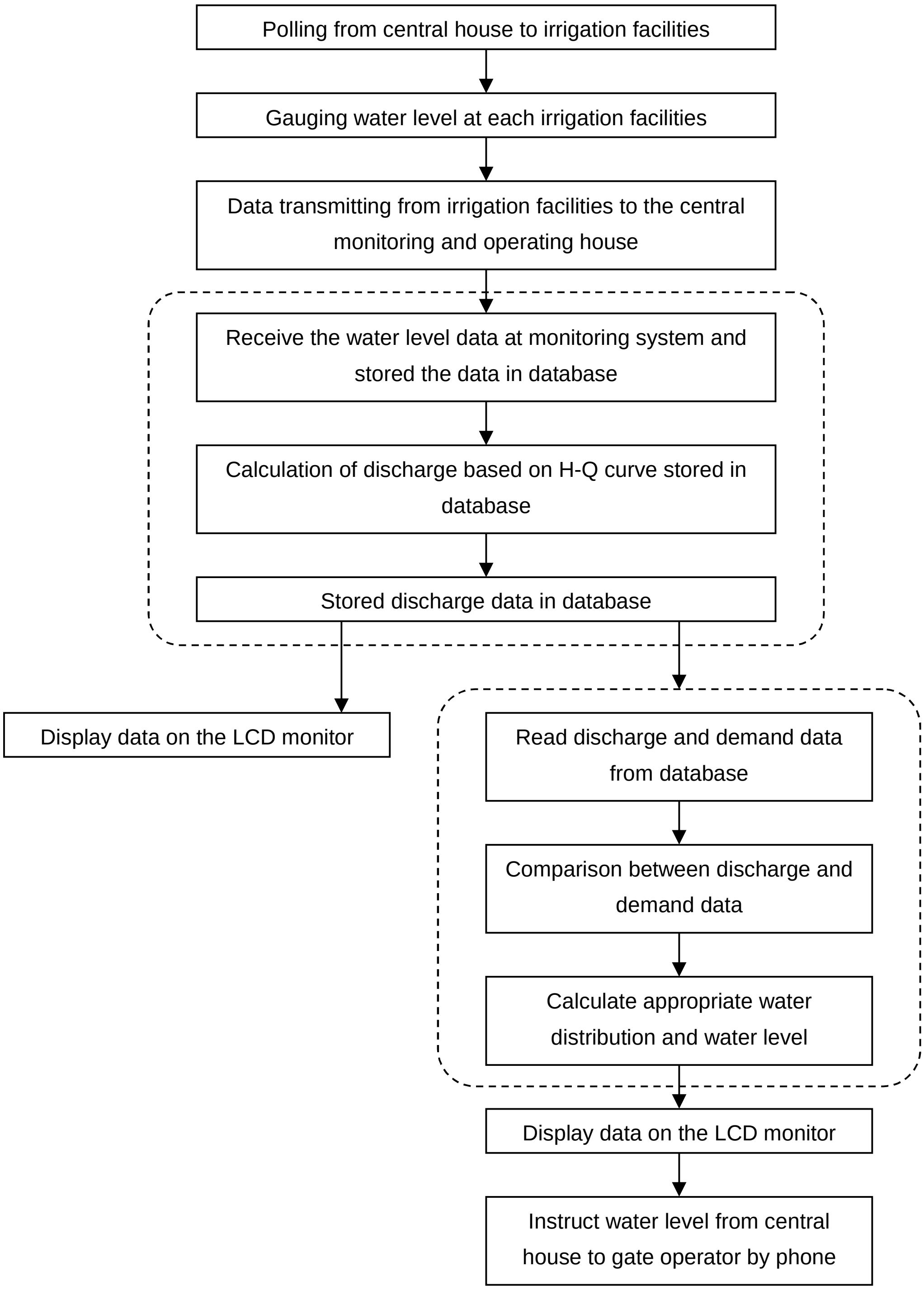


Figure 3-2.2 Data flow for the integrated water management system

4. Detailed Design

4-1 Design of transmission system and route

4-1-1 Date transmission network and protocol

In this chapter, the communication methods for water measurement in the integrated water management, data transmitting method, composition of gauging and monitoring stations and specification of equipments for each station are considered. The existing water management system is using the GPRS communication network system. And, the data transmission method is the TCP/IP method. The access point (APN (Access Point Name)), that is, the facility for implementing TCP/IP data transmission by GPRS communication, is managed by MWRI.

As described before, the integrated water management system uses the same communication method and data transmission method in order to integrate with the current telemetry system, and uses the same facility of APN.

GPRS communication has wide coverage area as a mobile phone network in Egypt. All the water level monitoring stations are located under this GPRS coverage area, which means securing communication coverage.

The TCP/IP method applying as a data transmission method is widely used in the internet and intranet networks. TCP/IP method has features of the detection of data transmission errors that is occurred when the communication network is unstable, and the function of retransmitting the data when an error occurred (securing data reliability).

The main function of the APN is to give an IP address to access the internet network. This IP address changes each time when the APN is requested to give an IP address. That is, it is very unlikely to communicate using the same IP address among each water level gauging stations. This makes it possible to avoid access from outside and attacks using IP addresses illegally (securing security).

Figure 4-1.1 and Figure 4-2.2 show the system composition using the GPRS communication method, and the system composition using the TCP/IP method respectively.

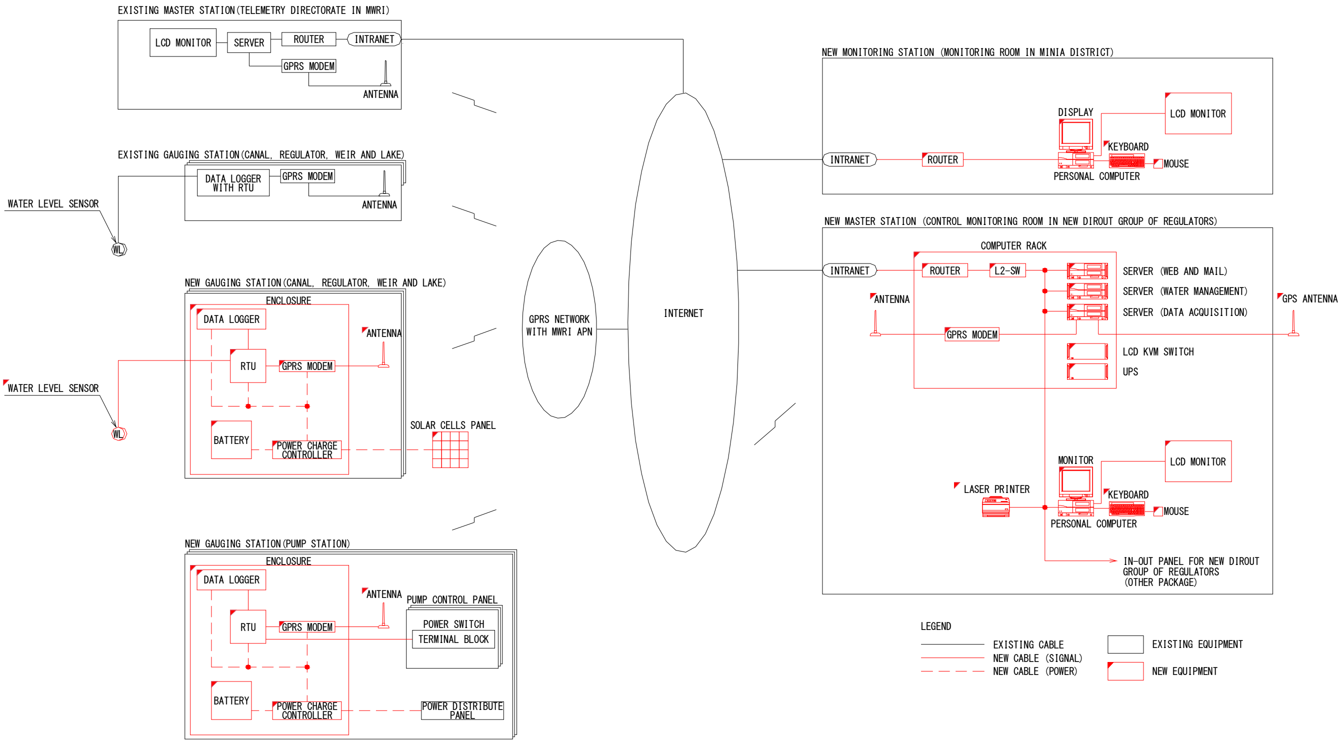


Figure 4-1.1 System composition of GPRS communication

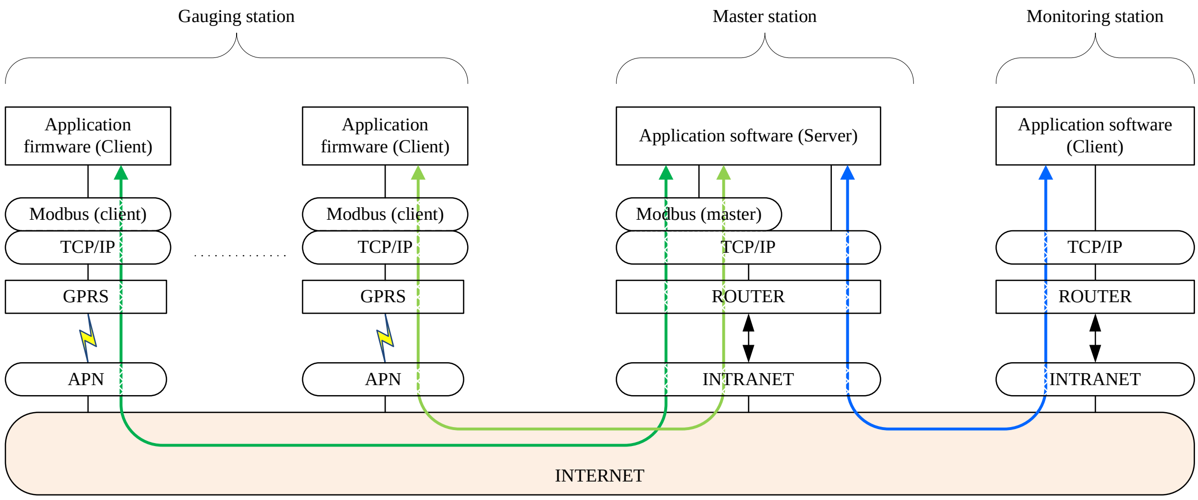


Figure 4-1.2 System composition using the TCP/IP method

4-1-2 Telemetry sub-system

Telemetry sub-system shall compose with Data acquisition server, RTU and relevant network equipment which are NTP server, GPRS modem, L2-SW and Router mainly. GPRS modem is connected to the GPRS network based upon IP (Internet Protocol) according to SIM card set up beforehand in this modem. The connection with this GPRS network is begun from RTU by the incoming connection.

The main incoming connection shall consist of the continuous connection and a regular time connection. Router shall be connected to the Internet through the ADSL provider or the broadband provider by the continuous connection. All the data from the gauging stations shall be gathered and processed at the master station. In Data acquisition server, the data is collected from 1024 RTUs or less.

The collected and processed of measurement data shall be stored in data base for ten (10) years and more, and shall be transferred to another computer system. This data will be collected by the data transmission function. All function to prevent unlawful access must be installed as a network security precaution.

4-1-3 Data transmission method

Telemetry sub-system corresponds to two data transmission methods of the autonomous transmission and call transmission.

(1) The autonomous transmission

The gauge station shall begin the data transmission autonomous when becoming set time. This transmission shall have the autonomous mode.

1) Autonomous mode

This transmission shall be started automatically by a clock of the gauging station. This clock will be implemented in RTU. And, this local clock is regularly corrected. A local clock synchronizes with the clock server of the master station, and this correction is completed. The protocol used by this clock synchronization will be NTP. Moreover, a local clock will be NTP client, and the clock server will be NTP server.

Data acquisition server of the master station shall always receive the data from all of the gauging station consecutively.

(2) The call transmission

In case of the call transmission, the data collection command will be activated from the master station mainly. The gauging station is called in a moment anytime when required. This transmission shall have the calling modes and the respond modes.

1) Calling modes

The system shall have the following four (4) kinds of calling mode.

Table 4-1.1 Calling modes

Calling modes	Description
Automatic calling	Automatic calling mode by a clock of Data acquisition server. There are seven intervals such as 15 minutes, 30 minutes, 1 hour, 3 hours, 6 hours, 12 hours and 24 hours.
Manual calling	This calling shall be started manually and be directed to the selected telemetry gauging stations by individual calling.
Manual calling to individual	This calling shall be started manually at any manually time, and shall be used for manual measurements, calling any of the stations manually selected.

Re-calling	The station called fails to respond or if any erroneous code has been detected in the data code received from the station called shall automatically recall the station once more. If there is still an erroneous code, or the station recalled fails to respond again, the system shall then shift to the next procedure, actuating visual and audible alarms to the operator.

a) Automatic calling

This calling shall be started automatically by a clock of Data acquisition server, and shall call each gauging stations consecutively. The calling shall be made at one of the following seven (7) intervals: fifteen (15) minutes, thirty (30) minutes, one (1) hour, three (3) hours, six (6) hours, twelve (12) hours and twenty-four (24) hours.

The automatic calling shall have priority over another calling: i.e. one (1) minutes before the scheduled calling, manual calling shall be automatically done until the end of the observation. The calling time intervals shall be able to be selected optionally, and the automatic calling shall have an operational priority under normal conditions over other modes of calling listed above. The priority control of the automatic calling system shall be able to be released in case of an emergency. The designated calling time interval is one (1) hour.

b) Manual calling

This calling shall be started manually and be directed to all the selected telemetry gauging stations by individual calling. And it shall be used for manual measurements, calling all stations one by one in the present order.

c) Manual calling to individual

This calling shall also be started manually at any manually time, and shall be used for manual measurements, calling any one of the stations manually selected.

d) Re-calling

The station called fails to respond or if any erroneous code has been detected in the data code received from the station called shall automatically recall the station once more. If there is still an erroneous code, or the station recalled fails to respond again, the system shall then shift to the next procedure, actuating visual and audible alarms to the operator.

Moreover, re-calling shall be actuated only for the individual gauging station after the completion of the automatic calling. The maximum time required for calling and response to one gauging station shall be less than 20 seconds.

e) Response modes

The gauging station called by the master station shall send the data which is composed with the measuring data, status and warning immediately.

4-1-4 Transmission format

(1) General

The basic transmission format shall be as shown below. The Contractor shall propose the data format of the data acquisition referring to following items

1) Flag sequence

Flag sequence shall comprise 8 bits. It shall indicate the start or end of a frame.

2) Address bit

Address shall be used to represent station No., system No., group No., and area code. Address shall comprise 24 bits.

3) Control field

Control field shall indicate the function of transmission code such as automatic calling or individual calling or response. This field shall comprise 16 bits.

4) Information field

Information field shall be used present measured data, measured time data, flag data, etc. This field shall comprise 98 bits x n.

5) Frame check sequence

Frame check sequence shall comprise 16 bits.

Table 4-1.2 Transmission format

System	Specification
Flag sequence	8 bits
Address bit	24 bits (Station No., System No., Group No., Area code)
Control field	16 bits
Information field	98 bits x n
Frame check sequence	16 bits

(2) Calling signal format

Calling signal format for calling shall consist of as follows:

Flag sequence, Address bit, Control field, Information field, Frame check sequence and Flag sequence.

(3) Response signal format

The frame and word configuration of the response signal shall consist of as follows:

Flag sequence, Address bit, Control field, Information field, Frame check sequence and Flag sequence.

4-1-5 Data acquisition function

Data acquisition function shall be installed in the master station. Data acquisition function consists of the Server (Data acquisition), GPRS modem and Network function. Main function is shown below,

- Data transmission function

- Time control function
- Operation and status indication function
- Simplification database function

Data acquisition function shall collect all the information which is measurement data from the gauging station by call with data transmission function. Call is carried out through GPRS modem by the data acquisition function. This calling interval shall be set in the operation and maintenance screen of the data acquisition function. Data collected are stored in data base.

Table 4-1.3 Data acquisition function

No	Function	Contests
1	Data transmission	seven (7) intervals: fifteen (15) minutes, thirty (30) minutes, one (1) hour, three (3) hours, six (6) hours, twelve (12) hours and twenty-four (24) hours.
2	Time control and calibration	RTU, Data acquisition server and another server shall be connected to NTP server for calibrating a clock time by itself.
3	Time schedule management	Data acquisition server as a time management shall manage the transmission time of each gauging station
4	Registration and deletion	Registration and the deletion of the gauging station shall be done with the data acquisition server.
5	System monitoring	Data acquisition server shall supervise the status and condition of the communication
6	Data transfer	Data from the gauging station is transmitted by LAN interface from Data acquisition server to an outside database server
7	Screen display	The gauging data collected from the gauging station shall be displayed
8	Operation and status indication	Data acquisition server shall have functions for system monitoring and maintenance of gauging station on it display contents.
9	Simplification database	Data acquisition server shall include simplification database to store the received data such as present water level, status of equipment in the gauging station for temporary.
10	Other	The measuring capacity shall be expandable to a maximum 1024 gauging stations

(1) Data transmission function

As the call transmission, the automatic calling for data transmission function shall be conducted at seven (7) intervals: fifteen (15) minutes, thirty (30) minutes, one (1) hour, three (3) hours, six (6) hours, twelve (12) hours and twenty-four (24) hours. And, the manual calling shall be started manually and be directed to all the selected gauging station by individual calling.

As the autonomous transmission, data acquisition function shall always receive the data from all of the gauging station consecutively.

If any error code has been detected in the data from the gauging station, or if there is no response from the gauging station, that gauging station shall be automatically re-called once more. If there is an error code or a called the gauging station failed to respond again, a visible and audible alarm shall be actuated and the relative system shall shift to the next operation. The maximum time required for calling and response to one (1) gauging station shall be less than 20 seconds. This function shall have the following functions also:

- Selection of gauging stations
- Selection of calling time interval
- Selection of calling mode, automatic or manual calling

(2) Time control function and calibration function

RTU, Data acquisition server and another server shall be connected to NTP server for calibrating a clock time by itself. A clock time can be regularly corrected by NTP protocol. A clock time synchronizes with NTP server in the master station, and will be highly accurate. Therefore, NTP client shall be installed in RTU, Data acquisition server and another server for calibrating a clock time.

NTP server shall be connected GPS antenna, and shall provide year, month, day, hour and minute data. The time and date of NTP server shall be calibrated automatically, and the number of days on month shall be maintained automatically by an internal calendar program. The accuracy of a clock time shall be within one (1) seconds per day.

(3) Time schedule management function

Data acquisition server as a time management shall manage the transmission time of each gauging station, and the interval time between the gauging stations, and the switching time of the communication line, and the transmission schedule. The communication line switch time is required time to the communication line switch from the router route to the GPRS route.

The above-mentioned time management is registered in the time schedule management function.

(4) Registration and the deletion function

Registration and the deletion of the gauging station shall be done with the data acquisition server. Moreover, the observation stop setting of the gauging station is also possible.

(5) System monitoring function

Data acquisition server shall supervise the status and condition of the communication between the gauging station and the master station, and of the transmission between servers, and the gauging station. When abnormally generated, generation time and an abnormal content, etc. are accumulated as a history for thirty (30) days or more.

(6) Data transfer function

Data from the gauging station is transmitted by LAN interface from Data acquisition server to an outside database server which means the external server. Data acquisition server shall include simplification database to store the received data such as present water level, status of equipment in the gauging station for temporary.

The data received from all Gauging station shall store for 30 days in the simplification database. Data acquisition server shall have the function of reading data collected and processed by database through the LAN network.

(7) Screen display function

Data acquisition server shall have Screen display function. The gauging data collected from the gauging station shall be displayed the following items on the screen.

1) Present data and status

The current state of the collected gauging data is displayed. The visible alarm and sound are generated in this function when it receives information that the warning and the event information is detected.

2) Time schedule management

A time management which is composed with the transmission time of each gauging station and the interval time between the gauging stations and the switching time of the communication line and the transmission schedule is displayed.

3) Registration and the deletion

Registration and the deletion of the gauging station is for configured on display. Moreover, the observation stop setting of the gauging station is also for configured on display.

4) System monitoring

The status and condition of the communication between the gauging station and the master station and of the transmission between servers, and the gauging station is displayed. A history of the generation time and an abnormal content is displayed.

(8) Operation and status indication function

Data acquisition server shall have functions for system monitoring and maintenance of gauging station on it display contents. This server shall have, but not limited to, the following functions:

1) Operation

- Manual measurement
- Measurement interval change
- Missing data supplementation
- CSV save (for back up)
- CSV load (for loading from gauging station external media)
- Data correction
- Operation reset
- Alarm off

2) Monitoring

- Latest condition
- Received data

(9) Simplification database

Data acquisition server shall include simplification database to store the received data such as present water level, status of equipment in the gauging station for temporary. The data received from all Gauging station shall store for 30 days. Data acquisition server shall have the function of reading data collected and processed by database through the LAN network.

(10) Other

The measuring capacity shall be expandable to a maximum 1024 gauging stations, when required with minor modifications.

4-1-6 Computer Sub-system

Computer sub-system shall be composed of Water management function, Database function, Web & Mail function and Monitoring function. Computer sub-system shall be installed in the master station and the monitoring station. The monitoring station shall have Monitoring function only.

Computer sub-system shall have high quality graphics which shall be mounted within the "WINDOW" environment in order to be more accessible to the common user.

To spread an information and communication, the router shall be provided in the master station, and government authorities are connected each other using internet communication. When available capacity of Database and DAS will be less than the configured threshold, the alarm is displayed.

All function to prevent unlawful access must be installed.

(1) Water management function

Water management function consists of Server (Water management) and Network function.

When the data in Database is updated, the Flow and discharge are calculated on the water management function. And then, the water management function records the quantity of flow and discharge in Database. Main function is shown below,

- Database
- Flow and discharge calculation
- Operation and maintenance screen

1) Database

Water management function shall transfer the storage data from the Simplification database to Database by synchronization. And, Database shall provide the demand data to Web & Mail function.

Database software is preferably SQL or equivalent, which shall be possible to convert to usual database format such as Excel or Access or CSV file. The collected data and processed data in database shall be converted to any file format and shall be storage to CD/DVD or equivalent.

Water management server shall have the function of reading data collected and processed by data base through the LAN network.

2) Flow and discharge calculation

Water management function calculates the Flow and discharge in Database.

3) Operation and maintenance screen

Operational screen in the table form and the graph is made by using the data operated with data base, and disseminates it to external LCD monitor.

Operation and maintenance screen shall be composed with the information of water management which includes the name of gauging station, the item of measurement, the measurement data, time, and date, status of equipment, reporting and printing.

(2) Web & Mail function

Web & Mail function consists of Server and Network function.

Web & Mail function shall provide the web page including that information to give an accurate situation. The related government only can access this server by using browser. This access must demand ID and Password. And, between this server and web browser in clients the strong security device must be installed such as a firewall and router.

Web & Mail server shall have the function of reading data collected and processed by data base through the LAN network. Web file in the table form and the graph is made by using the data operated with data base, and disseminates the web file to LCD monitor, monitoring terminal by the function of the web opening to the public.

Mail with Report which is made in the water management server is sent by Mail function. The sender method used by the mail function shall be selected from E-mail and / or a short message (SMS). The report of water management will be transmitted to the registered addressee. The transmission cycle can be arbitrarily set.

(3) Monitoring function

Monitoring function consists of Personal Computer LCD monitor and Network function. Monitoring function shall be used to control and connect to the web server for monitoring measured data and processing data. Monitoring function shall have function to update display data automatically using Java language or equivalent and shall be installed at the master station and the monitoring station.

LCD monitor shall display the screen from the monitoring terminal. Laser printer shall print out the all necessary documents required from the LAN network.

(4) Network function

Network function consists of Router, L2-SW, LAN cable, Laser printer and Intranet. Network function shall be suitable to Ethernet and protocol shall be based on TCP/IP.

L2-SW shall be the hub where the switching facility is added. The switching hub shall learn the physical address (MAC address) of the Ethernet device connected to each port, and link port required for intelligence directly and enable it exchange data.

Router shall be the router equipped with the connection function conformed to existing intranet which is able to use internet line. Moreover, router, server and terminal shall have the function of security which means Malware inspection and Anti-virus. The computer virus and related malware must be completely excluded from the network and the relating equipment.

4-2 Design of gauging station

4-2-1 Location and function of gauging station

(1) Location of gauging stations

Gauging stations under the master station are shown on Table 4-2.1. The table shows the latitude and longitude coordinates of each gauging station, the provisional installation position of the water level sensor (the distance from the gate to the sensor), and the depth of the canal.

Table 4-2.1 Location of gauging stations

No.	Irrigation facilities			Name	Coordinate		Position of water level sensor (m)		
					Latitude	Longitude	Upstream (Distance before gate)	Downstream (Distance after gate)	Deapth of Canal
1	Ibrahimia Main Canal			Ibrahimia Head Regulator	27° 11' 44 .7"	31° 11' 07.8"	47	40	10
2	Regulator	Bahr Yusef Canal		Dahab Regulator	27° 59' 45.5"	30° 41' 25.84"	6	93	8
3				Sakoula Regulator	28° 39' 22.8"	30° 41' 15.7"	10	88	8
4				Mazoura Regulator	28° 53' 48.2"	30° 48' 43.8"	10	85	8
5				Lahoun Regulator	29° 12' 22.0"	30° 58' 15.7"	14	36	8
6				Abo El Shekok Regulator	29° 19' 34.86"	31° 07' 52.16"	15	27	8
7				km39 Regulator	29° 27' 23.7"	31° 11' 52.52"	9	20	8
8		Ibrahimia Canal		New Hafze Regulator	27° 48' 49.02"	30° 42' 15.5"	8	32	5
9				Matay Regulator	28° 24' 56.1"	30° 47' 15.1"	16	40	5
10				Maghagha Regulator	28° 38' 54.9"	30° 50' 14.3"	15	32	5
11				Sharahna Regulator	28° 51' 07.88"	30° 54' 48.29"	6	17	4
12				El Gandy Regulator	29° 05' 36.00"	31° 06' 29.03"	8	24	4
13				Ashmont Regulator	29° 11' 25.2"	31° 09' 49.9"	3	15	4
14	Branch Canal	Bahr Yusef Canal	Intake	Manshat El Dahab	27° 59' 52"	30° 41' 12.5"	2	25	3
15				El Hareka	28° 34' 54.32"	30° 40' 40.7"	2	20	3
16				El Sabaa	28° 34' 53.9"	30° 40' 39.2"	4	16	3
17				Quftan	28° 53' 41.4"	30° 48' 14.74"	6	20	3
18				Wesh El Bab	29° 03' 07.07"	30° 54' 50.81"	5	6	3
19				El-Giza	29° 12' 22.00"	30° 58' 15.7"	30	30	4
20			Weir	Hassan Wasef Weir	29° 12' 26.31"	30° 57' 42.11"	3m before weir	-	4
21		Ibrahimia Canal	Intake	Irad El Maharak	27° 22' 25.7"	30° 54' 14.1"	2	18	4
22				El Kosia	27° 26' 56.5"	30° 49' 33.0"	3	18	3
23				East Hafze	27° 48' 29.9"	30° 48' 26.7"	85	13	3
24				West Hafze	27° 48' 28.7"	30° 48' 23.3"	10	15	4
25				Adkak	28° 23' 20.7"	30° 46' 09.7"	3	55	4
26				Gendia	28° 38' 07.1"	30° 49' 39.13"	2	12	4
27				Abo shosha	28° 49' 54.14"	30° 54' 23.09"	3	30	4
28				El Soultany	28° 51' 05.37"	30° 54' 46.45"	3	16	4
29				Tansa	29° 00' 34.56"	31° 01' 14.01"	7	18	4
30				El Mansour	29° 11' 22.2"	31° 09' 48.5"	3	30	3
31			Weir	Serry Weir	27° 49' 17.2"	30° 47' 37.2"	10m before weir	-	4
32				Maghagha Weir	28° 39' 30.2"	30° 50' 45.1"	2m before weir	-	4
33	Pump Station	Bahr Yusef Canal		New Kamdeer PS	28° 9' 25.41"	30°39' 53.91"	25	60	5 *)
34				New Terfa PS	28°21'23.32"	30°37'40.31"	25	65	5 *)
35				Old Terfa PS	28°21'22.01"	30°37'39.99"	25	65	5 *)
36				Old Sakoura PS	28°37'13.43"	30°40'43.50"	25	40	5 *)
37				Mazoura PS	28°50'57.71"	30°48'2.64"	35	40	5 *)
38	Lake			Quarun Lake	29° 28' 1.08"	30° 42' 6.69"	observation well	-	2

NOTE; New Dirout Group of Regulators : Other package

**) Assumed value*

(2) Function of gauging station

Functions of gauging stations are shown in Table 4-2.2.

Table 4-2.2 Function of gauging station

No.	Function	Specification	Remarks
1	Measuring water level	The pulse of the water level is detected continuously and a proper water level can be obtained.	
2	Measuring discharge flow	The existing On/Off state of the power switch at Pump control panel is detected, and a proper discharge flow can be calculated in the server of the master station.	
3	Communication	The communication transmission line by GPRS is established between the gauging station and master station.	
4	Transmission	The water level, the state of the battery, and the state of the device are transmitted to the master station.	
5	Solar power	All devices work by the photovoltaic generation.	
6	Power saving	Power consumption excluding active works of the water level measurement and the data transmission becomes minimum.	

4-2-2 Function of gauging station at branch canal intake

(1) Monitoring function

The central monitoring house will monitors the status of the power supply system of the gauging station at branch canal intake.

For the commercial power supply, it is possible to know the status of the gauging station by the information of black out. However, since the power supply system of the gauging station consists of a solar panel and a battery, it is necessary to monitor the power status from master station.

1) Power supply status

Power supply status which is consisted of solar panel and battery will be monitored.

(2) Measuring function

The measurements of upstream and downstream water levels in the main canal at the regulator are monitored. The data will be used to understand the amount of distributed discharge to manage the regulators at the main canal in the near future.

1) Water level data

The measurements of upstream and downstream water levels at the head of branch canal’s intake are monitored.

(3) Operation / Control

1) Branch canal’s gate : On-site control, No tele-control from remote site

(4) System diagram

Equipment composition and function composition are shown in Figure 4-2.1.

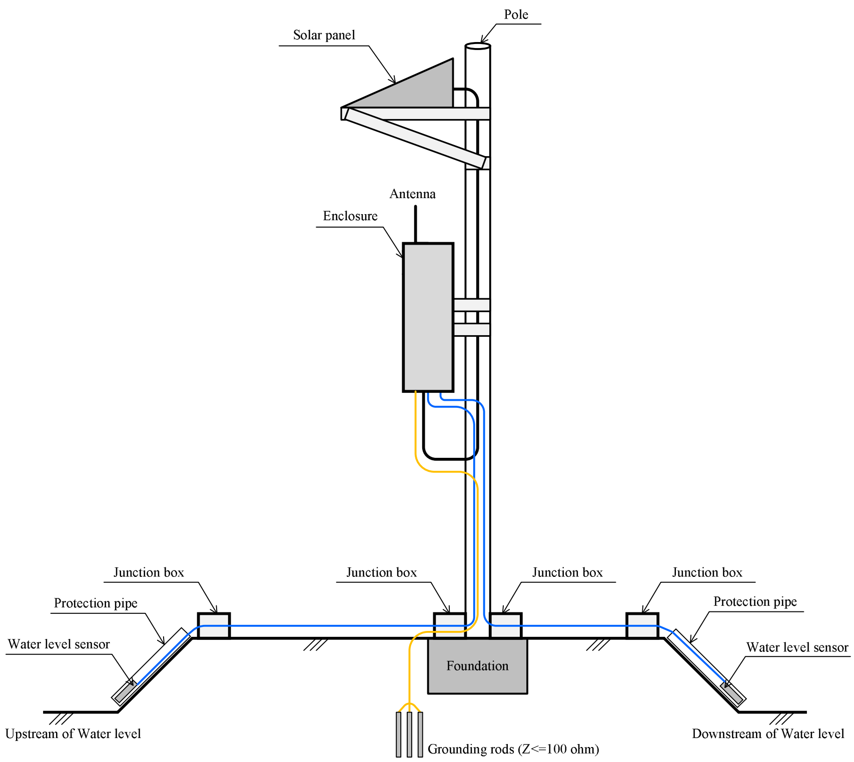


Figure 4-2.1 Equipment composition for gauging station (1/2)

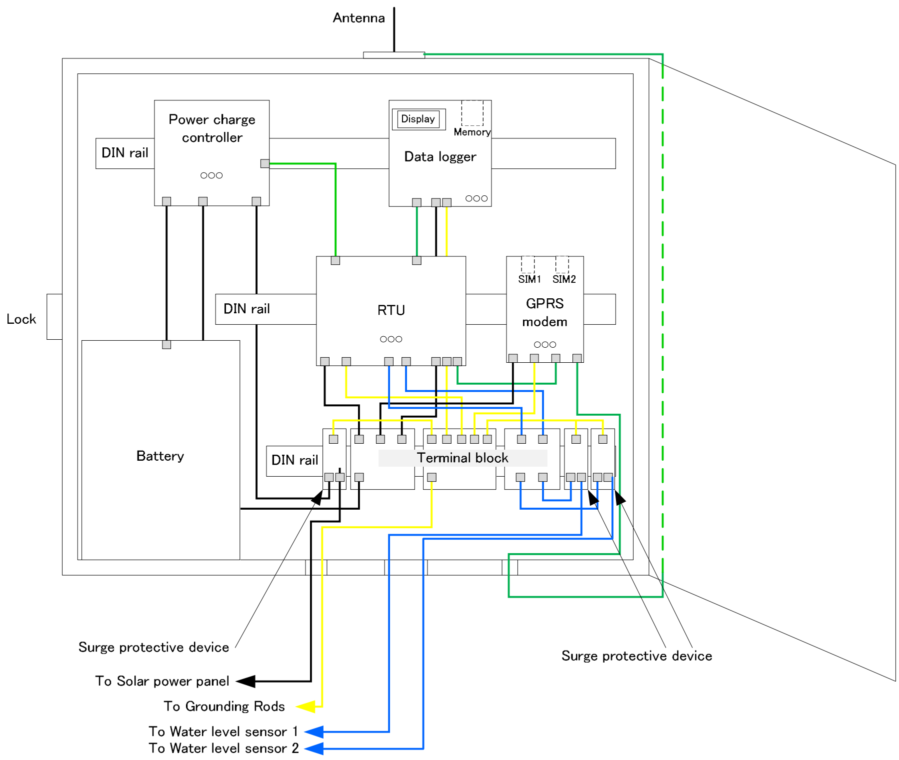


Figure 4-2.2 Equipment composition for gauging station (2/2)

Almost of all equipment shall operate in DC 12V (or 24V) which is fed from Storage battery. Power charge controller makes the electric power from the solar panel a fixed voltage, and charges the battery.

The water level sensor shall be measured in the input interface of RTU. The water level measured shall be recorded as measurement data in the data logger. The water level shall be recorded according to the setting of interval time in the data logger. And, all data can be monitored in the data logger.

The discharge flow shall be measured in the digital input interface of RTU. This interface shall connect to the existing spare points as a power switch interface on the terminal block in the Pump control panel. The discharge flow is calculated by the cycle of state (On / off) on the power switch. The existing power switch interface on the terminal block in the Pump control panel as the dedicated interface shall be prepared by MED before the connecting of this system.

Usually GPRS modem shall begin operating after it is called from the master station. GPRS modem called transmits the water level which is measured in input interface of RTU and also transmits the status of equipment at the same time.

Almost equipment shall be set up in an appropriate enclosure. And, the enclosure shall be mounted on the desk table or pole.

These functions to prevent unlawful access must be installed. And, function to prevent vandalizing also must be installed. Main function of gauging station is shown below table (Table 4-2.3).

Table 4-2.3 List of equipment composed in the gauging station

No.	Equipment	Quantity	Remarks
1	GPRS modem	1	
2	RTU with Data logger	1	
3	Charge controller	1	
4	Battery	1	
5	Solar panel	1	
6	Water level sensor	2	
7	Enclosure	2	
8	Pole	1	
9	Foundation	1	
10	Junction box	1	
11	Protection pipe	1	
12	Frame of solar panel	1	
13	Frame of enclosure	1	
14	Wiring cable	−	

4-2-3 Regulator

(1) Monitoring function

For the commercial power supply, it is possible to know the status of the gauging station by the information of black out. However, since the power supply system of the gauging station consists of a solar panel and a battery, it is necessary to monitor the power status from master station.

1) Power supply status

Power supply status which is consisted of solar panel and battery will be monitored.

(2) Measuring function

The measurements of upstream and downstream water levels at the head of branch canal's intake are monitored. The data will be used to understand the amount of distributed discharge to manage the regulators at the main canal in the near future.

1) Water level data

The upstream and downstream water levels at the regulator are measured. The telemetry system installed through this project will be the compatible system with the one which have been installed nation-widely and maintained by Egyptian government. Therefore, the system to be introduced in the project shall be technically maintained and managed by the CDT itself

The water level monitoring equipment installed by the Japanese Grant Aid Project at regulators such as Lahoun, Mazoura, Sakoula, and Dahab is using as a Regulator's gate operation index. Therefore, it is not easy for the CDT to maintain and manage said system systematically. Based on the above points, the introducing type of gauging station through this project will follow the same design concept that CDT has a lot of installation experience. In addition, gauging station will be newly installed on the upper and lower sides of each regulator, and monitoring from a master station remotely will be carried out.

(3) Operation / control

1) Regulator's gate : On-site control, No tele-control from remote site

(4) System diagram

Description of equipment composition and function composition is omitted because the system is the same as that of the branch canal.

4-2-4 Weir

(1) Monitoring function

The central monitoring house will monitors the status of the power supply system of the gauging station at weir. For the commercial power supply, it is possible to know the status of the gauging station by the information of black out. However, since the power supply system of the gauging station consists of a solar panel and a battery, it is necessary to monitor the power status from master station.

1) Power supply status

Power supply status which is consisted of solar panel and battery will be monitored.

(2) Measuring function

The measurements of upstream water level in the canal at the weir are monitored. The data will be used to understand the amount of distributed discharge to manage the regulators at the main canal in the near future.

1) Water level data

The measurements of upstream water level in the canal at the weir are measured.

(3) System diagram

Description of equipment composition and function composition is omitted because the system is the same as that of the branch canal.

4-2-5 Pump station

(2) Monitoring function

The central monitoring house will monitors the status of the power supply system of the gauging station at pump station. However, since the power supply for the gauging station will be connected to the distribution power board of the pump station, it is about the power supply status of the pump station such as black out that will be monitored by the master station.

(3) Measuring function

The measurements of upstream (suction tank) and downstream (discharge tank) water levels in the canal at the pump station are monitored. Also, the operation status (On/Off) of each pump is measured, and the operation time is calculated and recorded based on the operation cycle. This data will be used to understand the amount of distributed discharge, and manage the pump station's operations in the future.

1) Water level data

The measurements of upstream (suction tank) and downstream (discharge tank) water levels in the canal at the pump station are monitored.

2) Pump station's status

The pumping station where the gauging station is installed is operated and managed by the MED. In this project, the modification work on the pumping station is out of scope. Therefore, the measuring equipment that recognizes the pump operation status (On/Off) and the output connection terminal on the control panel for each pump shall be modified by MED. The pumped discharge is calculated as the theoretical discharge amount by multiplying the pump operation time by the designed pumping ability of each pump.

(4) Operation / control

1) Pump station : On-site control, No tele-control from remote site

(5) System diagram

Description of equipment composition and function composition is omitted because the system is the same as that of the branch canal.

Lake

(1) Monitoring function

The central monitoring house will monitors the status of the power supply system of the gauging station at Quarun Lake. For the commercial power supply, it is possible to know the status of the gauging station by the information of black out. However, since the power supply system of the gauging station consists of a solar panel and a battery, it is necessary to monitor the power status from master station.

1) Power supply status

Power supply status which is consisted of solar panel and battery will be monitored.

(2) Measuring function

The measurements of water level in the monitoring well of Quarun Lake are monitored. The data will be used to understand the amount of distributed discharge to manage the regulators at the main canal in the near future.

1) Water level data

The measurements of water level in the monitoring well are measured.

(3) System diagram

Description of equipment composition and function composition is omitted because the system is the same as that of the branch canal.

4-3 Wiring plan

Wiring plan of Regulators and Branch canal intake, and wiring plan of central monitoring house are shown in Figure 4-3.1 and Figure 4-3.2 respectively.

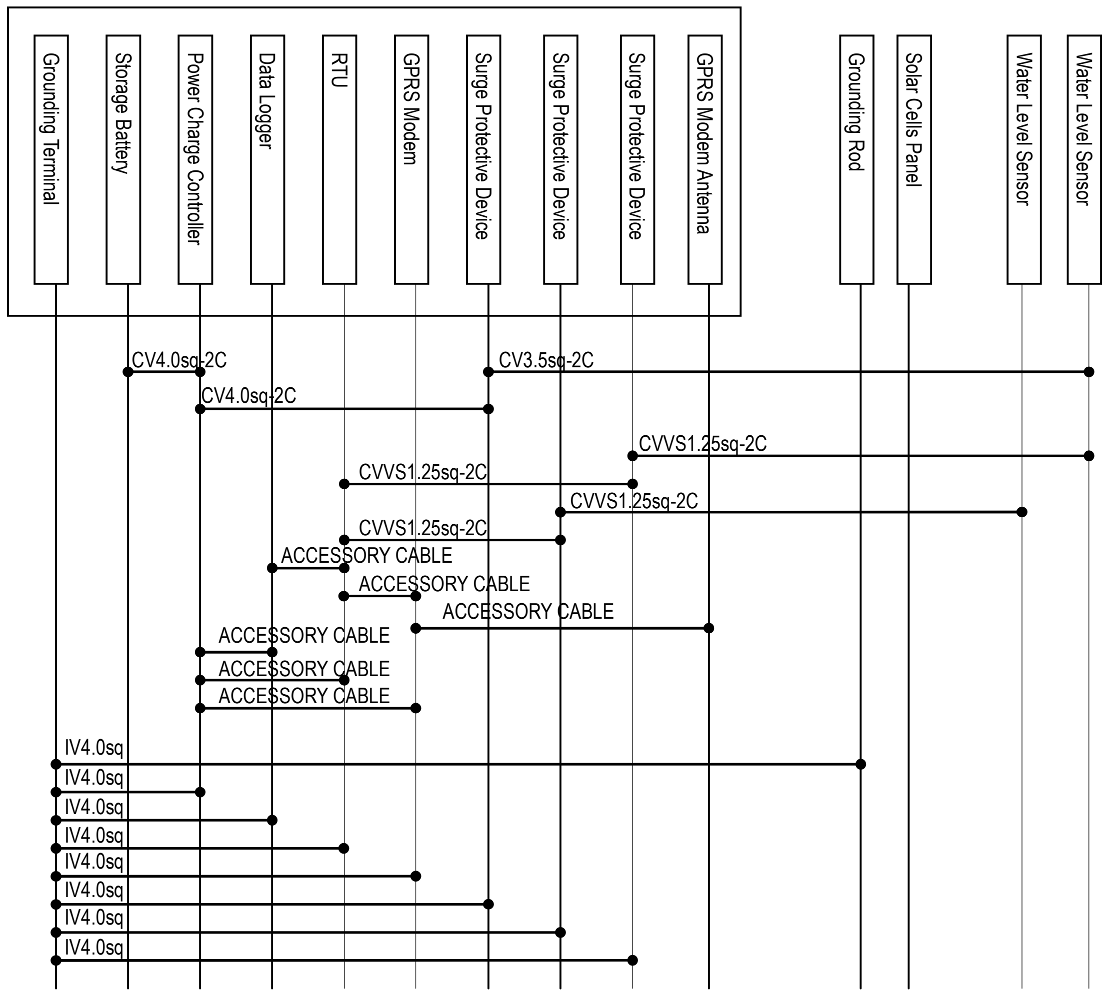


Figure 4-3.1 Wiring plan of regulator and branch canal's intake

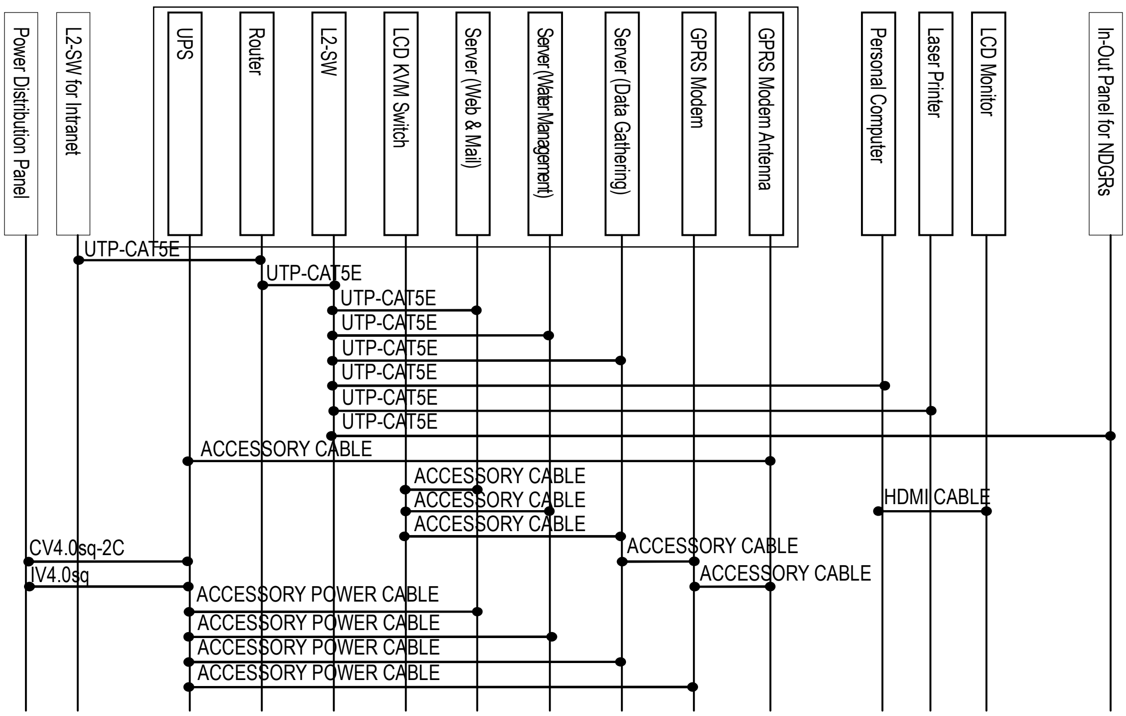


Figure 4-3.2 Wiring plan of Central Monitoring House

4-4 Gauging station plan

Construction of the gauging station in this area follows the existing telemetry station method. Each gauging station is mainly consists of enclosure, poles and fences.

The gauging station is planned to install along the road side except the location of Regulators. Therefore, in order to prevent theft or mischief at the gauging station, each device is fixed in an enclosure and surrounded by a fence. Devices such as GPRS modem, RTU, data logger, power controller, battery, surge protector are stored in the enclosure.

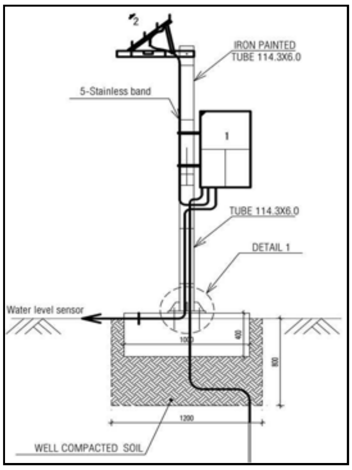


Figure 4-4.1 Gauging Station

4-4-1 Lightning countermeasure

Gauging stations are constructed in various places such as remote areas and nearby canals. Therefore, countermeasures against lightning and external noise are required. However, since the height of the gauging station's pole is 3m to 5m, it is not the height directly receiving lighting, so the function of lightning protection is only measures against induced lighting. Induction lightning is discharged to the ground through a surge protector.

4-5 Design of monitoring station

4-5-1Central monitoring station (Master station)

The central monitoring station (master station) will be installed in the same building of the control house for NDGRs. Table 4-5.1, Figure 4-5.1, and Table 4-5.2 show the function of central monitoring station, typical operation diagram of the master station and equipment in the master station, respectively.

Table 4-5.1 Function of the master station

No.	Function	Specification	Remarks
1	Data acquisition	Collected all the information which is measurement data from the gauging station by call.	
2	Water management	Making a report of all operation and management screens. And, installing the flow calculation	
3	Data base	Data base, data indication, data transferring, data store and restore	
4	Web server	The basis of the Water management screen is web display. This server provide the Water management screen to the WEB client.	
5	Mail server	The data are delivered to the mail address registered beforehand as information allows adding and remove addresses, address grouping... Etc.	
6	Monitoring	Monitoring the web screen. And, Print out.	
7	Network	LAN network	

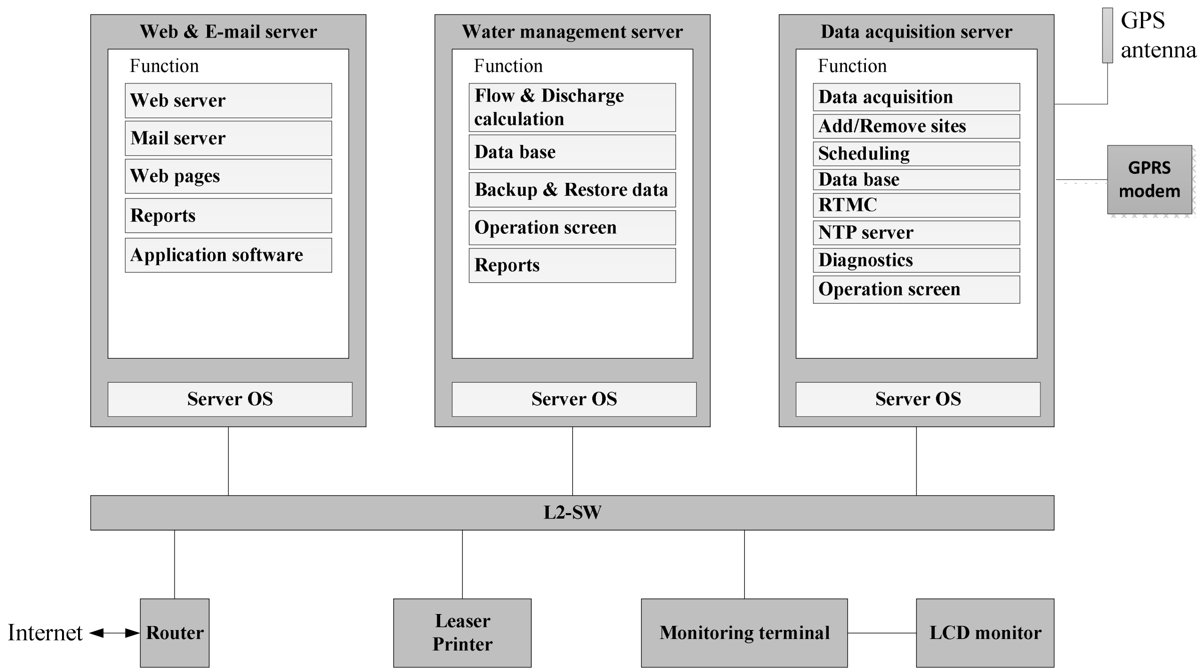


Figure 4-5.1 Typical operation diagram of the master station

Table 4-5.2 Equipment of the master station

No.	Equipment	Quantity	Remarks
1	GPRS modem	1	
2	Router	1	
3	L2-SW	1	
4	Data acquisition server	1	
5	Water management server	1	
6	Web & E-mail server	1	
7	NTP server	1	GPS antenna
8	KVM Switch	1	
9	KVM Monitor	1	
10	Keyboard & Mouse	1	
11	UPS	2	
12	Computer rack	1	
13	Monitoring terminal	1	
14	Laser printer	1	
15	LCD Monitor	1	

4-5-2 Minia monitoring station

Minia monitoring station will be set in telemetry office in Minia district. Table 4-5.3, Figure 4-5.2, and Table 4-5.4 show the function of monitoring station, typical operation diagram of monitoring station and equipment in the monitoring, respectively.

Table 4-5.3 Function of the monitoring station

No.	Function	Specification	Remarks
1	Monitoring	Monitoring the web screen. And, Print out.	
2	Network	LAN network	

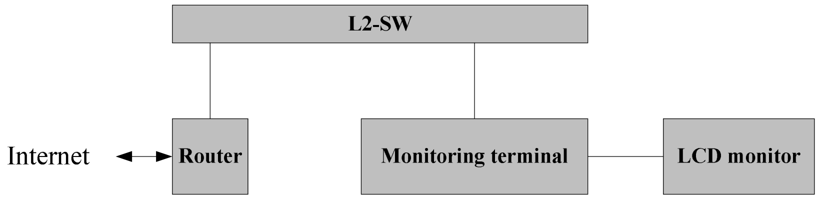


Figure 4-5.2 Typical operation diagram of the monitoring station

Table 4-5.4 Equipment of the monitoring station

No.	Equipment	Quantity	Remarks
1	Router	1	
2	L2-SW	1	
3	UPS	2	
4	Monitoring terminal	1	
5	LCD Monitor	1	

4-6 Specifications for equipment

4-6-1 GPRS modem

GPRS model shall be plug-in type and have moisture-proof type. The GPRS modem is a device for using the GPRS service of the mobile phone network and has a function for connecting to this network. The GPRS modem connects to the communication network of the mobile company of the built-in SIM card. The GPRS modem modulates data such as the water level from the RTU into a signal for GPRS communication and sends a modulation signal to the mobile phone network. Also, the modulated signal from the mobile phone network is received by the GPRS modem and then demodulated into predetermined data. The functions of the GPRS modem are shown in Table 4-6.1. The detailed contents are described in the technical specification.

Table 4-6.1 Technical specifications for GPRS modem

1)	Cellular interface	GSM / GPRS
	Frequency	Dual-band or more
2)	SIM Card	Two (2) slots or more
3)	Antenna interface	External Antenna
4)	Data interface	One (1) port or more
	Type	Serial port (RS232) or equivalent
	Baud rate	110 to 38,400 bps or more
5)	Command	AT commands or equivalent
6)	Health and Status monitoring	LED indicator
7)	Power	DC 12 V +/- 2V
8)	Standard	IP65 or more
9)	Mounting method	DIN rail or Screw mount
10)	Auxiliary	External antenna, The dedicated cable between modem and antenna
11)	Operating Temperature	10° to 55°C

4-6-2 RTU

RTU shall be plug-in type and have moisture-proof type construction, and consist of the following function, serial interface, I/O interface (external signal input / output), I/O interface controller and data exchange. This controller shall control these interface and functions according to user program.

RTU shall have the following function,

a) Transmission control

- To transmit the measured data and/or alarm and status data to Data acquisition server through GPRS modem.
- To receive control signal from Data acquisition server through GPRS modem.

b) I/O signal interface

- To read the analogue input signal value from the water level sensor, the range of the analogue input signal shall be 0 - 5 Volt or 4- 20 mA.
- To read the digital input signal status, the input signal shall be high / low condition (0 volt/5 volt) or open / close state. The input interface shall be electronically isolated.
- The spare port of I/O interface shall remain around 25% at all number of port.

c) Clock synchronizes

- The internal clock is regularly corrected. An internal clock synchronizes with NTP server in the master station, and this correction is completed.
- The protocol used by this clock synchronization shall be NTP. Moreover, NTP client shall be installed in RTU for calibrating an internal clock.

d) Data memory

- To store the data measured (analogue or digital) in the data logger to be retrieved when needed.

e) Power supply

- To supply the electrical power to each sensor. The voltage shall be 12VDC.

f) Data convert

- The data measured is received with Analog signal input port will be corrected according to meteorological conditions and a geographic condition. The measurement value after it corrects it is converted into the water level.

g) Internal control program

- The controller shall control these interface and functions according to user program. The Contractor shall prepare the user program which must work all function.

The specification is shown in Table 4-6.2. The detailed contents are described in the technical specification.

Table 4-6.2 Technical specifications for RTU

1)	Communication interface (for GPRS modem)	One (1) port or more
	Type	Ethernet (RJ45) or Serial port (RS232) or equivalent
	Speed	10/100 Base @ Ethernet, 110 to 38,400 bps @ Serial port or more
2)	External data interface (for Datalogger)	One (1) port or more
	Type	Ethernet (RJ45) or Serial port (RS232) or equivalent
	Baud rate	10/100 Base @ Ethernet, 110 to 38,400 bps @ Serial port or more
3)	I/O Interface	Spare port shall be set 25%.
	Analog signal input	8 ports or more, Analog (4-20mA, 0-5V), Isolation or line arrester shall be provided
	Digital signal input	12 ports or more, High/Low condition or Open/Close state (0 volt / 5 volt) or BCD 4 digits. Isolation or line arrester shall be provided
	Digital signal output	8 ports or more, High/Low condition or Open/Close state (0 volt / 5 volt) or BCD 4 digits.
4)	Protocol	IP, TCP, SNMP, NTP or more
5)	Health and Status monitoring	LED indicator
6)	Power	DC 12V +/- 2V
7)	Standard	IP65 or more
8)	Mounting method	DIN rail or Screw mount
9)	Operating Temperature	10° to 55°C

4-6-3 Data logger

Data logger shall consist of data logging and serial interface. Data logger enables to build it into RTU. Data logger shall fully satisfy the following function;

a) Data logging and display

- The converted water level data and current time are stored in the internal memory, and displayed on LCD display too by automatically or manually. The displayed time will be synchronized with internal clock or equivalent. For manual control, some buttons and LCD display must be located on the outlet of RTU. These data from internal memory is read, and displayed on LCD display too.

b) Clock synchronizes

- The internal clock is regularly corrected. An internal clock synchronizes with NTP server in the master station, and this correction is completed. The protocol used by this clock synchronization shall be NTP. Moreover, NTP client shall be installed in RTU for calibrating an internal clock.

c) Backup to external memory

- The external memory shall be back up for internal memory. Backup of internal memory will automatically execute a few times a day. Also, this backup can manually execute when it requires. Moreover, anytime this external memory shall be taken and setup. The data format stored must be Standard ASCII/CSV/XML. The data will be stored as permanent nonvolatile data. The storage period shall be for one (1) year and more.

d) Data memory

- To store the data measured (analogue or digital) from RTU and other to be retrieved when needed. The data will be stored as permanent non volatile data. The storage period shall be for one (1) year or more.

The specification is shown in Table 4-6.3. The detailed contents are described in the technical specification.

Table 4-6.3 Technical specifications for data logger

1)	External data interface (for RTU)	One (1) port or more
	Type	Ethernet (RJ45) or Serial port (RS232) or equivalent
	Speed	10/100 Base @ Ethernet, 110 to 38,400 bps @ Serial port or more
2)	Internal memory	One (1) Gbyte or more
3)	External memory	SD-Card FAT-16 or equivalent
4)	Protocol	IP, TCP, SNMP, NTP or more
5)	Maintenance port	One (1) port or more, Serial port (RS-232) or equivalent
6)	LCD display	Two (2) lines or more
7)	Health and Status monitoring	LED indicator
8)	Power	DC 12V +/- 2V
9)	Standard	IP65 or more
10)	Mounting method	DIN rail or Screw mount
11)	Operating Temperature	10° to 55°C

4-6-4 Water level sensor

Water level sensor shall be equipped a semi-conductor type pressure sensor which converts a pressure into a voltage or current. Water level sensor shall compose the sensor which is pressure type and the dedicated cable which shall be covered by the suitable pipe and fixed on the concrete structure or other approved method.

Water level sensor shall be designed to be protected from a lightning surge. Output signal shall be of the Analog 4 to 20 [mA] or equivalent for RTU.

Protective device with box to prevent the sensor and RTU from the lightning surge shall be provided at both end (when the distance between the water level sensor and RTU is short, one protective device is acceptable).

The specification is shown in Table 4-6.4. The detailed contents are described in the technical specification.

Table 4-6.4 Technical specifications for water level sensor

1)	Type	Pressure sensitive diffusion type semi-conductor or equivalent
2)	Measuring range	According to site specification
3)	Cable length	According to site specification
4)	Accuracy	± 0.10 % at F.S. at constant temperature, ± 0.2% over 35°F to 70°F(1.37° to 21.1°C) range
5)	Output signal	Analogue signal 0-5 volt or 4 - 20 mA or equivalent
6)	Sensor element	Titanium
7)	Sensor body	Stainless steel

4-6-5 Server

Server is manufactured based on the latest computer technology and ensure the trouble-free operation.

The basic component shall be composed of processor, serial interface, Local Area Network (LAN) interface, keyboard, color display monitor, Operating Software (OS) and shall be of the hot-standby system due to improve the system reliability.

The processor of computer shall be quad core and more.

Server shall be connected on LAN and shall prepare a necessary interface for peripheral devices.

Main memory shall be prepared a sufficient capacity, at least more than ten (10) years of data storage, and shall perform all process tasks without mutual interface and shall be provided efficient execution of all programs supplied by the Contractor and to cater for future expansion of the system.

LAN interface shall be suitable to Ethernet and protocol shall be based on TCP/IP (Transmission Control Protocol / Interface Protocol).

Operating System (OS) shall be selected from the “De Facto Standard” such as Windows, or Linux etc. Programming language shall be workable in the Windows, or Linux etc., which have used widely in the world. Anti-virus and screen saver software shall be provided to the server.

The specification is shown in Table 4-6.5. The detailed contents are described in the technical specification.

Table 4-6.5 Technical specifications for server

1)	Type	Computer rack mount
2)	CPU	Intel Xeon E5 or more
3)	Memory	16.0 GB or more
4)	HDD	8.0 TB (RAID5/Hot plug) or more
5)	RAID	RAID level 5 or more
6)	External drive	DVD-ROM/DVD-RW/DVD-R or equivalent
7)	Buck up System	Hot-Standby system
8)	I/O Interface	Two or more ports - 10/100/1000 BASE-TX
		Two or more ports - Serial port (RS232C)
		Four or more ports - USB 3.0
9)	Power	AC 230V +/-10 %, 50 Hz +/- 2 Hz, Dual supply/Hot plug
10)	OS	Windows Server 2016 English version or equivalent
11)	Apprication software	Apprication software that satisfies a specified function and the performance must be installed with OS.
12)	Waranty	5years
13)	Operating Temperature	10° to 55°C

4-6-6 Personal Computer

Personal Computer (PC) shall be factory automation (FA) type PC and shall be used to control and connect to Server via, Network.

The basic component shall be composed of processor, serial interface, Local Area Network (LAN) interface, keyboard, color display monitor and Operating Software (OS).

The processor of computer shall be quad core and more. It shall be connected on LAN and shall prepare a necessary interface for peripheral devices.

Main memory shall be prepared a sufficient capacity, at least more than ten (10) years of data storage, and shall perform all process tasks without mutual interface and shall be provided efficient execution of all programs supplied by the Contractor and to cater for future expansion of the system.

LAN interface shall be suitable to Ethernet and protocol shall be based on TCP/IP (Transmission Control Protocol / Interface Protocol).

Operating System (OS) shall be selected from the “De Facto Standard” such as Windows, or Linux etc. Programming language shall be workable in the Windows, or Linux etc., which have used widely in the world. It shall have function to update display data automatically using Java language or equivalent. Anti-virus and screen saver software shall be provided to the server.

The specification is shown in Table 4-6.6. The detailed contents are described in the technical specification.

Table 4-6.6 Technical specifications for personal computer

1)	Type	Factory Automation Type
2)	CPU	Intel Core i7, 2.0 GHz or more
3)	Memory	4.0 GB or more
4)	HDD	1.0 TB or more
5)	External drive	DVD-ROM/DVD-RW/DVD-R
6)	I/O Interface	Two or more ports - 10/100/1000 BASE-TX
		Two or more ports - Serial port (RS232C)
		Four or more ports - USB 3.0
7)	Power	AC 230V +/-10 %, 50 Hz +/- 2 Hz
8)	OS	Windows 8.1 Pro English version or equivalent
9)	Apprication software	Apprication software that satisfies a specified function and the performance must be installed with OS.
10)	Auxiliary	Cable, TFT LCD monitor (21inch or more), Keyboard & Mouse
11)	Waranty	5years
12)	Operating Temperature	10° to 55°C

4-6-7 LCD monitor

The LCD monitor is a device for displaying observed data such as schematic diagram of integrated water management system, measured water level sensor, gauging station with abnormal power supply status and etc. LCD monitor can be set up as follows, wall mounting, the self-stand mounting, and the ceiling mounting.

The specification is shown in Table 4-6.7. The detailed contents are described in the technical specification.

Table 4-6.7 Technical specifications for LCD monitor

1)	Display size	60 inch or more
2)	Display type	Liquid Crystal Display
3)	Resolution	1,280 x 1,024 dot or more
4)	PC interface	Analogue RGB (mini D-sub 15 pin) x 1 or equivalent
5)	Video interface	(Input) NTSC x1 or equivalent
		(Input) HDMI x3
		(Output) NTSC x1 or equivalent
		(Output) HDMI x1
6)	Installation	The wall mounting, the self-stand mounting, and the ceiling mounting
7)	Power	AC230 V +/-10 %, 50 Hz +/- 2 Hz
8)	Operating Temperature	10° to 55°C

4-6-8 L2-SW

L2-SW shall be hub where the switching facility is added, and shall learn the MAC address of Ethernet device connected to each port, and link port required for intelligence directly and enable it exchange data.

The specification is shown in Table 4-6.8. The detailed contents are described in the technical specification.

Table 4-6.8 Technical specifications for L2-SW

1)	LAN interface	10BASE-T/100BASE-TX x 8 ports or more
2)	LAN protocol	TCP/IP, IP multi-cast, etc
3)	Layer 2 switching	Shall be Provided
4)	Maximum VLAN	Approx. 63 or more
5)	VLAN trunk	Shall be Provided
6)	Spanning tree	Shall be Provided
7)	Multicast	IGMP etc
8)	Connector	RJ-45 jacks
9)	Network management	SNMP
10)	Power	AC230 V +/-10 %, 50 Hz +/- 2 Hz
11)	Switching Function	Frame forwarding ability is 10.0 Mbps or more
		Switching method shall be Store and-forward
		The priority control of traffic must be possible based on COS, TOS, and the DSCP value of priority control IEEE802.1p.
		Several 127 to which the VLAN function can be set VLAN or more of each port can be set and tag VLAN (IEEE802.1Q) should be able to be set.
		Independent spanning tree protocol operation (Tag VLAN is contained) at each trouble detour VLAN MSTP (IEEE802.1s) and RSTP (IEEE802.1w).
		The multicast packet is forwarded only to a necessary multicast port (IGMP Snooping equivalent function).
		Possess the function (Storm Control equivalent function) to suppress a large amount of Broadcast, Multicast, and Unicast by the traffic control each other port.
12)	Management function	Management protocol SNMP (v1,v2,v3)
		Remote access function by remote triggering Telnet
13)	Operation and maintenance function	Limitation access. By password
		Preservation, remote maintenance, and the log output of composition definition information by the set management text form must be possible.
		Power On automatically after it electrical power failure.
14)	Operating Temperature	10° to 55°C

4-6-9 Router

Router shall be equipped with the connection function conformed to intranet provided for accessing to internet. Router shall be connected when transmission with an external network between Master station and other government office.

The specification is shown in Table 4-6.9. The detailed contents are described in the technical specification.

Table 4-6.9 Technical specifications for router

1)	IP routing protocol	RIP, RIPv2
		Number of route entries is 5000 or more
2)	WAN protocol	To be suitable internet line provided by communication company
		PPP, PPPoE, IPv4
		Number of PPPoE session is 100 or more
3)	LAN protocol	IPv4, TCP, UDP, Multicast
4)	LAN ports	RJ45 type
		10BASE-T/100BASE-TX
		8 ports or more, (all port supports MDI/MDI-X)
5)	WAN ports	To be suitable intranet and internet line provided
6)	Throughput	50 Mbps or more
7)	NAT descriptor function	NAT, IP masquerade, Static NAT, DMZ, PPTP pass through,
		IPsec pass through
		Number of NAT session is 10,000 or more
8)	Quality of Control (QoS) function	Priority control, Traffic control (Dynamic traffic control),
		Support for CBQ, WFQ,
9)	VPN function	IPsec (NAT traversal, XAUTH)
		Encryption; AES, DES (Hardware processing)
		IKE/IKEv2, PPTP
10)	Authentication function	PAP/CHAP,MS-CHAP/MS-CHAPv2 or more
11)	Firewall function	IP address, Protocol, Destination / Source, Port number
		Number of static session filter is 1000 or more
		IDS detection, SYN flag attacking is blocked automatically
12)	Security function	URL filtering
		MAC address filtering
13)	Management function	Management protocol SNMP(v1,v2,v3)
		Remote access function by remote triggering Telnet
14)	Operation and maintenance function	Limitation access. By password
		Preservation, remote maintenance, and the log output of composition definition information
		Power On automatically after it electrical power failure.
15)	Power	AC230 V +/-10 %, 50 Hz +/- 2 Hz
16)	Operating Temperature	10° to 55°C

4-6-10 Laser printer

A laser printer is a device for outputting information processed by integrated water management.

The specification is shown in Table 4-6.10. The detailed contents are described in the technical specification.

Table 4-6.10 Technical specifications for laser printer

1)	Printing method	Electro photographic laser beam scanning
2)	Data process resolution	600 x 600 dpi or more
3)	Paper size	A4, A3 or more
4)	Network connection	10BASE-T/100BASE-TX
5)	Power	AC230 V +/-10 %, 50 Hz +/- 2 Hz
6)	Operating Temperature	10° to 55°C

4-6-11 Enclosure

Enclosures for equipment shall be wall mounting, rigid welded steel frames, completely enclosed by metal sheets and suitable for outdoor installation. It shall have provisions for lifting and ample strength to withstand all stresses incidental to shipping, installation and operation without distortion or other damage. Enclosure in the gauging station shall be set up the following equipment;

- GPRS modem with antenna

- RTU
- Data logger
- Power charge controller
- Storage battery
- Surge protector

The specification is shown in Table 4-6.11. The detailed contents are described in the technical specification.

Table 4-6.11 Technical specifications for enclosure

1)	Construction	Outdoor pole-mounting
2)	Material	Steel plate, and it shall be coated with anti-corrosive paint
3)	Dimension	W600 x D200 x H600 mm or equivalent
4)	Locking system	Key
5)	Standard	IP65 or more
6)	Operating Temperature	10° to 55°C

4-6-12 Computer rack

Computer rack shall be IP20 degree of protection and be dead-front, floor mounting, rigid welded steel frames, completely enclosed by steel plates. It shall have provisions for lifting and ample strength to withstand all stresses incidental to shipping, installation and operation without distortion or other damage. Computer rack shall be set up the following equipment;

- GPRS modem with antenna
- Data acquisition server
- Water management server
- Web & Mail server
- L2-SW
- Router
- UPS
- KVM switch, monitor, keyboard and mouse
- Extension Tap

The specification is shown in Table 4-6.12. The detailed contents are described in the technical specification.

Table 4-6.12 Technical specifications for computer rack

1)	Construction	Indoor self-standing (19 inch rack)
2)	Material	Steel plate
3)	Dimension	W600 x D600 x H2,000 mm or equivalent
4)	Thickness of plate	1.6 mm or more
5)	Operating Temperature	10° to 55°C

4-6-13 LCD KVM switch

LCD KVM switch integrates a LCD panel, full keyboard and touchpad into a streamlined, 1U housing of the computer rack. This shall be rack mount type. LCD KVM switch allows a user to control multiple Server and/or Computers from one or more sets of Keyboards, VGA monitors and Mousse. Although multiple Server and /or Computers are connected to KVM switch.

LCD panel capable of full HD video incorporates the YUV video format for greater compatibility with high-definition signals (e.g. NVR sources). Similarly, this is also High-Bandwidth Digital Content Protection (HDCP) compatible.

The specification is shown in Table 4-6.13. The detailed contents are described in the technical specification.

Table 4-6.13 Technical specifications for LCD KVM switch

1)	Server (Computer) connection	8 [nos]
2)	Port selection	OSD, Hotkey, Pushbutton
3)	Connectors	
	External ports	USB type A (Female) 2 ports (or PS/2 (Female) 2 ports), Stereo Mini Jack (Female) 1 port, DVI-I (Female) 1 port (or VGA (Female) 1 port)
	KVM Ports	USB type A (Female) 4 ports (or PS/2 (Female) 4 ports), Stereo Mini Jack (Female) 4 ports, DVI-I (Female) 4 ports (or VGA (Female) 4 ports)
4)	Emulation (Keyboard / Mouse)	USB or PS/2
5)	LCD panel	
	Screen size	17 inch or more
	Support color	262144 colors
	Luminance	300 cd/m² or more
	Response time	less than 8 ms
6)	Video	1920 x 1080 or more
7)	Scan Interval	1 to 255 sec.
8)	Mount type	Computer rack mount
9)	Power	AC230 V +/-10 %, 50 Hz +/- 2 Hz
10)	Operating Temperature	10° to 55°C

4-6-14 NTP server

NTP server shall provide accurate year, month, day, hour and minute data via LAN network. GPS receiver shall be built into NTP server, and shall be connected to the external GPS antenna. GPS receiver in NTP server shall receive the signal from several GPS satellites in the sky, and GPS receiver shall get own present location and time.

GPS satellite is a semi-synchronous satellite that rounds and moves highly of about 20,000km in about 12 hours. And this is not a fixed satellite. In view of the point on a certain earth, GPS satellite changes the position hour by hour. Therefore, the error margin can be leveled on the all earth. However, the number of GPS satellites that can be received is according to the region on the earth and there are always few places, too.

Information on the data of time from the atomic clock installed in the GPS satellite and the astronomical ephemeris of the satellite are included in the signal from the GPS satellite to GPS receiver. GPS receiver in NTP server shall receive the wave from GPS satellite, and measures the sending time. GPS receiver shall calculate the distance from GPS satellite by using the speed of the wave (the same 300,000km/second as the speed of optical light) for the difference of a time of the transmission and the reception.

The clock installed by GPS receiver is using Quarts. Therefore, this clock is not accurate. For example, the error margin of the calculated distance becomes about 300m when the error margin of GPS receiver at time is 1/1,000,000 seconds. To secure the accuracy of this clock, GPS receiver receives the wave from four GPS satellites, and calculates accurate reception time and the receiver coordinates by the measurement calculation.

GPS time shall be UTC which began a start time from January 6, 1980 (standard time). Moreover, the leap second adjustment is not executed like UTC. The difference data of the time between GPS time and UTC is included in GPS receiving data. Therefore, NTP server is outputting the accurate UTC calibrated by using difference data. And, there is an offset signal to which this time difference is corrected up to 255 (eight bits). This means that it is possible to use it until 2300yr without trouble in case of the leap second insertion of current state correction.

The specification is shown in Table 4-6.14. The detailed contents are described in the technical specification.

Table 4-6.14 Technical specifications for NTP server

1)	GPS receiver	Built-in, 6-channel GPS C/A-code receiver or equivalent
2)	GPS antenna	External
3)	Accuracy (time)	less than 1 ms GPS synchronized,
4)	Accuracy (frequency)	less than 1E-11 GPS synchronized, avg, over 24 hours
5)	Output	10/100 Base Ethernet
6)	LAN interface	RJ45, One (1) port or more
7)	Serial interface	One (1) port or more
8)	Supported network protocol	NTP(V2, v3, v4), SNMP(v3,v4), IP, DHCP(client), Secured protocol
9)	Health and Status monitoring	LED indicator
10)	Mount type	Computer rack mount or Standalone
11)	Accessory	Surge arrestor, The dedicated cable between the receiver and antenna
12)	Power	AC230 V +/-10 %, 50 Hz +/- 2 Hz
13)	Operating Temperature	10° to 55°C

5. Operation and Maintenance Plan for Integrated Water Management

The purpose of introducing the integrated water management system is to monitor the irrigation facilities such as the regulators, the branch canal intakes and the pump stations, etc. in a centralized monitoring, thereby making effective use of irrigation water in the beneficially area, rational water allocation, securing safety of irrigation facilities, and reducing operation and maintenance cost of each facility. As irrigation facilities are widely scattered in the Project area, operation and maintenance manuals of the integrated water management system are necessary for these effective operations.

In addition, it is needed the certain level of training of data gathering, data evaluation and data utilization at the one site via the remote monitoring system and gate operation techniques for establishing the appropriate gate operation of NDGRs which was constructed this project, resolving the unbalanced water distribution at each site along Ibrahimia and Bahr Yusef canal with a length of more than 300 km.

The contents of technical cooperation for operation and maintenance for establishment of the appropriate operation in the near future are described below. And following figure mentions the position of strengthening program framework after the completion of this project.

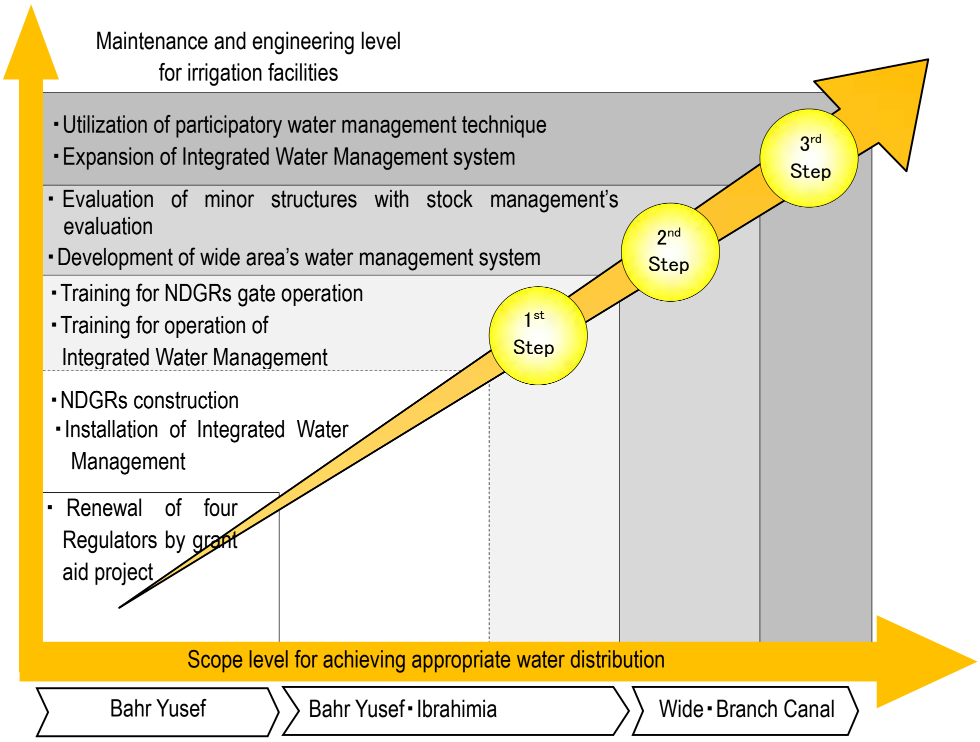


Figure 5-1.1 Position of strengthening program framework and project road map (draft)

The following proposal could be arisen as operation and maintenance activity in this project, which should be supposed as improvement of technical skills of Egyptian engineers. To achieve these outcomes, the draft technical topics and strengthening program contents are shown in Table 5-1.1.

(1) Through the project, the operation rules of NDGRs are formulated together with CP, and technical transfer will be carried out.

(2) Discharge measurement at the downstream of NDGRs and technical transfer of water distribution method will be carried out.

(3) In the NDGRs, a manual for gate operation and integrated water management method will be formulated together with CP

Table 5-1.1 Program for strengthening of operation and maintenance capacity (draft)

Topics	Contents of strengthening program	Example of specialized Japanese skilled expert
Gate operation technique for NDGRs	Training of gate operation skills for establishment of appropriate water distribution for seven canals	Irrigation development, Irrigation facility operation, Operation and maintenance, Electrical and mechanical
Maintenance skills of gate facilities for NDGRs	Maintenance skill's support for mechanical engineers due to conversion from human power driven gate operation to mechanical driven gate operation	Operation and maintenance, Electrical and mechanical, Telecommunication
Improvement of discharge measurement technique in major regulator and branch canal's intake	Technical and measuring equipment support for creating H~Q rating curve (relationship between water level and discharge)	Irrigation, Operation and maintenance, Hydraulics
Expansion of integrated water management technique	Technical support for gate operation of NDGRs and proper water distribution method at the regulators along the two main canals and branch canal's intake	Irrigation planning, Water management, Telemetry, Irrigation facility operation (Canal, Minor structure), etc.
Operational support for stakeholder meetings for appropriately operation of integrated water management technique	Cooperation with the Ministry of Agriculture and other governmental organizations such as MED related to latest irrigation area and cropping information.	Irrigation planning, Agriculture, Water management, GIS, Remote sensing

Operation and Maintenance Manual of Integrated Water Management System

1. Purpose of the Manual

The manual is prepared for rational water management and proper water distribution at the NDGRs, primary canals, main canals and main branch canal's intakes by integrated water management system.

2. Concept of Water Management in the Area

Irrigation water of 9.6 billion m^3, taken from the Nile River, is diverted to the Ibrahimia Primary Canal. The water will be diverted from the NDGRs to the seven canals, and it is finally distributed among the 600,000ha beneficiary area by the Project. It means that proper water distribution to the seven canals will be implemented due to recovery of original functions of the Regulators.

Out of seven canals, the Bahr Yusef Canal and Ibrahimia Canal are very long, exceeding 300 km in length. By means of integrated management of scattered regulators in such wide area, effective water distribution targeting the five beneficiary Governorates, namely, Assiut, Giza, Beni Suef, Fayoum and Minia can be implemented. The Project establishes a monitoring system to operate water distribution in centralized manner for the purpose of dissolution of current imbalanced one.

In the integrated water management system to be installed by the Project, not only discharge at regulators which are located on the boundary of Governorates but also that at other regulators and branch canal intakes will be observed. In addition to establishment of such a centralized system in the remote areas, H-Q curve (water level – discharge) is to be prepared, and it is possible to estimate water volume by measured water level at regulators and branch canal intakes. It means that centralized data collection system makes it possible to evaluate the water discharge data and to give instruction for gate operation, which leads to proper and even water distribution at the level of main canal.

Expected outcomes by the integrated water management system are as follows:

・Rational water distribution

Identification of discharge in the main canal at the regulators, data collection of discharge from main canals to branch canals, just enough and proper water distribution, even water distribution based on water rights in governorates can be implemented. Water allocation is based on the amount of water actually supplied, which leads to fair water management.

・Awareness improvement of water distribution

It is possible for the third party to check the actual water distribution by centralized water management system and visual presentation of water level and water distribution conditions at plural sites. Moreover, some governorates, which interfere, can share the same data by the new visualized system, which leads to improve transparency of water distribution.

・Speed-up of giving instruction for water distribution

Since measured data collection is done in the centralized manner and instruction of water distribution is given based on the collected data, speedy instruction will be given.

・Improved operation & maintenance of irrigation facilities

Since water level discharge of targeted main irrigation facilities can be measured even in the remote area, it is possible to identify any accidents of facilities and improper water distribution immediately, when trouble and failure in water level data are observed. Due to the new system, repair at early stage and daily maintenance can be practiced.

3. Target Facilities

The target water management facilities are mainly 1) monitoring systems in the remote area to be installed by the Project, which are listed in Table 5-1.2 and Table 5-1.3, 2) the integrated water management system in the central control house at NDGRs, and 3) the monitoring room to be installed in Minia Governorate.

Specific targeted facilities are 1) Ibrahimia head regulator at the intake point from the Nile River, 2) NDGRs which diverts water from the Ibrahimia Primary Canal to the seven canals, 3) Regulators at Ibrahimia Canal and Bahr Yusef Canal, 4) branch canal’s intake at Ibrahimia canal and Bahr Yusef canal including pump stations, 5) weirs for discharge observation at main canals and branch canals, and 6) lake at the end of the Bahr Yusef Canal. In addition, 7) integrated water management system in the central control house at NDGRs, which centralizes measured water level in the remote areas, and 8) monitoring room in Minia Governorate are also targeted.

4. Administration Structure

The newly established “Integrated Water Management Center” will be in charge of management of the target facilities mentioned above. The center is under the Central Directorate for Water Distribution (CDWD) in Assiut, and it will be responsible for centralized operation and maintenance of the facilities.

The center is to be installed at the NDGRs control house. Under the center, four sectors shall be established and each sector manages East Minia, West Minia, Beni Suef and Fayoum, respectively. It is possible for the staff to double plural sections.

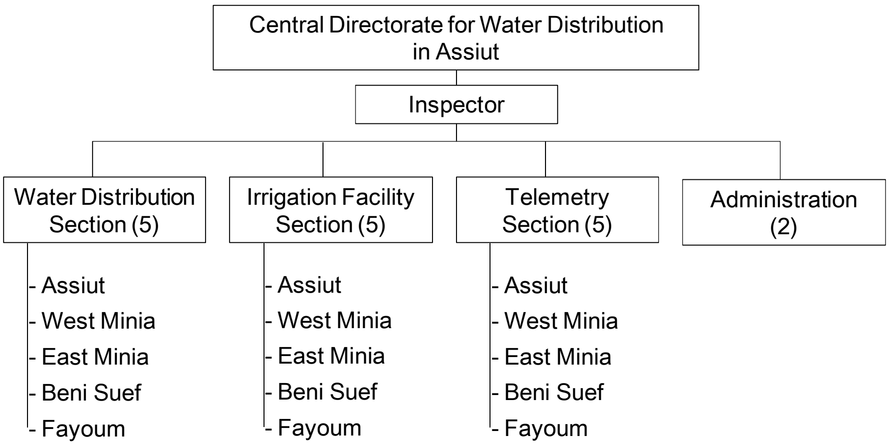


Figure 5-1.2 Organization chart of the new integrated water management center

5. Roles and Responsibility of the Integrated Water Management Center

Roles and responsibility of the Integrated Water Management Center are stipulated in the manual. The Center will be in charge of following matters:

(1) Operation and maintenance of the facilities

(2) Operation of facilities by close communication with CDWD in Assiut, and speedy and proper implementation based on the instruction by the CDWD

(3) Close monitoring of the canal conditions and handling of any issues as required

(4) Works for water distribution

1) Observation of water level in the facilities listed in Table 1

2) Decision of discharge at the regulators and discharge to be distributed to the branch canal intakes

3) Instruction of gate operation at the regulators

4) Instruction of gate operation at the branch canal intakes

5) Instruction of pump station operation

6) Others

(5) Works for operation & maintenance

1) Cleaning and adjustment of the remote area observation equipment (water level meter, data logger, transmitter and so on)

2) Cleaning and adjustment of the integrated water management system equipment in the Central monitoring & operating house and the Minia monitoring room

3) Prevention of damage to the facilities

4) Early identification of damage to the facilities and immediate repair

5) Thief proof of equipment

6) Control of excessive irrigation water use at the target facilities

7) Others

6. Works for Water Distribution

Works for water distribution mentioned in 5(4) are as follows:

(1) Any other organizations except those under the General Directorates of Irrigations (GDIs) shall not touch the gate operation.

(2) Integrated Water Management Center shall confirm whether water is distributed at regulators and branch canals as planned. (H-Q curve will be formulated gradually from the 3rd year after the start of NDGRs construction, and the draft H-Q curve will be tried after the completion of construction works.)

(3) Discharge at the regulators and water volume to be distributed to the branch canals are to be determined based on “Water Distribution Regulation”.

(4) Integrated Water Management Center basically shall confirm three times per day whether water is distributed through the integrated water management system as planned. According to necessity, it shall give instruction to GDIs regarding operation adjustment at regulators and branch canal intakes.

(5) Main gates at regulators and branch canal intakes shall be locked to prevent from illegal water diversion.

7. Works for Operation & Maintenance

Works for operation & maintenance mentioned in 5(5) are as follows:

(1) If minor issues are identified, the staff shall handle them.

(2) If there are some issues which cannot be managed in previous item, namely, 7 (1), the staff shall report them to the superiors and follow the instructions.

8. Water Distribution Methodology

Water volume to be distributed at the irrigation facilities are determined based on the Water Distribution Plan prepared by the NDGRs Project.

9. Record of Works

Integrated Water Management Center shall record the observed water level in the monthly report and submit it to the CDWD in Assiut.

10. Countermeasures against Water Shortage at the Ibrahimia Head Regulator

If water intake volume at Ibrahimia Main Canal from the Nile River is limited, which results in water shortage in the command area, the Integrated Water Management Center shall discuss with GDIs to take countermeasures against the issue.

11. Maintenance

Facilities and equipment mentioned in “3. Target facilities” shall be regularly maintained to keep original functions.

At the branch canal intakes and branch canals, adequate hydraulic functions could not be implemented due to deteriorated intake gate condition and sediment blockage of water flow along the branch canal. These minor irrigation facilities such as branch canal intakes and branch canals shall be regularly maintained to keep original functions.

12. Inspection

For the purpose of functioning of the Integrated Water Management System, daily inspection and regular check shall be implemented. These works shall be done following the criteria:

1) Daily check: Minimized check for daily operation
2) Regular inspection: The staff shall monitor the equipment regularly to identify any errors from outside and implement operation tests, trial measurement, exchange of spare parts, repair, adjustment, cleaning and so on to recover the original functions of the equipment. The inspection frequencies are quarterly, biannually and annually depending on the inspection items.

Table 5-1.2 Facilities targeted for monitoring (1/2)

<table>
<tr><th colspan="3">Irrigation facilities</th><th colspan="2">Name of the Target facilities</th><th>No.</th></tr>
<tr><td rowspan="2">Regulator</td><td colspan="2">Bahr Yusef canal</td><td>Dahab Regulator
Sakoula Regulator
Mazoura Regulator</td><td>Lahoun Regulator
Abo El Shekok Regulator
Regulator km39</td><td>6</td></tr>
<tr><td colspan="2">Ibrahimia canal</td><td>New Hafze Regulator
Matay Regulator
Maghagha Regulator</td><td>Sharahna Regulator
El Gandy Regulator
Ashmont Regulator</td><td>6</td></tr>
<tr><td rowspan="5">Branch canal</td><td rowspan="3">Bahr Yusef canal</td><td>Intake</td><td>Manshat EL Dahab
El Hareka
El Sabaa</td><td>Quftan
Wesh El-Bab
EL-Giza</td><td>6</td></tr>
<tr><td>Weir</td><td>Hassan Wasef Weir</td><td></td><td>1</td></tr>
<tr><td>Pump</td><td>New Kamdeer P.S.
New Terfa P.S.
Old Terfa P.S.</td><td>Old Sakoula P.S.
Mazoura P.S.(2)</td><td>5</td></tr>
<tr><td rowspan="2">Ibrahimia canal</td><td>Intake</td><td>Irad El Maharak
El Kosia
East Hafze
West Hafze
Adkak</td><td>Gendia
Abo Shosha
EL Soultany
Tansa
El Mansour</td><td>10</td></tr>
<tr><td>Weir</td><td>Serry Weir</td><td>Maghagha Weir</td><td>2</td></tr>
<tr><td colspan="3">Ibrahimia main canal</td><td>Ibrahimia Head Regulator</td><td></td><td>1</td></tr>
<tr><td colspan="3">Lake</td><td>Quarun Lake</td><td></td><td>1</td></tr>
<tr><td colspan="5">Total</td><td>38</td></tr>
</table>

Table 5-1.3 Facilities targeted for monitoring (2/2)

<table>
<tr><th>Irrigation facilities</th><th colspan="2">Name of the Target facilities</th><th>No.</th></tr>
<tr><td>Dirout Group of Regulators</td><td>Bahr Yusef Regulator
Ibrahimia Regulator
Irad Delgaw Regulator
Abo Gabal Regulator</td><td>Badraman Regulator
Dairotiah Regulator
Sahelyia Regulator</td><td>7</td></tr>
<tr><td colspan="3">Total</td><td>7</td></tr>
</table>

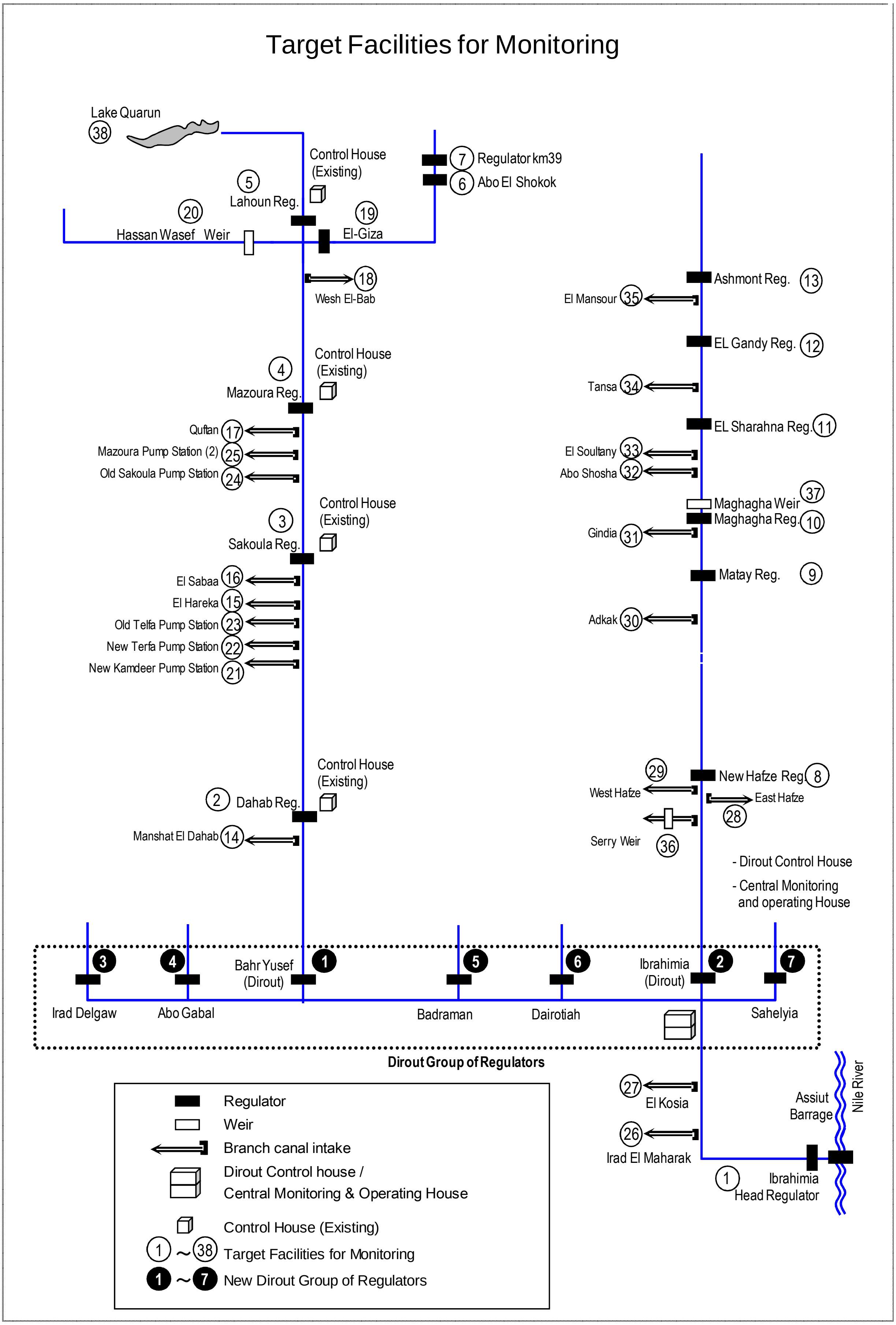


Figure 5-1.3 Schematic diagram of the facilities to be monitored in water management system

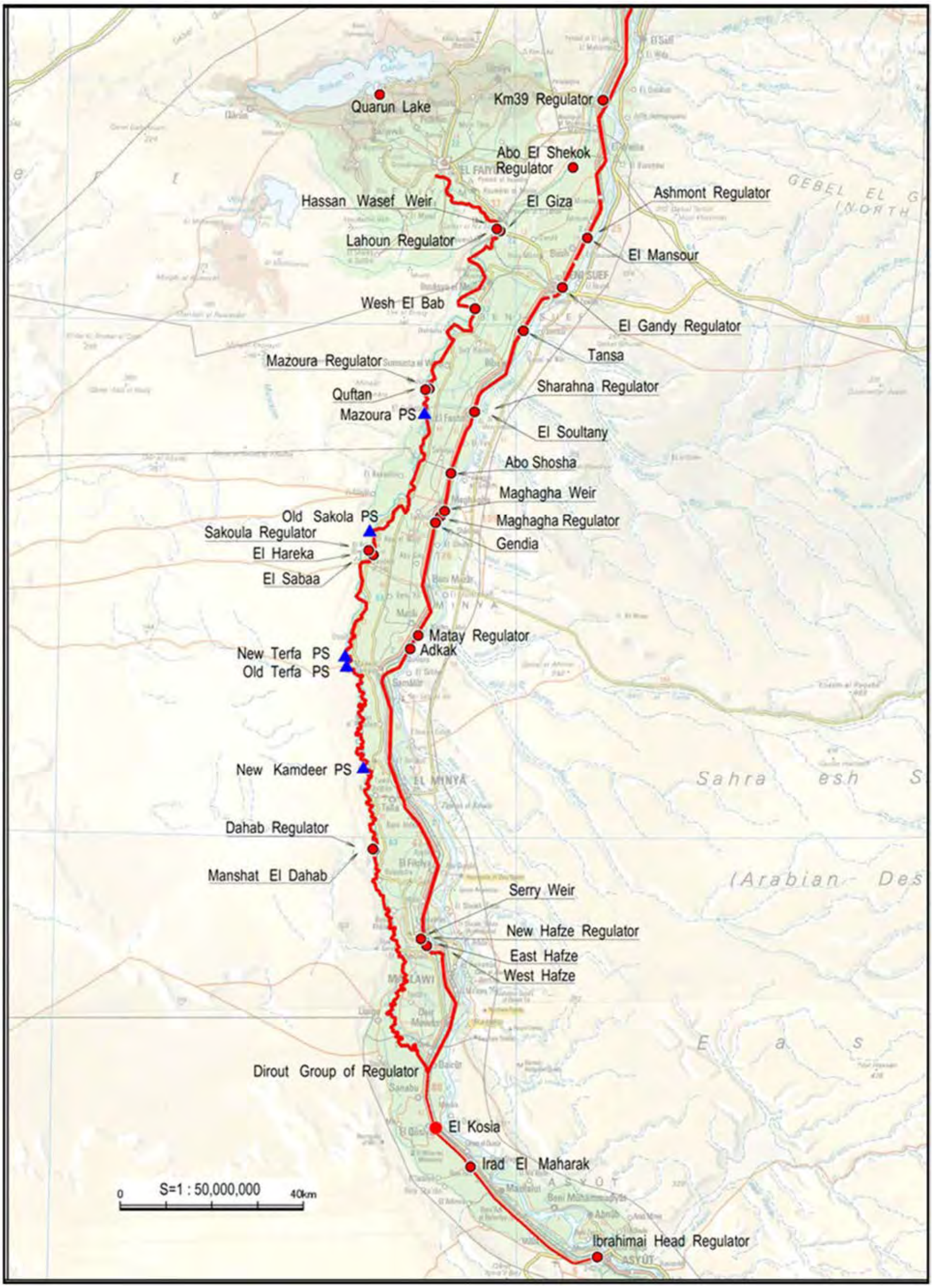


Figure 5-1.4 Location map

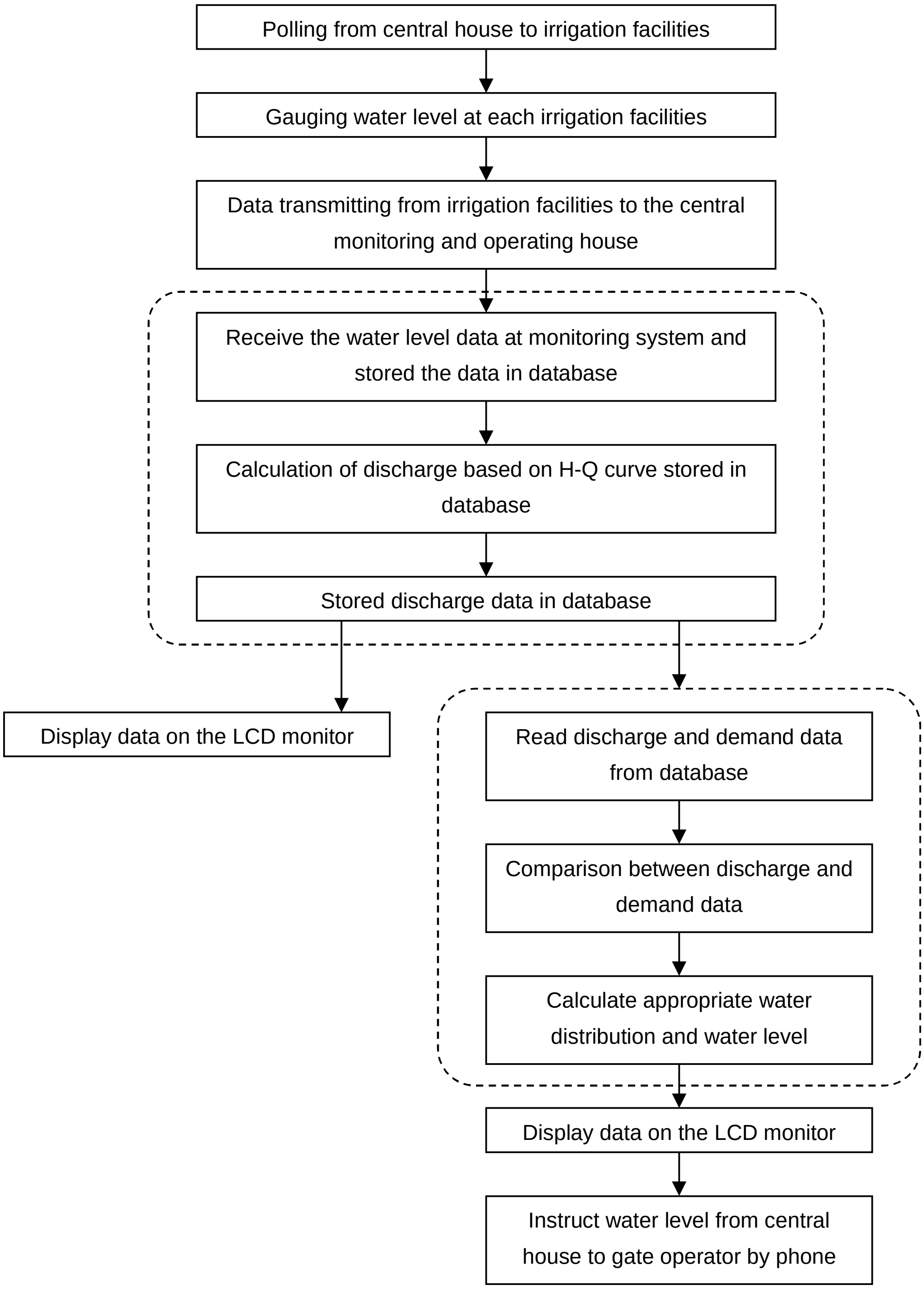
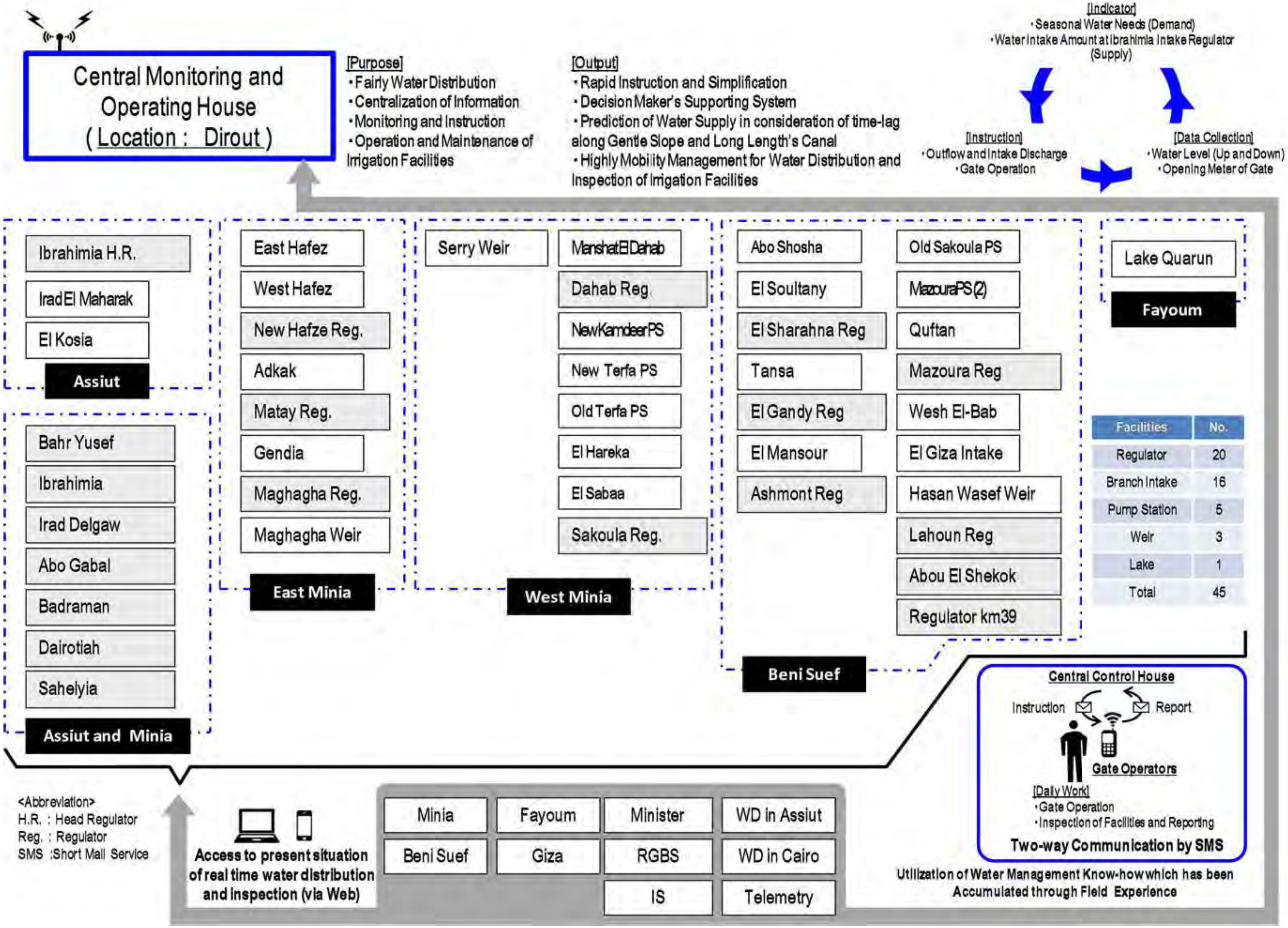
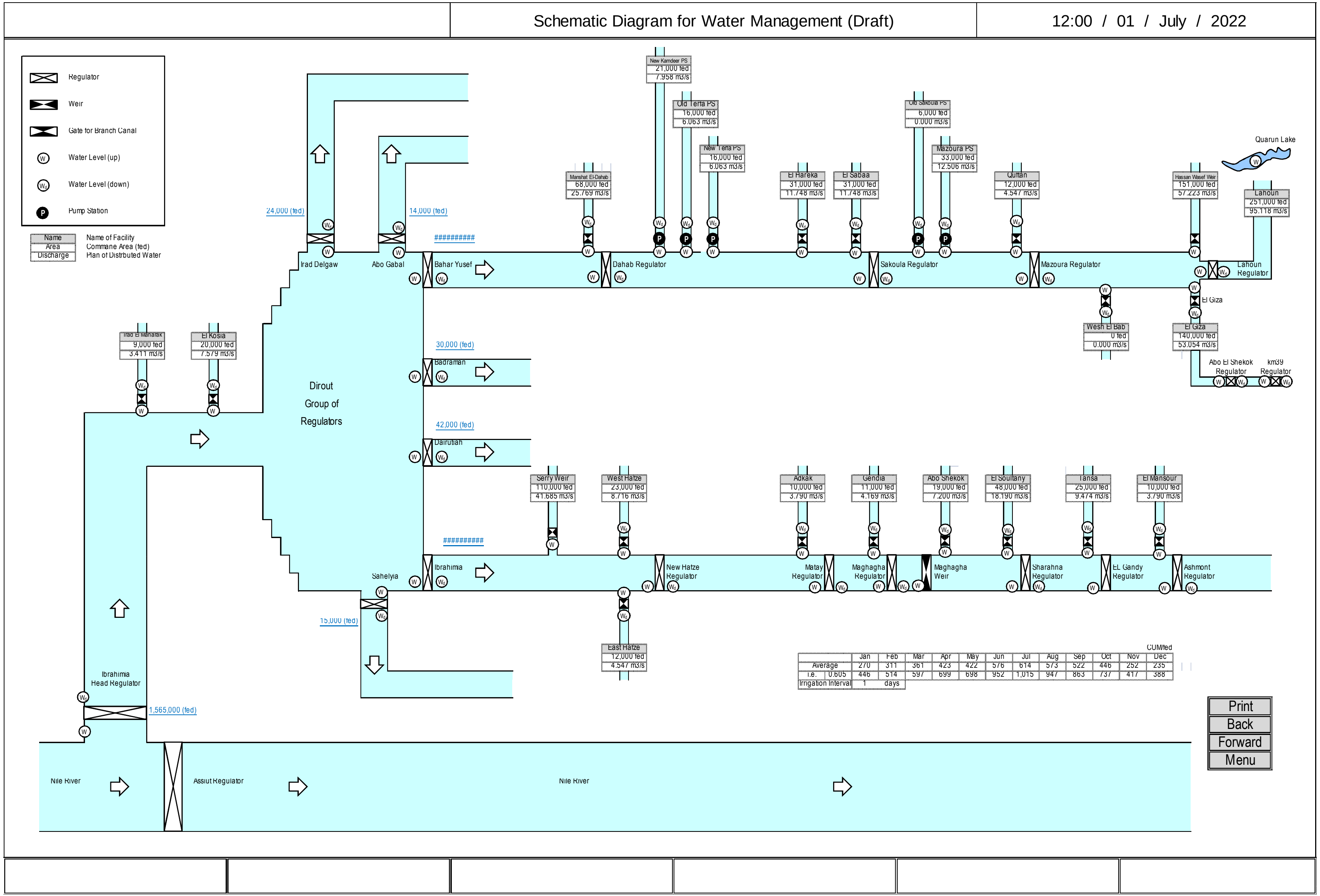


Figure 5-1.5 Data flow



Facilities	No.
Regulator	20
Branch Intake	16
Pump Station	5
Weir	3
Lake	1
Total	45

Figure 5-1.6 Hierarchic diagram for the integrated water management system



CUM/fed

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average		270	311	361	423	422	576	614	573	522	446	252	235
i.e.	0.605	446	514	597	699	698	952	1,015	947	863	737	417	388
Irrigation Interval		1	days										

Figure 5-1.7 Layout map of the target area (draft)

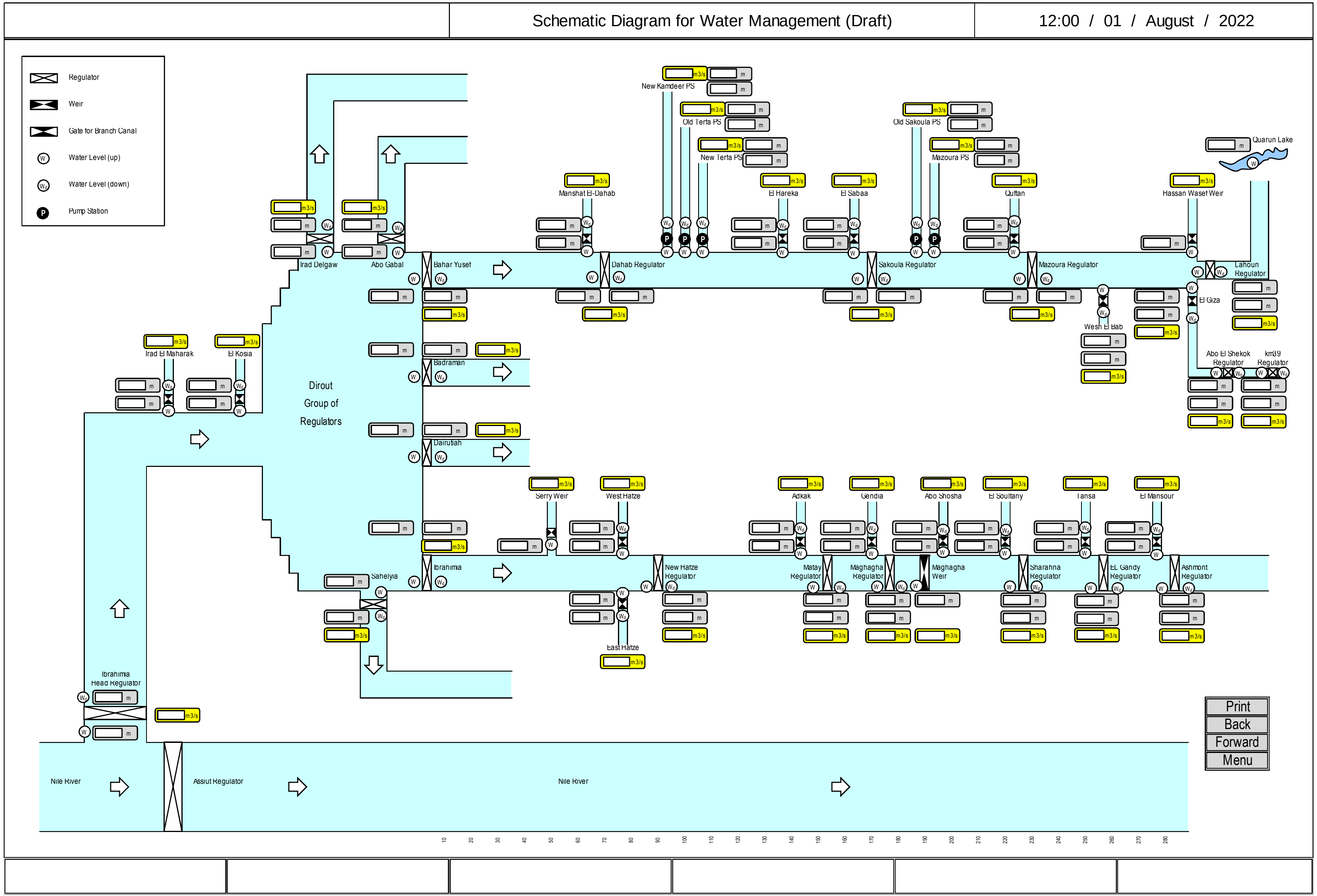


Figure 5-1.8 Layout of the monitored data at target area (draft)

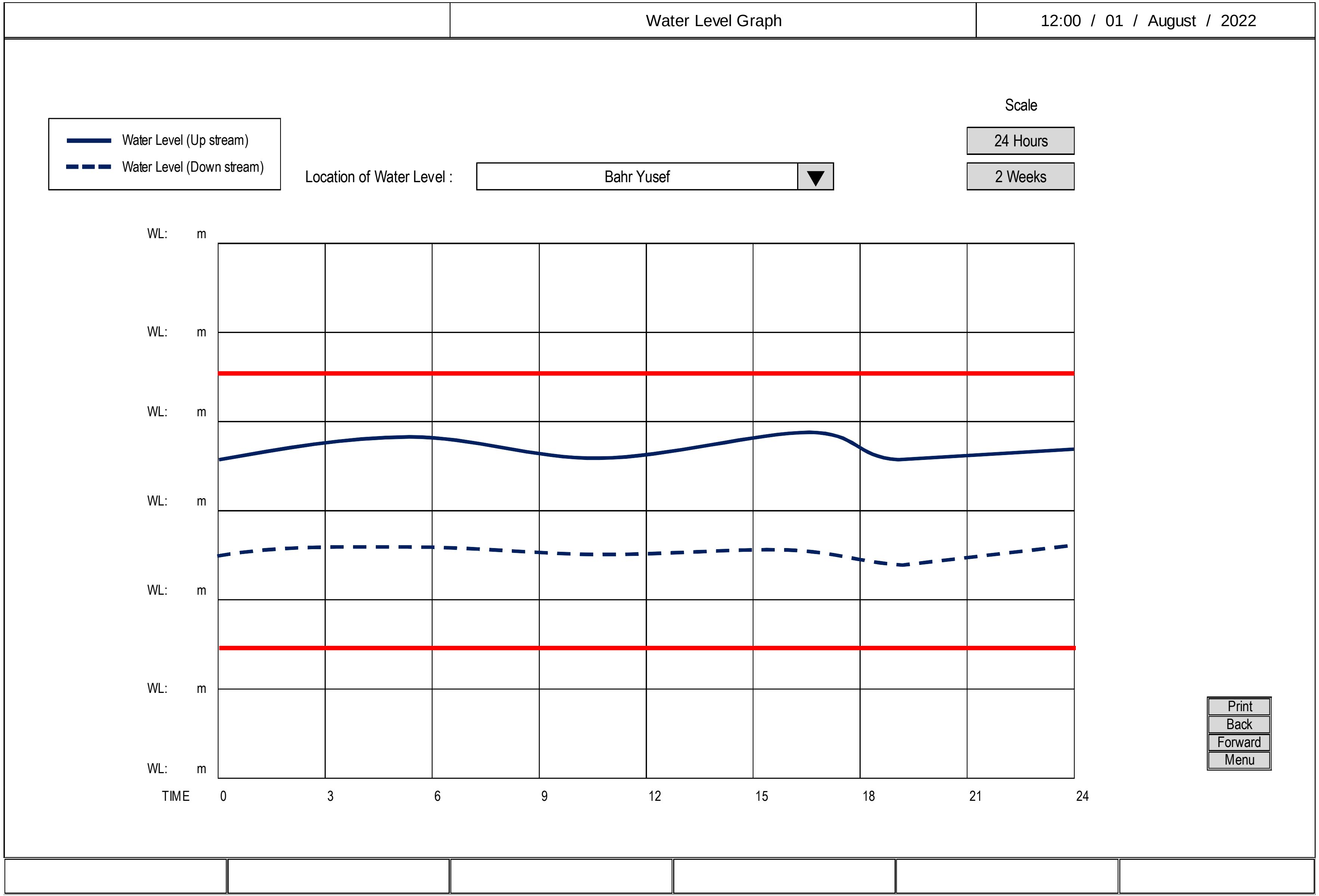


Figure 5-1.9 Output image of graph of water level data (draft)

	Water Level (1)	12:00 / 01 / August / 2022

	Ibrahimia Head Regulator		Irad El Maharak Canal		El Kosia Canal									
TIME	Upstream WL (m)	Downstream WL (m)	Upstream WL (m)	Downstream WL (m)	Upstream WL (m)	Downstream WL (m)	Upstream WL (m)	Downstream WL (m)	Upstream WL (m)	Downstream WL (m)	Upstream WL (m)	Downstream WL (m)	Upstream WL (m)	Downstream WL (m)
00:00	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX
01:00														
02:00														
03:00														
04:00														
05:00														
06:00														
07:00														
08:00														
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19:00														
20:00														
21:00														
22:00														
23:00														

Print	Back	Forward	Menu

Figure 5-1.10 Output image of table of water level data (draft)

Table 5-1.4 Example of crop consumptive water use

Season	Crop	Water Duties (CUM/fed)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Winter	Wheat	265.44	328.02	557.34	485.10	70.98						47.46	242.34
	Long berseem	247.80	352.80	541.80	663.60	550.20						231.60	252.00
	Sugar beet	258.32	335.83	615.35	932.06	1,195.49	603.60						135.51
	Legums	272.16	302.40	500.22	101.60							142.80	248.64
	Vegetables	117.60	67.20	71.40	58.80				29.40	210.00	394.80	373.80	285.60
	Other crops	420.00	399.00	273.00									146.00
	Short berseem	247.80	352.80									235.20	256.20
Summer	Rice					21.00	130.20	1,289.40	1,457.40	1,423.80	369.60		
	Maize					205.80	638.40	640.80	680.40	147.00			
	Sorghum					194.30	620.10	930.00	660.80	140.00			
	Oil crop					575.40	945.00	890.40	176.40				
	Vegetables			92.40	142.80	260.40	697.20	432.60	201.60	184.80	197.40	117.60	
	Other crops							147.00	520.80	609.00	537.60	474.60	113.40
Nile	Maize							252.00	663.60	751.80	529.20	163.40	
	Sorghum							241.30	650.20	740.00	515.10	110.20	
	Vegetables					21.00	100.80	260.40	403.20	344.40	277.00	197.40	
	Other crops			298.00	449.40	478.80	520.80	600.60	680.40	659.40	453.00		
Permanent	Sugar cane	195.30	294.00	428.40	516.60	716.10	768.60	859.32	950.46	894.60	690.06	541.80	312.48
	Cotton			127.68	390.60	664.02	806.40	915.18	429.66	207.60			
	Fruit trees	403.00	364.00	465.00	490.00	527.00	510.00	527.00	518.00	480.00	496.00	390.00	356.00

Source: MWRI (as for fruit trees, data of sprinkler in delta is used)

Table 5-1.5 Inspection items (water level sensor)

No	Outline	Scope of inspection works	Inspection interval				
			Everyday	one month	three month	six month	twelve month
1	Status of installation	Check the installation status of the sensors				○	
2	Confirmation of outdoor facilities and cleaning of protective pipe	Confirmation of the status of outdoor facilities such as water level sensor's protective pipe, pull box, conduit and mounting parts with deformation, damage, abnormal rusting, corrosion and paint peeling etc. Confirmation of loosening and dropping of screws and bolts. Remove sediments such as mud and sand accumulated in the lower part of the water level sensor's protective pipe and inside the pipe.			○		
3	Comparative test	Compare and check the level of staff gauge and water level displayed on the remote and master station. Confirm the water level by the sensor submersion test.					○
4	Confirmation of connection status	Check the connection status of connection cable, connector and terminal etc.			○		
5	Cleaning of sensor	Clean the inner and outer of the equipment body.				○	
6	Confirmation of documents	Confirm that the documents and drawings are organized and kept.					○

Table 5-1.6 Inspection items (solar panel)

No	Outline		Scope of inspection works	Inspection interval				
				Everyday	one month	three month	six month	twelve month
1	Confirmation of charging status		Check on remote station or master station that it is being charged every day				○	
2	Solar panel	Inspection of appearance	Confirmation of the status of outdoor facilities such as solar panel and mounting parts with deformation, damage, abnormal rusting, corrosion and paint peeling etc. Confirmation of loosening and dropping of screws and bolts.				○	
		Confirmation of connection cable	Confirmation of cable deterioration and cable laying status.				○	
		Sunshine condition	The surrounding environment at the installation direction of the solar panel. Confirm that there is no obstructing the sunlight for solar panel by tree growth etc.				○	
4	Confirmation of connection status		Check the connection status of connection cable, connector and terminal etc.				○	
5	Cleaning of solar panel		Clean the inner and outer of the solar panel					○
6	Confirmation of document		Confirm that the documents and drawings are organized and kept.					○

Table 5-1.7 Inspection items (measuring equipment)

No	Outline		Scope of inspection works	Inspection interval				
				Everyday	one month	three month	six month	twelve month
1	Measurement of Voltage		Measure (check) the circuit voltage etc. at the remote station of master station.				○	
2	Operation confirmation		Whether the water level sensor is correct or not, confirmed by the displayed present water level data through the monitoring device and the water level trend (operation log).				○	
3	Battery checking		Check the replacement cycle of the storage battery and replace the target one.					○
			Confirmation of the status of facilities such as battery and mounting parts with deformation, damage, abnormal rusting, corrosion and paint peeling etc. Replacement of the target one.					○
			Check that the voltage etc. are normal. Replace targeted items.					○
4	Cable checking	Inspection of appearance	Confirmation of the status of outdoor facilities such as cables and mounting parts with deformation, damage, abnormal rusting, corrosion and paint peeling etc. Confirmation of loosening and dropping of screws and bolts.					○
		Confirmation of cable	Confirmation of cable deterioration and cable laying status.					○
5	Enclosure checking		Confirmation of the status of outdoor facilities such as enclosure and mounting parts with deformation, damage, abnormal rusting, corrosion and paint peeling etc. Confirmation of loosening and dropping of screws and bolts.					○
6	Confirmation of connection status		Check the connection status of connection cable, connector and terminal etc.					○
7	Cleaning of equipment		Clean the inner and outer of the equipment body and filter.					○
8	Confirmation of document		Confirm that the documents and drawings are organized and kept					○

Table 5-1.8 Inspection items (monitoring equipment)

No	Outline		Scope of inspection works	Inspection interval				
				Everyday	one month	three month	six month	twelve month
1	Server	Confirmation of voltage etc.	Check the power supply voltage etc. with the check terminal					○
		Replacement of battery	Check the replacement cycle of the backup battery and replace the target battery.					○
		Confirmation of CRT display	Check brightness and color etc and check that there is no abnormality status.					○
		Confirmation of hard disk	Check operating time and bad sector status					○
		Confirmation of function of black out and power supply recovery	Confirm that power failure detection, data save processing at power failure detection, etc. are normally performed by interlocking with the uninterruptible power supply.					○
			Confirm that automatic startup processing at power recovery is performed normally.					○
			Check file protection function, backup function, etc					○
		Operation check	Use the test program to check the operation status as a server.					○
		Confirmation of event log	Check the OS event log (system and application) and confirm that there are no logs showing symptoms or occurrence of hardware abnormality or OS abnormality.					○
		Confirmation of connection status	Confirmation of connection cable, connecter, connection status of terminals and loosening of plug-in.					○
		Cleaning of equipment	Clean the outer of the equipment body					○
			Confirmation and cleaning of keyboard and mouse etc.					○
			Cleaning of fun and filter					○
			Check the status of equipment installation.					○
2	System operation (confirmation of monitoring display)	Display of status of remote station	Confirm that the equipment status of the node (water level measurement data and detailed node information) is displayed.				○	
		Display of current water level	Confirmation of displaying the latest water level data				○	
		Display of water level trend	Confirmation of historical water level data				○	
		Display of historical record	Confirmation of display of historical event data				○	
		Data recording	Confirmation of recorded data				○	
3	Confirmation of document		Confirm that the documents and drawings are organized and kept					○

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Volume Ⅲ - CONSTRUCTION PLANNING & COST ESTIMATE

1 Temporary Works

1-1 Outline of the project

The construction site is located in an urban area, and the national railway and the national road run on the east and west sides, respectively, of the construction site. Both the temporary work plan and the construction plan were formulated using the field survey, the existing condition survey, and the construction equipment and materials survey, and take the actual conditions around the site into consideration.

The project consists of the following two components.

(a) Construction of the NDGRs 140 m downstream from the existing DGRs.

(b) Improvement of the communications facilities pertaining to the construction of the water distribution system.

Components (a) and (b) are formulated based on the principle that (1) the DGR renovation plan and (2) improvement of the system environment to support daily water management policy are inseparable if the original capabilities of the existing dysfunctional DGRs are to be restored. RGBS is the main agency responsible for the execution of this project.

The two sub-projects consist of the following works.

Table 1-1.1 Outline of the project

Item	Structures
(1) New Dirout Group of Regulators	
(a) Construction of new regulators	Construction work on six regulators
(b) Installation of gates	
Bahr Yusef	W 6.0 m × H 6.55 m, total 4 vents
Ibrahimia	W 6.0 m × H 6.55 m, total 4 vents
Abo Gabal	W 2.0 m × H 2.95 m, total 4 vents
Badraman	W 2.0 m × H 2.65 m, total 2 vents
Diroutiah	W 2.0 m × H 2.35 m, total 3 vents
Sahelyia	W 2.0 m × H 3.55 m, total 2 vents
(c) Improvement of peripheral facilities	Construction parallel bridge Improvement of retaining walls
(d) Cofferdam works	Single and double cofferdams of steel sheet pile
(2) Integrated Water Management	
(a) Main canal gates management system (b) Branch canal intake management system (c) Establishment of integrated water management centre	Monitoring system installation work Monitoring system installation work Construction of centre building

The applied reference criteria and manual used in the study are:

1. *Manual for double steel sheet pile method*, Ministry of Land, Infrastructure, Transport and Tourism.
2. *Guidelines for temporary structures in road works*, Japan Road Association.

Figures 1-1.1, 1-1.2 and 1-1.3 show the drawings for the construction plan and the cross-sectional map of the two large regulators (new Bahr Yusef and Ibrahimia regulators).

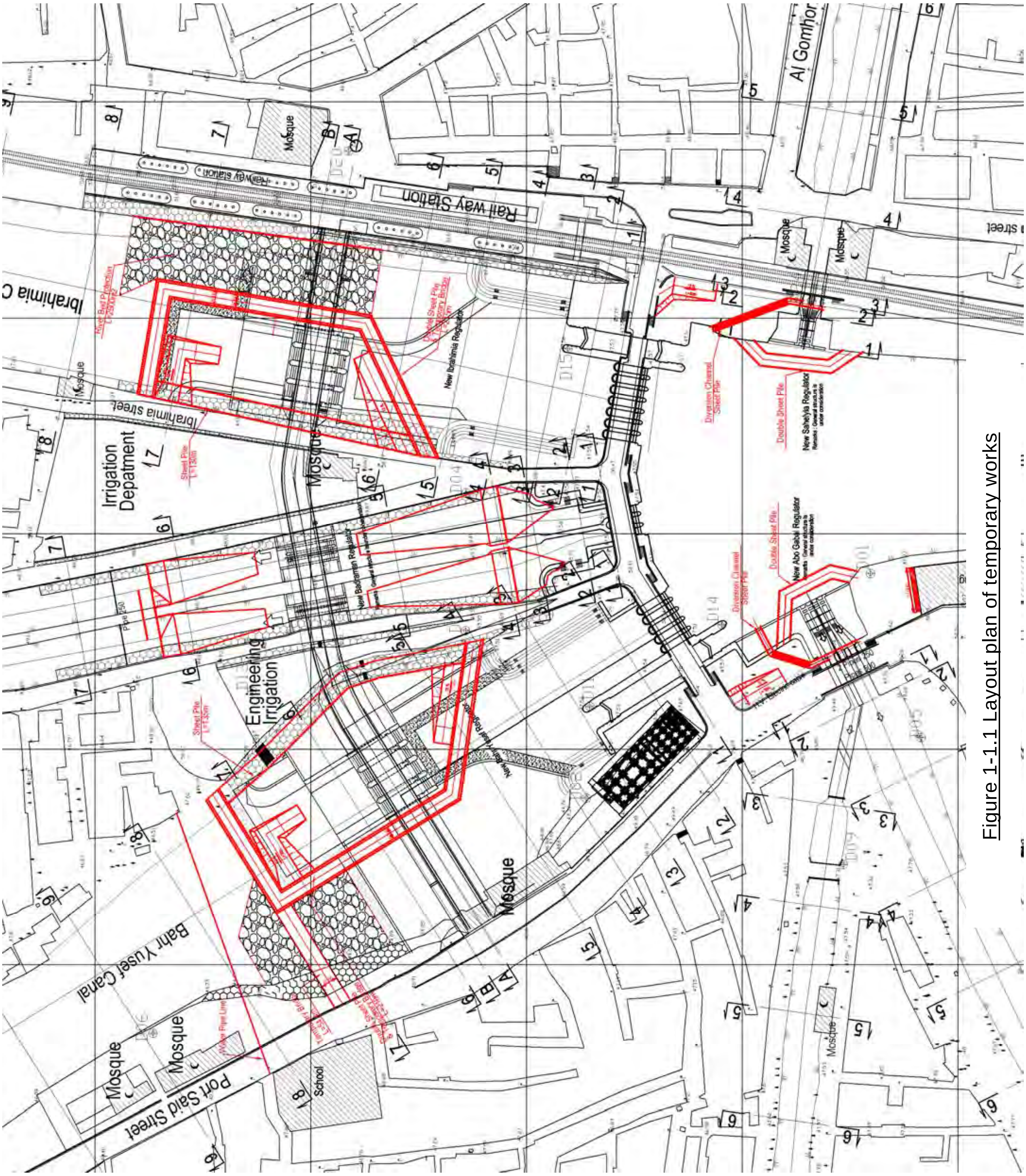
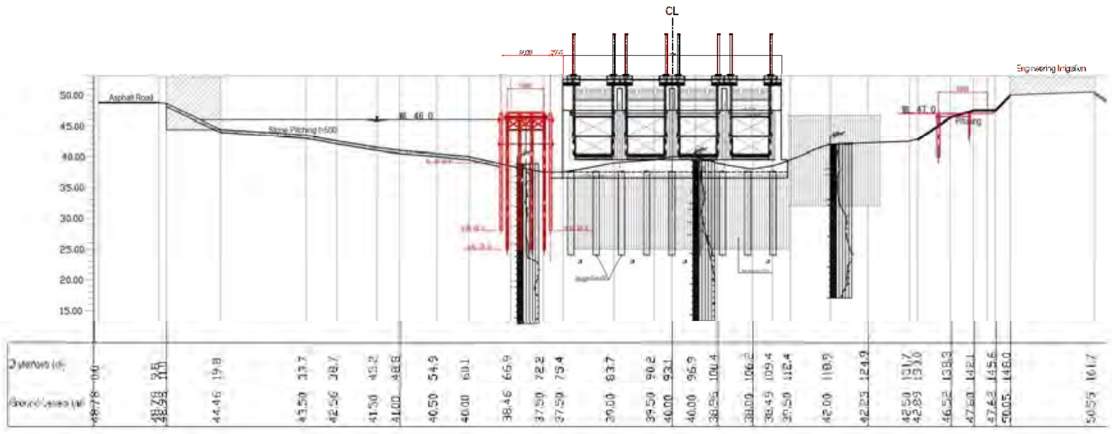


Figure 1-1.1 Layout plan of temporary works

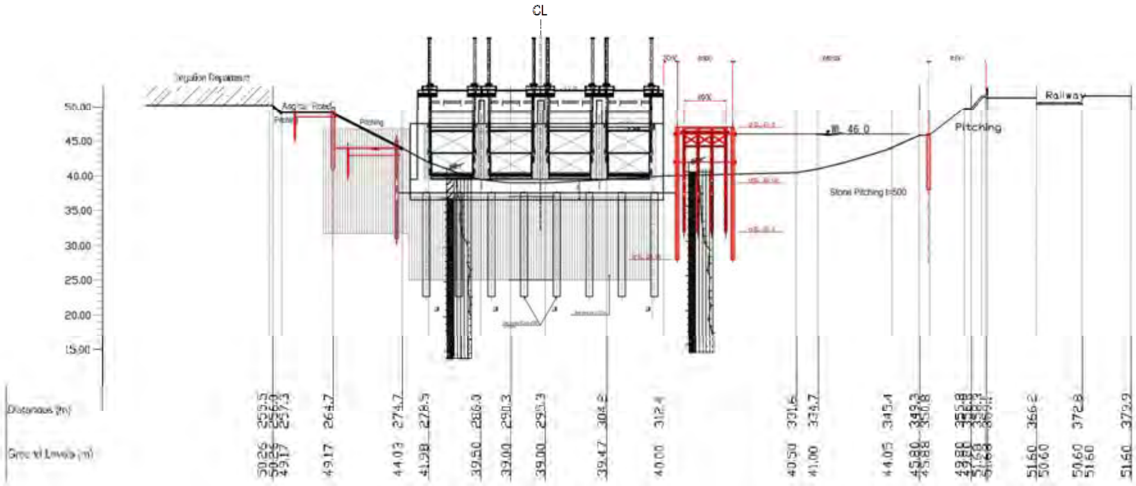
Bahr Yusef Canal



Cross Section No A (at 140 m from regulator)

Figure 1-1.2 Cross section of the new Bahr Yusef regulator during temporary works

Ibrahimia Canal



Cross Section No A (at 140 m from regulator)

Figure 1-1.3 Cross section of the new Ibrahimia regulator during temporary works

1-2 Work conditions

(1) Construction Period

Due to the volume of work to be done, the planned construction period of the New Dirout Group of Regulators is 51 months.

Start of construction: February 2018

Completion of construction: April 2022

(2) Work Days

The work on the New Dirout Group of Regulators involves mainly earth works (excavation, embankment etc.) and concrete work. The work days are the number of days less the days no work is possible due to weather (temperature or rainfall etc.) and holidays. The weather is unlikely to influence the construction, because the temperature at the construction site is 3°C or higher throughout the year and rainfall is less than 1 mm; thus, the non-working coefficient is 1.35, which is the normal value for construction works.

Nonworking coefficient (1.35)

General works: 1.35

Working days per year: 270 days (365/1.35)

Working days per month: 270 days/12 months = 22.5 days

Working hours: 8:00~17:00 (9 hours): 8 working hours per day plus 1 rest hour.

(3) Soil Classifications

The soil classifications applied for the New Dirout Group of Regulators are as follows:

Table 1-2.1 Soil classification

Soil & Geology Classification	Soil Classification	Applicable name	After excavation
Top soil	Clay	—	Clay
River bed deposits	Sand (with gravel)	Sand (with gravel)	Sand (with gravel)
Purchased material	Sand and gravel	Sand and gravel	Sand and gravel

1-3 Construction plan

(1) Temporary bridge

The DGR crosses the upstream Ibrahimia canal and is used as the bridge for the local main road as there are few bridges crossing the Ibrahimia canal in this area. Heavy trucks weighing more than 20 tonnes are prohibited from passing over the bridge; therefore, a temporary bridge strong enough to withstand heavy construction vehicles is needed. A temporary bridge cannot be built on the Ibrahimia canal because the railway goes along the right bank of the Ibrahimia canal.

The conditions for a temporary bridge over the Bahr Yusef canal are discussed below.

(a) Location

The location of the temporary bridge will be selected in accordance with the following conditions:

1) Land acquisition will not upset the lives of residents.
2) Location is near the construction site, without obstacles preventing access to the construction yards.

Candidate sites for the temporary bridge are proposed upstream and downstream of the Bahr Yusef regulator. The upstream site is not as wide as the downstream site, and is too close to the DGRs. Therefore, the downstream site is better for the construction of the temporary bridge. In order to ensure road access for construction vehicles, the temporary bridge will be designed to extend over the entire width of the Bahr Yusef canal.

(b) Length

The temporary bridge will be 100 m long to span the Bahr Yusef canal, as construction vehicles are prohibited from crossing the DGR bridge. The location of the temporary bridge was moved slightly upstream (closer to the downstream end of the double cofferdam) to avoid a water pipe discovered in the original location during the field survey.

(c) Design load

The design load of the temporary bridge should be more than 20 tonnes, which is the general traffic load of construction vehicles, machinery and cars. The maximum design load at the time of the installation of the gate is assessed as the weight of a truck crane, which can carry a load of up to 80 tonnes.

(d) Width

The construction of the temporary bridge will begin on the left side of the canal, and the H-steel bridge piers will be driven into the pier at 6 m intervals using heavy machinery. The driver machine will drive in the H-steels moving along the temporary bridge from the left side of the canal to the right side. The width of the temporary bridge is designed to be 8 m.

Since the temporary bridge will also be used by construction vehicles, the width of the temporary bridge will be 8 m to allow for two-way traffic.

(e) Span length

The pier spacing for the temporary bridge is planned to be 6 m, as the pier interval is usually set between 5 m and 6 m.

(2) Temporary cofferdam

The steel double sheet pile method, which is widely used in Japanese engineering projects, shall be applied on account of its high water cut-off performance- and smaller working area. Because the construction site is situated in the centre of Dirout City, vibration and noise must be kept to a minimum.

The reasons for use of the steel double sheet pile method are as follows:

1) The construction site is in a canal with flowing surface water, hence a high level of water-tightness is required to keep the worksite dry.

2) A temporary bypass canal cannot be used during construction because of the urban location of the works.

3) A multiple-stage diversion method will be adopted to ensure that water distribution through the canals is not stopped during the construction of the NDGRs. The work area in the canals should be kept as small as possible, and the steel double sheet pile method can help minimize

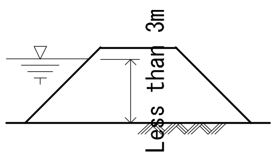
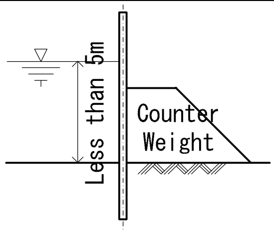
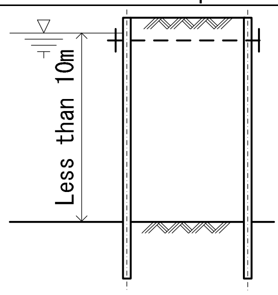
the size of the work area.

4) The steel double sheet pile is considered appropriate for the water depth.

There are three main cofferdam methods for the construction of temporary works: (1) the fill materials embankment method, (2) the single steel sheet pile method, and (3) the steel double sheet pile method. The method is chosen according to the water depth of the worksite, in this case about 7 m.

The maximum water depths for each method are shown in Table 1-3.1. The fill materials embankment method is suited to depths of around 3 m; the single steel sheet pile method to depths of around 5 m: and the steel double sheet pile method to depths of around 10 m. Therefore, the steel double sheet pile method will be adopted for the design water depth of 7 m.

Table 1-3.1 Cofferdam method

Method	Embankment	Single sheet pile	Steel sheet pile
Overview			
Maximum Water Depth	Up to 3 m	Up to 5 m	Up to 10 m
Design Water Depth	7 m	7 m	7 m
Assessment	NG (7 m > 3 m) Design depth is more than maximum water depth	NG (7 m > 5 m) Design depth is more than maximum water depth	OK (7 m < 10 m) Design depth is less than maximum water depth

Steel double sheet pile cofferdams have already been successfully used in the Dahab and the Sakoula regulators, which are on a similar scale to the NDGRs. The work process is as follows:

1) Construction of temporary bridge substructure (H-steel bearing piles)
2) Reinforcement work (strut or brace)
3) Construction of temporary bridge superstructure (W=6 m)
4) Steel sheet piling
5) Reinforcement work (waling)
6) Tie rod and waling work
7) Ground improvement and banking
8) Removal of temporary bridge
9) Filling embankment

The use of a hydraulic piledriver and electric water jet to drive the steel sheet piling is planned because the N value of the foundation layer is higher than 20.

The filling soil used in the steel double sheet pile will be brought from the borrow site located

19 km from the construction site. The filling soil is for the banking of the regulator and should be removed immediately after the removal of the first cofferdam, stored temporarily, and then moved to be used as filling soil for another cofferdam.

And the type of revetment works is planned by sheet pile with tie rods binding. After construction of the stage for heavy equipment with pre-embankment performing, the sheet piles drive by vibro-hammer. The tie rods set after embankment and excavation trench for the tie rod portion, and then backfilling of the trench for the tie rods.

1-4 Preparation plan

(1) Transport and packing plan

- **Transport from Japan and third countries**

The transportation route is from a port in Japan through the Indian Ocean and the Suez Canal to Alexandria. Packing and customs clearance in Japan will take two weeks, and then it will take about one month to reach Alexandria Port. It will take another two weeks to unload and pass through customs at Alexandria Port, and two days to travel inland from Alexandria to the Dirout site by truck or trailer.

- **Domestic transport**

The construction materials and machinery from Cairo City, Minia city and surrounding suburbs will be transported on trucks or trailers. The large construction materials (steel sheet piles, H steel, gate equipment, large machinery, etc.) will be transported on large trucks and trailers, and will be brought into the site from the left bank.

Preparation works are planned at the start of construction, during the construction period, and during the cleaning-up stage after completion of the works.

(2) Preparation Work

The preparation works planned include preparation at the start of construction and during construction, clearing-up and clean-up after the completion of the works.

(3) Security

Security precautions such as the erection of a fence around the construction site and the hiring of guards are planned. The fence around the site will be of wooden stakes (l=2.5 m) and barbed wire (B=1.25 m).

Table 1-4.1 Assignment of security guards

Traffic control	Temporary road	2 persons × 20 months
Security guards	Temporary yard	Day and night shift 2 persons × 3 locations × 21 months
	Site office	Day and night shift 2 persons × 21 months

(4) Temporary yards

The temporary yards will accommodate a workshop (rebar/formwork), a warehouse (for general materials and cement), a testing laboratory, a concrete plant and a yard for the storage and assembly of steel materials and gate equipment. A batching plant and temporary storage yard will also be necessary near the construction site. The required area of the temporary yards as follows.

Batching plant:	2,500 m^2
Material stockyard:	4,000 m^2 (sheet piles, foundation piles, etc.)
Material stockyard:	2,000 m^2 (backfill materials, etc.)
Workshop yard:	1,000 m^2 (reinforcing bars, formwork, etc.)
Heavy equipment yard:	2,000 m^2
Office and parking:	500 m^2
Total	12,000 m^2

It is planned to locate the temporary yards close to the construction site but if there is not enough space other prospective sites will be prepared in the area around the site.

Table 1-4.2 Temporary yards near the construction site

No.	Temporary Yard	Area (m^2)	Remarks
①	Irrigation Department	2,300	Batching plant
②	Irrigation Department	700	Administration office
③	Irrigation Engineering	1,700	
④	Irrigation Department	1,100	
⑤	Irrigation Department	600	Construction road
⑥	Bahr Yusef left bank	450	Materials stock yard
⑦	〃	350	Materials stock yard
⑧	〃	600	Former site of Mosque
⑨	〃	450	Materials stock yard
⑩	Bahr Yusef right bank	500	Materials stock yard
	Total	8,570	

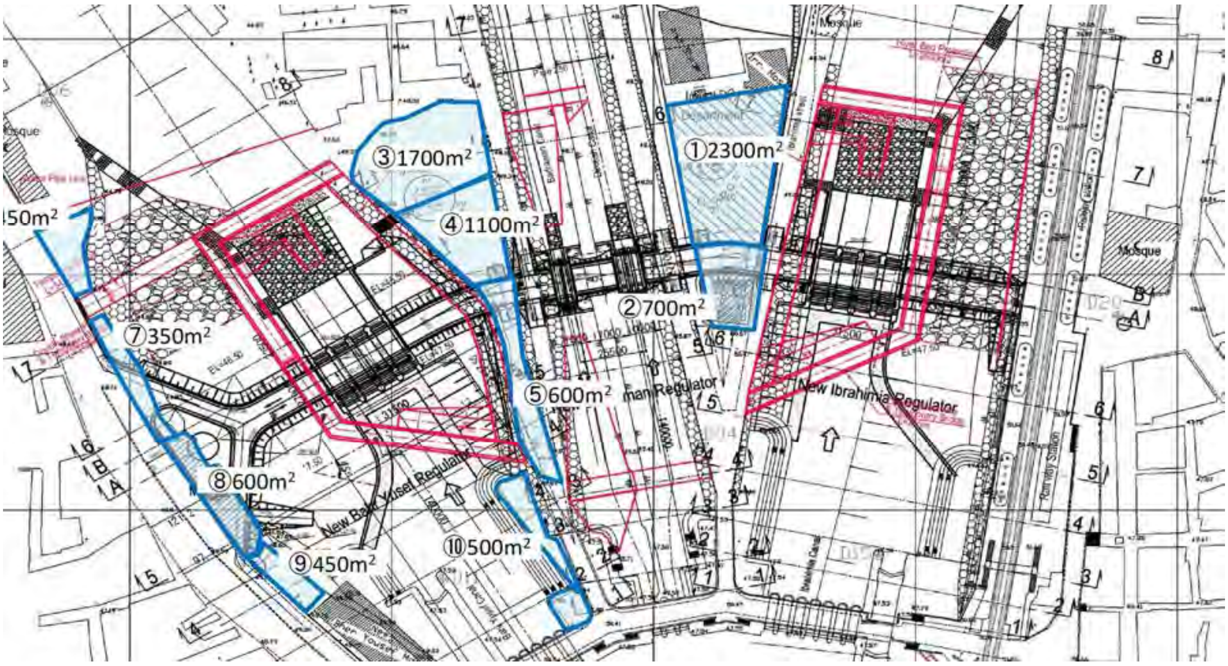


Figure 1-4.1 Location of temporary yards

Table 1-4.3 Prospective temporary yards around the site

Temporary yard	Location	Distance (km)	Area (m^2)	Condition	Remarks
1	Near Cotton Factory	0.5	15,000	Residential area	
2	Beside ring road	3	5,000	Field	
3	Beside ring road	4	4,000	Field	2 areas
4	Beside Badraman Canal	1	4,000	Field	
5	Beside Badraman Canal	2	4,000	Field	

Figure 1-4.2 Prospective temporary yards around the site

(5) Temporary facilities

The temporary facilities will be built in the temporary yards as follows:

Table 1-4.4 Temporary facilities

Temporary Facility	Purpose	Area
Site office	Consultant and contractor office for construction management	About 200 m^2
Work shop	Preparation of reinforcing bars and formwork, 25 persons	About 200 m^2
Warehouse	Storage of tools, small machinery, materials and mechanical and electrical equipment	About 200 m^2
Cement warehouse	Storage of cement, volume 100 tonnes (maximum concrete casting volume: 250 m^3/day)	40 m^2
Laboratory	Testing of concrete and soil	40 m^2
Toilet / Shower room	For workers	3 m^2
Break room	For workers	40 m^2
Workers' camp	Accommodation for skilled construction labourers employed away from home	About 200 m^2

(6) Power plan

During the construction period, electric power can be provided from an electric power source (150 kVA) beside the main road to the construction site. However, as power outages occur frequently in the area, electric generators will be kept on standby at the site. A major construction accident could occur if the power were to stop in the middle of steel sheet pile driving work or deep well work where power is needed for short concentrated periods.

Electricity will be needed constantly over the long term in the temporary yards, for tools, lighting, the workers' camp, and the concrete plant. A backup power generator (1 unit, 80 kVa) will be installed.

(7) Construction management

(a) Materials

The office equipment used to prepare management reports on the quality control and volume of earth work, foundation work, concrete work, pavement work, mechanical and electrical work, etc., and survey, drafting and photographic equipment etc., will be appropriated.

Table 1-4.5 Construction management equipment

Item	Equipment	Quantity
Survey	Auto level	2
	Total station	1
Photo	Camera (including compact camera 1)	2
Office	Personal computer	2
	Copy machine	2

(b) Quality control

Quality control will be carried out for the earth work, concrete work, pavement work, and the mechanic and electrical work.

Table 1-4.6 Quality control

Work	Control item	Method	Measurement
Basement	Soil condition Width, Height Bearing capacity	Visual Measurement Flat-plate load test	Per main section Per main section Once per main structure
Banking	Compaction	Site density	Every 400 m^2
Concrete	Aggregate Cement Fresh concrete Strength	Grain size test Physical / chemical test Slump / air / chloride / alkali aggregate reaction test Compression strength test	Every 3,000 m^3 Every 1,000 tonnes Each casting Each cast section or Every 200 m^3
Reinforcing bar	Strength bar arrangement	Tension strength test Check of condition	Every 200 tonnes Each cast section
Completed structure	Completed dimensions	Dimensional measurement	Each main member
Mechanical equipment	Installation precision Performance	Installation position measurement Load operation test	All equipment All equipment at test Operation

(8) Building and maintenance

(a) Site office

The plan is to build the site offices of the consultants and the contractor in the temporary yard and to lease a liaison office in Cairo City. This is because the construction site in Dirout is 500 km from Cairo City, which is well situated to relay the procurement and transportation of construction equipment between Alexandria and Dirout.

(b) Lodging

A rented house near the temporary yard will house the Japanese engineers, and the skilled labourers and workers from Cairo or elsewhere will reside in a specially-built concrete block building with wood trusses and galvanized iron roofing.

1-5 Procurement plan

(1) Workforce

(a) Engineers and labourers

Ordinary workers, security guards and clerical staff can be procured from Dirout City and towns and villages close to the construction site.

Other employees, such as engineers, drivers, skilled workers such as carpenters, rodmen and plasterers shall also be hired. Shortages of skilled and short-term labour during the construction peak period will be hired from Cairo.

(b) Labour benefits

In addition to severance pay, social insurance and bonuses, government offices and private companies in Egypt must pay workers who cannot commute from home overtime pay, remote location allowance, commuting allowance and accommodation allowance. Thus, all these benefits will be paid with the exclusion of the accommodation allowance, as labourer accommodation in the temporary yard is already planned.

As ordinary workers, security guards, and clerical staff will be hired from Minia City and towns and villages close to the construction site, a commuting allowance to cover transport from their residence will be paid but there are no plans to pay the remote location allowance.

The workers to be paid daily and the workers to be paid monthly under this plan are as follows:

Table 1-5.1 Personnel expenses

	Work	Overtime	Remote location	Commuting	Remark
Paid daily	Manager	○	○	−	
	Special worker	○	○	−	
	Ordinary worker	○	−	○	Hired from local area
	Scaffold worker	○	○	−	
	Steel worker	○	○	−	
	Special driver	○	○	−	
	Driver	○	○	−	
	Carpenter	○	○	−	
	Masonry worker	○	○	−	
	Painter	○	○	−	
	Welder	○	○	−	
	Electrician	○	○	−	
	Mechanic	○	○	−	
	Plumber	○	○	−	
	Security guard	○	−	○	Hired from local area
Paid monthly	Civil engineer A	○	○	−	15 years of experience or more
	Civil engineer B	○	○	−	10 years of experience or more
	Surveyor	○	○	−	
	Assistant surveyor	○	○	−	
	CAD operator	○	○	−	
	Accountant	○	○	−	
	Office worker	○	−	○	Hired from local area
	Driver	○	○	−	
	Mechanical engineer	○	○	−	
	Electrical engineer	○	○	−	

Standard working hours in Egypt is 7 hours, but an 8-hour workday (9 hours less one rest hour) is planned for this project; hence one hour of overtime should be paid. Overtime pay in the case of work in excess of 7 hours/ weekday in Egypt is as follows:

3 hours' overtime	135%
Night shift work	150%
Holidays and Fridays	200%

Severance pay shall be paid only to those local employees who are employed by the Japanese contractor and are paid on a monthly basis. The normal rate for severance payment in Egypt is 25% of the total amount paid.

(2) Construction materials

(a) General Construction Materials

A stable supply of most of the construction materials such as cement, reinforcing bars, wood, steel products, joinery and ventilation and lighting equipment can be procured in Egypt and transported to the site from Cairo. The reinforcing bars are available only from a factory in Alexandria City.

(b) Filling materials, aggregate and stone materials

Borrow sites for the filling material and quarry sites for the aggregate and stone materials will be situated near the construction site.

Filling materials: The borrow site at Dirout on the desert road, about 19 km from the construction site.

Rubble, masonry: The quarry site at Assiut, about 60 km from the construction site.

Coarse aggregate: The quarry site at Dirout, about 30 km from the construction site.

Fine aggregate: The quarry site at Minia about 100 km from the construction site.

Figure 1-5.1 Quarry sites in Assiut

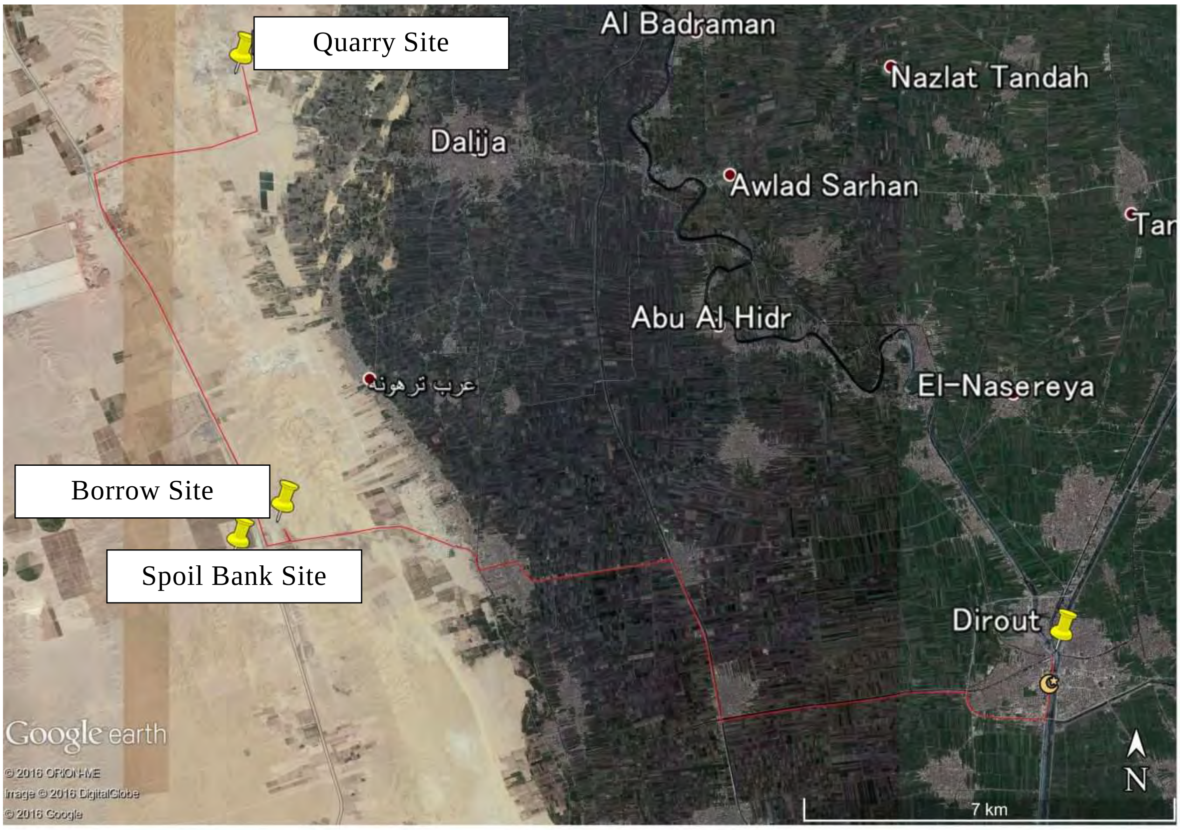


Figure 1-5.2 Locations of borrow site, quarry site and spoil bank site near Dirout

Figure 1-5.3 Location of quarry sites in Minia and Dirout

- Quarry site

The quarry site for coarse aggregate is located 30 km from the NDGRs. This quarry site is managed by a private company and has alternate layers of sand and gravel. The company excavates directly at the exposed sand and gravel layer, and screens the excavated materials by machine.

The quarry site for fine aggregate is located at Minia.

- Borrow site

The borrow site is located near the junction of the desert road. Backfill material can be provided from the site. The distance from the NDGR is approximately 19 km. The road is wide enough for a dump truck to pass along. The geological conditions are the same as those at the quarry site, with alternate layers of sand and gravel.

- Spoil bank site

The spoil bank site is located near the junction of the desert road and the borrow site.

(c) Steel materials

H-steel of up to H-250 mm can be procured from the local market, whereas H-steel of H-300 mm and more must be imported. This is because H-300 mm H-steel is not produced in Egypt but is imported through an import agent. It is therefore difficult to ensure the timely procurement of sufficient quantities of the imported material (H-steel of 300 mm or more).

Therefore, it is planned to procure H-steel of up to 250 mm locally and to procure larger size H-steel materials from Japan.

(d) Scaffolding and formwork

Most of the local construction companies use wooden scaffolding and loose-plank formwork materials, so wooden materials can be procured. However, the local plywood formwork is of low quality and cannot be used repeatedly, and the low mould accuracy reduces the quality of the finished concrete structure, making it of lower quality than that of the regulators of Lahoun, Mazoura, and Sakoula.

Thus, plywood formwork, steel scaffolding and support materials are to be procured from Japan, while the wooden scaffolding, support materials and square timber will be procured locally.

(e) Special materials

Special materials such as steel sheet piles, large steel materials and plywood formwork material are to be procured from Japan to alleviate anxiety regarding delivery and to ensure sufficient quantities. The high-tension tie rods, bridge bearings and expansion equipment will be procured from Japan, because quality is of particular importance for these special materials.

(f) Gate materials

The gates to be installed in the weirs are of the double leaf gate type. These gate sets are to be procured from Japan in consideration of the excellent production technology, track record, and quality.

Table 1-5.2 Procurement of construction materials

Item	Equipment	Local	Japan	Third country	Remarks
Construction materials	H-steel	○			100~250 mm
	H-steel		○		300 mm or more cannot be procured locally
	Steel sheet pile			○	Comparison of procurement cost
	Deck plate		○		Cannot be procured locally
	Barbed wire	○			
	Deformed bar	○			
	High-tension tie rod		○		Cannot be procured locally
	Cement	○			
	Fine aggregate	○			
	Coarse aggregate	○			
	Water reducing agent	○			
	Banking soil	○			
	Rubble, masonry	○			
	Crushed stone	○			
	Square timber	○			
	Plywood formwork	○			Cannot be procured locally
	Steel scaffolding support	○			Cannot be procured locally
	Straight asphalt	○			
	Bridge bearing stretcher		○		Cannot be procured locally
	Step/ bridge railing	○			
	Gasoline, diesel oil	○			
	Cement board	○			
	Water stop	○			
	High voltage incoming panel	○			
Equipment and Facilities	Gate machinery		○		See “Gate materials” above.
	Gate distribution/ control equipment		○		See “Gate materials” above.

(3) Construction machinery

(a) General purpose machinery

Most general-purpose machinery is owned by the local construction companies. It is also possible to rent from local leasing companies. General-purpose machinery includes: backhoe, bulldozer, truck, trailer, truck with crane, crawler crane, rough terrain crane, truck crane, wheel loader, tire roller, vibration roller, mixer truck, rebar processing machine, emergency power generator, etc.

(b) Special machines

The steel sheet pile drivers (vibro-hammer and water jet) and the soil improvement machine will be brought from Japan, as issues relating to the site soil mean that special technologies and operating skills are needed.

(c) Concrete plant

A concrete plant will be installed to produce concrete. Although construction companies and ready mix concrete companies in Egypt own concrete batchers, they are not rented out. The concrete batching plant will be procured from Japan and its rent accounted for, because the concrete batching plant affects the concrete quality and the construction period. It is necessary to arrange immediate procurement once the construction contracts are secured, as the installation of the plant and the concrete mixing test will take time. The concrete plant can be procured through a local agency.

Table 1-5.3 Procurement of construction machines

Purpose	Machine	Local	Japan	Remarks
Construction Machine	Bulldozer (15 t)	○		
	Backhoe (0.8 m^3)	○		
	Dump truck (10 t)	○		
	Truck with crane (4 t/2.9 t)	○		
	Truck (11t), Trailer (20 t)	○		
	Crawler crane (50 t),	○		
	Rough terrain crane (25 t)	○		
	Truck crane (50 t)	○		
	Wheel loader (2.1 m^3)	○		
	Tire roller (8-20 t)	○		
	Vibration roller (10 t)	○		
	Vibration hammer (hydraulic)		○	Procurement must be done in a short time, and it is difficult for Japanese engineers to operate the Egyptian-made machinery.
	Water jet (14.7 MPa, 325 l/min)		○	Procurement must be done in a short time, and it is difficult for Japanese engineers to operate the Egyptian-made machinery.
	Concrete plant (30 m^3/hr)	○		
	Mixer truck (4.4 m^3)	○		
	Generator (75 kVA)	○		
	Generator (200 kVA)		○	To be used for the sheet pile driving in the early construction work; procurement must be done in a short time, and it is difficult to obtain a large generator in Egypt.

2. Construction of the NDGRs and Water Management Facilities

In the construction of the New Dirout Group of Regulators, the construction of Bahr Yusef regulator on the downstream side will begin first and next, the construction of Ibrahimia regulator will start. The construction of the other regulators, Badraman and Diroutiah, and on the upstream side, Abo Gabal and Sahelyia, will be performed in parallel with the construction of Bahr Yusef and Ibrahimia.

The construction flow of Bahr Yusef, Ibrahimia and the other regulators is as follows:

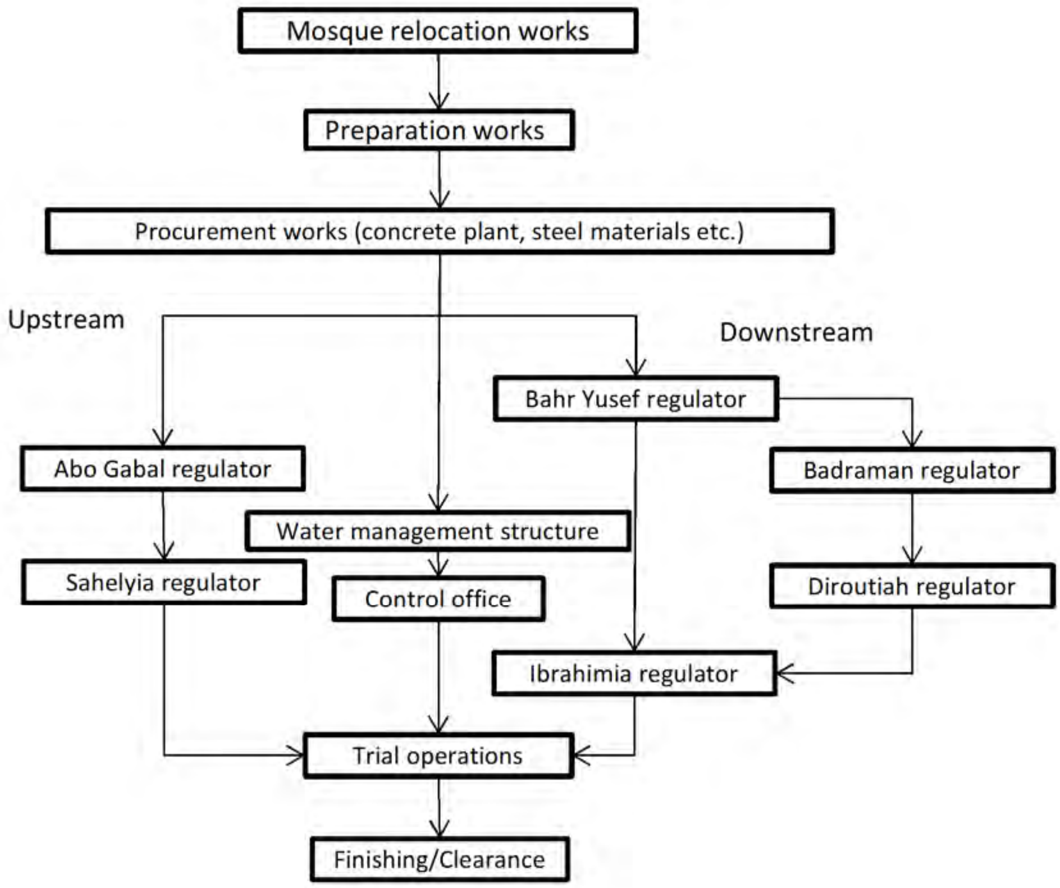


Figure 2-1.1 Regulator construction flow

The construction will start after the relocation of the mosque is completed by the Egypt side.

Preparation work → Temporary bridge → Double sheet coffer dam → Removal of existing facilities, Excavation inside site → Foundation piles and waterstop sheet piles → Construction of regulator structure → Installation of gates and trial operation → Removal of double sheet piles and switching diversion → Revetment work and appurtenant work (road works and electrical work) → Integrated trial operation/Operation training → Finishing/Clearing

The manufacture and transport of the gates, machinery and electrical equipment, the building work and the revetment work proceed in parallel with the construction of the structures and the installation and trial operation of the gates.

2-1 Construction of Bahr Yusef Regulator

The construction of the Bahr Yusef regulator begins after the relocation and demolition of the mosque by Egypt side.

(1) Preparation work

In the preparation work, preparations for the construction, investigation, surveying, staking, clearing and cutting, stumping and land grading are performed. The period of the preparation work is one month.

(2) Temporary Bridge

The temporary bridge for the Bahr Yusef regulator is constructed on the downstream side of the regulator and connects the road on the left bank and the double sheet coffer dam. The temporary bridge is 43 m long and 8 m wide. The temporary bridge is made of steel and the construction work is divided into superstructure and substructure. The bridge piers are constructed first as the substructure and the superstructure is constructed.

(a) Superstructure

① Installation work   Weight of steel: 48.8 tons, crawler crane with 50 tons tonne lift capacity

② Deck plate work   Area: 336.0 m^2, crawler crane with 50 tons lift capacity

③ Handrail installation   Length: 86 m, crawler crane with 50 tons lift capacity

(b) Substructure

① Pier pile driving work

・Driving length: 9.3 m

Machine:	Maximum N value	N max < 50
	Driving length	9.3 m < 25 m (H350 steel)
	Extraction length	9.3 m < 25 m Hydraulic vibratory hammer

Ancillary machine: Crawler crane with 50 tons lift capacity (Hydraulic vibratory hammer)

③ Installation of pier piles Weight of steel: 92.9 tons, crawler crane with 50 tons lift capacity

(3) Temporary Cradle

After the construction of the temporary bridge, the temporary cradle (width 6 m) is constructed. The sheet piles of the double sheet coffer dam are driven in from the temporary cradle. The temporary cradle is constructed first together with the driving in of the sheet piles. The temporary cradle is 210 m long and 6 m wide. The temporary cradle is made of steel and the construction work is divided into superstructure and substructure. The cradle piers are constructed first as the substructure and the superstructure is constructed.

(a) Superstructure

① Installation work Weight of steel: 179.8 tons, crawler crane with 50 tons lift capacity
② Deck plate work Area: 1,260 $m^{2,}$ crawler crane with 50 tons lift capacity
③ Handrail installation Length: 420 m, crawler crane with 50 tons lift capacity

(b) Substructure

① Pier pile driving work
・Driving length: 9.3 m

Machine:	Maximum N value	N max < 50
	Driving length	9.3 m < 25 m (H400 steel)
	Extraction length	9.3 m < 25 m Hydraulic vibratory hammer

Ancillary machine: Crawler crane with 50 tons lift capacity (Hydraulic vibratory hammer) 20 piles

② Installation of pier piles Weight of steel: 510.1 tons, crawler crane with 50 tons lift capacity

(4) Double Sheet Coffer Dam

The installation of the double sheet coffer dam is performed together with the temporary cradle work. Driving and extraction of the sheet piles are carried out by hydraulic vibratory hammer.

Sheet pile driving work
Driving length: 11 m
Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Driving length	11 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

Connection of the sheet piles, PU28+1 (equivalent of Type IVw), is performed on the temporary cradle. The number of piles installed per day is 20 at less than 12 m in length (including the connection work).

(5) Double Sheet Coffer Dam Embankment Work and Removal of Temporary Cradle

After the installation of the double sheet coffer dam, the embankment is constructed and the temporary cradle is removed. The embankment volume is 14,280 m^3 and the transport distance is 19 km from the borrow site. The combination of loading and transport is backhoe loading 1.4 m^3 + 10 t dump truck.

The double sheet coffer dam embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(6) Demolition of Slope on Right Bank

The demolition and removal of the slope on the right bank are carried out by backhoe and the generated rubble is loaded by backhoe and transported by dump truck. The rubble is reused for temporary riverbed protection work.

(7) Sheet Pile Revetment Work on Right Bank

The sheet pile revetment is constructed on the right bank and the revetment type is anchorage by H-steel. The sheet piles and H-steel piles for the revetment are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 4 m, H-250 2.25 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	L < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (sheet pile PU28+1 (equivalent to Type IVw): 244 piles, driving length: 4 m)

Sheet pile PU28+1 (equivalent to Type IVw)

Driving work: the number of piles installed per day is 38 at less than 4 m in length.

③ Driving work (H-250 steel pile: 83 piles, driving length: 2.25 m)

Driving work: the number of piles installed per day is 48 at less than 4 m in length.

(8) Drainage Work

Drainage of the percolation from the foundation surface of the double steel sheet piles is conducted using the pump drain method and well point method, both separately and in combination. The construction site of the double steel sheet piles is surrounded by canal water and it is therefore necessary to select a drainage method that ensures the smooth progress of construction work, as the foundation surface of the excavation is highly permeable.

As the foundation conditions are such that there are thick geological layers with high permeability (silty clay and sand etc.), the combination of pump drain and well point methods is selected for the drainage work at the site. It is necessary to check the turbidity of the drainage water to prevent piping.

① Installation and removal of well points (length 360 m, interval 3 m, 120 well points)

② Installation and removal of well-point pumps (2 pumps, 2 spare pumps)

(9) Excavation Work and Embankment Work for Temporary Road

During the enlargement of the cross section of the canal by the installation of double steel sheet piles, underwater excavation is performed by backhoe (0.8 m^3) to a water depth of 6 m. Beyond 6 m, excavation is performed by clamshell. The embankment work uses the sand and gravel soil from the borrow pit and compacts it by vibrating roller.

It is difficult to obtain clay materials, because all the borrow sites around the site contain sand. The sand is embanked by sprinkling with water to ensure the strength of the embankment. The borrow site is located 19 km from the construction site near the spoil bank site.

① Excavation

・In double sheet coffer dam

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

・Riverbed area

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment of temporary road

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

(10) Bed Protection Work

The bed protection and riprap works are planned under dry conditions before removing the double steel sheet piles. However, in the riprap work on the downstream side, which is outside the double steel sheet piles, the rock material will be cast into the water during the removal of the double steel sheet piles. The riprap material will be brought from the quarry site for the riprap and masonry work near Assiut.

The transport distance is 60 km.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

Spreading of the riprap material is carried out by 21 tons bulldozer.

(11) Foundation Pile Work

Cast-in-place concrete piles are planned for the foundation of the regulator and the bored pile method is applied as the construction method. Excavation is carried out by earth auger and bentonite is used to secure the walls of the hole. The boring machine is used by Bore pile machine and the base machine is used by a 42 tons crawler crane and the construction capacity is 3 piles per day.

(12) Waterstop Sheet Piles

The waterstop sheet piles are driven in by hydraulic vibratory hammer

Driving work: Driving length: sheet pile 4.5 m, 6 m, 12 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	4.5 m, 6 m, 12 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

(13) Concrete Work

The NDGR is a mass concrete structure with a high concrete placement volume. A method to ensure a high quality, stable supply of mass concrete shall be considered in order to prevent temperature cracks caused by heat of hydration.

Concrete placing conditions:

1) Ensuring quality: Unit concrete placement volume, concrete curing method
2) Ensuring a stable supply (production method): Procurement from an existing ready-mixed concrete plant or production by concrete batching at construction site

(a) Concrete production

Two concrete plants are located in this area, one in Minia and the other in Assiut, both within a radius of 100 km and a distance of one hour from the construction site, but they cannot be relied upon. In the construction plan, the contractor needs to cast 6,000 m^3 of concrete in 8 months, so a large volume of concrete of stable quality must be provided. There is a scheduled plan to install a concrete plant with 30 m^3/hr production capacity in the temporary yard adjacent to the construction site. This will produce a volume of 250 m^3/day.

(b) Concrete casting

The contractor determines the appropriate segment block for concrete casting and uses a Japanese reusable plywood formwork when placing the concrete, taking into account the structural stress, construction joints, water-tightness, and concrete production and casting ability. Considering that the summer temperature in Egypt reaches 40ºC, concrete casting should be done during the night when the temperature drops. It is necessary to take into account cracks and hot weather concrete during concrete casting of the weir apron and the bridge abutment as they are mass concrete structures.

(c) Outline of Construction

The gate is a long structure on the upstream side with a length of 27.9 m and on the downstream side with a length of 23.5 m. The total volume of concrete is 6,065 m^3.

(d) Basic Conditions

① Specifications of concrete

Concrete is produced at the batching plant and transported to the site. The maximum size of the coarse aggregate is 40 mm, and the slump value is 8~12 cm.

② Concrete casting

The maximum lift height is 3.5 m.

④ Casting method

The casting is done by 50 tons crane and the placement volume per day is 200 m^3.

④ Formwork

The formwork is made of wood.

(e) Casting schedule

① Casting schedule

The casting schedule is decided based on the following conditions:

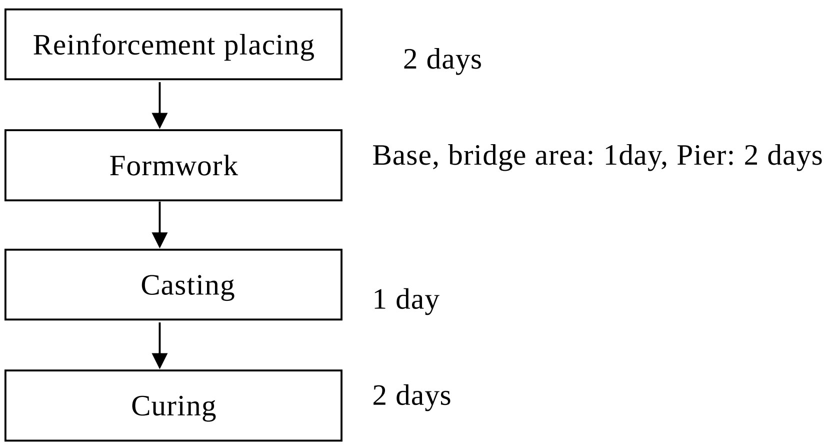
- The maximum volume of concrete placement is approximately 200 m^3 per day.
- The maximum height of one lift is 3.0 m.
- The concrete joints are treated by green cutting, etc.
- The casting schedule is decided by the structure scale and the concrete casting is divided into 5 parts.

  Base of gates on upstream side
  Piers of gates on upstream side
  Bridge area of gates on upstream side
  Base of apron on downstream side
  Wall of apron on downstream side

② Casting capacity

The volume of concrete per block is approximately 200 m^3 and the casting capacity including preparations is as follows:

Casting: one day including preparations
Demoulding: four days for cross section formwork



The workable days are considered except the curing days.
No. of days per cycle for casting (except curing) =2+1+1 = 4 days (base, bridge area)
=2+2+1 = 5 days (pier area)
After completion of the casting at the pier, work starts on the next block and the number of curing days is decided as 2 days.
The casting interval is normally a cycle of 5+2=7 days.

(14) Embankment on Right Side

The embankment on the right side is constructed after completion of the concrete work for the regulator. The volume of the embankment on the right side is 7,200 m^3 by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(15) Installation of Gates and Trial Operation

The installation of the gates takes 2 months for the 4 guide frames and another 2 months for the 4 gates and 4 hoisting devices.

After the installation of the gates, trial operation is performed before removal of the coffer dam, and the operation and control conditions are confirmed. After the removal of the coffer dam and the flow of water through the gates, trial operation and instruction in operation are conducted.

(16) Double Sheet Coffer Dam Excavation and Embankment on Left Bank

The soil for the double sheet coffer dam is excavated and transported, and the embankment on the left bank is constructed.

① Excavation

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment on left bank

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(17) Removal of Double Sheet Coffer Dam

The double sheet coffer dam is removed by hydraulic vibratory hammer.

① Machine

Extraction length: 11m

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value	N max < 50
Extraction length	11 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Extraction work (outside: 400 piles, length 11 m, inside: 350 piles, length 10 m)

The number of extracted piles per day is 50 at less than 12 m in length.

(18) Sheet Pile Revetment Work

The sheet pile revetment work is performed by hydraulic vibratory hammer.

Machine

Driving work

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value	N max < 50
Extraction length	L < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

(19) Embankment on Left Bank

The embankment on the left bank is constructed.

① Excavation

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment on left bank

Filling-in of the double sheet coffer dam: 14,280 m^3

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(20) Removal of Temporary Bridge

The superstructure work includes installation, deck plate work and handrail installation and the machine used is a crawler crane with 50 tons lift capacity.

The substructure work is performed by crawler crane with 50 tons lift capacity and hydraulic vibratory hammer, and the pier piles are extracted.

Machine: Maximum N value N max < 50

Extraction length 9.3 m < 25 m (H350 steel)

Ancillary machine: Crawler crane with 50 tons lift capacity (Hydraulic vibratory hammer)

(21) Building Work

The integrated water management centre is built on the premises of the Egyptian Irrigation Department, A two-storey building is constructed.

2-2 Construction of the Badraman Regulator

The Badraman regulator is constructed at the same time as construction of the Bahr Yusef regulator.

(1) Preparation Work

In the preparation work, preparations for construction, investigation, surveying, staking, clearing and cutting, stumping and land grading are performed. The period of the preparation work is one month.

(2) Entrance Road Embankment on Upstream Side

First of all, work on the embankment of the entrance road on the upstream side starts.

① Transportation from borrow site

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment of entrance road

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(3) Sheet Pile Work on Upstream Side

The sheet piles are driven in the upstream embankment.

① Machine

Sheet pile driving work (driving length 6 m)

Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Driving length	6 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (46 piles, driving length 6 m)

The number of piles installed per day is 31 at less than 6 m in length.

(4) Entrance Road Embankment on Downstream Side

The embankment of the entrance road on the downstream side is constructed.

① Transport from borrow site

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment of entrance road

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(5) Sheet Pile Revetment Work (Downstream)

The sheet pile revetment is constructed on the downstream side and the revetment type is anchorage by H-steel. The sheet piles and H-steel piles for the revetment work are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 6 m, H-250 3.7 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	L < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (sheet pile: 53 piles, driving length: 6 m)

Sheet pile, PU28+1 (equivalent to Type IVw)

Driving work: the number of piles installed per day is 31 at less than 6 m in length.

③ Driving work (H-250 steel pile: 17 piles, driving length: 3.7 m)

Driving work: the number of piles installed per day is 44 at less than 6 m in length.

(6) Sheet Pile Work on Downstream Side (Straight line)

The sheet piles are installed on the downstream side and the sheet pile type is anchorage by H-steel.

The sheet piles and H-steel piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 6 m, H-250 3.7 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	L < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (sheet pile: 34 piles, driving length: 6 m)

Sheet pile, PU28+1 (equivalent to Type IVw)

Driving work: the number of piles installed per day is 31 at less than 6 m in length.

③ Driving work (H-250 steel pile: 12 piles, driving length: 3.7 m)

Driving work: the number of piles installed per day is 44 at less than 6 m in length.

(7) Temporary Bridge

The embankment coffer dam for the Badraman regulator is constructed on the upstream side and a temporary bridge is also constructed at the Diroutiah canal. The embankment coffer dam and the temporary bridge are used as the construction road across the Badraman canal. The temporary bridge is 30 m long and 8 m wide. The temporary bridge is made of steel and the construction work is divided into superstructure and substructure. The construction of the bridge piers as the substructure is advanced first and the superstructure is constructed.

(a) Superstructure

② Installation work	Weight of steel: 24.0 tons, crawler crane with 50 tons lift capacity
② Deck plate work	Area: 240.0 $m^{2,}$ crawler crane with 50 tons lift capacity
③ Handrail installation	Length: 60 m, crawler crane with 50 tons lift capacity

(b) Substructure

① Pier pile driving work

・Driving length: 5.3 m

Machine: Maximum N value	N max < 50
Driving length	5.3 m < 25 m (H300 steel)

Ancillary machine: Crawler crane with 50 tons lift capacity (Hydraulic vibratory hammer) 28 piles

② Installation of pier piles

Weight of steel: 29.7 tons, Machine: Crawler crane with 50 tons lift capacity

(8) Excavation and Embankment

The excavation and embankment works on the construction site are performed. The excavated soil is stocked on the construction site and used for backfill.

① Excavation

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Backfill embankment

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(9) Sheet Pile Revetment Work (Gate Structure)

The sheet pile revetment for the Badraman regulator is constructed. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 6.5 m, 7.95 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	6.5 m, 7.95 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, driving length 7.95 m, PU18 (equivalent to Type IIIw) 11 piles

Driving work: the number of piles installed per day is 29.

Sheet pile, driving length 6.5 m, PU12 (equivalent to Type IIw) 6 piles

Driving work: the number of piles installed per day is 33.

(10) Waterstop Sheet Pile (Gate Structure)

The waterstop sheet piles for the Badraman regulator are installed. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 2.0 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	2.0 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, driving length 2.0 m, PU12 (equivalent to Type IIw) 28 piles

Driving work: the number of piles installed per day is 55.

(11) Concrete Work

The NDGR is a mass concrete structure with a high concrete placement volume. A method to ensure a high quality, stable supply of mass concrete shall be considered in order to prevent temperature cracks caused by heat of hydration.

Concrete placing conditions:

1) Ensuring quality: Unit concrete placement volume, concrete curing method

2) Ensuring a stable supply (production method): Procurement from an existing ready-mixed concrete plant or production by concrete batching at the construction site

(a) Concrete production

Two concrete plants are located in this area, one in Minia and the other in Assiut, both within a radius of 100 km and a distance of one hour from the construction site, but they cannot be relied upon. In the construction plan, the contractor needs to cast 6,000 m^3 of concrete in 8 months, so a large volume of concrete of stable quality must be provided. There is a scheduled plan to install a concrete plant with a 30 m^3/hr production capacity in the temporary yard adjacent to the construction site. This will produce a volume of 250 m^3 per day.

(b) Concrete casting

The contractor determines the appropriate segment block for concrete casting and uses a Japanese reusable plywood formwork when placing the concrete, taking into account the structural stress, construction joints, water-tightness, and concrete production and casting ability. Considering that the summer temperature in Egypt reaches 40ºC, concrete placement should be done during the night when the temperature drops. It is necessary to take into account cracks and hot weather concrete during casting of the weir apron and bridge abutment as they are mass concrete structures.

(c) Outline of Construction

The gate structure is 28.2 m in length and the total volume of concrete is 770 m^3.

(d) Basic Conditions

① Specifications of concrete

The concrete is produced at the batching plant and transported to the site. The maximum size of the coarse aggregate is 40 mm and the slump value is 8~12 cm.

② Concrete casting

The maximum lift height is 3.5 m.

③ Casting Method

The casting is done by 50 tons crane and the casting volume per day is 200 m^3.

④ Formwork

The formwork is made of wood.

(e) Casting schedule

① Casting schedule

The casting schedule is decided based on the following conditions:

- The maximum casting volume is approximately 200 m^3 per day.

- The maximum height of one lift is 3.0 m.
- The concrete joints are treated by green cutting, etc.
- The casting schedule is decided by the structure scale and the casting is divided into 3 parts.

  Base of gates

  Piers of gates

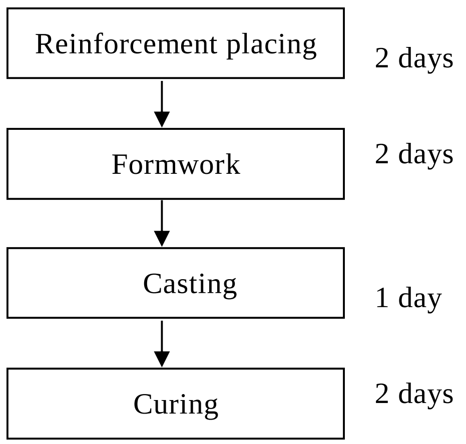
  Bridge area of gates

② Casting capacity

The volume of concrete per block is approximately 150 m^3 and the casting capacity including preparations is as follows:

Concrete casting: one day including preparations

Demoulding: four days for cross section formwork



The number of workable days is considered except the curing days.

Number of days per cycle (except curing) =2+2+1=5 days (pier area)

After completion of the casting at the pier, work starts on the next block and the number of curing days is decided as 2 days.

The casting interval is normally a cycle of 5+2=7 days.

(12) Bed Protection Work on Downstream Side

The riprap material is brought from the quarry site for the riprap and masonry work near Assiut.

The transport distance is 60 km.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

The riprap material is spread by 21 tons bulldozer.

(13) Installation of Gates and Trial Operation

The installation of the gates takes 2 months for the 4 guide frames and another 2 months for the 4 gates and 4 hoisting devices.

After the installation of the gates, trial operation is performed before the removal of the coffer dam, and the operation and control conditions are confirmed. After the removal of the coffer dam and the flow of water through the gates, trial operation and instruction in operation are planned.

(14) Removal of Temporary Bridge

The superstructure and substructure are removed.

(15) Sheet Pile Removal on Upstream Side

The sheet piles are removed by hydraulic vibratory hammer and crawler crane with 50 tons lift capacity.

(16) Removal of Sheet Pile Revetment Downstream

The sheet piles are removed by hydraulic vibratory hammer and crawler crane with 50 tons lift capacity.

2-3 Construction of the Diroutiah Regulator

The construction of the Diroutiah regulator is performed after the construction of the Badraman regulator.

(1) Preparation work

In the preparation work, preparations for construction, investigation, surveying, staking, clearing and cutting, stumping and land grading are performed. The period of the preparation work is one month.

(2) Entrance Road Embankment on Upstream Side

The embankment of the entrance road on the upstream side is constructed with embankment material from the Badraman work.

① Transport from the Badraman embankment

Embankment on the upstream side: 2,100 m^3

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment of entrance road

Embankment: 2,100 m^3

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the Badraman site directly.

(3) Sheet Pile Work on Upstream Side

The sheet piles are driven into the upstream embankment.

① Machine

Sheet pile driving work (driving length 6 m)

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value	N max < 50
Driving length	6 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (46 piles, driving length 6 m)

The number of piles installed per day is 31 at less than 6 m in length.

(4) Entrance Road Embankment on Downstream Side

The embankment of the entrance road on the downstream side is constructed first.

① Transport from Badraman site

Embankment on the downstream side: 336 m^3

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment on the downstream side

Embankment: 336 m^3

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the Badraman site directly.

(5) Sheet Pile Revetment Work (Downstream)

The sheet pile revetment is constructed on the downstream side and the revetment type is anchorage by H-steel. The sheet piles and H-steel piles for the revetment are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 6 m, H-250 3.7 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	L < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (sheet pile: 53 piles, driving length: 6 m)

Sheet pile, PU28+1 (equivalent to Type IVw)

Driving work: the number of piles installed per day is 31 at less than 6 m in length.

③ Driving work (H-250 steel pile: 17 piles, driving length: 3.7 m)

Driving work: the number of piles installed per day is 44 at less than 6 m in length.

(6) Temporary Bridge

The embankment coffer dam for the Diroutiah regulator is constructed on the upstream side and a temporary bridge is also constructed over the Badraman canal. The embankment coffer dam and the temporary bridge are used as the construction road across the Badraman canal. The temporary bridge is 30 m long and 8 m wide. The temporary bridge is made of steel and the construction work is divided into superstructure and substructure. The construction of the bridge piers as the substructure is advanced first and the superstructure is constructed.

(a) Superstructure

② Installation work Weight of steel: 24.0 tons, crawler crane with 50 tons lift capacity
② Deck plate work Area: 240.0 m^{2}, crawler crane with 50 tons lift capacity
③ Handrail installation Length: 60 m, crawler crane with 50 tons lift capacity

(b) Substructure

① Pier pile driving work
・Driving length: 5.3 m

Machine	Maximum N value	N max < 50
	Driving length	5.3 m < 25 m (H-300 steel)

Ancillary machine: Crawler crane with 50 tons lift capacity (Hydraulic vibratory hammer) 28 piles

② Installation of pier piles
Weight of steel: 29.7 tons, Machine: Crawler crane with 50 tons lift capacity

(7) Excavation and Embankment

The excavation and embankment works on the construction site are performed. The excavated soil is stocked on the construction site and used for backfill.

① Excavation
The transport distance is 0.1 km within the site area.
The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Backfill embankment
The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(8) Sheet Pile Revetment Work (Gate Structure)

The sheet pile revetments on the right and left banks of the Badraman regulator are constructed. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine
Driving work: Driving length: sheet pile 6.65 m, 7.10 m
Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	6.65 m, 7.10 m <15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work
Sheet pile, driving length 6.65 m, PU12 (equivalent to Type IIw) 7 piles
Driving work: the number of piles installed per day is 33.

Sheet pile, driving length 7.1 m, PU12 (equivalent to Type IIw) 11 piles
Driving work: the number of piles installed per day is 33.

(9) Waterstop Sheet Piles (Gate Structure)

The waterstop sheet piles are installed for the Diroutiah regulator. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 2.0 m

Machine: Hydraulic vibratory hammer

Maximum N value N max < 50

Driving length 2.0 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, driving length 2.0 m, PU12 (equivalent to Type IIw) 19piles

Driving work: the number of piles installed per day is 55.

(10) Concrete Work

The NDGR is a mass concrete structure with a high concrete placement volume. A method to ensure a high quality, stable supply of mass concrete shall be considered in order to prevent temperature cracks caused by heat of hydration.

Concrete placement conditions:

1) Ensuring quality: Unit concrete placement volume, concrete curing method
2) Ensuring a stable supply (production method): Procurement from an existing ready-mixed concrete plant or production by concrete batching at construction site

(a) Concrete production

Two concrete plants are located in this area, one in Minia and the other in Assiut, both within a radius of 100km and a distance of one hour from the construction site, but they cannot be relied upon. In the construction plan, the contractor needs to cast 6,000m^3 of concrete in 8 months, so a large volume of concrete of stable quality must be provided. There is a scheduled plan to install a concrete plant with 30m^3/hr production capacity in the temporary yard adjacent to the construction site. This will produce a volume of 250m^3 per day.

(b) Concrete casting

The contractor determines the appropriate segment block for concrete casting and uses a Japanese reusable plywood formwork when placing the concrete, taking into account the structural stress, construction joints, water-tightness, and concrete production and casting ability. Considering that the summer temperature in Egypt reaches 40°C, concrete casting should be done during the night when the temperature drops. It is necessary to take into account cracks and hot weather concrete during casting of the weir apron and bridge abutment as they are mass concrete structures.

(c) Outline of Construction

The gate structure is 27.7 m in length and the total volume of concrete is 987 m^3.

(d) Basic Conditions

① Specifications of concrete

The concrete is produced at the batching plant and transported to the site. The maximum size of the coarse aggregate is 40 mm and the slump value is 8~12 cm.

② Concrete casting

The maximum lift height is 3.5 m.

③ Casting method

The casting is done by 50 tons crane and the volume of casting per day is 200 m^3.

④ Formwork

The formwork is made of wood.

(e) Casting schedule

① Casting schedule

The casting schedule is decided based on the following conditions:

- The maximum volume of concrete casting is approximately 200 m^3 per day.
- The maximum height of one lift is 3.0 m.
- The concrete joints are treated by green cutting, etc.
- The casting schedule is decided by the structure scale and the casting is divided into 3 parts.

  Base of gates

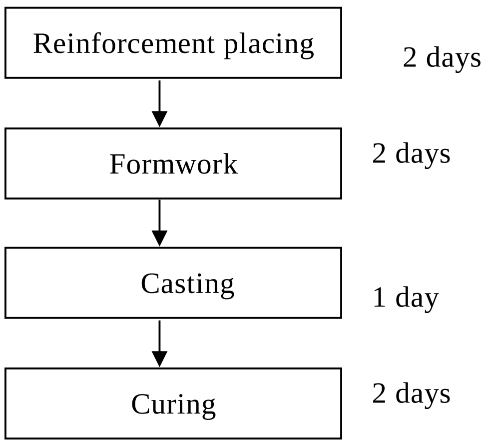
  Piers of gates

  Bridge area of gates

② Casting capacity The volume of concrete per block is approximately 150 m^3 and the casting capacity including the preparations is as follows:

Casting: one day including preparations

Demoulding: four days for cross section formwork



The number of workable days is considered except the curing days.

Number of days per cycle (except curing) = 2+2+1 = 5 days (pier area)

After completion of the pier casting, work starts on the next block and the number of workable days for curing is decided as 2 days.

The casting interval is normally a cycle of 5+2 = 7 days.

(11) Bed Protection Work on Downstream Side

The riprap material is brought from the quarry site for the riprap and masonry work near Assiut.

The transport distance is 60 km.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck

The riprap material is spread by 21 tons bulldozer.

(12) Installation of Gates and Trial Operation

The installation of the gates takes 2 months for the 4 guide frames and another 2 months for the 4 gates and 4 hoisting devices.

After the installation of the gates, trial operation is performed before the removal of the coffer dam, and the operation and control conditions are confirmed. After the removal of the coffer dam and the flow of water through the gates, trial operation and instruction in operation are planned.

(13) Removal of Temporary Bridge

The superstructure and substructure are removed.

(14) Removal of Sheet Piles on Upstream Side

The sheet piles are removed by hydraulic vibratory hammer and crawler crane with 50 tons lift capacity.

(15) Removal of Sheet Pile Revetment Downstream

The sheet piles are removed by hydraulic vibratory hammer and crawler crane with 50 tons lift capacity.

2-4 Construction of Ibrahimia Regulator

The construction of the Bahr Yusef regulator begins after the relocation and demolition of the mosque on the left bank.

(1) Preparation work

In the preparation work, preparations for the construction, investigation, surveying, staking, clearing and cutting, stumping and land grading are performed. The period of the preparation work is one month.

(2) Entrance Road Embankment on Upstream Side

The entrance road embankment on the upstream side is constructed with embankment material from the Diroutiah work. The borrow site is located 19 km from the construction site near the spoil bank site.

・Diroutiah

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

・Embankment material deficiency

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

・Entrance road embankment

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(3) Excavation and Embankment Work (Railway Side)

The embankment material for the sheet pile work on the railway side is the excavated material from the riverbed portion.

・Excavation of riverbed portion

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

・Embankment

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly. The remaining excavated material is used for the embankment on the downstream side.

(4) Sheet Pile Work on Railway Side

The sheet piles on the railway side are driven in by hydraulic press-in machine.

① Machine

Sheet pile driving work (driving length 8 m)

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value N max < 50

Driving length 8 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (PU28+1 (equivalent to Type IVw) 195 piles, driving length 8 m)

The number of the piles installed per day is 25.

(5) Bed Protection Work

The riprap material is brought from the quarry site for the riprap and masonry work near Assiut.

The transport distance is 60 km.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

(6) Entrance Road Embankment on Downstream Side

The entrance road embankment on the downstream side is constructed with the excavated material and embankment material on the railway side. The material from the railway side is used after completion of the sheet pile work.

① Excavation

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment on the downstream side

Embankment: 3,273 m^3

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(7) Temporary Cradle

After the construction of the temporary bridge, work goes ahead on the temporary cradle (width 6 m). The double sheet coffer dam sheet piles are driven in from the temporary cradle. The temporary cradle is constructed first and driving of the sheet piles is performed at the same time. The temporary cradle is 215 m long and 6 m wide. The temporary cradle is made of steel and the construction work is divided into superstructure and substructure. The cradle piers are constructed first as the substructure, and the superstructure is constructed.

(a) Superstructure

②	Installation work	Weight of steel: 184.9 tons, crawler crane with 50 tons lift capacity
②	Deck plate work	Area: 1,296 m^2, crawler crane with 50 tons lift capacity
③	Handrail installation	Length: 430 m, crawler crane with 50 tons lift capacity

(b) Substructure

① Pier pile driving work

・Driving length: 7.5 m

Machine:	Maximum N value	N max < 50
	Driving length	7.5 m < 25 m (H400 steel)
	Extraction length	7.5 m < 25 m Hydraulic vibratory hammer

Ancillary machine: Crawler crane with 50 tons lift capacity (Hydraulic vibratory hammer) 148 piles

② Installation of pier piles Weight of steel: 291.4 tons, crawler crane with 50 tons lift capacity

(8) Double Sheet Coffer Dam

The double sheet coffer dam is installed along with the temporary cradle work. The sheet pile driving and extraction work is performed by hydraulic vibratory hammer.

① Machine

Sheet pile driving work

Driving length: 11 m

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value N max < 50

Driving length 11 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile (PU28+1 (equivalent to Type IVw), outside: 381 piles, driving length 11 m, inside: 331 piles, driving length 10 m)

Connection of the sheet piles is performed from the temporary cradle. The number of piles installed per day is 20 at less than 12 m in length (including the connection work).

(9) Double Sheet Coffer Dam Embankment and Removal of Temporary Cradle

After the installation of the double sheet coffer dam, the double sheet coffer dam embankment is constructed and the temporary cradle is removed.

① Embankment material

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Double sheet coffer dam embankment

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(10) Excavation Work on Lower Left Side

The excavation work on the lower left side is performed and the excavated material is stocked on the left embankment of the Bahr Yusef regulator.

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

The embankment at the stock pile is compacted by 10 tons vibrating roller.

(11) Sheet Pile Revetment Work on Lower Left Side

The sheet pile revetment on the lower left side is constructed and the revetment type is anchorage by H-steel. The revetment sheet piles and H-steel piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 8 m, H-250 4.1 m

Machine: Hydraulic vibratory hammer

Maximum N value N max < 50

Driving length 8 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (sheet pile PU28+1 (equivalent to Type IVw): 200 piles, driving length: 8 m)

Sheet pile, PU28+1 (equivalent to Type IVw)

Driving work: the number of piles installed per day is 25 at less than 9 m in length.

③ Driving work (H-250 steel pile: 68 piles, driving length: 4.1 m)

Driving work: the number of piles installed per day is 37 at less than 6 m in length.

(12) Excavation Work on Upper Left Side

The excavation work on the upper left side is performed and the excavated material is stocked on the left embankment of the Bahr Yusef regulator.

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

The embankment at the stock pile is compacted by 10 tons vibrating roller.

(13) Sheet Pile Revetment Work on Upper Left Side

The sheet pile revetment on the upper left side is constructed and the revetment type is anchorage by H-steel. The sheet piles and H-steel piles for the revetment are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 3 m, H-250 2.5m

Machine: Hydraulic vibratory hammer

Maximum N value N max < 50

Driving length 3 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (sheet pile PU28+1 (equivalent to Type IVw): 223 piles, driving length: 3 m)

Sheet pile, PU28+1 (equivalent to Type IVw)

Driving work: the number of piles installed per day is 223 at less than 3 m in length.

③ Driving work (H-250 steel pile: 68 piles, driving length: 3.0 m)

Driving work: the number of piles installed per day is 48 at less than 4 m in length.

(14) Demolition of Slope on Left Bank

The demolition and removal of the slope on the left bank are performed by backhoe and the generated rubble is loaded by backhoe and transported by dump truck. The generated rubble is stocked on the left embankment of the Bahr Yusef regulator.

(15) Drainage Work

The drainage of the percolation from the foundation surface of the double steel sheet piles is conducted using the pump drain method and well point method, both separately and in combination. The construction site of the double steel sheet piles is surrounded by canal water and it is therefore necessary to select a drainage method that ensures smooth progress of the construction work, as the foundation surface of the excavation is highly permeable

As the foundation conditions are such that there are thick geological layers with high permeability (silty clay and sand etc.), the combination of the pump drain and well point methods is selected for the drainage work on the site. It is necessary to check the turbidity of the drainage water to prevent piping.

① Installation and removal of well-points (length 360 m, interval 3 m, 120 well points)

② Installation and removal of well-point pumps (2 pumps, 2 spare pumps)

(16) Excavation Work

The excavation work in the site area is performed. The excavated material is loaded on the dump truck by backhoe and stocked on the left embankment of the Bahr Yusef regulator.

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

The embankment at the stock pile is compacted by 10 tons vibrating roller.

(17) Foundation Pile Work

Cast-in-place concrete piles are planned for the foundation of the regulator and the bored pile method is applied as the construction method. The excavation is done by earth auger and bentonite is used to secure the walls of the hole. The bore hole machine is used by Bore pile machine and the base machine is used by a 42 tons crawler crane and the construction capacity is 3 piles per day.

(18) Waterstop Sheet Piles

The sheet piles are driven in by hydraulic vibratory hammer.

① Machine

Sheet pile driving work (driving length 4.5 m, 6 m, 12 m)

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value	N max < 50
Driving length	4.5 m, 6 m, 12 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, PU12 (equivalent to Type IIw), outside: 60 piles, driving length 4.5 m
The number of piles installed per day is 40.

Sheet pile, PU12 (equivalent to Type IIw), outside: 59 piles, driving length 6.0 m
The number of piles installed per day is 40.
Sheet pile, PU12 (equivalent to Type IIw), outside: 60 piles, driving length 12.0 m
The number of piles installed per day is 40.

(19) Concrete Work

The NDGR is a mass concrete structure with a high concrete placement volume. A method to ensure a high quality, stable supply of mass concrete shall be considered in order to prevent temperature cracks caused by heat of hydration.

Concrete placing conditions:

1) Ensuring quality: Unit concrete placement volume, concrete curing method

2) Ensuring a stable supply (production method): Procurement from an existing ready-mixed concrete plant or production by concrete batching at construction site

(a) Concrete production

Two concrete plants are located in this area, one in Minia and the other in Assiut, both within a radius of 100km and a distance of one hour from the construction site, but they cannot be relied upon. In the construction plan, the contractor needs to cast 6,000 m^3 of concrete in 8 months, so a large volume of concrete of stable quality must be provided. There is a scheduled plan to install a concrete plant with 30 m^3/hr production capacity in the temporary yard adjacent to the construction site. This will produce a volume of 250 m^3 per day.

(b) Concrete casting

The contractor determines the appropriate segment block for concrete casting and uses a Japanese reusable plywood formwork when placing the concrete, taking into account the structural stress, construction joints, water-tightness, and concrete production and casting ability. Considering that the summer temperature in Egypt reaches 40ºC, concrete casting should be done during the night when the temperature drops. It is necessary to take into account cracks and hot weather concrete during concrete casting of the weir apron and bridge abutment as they are mass concrete structures.

(c) Outline of Construction

The gate is a long structure on the upstream side with a length of 27.9 m and on the downstream side, with a length of 23.5 m. The total volume of concrete is 6,022 m^3.

(d) Basic Conditions

① Specifications of concrete

Concrete is produced at the batching plant and transported to the site. The maximum size of the coarse aggregate is 40 mm, and the slump value is 8~12 cm.

② Concrete casting

The maximum lift height is 3.5 m.

③ Casting method

The casting is done by 50 tons crane and the casting volume per day is 200 m^3.

④ Formwork

The formwork is made of wood.

(e) Casting schedule

① Casting schedule

The casting schedule is decided based on the following conditions:

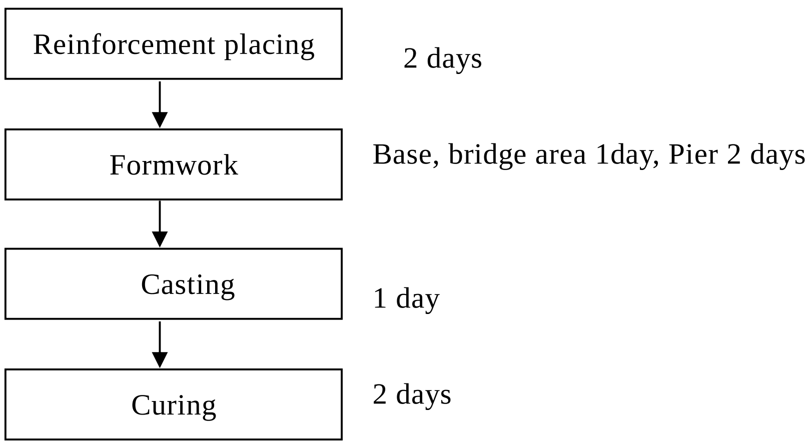
- The maximum casting volume is approximately 200 m^3 per day.
- The maximum height of one lift is 3.0 m.
- The concrete joints are treated by green cutting, etc.
- The casting schedule is decided by the structure scale and the casting is divided into 5 parts.
  - Base of gates on upstream side
  - Piers of gates on upstream side
  - Bridge area of gates on upstream side
  - Base of apron on downstream side
  - Wall of apron on downstream side

② Casting capacity

The volume of concrete per block is approximately 200 m^3 and the casting capacity including the preparations is as follows:

Casting concrete: one day including preparations

Demoulding: four days for cross section formwork



The workable days are considered except curing days.

1 casting cycle (except curing) =2+1+1=4 days (base, bridge area)

=2+2+1=5 days (pier area)

After completion of the casting at the pier, work on the next block starts and the number of workable days for curing is decided as 2 days.

The interval for concrete casting is normally a cycle of 5+2=7 days.

(20) Embankment on Left Side

The embankment on the left side is constructed after the concrete work for the regulator. The embankment is compacted by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(21) Installation of Gates and Trial Operation

The installation of the gates takes 2 months of the 4 guide frames and another 2 months for the 4 gates and 4 hoisting devices.
After the installation of the gates, trial operation is performed before the removal of the coffer dam, and the operation and control conditions are confirmed. After the removal of the coffer dam and the flow of water through the gates, trial operation and instruction in operation are planned.

(22) Excavation for Double Sheet Coffer Dam and Embankment on Left Bank

The excavation and transport of soil for the double sheet coffer dam are performed and the embankment on the right bank is constructed.

① Excavation

The transport distance is 0.3 km within the site area.
The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment on right bank

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(23) Removal of Double Sheet Coffer Dam

The double sheet coffer dam is removed by hydraulic vibratory hammer.

① Machine

Extraction length: 11 m
Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Extraction length	11 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Extraction work (outside: 381 piles, length 11 m, inside: 331 piles, length 10 m)

The number of piles extracted per day is 50 at less than 12 m in length.

(24) Sheet Pile Revetment Work

The sheet pile revetment work is performed by hydraulic vibratory hammer.

① Machine

Driving work
Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Extraction length	L < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

(25) Embankment on Right Bank

The embankment on the right bank is constructed with material from the stock pile and the backfill from the double sheet coffer dam.

① Excavation

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment on left bank

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

2-5 Construction of the Abo Gabal Regulator

The construction of the Abo Gabal regulator is performed after the construction of the Diroutiah regulator.

(1) Preparation Work

In the preparation work, the preparations for construction, investigation, surveying, staking, clearing and cutting, stumping and land grading are performed. The period of the preparation work is one month.

(2) Entrance Road Embankment

The material for the embankment work for the entrance road is transported from the borrow site.

① Transport from the borrow site

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment of entrance road

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(3) Diversion Canal Sheet Pile Work

The sheet piles or the diversion canal are constructed.

① Machine

Sheet pile driving work (driving length 5 m)

Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Driving length	5 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (PU28+1 (equivalent to Type IVw) outside 92 piles, inside: 75 piles, driving length 6 m)

The number of piles installed per day is 31 at less than 6 m in length.

③ Excavation

The excavation is performed inside the sheet piles and the excavated soil is used for backfill for the double sheet coffer dam.

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

④ Superstructure

- Installation work Weight of steel: 3.9 tons, crawler crane with 50 tons lift capacity
- Deck plate work Area: 54 m^2,crawler crane with 50 tons lift capacity
- Handrail installation Length: 39 m, crawler crane with 50 tons lift capacity

(4) Double Sheet Coffer Dam Embankment

Backfilling of the double sheet coffer dam is advanced first.

① Excavation and transport

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Backfilling of the double sheet coffer dam

The spreading and compaction of the embankment material is done by 11 tons bulldozer.

(5) Double Sheet Coffer Dam

The double sheet coffer dam is constructed. The sheet pile driving and extraction work is done by hydraulic vibratory hammer.

① Machine

Sheet pile driving work

Driving length: 5 m

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value N max < 50

Driving length 5 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, PU28+1 (equivalent to Type IVw), outside: 116 piles, driving length 5 m, inside: 80 piles, driving length 5 m)

The connection of the sheet piles is performed from the temporary cradle. The number of piles installed per day is 31 at less than 6 m in length.

(6) Excavation Work

The excavation work is performed. The excavated material is stocked in the site area and used for backfill.

Excavation: 1,510 m^3

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

(7) Backfilling

The embankment is constructed and the embankment is compacted by 4 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(8) Sheet Pile Revetment Work (Gate Structure)

The sheet pile revetments on the right and left banks of the Abo Gabal regulator are constructed. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 4.6 m, 5.0 m

Machine: Hydraulic vibratory hammer

Maximum N value N max < 50

Driving length 4.6 m, 5.0 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, driving length 4.6 m, PU12 (equivalent to Type IIw) 75 piles

Driving work: the number of piles installed per day is 33.

Sheet pile, driving length 5.0 m, PU12 (equivalent to Type IIw) 72 piles

Driving work: the number of piles installed per day is 33.

(9) Waterstop Sheet Piles (Gate Structure)

The waterstop sheet piles for the Abo Gabal regulator are constructed. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 2.0 m

Machine: Hydraulic vibratory hammer

Maximum N value N max < 50

Driving length 2.0 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, driving length 2.0 m, PU12 (equivalent to Type IIw) 24 piles

Driving work: the number of piles installed per day is 55.

(10) Concrete Work

The NDGR is a mass concrete structure with a high concrete placement volume. A method to ensure a high quality, stable supply of mass concrete shall be considered in order to prevent temperature cracks caused by heat of hydration.

Concrete placing conditions:

1) Ensuring quality: Unit concrete placement volume, concrete curing method

2) Ensuring a stable supply (production method): Procurement from an existing ready-mixed concrete plant or production by concrete batching at construction site

(a) Concrete production

Two concrete plants are located in this area, one in Minia and the other in Assiut, both within a radius of 100 km and a distance of one hour from the construction site, but they cannot be relied upon. In the construction plan, the contractor needs to cast 6,000 m^3 of concrete in 8 months, so a large volume of concrete of stable quality must be provided. There is a scheduled plan to install a concrete plant with 30 m^3/hr production capacity in the temporary yard adjacent to the construction site. This will produce a volume of 250 m^3 per day.

(b) Concrete casting

The contractor determines the appropriate segment block for concrete casting and uses a Japanese reusable plywood formwork when placing the concrete, taking into account the structural stress, construction joints, water-tightness, and concrete production and casting ability. Considering that the summer temperature in Egypt reaches 40ºC, concrete casting should be done during the night when the temperature drops. It is necessary to take into account cracks and hot weather concrete during casting of the weir apron and bridge abutment as they are mass concrete structures.

(c) Outline of Construction

The gate structure is 27.9 m in length and the total volume of concrete is 1,441 m^3.

(d) Basic Conditions

① Specifications of concrete

The concrete is produced at the batching plant and transported to the site. The maximum size of the coarse aggregate is 40 mm, and the slump value is 8~12 cm.

② Concrete casting

The maximum lift height is 3.5 m.

③ Casting method

The casting is done by 50 tons crane and the casting volume per day is 200 m^3.

④ Formwork

The formwork is made of wood.

(e) Casting schedule

① Casting schedule

The casting schedule is decided based on the following conditions:

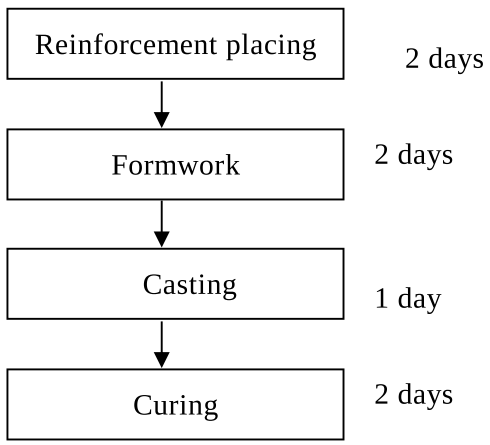
- The maximum volume of cast concrete is approximately 200 m^3 per day.
- The maximum height of one lift is 3.0 m.
- The concrete joints are treated by green cutting, etc.
- The casting schedule is decided by the structure scale and the casting is divided into 3 parts.

  Base of gates
  Piers of gates
  Bridge area of gates

② Casting capacity

The volume of concrete per block is approximately 150 m^3 and the casting capacity including the preparations is as follows:

Casting: one day including preparations
Demoulding: four days for cross section formwork



The workable days are considered except curing days.
1 casting cycle (except curing) =2+2+1=5 days (pier area)
After completion of the casting at the pier, work starts on the next block and the number of workable days for curing is decided as 2 days.
The casting interval is normally a cycle of 5+2=7 days.

(11) Installation of Gates and Trial Operation

The installation of the gates takes 2 months for the 4 guide frames and another 2 months for the 4 gates and 4 hoisting devices.
After the installation of the gates, trial operation is performed before the removal of the coffer dam, and the operation and control conditions are confirmed. After the removal of the coffer dam and

the flow of water through the gates, trial operation and instruction in operation are planned.

(12) Excavation for Double Sheet Coffer Dam and Removal of Sheet Piles

The excavation and transport of backfill for the double sheet coffer dam are performed and stocked on the left bank of Bahr Yusef.

① Excavation

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Stockpile

The spreading and compaction of the embankment are done by 11 ton bulldozer.

③ Removal of Sheet Piles

Extraction length: 11m

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value N max < 50

Extraction length 11 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

(13) Removal of Diversion Canal and Backfilling

Removal of diversion canal (sheet piles and superstructure)

Backfill: The spreading and compaction of the embankment are done by 11 tons bulldozer.

(14) Removal of Entrance Road

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

The spreading and compaction of the embankment are done by 11 tons bulldozer.

2-6 Construction of the Sahelyia Regulator

The construction of the Sahelyia regulator is performed after the construction of the Abo Gabal regulator.

(1) Preparation Work

In the preparation work, preparations for the construction, investigation, surveying, staking, clearing and cutting, stumping and land grading are performed. The period of the preparation work is one month.

(2) Entrance Road Embankment

The embankment material for the entrance road is transported from the borrow site.

① Transport from the borrow site

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment of entrance road

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(3) Diversion Canal Sheet Pile Work

The sheet piles for the diversion canal are installed.

① Machine

Sheet pile driving work (driving length 5 m)

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value   N max < 50

Driving length   5 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (PU28+1 (equivalent to Type IVw) outside: 89 piles, inside: 76 piles, driving length 6 m)

The number of piles installed per day is 31 at less than 6 m in length.

③ Excavation

The excavation is performed inside the sheet piles and the excavated soil is used for backfill for the double sheet coffer dam. (Excavation 307 m^3)

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

④ Superstructure

- Installation work   Weight of steel: 7.8 tons, crawler crane with 50 tons lift capacity
- Deck plate work   Area: 108 m^2, crawler crane with 50 tons lift capacity
- Handrail installation   Length: 72 m, crawler crane with 50 tons lift capacity

(4) Embankment of Double Sheet Coffer Dam

The backfilling of the double sheet coffer dam is advanced first.

① Excavation and transport

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Backfilling of the double sheet coffer dam

The spreading and compaction of the embankment material are done by 11 tons bulldozer.

(5) Double Sheet Coffer Dam

The double sheet coffer dam is constructed. The sheet pile driving and extraction work is done by hydraulic vibratory hammer.

① Machine

Sheet pile driving work

Driving length: 5 m

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value N max < 50

Driving length 5 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, PU28+1 (equivalent to Type IVw), outside: 115 piles, driving length 5 m, inside: 77 piles, driving length 5 m)

The connection of the sheet piles is performed from the temporary cradle. The number of piles installed per day is 31 at less than 6 m in length.

(6) Excavation Work

The excavation work is performed. The excavated material is stocked in the site area and used for backfill.

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

(7) Backfilling

The embankment is constructed and compacted by 4 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(8) Sheet Pile Revetment Work (Gate Structure)

The sheet pile revetments on the right and left banks of the Abo Gabal regulator are constructed. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 5.75 m, 5.0 m

Machine: Hydraulic vibratory hammer

Maximum N value N max < 50

Driving length 5.75 m, 5.0 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, driving length 5.75 m, PU12 (equivalent to Type IIw) 32piles

Driving work: the number of piles installed per day is 33.

Sheet pile, driving length 5.0 m, PU12 (equivalent to Type IIw) 32 piles

Driving work: the number of piles installed per day is 33.

(9) Waterstop Sheet Piles (Gate Structure)

The waterstop sheet piles for the Abo Gabal regulator are constructed. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 2.0 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	2.0 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, driving length 2.0 m, PU12 (equivalent to Type IIw) 14 piles

Driving work: the number of piles installed per day is 55.

(10) Concrete Work

The NDGR is a mass concrete structure with a high concrete placement volume. A method to ensure a high quality, stable supply of mass concrete shall be considered in order to prevent temperature cracks caused by heat of hydration.

Concrete placing conditions:

1) Ensuring quality: Unit concrete placement volume, concrete curing method

2) Ensuring a stable supply (production method): Procurement from an existing ready-mixed concrete plant or production by concrete batching at construction site

(a) Concrete production

Two concrete plants are located in this area, one in Minia and the other in Assiut, both within a radius of 100 km and a distance of one hour from the construction site, but they cannot be relied upon. In the construction plan, the contractor needs to cast 6,000 m^3 of concrete in 8 months, so a large volume of concrete of stable quality must be provided. There is a scheduled plan to install a concrete plant with 30 m^3/hr production capacity in the temporary yard adjacent to the construction site. This will produce a volume of 250 m^3 per day.

(b) Concrete casting

The contractor determines the appropriate segment block for concrete casting and uses a Japanese reusable plywood formwork when placing the concrete, taking into account the structural stress, construction joints, water-tightness, and concrete production and casting ability. Considering that the summer temperature in Egypt reaches 40ºC, concrete casting should be done during the night when the temperature drops. It is necessary to take into account cracks and hot weather concrete during concrete casting of the weir apron and bridge abutment as they are mass concrete structures.

(c) Outline of Construction

The gate structure is 28.8 m in length and the total volume of concrete is 752 m^3.

(d) Basic Conditions

① Specifications of concrete

The concrete is produced at the batching plant and transported to the site. The maximum size of the coarse aggregate is 40 mm, and the slump value is 8~12 cm.

② Concrete casting

The maximum lift height is 3.5 m.

⑤ Casting method

The casting is done by 50 tons crane and the casting volume per day is 200 m^3.

④ Formwork

The formwork is made of wood.

(e) Casting schedule

① Casting schedule

The casting schedule is decided based on the following conditions:

- The maximum casting volume is approximately 200 m^3 per day.
- The maximum height of one lift is 3.0 m.
- The concrete joints are treated by green cutting, etc.
- The casting schedule is decided by the structure scale and the casting is divided into 3 parts.

  Base of gates

  Piers of gates

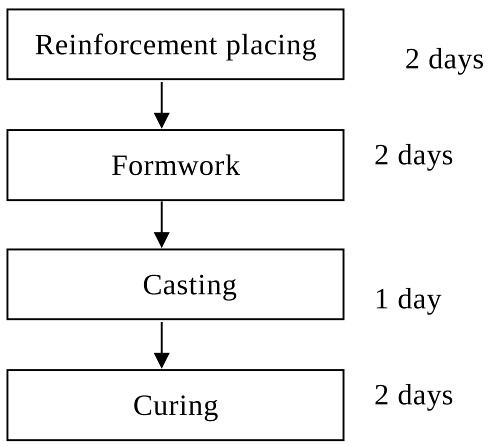
  Bridge area of gates

② Casting capacity

The volume of concrete per block is approximately 150 m^3 and the casting capacity including the preparations is as follows:

Casting concrete: one day including preparations

Demoulding: four days for cross section formwork



The workable days are considered except curing days.

1 casting cycle (except curing) =2+2+1=5 days (pier area)

After completion of the casting at the pier, work starts on the next block and the number of workable days for curing is decided as 2 days.

The interval for concrete casting is normally a cycle of 5+2=7 days.

(11) Installation of Gates and Trial Operation

The installation of the gates takes 1 month for the 2 guide frames and another month for the 2 gates and 4 hoisting devices.

After the installation of the gates, trial operation is performed before the removal of the coffer dam, and the operation and control conditions are confirmed. After the removal of the coffer dam and the flow of water through the gates, trial operation and instruction in operation are planned.

(12) Excavation for Double Sheet Coffer Dam and Removal of Sheet Piles

The excavation and transport of backfill for the double sheet coffer dam are performed and stocked on the left bank of Bahr Yusef.

① Excavation

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Stockpile

The spreading and compaction of the embankment is done by 11 tons bulldozer.

③ Removal of Sheet Piles

Extraction length: 11 m

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value N max < 50

Extraction length 11 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

(13) Removal of Diversion Canal and Backfilling

Removal of diversion canal (sheet piles and superstructure)

Backfill: The spreading and compaction of the embankment are done by 11 tons bulldozer.

(14) Removal of Entrance Road

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

The spreading and compaction of the embankment are done by 11 tons bulldozer.

2-7 Construction of water management sysytem

(1) Location of construction

The contractor conducts a field survey before construction and confirms construction conditions (installation path of vehicle, installation site of equipment, machinery and equipment necessary for construction etc.). The installation location shall be the location shown in the table below.

Table 2-7.1 Location of the construction of water management system

<table>
<tr><th colspan="3">Irrigation facilities</th><th colspan="2">Name of the Target facilities</th><th>No.</th></tr>
<tr><td rowspan="2">Regulator</td><td colspan="2">Bahr Yusef canal</td><td>Dahab Regulator
Sakoula Regulator
Mazoura Regulator</td><td>Lahoun Regulator
Abo El Shekok Regulator
Regulator km39</td><td>6</td></tr>
<tr><td colspan="2">Ibrahimia canal</td><td>New Hafze Regulator
Matay Regulator
Maghagha Regulator</td><td>Sharahna Regulator
El Gandy Regulator
Ashmont Regulator</td><td>6</td></tr>
<tr><td rowspan="5">Branch canal</td><td rowspan="3">Bahr Yusef canal</td><td>Intake</td><td>Manshat EL Dahab
El Hareka
El Sabaa</td><td>Quftan
Wesh El-Bab
EL-Giza</td><td>6</td></tr>
<tr><td>Weir</td><td colspan="2">Hassan Wasef Weir</td><td>1</td></tr>
<tr><td>Pump</td><td>New Kamdeer P.S.
New Terfa P.S.
Old Terfa P.S.</td><td>Old Sakoula P.S.
Mazoura P.S.(2)</td><td>5</td></tr>
<tr><td rowspan="2">Ibrahimia canal</td><td>Intake</td><td>Irad El Maharak
El Kosia
East Hafze
West Hafze
Adkak</td><td>Gendia
Abo Shosha
EL Soultany
Tansa
El Mansour</td><td>10</td></tr>
<tr><td>Weir</td><td>Serry Weir</td><td>Maghagha Weir</td><td>2</td></tr>
<tr><td colspan="3">Ibrahimia main canal</td><td colspan="2">Ibrahimia Head Regulator</td><td>1</td></tr>
<tr><td colspan="3">Lake</td><td colspan="2">Quarun Lake</td><td>1</td></tr>
<tr><td colspan="5">Total</td><td>38</td></tr>
</table>

(2) Contents of construction works

The construction will be the new construction works of 38 observation stations, one central monitoring station and one monitoring station, mainly consisting of the following contents.

① Installation and adjustment of the central monitoring station (Server, Laptop, Network facilities, Display panel, etc.)

② Installation and adjustment of the monitoring station (Server, Laptop, Network facilities, Display panel, Dater logger, Modem, etc.)

③ Installation and adjustment of the monitoring equipments (Fence, Pole, Water level sensor, Solar panel,

④ Installation of wiring and conduit

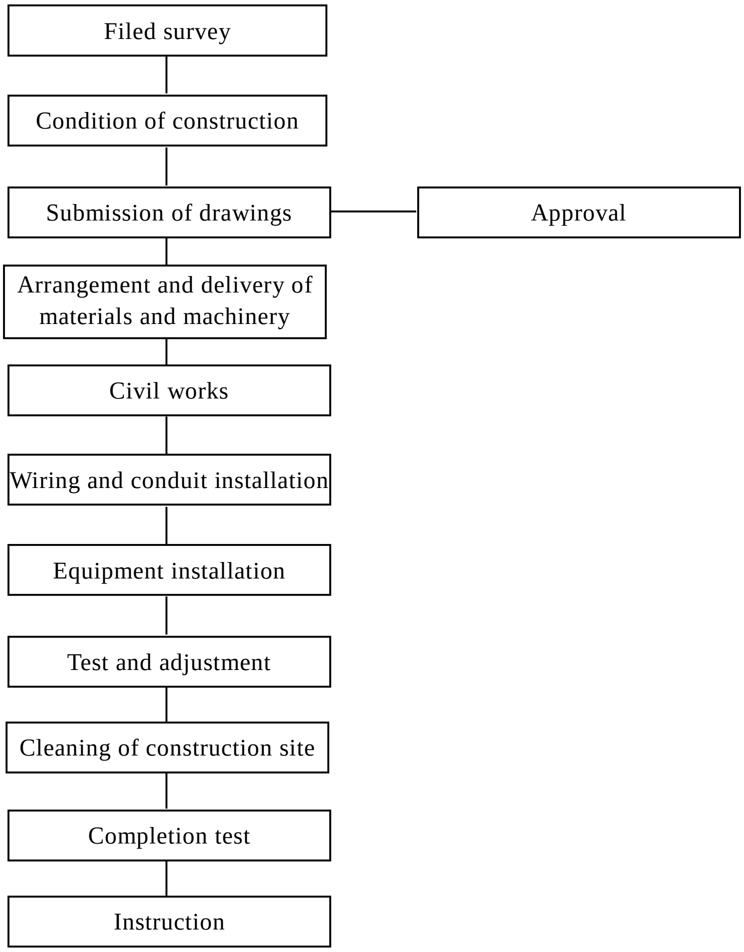
(3) Flow of construction works

① General items

This construction will be implemented according to the civil works specifications and electrical works specifications in Egypt.

② Overall plan

The main procedures from field survey to completion of construction are as follows.



(4) Test and adjustment

① Inspection

In the completion inspection, the necessary personnel, materials, equipment, measuring instruments, etc. shall be prepared by the contractor.

② Test

Various test adjustments shall be carried out under supervision staff witnessing. However, if supervisory staff could not attend, the contractor shall submit a report of the test results with photographs.

(5) Construction period

Based on the construction contents and method described above, the standard periods of construction in each process are as follows.

① Planning and designing : Two months

② Equipment procurement, material arrangement and loading, acceptance inspection : Three months

③ Civil works : Two months

④ Electrical works : Two months

⑤ Planning and designing : Two months

From the above, the total period for this construction works will be 9.5 months. In addition, in parallel with the above civil works and electrical works, software development will be carried out. The construction period for software development will be assumed to be 10 months.

Assuming simultaneous execution of civil engineering works, electrical work and software development period, the period of water management construction complete shall be 12.5 months.

3. Work Schedule

3-1 Criteria on work schedule

(1) Critical path work

Bahr Yusef construction work is to be carried out first, followed by Ibrahimia construction work. In order to even out the work volume and reduce the project cost; temporary material and heavy machinery such as double sheet piles and temporary bridges are to be reutilized in each construction.

(2) Work procedure

The work procedure is shown in Figure 3-1.1.

(3) Conditions of project period

- Working days coefficient[1]: 1.35
- Yearly working days: 270 days/year (=365/1.35)
- Monthly working days: 22.5 days/month (=270/12)
- Daily working time: 8:00-17:00 (working hours: 8 hours/day, excluding one hour break)

3-2 Formulation of work schedule

The critical path schedule has set the Bahr Yusef construction work first, followed by Ibrahimia. Other works at Badraman, Abo Gabal, and Saheliya are scheduled based on the principle that work volume can be leveled throughout the construction period. The critical path work for Bahr Yusef and Ibrahimia construction work are as follows.

(1) Critical path work

Preparatory work → Temporary bridge and Platform for Driving Sheet pile inside of Coffer Dam→ Temporary double sheet pile coffer dam work →Embankment for Temporary Road & Hardening for Soft Soil→ excavation inside dam → Foundation pile work & cut-off sheet pile → Structure concrete work → Installation work of gate facility and commissioning → Removal work of temporary bridge and coffer dam and changing water flow → Embankment and Sheet pile for Bank protection and gabion and permanent road etc. → Overall integrated test operating and operation training → Finishing and clearance→Handover.

[1] Actual days for each work day considering holidays and days where no work is possible

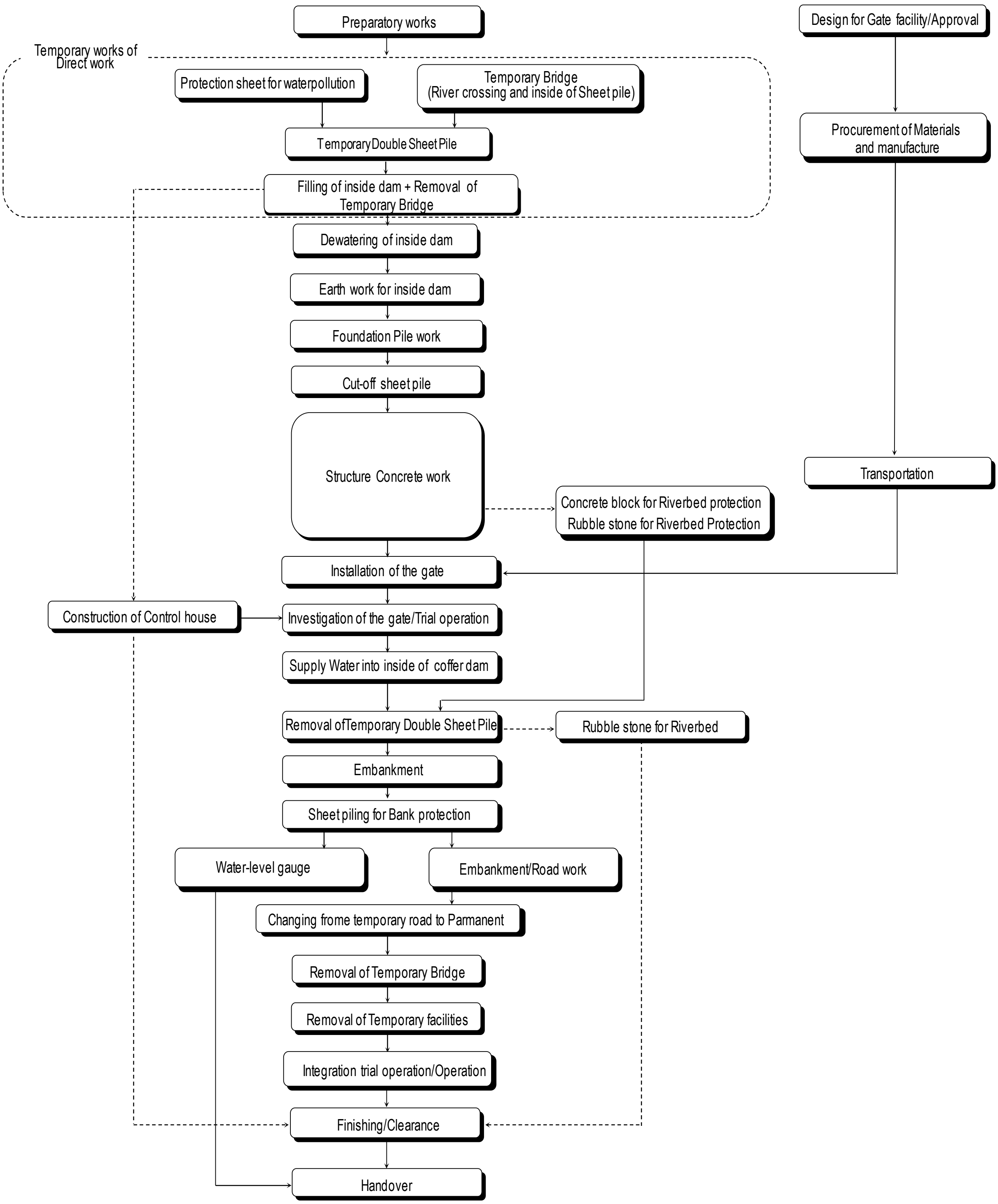


Figure 3-1.1 Work procedure

Works on the manufacturing of mechanical and electric facilities for gates, transportation, construction of the control house, and river bed protection work etc, will proceed in parallel with the structure concrete work, gate facility installation work, and commissioning, etc.

The work schedule of this critical path is found to be the shortest and most economical given the above conditions, the construction period, and standard daytime work conditions.

The overall project period is set for 51 months (Bahr Yusef, 25.5 months, and Ibrahimia, 25.5 months) based on the final design and quantity.

Bahr-Yusef

Table 3-2.1 Critical pass work (Bahr Yusef) (1/5)

Number of days for each work item

each work item	detail of each work	work quantity	unit	work volume a day	no.of party	working days	Working days coefficient	period of excecution	critical pass days	
gate manufacture	design・approval	1	lot			90	1	90	-	
	material procurement	1	lot			60	1	60	-	0
	manufacture・inspection at factory	1	lot			135	1	135	-	
preparatory work	procurement/temporary office/temporary yard/transportation	1	lot			150	1	150	90	90
Direct temporary work	setting barge for dredging for diversion canal		m3	190	2	0.0	1.35	0	-	0
	dredging for diversion canal									
	stone riprap for riverbed									
	removing barge for dredging for diversion canal									
across the canal	erection of temporary bridge									143
	preparation	1	lot			3	1	3	3	
	driving H-beam （driving L less 6m）L=14.5	25	pcs	20	1	1.3	1.35	2	2	
	driving H-beam （driving L less 16m）L=21.5	15	pcs	7	1	2.1	1.35	3	3	
	erection for platform	56.5	t	8.3	1	6.8	1.35	9	9	
	installation for steel top deck	336	m2	111	1	3.0	1.35	4	4	
inside of double sheet	driving H-beam （driving L less 6m）L=14.5	20	pcs	20	1	1.0	1.35	1	1	
	driving H-beam （driving L less 16m）L=21.5	124	pcs	7	1	17.7	1.35	24	24	
	erection for platform	209.5	t	8.3	1	25.2	1.35	34	34	
	installation for steel top deck	1,260	m2	111	1	11.4	1.35	15	15	
	filling for inside double sheet	14,280	m3	410	1	34.8	1.35	47	47	
	driving steel sheet pile for cofferdam									129
	Ⅳ-type （driving L less 12m）j oint	750	pcs	8	1	93.8	1.35	127	127	
	(PU28+1 W=0.6m L=20.0m)									
	installation for tie-rod	1	lot						2	
Bank protection work	Bank protection by sheet pile(upstream,downstream at right bank)									
	front Ⅲw （riving L less 15m）L=18m C2	15	pcs	10	1	1.5	1.35	2		
	Ⅳw （driving L less 12m）L=20m C1	6	pcs	11	1	0.5	1.35	1		
	frontⅢw （driving L less 9m）L=12m BR2	15	pcs	29	1	0.5	1.35	1		
	Ⅳw （driving L less 12m）L=18m BR1	8	pcs	11	1	0.7	1.35	1		

Table 3-2.2 Critical pass work (Bahr Yusef) (2/5)

	back Ⅱw （driving L less 6m） L=6m PU12	21	pcs	39	1	0.5	1.35	1		
	Ⅱw （driving L less 6m） L=6m PU12	23	pcs	39	1	0.6	1.35	1		
	installation for tie-rod		pcs	40	1	0.0	1.35	0		
	capping concrete	1	lot			30	1.35	41	-	
temporary work										
	embankment for access road（upstream & downstream）	7,382	m3	410	2	9.0	1.35	12	12	
	embankment for temporary road on bottom area	705	m3	190	1	3.7	1.35	5	5	
	backfill for structure	740	m3	190	1	3.9	1.35	5	5	39
	hardening of soft soil（road and structure area）	1,676	m3	190	1	8.8	1.35	12	12	
	curing								3	
	dewatering of inside dam	1	lot			2	1	2	2	
temporary dewatering	wellpoint	1	lot							
removal for ex. structure	all removal (inside coffer dam)	0.00	m3	63	2	0.0	1.35	0	-	
earth work	preparation								3	
	excavation for structure inside coffer dam	4,790.00	m3	190	2	12.6	1.35	17	17	20
	embankment inside coffer dam(right bank)	7,200.00	m3	300	1	24.0	1.35	32		
	backfill	2,900.00	m3	350	2	4.1	1.35	6	-	
riverbed protection	driving cut-off sheet pile									
	Ⅳw （driving L less 12m）L-12.0m PU-12	60	pcs	28	1	2.1	1.35	3	3	
	Ⅱw （driving L less 6m）L=6.0m PU-12	59	pcs	39	1	1.5	1.35	2	2	
	（driving L less 4m）L=5.0m PU-12	60	pcs	39	1	1.5	1.35	2	2	7
	Ⅳw （driving L less 12m）L-22.0m PU-28	1	pcs	8	1	0.1	1.35	0	0	
	Ⅳw （driving L less 9m）L-20.0m PU-28	1	pcs	9	1	0.1	1.35	0	0	
	Ⅳw （driving L less 9m）L-18.0m PU-18	1	pcs	12	1	0.1	1.35	0	0	
	Ⅳw （driving L less 4m） L-12.0m PU-18	1	pcs	42	1	0.0	1.35	0	0	
	cast-inplace concrete pile									
	φ1000 L=13.50m	72	pcs	3	1	24.0	1.35	32	32	
	φ1000 L=7.50m	32	pcs	3	1	10.7	1.35	14	14	52
removing for temporary embankment										
	removing for temporary embankment	1,445		190	2	3.8	1.35	5	5	
Concrete work	main structure lean concrete	153.3	m3	38.3	1	4.0	1.35	5	5	183
	base									
	scaffolding	476	m2	71	1	6.7	1.35	9	4	

Table 3-2.3 Critical pass work (Bahr Yusef) (3/5)

	re-bar	268.92	t	3.3	3	27.2	1.35	37	37	
	formwork	694.36	m2	30	1	23.1	1.35	31	8	
	placing concrete	2,987.97	m3	182.6	1	33	1.35	45	-	
	pier									
	scaffolding	2,816.33	m2	71	1	39.7	1.35	54	4	
	re-bar	233.11	t	3.3	3	23.5	1.35	32	32	
	formwork	2,983.47	m2	30	3	33.1	1.35	45	8	
	placing concrete	2,590.14	m3	84	1	24	1.35	32	1	
	other concrete(support bridge etc)									
	re-bar	22.35	t	3.3	2	3.4	1.35	5	5	
	formwork	402.90	m2	30	3	4.5	1.35	6	3	
	placing concrete	248.30	m3	84	1	3.0	1.35	4	1	
	curing									
	removal of form & support									
	passage									
	scaffolding	0	m2	71	1	0.0	1.35	0	0	
	support	651.9	m3	71	1	9.2	1.35	12	6	
	re-bar	4.1	t	3.3	1	1.3	1.35	2	2	
	formwork	192.0	m2	30	1	6.4	1.35	9	9	
	placing concrete	45.8	m3	48	1	1.0	1.35	1	1	
	curing	1	lot			14	1	14	14	
	removal of form & support	3,680.40	m3	71	6	8.6	1.35	12	-	
	maintenance bridge									
	scaffolding	388.4	m2	71	2	2.7	1.35	4		
	support	2,700.00	m3	71	4	9.5	1.35	13		
	re-bar	46.3	t	3.3	2	7.0	1.35	9	9	
	formwork	759.4	m2	30	2	12.7	1.35	17		
	placing concrete	231.8	m3	153.8	1	6	1.35	8	8	
	curing	1	lot			14	1	14	14	
	removal of form･support	3,847.80	m3	71	6	9.0	1.35	12	12	
Gate facility work	**groove**	1	lot			30.0	1	30		
	installation for Gate									
	assemble	1	lot			15	1.35	20	20	26
	installation	1	lot			4	1.35	5	5	

Table 3-2.4 Critical pass work (Bahr Yusef) (4/5)

Concrete work	**upper pier**									
	scaffolding	463	m2	71	2	3.3	1.35	4	2	
	re-bar	9.82	t	3.3	1	3.0	1.35	4	1	
	formwork	319.99	m2	30	2	5.3	1.35	7	2	
	placing concrete	109.14	m3		2	2.0	1.35	3	1	
	platform for operation									26
	suppoort	937.75	m2	71	2	6.6	1.35	9	2	
	re-bar	7.07	t	3.3	1	2.1	1.35	3	1	
	formwork	205.52	m2	30	2	3.4	1.35	5	2	
	placing concrete	78.58	m3		2	2.0	1.35	3	1	
	curing	1	lot	71	2			14	14	
	removal for form, scaffolding & support	1,143.27	m2							
Gate facility work	installation for groove	1	lot			40	1.35	54	-	0
	lifting gear assemble/installation/adjustment									
	assemble	1	lot			15	1.35	20	20	26
	installation	1	lot			4	1.35	5	5	
control house		1	lot			160	1	160	-	0
riverbed protection	concrete block	494	pcs	5	2	49.4	1.35	67	-	0
	riprup	1,998.00	m2	58.8	1	34	1.35	46	-	
temporary work	removal of temporary access road(ramp)	7,382	ｍ3	300	1	24.6	1.35	33	33	
	fire-flow inside cofferdam	1	lot			1	1	1	1	1
	removal for steel sheet pile									
	Ⅳw-type （driving L less 12m）	750	pcs	40	1	18.8	1.35	25	25	27
	Ⅲw-type （driving L less 15m）		pcs	43	1	0.0	1.35	0	-	
	tie-rod	1	lot						2	
removal for ex. structure	removal for outside of coffer dam	0	m3	63	1	0.0	1.35	0	0	
Bank protection	embankment	40,800.00	m3	350	2	58.3	1.35	79	79	
	driving sheet pile outside coffer dam Type-Ａ									
	Ⅳw型 （driving L less 23m） L=22.0m	111	枚	6	1	18.5	1.35	25	25	
	Ⅲw型 （(driving L less 6m） L=6.0m	94	枚	39	1	2.4	1.35	3	3	
	capping concrete for steel sheet pile	1	lot			38	1.35	51	26	
		1	lot			30	1.35	41	-	

Table 3-2.5 Critical pass work (Bahr Yusef) (5/5)

	curing	1	lot			5	1	5	-	
	driving sheet pile outside coffer dam Type-BL									
	Ⅳw type （driving L less 12m） L=12.0m	5	pcs	28	1	0.2	1.35	0	4	
	Ⅲw type （driving L less 6m） L=5.0m		pcs	35	1	0.0	1.35	0		
	capping concrete for steel sheet pile	1	lot			38	1.35	51	26	
		1	lot			30	1.35	41	-	
	curing	1	lot			5	1	5	-	
Gate facility work	water level indicator setting/adjustment	1	lot			7	1.35	9	-	
appurtenant work	embankment for left bank & road work	7,013.73	m3	250	2	14.0	1.35	19		
	curbstone work	625.34	m	22.5	2	13.9	1.35	19		
	base course t=20cm	1,766.29	m2	1,110	1	1.6	1.35	2		
	sub-base courset=20cm	1,766.29	m2	1,110	1	1.6	1.35	2		
	paving（surface）t=5cm	1,766.29	m2	2,300	1	0.8	1.35	1		
	paving（sublayer）t=6cm	1,766.29	m2	2,300	1	0.8	1.35	1		
	Footpath									
	base course t=15cm	306.44	m2	268	1	1.1	1.35	2		
	paving（surface) t=5cm	306.44	m2	940	1	0.3	1.35	0		
commissioning・inspection	commissioning・operation training					30	1	30	-	
temporary work	removal for temporary bridge									0
temporary bridge(across river)	removal H-beam （driving L less 6m）L=14.5	25	pcs	39	1	0.6	1.35	1		
	removal H-beam （driving L less 16m）L=21.5	15	pcs	22	1	0.7	1.35	1		
	removal for platform	56.5	t	8.3	1	6.8	1.35	9		
	removal for steel top deck	336	m2	111	1	3.0	1.35	4		
	removal for inside coffer dam soil	14,280	m3	300	1	47.6	1.35	64		
cleaning・handover						22	1.35	30		
				Critical pass days=			**768**	**days**		768
				Critical pass month=			**25.6**	**months ≒**	**25.5months**	25.6

Ibrahimia

Number of days for each work item

Table 3-2.6 Critical pass work (Ibrahimia) (1/5)

each work item	detail of each work	work quantity	unit	work volume a day	no.of party	working days	Working days coefficient	period of excecution	critical pass days	
Direct temporary work	setting barge for dredging for diversion canal									
	dredging for diversion canal									
	stone riprap for riverbed									
	removing barge for dredging for diversion canal									
inside of double sheet	erection of temporary bridge									
	driving H-beam （driving L less 8m）L=14.5 H350	24	pcs	16	1	1.5	1.35	2	2	
	driving H-beam （driving L less 8m）L=14.5 H400	124	pcs	13	1	9.5	1.35	13	13	
	erection for platform	215.5	t	8.3	1	26.0	1.35	35	35	
	installation for steel top deck	1,296	m2	111	1	11.7	1.35	16	16	
	driving steel sheet pile for cofferdam									
	Ⅳ-type （driving L less 12m） joint	712	pcs	8	1	89.0	1.35	120	120	
	(PU28+1 W=0.6m L=20.0m)									170
	installation for tie-rod	1	lot						2	
	filling for inside double sheet	14,620	m3	410	1	35.7	1.35	48	48	
Bank protection work	Bank protection by sheet pile(upstream,downstream at left bank)									0
	frontⅢw （driving L less 9m）L=16m D1PU18	6	pcs	12	1	0.5	1.35	1		
	Ⅳw （driving L less 9m）L=10m D2 PU12	9	pcs	33	1	0.3	1.35	0		
	frontⅢw （driving L less 9m）L=14m E1	5	pcs	16	1	0.3	1.35	0		
	Ⅳw （driving L less 12m）L=8m E2	3	pcs	11	1	0.3	1.35	0		
	backⅡw （driving L less 6m） L=6m PU12	6	pcs	39	1	0.2	1.35	0		
	Ⅱw （driving L less 6m） L=6m PU12	5	pcs	39	1	0.1	1.35	0		
	installation for tie-rod		pcs	40	1	0.0	1.35	0		
	capping concrete	1	lot			30	1.35	41	-	
temporary work										
	embankment for access road（upstream & downstream）	6,545	m3	410	2	8.0	1.35	11	11	
	embankment for temporary road on bottom area	492	m3	190	1	2.6	1.35	3	3	
	backfill for structure	740	m3	190	1	3.9	1.35	5	5	35
	hardening of soft soil(road and structure area)	1,514	m3	190	1	8.0	1.35	11	11	
	curing								3	

Table 3-2.7 Critical pass work (Ibrahimia) (2/5)

	dewatering of inside dam	1	lot			2	1	2	2	
temporary dewatering	wellpoint	1	lot							
removal for ex. structure	all removal (inside coffer dam)	0.00	m3	63	2	0.0	1.35	0	-	
earth work	preparation								3	
	excavation for structure inside coffer dam	13,540.00	m3	190	2	35.6	1.35	48	48	51
	embankment inside coffer dam(right bank)	1,200.00	m3	300	1	4.0	1.35	5		
	backfill	3,700.00	m3	350	2	5.3	1.35	7	-	
riverbed protection	driving cut-off sheet pile									
	Ⅳw （driving L less 12m）L-12.0m PU-12	60	pcs	28	1	2.1	1.35	3	3	
	Ⅱw （driving L less 6m）L=6.0m PU-12	59	pcs	39	1	1.5	1.35	2	2	
	Ⅱw （driving L less 4m）L=5.0m PU-12	60	pcs	39	1	1.5	1.35	2	2	7
	Ⅳw （(driving L less 9m）L-18.0m PU-18	1	pcs	12	1	0.1	1.35	0	0	
	Ⅳw （driving L less 6m）L-16.0m PU-18	1	pcs	13	1	0.1	1.35	0	0	
	Ⅳw （driving L less 6m）L-14.0m PU-12	1	pcs	17	1	0.1	1.35	0	0	
	Ⅳw （driving L less 4m） L-10.0m PU-12		pcs	42	1	0.0	1.35	0	0	
	cast-inplace concrete pile									
	φ1000 L=15.00m	56	pcs	3	1	18.7	1.35	25	25	
	φ1000 L=7.00m	32	pcs	3	1	10.7	1.35	14	14	
removing for temporary embankment										45
	removing for temporary embankment	1,232		190	1	6.5	1.35	9	5	
Concrete work	main structure lean concrete	154.6	m3	38.6	1	4.0	1.35	5	5	221
	base									
	scaffolding	476	m2	71	1	6.7	1.35	9	4	
	re-bar	269.03	t	3.3	2	40.8	1.35	55	55	
	formwork	694.36	m2	30	1	23.1	1.35	31	8	
	placing concrete	2,989.22	m3	182.6	1	33	1.35	45	-	
	pier									
	scaffolding	2,686.54	m2	71	1	37.8	1.35	51	4	
	re-bar	226.40	t	3.3	2	34.3	1.35	46	46	
	formwork	2,712.47	m2	30	3	30.1	1.35	41	8	
	placing concrete	2,515.56	m3	84	1	24	1.35	32	1	
	other concrete(support bridge etc)									
	re-bar	25.51	t	3.3	2	3.9	1.35	5	5	
	formwork	391.87	m2	30	3	4.4	1.35	6	8	
	placing concrete	283.45	m3	84	1	3.4	1.35	5	1	

Table 3-2.8 Critical pass work (Ibrahimia) (3/5)

	curing									
	removal of form & support									
	passage									
	scaffolding	0	m2	71	1	0.0	1.35	0	0	
	support	637.5	m3	71	1	9.0	1.35	12	6	
	re-bar	4.1	t	3.3	1	1.3	1.35	2	2	
	formwork	192.0	m2	30	1	6.4	1.35	9	9	
	placing concrete	45.8	m3	48	1	1.0	1.35	1	1	
	curing	1	lot			14	1	14	14	
	removal of form & support	3,680.40	m3	71	6	8.6	1.35	12	-	
	maintenance bridge									
	scaffolding	388.4	m2	71	2	2.7	1.35	4		
	support	2,700.00	m3	71	4	9.5	1.35	13		
	re-bar	46.3	t	3.3	2	7.0	1.35	9	9	
	formwork	759.4	m2	30	2	12.7	1.35	17		
	placing concrete	231.8	m3	153.8	1	6	1.35	8	8	
	curing	1	lot			14	1	14	14	
	removal of form・support	3,847.80	m3	71	6	9.0	1.35	12	12	
Gate facility work	**groove**	1	lot			30.0	1	30		
	installation for Gate									
	assemble	1	lot			15	1.35	20	20	26
	installation	1	lot			4	1.35	5	5	
Concrete work	**upper pier**									
	scaffolding	463	m2	71	2	3.3	1.35	4	2	
	re-bar	9.82	t	3.3	1	3.0	1.35	4	1	
	formwork	319.99	m2	30	2	5.3	1.35	7	2	
	placing concrete	109.14	m3		2	2.0	1.35	3	1	
	platform for operation									12
	suppoort	937.75	m3	71	2	6.6	1.35	9	2	
	re-bar	7.07	t	3.3	1	2.1	1.35	3	1	
	formwork	205.52	m2	30	2	3.4	1.35	5	2	
	placing concrete	78.58	m3		2	2.0	1.35	3	1	
	curing	1	lot	71	2			14		
	removal for form, scaffolding & support	1,143.27	m2							

Table 3-2.9 Critical pass work (Ibrahimia) (4/5)

Gate facility work	installation for groove	1	lot			40	1.35	54	-	0
	lifting gear assemble/installation/adjustment									
	assemble	1	lot			15	1.35	20	20	
										26
	installation	1	lot			4	1.35	5	5	
control house		1	lot			160	1	160	-	0
riverbed protection	concrete block	494	pcs	5	2	49.4	1.35	67	-	0
	riprup	1,998.00	m2	58.8	1	34	1.35	46	-	
temporary work	fire-flow inside cofferdam	1	lot			1	1	1	1	1
	removal for steel sheet pile									
	Ⅳw-type （driving L less 12m）	712	pcs	40	1	17.8	1.35	24	24	
	Ⅲw-type （driving L less 15m）		pcs	43	1	0.0	1.35	0	-	33
	tie-rod	1	lot						2	
	removal for inside coffer dam soil	14,620	m3	300	2	24.4	1.35	33	7	
removal for ex. structure	removal for outside of coffer dam	0	m3	63	1	0.0	1.35	0	0	
Bank protection	embankment	28,300.00	m3	350	2	40.4	1.35	55	55	20
	Gabion	800.00	pcs	4	5	40.0	1.35	54	54	54
	driving sheet pile outside coffer dam Type-F									
	Ⅳw-type （driving L less 23m） L=18.0m	121	pcs	9	1	13.4	1.35	18	3.5	
	Ⅲw-type（driving L less 6m） L=6.0m	104	pcs	39	1	2.7	1.35	4	2.5	
	capping concrete for steel sheet pile	1	lot			38	1.35	51	25.5	
		1	lot			30	1.35	41	-	
	curing	1	lot			5	1	5	-	
	driving sheet pile outside coffer dam Type-G									
	Ⅳw type （driving L less 12m） L=10.0m	5	pcs	28	1	0.2	1.35	0	3.5	
	Ⅲw type （driving L less 6m） L=5.0m		pcs	35	1	0.0	1.35	0		
	capping concrete for steel sheet pile	1	lot			38	1.35	51	25.5	
		1	lot			30	1.35	41	-	
	curing	1	lot			5	1	5	-	
Gate facility work	water level indicator setting/adjustment	1	lot			7	1.35	9	-	
appurtenant work	embankment for left bank & road work	2,469.03	m3	250	2	4.9	1.35	7	7	
	curbstone work	164.84	m	22.5	2	3.7	1.35	5	5	
	base course t=20cm	583.65	m2	1,110	1	0.5	1.35	1	1	
	sub-base courset=20cm	583.65	m2	1,110	1	0.5	1.35	1	1	

Table 3-2.10 Critical pass work (Ibrahimia) (5/5)

	paving(surface)t=5cm	4,075.00	m2	2,300	1	1.8	1.35	2	2	18
	paving(sublayer)t=6cm	4,075.00	m2	2,300	1	1.8	1.35	2	2	
	Footpath								0	
	base course t=15cm	82.42	m2	268	1	0.3	1.35	0	0	
	paving(surface) t=5cm	82.42	m2	940	1	0.1	1.35	0	0	
trial operation	Trial operation･operation training					30	1	30	30	30
temporary work	removal for temporary platform									0
inside of Coffer dam	removal H-beam （driving L less 6m）L=14.5	24	pcs	39	1	0.6	1.35	1		
	removal H-beam （driving L less 16m）L=21.5	124	pcs	22	1	5.6	1.35	8		
	removal for platform	215.5	t	8.3	1	26.0	1.35	35		
	removal for steel top deck	1,296	m2	111	1	11.7	1.35	16		
cleaning･handover						22	1.35	30	15	15
				Critical pass days=			**765**	**days**		765
				Critical pass month=			**25.5**	**months ≒**	**25.5months**	25.5

(2) small regulators

The number of days for each work item is shown from Table 3-2.11 to 3-2.24. The construction period is:

- Badraman: 9 months
- Diroutiah: 10 months
- Abo Gabal: 11 months
- Sahelyia: 10 months

Table 3-2.11 Number of days for work item (Badraman) (1/4)

Badraman

Number of days for each work item

each work item	detail of each work	work quantity	unit	work volume a day	no.of party	working days	Working days coefficient	period of excecution	critical pass days	
Preparation		1	lot					3	3	3
Temporary closure	Embankment（upstream）	1,768.20	m3	190	1	9.3	1.35	13	13	13
	Embankment（downstream）	802.20	m3	190	1	4.2	1.35	6	6	6
	sheet pile（single upstream）drivung L less 12m L-10m PU-28+1	46	pcs	20	1	2.3	1.35	3	3	
	sheet pile（double downstream） drivung L less 9m Ｌ＝8ｍ	53	pcs	25	1	2.1	1.35	3	3	
	support Ｈbeam for diversion canal driving L less 6m L=5m	17	pcs	31	1	0.5	1.35	1	1	9
	sheet pilefor diversion canal drivung L less 9m Ｌ＝8ｍ	34	pcs	25	1	1.4	1.35	2	2	
	support Ｈbeam for diversion canal driving L less 6m L=5m	12	pcs	31	1	0.4	1.35	1	1	
embankment at right bank	temporary road for excavation									
Temporary work	hardening of soft soil	500	m3	190	1	2.6	1.35	4	4	9
	curing	1	lot					5	5	
earth work	preparation								3	
	excavation inside coffer dam	1,030	m3	190	1	5.4	1.35	7	7	
	embankment at left bank inside coffer dam	160	m3	300	1	0.5	1.35	1	1	24
	embankment at right bank inside coffer dam	180	m3	300	1	0.6	1.35	1	1	
	back fill	710	m3	190	1	3.7	1.35	5	5	
	earth foundation grading	500	ｍ2	100	1	5.0	1.35	7	7	
riverbed protection	driving cut-off sheet pile									
	Ⅳw （driving L less 2m）L-2ｍ PU-12 upstream	14	pcs	55	1	0.3	1.35	0	0	1
	Ⅳw （driving L less 2m）L-2ｍ PU-12 downstream	14	pcs	55	1	0.3	1.35	0	0	
	Ⅱw （driving L less 4m）L=10m PU-18	2	pcs	42	1	0.0	1.35	0	0	
	Ⅳw （driving L less 4m）L-8.0m PU-12	2	pcs	45	1	0.0	1.35	0	0	
concrete work	main structure lean concrete	154.6	m3	38.6	1	4.0	1.35	5	5	95
	base									
	scaffolding	111.6	m2	71	1	1.6	1.35	2	2	
	re-bar	31.07	t	3.3	1	9.4	1.35	13	13	
	formwork	160.14	m2	30	1	5.3	1.35	7	4	
	placing concrete	345.17	m3	86	1	4.0	1.35	5	-	
	pier									
	scaffolding	634.00	m2	71	1	8.9	1.35	12	4	

Table 3-2.12 Number of days for work item (Badraman) (2/4)

	re-bar	24.45	t	3.3	1	7.4	1.35	10	10	
	formwork	559.62	m2	30	2	9.3	1.35	13	4	
	placing concrete	271.68	m3	45	1	6.0	1.35	8	1	
	other concrete(support bridge etc)									
	support		m3							
	re-bar	11.08	t	3.3	1	3.4	1.35	5	5	
	formwork	313.20	m2	30	2	5.2	1.35	7	2	
	placing concrete	123.11	m3	30	1	4.1	1.35	6	1	
	curing	1.00	lot							
	removal of form & support									
	passage									
	scaffolding	0	m2	71	1	0.0	1.35	0	0	
	support	45.8	m3	71	1	0.6	1.35	1	1	
	re-bar	0.7	t	3.3	1	0.2	1.35	0	0	
	formwork	32.0	m2	30	1	1.1	1.35	1	1	
	placing concrete	7.6	m3	7.6	1	1.0	1.35	1	1	
	curing	1	lot			14	1	14	14	
	removal of form & support	3,680.40	m3	71	6	8.6	1.35	12	-	
	maintenance bridge									
	scaffolding	42.7	m2	71	1	0.6	1.35	1	1	
	support	298.00	m3	71	1	4.2	1.35	6	3	
	re-bar	5.0	t	3.3	1	1.5	1.35	2	2	
	formwork	71.4	m2	30	1	2.4	1.35	3	4	
	placing concrete	34.1	m3	17	1	2.0	1.35	3	1	
	curing	1	lot			14	1	14	14	
	removal of form･support	412.10	m3	71	6	1.0	1.35	1	1	
Gate facility work	**groove**	1	lot			30.0	1	30		
	installation for Gate									
	assemble	1	lot			15	1.35	20	20	26
	installation	1	lot			4	1.35	5	5	
concrete work	**upper pier**									
	scaffolding	103	m2	71	1	1.4	1.35	2	2	
	re-bar	1.25	t	3.3	1	0.4	1.35	1	1	
	formwork	57.33	m2	30	1	1.9	1.35	3	3	
	placing concrete	13.86	m3		2	2.0	1.35	3	1	

Table 3-2.13 Number of days for work item (Badraman) (3/4)

	platform for operation									12
	suppoort	75.16	m3	71	1	1.1	1.35	1	2	
	re-bar	0.85	t	3.3	1	0.3	1.35	0	1	
	formwork	24.20	m2	30	1	0.8	1.35	1	1	
	placing concrete	9.45	m3	9.45	1	1.0	1.35	1	1	
	curing	1	lot					14	14	
	removal for form, scaffolding & support	99.36	m2							
Gate facility work	installation for groove	1	lot			40	1.35	54	-	0
	lifting gear assemble/installation/adjustment									
	assemble	1	lot			15	1.35	20	20	26
	installation	1	lot			4	1.35	5	5	
		1	lot			160	1	160	-	0
riverbed protection stone riprap										
	foundation gravel	210	m2	155	1	1.4	1.35	2	2	
	surface leveling	210.00	m2	89	1	2.4	1.35	3	3	6
	stone setting	84	m3	129	1	0.7	1.35	1	1	
temporary work	fire-flow inside cofferdam	1	lot			1	1	1	1	1
	removal of sheet pile									
	sheet pile（single upstream）drivung L less 12m L-10m PU-28+1	46	pcs	40	1	1.2	1.35	2	2	
	sheet pile（double downstream） drivung L less 9m Ｌ＝8ｍ	53	pcs	46	1	1.2	1.35	2	2	
	support Ｈbeam for diversion canal driving L less 6m L=5m	17	pcs	68	1	0.3	1.35	0	0	16
	sheet pilefor diversion canal drivung L less 9m Ｌ＝8ｍ	34	pcs	46	1	0.7	1.35	1	1	
	support Ｈbeam for diversion canal driving L less 6m L=5m	12	pcs	68	1	0.2	1.35	0	0	
	removal of embankment	2,570	m3	300	1	8.6	1.35	12	12	
removal for ex. structure	all removal (inside coffer dam)	0	m3	63	1	0.0	1.35	0	0	
Bank protection	embankment	340	m3	190	1	1.8	1.35	2	2	2
	Driving sheet pile inside dam Type-F									
	Ⅳw （driing L less 9m） L=10m PU18	11	pcs	29	1	0.4	1.35	1	1	1
	Ⅲw （driing L less 9m） L=8m PU12	6	pcs	33	1	0.2	1.35	0	0	
Gate facility work	water level indicator setting/adjustment	1	lot			7	1.35	9	-	
appurtenant work	embankment for left bank & road work	371.34	m3	250	1	1.5	1.35	2	2	
	curbstone work	205.44	m	22.5	1	9.1	1.35	12	12	
	base course t=20cm	853.38	m2	1,110	1	0.8	1.35	1	1	

Table 3-2.14 Number of days for work item (Badraman) (4/4)

	sub-base courset=20cm	853.38	m2	1,110	1	0.8	1.35	1	1	17
	paving（surface）t=5cm	853.38	m2	2,300	1	0.4	1.35	0	0	
	paving（sublayer）t=6cm								0	
	base course t=15cm	103.03	m2	268	1	0.4	1.35	1	1	
	paving（surface) t=5cm	103.03	m2	940	1	0.1	1.35	0	0	
commissioning・inspection	commissioning・operation training					15	1	15	15	15
	removal of soil inside dam		m3	300	1	0.0	1.35	0		
cleaning・handover						7	1.35	9		0
				Critical pass days=			**277**	**days**		277
				Critical pass month=			**9.2**	**months ≒**	**9 months**	9.2

Table 3-2.15 Number of days for work item (Diroutiah) (1/4)

Diroutiah

Number of days for each work item

each work item	detail of each work	work quantity	unit	work volume a day	no.of party	working days	Working days coefficient	period of excecution	critical pass days	
Temporary closure	Embankment（upstream）	1,768.20	m3	190	1	9.3	1.35	13	13	
	Embankment（downstream）	802.20	m3	190	1	4.2	1.35	6	6	
	sheet pile（single upstream) drivung L less 12m L-10m PU-28+1	46	pcs	20	1	2.3	1.35	3	3	
	sheet pile（double downstream） drivung L less 9m Ｌ＝8ｍ	53	pcs	25	1	2.1	1.35	3	3	27
	support Ｈbeam for diversion canal driving L less 6m L=5m	17	pcs	31	1	0.5	1.35	1	1	
	sheet pilefor diversion canal drivung L less 9m Ｌ＝8ｍ	34	pcs	25	1	1.4	1.35	2	2	
	support Ｈbeam for diversion canal driving L less 6m L=5m	12	pcs	31	1	0.4	1.35	1	1	
embankment at right bank	temporary road for excavation									
Temporary work	hardening of soft soil	650	ｍ3	190	1	3.4	1.35	5	5	10
	curing	1	lot					5	5	
earth work	preparation								3	
	excavation inside coffer dam	1,140.00	m3	190	1	6.0	1.35	8	8	
	embankment at left bank inside coffer dam	100.00	m3	300	1	0.3	1.35	0	0	24
	embankment at right bank inside coffer dam	230.00	m3	300	1	0.8	1.35	1	1	
	back fill	600.00	m3	190	1	3.2	1.35	4	4	
	earth foundation grading	500	ｍ2	100	1	5.0	1.35	7	7	
riverbed protection	driving cut-off sheet pile									
	Ⅳw （driving L less 2m）L-2ｍ PU-12 upstream	19	pcs	55	1	0.3	1.35	0	0	
	Ⅳw （driving L less 2m）L-2ｍ PU-12 downstream	19	pcs	55	1	0.3	1.35	0	0	1
	Ⅱw （driving L less 4m）L=10m PU-12	2	pcs	45	1	0.0	1.35	0	0	
	Ⅳw （driving L less 4m）L-8.0m PU-12	2	pcs	45	1	0.0	1.35	0	0	
concrete work	main structure lean concrete	24.28	m3	12	1	2.0	1.35	3	3	108
	base									
	scaffolding	119.1	m2	71	1	1.7	1.35	2	2	
	re-bar	43.07	t	3.3	1	13.1	1.35	18	18	
	formwork	182.92	m2	30	1	6.1	1.35	8	4	
	placing concrete	478.61	m3	86	1	5.6	1.35	8	-	
	pier									
	scaffolding	699.66	m2	71	1	9.9	1.35	13	4	
	re-bar	28.09	t	3.3	1	8.5	1.35	11	11	

Table 3-2.16 Number of days for work item (Diroutiah) (2/4)

	formwork	632.26	m2	30	1	21.1	1.35	28	8	
	placing concrete	312.09	m3	45	1	6.9	1.35	9	1	
	other concrete(support bridge etc)									
	re-bar	14.00	t	3.3	1	4.2	1.35	6	6	
	formwork	382.90	m2	30	2	6.4	1.35	9	2	
	placing concrete	155.56	m3	20	1	7.8	1.35	11	1	
	curing									
	removal of form & support									
	passage									
	scaffolding	0	m2	71	1	0.0	1.35	0	0	
	support	61.5	m3	71	1	0.9	1.35	1	1	
	re-bar	1.0	t	3.3	1	0.3	1.35	0	0	
	formwork	48.0	m2	30	1	1.6	1.35	2	2	
	placing concrete	11.5	m3	48	1	0.2	1.35	0	0	
	curing	1	lot			14	1	14	14	
	removal of form & support	3,680.40	m3	71	6	8.6	1.35	12	-	
	maintenance bridge									
	scaffolding	42.7	m2	71	1	0.6	1.35	1	1	
	support	424	m3	71	1	6.0	1.35	8	3	
	re-bar	7.4	t	3.3	1	2.2	1.35	3	3	
	formwork	106	m2	30	1	3.5	1.35	5	5	
	placing concrete	51.2	m3	24	1	2.1	1.35	3	3	
	curing	1	lot			14	1	14	14	
	removal of form・support	572.70	m3	71	6	1.3	1.35	2	2	
Gate facility work	**groove**	1	lot			30.0	1	30		
	installation for Gate									
	assemble	1	lot			15	1.35	20	20	
										26
	installation	1	lot			4	1.35	5	5	
concrete work	**upper pier**									
	scaffolding	114.57	m2	71	1	1.6	1.35	2	2	
	re-bar	1.48	t	3.3	1	0.4	1.35	1	1	
	formwork	70.11	m2	30	1	2.3	1.35	3	2	
	placing concrete	16.39	m3		2	2.0	1.35	3	1	
	platform for operation									12
	suppoort	101.13	m3	71	2	0.7	1.35	1	2	

Table 3-2.17 Number of days for work item (Diroutiah) (3/4)

	re-bar	1.22	t	3.3	1	0.4	1.35	0	1	
	formwork	33.95	m2	30	2	0.6	1.35	1	2	
	placing concrete	13.50	m3		1	2.0	1.35	3	1	
	curing	1	lot	71	2			14		
	removal for form, scaffolding & support	135.08	m2							
Gate facility work	installation for groove	1	lot			40	1.35	54	-	0
	lifting gear assemble/installation/adjustment									
	assemble	1	lot			15	1.35	20	20	26
	installation	1	lot			4	1.35	5	5	
		1	lot			160	1	160	-	0
riverbed protection stone riprap										
	foundation gravel	240	m2	155	1	1.5	1.35	2	2	
	surface leveling	240.00	m2	89	1	2.7	1.35	4	4	7
	stone setting	96	m3	129	1	0.7	1.35	1	1	
temporary work	fire-flow inside cofferdam	1	lot			1	1	1	1	1
	removal of sheet pile									
	sheet pile（single upstream）drivung L less 12m L-10m PU-28+1	46	pcs	40	1	1.2	1.35	2	2	
	sheet pile（double downstream） drivung L less 9m Ｌ＝8ｍ	53	pcs	46	1	1.2	1.35	2	2	
	support Ｈbeam for diversion canal driving L less 6m L=5m	17	pcs	68	1	0.3	1.35	0	0	16
	sheet pilefor diversion canal drivung L less 9m Ｌ＝8ｍ	34	pcs	46	1	0.7	1.35	1	1	
	support Ｈbeam for diversion canal driving L less 6m L=5m	12	pcs	68	1	0.176471	1.35	0	0	
	removal of embankment	2,570	m3	300	1	8.6	1.35	12	12	
removal for ex. structure	all removal (inside coffer dam)	0	m3	63	1	0.0	1.35	0	0	
Bank protection	embankment	330.00	m3	190	1	1.7	1.35	2	2	2
	Driving sheet pile inside dam Type-F									
	Ⅳw （driing L less 9m） L=10m PU12	11	pcs	29	1	0.4	1.35	1	1	1
	Ⅲw （driing L less 9m） L=8m PU12	7	pcs	33	1	0.2	1.35	0	0	
Gate facility work	water level indicator setting/adjustment	1	lot			7	1.35	9		
appurtenant work	embankment for left bank & road work	371.22	m3	250	1	1.5	1.35	2	2	
	curbstone work	269.44	m	22.5	1	12.0	1.35	16	16	
	base course t=20cm	1,027.81	m2	1,110	1	0.9	1.35	1	1	21
	sub-base courset=20cm	1,027.81	m2	1,110	1	0.9	1.35	1	1	
	paving（surface）t=5cm	1,027.81	m2	2,300	1	0.4	1.35	0	0	

Table 3-2.18 Number of days for work item (Diroutiah) (4/4)

	paving(sublayer) t=6cm								0	
	base course t=15cm	131.83	m2	268	1	0.5	1.35	1	1	
	paving(surface) t=5cm	131.83	m2	940	1	0.1	1.35	0		
commissioning・inspection	commissioning・operation training					15	1	15	15	15
	removal of soil inside dam		m3	300	1	0.0	1.35	0		
cleaning・handover						7	1.35	9		0
				Critical pass days=			**296**	**days**		296
				Critical pass month=			**9.9**	**months ≒**	**10 months**	9.9

Abo Gabal

Number of days for each work item

Table 3-2.19 Number of days for work item (Abo Gabal) (1/3)

each work item	detail of each work	work quantity	unit	work volume a day	no.of party	working days	Working days coefficient	period of excecution	critical pass days	
Preparation		1	lot					3	3	3
Embankment for Access road		626.8	m3	300	1	2.1	1.35	3	3	3
Temporary coffer dam	driving sheet pile river side driving L less 6m L=10m	116	pcs	31	1	3.7	1.35	5	5	26
	driving sheet pile excavation side driving L less 6m L=10m	80	pcs	31	1	2.6	1.35	3	3	
	installation for tie-rod	1	lot			0.0	1.35	7	7	
	filling for inside double sheet	2,377.35	m3	300	1	7.9	1.35	11	11	
Temporary diversion canal	driving sheet pile river side driving L less 6m L=6m	92	pcs	31	1	3.0	1.35	4	4	17
	driving sheet pile excavation side driving L less 6m L=6m	75	pcs	31	1	2.4	1.35	3	3	
	waling・strut・jack	1	pcs			0.0	1.35	0	0	
	inside excavation	286.30	m3	4	10	7.2	1.35	10	10	
embankment at right bank	temporary road for excavation									
Temporary work	hardening of soft soil	600	m3	190	1	3.2	1.35	4	4	9
	curing	1	lot					5	5	
earth work	preparation								3	21
	excavation inside coffer dam	1,510.00	m3	190	1	7.9	1.35	11	11	
	embankment at left bank inside coffer dam		m3	300	1	0.0	1.35	0	0	
	embankment at right bank inside coffer dam		m3	300	1	0.0	1.35	0	0	
	back fill	550.00	m3	100	1	5.5	1.35	7	7	
riverbed protection	driving cut-off sheet pile									
	upstream driving L less 2m L=2m	24	pcs	55	1	0.4	1.35	1	1	1
	upstream driving L less 2m L=10m	2	pcs	55	1	0.0	1.35	0	0	
concrete work	main structure lean concrete	18.81	m3	6	1	3.1	1.35	4	4	134
	base									
	scaffolding	119.1	m2	71	1	1.7	1.35	2	2	
	re-bar	58.30	t	3.3	1	17.7	1.35	24	24	
	formwork	173.54	m2	30	1	5.8	1.35	8	4	
	placing concrete	647.80	m3	130	1	5.0	1.35	7	-	
	pier									
	scaffolding	699.66	m2	71	1	9.9	1.35	13	4	
	re-bar	64.70	t	3.3	1	19.6	1.35	26	26	
	formwork	1,245.14	m2	30	2	20.8	1.35	28	8	
	placing concrete	718.92	m3	40	1	18.0	1.35	24	1	

Table 3-2.20 Number of days for work item (Abo Gabal) (2/3)

	other concrete(support bridge etc)									
	re-bar	0.00	t	3.3	2	0.0	1.35	0	0	
	formwork	0.00	m2	30	3	0.0	1.35	0	8	
	placing concrete	0.00	m3	20	1	0.0	1.35	0	1	
	curing									
	removal of form & support									
	passage									
	scaffolding	0	m2	71	1	0.0	1.35	0	0	
	support	61.2	m3	71	1	0.9	1.35	1	1	
	re-bar	0.7	t	3.3	1	0.2	1.35	0	0	
	formwork	32.0	m2	30	1	1.1	1.35	1	1	
	placing concrete	7.64	m3	7.64	1	1.0	1.35	1	1	
	curing	1	lot			14	1	14	14	
	removal of form & support	3,680.40	m3	71	6	8.6	1.35	12	-	
	maintenance bridge									
	scaffolding	388.4	m2	71	1	5.5	1.35	7	7	
	support	221.00	m3	71	1	3.1	1.35	4	4	
	re-bar	3.2	t	3.3	1	1.0	1.35	1	1	
	formwork	68.1	m2	30	1	2.3	1.35	3	3	
	placing concrete	26.98	m3	26.98	1	1.0	1.35	1	1	
	curing	1	lot			14	1	14	14	
	removal of form･support	677.50	m3	71	6	1.6	1.35	2	2	
Gate facility work	**groove**	1	lot			30.0	1	30		
	installation for Gate	1	lot			16	1.35	22	22	
	assemble									28
	installation	1	lot			5	1.35	7	7	
concrete work	**upper pier**									
	scaffolding	161.16	m2	71	1	2.3	1.35	3	2	
	re-bar	1.89	t	3.3	1	0.6	1.35	1	1	
	formwork	93.15	m2	30	1	3.1	1.35	4	2	
	placing concrete	21.05	m3		2	2.0	1.35	3	1	
	platform for operation									12
	suppoort	195.47	m3	71	2	1.4	1.35	2	2	
	re-bar	1.76	t	3.3	1	0.5	1.35	1	1	
	formwork	48.90	m2	30	2	0.8	1.35	1	2	
	placing concrete	19.50	m3		2	2.0	1.35	3	1	

Table 3-2.21 Number of days for work item (Abo Gabal) (3/3)

	curing	1	lot	71	2			14		
	removal for form, scaffolding & support	244.37	m2							
Gate facility work	installation for groove	1	lot			40	1.35	54	-	0
	lifting gear assemble/installation/adjustment									
	assemble	1	lot			12	1.35	16	16	22
	installation	1	lot			4	1.35	5	5	
		1	lot			160	1	160	-	0
			pcs	5	2	49.4	1.35	67	-	0
			m2	58.8	1	34	1.35	46	-	
temporary work	fire-flow inside cofferdam	1	lot			1	1	1	1	1
	removal for sheet pile for coffer dam									
	river side driving L less 6m L=10m	116	pcs	54	1	2.1	1.35	3	3	
	excavation side driving L less 6m L=10m	80	pcs	54	1	1.5	1.35	2	2	22
	tie-rod	1	lot						0	
	removal for inside soil	2,377.35	m3	190	1	12.5	1.35	17	17	
removal for diversion canal	river side driving L less 6m L=6m	92	pcs	54	1	1.7	1.35	2	2	
	excavation side driving L less 6m L=6m	75	pcs	54	1	1.4	1.35	2	2	14
	waling・strut・jack	1	lot							
	backfill	286	m3	4	10	7.2	1.35	10	10	
removal for ex. structure	all removal (inside coffer dam)	0	m3	63	1	0.0	1.35	0	0	
Bank protection work	Embankment	3,060.00	m3	350	2	4.4	1.35	6	6	6
	driving sheet pile Type-M									
	PU-12（driving L less 12m） L=10m front	75	pcs	28	1	2.7	1.35	4	4	6
	Ⅲw型 （driving L less 6m） L=6m back	72	pcs	39	1	1.8	1.35	2	2	
Gate facility work	water level indicator setting/adjustment	1	lot			7	1.35	9	-	
commissioning・inspection	commissioning・operation training					15	1	15	15	15
cleaning・handover						22	1.35	30		0
				Critical pass days=			**334**	**days**		334
				Critical pass month=			**11.1**	**months ≒**	**11 months**	11.1

Sahelyia

Table 3-2.22 Number of days for work item (Sahelyia) (1/3)

Number of days for each work item

each work item	detail of each work	work quantity	unit	work volume a day	no.of party	working days	Working days coefficient	period of excecution	critical pass days	
Preparation		1	lot					3	3	3
Embankment for Access road		460	m3	300	1	1.5	1.35	2	2	2
Temporary coffer dam	driving sheet pile river side driving L less 6m L=10m	115	pcs	31	1	3.7	1.35	5	5	
	driving sheet pile excavation side driving L less 6m L=10m	77	pcs	31	1	2.5	1.35	3	3	24
	installation for tie-rod	1	lot					5	5	
	filling for inside double sheet	2,316.60	m3	300	1	7.7	1.35	10	10	
Temporary diversion canal	driving sheet pile river side driving L less 6m L=6m	76	pcs	31	1	2.5	1.35	3	3	
	driving sheet pile excavation side driving L less 6m L=6m	89	pcs	31	1	2.9	1.35	4	4	
	waling・strut・jack	1	lot							18
	inside excavation	307.30	m3	4	10	7.7	1.35	10	10	
embankment at right bank	temporary road for excavation									
Temporary work	hardening of soft soil	600	m3	190	1	3.2	1.35	4	4	9
	curing	1	lot					5	5	
earth work	preparation								3	
	excavation inside coffer dam	1,010.00	m3	190	1	5.3	1.35	7	7	
	embankment at left bank inside coffer dam		m3	300	1	0.0	1.35	0	0	17
	embankment at right bank inside coffer dam		m3	300	1	0.0	1.35	0	0	
	back fill	510.00	m3	100	1	5.1	1.35	7	7	
riverbed protection	driving cut-off sheet pile									
	upstream driving L less 2m L=2m	14	pcs	55	1	0.3	1.35	0	0	0
	upstream driving L less 2m L=12m	2	pcs	55	1	0.0	1.35	0	0	
concrete work	main structure lean concrete	15.61	m3	5.2	1	3.0	1.35	4	4	108
	base									
	scaffolding	119.1	m2	71	1	1.7	1.35	2	4	
	re-bar	25.97	t	3.3	1	7.9	1.35	11	11	
	formwork	121.94	m2	30	1	4.1	1.35	5	4	
	placing concrete	288.50	m3	58	1	5.0	1.35	7	-	
	pier									
	scaffolding	699.66	m2	71	1	9.9	1.35	13	4	
	re-bar	37.82	t	3.3	1	11.5	1.35	15	15	

Table 3-2.23 Number of days for work item (Sahelyia) (2/3)

	formwork	795.16	m2	30	2	13.3	1.35	18	8	
	placing concrete	420.22	m3	23	1	18.3	1.35	25	1	
	other concrete(support bridge etc)									
	re-bar	0.00	t	3.3	2	0.0	1.35	0	0	
	formwork	0.00	m2	30	3	0.0	1.35	0	8	
	placing concrete	0.00	m3	20	1	0.0	1.35	0	1	
	curing									
	removal of form & support									
	passage									
	scaffolding		m2	71	1	0.0	1.35	0	0	
	support	37.8	m3	71	1	0.5	1.35	1	1	
	re-bar	0.3	t	3.3	1	0.1	1.35	0	0	
	formwork	16.0	m2	30	1	0.5	1.35	1	1	
	placing concrete	3.82	m3	3.82	1	1.0	1.35	1	1	
	curing	1	lot			14	1	14	14	
	removal of form & support	3,680.40	m3	71	6	8.6	1.35	12	-	
	maintenance bridge									
	scaffolding	388.4	m2	71	1	5.5	1.35	7	7	
	support	141.70	m3	71	1	2.0	1.35	3	3	
	re-bar	1.6	t	3.3	1	0.5	1.35	1	1	
	formwork	34.5	m2	30	1	1.2	1.35	2	2	
	placing concrete	13.53	m3	7	1	1.9	1.35	3	3	
	curing	1	lot			14	1	14	14	
	removal of form・support	564.60	m3	71	6	1.3	1.35	2	2	
Gate facility work	**groove**	1	lot			30.0	1	30		
	installation for Gate									
	assemble	1	lot			15	1.35	20	20	26
	installation	1	lot			4	1.35	5	5	
concrete work	**upper pier**									
	scaffolding	131.04	m2	71	1	1.8	1.35	2	2	
	re-bar	1.42	t	3.3	1	0.4	1.35	1	1	
	formwork	65.61	m2	30	1	2.2	1.35	3	2	
	placing concrete	15.80	m3		2	2.0	1.35	3	1	
	platform for operation									11
	suppoort	115.33	m3	71	1	1.6	1.35	2	2	
	re-bar	0.95	t	3.3	1	0.3	1.35	0	1	

Table 3-2.24 Number of days for work item (Sahelyia) (3/3)

	formwork	27.10	m2	30	1	0.9	1.35	1	1	
	placing concrete	10.50	m3	10.5	1	1.0	1.35	1	1	
	curing	1	lot	71	2			14		
	removal for form, scaffolding & support	142.43	m2							
Gate facility work	installation for groove	1	lot			40	1.35	54	-	0
	lifting gear assemble/installation/adjustment									
	assemble	1	lot			15	1.35	20	20	
										26
	installation	1	lot			4	1.35	5	5	
		1	lot							0
riverbed protection	concrete block		pcs	5	2	0.0	1.35	0	-	0
	riprup		m2	58.8	1	0.0	1.35	0	-	
temporary work	fire-flow inside cofferdam	1	lot				1	0	1	1
	removal for sheet pile for coffer dam									
	river side driving L less 6m L=10m	115	pcs	54	1	2.1	1.35	3	3	
	excavation side driving L less 6m L=10m	77	pcs	54	1	1.4	1.35	2	-	16
	tie-rod	1	lot						2	
	removal for inside soil	1,544	m3	190	1	8.1	1.35	11	11	
removal for diversion canal	river side driving L less 6m L=6m	76	pcs	54	1	1.4	1.35	2	2	
	excavation side driving L less 6m L=6m	89	pcs	54	1	1.6	1.35	2	2	
	waling・strut・jack	1	lot							14
	backfill	307.30	m3	4	10	7.7	1.35	10	10	
removal for ex. structure	all removal (inside coffer dam)	0	m3	63	1	0.0	1.35	0	0	
Bank protection work	Embankment	1,320.00	m3	350	2	1.9	1.35	3	3	3
	driving sheet pile Type-H									
	PU-12（driving L less 12m） L=10m front	32	pcs	28	1	1.1	1.35	2	4	
	Ⅲw型 （driving L less 6m） L=6m back	32	pcs	39	1	0.8	1.35	1	3	
Gate facility work	water level indicator setting/adjustment	1	lot			7	1.35	9	-	
commissioning・inspection	commissioning・operation training					15	1	15	15	15
cleaning・handover						22	1.35	30		0
				Critical pass days=			**287**	**days**		287
				Critical pass month=			**9.6**	**months ≒**	**10 months**	9.6

3-3 Construction schedule

Table 3-3.1 Construction schedule (large regulators)

		First year	Second year	Third year	Fourth year	Fifth year	Note
Preparatory and Procurement work		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 34 35 36	37 38 39 40 41 42 43 44 45 46 47 48	49 50 51 52	
-01	Preparatory works						
-04	Procurement and Installation of the Concrete Plant						
-05	Procurement of Steel materials for Temporary and Permanent						
-06	Procurement of the gate facility						
Critical Path of the Regulator Construction							
	Bahr-Yusef						
	Ibrahimia						
	Integration trial operation/Operation Training						
	Finishing/Clearance/Handover						
Detail of Critical path							
	Bahr-Yusef						
-01	Preparatory works						
-02	Dredging for Diversion Canal・Stone Riprap for Riverbed (t=0.5m)						
-03	Temporary Bridge(River crossing and inside of Sheet pile)						
-04	Temporary Double Sheet Pile Coffer Dam wc						
-05	Embankment for Temporary road・Hardening for Soft soil						
-06	Earth work for inside dam						
-07	Cut-off sheet pile						
-08	Foundation Pile work・Removal for Temporary embankment						
-09	Structure Concrete work						
-10	Installation work of the gate and hoist facility						
-11	Removal work of Temporary Bridge and Coffer Dam						
-12	Embankment・Gabion・Bank protection・Road Work						
	Ibrahimia						
-01	Platform for Sheet pile inside Coffer Dam・Dredging、Stone Riprap for Riverbed (t=0.5m)						
-02	Temporary Double Sheet Pile Coffer Dam work						
-03	Embankment for Temporary road・Hardening for Soft soil						
-04	Earth work for inside dam						
-05	Cut-off sheet pile						
-06	Foundation Pile work・Removal for Temporary embankment						
-07	Structure Concrete work						
-08	Installation work of the gate and hoist facility						
-09	Removal work of Sheet pile for Coffer Dam						
-10	Embankment・Gabion						
-11	Bank protection						
-12	Road Work						
-13	Local control House						
-14	Integration trial operation/Operation Training						
-15	Finishing/Clearance/Handover						
Each ReguLator Construction Schedule							
-01	Bahr-Yusef						
-02	Ibrahimia						
-03	Badraman/Dairoutiah						
-04	Abo Gabal/Sahelyia						
-05	Finishing/Clearance/Handover						
Building Work							
-01	Control house/Monitoring hoise						
-02	Stop log house						
-03	Local control House for Bahr-Yusef						
-04	Local control House for Ibrahimia						
Water Mnagement System							
-01	Water Mnagement System						

Table 3-3.2 Construction schedule (small regulators)

		First year												Second year												Third year												Fourth year												Fifth year				Note
Detail of Critical path for Small Regulator		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	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	
	Badraman																																																					
−01	Preparatory works・Temporary Embankment for Coffer Dam・Steel Sheet Pile																																																					
−02	Hardning for Soft Soil・Earth Work・Cut-off Steel Sheet Pile																																																					
−03	Structure Concrete work																																																					
−04	Installation work of the gate and hoist facility																																																					
−05	Bank Protection・Stone Riprap・Removal for Embankment for Coffer Dam & Sheet pile																																																					
−06	Road Work・Trial Operatio																																																					
	Diroutiah																																																					
−01	Preparatory works・Temporary Embankment for Coffer Dam・Steel Sheet Pile																																																					
−02	Hardning for Soft Soil・Earth Work・Cut-off Steel Sheet Pile																																																					
−03	Structure Concrete work																																																					
−04	Installation work of the gate and hoist facility																																																					
−05	Bank Protection・Stone Riprap・Removal for Embankment for Coffer Dam & Sheet pile																																																					
−06	Road Work・Trial Operation																																																					
	Abo Gabal																																																					
−01	Preparatory works・Embankment for Access Road・Sheet pile for Coffer Dam & Temporary Canal																																																					
−02	Hardning for Soft Soil・Earth Work・Cut-off Steel Sheet Pile																																																					
−03	Structure Concrete work																																																					
−04	Installation work of the gate and hoist facility																																																					
−05	Bank Protection・Stone Riprap・Removal for Embankment for Coffer Dam & Sheet pile																																																					
−06	Trial Operation																																																					
	Sahelyia																																																					
−01	Preparatory works・Embankment for Access Road・Sheet pile for Coffer Dam & Temporary Canal																																																					
−02	Hardning for Soft Soil・Earth Work・Cut-off Steel Sheet Pile																																																					
−03	Structure Concrete work																																																					
−04	Installation work of the gate and hoist facility																																																					
−05	Bank Protection・Stone Riprap・Removal for Embankment for Coffer Dam & Sheet pile																																																					
−06	Trial Operation																																																					
	Water Management System																																																					
	Civil works																																																					
−01	Assiut (4 sites)																																																					
−02	West Minia (6 sites)																																																					
−03	East Minia (8 sites)																																																					
−04	Beni suef and Fayoum (8 sites)																																																					
	Electrical works																																																					
−01	Master station (Dirout)																																																					
−02	Monitoring station (Minia)																																																					
−03	Assiut (4 sites)																																																					
−04	West Minia (6 sites)																																																					
−05	East Minia (8 sites)																																																					
−06	Beni suef and Fayoum (8 sites)																																																					
−07	Software development in cairo																																																					
−08	Commissioning test																																																					

4. Project Cost Estimation

4-1 Criteria and manual of project cost estimation

There are no official standards for construction cost estimation in Egypt. The project cost is estimated by using Japanese Standards articulated in *JICA's Design & Estimation Manual, Estimate Standards* (hereinafter referred to as 'Manual').

(1) Time of cost estimation and expected commencement date

Time of cost estimation is January 2017. The commencement date is expected in February 2018 according to the memorandum signed on July 2015. The amount of price escalation from the time of cost estimation to the project completion date is included in the price contingency.

(2) Exchange rate

A fixed exchange rate system in the Egyptian market was shifted to a flexible exchange rate system on 3rd of November 2016. At the beginning of the trading, the US$-LE exchange rate was provisionally set at US$1 = LE13, a devaluation of approximately 48%. Also, a reduction of the fuel subsidy was made on 4th of November 2016, and the prices of gasoline, diesel oil, and butane gas were raised.

As of April 2017, the exchange rate system completely shifted to the flexible exchange rate. As a result, the value of LE was going down about half.

These changes in the economic policy of the Egyptian government were the conditions for receiving a loan from the IMF. The exchange rate and the prices will be affected by the policy for a while, and the unstable situation with Egyptian market is predicted to continue.

In order to reflect such social context to the detail cost estimation, exchange rate was applied as the average rate for the three months from February to April 2017, and the risk due to the rapid price increase and unstable exchange rate after November 2016 is covered by the consideration of the price contingency.

As a result, the exchange rate is calculated as follows;

1USD = ¥113.34, 1EUR = ¥121.26, 1LE = ¥6.49

(3) Working days coefficient

1.35 of the ratio was applied to the working days coefficient.

(4) Indirect cost

The ratio of indirect cost was applied based on the cost calculations in the Minutes of Discussions (May 2014).

- Indirect cost for Civil and Temporary Works : 35% of each direct cost
- Indirect cost for Gate Manufacture : 3% of the direct cost

(5) Unit price of manpower, materials, and rental fee of heavy equipment etc.

- Regarding the unit price of manpower, materials, and rental fee of heavy equipment etc. which are from Japan, the unit price was applied as 90% of the average price between two books for monthly unit price published in Japan. When there was any item not described on the two books, competitive estimations from three companies were applied.
- Labor fee for public work in Tokyo is applied to the unit price of Japanese skilled labor.
- Regarding the unit price of manpower, materials, and rental fee of heavy equipment etc. in Egypt, 100% of the average price of the competitive estimations from three companies was applied.

(6) Price escalation

The price escalation rate in the target country is calculated using the economic growth rate of the world economy and the predicted value of inflation rate set by the IMF.

However, because the avobe calculation method of the price escalation rate is not considered the recent rapid price increase, it is not reflected in reality. Therefore, the recent price escalation was reflected by additional calculation applying a monthly inflation rate issued by the Central Bank of Egypt.

- Price escalation rate for LC :
  total ratio is 18.9% (17.2% of recent price escalation + 1.0% per year during construction)
- Price escalation rate for FC :
  total ratio is 4.2% (1.6% per year during construction)

(7) Depreciation ratio for temporary steel material

Steel material for temporary works has a remaind value even after the completion of the construction. The depreciation ratio for temporary steel material was applied 50% according to the Egyptian law.

4-2 Estimation of the project cost

Project cost estimation was carried out based on final design and quauntity which was discussed after submitting the B/D report.

According to the discussion on the B/D cost estimation, the procurement of steel material was changed from Japan to a third country in Europe, and small scale gates and stoplogs were also changed to be procured in Egypt.

The changing points on the design of regulators from the B/D stage are as follows:

(1) Foundation work: from steel sheet pile to cast-in-place RC pile

(2) Bank protection: embankment and gabion protection were newly added at downstream of the left bank of the Bahr Yusef canal and the right bank of the Ibrahimia canals

(3) Dewatering method: from deepwell method to well-point method

The construction and project cost calculated by the above conditions are as follows. It is the approved cost in the 28th TAC meeting on 26th April 2017, and the updated cost of Integrated Water Management System needs to refer to “Volume II Water Management System”.

Table 4-2.1 Construction and project cost estimation

Item	Unit	Quantity	Amount			Total
			US$	LE	YEN	(Exchange to "YEN")
I Construction Cost	**L.S**	**1**	**6,138,654**	**377,480,579**	**2,219,659,487**	**5,365,263,000**
(breakdown)						
A. Civil Works	L.S	1	1,422,252	213,048,447	1,870,904,765	3,414,787,000
B. Temporary works	L.S	1	4,309,402	117,144,168	348,754,722	1,597,447,000
C. Building works	L.S	1		4,589,565		29,786,000
D. Integrated Water Management System	L.S	1		42,698,399		277,112,000
E. Dispute Board	L.S	1	407,000			46,129,000
II Consultant Service	**L.S**	**1**		**17,131,288**	**277,426,230**	**388,607,000**
III Contingency for Construction	**L.S**	**1**	**577,647**	**93,785,050**	**208,869,958**	**883,006,000**
(breakdown)						
Price Contingency	L.S	1	257,823	71,343,829	93,225,698	585,469,000
Physical Contingency	L.S	1	319,824	22,441,220	115,644,259	297,537,000
IV Contingency for Consultant Service	**L.S**	**1**		**4,256,269**	**26,105,808**	**53,729,000**
(break down)						
Price Contingency	L.S	1		3,237,813	11,651,902	32,665,000
Physical Contingency	L.S	1		1,018,455	14,453,907	21,064,000
V Interest During Construction	**L.S**	**1**			**20,100,000**	**20,100,000**
Project Cost (I～V)			**6,716,301**	**492,653,185**	**2,752,161,483**	**6,710,705,000**
VI Other Cost Estimation	**L.S**	**1**		**94,821,619**		**615,391,000**
(breakdown)						
Administration Cost	L.S	1		25,850,173		167,767,000
VAT	L.S	1		68,971,446		447,624,000
Front-end Fee	L.S	1		-		-
Total Project Cost (I～VI)			**6,716,301**	**587,474,805**	**2,752,161,483**	**7,326,096,000**

This project is aimed at STEP (Special Terms for Economic Partnership) of Japanese ODA Loans. The following items are mainly expected to be applied in this project;

- Steel double-sheet pile method
- overflow double-leaf gate to regulators

Ratio of the goods and services to be procured from Japan (“the Ratio”) is shown in Table 4-2.2.

Table 4-2.2 Ratio for STEP loan

Item	Grade	Detail	Unit	Quantity	Amount
A-11. Gate manufactures and works					
1. Gate manufacture	gate leaf	6.0×6.55	L.S	2.0	324,769,300
	gate guide		L.S	2.0	272,305,220
	hoisting device	hydraulic	L.S	2.0	846,320,100
	remote operation system		L.S	2.0	228,439,580
1. Installation for manufactures	Japanese mechanical engineer		day	1,050.0	31,403,295
	Japanese electrical engineer fo		day	1,050.0	35,009,415
sub-total					1,738,246,910
A-12. Expense of the machine and facilities					
1. Rent fee for heavy equipment	2). Vibration hunmer (1)	Hydraulic, 232KW	day	1,507.0	42,926,895
sub-total					42,926,895
B-1. Temporary Coffer Dam					
1. Double sheet pile	14). Japanese sheet pile operat		day	2,190.0	79,914,195
sub-total					79,914,195
B-8. Transportation / Shipment					
	B-8-13. packing	951.0 F/T	L.S	1.0	12,754,883
	B-8-14. loading		L.S	1.0	7,095,825
	B-8-15. ocean transpotation		F/T	951.0	26,190,947
sub-total					46,041,655
Total					1,907,129,655

Ratio of the goods and services to be procured from Japan

1) Construction Cost 5,365,263 10^3 YEN

2) Cost of the goods and services to be procured from Japan 1,907,130 10^3 YEN

2)／1)＝ 35.5% ＞30%

Table 4-2.3 Summary of the project cost estimation

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

Exchange Rate	1USD= 113.34 (YEN)
	1EUR= 121.26 (YEN)
	1LE= 6.49 (YEN)

Item				Unit	Quantity	Amount			Total (Exchange to YEN)	Remarks
						US$	LE	YEN		
I Construction Cost	I-1 Direct Cost	A. Civil Works	A-1. Excavation	L.S	1.0		4,438,016.50		28,802,000	
			A-2. Embankment	L.S	1.0		18,815,688.70		122,113,000	
			A-3. Demolition work	L.S	1.0		131,996.64		856,000	
			A-4. Sheet pile bank protection	L.S	1.0	636,160.04	5,394,080.56	6,996,465	114,106,000	
			A-5. Bank protection	L.S	1.0		5,023,275.06	10,700,560	43,301,000	
			A-6. Canal bed protection	L.S	1.0	196,050.69	2,641,631.39		39,364,000	
			A-7. Concrete work for regulators	L.S	1.0		44,873,249.71	686,206	291,913,000	
			A-8. Pile foundation work	L.S	1.0		13,382,883.34		86,854,000	
			A-9. Accessory works	L.S	1.0		19,516,170.59	17,569,265	144,229,000	
			A-10. Electric works	L.S	1.0		3,626,535.45	8,650,000	32,186,000	
			A-11. Gate manufactures and works	L.S	1.0		19,081,522.83	1,672,334,600	1,796,173,000	
			A-12. Expense of the machine and facilities	L.S	1.0	221,309.66	23,815,178.13	53,661,990	233,305,000	
		sub total (A. Civil works)				1,053,520.39	160,740,228.90	1,770,599,086	2,933,209,000	
		B. Temporary Works	B-1. Temporary Coffer Dam	L.S	1.0	840,284.40	19,099,569.97	110,691,135	329,885,000	
			B-2. Single Sheet Pile	L.S	1.0	438,170.24	2,790,300.38	6,347,427	74,118,000	
			B-3. Temporary bridge	L.S	1.0		4,976,786.73	53,423,642	85,722,000	
			B-4. Dewatering	L.S	1.0		10,519,709.00		68,272,000	
			B-5. Temporary road & preparation	L.S	1.0		7,783,260.59		50,513,000	
			B-6. diversion works	L.S	1.0		11,759,640.95		76,320,000	
			B-7. Other temporary works	L.S	1.0		18,178,115.27	17,112,000	135,087,000	
			B-8. Transpotation / Shipment	L.S	1.0	1,913,684.57	13,325,895.23	75,199,059	378,581,000	
		sub total (B. Temporary works)				3,192,139.21	88,433,278.12	262,773,263	1,198,502,000	
		C. Building Works	C-1. Control house	L.S	1.0		1,977,700.00		12,835,000	
			C-2. Local contrl house	L.S	1.0		301,900.00		1,959,000	
			C-3. Local contrl house	L.S	1.0		301,900.00		1,959,000	
			C-4. Stop log room	L.S	1.0		818,200.00		5,310,000	
		sub total (C. Building works)					3,399,700.00		22,064,000	
		D. Integrated Water Management System	D-1. IWMS manufactures	L.S	1.0		15,676,546.12		101,740,000	
			D-2. Installation for IWMS	L.S	1.0		15,951,897.71		103,527,000	
		sub total (D. Integrated Water Management System)					31,628,443.83		205,268,000	
		E. Dispute Board	E-1. Dispute Board	L.S	1.0	407,000.00			46,129,000	
		sub total (E. Dispute Board)				407,000.00			46,129,000	
						4,652,659.60	284,201,650.85	2,033,372,349	4,405,173,000	
	I-2 Indirect Cost					1,485,994.40	93,278,928.15	186,287,138	960,089,000	
						6,138,654.00	377,480,579.00	2,219,659,487	**5,365,263,000**	
						13.0%	45.7%	41.3%		
II Consultant Service	Remuneration			L.S	1.0		10,092,110.00	230,823,000	296,320,000	
	Direct Expense			L.S	1.0		7,039,178.00	46,603,230	92,287,000	
							17,131,288.00	277,426,230	**388,607,000**	
III Contingency for Construction	Price Contingency		LC: 1.0%/year, total ratio is 18.9%	L.S	1.0		71,343,829.43		**463,021,000**	
			FC: 1.6%/year, total ratio is 4.2%	L.S	1.0	257,823.47		93,225,698	**122,448,000**	
	Physical Contingency			%	5.0	319,823.87	22,441,220.42	115,644,259	**297,537,000**	
Ⅳ Contingency for Consultant Service	Price Contingency		LC: 1.0%/year, total ratio is 18.9%	L.S	1.0		3,237,813.43		**21,013,000**	
			FC: 1.6%/year, total ratio is 4.2%	L.S	1.0			11,651,902	**11,652,000**	
	Physical Contingency			%	5.0		1,018,455.07	14,453,907	**21,064,000**	
V Interest During Construction	0.01 %/year			L.S	1.0			20,100,000	**20,100,000**	

	US$	LE	YEN	Total	Remarks
Total Construction Cost (I～V)	6,716,301.34	492,653,185.36	2,752,161,483	**6,710,705,000**	
	11.3%	47.6%	41.1%		

Table 4-2.4 Bill of quantities (1/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
I Construction Cost										6,138,654.00	377,480,579.00	2,219,659,487	**5,365,263,489**	
I-1 Direct Cost										4,652,659.60	284,201,650.85	2,033,372,349	**4,405,173,502**	
A. Civil Works										1,053,520.39	160,740,228.90	1,770,599,086	**2,933,209,173**	
A-1. Excavation	A-1-1. Excavation	1. excavation	1). excavation and loading	0.8m3 back hoe	m3	23,390.0		19.82			463,589.80		3,008,698	
			2). excavation for concrete basement	0.8m3 back hoe	m3	1,320.0		28.32			37,382.40		242,612	
		sum									500,972.20		3,251,310	
		2. excavated soil disposal	1). excavated soil disposal	Distance 20km	m3	24,710.0		159.33			3,937,044.30		25,551,418	
total											4,438,016.50		28,802,727	
A-2. Embankment	A-2-1. Embankment	1. Embankment	1). backfill 1	15t bulldozer	m3	76,490.0		37.90			2,898,971.00		18,814,322	
			2). backfill 2	vibration roller,tamping machine	m3	7,470.0		45.37			338,913.90		2,199,551	
			3). material fee for backfill	sand	m3	60,873.0		67.10			4,084,578.30		26,508,913	
		sum									7,322,463.20		47,522,786	
		2. transportation fee for buying material	1). excavation and loading	0.8m3 back hoe loose soil	m3	60,873.0		19.22			1,169,979.06		7,593,164	
			2). transportation by damp truck	Distance 20km	m3	60,873.0		135.51			8,248,900.23		53,535,362	
		sum									9,418,879.29		61,128,527	
		3. transportation fee for reused material	1). excavation and loading	0.8m3 back hoe loose soil	m3	45,183.0		19.22			868,417.26		5,636,028	
			2). transportation by damp truck	Distance 0.3km	m3	45,183.0		18.47			834,530.01		5,416,100	
		sum									1,702,947.27		11,052,128	
		4. Earth finishing	1). earth finishing foundation		m3	4,640.0		7.36			34,150.40		221,636	
			2). rough finishing	0.8m3 back hoe	m2	1,610.0		34.70			55,867.00		362,577	
		sum									90,017.40		584,213	
		5. protection fence for waterpollution	1). protection fence		m	253.0		1,112.18			281,381.54		1,826,166	
total											18,815,688.70		122,113,820	
A-3. Demolition work	A-3-1. Demolition work	1. Demolition work	1). concrete demolition	reinforced concrete	m3	195.4		469.06			91,663.70		594,897	
			2). concrete demolition	plain concrete	m3	5.8		224.59			1,298.13		8,425	
			3). breaked concrete disposal	Distance 20km	m3	201.2		194.01			39,034.81		253,336	
total											131,996.64		856,658	
A-4. Sheet pile bank protection	A-4-1. Capping concrete	1. crown works	1). formwork	reinforced concrete	m2	1,663.9		400.74			666,791.28		4,327,475	
			2). placing reinforced concrete	25N/mm2 by crane	m3	517.9		1,356.29			702,409.02		4,558,635	
			3). curing	reinforced concrete	m3	517.9		7.83			4,055.07		26,317	
			4). bending,cutting and placing for re-bar	D12	t	13.6		18,857.16			256,777.94		1,666,489	
			5). joint filler	@10m	m2	53.5		403.70			21,614.09		140,275	
	sub total										1,651,647.40		10,719,192	
	A-4-2. Sheet pile	1. Sheet pile protection	1). driving sheet pile	PU18, L≦15m (driving length)	sheet	126.0		1,466.45			184,772.70		1,199,175	
				PU18, L≦12m (driving length)	sheet	146.0		1,231.17			179,750.82		1,166,583	
				PU18, L≦9m (driving length)	sheet	43.0		997.84			42,907.12		278,467	
				PU12, L≦12m (driving length)	sheet			1,055.19						
				PU12, L≦9m (driving length)	sheet	62.0		880.52			54,592.24		354,304	
				PU12, L≦6m (driving length)	sheet	486.0		761.90			370,283.40		2,403,139	
				PU12, L≦4m (driving length)	sheet			645.24						
				PU12, L≦2m (driving length)	sheet			527.92						
			2). Sheet pile press fitting	PU, L≦15m (driving length)	sheet			165.71	5,233					
				PU, L≦12m (driving length)	sheet			130.98	4,139					
			3). Mobilization & demobilization	press fitting machine for sheet pile	nos			700.36	19,332					
			4). material fee for sheet pile	PU12, 18	t	722.1	881.00			636,160.04			72,102,379	
			5). installation for tie-rod and waling		t	47.7		3,311.13			157,866.66		1,024,555	
			6). material fee for tie-rod (NHT690)	φ46 L=10.0m 2pcs/rod	nos	2.0			68,175			136,350	136,350	
				φ46 L=11.0m 2pcs/rod	nos	2.0			74,295			148,590	148,590	
				φ46 L=11.5m 2pcs/rod	nos	23.0			77,040			1,771,920	1,771,920	
				φ46 L=12.0m 2pcs/rod	nos	20.0			79,785			1,595,700	1,595,700	
				φ46 L=13.0m 2pcs/rod	nos	2.0			85,905			171,810	171,810	
				φ46 L=13.5m 2pcs/rod	nos	8.0			89,325			714,600	714,600	
				φ46 L=14.0m 2pcs/rod	nos	6.0			92,025			552,150	552,150	
				φ42 L=12.0m 2pcs/rod	nos	8.0			51,255			410,040	410,040	
				φ42 L=9.0m 2pcs/rod	nos	2.0			53,595			107,190	107,190	
				φ42 L=8.5m 2pcs/rod	nos	9.0			69,480			625,320	625,320	
				φ32L=7.5m 2pcs/rod	nos	22.0			27,990			615,780	615,780	
				φ32 L=8.0m 2pcs/rod	nos	1.0			29,385			29,385	29,385	
				φ32 L=9.0m 2pcs/rod	nos	1.0			32,670			32,670	32,670	

Table 4-2.5 Bill of quantities (2/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price US$	Unit Price LE	Unit Price YEN	Amount US$	Amount LE	Amount YEN	Exchange to YEN	Remarks
				φ25 L=7.5m 2pcs/rod	nos	4.0			21,240			84,960	84,960	
			7). material fee for waling	UPN	t	32.7		12,553.60			410,389.73		2,663,429	
			8). sheet pile welding	on site	nos	293.0		1,944.85			569,841.05		3,698,268	
			9). anticorrosion painting (bitumen)		m2	7,145.3		248.00			1,772,029.44		11,500,471	
	sub total									636,160.04	3,742,433.16	6,996,465	103,387,235	
total										636,160.04	5,394,080.56	6,996,465	114,106,427	
A-5. Bank protection	A-5-1. Bank protection	1. Riprap	1). wet stone pitching	t=35cm	m2	2,008.8		841.71			1,690,827.04		10,973,467	
			2). placing backfill concrete	18N/mm2 by crane	m3	161.4		1,479.36			238,709.52		1,549,225	
			3). curing	plain concrete	m3	161.4		12.92			2,084.77		13,530	
		sum									1,931,621.33		12,536,222	
		2. crown works	1). form for lean concrete		m2	10.2		209.60			2,137.92		13,875	
			2). placing lean concrete	18N/mm2 by crane	m3	1.8		1,479.36			2,640.65		17,138	
			3). curing	plain concrete	m3	1.8		12.92			23.06		150	
			4). formwork	for small structure	m2	107.8		355.10			38,295.03		248,535	
			5). placing plain concrete	18N/mm2 by man power	m3	16.0		1,109.76			17,750.61		115,201	
			6). curing	small structure	m3	17.8		30.22			537.31		3,487	
			7). gravel for under concrete	t=100mm	m2	3.6		99.31			354.53		2,301	
			8). joint filler	expansion joint	m2	1.3		45.20			59.93		389	
		sum									61,799.04		401,076	
		3. base concrete	1). form for lean concrete		m2	10.7		209.60			2,232.24		14,487	
			2). placing lean concrete	18N/mm2 by crane	m3	2.7		1,479.36			3,938.79		25,563	
			3). curing	plain concrete	m3	2.7		12.92			34.39		223	
			4). formwork	for small structure	m2	104.4		355.10			37,089.90		240,713	
			5). placing plain concrete	18N/mm2 by man power	m3	16.4		1,109.76			18,201.72		118,129	
			6). curing	small structure	m3	16.4		30.22			495.65		3,217	
			7). gravel for under concrete	t=100mm	m2	4.5		99.31			445.55		2,892	
			8). joint filler	expansion joint	m2	1.7		45.20			75.27		489	
		sum									62,513.51		405,713	
		4. gabion protection	1). installation for gabion	0.5×1.0×2.0	nos	1,184.0		1,173.37	3,990		1,389,270.08	4,724,160	13,740,523	
				1.0×1.0×2.0	nos	670.0		2,355.33	8,920		1,578,071.10	5,976,400	16,218,081	
		sum									2,967,341.18	10,700,560	29,958,604	
total											5,023,275.06	10,700,560	43,301,615	
A-6. Canal bed protection	A-6-1. bed protection for upstream	1. Bed protection for upstream	1). stone riprap	working radius r=less 9m	m3	956.5		606.24			579,868.56		3,763,347	
			2). grading for riprap		m2	1,952.0		76.86			150,030.72		973,699	
		sum									729,899.28		4,737,046	
	A-6-2. bed protection for downstream	1. Bed protection for downstream	1). stone riprap	working radius r=less 9m	m3	1,701.0		606.24			1,031,214.24		6,692,580	
			2). grading for riprap		m2	1,890.0		76.86			145,265.40		942,772	
			3). gravel for backfill	t=0.1m	m3	208.5		746.76			155,699.46		1,010,489	
			4). geotextile	t=0.5mm, Nylon,polyester	m2	2,085.0		46.42			96,785.70		628,139	
		sum									1,428,964.80		9,273,982	
	A-6-3. Sheet pile for water stop	1. Sheet pile for water stop	1). driving sheet pile	PU18, L≦15m (driving length)	sheet	1.0		1,466.45			1,466.45		9,517	
				PU18, L≦12m (driving length)	sheet	3.0		1,231.17			3,693.51		23,971	
				PU18, L≦9m (driving length)	sheet	4.0		997.84			3,991.36		25,904	
				PU12, L≦12m (driving length)	sheet	120.0		1,055.19			126,622.80		821,782	
				PU12, L≦9m (driving length)	sheet	8.0		880.52			7,044.16		45,717	
				PU12, L≦6m (driving length)	sheet	122.0		761.90			92,951.80		603,257	
				PU12, L≦4m (driving length)	sheet	120.0		645.24			77,428.80		502,513	
				PU12, L≦2m (driving length)	sheet	104.0		527.92			54,903.68		356,325	
			2). material fee for sheet pile	PU12, 18	t	222.5	881.00			196,050.69			22,220,385	
			3). sheet pile welding	on site	nos	31.0		1,944.85			60,290.35		391,284	
			4). anticorrosion painting	sand plasting and painting	m2	193.7		248.00			48,032.64		311,732	
			5). sheet pile cutting		m	24.0		264.24			6,341.76		41,158	
		sum								196,050.69	482,767.31		25,353,545	
total										196,050.69	2,641,631.39		39,364,573	
A-7. Concrete work for regulators	A-7-1. concrete works	regulator body	1). earth foundation finishing		m2	4,553.1		28.06			127,759.42		829,159	
			2). form for lean concrete		m2	51.9		209.60			10,882.43		70,627	
			3). placing lean concrete	18N/mm2 by crane	m3	403.1		1,326.22			534,599.28		3,469,549	
			4). curing	plain concrete	m3	403.1		12.92			5,208.05		33,800	
			5). formwork	reinforced concrete	m2	14,302.0		400.74			5,731,375.46		37,196,627	

Table 4-2.6 Bill of quantities (3/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			6). formwork	circular structure	m2	490.7		525.17			257,706.17		1,672,513	
			7). placing concrete	25N/mm2(src, night time)	m3	14,667.0		1,446.03			21,208,922.01		137,645,904	
			8). placing concrete	25N/mm2(opc)	m3	1,372.5		1,356.29			1,861,467.33		12,080,923	
			9). curing	reinforced concrete	m3	16,039.5		7.83			125,589.05		815,073	
			10). bending,cutting and placing for re-bar	D13～D25mm	t	586.0		17,805.74			10,434,680.00		67,721,073	
			11). scaffolding	not less than 4m	m2	10,755.1		161.52			1,737,170.21		11,274,235	
			12). pipe support falsework	not greater than 4t/m2	m3	4,360.7		144.07			628,244.60		4,077,307	
			13). joint filler	t=20mm	m2	488.7		403.70			197,284.15		1,280,374	
			14). water stop	w=300mm	m	251.0		37.54	2,214		9,423.29	555,758	616,915	
			15). water stop	water-swelling	m	66.1		16.56	1,975		1,093.78	130,448	137,547	
			16). addtive for rust-proofing	for reinforced condrete	m3	16,039.5		124.81			2,001,844.48		12,991,971	
total											44,873,249.71	686,206	291,913,597	
A-8. Pile foundation work	A-8-1. Cast-in-place RC pile	φ1,000	1). mobilization and demobilization		L.S	2.0		297,720.00			595,440.00		3,864,406	
			2). pile drilling	including fabricate and lowering stell cage and pour concrete	m	2,429.6		1,712.00			4,159,475.20		26,994,994	
			3). placing concrete	25N/mm2(src)	m3	1,908.2		1,386.07			2,644,903.45		17,165,423	
			4). bending,cutting and placing for re-bar		t	301.0		17,805.74			5,359,812.63		34,785,184	
			5). pile head demolishing	φ1,000, 0.8m	m3	120.6		469.06			56,586.06		367,244	
			6). load test		L.S	2.0		283,333.00			566,666.00		3,677,662	
total											13,382,883.34		86,854,913	
A-9. Accessory works	A-9-1. Road works	1. Asphalt pavement	1). enbankment		m3	10,225.3		37.90			387,539.62		2,515,132	
		roadway	material fee for temporary road	sand	m3	12,916.2		67.10			866,676.59		5,624,731	
			transportation fee for buying material											
			excavation and loading	0.8m3 back hoe loose soil	m3	12,916.2		19.22			248,249.24		1,611,138	
			transportation by damp truck	Distance 20km	m3	12,916.2		135.51			1,750,273.40		11,359,274	
			2). wearing course	t=50mm	m2	4,379.6		143.00			626,287.09		4,064,603	
			3). binder course	t=60mm	m2	4,379.6		143.00			626,287.09		4,064,603	
			4). base course	t=200mm	m2	4,379.6		132.78			581,527.27		3,774,112	
			5). sub base course	t=200mm	m2	4,379.6		132.78			581,527.27		3,774,112	
			6). tack coat		m2	4,379.6		16.00			70,074.08		454,781	
			7). prime coat		m2	4,379.6		19.00			83,212.97		540,052	
		sum									5,821,654.62		37,782,538	
		2. Asphalt pavement	1). wearing course	t=50mm	m2	623.7		143.00			89,191.96		578,856	
		pathway	2). base course	t=200mm	m2	623.7		132.78			82,817.54		537,486	
			3). prime coat		m2	623.7		19.00			11,850.68		76,911	
		sum									183,860.18		1,193,253	
		3. curb concrete	1). form for lean concrete		m2	127.3		209.60			26,689.20		173,213	
			2). placing lean concrete	18N/mm2 by crane	m3	20.7		1,479.36			30,585.21		198,498	
			3). curing	plain concrete	m3	20.7		12.92			267.11		1,734	
			3). formwork	for small structure	m2	964.9		355.10			342,646.12		2,223,773	
			4). placing plain concrete	18N/mm2 by man power	m3	109.5		1,109.76			121,480.35		788,407	
			5). curing	small structure	m3	109.5		30.22			3,308.04		21,469	
			6). gravel for under concrete	t=100mm	m2	41.3		99.31			4,106.39		26,650	
		sum									529,082.42		3,433,745	
		4. guard pipe	H=1.1m		m	629.81		1,212.12			763,405.29		4,954,500	
		5. slope protection	1). stone masonry with mortar	t=35cm	m2	1,765.25		841.71			1,485,828.57		9,643,027	
			2). placing backfill concrete	18N/mm2 by crane	m3	214.54		1,479.36			317,374.66		2,059,762	
			3). curing	plain concrete	m3	214.54		12.92			2,771.79		17,989	
		sum									1,805,975.02		11,720,778	
		6. crown concrete	1). form for lean concrete		m2	47.9		209.60			10,031.45		65,104	
			2). placing lean concrete	18N/mm2 by crane	m3	7.9		1,479.36			11,751.29		76,266	
			3). curing	plain concrete	m3	7.9		12.92			102.63		666	
			4). formwork	for small structure	m2	395.9		355.10			140,574.81		912,331	
			5). placing plain concrete	18N/mm2 by man power	m3	59.1		1,109.76			65,531.32		425,298	
			6). curing	small structure	m3	20.7		30.22			624.78		4,055	
			7). gravel for under concrete	t=100mm	m2	15.9		99.31			1,577.73		10,239	
			8). joint filler	expansion joint	m2	5.9		45.20			266.90		1,732	
		sum									230,460.91		1,495,691	
		7. base concrete	1). form for lean concrete		m2	53.7		209.60			11,250.69		73,017	
			2). placing lean concrete	18N/mm2 by crane	m3	13.4		1,479.36			19,851.90		128,839	

Table 4-2.7 Bill of quantities (4/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
						US$	LE	YEN	US$	LE	YEN		
		3). curing	plain concrete	m3	13.4		12.92			173.37		1,125	
		4). formwork	for small structure	m2	474.3		355.10			168,431.08		1,093,118	
		5). placing plain concrete	18N/mm2 by man power	m3	72.5		1,109.76			80,417.59		521,910	
		6). curing	small structure	m3	72.5		30.22			2,189.86		14,212	
		7). gravel for under concrete	t=100mm	m2	18.8		99.31			1,865.73		12,109	
		8). joint filler	expansion joint	m2	7.2		45.20			327.53		2,126	
	sum									284,507.75		1,846,455	
	8. concrete stair	1). form for lean concrete		m2	16.9		209.60			3,535.78		22,947	
		2). placing lean concrete	18N/mm2 by crane	m3	8.4		1,479.36			12,417.03		80,587	
		3). curing	plain concrete	m3	8.4		12.92			108.44		704	
		4). formwork	reinforced concrete	m2	118.6		400.74			47,509.37		308,336	
		5). placing concrete	25N/mm2(opc)	m3	31.0		1,356.29			42,068.86		273,027	
		6). curing	reinforced concrete	m3	31.0		7.83			242.86		1,576	
		7). gravel for under concrete	t=100mm	m2	12.5		99.31			1,243.54		8,071	
		8). bending,cutting and placing for re-bar	D12	t	0.4		18,857.16			7,970.69		51,730	
	sum									115,096.57		746,977	
sub total										9,734,042.76		63,173,938	
A-9-2. Bridge works	1. concrete work	1). formwork	reinforced concrete	m2	1,696.3		400.74			679,775.92		4,411,746	
		2). placing concrete	25N/mm2(opc)	m3	548.9		1,356.29			744,406.81		4,831,200	
		3). curing	reinforced concrete	m3	548.9		7.83			4,297.53		27,891	
		4). bending,cutting and placing for re-bar	D12	t	105.1		18,857.16			1,981,642.37		12,860,859	
		5). pipe support falsework	not greater than 4t/m2	m3	6,121.3		144.07			881,888.48		5,723,456	
		6). Styrofoam	t=20～150mm	m3	14.0			26,190			366,607	366,607	
	sum									4,292,011.11	366,607	28,221,759	
	2. shoe	1). rubber bearing	330×150×40	nos	20.0			11,760			235,200	235,200	
			330×300×40	nos	40.0			23,590			943,600	943,600	
			150×10,000×20	nos	2.0			108,780			217,560	217,560	
			300×10,000×20	nos	5.0			217,560			1,087,800	1,087,800	
		2). corrosion-proof anchor	Fixed, F25D	nos	12.0			6,930			83,160	83,160	
			Movable, M25D	nos	20.0			8,260			165,200	165,200	
			for F25D	nos	12.0			1,190			14,280	14,280	
			for M25D	nos	20.0			2,940			58,800	58,800	
	sum										2,805,600	2,805,600	
	3. steel expansion joint	1). expansion joint (brof joint)	displacement⊿=20mm	m	24.2		232.34	35,190		5,622.62	851,598	888,089	
		2). expansion joint (brof joint)	displacement⊿=35mm	m	96.8		232.34	55,800		22,490.51	5,401,440	5,547,403	
		3). Anchor bar	D12	t	0.6		11,442.00			7,029.08		45,619	
	sum									35,142.21	6,253,038	6,481,111	
	4. balustrade for bridge	1). balustrade	h=1.100	m	165.2		1,212.12			200,242.22		1,299,572	
		2). Anchor bar	D12	t	0.6		11,442.00			7,029.08		45,619	
	sum									207,271.30		1,345,191	
sub total										4,534,424.62	9,425,245	38,853,661	
A-9-3. Approach slab	1. concrete work	1). formwork	reinforced concrete	m2	96.0		400.74			38,471.04		249,677	
		2). placing concrete	25N/mm2(opc)	m3	160.0		1,356.29			217,006.40		1,408,372	
		3). curing	reinforced concrete	m3	160.0		7.83			1,252.80		8,131	
		4). bending,cutting and placing for re-bar	D22	t	14.2		17,805.74			253,553.73		1,645,564	
		5). Anchor cap	SGP φ40×80	nos	200.0		67.00			13,400.00		86,966	
		6). Anchor bar	D22×500×200nos	t	0.3		11,442.00			3,478.36		22,575	
		7). joint filler	expansion joint	m2	34.4		45.20			1,554.88		10,091	
	sum									528,717.21		3,431,375	
	2. shoe	1). rubber shoe	t=30mm	m2	24.0			166,050			3,985,200	3,985,200	
sub total										528,717.21	3,985,200	7,416,575	
A-9-4. Accessory works around regulator	1. accessory work for gate	1). formwork for post-placing concrete	reinforced concrete	m2	1,248.8		400.74			500,448.11		3,247,908	
		2). post-placing concrete	25N/mm2(src, night time)	m3	340.2		1,446.03			491,953.86		3,192,781	
		3). post-placing concrete	25N/mm2(opc)	m3	7.5		1,356.29			10,185.73		66,105	
		4). curing	for post-placing concrete	m3	347.7		7.83			2,722.64		17,670	
		5). joint bar	D22	t	2.9		11,442.00			33,457.14		217,137	
		6). installation for joint bar	D22	nos	7,900.0		83.45			659,255.00		4,278,565	
	sum									1,698,022.48		11,020,166	
	2. hydraulic pipe pit works	1). form for lean concrete		m2	9.1		209.60			1,909.45		12,392	

Table 4-2.8 Bill of quantities (5/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			2). placing lean concrete	18N/mm2 by crane	m3	10.5		1,479.36			15,562.86		101,003	
			3). curing	plain concrete	m3	10.5		12.92			135.91		882	
			4). formwork	reinforced concrete	m2	374.7		400.74			150,169.30		974,599	
			5). placing concrete	25N/mm2(opc)	m3	85.8		1,356.29			116,383.24		755,327	
			6). curing	reinforced concrete	m3	85.8		7.83			671.89		4,361	
			7). bending,cutting and placing for re-bar	D22	t	8.5		17,805.74			151,687.09		984,449	
			8). scaffolding	not less than 4m	m2	160.1		161.52			25,865.81		167,869	
			9). pipe support falsework	not greater than 4t/m2	m3	92.0		144.07			13,250.11		85,993	
			10). water stop	w=300mm	m	16.8		37.54	2,214		630.67	37,195	41,288	
			11). joint filler	expansion joint	m2	5.1		45.20			231.87		1,505	
			12). joint filler	construction joint	m2	0.6		403.70			250.29		1,624	
			13). checker plate	t=3.2mm	m2	1.0		349.41			342.41		2,222	
				t=4.5mm	m2	18.8		476.12			8,946.24		58,061	
			14). Anchor bar	D16	t	0.0		11,442.00			57.11		371	
			15). installation for hydraulic pipe	SUS 32A	m	4,004.0		75.50			302,302.00		1,961,940	
		sum									788,396.25	37,195	5,153,887	
		3. steel stairs	1). steel stairs		L.S	2.0		129,944.00			259,888.00		1,686,673	
			2). foundation for support		L.S	2.0		14,774.67			29,549.34		191,775	
		sum									289,437.34		1,878,448	
		4. installation for grating		IB, 44×5×3	m2	227.8		232.34	18,090		52,936.34	4,121,625	4,465,182	
		5. installation for handrail		H=1.1m	m	563.2		1,395.28			785,821.69		5,099,983	
		6. crane facility	1). chain block	manual operation, 5t	L.S	2.0		32,157.16			64,314.32		417,400	
			2). rail	I 300x150x10x18.5	t	1.1		15,692.00			16,711.98		108,461	
		sum									81,026.30		525,861	
		7. installation for steel steps	b=300mm		nos	765.0		370.65			283,547.25		1,840,222	
		8. staff gauge			m	65.2		1,664.10			108,416.02		703,620	
		9. gate lighting	1). high pressure mercury lamp	400W	nos	6.0		5,075.00			30,450.00		197,621	
			2). installation for gate lighting		nos	6.0		18,533.63			111,201.78		721,700	
		sum									141,651.78		919,320	
		10. water level detector	1). water level detector	DC4-20A	nos	13.0		34,927.58			454,058.55		2,946,840	
			2). installation for water level detector		nos	13.0		2,744.00			35,672.00		231,511	
		sum									489,730.55		3,178,351	
	sub total										4,718,986.00	4,158,820	34,785,039	
total											19,516,170.59	17,569,265	144,229,212	
A-10. Electric works	A-10-1. installation for facilities of receiving po	1. Installation for power receiving and distribu	1). installation for power receiving and distribution pane		nos	1.0		3,388.00			3,388.00		21,988	
			2). emergency generator with panel	80kVA, 3phase 4wire	nos	1.0			8,650,000			8,650,000	8,650,000	
			3). installation for backup generator		nos	1.0		33,246.50			33,246.50		215,770	
			4). transformer	three phase100KVA	nos	1.0		211,500.00			211,500.00		1,372,635	
	sub total										248,134.50	8,650,000	10,260,393	
	A-10-2. Installation for electric cable and wire	1. electric cable and wire	1). electric cable											
			CV 3.5sq -2C		m	323.6		43.25			13,995.70		90,832	
			CV 8sq -2C		m	340.3		66.44			22,609.53		146,736	
			CV 14sq -2C		m	40.0		92.29			3,691.60		23,958	
			CV 22sq -2C		m	20.0		124.83			2,496.60		16,203	
			CV 2sq -3C		m	64.5		41.83			2,698.03		17,510	
			CV 5.5sq -3C		m	268.6		71.80			19,285.48		125,163	
			CV 8sq -3C		m	458.6		87.30			40,035.78		259,832	
			CV 14sq -3C		m	820.4		123.72			101,499.88		658,734	
			CV 22sq -3C		m	125.8		168.44			21,189.75		137,521	
			CV 38sq -3C		m	225.2		254.94			57,412.48		372,607	
			CV 8sq -4C		m	20.0		110.31			2,206.20		14,318	
			CV 38sq -4C		m	30.0		327.64			9,829.20		63,792	
			CVV 2sq -4C		m	5.0		52.36			261.80		1,699	
			CVV 2sq -5C		m	969.3		63.91			61,947.96		402,042	
			CVV 2sq -8C		m	919.8		86.62			79,673.07		517,078	
			CVV 2sq -10C		m	74.5		106.68			7,947.66		51,580	
			CVV 2sq -20C		m	785.2		191.53			150,389.35		976,027	
			CVV 2sq -30C		m	4,164.6		253.71			1,056,600.66		6,857,338	
			CVVS 2sq -2C		m	451.5		47.59			21,486.88		139,450	

Table 4-2.9 Bill of quantities (6/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			CVVS 2sq -10C		m	497.6		124.83			62,115.40		403,129	
			CVVS 2sq -15C		m	113.8		174.84			19,896.79		129,130	
			CVVS 2sq -30C		m	910.4		272.75			248,311.60		1,611,542	
			2). electric wire											
			IV 3.5sq		m	819.6		25.93			21,252.22		137,927	
			IV 5.5sq		m	95.1		29.50			2,805.45		18,207	
			IV 8sq		m	1,050.8		36.46			38,312.16		248,646	
			IV 14sq		m	351.0		52.56			18,448.56		119,731	
			IV 22sq		m	30.0		69.60			2,088.00		13,551	
			CPEV 0.9mm -3P		m	1,521.8		48.34			73,563.81		477,429	
			3). conduits											
			FEP 30		m	576.6		72.87			42,016.84		272,689	
			FEP 40		m	990.8		83.30			82,533.64		535,643	
			FEP 50		m	45.8		96.10			4,401.38		28,565	
			FEP 65		m	155.8		114.00			17,761.20		115,270	
			FEP 80		m	762.8		139.03			106,052.08		688,278	
			FEP 100		m	613.2		188.15			115,373.58		748,775	
			FEP 125		m	474.8		232.23			110,262.80		715,606	
			G 28		m	285.2		163.84			46,727.16		303,259	
			G 36		m	458.9		201.06			92,266.43		598,809	
		sum									2,779,446.71		18,038,609	
		2. earth work	excavation and backfill		m3	32.0		116.67			3,733.44		24,230	
		3. handhole	900×900×900		nos	32.0		18,600.65			595,220.80		3,862,983	
	sub total										3,378,400.95		21,925,822	
total											3,626,535.45	8,650,000	32,186,215	
A-11. Gate manufactures and works	A-11-1. gate manufacture	1. Gate manufacture	1). double stage roller gate	h=1.100										
			gate leaf	6.0×6.55	L.S	2.0			157,655,000			315,310,000	315,310,000	
			gate guide		L.S	2.0			132,187,000			264,374,000	264,374,000	
			hoisting device	hydraulic	L.S	2.0			410,835,000			821,670,000	821,670,000	
			remote operation system		L.S	2.0			110,893,000			221,786,000	221,786,000	
			2). slide gate	small gate										
			for Badraman	2.0×2.65, including hoist	L.S	2.0		461,044.07			922,088.13		5,984,352	
			for Diroutiah	2.0×2.35, including hoist	L.S	3.0		461,044.07			1,383,132.20		8,976,528	
			for Abo Gabal	2.0×2.95, including hoist	L.S	4.0		499,464.41			1,997,857.62		12,966,096	
			for Sahelyia	2.0×3.55, including hoist	L.S	2.0		527,406.47			1,054,812.94		6,845,736	
			3). stop log											
			for large regulator	Type-A×2、 Type-B×8	L.S	2.0		2,368,089.98			4,736,179.96		30,737,808	
			for asmall regulator	Type-A×2、 Type-B×7	L.S	2.0		1,128,160.86			2,256,321.72		14,643,528	
		sum									12,350,392.57	1,623,140,000	1,703,294,048	
	A-11-2. installation for gate facilities	1. Installation for manufactures	1). installation for gate	for gate, gate guide, hoist	L.S	1.0		5,372,924.63			5,372,924.63		34,870,281	
			2). installation for stop log	for gate guide, crane	L.S	1.0		1,351,345.63			1,351,345.63		8,770,233	
			3). control panel for gate operation											
			remote operation panel		nos	1.0		6,860.00			6,860.00		44,521	
			4). Japanese mechanical engineer for gate		day	1,050.0			22,154			23,261,700	23,261,700	
			5). Japanese electrical engineer for gate		day	1,050.0			24,698			25,932,900	25,932,900	
		sum									6,731,130.26	49,194,600	92,879,635	
total											19,081,522.83	1,672,334,600	1,796,173,683	
A-12. Expense of the machine and facilities	A-12-1. Expense of the machine and facilities	1. Rent fee for heavy equipment	1-1. rent in Egypt											
			1). rough terrain crane	25t	day	1,410.0		3,194.17			4,503,775.00		29,229,500	
			2). truck with crane	4t/2.9t	day	1,350.0		1,927.50			2,602,125.00		16,887,791	
			3). Truck	11t	day	1,350.0		1,591.67			2,148,750.00		13,945,388	
			4). Truck mixer	4.4m3	day	1,260.0		2,150.00			2,709,000.00		17,581,410	
			5). Truck mixer	4.4m3	day	1,230.0		2,150.00			2,644,500.00		17,162,805	
			6). Truck mixer	4.4m3	day	915.0		2,150.00			1,967,250.00		12,767,453	
			7). Truck mixer	4.4m3	day	450.0		2,150.00			967,500.00		6,279,075	
			8). cement silo	50t	day	1,290.0		1,595.83			2,058,625.00		13,360,476	
			9). Wheel Loader	2.1m3	day	400.0		2,030.83			812,333.33		5,272,043	
			1-2. rent in Japan											
			1). Batching plant	30m3/h	LS	1.0	221,309.66			221,309.66			25,083,237	

Table 4-2.10 Bill of quantities (7/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5 Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			2). Vibration hunmer (1)	Hydraulic, 232KW	day	1,507.0			21,100			31,797,700	31,797,700	
			3). Vibration hunmer (2)	Hydraulic, 232KW	day	367.0			21,100			7,743,700	7,743,700	
			4). Water jet	14.7Mpa 325L/min	day	1,507.0			9,370			14,120,590	14,120,590	
		sum								221,309.66	20,413,858.33	53,661,990	211,231,167	
		2. Operator wage	rent in Egypt											
			1). rough terrain crane	25t	day	1,058.0		435.00			460,230.00		2,986,893	
			2). truck with crane	4t/2.9t	day	1,013.0		435.00			440,655.00		2,859,851	
			3). Truck	11t	day	1,013.0		435.00			440,655.00		2,859,851	
			4). Truck mixer	4.4m3	day	945.0		435.00			411,075.00		2,667,877	
			5). Truck mixer	4.4m3	day	923.0		435.00			401,505.00		2,605,767	
			6). Truck mixer	4.4m3	day	687.0		435.00			298,845.00		1,939,504	
			7). Truck mixer	4.4m3	day	338.0		435.00			147,030.00		954,225	
		sum									2,599,995.00		16,873,968	
		3. Fuel fee	rent in Egypt											
			1). rough terrain crane	25t	Lit	122,696.2		2.00			245,392.40		1,592,597	
			2). truck with crane	4t/2.9t	Lit	39,091.6		2.00			78,183.20		507,409	
			3). Truck	11t	Lit	61,620.7		2.00			123,241.40		799,837	
			4). Truck mixer	4.4m3	Lit	57,900.1		2.00			115,800.20		751,543	
			5). Truck mixer	4.4m3	Lit	56,552.2		2.00			113,104.40		734,048	
			6). Truck mixer	4.4m3	Lit	42,092.4		2.00			84,184.80		546,359	
			7). Truck mixer	4.4m3	Lit	20,709.2		2.00			41,418.40		268,805	
		sum									801,324.80		5,200,598	
total										221,309.66	23,815,178.13	53,661,990	233,305,733	
B. Temporary Works										3,192,139.21	88,433,278.12	262,773,263	**1,198,502,296**	
B-1. Temporary Coffer Dam	B-1-1. Double Sheet Pile	1. Double sheet pile	1). driving sheet pile	PU28+1, L≦15m (driving length)	sheet			1,730.41						
				PU28+1, L≦12m (driving length)	sheet	1,462.0		1,466.45			2,143,949.90		13,914,235	
				PU28+1, L≦9m (driving length)	sheet			1,173.16						
				PU28+1, L≦6m (driving length)	sheet	640.0		939.18			601,075.20		3,900,978	
				PU28+1, L≦4m (driving length)	sheet	80.0		763.21			61,056.80		396,259	
			2). Sheet pile press fitting	PU, L≦9m (driving length)	sheet			103.68	3,280					
			3). Mobilization & demobilization	press fitting machine for sheet pile	nos			700.36	19,332					
			4). material fee for sheet pile	PU28+1	t	1,907.6	440.50			840,284.40			95,237,834	
			5). material fee for sheet pile	PU28+1, near rail way	t		881.00							
			6). installation for tie-rod and waling		t	293.9		3,311.13			972,988.79		6,314,697	
			7). material fee for tie-rod (NHT690)	φ75 L=8.9m 2pcs/rod	nos	210.0			151,065			31,723,650	31,723,650	
				φ75 L=10.0m 2pcs/rod	nos	29.0			167,850			4,867,650	4,867,650	
				φ32 L=6.8m 2pcs/rod	nos	40.0			25,470			1,018,800	1,018,800	
				φ32 L=8.0m 2pcs/rod	nos	31.0			29,385			910,935	910,935	
				φ28 L=4.5m 2pcs/rod	nos				16,020					
				φ28 L=5.5m 2pcs/rod	nos				18,495					
				φ28 L=7.6m 2pcs/rod	nos				24,345					
				φ28 L=8.5m 2pcs/rod	nos				26,820					
			8). material fee for waling	H300未満	t	106.6		7,846.00			836,383.60		5,428,130	
			9). sheet pile welding	on site	nos	1,662.0		1,944.85			3,232,340.70		20,977,891	
			10). removing sheet pile	L≦15m (removing length)	nos			658.61						
				L≦12m (removing length)	nos	1,462.0		572.16			836,497.92		5,428,872	
				L≦9m (removing length)	nos			486.33						
				L≦6m (removing length)	nos	640.0		428.48			274,227.20		1,779,735	
				L≦4m (removing length)	nos	80.0		371.90			29,752.00		193,090	
			11). driving bearing pile	H150, L≦4m (driving length)	nos			615.91						
				H250, L≦4m (driving length)	nos			673.91						
			12). removing bearing pile	L≦4m (removing length)	nos			371.90						
			13). material fee for bearing pile		t			7,846.00						
			14). Japanese sheet pile operator A		day	2,190.0			27,030			59,195,700	59,195,700	
			15). Japanese sheet pile operator B		fay	480.0			27,030			12,974,400	12,974,400	
	sub total									840,284.40	8,988,272.11	110,691,135	264,262,855	
	B-1-2. Earth work	1. earth work	1). backfill	inside coffer dam	m3	29,986.8		37.90			1,136,499.72		7,375,883	
			2). backfill material fee	sand	m3	40,458.0		67.10			2,714,731.80		17,618,609	
			3). transportation fee for buying material											

Table 4-2.11 Bill of quantities (8/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			excavation and loading	0.8m3 back hoe loose soil	m3	40,458.0		19.22			777,602.76		5,046,642	
			transportation by damp truck	Distance 20km	m3	40,458.0		135.51			5,482,463.58		35,581,189	
	sub total										10,111,297.86		65,622,323	
total										840,284.40	19,099,569.97	110,691,135	329,885,178	
B-2. Single Sheet Pile	B-2-1. Single Sheet Pile	1. Single Sheet Pile	1). driving sheet pile	PU28+1, L≦15m (driving length)	sheet	200.0		1,730.41			346,082.00		2,246,072	
				PU28+1, L≦12m (driving length)	sheet			1,466.45						
				PU28+1, L≦9m (driving length)	sheet			1,173.16						
				PU28+1, L≦6m (driving length)	sheet	232.0		939.18			217,889.76		1,414,105	
				PU28+1, L≦4m (driving length)	sheet	467.0		763.21			356,419.07		2,313,160	
			2). Sheet pile press fitting	PU, L≦9m (driving length)	sheet	195.0		103.68	3,280		20,217.60	639,600	770,812	
			3). Mobilization & demobilization	press fitting machine for sheet pile	nos	1.0		700.36	19,332		700.36	19,332	23,877	
			4). material fee for sheet pile	PU28+1	t	663.3	440.50			292,188.54			33,116,649	
			5). material fee for sheet pile	PU28+1, near rail way	t	165.7	881.00			145,981.70			16,545,566	
			6). installation for tie-rod and waling		t	47.7		3,311.13			157,940.90		1,025,036	
			7). material fee for tie-rod (NHT690)	φ75 L=8.9m 2pcs/rod	nos				151,065					
				φ75 L=10.0m 2pcs/rod	nos				167,850					
				φ32 L=6.8m 2pcs/rod	nos				25,470					
				φ32 L=8.0m 2pcs/rod	nos				29,385					
				φ28 L=4.5m 2pcs/rod	nos	76.0			16,020			1,217,520	1,217,520	
				φ28 L=5.5m 2pcs/rod	nos	76.0			18,495			1,405,620	1,405,620	
				φ28 L=7.6m 2pcs/rod	nos	51.0			24,345			1,241,595	1,241,595	
				φ28 L=8.5m 2pcs/rod	nos	68.0			26,820			1,823,760	1,823,760	
			8). material fee for waling		t	26.7		7,846.00			209,488.20		1,359,578	
			9). sheet pile welding	on site	nos	200.0		1,944.85			388,970.00		2,524,415	
			10). removing sheet pile	L≦15m (removing length)	nos	200.0		658.61			131,722.00		854,876	
				L≦12m (removing length)	nos			572.16						
				L≦9m (removing length)	nos			486.33						
				L≦6m (removing length)	nos	232.0		428.48			99,407.36		645,154	
				L≦4m (removing length)	nos	467.0		371.90			173,677.30		1,127,166	
			11). driving bearing pile	H150, L≦4m (driving length)	nos	227.0		615.91			139,811.57		907,377	
				H250, L≦4m (driving length)	nos	46.0		673.91			30,999.86		201,189	
			12). removing bearing pile	L≦4m (removing length)	nos	273.0		371.90			101,528.70		658,921	
			13). material fee for bearing pile		t	53.0		7,846.00			415,445.70		2,696,243	
total										438,170.24	2,790,300.38	6,347,427	74,118,691	
B-3. Temporary bridge	B-3-1. Temporary bridge	1. pile driving	1). driving H-beam	H400, L≦12m (driving length)	piece	139.0		2,083.01			289,538.39		1,879,104	
				H400, L≦9m (driving length)	piece			1,641.77						
				H350, L≦12m (driving length)	piece	45.0		1,730.41			77,868.45		505,366	
				H350, L≦9m (driving length)	piece	148.0		1,407.14			208,256.72		1,351,586	
				H300, L≦6m (driving length)	piece	55.0		880.52			48,428.60		314,302	
			2). removing H-beam	L≦12m (removing length)	piece	184.0		572.16			105,277.44		683,251	
				L≦9m (removing length)	piece	148.0		486.33			71,976.84		467,130	
				L≦6m (removing length)	piece	55.0		428.48			23,566.40		152,946	
			3). material fee for H-beam	exclude re-used material	t	634.4			33,300			21,123,855	21,123,855	
		sum									824,912.84	21,123,855	26,477,539	
		2. substructure	1). installation for substructure		t	46.7		5,381.06			251,295.50		1,630,908	
			2). removal for substructure		t	46.7		2,884.85			134,722.49		874,349	
			3). material fee for substructure		t	25.6		7,846.00			200,857.60		1,303,566	
		sum									586,875.59		3,808,823	
		3. deck plate	1). installation for deck plate		m2	3,700.0		201.95			747,215.00		4,849,425	
			2). removal for deck plate		m2	3,700.0		103.28			382,136.00		2,480,063	
			3). material fee for deck plate	exclude re-used material	m2	1,916.5			11,700			22,423,160	22,423,160	
		sum									1,129,351.00	22,423,160	29,752,648	
		4. superstructure	1). installation for superstructure		t	468.1		2,736.49			1,280,950.96		8,313,372	
			2). removal for superstructure		t	468.1		1,511.24			707,411.44		4,591,100	
			3). material fee for superstructure	exclude re-used material	t	264.3			33,300			8,801,190	8,801,190	
		sum									1,988,362.40	8,801,190	21,705,662	
		5. guard pipe	1). installation for bridge railing		m	1,164.0		22.56			26,259.84		170,426	
			2). removal for bridge railing		m	1,164.0		12.88			14,992.32		97,300	
			3). material fee for bridge railing	@1.8m	nos	374.0			2,876			1,075,437	1,075,437	

Table 4-2.12 Bill of quantities (9/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price US$	Unit Price LE	Unit Price YEN	Amount US$	Amount LE	Amount YEN	Exchange to YEN	Remarks
		sum									41,252.16	1,075,437	1,343,164	
		6. stage end	1). installation/removal for stage end	steel plate	m2	317.0		95.64			30,319.78		196,775	
			2). material fee for stage end	steel plate	nos	59.1		6,357.00			375,712.96		2,438,377	
		sum									406,032.74		2,635,152	
total											4,976,786.73	53,423,642	85,722,988	
B-4. Dewatering	B-4-1. Dewatering	1. water pump	1). dewatering by water pump	φ50mm	day・nos	780.0		1,334.29			1,040,746.20		6,754,443	
			2). installation and removal for water pump		nos	8.0		1,238.60			9,908.80		64,308	
		sum									1,050,655.00		6,818,751	
		2. Wellpoint	1). installation/removal for wellpoint	121pcs×2 (Bahr-Yusef, Ibrahimia)	L.S	2.0		221,667.00			443,334.00		2,877,238	
			2). daily operation and control		day	803.0		11,000.00			8,833,000.00		57,326,170	
			3). fuel		Lit	96,360.0		2.00			192,720.00		1,250,753	
		sum									9,469,054.00		61,454,160	
total											10,519,709.00		68,272,911	
B-5. Temporary road & preparation	B-5-1. temporary road	1. temporary road	1). embankment		m3	21,331.2		37.90			808,452.48		5,246,857	
			2). material fee for temporary road	sand	m3	25,270.0		67.10			1,695,617.00		11,004,554	
			3). transportation fee for buying material											
			excavation and loading	0.8m3 back hoe loose soil	m3	25,270.0		19.22			485,689.40		3,152,124	
			transportation by damp truck	Distance 20km	m3	25,270.0		135.51			3,424,337.70		22,223,952	
			4). transportation fee for reused material											
			excavation and loading	0.8m3 back hoe loose soil	m3	2,016.0		19.22			38,747.52		251,471	
			transportation by damp truck	Distance 0.3km	m3	2,016.0		18.47			37,235.52		241,659	
			5). exsiting structure demolition	plain concrete	m3	3,089.3		224.59			693,825.88		4,502,930	
			6). breaked concrete disposal	Distance 20km	m3	3,089.3		194.01			599,355.09		3,889,815	
total											7,783,260.59		50,513,361	
B-6. diversion works	B-6-1. diversion works	1. diversion works	1). river side slope excavation	0.8m3 back hoe	m3	6,281.0		19.82			124,489.42		807,936	
			2). river bed excavation	0.4m3 long arm back hoe	m3	5,089.6		46.86			238,498.65		1,547,856	
			3). excavated soil disposal	Distance 20km	m3	11,370.6		159.33			1,811,677.69		11,757,788	
			4). stone riprap	for rever bed	m3	2,093.0		766.83			1,604,975.19		10,416,289	
			5). Barge	Bahr Yusef:60×10=600m2	day	100.0		50,400.00			5,040,000.00		32,709,600	
				Ibrahimia:35×10=350m2	day	100.0		29,400.00			2,940,000.00		19,080,600	
total											11,759,640.95		76,320,070	
B-7. Other temporary works	B-7-1. Temporary yard preparation	1. Temporary yard preparation	1). spreading gravel		m2	21,000.0		132.78			2,788,380.00		18,096,586	
			2). removal for gravel		m3	4,200.0		28.32			118,944.00		771,947	
			3). excavated soil disposal	distance 30km	m3	4,200.0		159.33			669,186.00		4,343,017	
			4). temporary fence	H=2.0m	m	1,860.0		1,083.00			2,014,380.00		13,073,326	
	sub total										5,590,890.00		36,284,876	
	B-7-2. Foudation improvement work	1. Foudation improvement work	1). embankment		m3	2,676.1		45.37			121,414.65		787,981	
			2). material fee for embankment	sand	m3	3,380.0		67.10			226,798.00		1,471,919	
			3). transportation fee for buying material											
			excavation and loading	0.8m3 back hoe loose soil	m3	3,380.0		19.22			64,963.60		421,614	
			transportation by damp truck	Distance 20km	m3	3,380.0		135.51			458,023.80		2,972,574	
			4). soil improvement	cement mixing	m3	3,189.0		123.60			394,160.40		2,558,101	
			5). installation for steel plate		m2	882.0		3.11			2,743.02		17,802	
			6). removal for steel plate		m2	882.0		2.46			2,169.72		14,081	
			7). material fee for steel plate	1.5m × 3.0m, t=22mm	nos	196.0		3,178.50			622,986.00		4,043,179	
	sub total										1,893,259.19		12,287,252	
	B-7-3. Batching plant facility	1. Batching plant facility	1). assembling and removal for batching plant		L.S	1.0		109,080.79			109,080.79		707,934	
			2). assembling and removal for cement silo		L.S	1.0		57,566.61			57,566.61		373,607	
			3). installation and removal for concrete aggregate yard		L.S	1.0		81,493.48			81,493.48		528,893	
	sub total										248,140.88		1,610,434	
	B-7-4. utility costs	1. Receiving power facilities	1). receiving power equipment		L.S	1.0		8,550.00			8,550.00		55,490	
			2). installation		L.S	1.0		4,918.48			4,918.48		31,921	
			3). foundation concrete	18N/mm2	m3									
			4). foundation gravel		m2	15.0		99.31			1,485.67		9,642	
			5). lean concrete		m3	1.3		1,257.46			1,690.02		10,968	
			6). formwork		m2	4.2		400.74			1,683.10		10,923	
			7). placing concrete	18N/mm2	m3	3.6		1,109.76			3,995.13		25,928	
			8). curing		m3	3.6		12.92			46.51		302	
			9). other materials	0.2% of facilities cost	%	0.2		8,550.00			1,710.00		11,098	

Table 4-2.13 Bill of quantities (10/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5 Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
		sum									24,078.91		156,272	
		2. electricity facilities	1). electric cable	600V 22mm2-3C	m	2,100.0		179.00			375,900.00		2,439,591	
			2). distribution board	75A-150A	nos	18.0		6,990.00			125,820.00		816,572	
			3). switching board		nos	1.0		5,500.00			5,500.00		35,695	
			4). installation for cable		day・nos	12.0		341.00			4,092.00		26,557	
			5). excavation		m3	585.0		154.56			90,417.60		586,810	
			6). backfill		m3	585.0		88.49			51,766.65		335,966	
		sum									653,496.25		4,241,191	
		3. water facilities	1). well	30m x 1piece	m	30.0								
			2). pump for well		nos	2.0		15,000.00			30,000.00		194,700	
			3). distribution pipe	φ50mm	m	226.0		316.00			71,416.00		463,490	
				φ25mm	m	46.5		136.00			6,324.00		41,043	
			4). valve	φ50mm	nos	5.0		307.00			1,535.00		9,962	
				φ25mm	nos	5.0		307.00			1,535.00		9,962	
			5). bibb cock		nos	7.0		1,491.00			10,437.00		67,736	
		sum									121,247.00		786,893	
		4. electricity connection fee			L.S	1.0		50,000.00			50,000.00		324,500	
		5. electric fee			Kwh	1,596,072.5		2.00			3,192,145.04		20,717,021	
	sub total										4,040,967.20		26,225,877	
	B-7-5. site expense	1. transportation fee for heavy construction equipment	1). Track crane	80t × 10 nos	t	800.0		550.00			440,000.00		2,855,600	
		Cairo - Dirout	2). Track crane	25t × 2 nos	t	50.0		550.00			27,500.00		178,475	
			2). Crawler crane	50t × 16 nos	t	800.0		550.00			440,000.00		2,855,600	
		sum									907,500.00		5,889,675	
		2. vehicle for site management	1). vehicle A	sedan	nos	180.0		15,750.00			2,835,000.00		18,399,150	
		including driver and fuel	2). vehicle B	pick-up	nos	142.0		18,749.00			2,662,358.00		17,278,703	
		sum									5,497,358.00		35,677,853	
		3. oversea travel cost	1). project manager		time	10.0			248,000			2,480,000	2,480,000	
			2). chief civil engeneer		time	10.0			248,000			2,480,000	2,480,000	
			3). civil engeneer 1		time	10.0			248,000			2,480,000	2,480,000	
			4). civil engeneer 2		time	10.0			248,000			2,480,000	2,480,000	
			5). architecture		time	3.0			248,000			744,000	744,000	
			6). mechanical engineer		time	8.0			248,000			1,984,000	1,984,000	
			7). electrical engineer		time	8.0			248,000			1,984,000	1,984,000	
			8). administrator		time	10.0			248,000			2,480,000	2,480,000	
		sum										17,112,000	17,112,000	
	sub total										6,404,858.00	17,112,000	58,679,528	
total											18,178,115.27	17,112,000	135,087,968	
B-8. Transpotation / Shipment	for civil work	B-8-1. packing	1). construction material for civil work	728.3 F/T	L.S	1.0			5,665,521			5,665,521	5,665,521	
			2). steel material for civil work	58.3 F/T	L.S	1.0			563,587			563,587	563,587	
		sum										6,229,108	6,229,108	
		B-8-2. loading	1). custom fee		L.S	2.0			5,900			11,800	11,800	
			2). loading	construction material for civil work	F/T	728.3			5,500			4,005,897	4,005,897	
				steel material for civil work	F/T	58.3			5,500			320,430	320,430	
			3). documentation		L.S	2.0			20,000			40,000	40,000	
		sum										4,378,127	4,378,127	
		B-8-3. ocean transpotation	1). construction material for civil work		F/T	728.3	180.00			131,102.10			14,859,112	
			2). steel material for civil work		F/T	58.3	180.00			10,486.83			1,188,577	
		sum								141,588.93			16,047,689	
		B-8-4. port charge	1). port charge		F/T	786.6		148.00			116,417.56		755,550	
			2). trust money for entry		F/T	786.6		60.00			47,196.31		306,304	
		sum									163,613.87		1,061,854	
		B-8-5. inland transpotation	1). inland transpotation	for permanent work	F/T	786.6		667.00			524,665.65		3,405,080	
				work)	F/T	944.6		667.00			630,061.93		4,089,102	
		sum									1,154,727.58		7,494,182	
		B-8-6. insurance	1). insurance	I = CIP × 1.1 × r	L.S	1.0	563.00	5,241.39	205,577	563.00	5,241.38	205,577	303,404	
		sum								563.00	5,241.38	205,577	303,404	
	sub total									142,151.93	1,323,582.83	10,812,812	35,514,364	
	for temporary work	B-8-7. packing	(from Japan to site)											
			1). material for temporary work	2,130.8 F/T	L.S	1.0			10,732,429			10,732,429	10,732,429	

Table 4-2.14 Bill of quantities (1112)

1	as of Estimation	January . 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
						US$	LE	YEN	US$	LE	YEN		
		2). steel material for temporary work	1,479.0 F/T	L.S	1.0			221,659			221,658	221,658	
		3). construction equipments	206.9 F/T	L.S	1.0			2,080,632			2,080,632	2,080,632	
		(from site to Japan)											
		1). material for temporary work	2,056.8 F/T	L.S	1.0			3,219,729			3,219,728	3,219,728	
		2). steel material for temporary work	1,428.6 F/T	L.S	1.0			66,498			66,497	66,497	
		3). construction equipment	186.9 F/T	L.S	1.0			624,190			624,189	624,189	
	sum										16,945,133	16,945,133	
	B-8-8. loading	(from Japan to site)											
		1). custom fee		L.S	3.0			5,900			17,700	17,700	
		2). loading	material for temporary work	F/T	2,130.8			5,500			11,719,516	11,719,516	
			steel material for temporary work	F/T	1,479.0			5,500			8,134,373	8,134,373	
			construction equipment	F/T	206.9			5,500			1,138,129	1,138,129	
		3). documentation		L.S	3.0			20,000			60,000	60,000	
		(from site to Japan)											
		1). custom fee		L.S	3.0			5,900			17,700	17,700	
		2). loading	material for temporary work	F/T	2,056.8		254.24			522,910.48		3,393,689	
			steel material for temporary work	F/T	1,428.6		254.24			363,203.38		2,357,190	
			construction equipment	F/T	186.9		254.24			47,525.22		308,439	
		3). documentation		L.S	3.0			20,000			60,000	60,000	
	sum									933,639.08	21,147,418	27,206,736	
	B-8-9. ocean transpotation	(from Japan to site)											
		1). material for temporary work		F/T	2,130.8	180.00			383,547.82			43,471,310	
		2). steel material for temporary work		F/T	1,479.0	180.00			266,215.86			30,172,906	
		3). construction equipment		F/T	206.9	180.00			37,247.86			4,221,672	
		(from site to Japan)											
		1). material for temporary work		F/T	2,056.8	180.00			370,220.62			41,960,805	
		2). steel material for temporary work		F/T	1,428.6	180.00			257,148.00			29,145,154	
		3). construction equipment		F/T	186.9	180.00			33,647.86			3,813,648	
		(from site to the third country)											
		1). material for steel sheet pile		F/T	2,736.6	90.00			246,292.26			27,914,765	
	sum								1,594,320.28			180,700,261	
	B-8-10. port charge	(from Japan to site)											
		1). port charge		F/T	3,816.7		148.00			564,876.16		3,666,046	
		2). trust money for entry		F/T	3,816.7		60.00			229,003.84		1,486,235	
		(from site to Japan)											
		1). port charge		F/T	3,672.3		148.00			543,502.44		3,527,331	
		2). trust money for entry		F/T	3,672.3		60.00			220,338.82		1,429,999	
	sum									1,557,721.26		10,109,611	
	B-8-11. inland transpotation	(from Alexandria to site)											
		1). inland transpotation	for temporary work	F/T	3,816.7		667.00			2,545,759.45		16,521,979	
			work)	F/T	2,736.6		667.00			1,825,299.32		11,846,193	
		(from site to Alexandria)											
		2). inland transpotation	for temporary work	F/T	3,672.3		667.00			2,449,433.31		15,896,822	
			imported sheet pile	F/T	2,736.6		667.00			1,825,299.32		11,846,193	
	sum									8,645,791.40		56,111,186	
	B-8-12. insurance	1). insurance (from Japan to Site)	I = CIP × 1.1 × r	L.S	1.0	2,731.00	13,277.55	1,979,481	2,731.00	13,277.55	1,979,481	2,375,184	
		2). insurance (from Site to Japan)	I = CIP × 1.1 × r	L.S	1.0	2,628.00	16,487.07	785,113	2,628.00	16,487.06	785,113	1,189,972	
	sum								5,359.00	29,764.61	2,764,594	3,565,155	
sub total									1,599,679.28	11,166,916.35	40,857,145	294,638,082	
for gate facilities	B-8-13. packing	1). gate facilities	951.0 F/T	L.S	1.0			9,448,061			9,448,061	9,448,061	
	sum										9,448,061	9,448,061	
	B-8-14. loading	1). custom fee		L.S	1.0			5,900			5,900	5,900	
		2). loading fee	Gate facilities	F/T	951.0			5,500			5,230,266	5,230,266	
		3). documennt fee		L.S	1.0			20,000			20,000	20,000	
	sum										5,256,166	5,256,166	
	B-8-15. ocean transpotation	1). gate facilities		F/T	951.0	180.00			171,172.36			19,400,675	
	sum								171,172.36			19,400,675	
	B-8-16. port charge	1). port charge		F/T	951.0		148.00			140,741.72		913,414	
		2). trust money for entry		F/T	951.0		60.00			57,057.45		370,303	

Table 4-2.15 Bill of quantities (12/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE＝ 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price US$	Unit Price LE	Unit Price YEN	Amount US$	Amount LE	Amount YEN	Exchange to YEN	Remarks
		sum									197,799.17		1,283,717	
		B-8-17. inland transpotation	1). inland transpotation		F/T	951.0		667.00			634,288.72		4,116,534	
		sum									634,288.72		4,116,534	
		B-8-18. insurance	1). insurance	I = CIP × 1.1 × r	L.S	1.0	681.00	3,308.17	8,824,875	681.00	3,308.16	8,824,875	8,923,529	
		sum								681.00	3,308.16	8,824,875	8,923,529	
	sub total									171,853.36	835,396.05	23,529,102	48,428,682	
total										1,913,684.57	13,325,895.23	75,199,059	378,581,128	
C. Building Works											3,399,700.00		**22,064,053**	
Building works		C-1. Control house			L.S	1.0		1,977,700.00			1,977,700.00		12,835,273	
		C-2. Local contrl house	Bahr Yusef		L.S	1.0		301,900.00			301,900.00		1,959,331	
		C-3. Local contrl house	Ibrahimia		L.S	1.0		301,900.00			301,900.00		1,959,331	
		C-4. Stop log room			L.S	1.0		818,200.00			818,200.00		5,310,118	
total											3,399,700.00		22,064,053	
D. Integrated Water Management System											31,628,443.83		**205,268,600**	
Integrated Water Management System	D-1. IWMS manufactures	1. IWMS manufactures	1). Gauging station	Type-A & B	L.S.	1.0		14,102,971.29			14,102,971.29		91,528,284	
			2). Central monitoring room	in Dirout	L.S.	1.0		1,387,148.88			1,387,148.87		9,002,596	
			3). Monitoring room	in Minia	L.S.	1.0		186,425.96			186,425.96		1,209,904	
	sub total										15,676,546.12		101,740,784	
.	D-2. Installation for IWMS	1. Installation for IWMS	1). installation for Gauging station	Type-A & B	L.S.	1.0		15,816,762.91			15,816,762.90		102,650,791	
			2). installation for Monitoring room	in Dirout and Minia	L.S.	1.0		135,134.81			135,134.81		877,025	
	sub total										15,951,897.71		103,527,816	
total											31,628,443.83		205,268,600	
E. Dispute Board										407,000.00			**46,129,380**	
Dispute Board	E-1. Dispute Board	1. regular Site Visit	1). Monthly Retainer Fee	US$3,000/day	month	45.0	3,000.00			135,000.00			15,300,900	
			2). Monthly Retainer Fee during DNP	US$2,000/day	month	12.0	2,000.00			24,000.00			2,720,160	
			3). Daily Fee	2day for Site Visit ×10nos	day	20.0	3,000.00			60,000.00			6,800,400	
				3day for travel ×10nos	day	30.0	3,000.00			90,000.00			10,200,600	
			4). Expenses	Air ticket, etc.	time	10.0	5,000.00			50,000.00			5,667,000	
		sum								359,000.00			40,689,060	
		2. supposed referrals	1). Additional Daily Fee		time	2.0	3,000.00			6,000.00			680,040	
			2). Reviewing Submission and Drafting Decision	(3+4 days)×2	time	14.0	3,000.00			42,000.00			4,760,280	
		sum								48,000.00			5,440,320	
total										407,000.00			46,129,380	
I-2 Indirect Cost					L.S	1.00				1,485,994.40	93,278,928.15	186,287,138	**960,089,987**	

4. Project Cost Estimation

4-1 Criteria and manual of project cost estimation

There are no official standards for construction cost estimation in Egypt. The project cost is estimated by using Japanese Standards articulated in *JICA's Design & Estimation Manual, Estimate Standards* (hereinafter referred to as 'Manual').

(1) Time of cost estimation and expected commencement date

Time of cost estimation is January 2017. The commencement date is expected in February 2018 according to the memorandum signed on July 2015. The amount of price escalation from the time of cost estimation to the project completion date is included in the price contingency.

(2) Exchange rate

A fixed exchange rate system in the Egyptian market was shifted to a flexible exchange rate system on 3rd of November 2016. At the beginning of the trading, the US$-LE exchange rate was provisionally set at US$1 = LE13, a devaluation of approximately 48%. Also, a reduction of the fuel subsidy was made on 4th of November 2016, and the prices of gasoline, diesel oil, and butane gas were raised.

As of April 2017, the exchange rate system completely shifted to the flexible exchange rate. As a result, the value of LE was going down about half.

These changes in the economic policy of the Egyptian government were the conditions for receiving a loan from the IMF. The exchange rate and the prices will be affected by the policy for a while, and the unstable situation with Egyptian market is predicted to continue.

In order to reflect such social context to the detail cost estimation, exchange rate was applied as the average rate for the three months from February to April 2017, and the risk due to the rapid price increase and unstable exchange rate after November 2016 is covered by the consideration of the price contingency.

As a result, the exchange rate is calculated as follows;

1USD = ¥113.34, 1EUR = ¥121.26, 1LE = ¥6.49

(3) Working days coefficient

1.35 of the ratio was applied to the working days coefficient.

(4) Indirect cost

The ratio of indirect cost was applied based on the cost calculations in the Minutes of Discussions (May 2014).

- Indirect cost for Civil and Temporary Works : 35% of each direct cost
- Indirect cost for Gate Manufacture : 3% of the direct cost

(5) Unit price of manpower, materials, and rental fee of heavy equipment etc.

- Regarding the unit price of manpower, materials, and rental fee of heavy equipment etc. which are from Japan, the unit price was applied as 90% of the average price between two books for monthly unit price published in Japan. When there was any item not described on the two books, competitive estimations from three companies were applied.
- Labor fee for public work in Tokyo is applied to the unit price of Japanese skilled labor.
- Regarding the unit price of manpower, materials, and rental fee of heavy equipment etc. in Egypt, 100% of the average price of the competitive estimations from three companies was applied.

(6) Price escalation

The price escalation rate in the target country is calculated using the economic growth rate of the world economy and the predicted value of inflation rate set by the IMF.

However, because the avobe calculation method of the price escalation rate is not considered the recent rapid price increase, it is not reflected in reality. Therefore, the recent price escalation was reflected by additional calculation applying a monthly inflation rate issued by the Central Bank of Egypt.

- Price escalation rate for LC :
  total ratio is 18.9% (17.2% of recent price escalation + 1.0% per year during construction)
- Price escalation rate for FC :
  total ratio is 4.2% (1.6% per year during construction)

(7) Depreciation ratio for temporary steel material

Steel material for temporary works has a remaind value even after the completion of the construction. The depreciation ratio for temporary steel material was applied 50% according to the Egyptian law.

4-2 Estimation of the project cost

Project cost estimation was carried out based on final design and quauntity which was discussed after submitting the B/D report.

According to the discussion on the B/D cost estimation, the procurement of steel material was changed from Japan to a third country in Europe, and small scale gates and stoplogs were also changed to be procured in Egypt.

The changing points on the design of regulators from the B/D stage are as follows:

(1) Foundation work: from steel sheet pile to cast-in-place RC pile

(2) Bank protection: embankment and gabion protection were newly added at downstream of the left bank of the Bahr Yusef canal and the right bank of the Ibrahimia canals

(3) Dewatering method: from deepwell method to well-point method

The construction and project cost calculated by the above conditions are as follows. It is the approved cost in the 28th TAC meeting on 26th April 2017, and the updated cost of Integrated Water Management System needs to refer to "Volume II Water Management System".

Table 4-2.1 Construction and project cost estimation

Item	Unit	Quantity	Amount			Total
			US$	LE	YEN	(Exchange to "YEN")
I Construction Cost	**L.S**	**1**	**6,138,654**	**377,480,579**	**2,219,659,487**	**5,365,263,000**
(breakdown)						
A. Civil Works	L.S	1	1,422,252	213,048,447	1,870,904,765	3,414,787,000
B. Temporary works	L.S	1	4,309,402	117,144,168	348,754,722	1,597,447,000
C. Building works	L.S	1		4,589,565		29,786,000
D. Integrated Water Management System	L.S	1		42,698,399		277,112,000
E. Dispute Board	L.S	1	407,000			46,129,000
II Consultant Service	**L.S**	**1**		**17,131,288**	**277,426,230**	**388,607,000**
III Contingency for Construction	**L.S**	**1**	**577,647**	**93,785,050**	**208,869,958**	**883,006,000**
(breakdown)						
Price Contingency	L.S	1	257,823	71,343,829	93,225,698	585,469,000
Physical Contingency	L.S	1	319,824	22,441,220	115,644,259	297,537,000
IV Contingency for Consultant Service	**L.S**	**1**		**4,256,269**	**26,105,808**	**53,729,000**
(break down)						
Price Contingency	L.S	1		3,237,813	11,651,902	32,665,000
Physical Contingency	L.S	1		1,018,455	14,453,907	21,064,000
V Interest During Construction	**L.S**	**1**			**20,100,000**	**20,100,000**
Project Cost (I～V)			**6,716,301**	**492,653,185**	**2,752,161,483**	**6,710,705,000**
VI Other Cost Estimation	**L.S**	**1**		**94,821,619**		**615,391,000**
(breakdown)						
Administration Cost	L.S	1		25,850,173		167,767,000
VAT	L.S	1		68,971,446		447,624,000
Front-end Fee	L.S	1		-		-
Total Project Cost (I～VI)			**6,716,301**	**587,474,805**	**2,752,161,483**	**7,326,096,000**

This project is aimed at STEP (Special Terms for Economic Partnership) of Japanese ODA Loans. The following items are mainly expected to be applied in this project;

- Steel double-sheet pile method
- overflow double-leaf gate to regulators

Ratio of the goods and services to be procured from Japan (“the Ratio”) is shown in Table 4-2.2.

Table 4-2.2 Ratio for STEP loan

Item	Grade	Detail	Unit	Quantity	Amount
A-11. Gate manufactures and works					
1. Gate manufacture	gate leaf	6.0×6.55	L.S	2.0	324,769,300
	gate guide		L.S	2.0	272,305,220
	hoisting device	hydraulic	L.S	2.0	846,320,100
	remote operation system		L.S	2.0	228,439,580
1. Installation for manufactures	Japanese mechanical engineer		day	1,050.0	31,403,295
	Japanese electrical engineer fo		day	1,050.0	35,009,415
sub-total					1,738,246,910
A-12. Expense of the machine and facilities					
1. Rent fee for heavy equipment	2). Vibration hunmer (1)	Hydraulic, 232KW	day	1,507.0	42,926,895
sub-total					42,926,895
B-1. Temporary Coffer Dam					
1. Double sheet pile	14). Japanese sheet pile operat		day	2,190.0	79,914,195
sub-total					79,914,195
B-8. Transportation / Shipment					
	B-8-13. packing	951.0 F/T	L.S	1.0	12,754,883
	B-8-14. loading		L.S	1.0	7,095,825
	B-8-15. ocean transpotation		F/T	951.0	26,190,947
sub-total					46,041,655
Total					1,907,129,655

Ratio of the goods and services to be procured from Japan

1) Construction Cost 5,365,263 10^3 YEN

2) Cost of the goods and services to be procured from Japan 1,907,130 10^3 YEN

2)／1)＝ 35.5% ＞30%

Table 4-2.3 Summary of the project cost estimation

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

Exchange Rate	1USD=	113.34 (YEN)
	1EUR=	121.26 (YEN)
	1LE=	6.49 (YEN)

Item				Unit	Quantity	Amount US$	Amount LE	Amount YEN	Total (Exchange to YEN)	Remarks
I Construction Cost	I-1 Direct Cost	A. Civil Works	A-1. Excavation	L.S	1.0		4,438,016.50		28,802,000	
			A-2. Embankment	L.S	1.0		18,815,688.70		122,113,000	
			A-3. Demolition work	L.S	1.0		131,996.64		856,000	
			A-4. Sheet pile bank protection	L.S	1.0	636,160.04	5,394,080.56	6,996,465	114,106,000	
			A-5. Bank protection	L.S	1.0		5,023,275.06	10,700,560	43,301,000	
			A-6. Canal bed protection	L.S	1.0	196,050.69	2,641,631.39		39,364,000	
			A-7. Concrete work for regulators	L.S	1.0		44,873,249.71	686,206	291,913,000	
			A-8. Pile foundation work	L.S	1.0		13,382,883.34		86,854,000	
			A-9. Accessory works	L.S	1.0		19,516,170.59	17,569,265	144,229,000	
			A-10. Electric works	L.S	1.0		3,626,535.45	8,650,000	32,186,000	
			A-11. Gate manufactures and works	L.S	1.0		19,081,522.83	1,672,334,600	1,796,173,000	
			A-12. Expense of the machine and facilities	L.S	1.0	221,309.66	23,815,178.13	53,661,990	233,305,000	
		sub total (A. Civil works)				1,053,520.39	160,740,228.90	1,770,599,086	2,933,209,000	
		B. Temporary Works	B-1. Temporary Coffer Dam	L.S	1.0	840,284.40	19,099,569.97	110,691,135	329,885,000	
			B-2. Single Sheet Pile	L.S	1.0	438,170.24	2,790,300.38	6,347,427	74,118,000	
			B-3. Temporary bridge	L.S	1.0		4,976,786.73	53,423,642	85,722,000	
			B-4. Dewatering	L.S	1.0		10,519,709.00		68,272,000	
			B-5. Temporary road & preparation	L.S	1.0		7,783,260.59		50,513,000	
			B-6. diversion works	L.S	1.0		11,759,640.95		76,320,000	
			B-7. Other temporary works	L.S	1.0		18,178,115.27	17,112,000	135,087,000	
			B-8. Transpotation / Shipment	L.S	1.0	1,913,684.57	13,325,895.23	75,199,059	378,581,000	
		sub total (B. Temporary works)				3,192,139.21	88,433,278.12	262,773,263	1,198,502,000	
		C. Building Works	C-1. Control house	L.S	1.0		1,977,700.00		12,835,000	
			C-2. Local contrl house	L.S	1.0		301,900.00		1,959,000	
			C-3. Local contrl house	L.S	1.0		301,900.00		1,959,000	
			C-4. Stop log room	L.S	1.0		818,200.00		5,310,000	
		sub total (C. Building works)					3,399,700.00		22,064,000	
		D. Integrated Water Management System	D-1. IWMS manufactures	L.S	1.0		15,676,546.12		101,740,000	
			D-2. Installation for IWMS	L.S	1.0		15,951,897.71		103,527,000	
		sub total (D. Integrated Water Management System)					31,628,443.83		205,268,000	
		E. Dispute Board	E-1. Dispute Board	L.S	1.0	407,000.00			46,129,000	
		sub total (E. Dispute Board)				407,000.00			46,129,000	
						4,652,659.60	284,201,650.85	2,033,372,349	4,405,173,000	
	I-2 Indirect Cost					1,485,994.40	93,278,928.15	186,287,138	960,089,000	
						6,138,654.00	377,480,579.00	2,219,659,487	**5,365,263,000**	
						13.0%	45.7%	41.3%		
II Consultant Service	Remuneration			L.S	1.0		10,092,110.00	230,823,000	296,320,000	
	Direct Expense			L.S	1.0		7,039,178.00	46,603,230	92,287,000	
							17,131,288.00	277,426,230	**388,607,000**	
III Contingency for Construction	Price Contingency		LC: 1.0%/year, total ratio is 18.9%	L.S	1.0		71,343,829.43		**463,021,000**	
			FC: 1.6%/year, total ratio is 4.2%	L.S	1.0	257,823.47		93,225,698	**122,448,000**	
	Physical Contingency			%	5.0	319,823.87	22,441,220.42	115,644,259	**297,537,000**	
IV Contingency for Consultant Service	Price Contingency		LC: 1.0%/year, total ratio is 18.9%	L.S	1.0		3,237,813.43		**21,013,000**	
			FC: 1.6%/year, total ratio is 4.2%	L.S	1.0			11,651,902	**11,652,000**	
	Physical Contingency			%	5.0		1,018,455.07	14,453,907	**21,064,000**	
V Interest During Construction	0.01 %/year			L.S	1.0			20,100,000	**20,100,000**	

	US$	LE	YEN	Total (Exchange to YEN)	Remarks
Total Construction Cost (I～V)	6,716,301.34	492,653,185.36	2,752,161,483	**6,710,705,000**	
	11.3%	47.6%	41.1%		

Table 4-2.4 Bill of quantities (1/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
I Construction Cost										6,138,654.00	377,480,579.00	2,219,659,487	**5,365,263,489**	
I-1 Direct Cost										4,652,659.60	284,201,650.85	2,033,372,349	**4,405,173,502**	
A. Civil Works										1,053,520.39	160,740,228.90	1,770,599,086	**2,933,209,173**	
A-1. Excavation	A-1-1. Excavation	1. excavation	1). excavation and loading	0.8m3 back hoe	m3	23,390.0		19.82			463,589.80		3,008,698	
			2). excavation for concrete basement	0.8m3 back hoe	m3	1,320.0		28.32			37,382.40		242,612	
		sum									500,972.20		3,251,310	
		2. excavated soil disposal	1). excavated soil disposal	Distance 20km	m3	24,710.0		159.33			3,937,044.30		25,551,418	
total											4,438,016.50		28,802,727	
A-2. Embankment	A-2-1. Embankment	1. Embankment	1). backfill 1	15t bulldozer	m3	76,490.0		37.90			2,898,971.00		18,814,322	
			2). backfill 2	vibration roller,tamping machine	m3	7,470.0		45.37			338,913.90		2,199,551	
			3). material fee for backfill	sand	m3	60,873.0		67.10			4,084,578.30		26,508,913	
		sum									7,322,463.20		47,522,786	
		2. transportation fee for buying material	1). excavation and loading	0.8m3 back hoe loose soil	m3	60,873.0		19.22			1,169,979.06		7,593,164	
			2). transportation by damp truck	Distance 20km	m3	60,873.0		135.51			8,248,900.23		53,535,362	
		sum									9,418,879.29		61,128,527	
		3. transportation fee for reused material	1). excavation and loading	0.8m3 back hoe loose soil	m3	45,183.0		19.22			868,417.26		5,636,028	
			2). transportation by damp truck	Distance 0.3km	m3	45,183.0		18.47			834,530.01		5,416,100	
		sum									1,702,947.27		11,052,128	
		4. Earth finishing	1). earth finishing foundation		m3	4,640.0		7.36			34,150.40		221,636	
			2). rough finishing	0.8m3 back hoe	m2	1,610.0		34.70			55,867.00		362,577	
		sum									90,017.40		584,213	
		5. protection fence for waterpollution	1). protection fence		m	253.0		1,112.18			281,381.54		1,826,166	
total											18,815,688.70		122,113,820	
A-3. Demolition work	A-3-1. Demolition work	1. Demolition work	1). concrete demolition	reinforced concrete	m3	195.4		469.06			91,663.70		594,897	
			2). concrete demolition	plain concrete	m3	5.8		224.59			1,298.13		8,425	
			3). breaked concrete disposal	Distance 20km	m3	201.2		194.01			39,034.81		253,336	
total											131,996.64		856,658	
A-4. Sheet pile bank protection	A-4-1. Capping concrete	1. crown works	1). formwork	reinforced concrete	m2	1,663.9		400.74			666,791.28		4,327,475	
			2). placing reinforced concrete	25N/mm2 by crane	m3	517.9		1,356.29			702,409.02		4,558,635	
			3). curing	reinforced concrete	m3	517.9		7.83			4,055.07		26,317	
			4). bending,cutting and placing for re-bar	D12	t	13.6		18,857.16			256,777.94		1,666,489	
			5). joint filler	@10m	m2	53.5		403.70			21,614.09		140,275	
	sub total										1,651,647.40		10,719,192	
	A-4-2. Sheet pile	1. Sheet pile protection	1). driving sheet pile	PU18, L≦15m (driving length)	sheet	126.0		1,466.45			184,772.70		1,199,175	
				PU18, L≦12m (driving length)	sheet	146.0		1,231.17			179,750.82		1,166,583	
				PU18, L≦9m (driving length)	sheet	43.0		997.84			42,907.12		278,467	
				PU12, L≦12m (driving length)	sheet			1,055.19						
				PU12, L≦9m (driving length)	sheet	62.0		880.52			54,592.24		354,304	
				PU12, L≦6m (driving length)	sheet	486.0		761.90			370,283.40		2,403,139	
				PU12, L≦4m (driving length)	sheet			645.24						
				PU12, L≦2m (driving length)	sheet			527.92						
			2). Sheet pile press fitting	PU, L≦15m (driving length)	sheet			165.71	5,233					
				PU, L≦12m (driving length)	sheet			130.98	4,139					
			3). Mobilization & demobilization	press fitting machine for sheet pile	nos			700.36	19,332					
			4). material fee for sheet pile	PU12, 18	t	722.1	881.00			636,160.04			72,102,379	
			5). installation for tie-rod and waling		t	47.7		3,311.13			157,866.66		1,024,555	
			6). material fee for tie-rod (NHT690)	φ46 L=10.0m 2pcs/rod	nos	2.0			68,175			136,350	136,350	
				φ46 L=11.0m 2pcs/rod	nos	2.0			74,295			148,590	148,590	
				φ46 L=11.5m 2pcs/rod	nos	23.0			77,040			1,771,920	1,771,920	
				φ46 L=12.0m 2pcs/rod	nos	20.0			79,785			1,595,700	1,595,700	
				φ46 L=13.0m 2pcs/rod	nos	2.0			85,905			171,810	171,810	
				φ46 L=13.5m 2pcs/rod	nos	8.0			89,325			714,600	714,600	
				φ46 L=14.0m 2pcs/rod	nos	6.0			92,025			552,150	552,150	
				φ42 L=12.0m 2pcs/rod	nos	8.0			51,255			410,040	410,040	
				φ42 L=9.0m 2pcs/rod	nos	2.0			53,595			107,190	107,190	
				φ42 L=8.5m 2pcs/rod	nos	9.0			69,480			625,320	625,320	
				φ32L=7.5m 2pcs/rod	nos	22.0			27,990			615,780	615,780	
				φ32 L=8.0m 2pcs/rod	nos	1.0			29,385			29,385	29,385	
				φ32 L=9.0m 2pcs/rod	nos	1.0			32,670			32,670	32,670	

Table 4-2.5 Bill of quantities (2/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
				φ25 L=7.5m 2pcs/rod	nos	4.0			21,240			84,960	84,960	
			7). material fee for waling	UPN	t	32.7		12,553.60			410,389.73		2,663,429	
			8). sheet pile welding	on site	nos	293.0		1,944.85			569,841.05		3,698,268	
			9). anticorrosion painting (bitumen)		m2	7,145.3		248.00			1,772,029.44		11,500,471	
	sub total									636,160.04	3,742,433.16	6,996,465	103,387,235	
total										636,160.04	5,394,080.56	6,996,465	114,106,427	
A-5. Bank protection	A-5-1. Bank protection	1. Riprap	1). wet stone pitching	t=35cm	m2	2,008.8		841.71			1,690,827.04		10,973,467	
			2). placing backfill concrete	18N/mm2 by crane	m3	161.4		1,479.36			238,709.52		1,549,225	
			3). curing	plain concrete	m3	161.4		12.92			2,084.77		13,530	
		sum									1,931,621.33		12,536,222	
		2. crown works	1). form for lean concrete		m2	10.2		209.60			2,137.92		13,875	
			2). placing lean concrete	18N/mm2 by crane	m3	1.8		1,479.36			2,640.65		17,138	
			3). curing	plain concrete	m3	1.8		12.92			23.06		150	
			4). formwork	for small structure	m2	107.8		355.10			38,295.03		248,535	
			5). placing plain concrete	18N/mm2 by man power	m3	16.0		1,109.76			17,750.61		115,201	
			6). curing	small structure	m3	17.8		30.22			537.31		3,487	
			7). gravel for under concrete	t=100mm	m2	3.6		99.31			354.53		2,301	
			8). joint filler	expansion joint	m2	1.3		45.20			59.93		389	
		sum									61,799.04		401,076	
		3. base concrete	1). form for lean concrete		m2	10.7		209.60			2,232.24		14,487	
			2). placing lean concrete	18N/mm2 by crane	m3	2.7		1,479.36			3,938.79		25,563	
			3). curing	plain concrete	m3	2.7		12.92			34.39		223	
			4). formwork	for small structure	m2	104.4		355.10			37,089.90		240,713	
			5). placing plain concrete	18N/mm2 by man power	m3	16.4		1,109.76			18,201.72		118,129	
			6). curing	small structure	m3	16.4		30.22			495.65		3,217	
			7). gravel for under concrete	t=100mm	m2	4.5		99.31			445.55		2,892	
			8). joint filler	expansion joint	m2	1.7		45.20			75.27		489	
		sum									62,513.51		405,713	
		4. gabion protection	1). installation for gabion	0.5×1.0×2.0	nos	1,184.0		1,173.37	3,990		1,389,270.08	4,724,160	13,740,523	
				1.0×1.0×2.0	nos	670.0		2,355.33	8,920		1,578,071.10	5,976,400	16,218,081	
		sum									2,967,341.18	10,700,560	29,958,604	
total											5,023,275.06	10,700,560	43,301,615	
A-6. Canal bed protection	A-6-1. bed protection for upstream	1. Bed protection for upstream	1). stone riprap	working radius r=less 9m	m3	956.5		606.24			579,868.56		3,763,347	
			2). grading for riprap		m2	1,952.0		76.86			150,030.72		973,699	
		sum									729,899.28		4,737,046	
	A-6-2. bed protection for downstream	1. Bed protection for downstream	1). stone riprap	working radius r=less 9m	m3	1,701.0		606.24			1,031,214.24		6,692,580	
			2). grading for riprap		m2	1,890.0		76.86			145,265.40		942,772	
			3). gravel for backfill	t=0.1m	m3	208.5		746.76			155,699.46		1,010,489	
			4). geotextile	t=0.5mm, Nylon,polyester	m2	2,085.0		46.42			96,785.70		628,139	
		sum									1,428,964.80		9,273,982	
	A-6-3. Sheet pile for water stop	1. Sheet pile for water stop	1). driving sheet pile	PU18, L≦15m (driving length)	sheet	1.0		1,466.45			1,466.45		9,517	
				PU18, L≦12m (driving length)	sheet	3.0		1,231.17			3,693.51		23,971	
				PU18, L≦9m (driving length)	sheet	4.0		997.84			3,991.36		25,904	
				PU12, L≦12m (driving length)	sheet	120.0		1,055.19			126,622.80		821,782	
				PU12, L≦9m (driving length)	sheet	8.0		880.52			7,044.16		45,717	
				PU12, L≦6m (driving length)	sheet	122.0		761.90			92,951.80		603,257	
				PU12, L≦4m (driving length)	sheet	120.0		645.24			77,428.80		502,513	
				PU12, L≦2m (driving length)	sheet	104.0		527.92			54,903.68		356,325	
			2). material fee for sheet pile	PU12, 18	t	222.5	881.00			196,050.69			22,220,385	
			3). sheet pile welding	on site	nos	31.0		1,944.85			60,290.35		391,284	
			4). anticorrosion painting	sand plasting and painting	m2	193.7		248.00			48,032.64		311,732	
			5). sheet pile cutting		m	24.0		264.24			6,341.76		41,158	
		sum								196,050.69	482,767.31		25,353,545	
total										196,050.69	2,641,631.39		39,364,573	
A-7. Concrete work for regulators	A-7-1. concrete works	regulator body	1). earth foundation finishing		m2	4,553.1		28.06			127,759.42		829,159	
			2). form for lean concrete		m2	51.9		209.60			10,882.43		70,627	
			3). placing lean concrete	18N/mm2 by crane	m3	403.1		1,326.22			534,599.28		3,469,549	
			4). curing	plain concrete	m3	403.1		12.92			5,208.05		33,800	
			5). formwork	reinforced concrete	m2	14,302.0		400.74			5,731,375.46		37,196,627	

Table 4-2.6 Bill of quantities (3/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			6). formwork	circular structure	m2	490.7		525.17			257,706.17		1,672,513	
			7). placing concrete	25N/mm2(src, night time)	m3	14,667.0		1,446.03			21,208,922.01		137,645,904	
			8). placing concrete	25N/mm2(opc)	m3	1,372.5		1,356.29			1,861,467.33		12,080,923	
			9). curing	reinforced concrete	m3	16,039.5		7.83			125,589.05		815,073	
			10). bending,cutting and placing for re-bar	D13～D25mm	t	586.0		17,805.74			10,434,680.00		67,721,073	
			11). scaffolding	not less than 4m	m2	10,755.1		161.52			1,737,170.21		11,274,235	
			12). pipe support falsework	not greater than 4t/m2	m3	4,360.7		144.07			628,244.60		4,077,307	
			13). joint filler	t=20mm	m2	488.7		403.70			197,284.15		1,280,374	
			14). water stop	w=300mm	m	251.0		37.54	2,214		9,423.29	555,758	616,915	
			15). water stop	water-swelling	m	66.1		16.56	1,975		1,093.78	130,448	137,547	
			16). addtive for rust-proofing	for reinforced condrete	m3	16,039.5		124.81			2,001,844.48		12,991,971	
	total										44,873,249.71	686,206	291,913,597	
	A-8. Pile foundation work	A-8-1. Cast-in-place RC pile	φ1,000	1). mobilization and demobilization		L.S	2.0		297,720.00			595,440.00		3,864,406	
				2). pile drilling	including fabricate and lowering stell cage and pour concrete	m	2,429.6		1,712.00			4,159,475.20		26,994,994	
				3). placing concrete	25N/mm2(src)	m3	1,908.2		1,386.07			2,644,903.45		17,165,423	
				4). bending,cutting and placing for re-bar		t	301.0		17,805.74			5,359,812.63		34,785,184	
				5). pile head demolishing	φ1,000, 0.8m	m3	120.6		469.06			56,586.06		367,244	
				6). load test		L.S	2.0		283,333.00			566,666.00		3,677,662	
	total										13,382,883.34		86,854,913	
	A-9. Accessory works	A-9-1. Road works	1. Asphalt pavement roadway	1). enbankment		m3	10,225.3		37.90			387,539.62		2,515,132	
				material fee for temporary road	sand	m3	12,916.2		67.10			866,676.59		5,624,731	
				transportation fee for buying material											
				excavation and loading	0.8m3 back hoe loose soil	m3	12,916.2		19.22			248,249.24		1,611,138	
				transportation by damp truck	Distance 20km	m3	12,916.2		135.51			1,750,273.40		11,359,274	
				2). wearing course	t=50mm	m2	4,379.6		143.00			626,287.09		4,064,603	
				3). binder course	t=60mm	m2	4,379.6		143.00			626,287.09		4,064,603	
				4). base course	t=200mm	m2	4,379.6		132.78			581,527.27		3,774,112	
				5). sub base course	t=200mm	m2	4,379.6		132.78			581,527.27		3,774,112	
				6). tack coat		m2	4,379.6		16.00			70,074.08		454,781	
				7). prime coat		m2	4,379.6		19.00			83,212.97		540,052	
			sum									5,821,654.62		37,782,538	
			2. Asphalt pavement pathway	1). wearing course	t=50mm	m2	623.7		143.00			89,191.96		578,856	
				2). base course	t=200mm	m2	623.7		132.78			82,817.54		537,486	
				3). prime coat		m2	623.7		19.00			11,850.68		76,911	
			sum									183,860.18		1,193,253	
			3. curb concrete	1). form for lean concrete		m2	127.3		209.60			26,689.20		173,213	
				2). placing lean concrete	18N/mm2 by crane	m3	20.7		1,479.36			30,585.21		198,498	
				3). curing	plain concrete	m3	20.7		12.92			267.11		1,734	
				3). formwork	for small structure	m2	964.9		355.10			342,646.12		2,223,773	
				4). placing plain concrete	18N/mm2 by man power	m3	109.5		1,109.76			121,480.35		788,407	
				5). curing	small structure	m3	109.5		30.22			3,308.04		21,469	
				6). gravel for under concrete	t=100mm	m2	41.3		99.31			4,106.39		26,650	
			sum									529,082.42		3,433,745	
			4. guard pipe	H=1.1m		m	629.81		1,212.12			763,405.29		4,954,500	
			5. slope protection	1). stone masonry with mortar	t=35cm	m2	1,765.25		841.71			1,485,828.57		9,643,027	
				2). placing backfill concrete	18N/mm2 by crane	m3	214.54		1,479.36			317,374.66		2,059,762	
				3). curing	plain concrete	m3	214.54		12.92			2,771.79		17,989	
			sum									1,805,975.02		11,720,778	
			6. crown concrete	1). form for lean concrete		m2	47.9		209.60			10,031.45		65,104	
				2). placing lean concrete	18N/mm2 by crane	m3	7.9		1,479.36			11,751.29		76,266	
				3). curing	plain concrete	m3	7.9		12.92			102.63		666	
				4). formwork	for small structure	m2	395.9		355.10			140,574.81		912,331	
				5). placing plain concrete	18N/mm2 by man power	m3	59.1		1,109.76			65,531.32		425,298	
				6). curing	small structure	m3	20.7		30.22			624.78		4,055	
				7). gravel for under concrete	t=100mm	m2	15.9		99.31			1,577.73		10,239	
				8). joint filler	expansion joint	m2	5.9		45.20			266.90		1,732	
			sum									230,460.91		1,495,691	
			7. base concrete	1). form for lean concrete		m2	53.7		209.60			11,250.69		73,017	
				2). placing lean concrete	18N/mm2 by crane	m3	13.4		1,479.36			19,851.90		128,839	

Table 4-2.7 Bill of quantities (4/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
						US$	LE	YEN	US$	LE	YEN		
		3). curing	plain concrete	m3	13.4		12.92			173.37		1,125	
		4). formwork	for small structure	m2	474.3		355.10			168,431.08		1,093,118	
		5). placing plain concrete	18N/mm2 by man power	m3	72.5		1,109.76			80,417.59		521,910	
		6). curing	small structure	m3	72.5		30.22			2,189.86		14,212	
		7). gravel for under concrete	t=100mm	m2	18.8		99.31			1,865.73		12,109	
		8). joint filler	expansion joint	m2	7.2		45.20			327.53		2,126	
	sum									284,507.75		1,846,455	
	8. concrete stair	1). form for lean concrete		m2	16.9		209.60			3,535.78		22,947	
		2). placing lean concrete	18N/mm2 by crane	m3	8.4		1,479.36			12,417.03		80,587	
		3). curing	plain concrete	m3	8.4		12.92			108.44		704	
		4). formwork	reinforced concrete	m2	118.6		400.74			47,509.37		308,336	
		5). placing concrete	25N/mm2(opc)	m3	31.0		1,356.29			42,068.86		273,027	
		6). curing	reinforced concrete	m3	31.0		7.83			242.86		1,576	
		7). gravel for under concrete	t=100mm	m2	12.5		99.31			1,243.54		8,071	
		8). bending,cutting and placing for re-bar	D12	t	0.4		18,857.16			7,970.69		51,730	
	sum									115,096.57		746,977	
sub total										9,734,042.76		63,173,938	
A-9-2. Bridge works	1. concrete work	1). formwork	reinforced concrete	m2	1,696.3		400.74			679,775.92		4,411,746	
		2). placing concrete	25N/mm2(opc)	m3	548.9		1,356.29			744,406.81		4,831,200	
		3). curing	reinforced concrete	m3	548.9		7.83			4,297.53		27,891	
		4). bending,cutting and placing for re-bar	D12	t	105.1		18,857.16			1,981,642.37		12,860,859	
		5). pipe support falsework	not greater than 4t/m2	m3	6,121.3		144.07			881,888.48		5,723,456	
		6). Styrofoam	t=20～150mm	m3	14.0			26,190			366,607	366,607	
	sum									4,292,011.11	366,607	28,221,759	
	2. shoe	1). rubber bearing	330×150×40	nos	20.0			11,760			235,200	235,200	
			330×300×40	nos	40.0			23,590			943,600	943,600	
			150×10,000×20	nos	2.0			108,780			217,560	217,560	
			300×10,000×20	nos	5.0			217,560			1,087,800	1,087,800	
		2). corrosion-proof anchor	Fixed, F25D	nos	12.0			6,930			83,160	83,160	
			Movable, M25D	nos	20.0			8,260			165,200	165,200	
			for F25D	nos	12.0			1,190			14,280	14,280	
			for M25D	nos	20.0			2,940			58,800	58,800	
	sum										2,805,600	2,805,600	
	3. steel expansion joint	1). expansion joint (brof joint)	displacement⊿=20mm	m	24.2		232.34	35,190		5,622.62	851,598	888,089	
		2). expansion joint (brof joint)	displacement⊿=35mm	m	96.8		232.34	55,800		22,490.51	5,401,440	5,547,403	
		3). Anchor bar	D12	t	0.6		11,442.00			7,029.08		45,619	
	sum									35,142.21	6,253,038	6,481,111	
	4. balustrade for bridge	1). balustrade	h=1.100	m	165.2		1,212.12			200,242.22		1,299,572	
		2). Anchor bar	D12	t	0.6		11,442.00			7,029.08		45,619	
	sum									207,271.30		1,345,191	
sub total										4,534,424.62	9,425,245	38,853,661	
A-9-3. Approach slab	1. concrete work	1). formwork	reinforced concrete	m2	96.0		400.74			38,471.04		249,677	
		2). placing concrete	25N/mm2(opc)	m3	160.0		1,356.29			217,006.40		1,408,372	
		3). curing	reinforced concrete	m3	160.0		7.83			1,252.80		8,131	
		4). bending,cutting and placing for re-bar	D22	t	14.2		17,805.74			253,553.73		1,645,564	
		5). Anchor cap	SGP φ40×80	nos	200.0		67.00			13,400.00		86,966	
		6). Anchor bar	D22×500×200nos	t	0.3		11,442.00			3,478.36		22,575	
		7). joint filler	expansion joint	m2	34.4		45.20			1,554.88		10,091	
	sum									528,717.21		3,431,375	
	2. shoe	1). rubber shoe	t=30mm	m2	24.0			166,050			3,985,200	3,985,200	
sub total										528,717.21	3,985,200	7,416,575	
A-9-4. Accessory works around regulator	1. accessory work for gate	1). formwork for post-placing concrete	reinforced concrete	m2	1,248.8		400.74			500,448.11		3,247,908	
		2). post-placing concrete	25N/mm2(src, night time)	m3	340.2		1,446.03			491,953.86		3,192,781	
		3). post-placing concrete	25N/mm2(opc)	m3	7.5		1,356.29			10,185.73		66,105	
		4). curing	for post-placing concrete	m3	347.7		7.83			2,722.64		17,670	
		5). joint bar	D22	t	2.9		11,442.00			33,457.14		217,137	
		6). installation for joint bar	D22	nos	7,900.0		83.45			659,255.00		4,278,565	
	sum									1,698,022.48		11,020,166	
	2. hydraulic pipe pit works	1). form for lean concrete		m2	9.1		209.60			1,909.45		12,392	

Table 4-2.8 Bill of quantities (5/12)

1	as of Estimation	January . 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			2). placing lean concrete	18N/mm2 by crane	m3	10.5		1,479.36			15,562.86		101,003	
			3). curing	plain concrete	m3	10.5		12.92			135.91		882	
			4). formwork	reinforced concrete	m2	374.7		400.74			150,169.30		974,599	
			5). placing concrete	25N/mm2(opc)	m3	85.8		1,356.29			116,383.24		755,327	
			6). curing	reinforced concrete	m3	85.8		7.83			671.89		4,361	
			7). bending,cutting and placing for re-bar	D22	t	8.5		17,805.74			151,687.09		984,449	
			8). scaffolding	not less than 4m	m2	160.1		161.52			25,865.81		167,869	
			9). pipe support falsework	not greater than 4t/m2	m3	92.0		144.07			13,250.11		85,993	
			10). water stop	w=300mm	m	16.8		37.54	2,214		630.67	37,195	41,288	
			11). joint filler	expansion joint	m2	5.1		45.20			231.87		1,505	
			12). joint filler	construction joint	m2	0.6		403.70			250.29		1,624	
			13). checker plate	t=3.2mm	m2	1.0		349.41			342.41		2,222	
				t=4.5mm	m2	18.8		476.12			8,946.24		58,061	
			14). Anchor bar	D16	t	0.0		11,442.00			57.11		371	
			15). installation for hydraulic pipe	SUS 32A	m	4,004.0		75.50			302,302.00		1,961,940	
		sum									788,396.25	37,195	5,153,887	
		3. steel stairs	1). steel stairs		L.S	2.0		129,944.00			259,888.00		1,686,673	
			2). foundation for support		L.S	2.0		14,774.67			29,549.34		191,775	
		sum									289,437.34		1,878,448	
		4. installation for grating		IB, 44×5×3	m2	227.8		232.34	18,090		52,936.34	4,121,625	4,465,182	
		5. installation for handrail		H=1.1m	m	563.2		1,395.28			785,821.69		5,099,983	
		6. crane facility	1). chain block	manual operation, 5t	L.S	2.0		32,157.16			64,314.32		417,400	
			2). rail	I 300x150x10x18.5	t	1.1		15,692.00			16,711.98		108,461	
		sum									81,026.30		525,861	
		7. installation for steel steps	b=300mm		nos	765.0		370.65			283,547.25		1,840,222	
		8. staff gauge			m	65.2		1,664.10			108,416.02		703,620	
		9. gate lighting	1). high pressure mercury lamp	400W	nos	6.0		5,075.00			30,450.00		197,621	
			2). installation for gate lighting		nos	6.0		18,533.63			111,201.78		721,700	
		sum									141,651.78		919,320	
		10. water level detector	1). water level detector	DC4-20A	nos	13.0		34,927.58			454,058.55		2,946,840	
			2). installation for water level detector		nos	13.0		2,744.00			35,672.00		231,511	
		sum									489,730.55		3,178,351	
	sub total										4,718,986.00	4,158,820	34,785,039	
total											19,516,170.59	17,569,265	144,229,212	
A-10. Electric works	A-10-1. installation for facilities of receiving po	1. Installation for power receiving and distribu	1). installation for power receiving and distribution pane		nos	1.0		3,388.00			3,388.00		21,988	
			2). emergency generator with panel	80kVA, 3phase 4wire	nos	1.0			8,650,000			8,650,000	8,650,000	
			3). installation for backup generator		nos	1.0		33,246.50			33,246.50		215,770	
			4). transformer	three phase100KVA	nos	1.0		211,500.00			211,500.00		1,372,635	
	sub total										248,134.50	8,650,000	10,260,393	
	A-10-2. Installation for electric cable and wire	1. electric cable and wire	1). electric cable											
			CV 3.5sq -2C		m	323.6		43.25			13,995.70		90,832	
			CV 8sq -2C		m	340.3		66.44			22,609.53		146,736	
			CV 14sq -2C		m	40.0		92.29			3,691.60		23,958	
			CV 22sq -2C		m	20.0		124.83			2,496.60		16,203	
			CV 2sq -3C		m	64.5		41.83			2,698.03		17,510	
			CV 5.5sq -3C		m	268.6		71.80			19,285.48		125,163	
			CV 8sq -3C		m	458.6		87.30			40,035.78		259,832	
			CV 14sq -3C		m	820.4		123.72			101,499.88		658,734	
			CV 22sq -3C		m	125.8		168.44			21,189.75		137,521	
			CV 38sq -3C		m	225.2		254.94			57,412.48		372,607	
			CV 8sq -4C		m	20.0		110.31			2,206.20		14,318	
			CV 38sq -4C		m	30.0		327.64			9,829.20		63,792	
			CVV 2sq -4C		m	5.0		52.36			261.80		1,699	
			CVV 2sq -5C		m	969.3		63.91			61,947.96		402,042	
			CVV 2sq -8C		m	919.8		86.62			79,673.07		517,078	
			CVV 2sq -10C		m	74.5		106.68			7,947.66		51,580	
			CVV 2sq -20C		m	785.2		191.53			150,389.35		976,027	
			CVV 2sq -30C		m	4,164.6		253.71			1,056,600.66		6,857,338	
			CVVS 2sq -2C		m	451.5		47.59			21,486.88		139,450	

Table 4-2.9 Bill of quantities (6/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price US$	Unit Price LE	Unit Price YEN	Amount US$	Amount LE	Amount YEN	Exchange to YEN	Remarks
			CVVS 2sq -10C		m	497.6		124.83			62,115.40		403,129	
			CVVS 2sq -15C		m	113.8		174.84			19,896.79		129,130	
			CVVS 2sq -30C		m	910.4		272.75			248,311.60		1,611,542	
			2). electric wire											
			IV 3.5sq		m	819.6		25.93			21,252.22		137,927	
			IV 5.5sq		m	95.1		29.50			2,805.45		18,207	
			IV 8sq		m	1,050.8		36.46			38,312.16		248,646	
			IV 14sq		m	351.0		52.56			18,448.56		119,731	
			IV 22sq		m	30.0		69.60			2,088.00		13,551	
			CPEV 0.9mm -3P		m	1,521.8		48.34			73,563.81		477,429	
			3). conduits											
			FEP 30		m	576.6		72.87			42,016.84		272,689	
			FEP 40		m	990.8		83.30			82,533.64		535,643	
			FEP 50		m	45.8		96.10			4,401.38		28,565	
			FEP 65		m	155.8		114.00			17,761.20		115,270	
			FEP 80		m	762.8		139.03			106,052.08		688,278	
			FEP 100		m	613.2		188.15			115,373.58		748,775	
			FEP 125		m	474.8		232.23			110,262.80		715,606	
			G 28		m	285.2		163.84			46,727.16		303,259	
			G 36		m	458.9		201.06			92,266.43		598,809	
		sum									2,779,446.71		18,038,609	
		2. earth work	excavasion and backfill		m3	32.0		116.67			3,733.44		24,230	
		3. handhole	900×900×900		nos	32.0		18,600.65			595,220.80		3,862,983	
	sub total										3,378,400.95		21,925,822	
total											3,626,535.45	8,650,000	32,186,215	
A-11. Gate manufactures and works	A-11-1. gate manufacture	1. Gate manufacture	1). double stage roller gate	h=1.100										
			gate leaf	6.0×6.55	L.S	2.0			157,655,000			315,310,000	315,310,000	
			gate guide		L.S	2.0			132,187,000			264,374,000	264,374,000	
			hoisting device	hydraulic	L.S	2.0			410,835,000			821,670,000	821,670,000	
			remote operation system		L.S	2.0			110,893,000			221,786,000	221,786,000	
			2). slide gate	small gate										
			for Badraman	2.0×2.65, including hoist	L.S	2.0		461,044.07			922,088.13		5,984,352	
			for Diroutiah	2.0×2.35, including hoist	L.S	3.0		461,044.07			1,383,132.20		8,976,528	
			for Abo Gabal	2.0×2.95, including hoist	L.S	4.0		499,464.41			1,997,857.62		12,966,096	
			for Sahelyia	2.0×3.55, including hoist	L.S	2.0		527,406.47			1,054,812.94		6,845,736	
			3). stop log											
			for large regulator	Type-A×2、Type-B×8	L.S	2.0		2,368,089.98			4,736,179.96		30,737,808	
			for asmall regulator	Type-A×2、Type-B×7	L.S	2.0		1,128,160.86			2,256,321.72		14,643,528	
		sum									12,350,392.57	1,623,140,000	1,703,294,048	
	A-11-2. installation for gate facilities	1. Installation for manufactures	1). installation for gate	for gate, gate guide, hoist	L.S	1.0		5,372,924.63			5,372,924.63		34,870,281	
			2). installation for stop log	for gate guide, crane	L.S	1.0		1,351,345.63			1,351,345.63		8,770,233	
			3). control panel for gate operation											
			remote operation panel		nos	1.0		6,860.00			6,860.00		44,521	
			4). Japanese mechanical engineer for gate		day	1,050.0			22,154			23,261,700	23,261,700	
			5). Japanese electrical engineer for gate		day	1,050.0			24,698			25,932,900	25,932,900	
		sum									6,731,130.26	49,194,600	92,879,635	
total											19,081,522.83	1,672,334,600	1,796,173,683	
A-12. Expense of the machine and facilities	A-12-1. Expense of the machine and facilities	1. Rent fee for heavy equipment	1-1. rent in Egypt											
			1). rough terrain crane	25t	day	1,410.0		3,194.17			4,503,775.00		29,229,500	
			2). truck with crane	4t/2.9t	day	1,350.0		1,927.50			2,602,125.00		16,887,791	
			3). Truck	11t	day	1,350.0		1,591.67			2,148,750.00		13,945,388	
			4). Truck mixer	4.4m3	day	1,260.0		2,150.00			2,709,000.00		17,581,410	
			5). Truck mixer	4.4m3	day	1,230.0		2,150.00			2,644,500.00		17,162,805	
			6). Truck mixer	4.4m3	day	915.0		2,150.00			1,967,250.00		12,767,453	
			7). Truck mixer	4.4m3	day	450.0		2,150.00			967,500.00		6,279,075	
			8). cement silo	50t	day	1,290.0		1,595.83			2,058,625.00		13,360,476	
			9). Wheel Loader	2.1m3	day	400.0		2,030.83			812,333.33		5,272,043	
			1-2. rent in Japan											
			1). Batching plant	30m3/h	LS	1.0	221,309.66			221,309.66			25,083,237	

Table 4-2.10 Bill of quantities (7/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			2). Vibration hunmer (1)	Hydraulic, 232KW	day	1,507.0			21,100			31,797,700	31,797,700	
			3). Vibration hunmer (2)	Hydraulic, 232KW	day	367.0			21,100			7,743,700	7,743,700	
			4). Water jet	14.7Mpa 325L/min	day	1,507.0			9,370			14,120,590	14,120,590	
		sum								221,309.66	20,413,858.33	53,661,990	211,231,167	
		2. Operator wage	rent in Egypt											
			1). rough terrain crane	25t	day	1,058.0		435.00			460,230.00		2,986,893	
			2). truck with crane	4t/2.9t	day	1,013.0		435.00			440,655.00		2,859,851	
			3). Truck	11t	day	1,013.0		435.00			440,655.00		2,859,851	
			4). Truck mixer	4.4m3	day	945.0		435.00			411,075.00		2,667,877	
			5). Truck mixer	4.4m3	day	923.0		435.00			401,505.00		2,605,767	
			6). Truck mixer	4.4m3	day	687.0		435.00			298,845.00		1,939,504	
			7). Truck mixer	4.4m3	day	338.0		435.00			147,030.00		954,225	
		sum									2,599,995.00		16,873,968	
		3. Fuel fee	rent in Egypt											
			1). rough terrain crane	25t	Lit	122,696.2		2.00			245,392.40		1,592,597	
			2). truck with crane	4t/2.9t	Lit	39,091.6		2.00			78,183.20		507,409	
			3). Truck	11t	Lit	61,620.7		2.00			123,241.40		799,837	
			4). Truck mixer	4.4m3	Lit	57,900.1		2.00			115,800.20		751,543	
			5). Truck mixer	4.4m3	Lit	56,552.2		2.00			113,104.40		734,048	
			6). Truck mixer	4.4m3	Lit	42,092.4		2.00			84,184.80		546,359	
			7). Truck mixer	4.4m3	Lit	20,709.2		2.00			41,418.40		268,805	
		sum									801,324.80		5,200,598	
total										221,309.66	23,815,178.13	53,661,990	233,305,733	
B. Temporary Works										3,192,139.21	88,433,278.12	262,773,263	**1,198,502,296**	
B-1. Temporary Coffer Dam	B-1-1. Double Sheet Pile	1. Double sheet pile	1). driving sheet pile	PU28+1, L≦15m (driving length)	sheet			1,730.41						
				PU28+1, L≦12m (driving length)	sheet	1,462.0		1,466.45			2,143,949.90		13,914,235	
				PU28+1, L≦9m (driving length)	sheet			1,173.16						
				PU28+1, L≦6m (driving length)	sheet	640.0		939.18			601,075.20		3,900,978	
				PU28+1, L≦4m (driving length)	sheet	80.0		763.21			61,056.80		396,259	
			2). Sheet pile press fitting	PU, L≦9m (driving length)	sheet			103.68	3,280					
			3). Mobilization & demobilization	press fitting machine for sheet pile	nos			700.36	19,332					
			4). material fee for sheet pile	PU28+1	t	1,907.6	440.50			840,284.40			95,237,834	
			5). material fee for sheet pile	PU28+1, near rail way	t		881.00							
			6). installation for tie-rod and waling		t	293.9		3,311.13			972,988.79		6,314,697	
			7). material fee for tie-rod (NHT690)	φ75 L=8.9m 2pcs/rod	nos	210.0			151,065			31,723,650	31,723,650	
				φ75 L=10.0m 2pcs/rod	nos	29.0			167,850			4,867,650	4,867,650	
				φ32 L=6.8m 2pcs/rod	nos	40.0			25,470			1,018,800	1,018,800	
				φ32 L=8.0m 2pcs/rod	nos	31.0			29,385			910,935	910,935	
				φ28 L=4.5m 2pcs/rod	nos				16,020					
				φ28 L=5.5m 2pcs/rod	nos				18,495					
				φ28 L=7.6m 2pcs/rod	nos				24,345					
				φ28 L=8.5m 2pcs/rod	nos				26,820					
			8). material fee for waling	H300未満	t	106.6		7,846.00			836,383.60		5,428,130	
			9). sheet pile welding	on site	nos	1,662.0		1,944.85			3,232,340.70		20,977,891	
			10). removing sheet pile	L≦15m (removing length)	nos			658.61						
				L≦12m (removing length)	nos	1,462.0		572.16			836,497.92		5,428,872	
				L≦9m (removing length)	nos			486.33						
				L≦6m (removing length)	nos	640.0		428.48			274,227.20		1,779,735	
				L≦4m (removing length)	nos	80.0		371.90			29,752.00		193,090	
			11). driving bearing pile	H150, L≦4m (driving length)	nos			615.91						
				H250, L≦4m (driving length)	nos			673.91						
			12). removing bearing pile	L≦4m (removing length)	nos			371.90						
			13). material fee for bearing pile		t			7,846.00						
			14). Japanese sheet pile operator A		day	2,190.0			27,030			59,195,700	59,195,700	
			15). Japanese sheet pile operator B		fay	480.0			27,030			12,974,400	12,974,400	
	sub total									840,284.40	8,988,272.11	110,691,135	264,262,855	
	B-1-2. Earth work	1. earth work	1). backfill	inside coffer dam	m3	29,986.8		37.90			1,136,499.72		7,375,883	
			2). backfill material fee	sand	m3	40,458.0		67.10			2,714,731.80		17,618,609	
			3). transportation fee for buying material											

Table 4-2.11 Bill of quantities (8/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			excavation and loading	0.8m3 back hoe loose soil	m3	40,458.0		19.22			777,602.76		5,046,642	
			transportation by damp truck	Distance 20km	m3	40,458.0		135.51			5,482,463.58		35,581,189	
	sub total										10,111,297.86		65,622,323	
total										840,284.40	19,099,569.97	110,691,135	329,885,178	
B-2. Single Sheet Pile	B-2-1. Single Sheet Pile	1. Single Sheet Pile	1). driving sheet pile	PU28+1, L≤15m (driving length)	sheet	200.0		1,730.41			346,082.00		2,246,072	
				PU28+1, L≤12m (driving length)	sheet			1,466.45						
				PU28+1, L≤9m (driving length)	sheet			1,173.16						
				PU28+1, L≤6m (driving length)	sheet	232.0		939.18			217,889.76		1,414,105	
				PU28+1, L≤4m (driving length)	sheet	467.0		763.21			356,419.07		2,313,160	
			2). Sheet pile press fitting	PU, L≤9m (driving length)	sheet	195.0		103.68	3,280		20,217.60	639,600	770,812	
			3). Mobilization & demobilization	press fitting machine for sheet pile	nos	1.0		700.36	19,332		700.36	19,332	23,877	
			4). material fee for sheet pile	PU28+1	t	663.3	440.50			292,188.54			33,116,649	
			5). material fee for sheet pile	PU28+1, near rail way	t	165.7	881.00			145,981.70			16,545,566	
			6). installation for tie-rod and waling		t	47.7		3,311.13			157,940.90		1,025,036	
			7). material fee for tie-rod (NHT690)	φ75 L=8.9m 2pcs/rod	nos				151,065					
				φ75 L=10.0m 2pcs/rod	nos				167,850					
				φ32 L=6.8m 2pcs/rod	nos				25,470					
				φ32 L=8.0m 2pcs/rod	nos				29,385					
				φ28 L=4.5m 2pcs/rod	nos	76.0			16,020			1,217,520	1,217,520	
				φ28 L=5.5m 2pcs/rod	nos	76.0			18,495			1,405,620	1,405,620	
				φ28 L=7.6m 2pcs/rod	nos	51.0			24,345			1,241,595	1,241,595	
				φ28 L=8.5m 2pcs/rod	nos	68.0			26,820			1,823,760	1,823,760	
			8). material fee for waling		t	26.7		7,846.00			209,488.20		1,359,578	
			9). sheet pile welding	on site	nos	200.0		1,944.85			388,970.00		2,524,415	
			10). removing sheet pile	L≤15m (removing length)	nos	200.0		658.61			131,722.00		854,876	
				L≤12m (removing length)	nos			572.16						
				L≤9m (removing length)	nos			486.33						
				L≤6m (removing length)	nos	232.0		428.48			99,407.36		645,154	
				L≤4m (removing length)	nos	467.0		371.90			173,677.30		1,127,166	
			11). driving bearing pile	H150, L≤4m (driving length)	nos	227.0		615.91			139,811.57		907,377	
				H250, L≤4m (driving length)	nos	46.0		673.91			30,999.86		201,189	
			12). removing bearing pile	L≤4m (removing length)	nos	273.0		371.90			101,528.70		658,921	
			13). material fee for bearing pile		t	53.0		7,846.00			415,445.70		2,696,243	
total										438,170.24	2,790,300.38	6,347,427	74,118,691	
B-3. Temporary bridge	B-3-1. Temporary bridge	1. pile driving	1). driving H-beam	H400, L≤12m (driving length)	piece	139.0		2,083.01			289,538.39		1,879,104	
				H400, L≤9m (driving length)	piece			1,641.77						
				H350, L≤12m (driving length)	piece	45.0		1,730.41			77,868.45		505,366	
				H350, L≤9m (driving length)	piece	148.0		1,407.14			208,256.72		1,351,586	
				H300, L≤6m (driving length)	piece	55.0		880.52			48,428.60		314,302	
			2). removing H-beam	L≤12m (removing length)	piece	184.0		572.16			105,277.44		683,251	
				L≤9m (removing length)	piece	148.0		486.33			71,976.84		467,130	
				L≤6m (removing length)	piece	55.0		428.48			23,566.40		152,946	
			3). material fee for H-beam	exclude re-used material	t	634.4			33,300			21,123,855	21,123,855	
		sum									824,912.84	21,123,855	26,477,539	
		2. substructure	1). installation for substructure		t	46.7		5,381.06			251,295.50		1,630,908	
			2). removal for substructure		t	46.7		2,884.85			134,722.49		874,349	
			3). material fee for substructure		t	25.6		7,846.00			200,857.60		1,303,566	
		sum									586,875.59		3,808,823	
		3. deck plate	1). installation for deck plate		m2	3,700.0		201.95			747,215.00		4,849,425	
			2). removal for deck plate		m2	3,700.0		103.28			382,136.00		2,480,063	
			3). material fee for deck plate	exclude re-used material	m2	1,916.5			11,700			22,423,160	22,423,160	
		sum									1,129,351.00	22,423,160	29,752,648	
		4. superstructure	1). installation for superstructure		t	468.1		2,736.49			1,280,950.96		8,313,372	
			2). removal for superstructure		t	468.1		1,511.24			707,411.44		4,591,100	
			3). material fee for superstructure	exclude re-used material	t	264.3			33,300			8,801,190	8,801,190	
		sum									1,988,362.40	8,801,190	21,705,662	
		5. guard pipe	1). installation for bridge railing		m	1,164.0		22.56			26,259.84		170,426	
			2). removal for bridge railing		m	1,164.0		12.88			14,992.32		97,300	
			3). material fee for bridge railing	@1.8m	nos	374.0			2,876			1,075,437	1,075,437	

Table 4-2.12 Bill of quantities (9/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
		sum									41,252.16	1,075,437	1,343,164	
		6. stage end	1). installation/removal for stage end	steel plate	m2	317.0		95.64			30,319.78		196,775	
			2). material fee for stage end	steel plate	nos	59.1		6,357.00			375,712.96		2,438,377	
		sum									406,032.74		2,635,152	
total											4,976,786.73	53,423,642	85,722,988	
B-4. Dewatering	B-4-1. Dewatering	1. water pump	1). dewatering by water pump	φ50mm	day・nos	780.0		1,334.29			1,040,746.20		6,754,443	
			2). installation and removal for water pump		nos	8.0		1,238.60			9,908.80		64,308	
		sum									1,050,655.00		6,818,751	
		2. Wellpoint	1). installation/removal for wellpoint	121pcs×2 (Bahr-Yusef, Ibrahimia)	L.S	2.0		221,667.00			443,334.00		2,877,238	
			2). daily operation and control		day	803.0		11,000.00			8,833,000.00		57,326,170	
			3). fuel		Lit	96,360.0		2.00			192,720.00		1,250,753	
		sum									9,469,054.00		61,454,160	
total											10,519,709.00		68,272,911	
B-5. Temporary road & preparation	B-5-1. temporary road	1. temporary road	1). embankment		m3	21,331.2		37.90			808,452.48		5,246,857	
			2). material fee for temporary road	sand	m3	25,270.0		67.10			1,695,617.00		11,004,554	
			3). transportation fee for buying material											
			excavation and loading	0.8m3 back hoe loose soil	m3	25,270.0		19.22			485,689.40		3,152,124	
			transportation by damp truck	Distance 20km	m3	25,270.0		135.51			3,424,337.70		22,223,952	
			4). transportation fee for reused material											
			excavation and loading	0.8m3 back hoe loose soil	m3	2,016.0		19.22			38,747.52		251,471	
			transportation by damp truck	Distance 0.3km	m3	2,016.0		18.47			37,235.52		241,659	
			5). exsiting structure demolition	plain concrete	m3	3,089.3		224.59			693,825.88		4,502,930	
			6). breaked concrete disposal	Distance 20km	m3	3,089.3		194.01			599,355.09		3,889,815	
total											7,783,260.59		50,513,361	
B-6. diversion works	B-6-1. diversion works	1. diversion works	1). river side slope excavation	0.8m3 back hoe	m3	6,281.0		19.82			124,489.42		807,936	
			2). river bed excavation	0.4m3 long arm back hoe	m3	5,089.6		46.86			238,498.65		1,547,856	
			3). excavated soil disposal	Distance 20km	m3	11,370.6		159.33			1,811,677.69		11,757,788	
			4). stone riprap	for rever bed	m3	2,093.0		766.83			1,604,975.19		10,416,289	
			5). Barge	Bahr Yusef:60×10=600m2	day	100.0		50,400.00			5,040,000.00		32,709,600	
				Ibrahimia:35×10=350m2	day	100.0		29,400.00			2,940,000.00		19,080,600	
total											11,759,640.95		76,320,070	
B-7. Other temporary works	B-7-1. Temporary yard preparation	1. Temporary yard preparation	1). spreading gravel		m2	21,000.0		132.78			2,788,380.00		18,096,586	
			2). removal for gravel		m3	4,200.0		28.32			118,944.00		771,947	
			3). excavated soil disposal	distance 30km	m3	4,200.0		159.33			669,186.00		4,343,017	
			4). temporary fence	H=2.0m	m	1,860.0		1,083.00			2,014,380.00		13,073,326	
	sub total										5,590,890.00		36,284,876	
	B-7-2. Foudation improvement work	1. Foudation improvement work	1). embankment		m3	2,676.1		45.37			121,414.65		787,981	
			2). material fee for embankment	sand	m3	3,380.0		67.10			226,798.00		1,471,919	
			3). transportation fee for buying material											
			excavation and loading	0.8m3 back hoe loose soil	m3	3,380.0		19.22			64,963.60		421,614	
			transportation by damp truck	Distance 20km	m3	3,380.0		135.51			458,023.80		2,972,574	
			4). soil improvement	cement mixing	m3	3,189.0		123.60			394,160.40		2,558,101	
			5). installation for steel plate		m2	882.0		3.11			2,743.02		17,802	
			6). removal for steel plate		m2	882.0		2.46			2,169.72		14,081	
			7). material fee for steel plate	1.5m × 3.0m, t=22mm	nos	196.0		3,178.50			622,986.00		4,043,179	
	sub total										1,893,259.19		12,287,252	
	B-7-3. Batching plant facility	1. Batching plant facility	1). assembling and removal for batching plant		L.S	1.0		109,080.79			109,080.79		707,934	
			2). assembling and removal for cement silo		L.S	1.0		57,566.61			57,566.61		373,607	
			3). installation and removal for concrete aggregate yard		L.S	1.0		81,493.48			81,493.48		528,893	
	sub total										248,140.88		1,610,434	
	B-7-4. utility costs	1. Receiving power facilities	1). receiving power equipment		L.S	1.0		8,550.00			8,550.00		55,490	
			2). installation		L.S	1.0		4,918.48			4,918.48		31,921	
			3). foundation concrete	18N/mm2	m3									
			4). foundation gravel		m2	15.0		99.31			1,485.67		9,642	
			5). lean concrete		m3	1.3		1,257.46			1,690.02		10,968	
			6). formwork		m2	4.2		400.74			1,683.10		10,923	
			7). placing concrete	18N/mm2	m3	3.6		1,109.76			3,995.13		25,928	
			8). curing		m3	3.6		12.92			46.51		302	
			9). other materials	0.2% of facilities cost	%	0.2		8,550.00			1,710.00		11,098	

Table 4-2.13 Bill of quantities (10/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
		sum									24,078.91		156,272	
		2. electricity facilities	1). electric cable	600V 22mm2-3C	m	2,100.0		179.00			375,900.00		2,439,591	
			2). distribution board	75A-150A	nos	18.0		6,990.00			125,820.00		816,572	
			3). switching board		nos	1.0		5,500.00			5,500.00		35,695	
			4). installation for cable		day・nos	12.0		341.00			4,092.00		26,557	
			5). excavation		m3	585.0		154.56			90,417.60		586,810	
			6). backfill		m3	585.0		88.49			51,766.65		335,966	
		sum									653,496.25		4,241,191	
		3. water facilities	1). well	30m × 1piece	m	30.0								
			2). pump for well		nos	2.0		15,000.00			30,000.00		194,700	
			3). distribution pipe	φ50mm	m	226.0		316.00			71,416.00		463,490	
				φ25mm	m	46.5		136.00			6,324.00		41,043	
			4). valve	φ50mm	nos	5.0		307.00			1,535.00		9,962	
				φ25mm	nos	5.0		307.00			1,535.00		9,962	
			5). bibb cock		nos	7.0		1,491.00			10,437.00		67,736	
		sum									121,247.00		786,893	
		4. electricity connection fee			L.S	1.0		50,000.00			50,000.00		324,500	
		5. electric fee			Kwh	1,596,072.5		2.00			3,192,145.04		20,717,021	
	sub total										4,040,967.20		26,225,877	
	B-7-5. site expense	1. transportation fee for heavy construction equipment	1). Track crane	80t × 10 nos	t	800.0		550.00			440,000.00		2,855,600	
		Cairo - Dirout	2). Track crane	25t × 2 nos	t	50.0		550.00			27,500.00		178,475	
			2). Crawler crane	50t × 16 nos	t	800.0		550.00			440,000.00		2,855,600	
		sum									907,500.00		5,889,675	
		2. vehicle for site management	1). vehicle A	sedan	nos	180.0		15,750.00			2,835,000.00		18,399,150	
		including driver and fuel	2). vehicle B	pick-up	nos	142.0		18,749.00			2,662,358.00		17,278,703	
		sum									5,497,358.00		35,677,853	
		3. oversea travel cost	1). project manager		time	10.0			248,000			2,480,000	2,480,000	
			2). chief civil engeneer		time	10.0			248,000			2,480,000	2,480,000	
			3). civil engeneer 1		time	10.0			248,000			2,480,000	2,480,000	
			4). civil engeneer 2		time	10.0			248,000			2,480,000	2,480,000	
			5). architecture		time	3.0			248,000			744,000	744,000	
			6). mechanical engineer		time	8.0			248,000			1,984,000	1,984,000	
			7). electrical engineer		time	8.0			248,000			1,984,000	1,984,000	
			8). administrator		time	10.0			248,000			2,480,000	2,480,000	
		sum										17,112,000	17,112,000	
	sub total										6,404,858.00	17,112,000	58,679,528	
total											18,178,115.27	17,112,000	135,087,968	
B-8. Transpotation / Shipment	for civil work	B-8-1. packing	1). construction material for civil work	728.3 F/T	L.S	1.0			5,665,521			5,665,521	5,665,521	
			2). steel material for civil work	58.3 F/T	L.S	1.0			563,587			563,587	563,587	
		sum										6,229,108	6,229,108	
		B-8-2. loading	1). custom fee		L.S	2.0			5,900			11,800	11,800	
			2). loading	construction material for civil work	F/T	728.3			5,500			4,005,897	4,005,897	
				steel material for civil work	F/T	58.3			5,500			320,430	320,430	
			3). documentation		L.S	2.0			20,000			40,000	40,000	
		sum										4,378,127	4,378,127	
		B-8-3. ocean transpotation	1). construction material for civil work		F/T	728.3	180.00			131,102.10			14,859,112	
			2). steel material for civil work		F/T	58.3	180.00			10,486.83			1,188,577	
		sum								141,588.93			16,047,689	
		B-8-4. port charge	1). port charge		F/T	786.6		148.00			116,417.56		755,550	
			2). trust money for entry		F/T	786.6		60.00			47,196.31		306,304	
		sum									163,613.87		1,061,854	
		B-8-5. inland transpotation	1). inland transpotation	for permanent work	F/T	786.6		667.00			524,665.65		3,405,080	
				work)	F/T	944.6		667.00			630,061.93		4,089,102	
		sum									1,154,727.58		7,494,182	
		B-8-6. insurance	1). insurance	I = CIP × 1.1 × r	L.S	1.0	563.00	5,241.39	205,577	563.00	5,241.38	205,577	303,404	
		sum								563.00	5,241.38	205,577	303,404	
	sub total									142,151.93	1,323,582.83	10,812,812	35,514,364	
	for temporary work	B-8-7. packing	(from Japan to site)											
			1). material for temporary work	2,130.8 F/T	L.S	1.0			10,732,429			10,732,429	10,732,429	

Table 4-2.14 Bill of quantities (1112)

1	as of Estimation	January . 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

Work	Item	Grade	Detail	Unit	Quantity	Unit Price US$	Unit Price LE	Unit Price YEN	Amount US$	Amount LE	Amount YEN	Exchange to YEN	Remarks
		2). steel material for temporary work	1,479.0 F/T	L.S	1.0			221,659			221,658	221,658	
		3). construction equipments	206.9 F/T	L.S	1.0			2,080,632			2,080,632	2,080,632	
		(from site to Japan)											
		1). material for temporary work	2,056.8 F/T	L.S	1.0			3,219,729			3,219,728	3,219,728	
		2). steel material for temporary work	1,428.6 F/T	L.S	1.0			66,498			66,497	66,497	
		3). construction equipment	186.9 F/T	L.S	1.0			624,190			624,189	624,189	
	sum										16,945,133	16,945,133	
	B-8-8. loading	(from Japan to site)											
		1). custom fee		L.S	3.0			5,900			17,700	17,700	
		2). loading	material for temporary work	F/T	2,130.8			5,500			11,719,516	11,719,516	
			steel material for temporary work	F/T	1,479.0			5,500			8,134,373	8,134,373	
			construction equipment	F/T	206.9			5,500			1,138,129	1,138,129	
		3). documentation		L.S	3.0			20,000			60,000	60,000	
		(from site to Japan)											
		1). custom fee		L.S	3.0			5,900			17,700	17,700	
		2). loading	material for temporary work	F/T	2,056.8		254.24			522,910.48		3,393,689	
			steel material for temporary work	F/T	1,428.6		254.24			363,203.38		2,357,190	
			construction equipment	F/T	186.9		254.24			47,525.22		308,439	
		3). documentation		L.S	3.0			20,000			60,000	60,000	
	sum									933,639.08	21,147,418	27,206,736	
	B-8-9. ocean transpotation	(from Japan to site)											
		1). material for temporary work		F/T	2,130.8	180.00			383,547.82			43,471,310	
		2). steel material for temporary work		F/T	1,479.0	180.00			266,215.86			30,172,906	
		3). construction equipment		F/T	206.9	180.00			37,247.86			4,221,672	
		(from site to Japan)											
		1). material for temporary work		F/T	2,056.8	180.00			370,220.62			41,960,805	
		2). steel material for temporary work		F/T	1,428.6	180.00			257,148.00			29,145,154	
		3). construction equipment		F/T	186.9	180.00			33,647.86			3,813,648	
		(from site to the third country)											
		1). material for steel sheet pile		F/T	2,736.6	90.00			246,292.26			27,914,765	
	sum								1,594,320.28			180,700,261	
	B-8-10. port charge	(from Japan to site)											
		1). port charge		F/T	3,816.7		148.00			564,876.16		3,666,046	
		2). trust money for entry		F/T	3,816.7		60.00			229,003.84		1,486,235	
		(from site to Japan)											
		1). port charge		F/T	3,672.3		148.00			543,502.44		3,527,331	
		2). trust money for entry		F/T	3,672.3		60.00			220,338.82		1,429,999	
	sum									1,557,721.26		10,109,611	
	B-8-11. inland transpotation	(from Alexandria to site)											
		1). inland transpotation	for temporary work	F/T	3,816.7		667.00			2,545,759.45		16,521,979	
			work)	F/T	2,736.6		667.00			1,825,299.32		11,846,193	
		(from site to Alexandria)											
		2). inland transpotation	for temporary work	F/T	3,672.3		667.00			2,449,433.31		15,896,822	
			imported sheet pile	F/T	2,736.6		667.00			1,825,299.32		11,846,193	
	sum									8,645,791.40		56,111,186	
	B-8-12. insurance	1). insurance (from Japan to Site)	I = CIP × 1.1 × r	L.S	1.0	2,731.00	13,277.55	1,979,481	2,731.00	13,277.55	1,979,481	2,375,184	
		2). insurance (from Site to Japan)	I = CIP × 1.1 × r	L.S	1.0	2,628.00	16,487.07	785,113	2,628.00	16,487.06	785,113	1,189,972	
	sum								5,359.00	29,764.61	2,764,594	3,565,155	
sub total									1,599,679.28	11,166,916.35	40,857,145	294,638,082	
for gate facilities	B-8-13. packing	1). gate facilities	951.0 F/T	L.S	1.0			9,448,061			9,448,061	9,448,061	
	sum										9,448,061	9,448,061	
	B-8-14. loading	1). custom fee		L.S	1.0			5,900			5,900	5,900	
		2). loading fee	Gate facilities	F/T	951.0			5,500			5,230,266	5,230,266	
		3). documennt fee		L.S	1.0			20,000			20,000	20,000	
	sum										5,256,166	5,256,166	
	B-8-15. ocean transpotation	1). gate facilities		F/T	951.0	180.00			171,172.36			19,400,675	
	sum								171,172.36			19,400,675	
	B-8-16. port charge	1). port charge		F/T	951.0		148.00			140,741.72		913,414	
		2). trust money for entry		F/T	951.0		60.00			57,057.45		370,303	

Table 4-2.15 Bill of quantities (12/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
		sum									197,799.17		1,283,717	
		B-8-17. inland transpotation	1). inland transpotation		F/T	951.0		667.00			634,288.72		4,116,534	
		sum									634,288.72		4,116,534	
		B-8-18. insurance	1). insurance	I = CIP × 1.1 × r	L.S	1.0	681.00	3,308.17	8,824,875	681.00	3,308.16	8,824,875	8,923,529	
		sum								681.00	3,308.16	8,824,875	8,923,529	
	sub total									171,853.36	835,396.05	23,529,102	48,428,682	
total										1,913,684.57	13,325,895.23	75,199,059	378,581,128	
C. Building Works											3,399,700.00		**22,064,053**	
Building works		C-1. Control house			L.S	1.0		1,977,700.00			1,977,700.00		12,835,273	
		C-2. Local contrl house	Bahr Yusef		L.S	1.0		301,900.00			301,900.00		1,959,331	
		C-3. Local contrl house	Ibrahimia		L.S	1.0		301,900.00			301,900.00		1,959,331	
		C-4. Stop log room			L.S	1.0		818,200.00			818,200.00		5,310,118	
total											3,399,700.00		22,064,053	
D. Integrated Water Management System											31,628,443.83		**205,268,600**	
Integrated Water Management System	D-1. IWMS manufactures	1. IWMS manufactures	1). Gauging station	Type-A & B	L.S.	1.0		14,102,971.29			14,102,971.29		91,528,284	
			2). Central monitoring room	in Dirout	L.S.	1.0		1,387,148.88			1,387,148.87		9,002,596	
			3). Monitoring room	in Minia	L.S.	1.0		186,425.96			186,425.96		1,209,904	
	sub total										15,676,546.12		101,740,784	
.	D-2. Installation for IWMS	1. Installation for IWMS	1). installation for Gauging station	Type-A & B	L.S.	1.0		15,816,762.91			15,816,762.90		102,650,791	
			2). installation for Monitoring room	in Dirout and Minia	L.S.	1.0		135,134.81			135,134.81		877,025	
	sub total										15,951,897.71		103,527,816	
total											31,628,443.83		205,268,600	
E. Dispute Board										407,000.00			**46,129,380**	
Dispute Board	E-1. Dispute Board	1. regular Site Visit	1). Monthly Retainer Fee	US$3,000/day	month	45.0	3,000.00			135,000.00			15,300,900	
			2). Monthly Retainer Fee during DNP	US$2,000/day	month	12.0	2,000.00			24,000.00			2,720,160	
			3). Daily Fee	2day for Site Visit ×10nos	day	20.0	3,000.00			60,000.00			6,800,400	
				3day for travel ×10nos	day	30.0	3,000.00			90,000.00			10,200,600	
			4). Expenses	Air ticket, etc.	time	10.0	5,000.00			50,000.00			5,667,000	
		sum								359,000.00			40,689,060	
		2. supposed referrals	1). Additional Daily Fee		time	2.0	3,000.00			6,000.00			680,040	
			2). Reviewing Submission and Drafting Decision	(3+4 days)×2	time	14.0	3,000.00			42,000.00			4,760,280	
		sum								48,000.00			5,440,320	
total										407,000.00			46,129,380	
I-2 Indirect Cost					L.S	1.00				1,485,994.40	93,278,928.15	186,287,138	**960,089,987**	

Volume IV DRAFT BIDDING DOCUMENTS

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Volume IV –DRAFT BIDDING DOCUMENTS

1. Contents of Works for the Preparation of Bidding Documents

1-1 Regulation and framework of procurement of public works in the Egyptian government

In Egypt, procurement of public works is made based on the Law No.89 of 1998 and its implementation regulations (Ministerial Decree No. 1367 of 1998), commonly referred to as "Tenders Law". Based on this law, executing agencies of public works prepare bidding documents, and execute pre-qualification, tendering and evaluation, and contract negotiations and signing.

The relevant agencies involved in procurement of public works and their tasks are as follows.

(1)Ministry of Finance: Policy making, issuing decrees on public procurement policy.

(2) Public Service Authority: Regulating and monitoring public contracts.

(3) Public Contracting Office (under MOF): Handling complaints from contractors/suppliers.

(4) Central Auditing Authority: Conducting independent auditing.

According to the assessment of the procurement process of public works in Egypt, in the "Public Procurement Sector Assessment -Review of Laws and Practice in the SEMED Region," which was published by EBRD in 2013, there is no independent authority to handle claims related to public works, and there is also no single entity to formulate policies and execute government procurement process/procedures, even though transparency and efficiency are somewhat secure.

1-2 Differences between the regulations of the Egyptian government and JICA's guidelines for procurement under Japanese ODA Loans

From the '7th Assignment' started in November 2016, series of works and discussions for the preparation of draft Bidding Documents for NDGRs project were started. Firstly, on the '7th Assignment', the differences between laws and regulations related to procurement in Egypt and JICA's Procurement Guideline (*Handbook: Guideline for Procurement under Japanese ODA Loans* April 2012) were discussed. The results are summarized in Table 1-2.1.

Table 1-2.1 Comparison between laws in Egypt and JICA's procurement guideline

JICA Guideline		Egyptian Laws And Regulations	
Article	**Contents**	**Law No./ Article**	**Contents**
1.08	All documents relating to the procurement shall be made in one of the languages; Japanese, English, French, or Spanish.	Ministerial Decree No.1367(1998) Article 7	The book of conditions, the lists, and the specifications shall be translated in case the invitation of tenders and bids in the adjudications is announced abroad, along with mentioning that the Arabic text shall be

			the one relied upon.
3.02	In case only one applicant is pre-qualified as a result of the evaluation, the Borrower should reject this PQ process.	Ministerial Decree No.1367(1998) Article 27	The adjudication may be cancelled in any of the following cases: (a) If one tender only is submitted in the adjudication, or……
5.10	In case only one bidder submits a bid, it does not mean lack of competition. “Single Bid” is only the result of bidding and different from direct contracting.		
4.03	The limitation of guarantor banks to those in the Borrowers country is not acceptable.	Ministerial Decree No.1367(1998) Article 70	If the bid and performance bond is in the form of a letter of guarantee, it shall be issued by one of the accredited local banks.
4.06	If specific national standards are cited, the bidding documents shall state that Japan Industrial Standards or other internationally accepted standards will also be accepted.	Ministerial Decree No.1367(1998) Article 3	Launching adjudications for submission of tenders hall be done on the basis of precise and detailed technical specifications as set by the Technical Committee having experience in the required items and works. It is conditional to observe Egyptian Standard Specifications and the Specifications of governmental Supplies and other specifications to be issued or approved by the concerned Technical Entities.
5.06	Any procedure, under which bids above or below a predetermined value are automatically disqualified, is not permitted.	Law No.89 (1998) Article 15	It may also be cancelled in any one of the following cases: If the value of the least tender would exceed the estimated value.
		Ministerial Decree No.1367(1998) Article 27	The adjudication may be cancelled in any of the following cases: If the amount of the lowest tender exceeds the estimated value.

In Article 4.7 of the Minutes of Discussions dated 21 May 2014 on the Loan Agreement for NDGRs, it was agreed that JICA Guidelines shall be applied for the procurements in this project. For the preparation of draft Bidding Documents, the issues identified on this table shall be taken into consideration. While JICA Guideline shall prevail, requests from RGBS to follow the Egyptian laws shall be also reflected in the documents as much as possible.

1-3 Framework of the procurement process of the NDGRs project

As stated above, necessary approvals shall be secured within the Ministry, i.e. Head of Irrigation Department for pre-qualification process, issuance of bidding documents, result of tender evaluations (technical and financial), and contracting. Also, legal review by the State Council is necessary for the contract preparation and/or signing. Necessary approvals and time needed for the process is summarized in Table 1-4.1 in the table next page.

Table 1-4.1 Procurement process and necessary time for NDGRs project in MWRI

Bidding Process	Japanese Side	Egyptian Side			
		Within MWRI		Outside MWRI	
	JICA concurrence Necessary?	Approval necessary?	Expected Days	Approval necessary?	Expected Days
Prepare PQ Documents					
Submit PQ Draft for concurrence	YES/NO	YES/NO If "YES": (Name of Office) **(Head, Irrigation Department)**	Maximum 7 days	YES/NO If "YES": (Name of Office) ( )	
Prepare the Bid Documents					
Submit PQ Draft for concurrence	YES/NO	YES/NO **(Head, Irrigation Department)**		YES/NO ( )	
Advertise the procurement on newspapers (Invitation for PQ)	YES/NO	YES/NO **(Head, Irrigation Department)**		YES/NO ( )	
Receive the PQ Documents from applicants					
Evaluate PQ Documents to select bidders					
Submit the PQ result for concurrence	YES/NO	YES/NO ( )		YES/NO **(Public Notification Period)**	7 days
Send Bid Documents to selected bidders					
Receive Bid Documents					
Open and Evaluate the Technical Proposal					
Submit Evaluation result on Technical Proposal for Approval	YES/NO	YES/NO **(Head, Irrigation Department)**	Maximum 7 days	YES/NO ( )	
Open the Price Bids only for Eligible Bidders for Technical Proposal					
Prepare the Bid Evaluation Report (Both Tech & Price)					
Obtain Concurrence on the Evaluation Report	YES/NO	YES/NO **(Head, Irrigation Department)**	Maximum 7 days	YES/NO **(Public Notification Period)**	7 days

Approval for Contract Signing	YES/NO	YES/NO **(Head, Irrigation Department)**		YES/NO **(State Council)**	(Contract can be signed and started. If any comments are made by Council, it shall be reflected later.)
Signing of the Contract					
Obtain Concurrence on the Signed Contract	YES/NO	YES/NO **( )**		YES/NO **(State Council)**	
Issue Notice to Proceed, and commence the Contract	YES/NO	YES/NO **( )**		YES/NO **( )**	

As for the actual record of procurement process in international bidding under RGBS, case of "New Assiut Barrage and Hydropower Plant (Lot 1: Civil Works)" can be referred as sample of International Competitive Bidding under RGBS. On this bidding, procurement process was made on the timeframe indicated below:

- Newspaper Advertisement for PQ: February 2010
  (PQ process took 5 months)
- Distribution of Tender Documents: October 2010
  (Submission deadline was 90 days from the date of invitation)
- Tender close: January 2011
- Commencement of evaluation: March 2011
- Awarding and negotiation: April 2011
- Completion of negotiation: August 2011
- Approval from KfW : December 2011
- Commencement of construction: May 2012

2. Preparation of Draft Bidding Documents

2-1 Contents of draft bidding documents

As stated in Chapter 1-2, the purpose of the series of meetings with RGBS on '7th Assignment' was to ensure a basic understanding of the procurement system under Japan's ODA as it is the first time for RGBS. Therefore, only explanations of *Standard Bidding Documents under Japanese ODA Loans* October 2012 were made at the time.

During the '7th Assignment', RGBS made opinions to include (1) number of engineers and construction equipment possessed by applicants as a capacity criteria, and (2) list of contractors debarred by the Egyptian government as a non-eligibility criteria. These requests were taken into consideration on the preparation of draft Bidding Documents during the '8th Assignment' in January 2017.

Also during the '7th assignment', RGBS made request to JICA to change the procurement process so as to combine the pre-qualification and bidding process to be made simultaneously, and bidding documents shall be made as "PQ-embedded bidding documents". This request was based on their intention to shorten the procurement process on the civil works contract. The team considered this issue as appropriate request, however the final decision shall be made by the direct discussion between RGBS and JICA. Under such circumstance, two patterns of draft Bidding Documents (PQ-embedded Documents, and separated PQ/Bidding Documents) were presented on '8th Assignment' period, however discussions thereafter were made basically on PQ-embedded Documents.

2-2 Contents of discussions and understanding with Egyptian side on draft bidding documents (except technical specifications)

On '8th assignment', substantial discussions on the Bidding Documents to be used for NDGRs project were started. Simultaneously with the discussions, various data and information were conveyed from JICA Egypt Office on their existing samples on bidding documents on STEP under Yen-Loan, particularly on Greater Cairo Metro Line No.4 Project. During the '8th Assignment', RGBS revealed its intention to delay commencement of civil works contract by February 2019, one year delay from the original schedule in February 2018. Though a detail of this idea is not yet thoroughly discussed between RGBS and JICA, RGBS considers that this idea would give more time for procurement process.

For this issue, RGBS requested the Study Team to maintain both patterns (though discussions were made on PQ embedded Documents) for the decision in future. Therefore, PQ embedded Documents are adopted as the final product as part of the Final Report, and separated PQ/Bidding Documents are also submitted but only in electric file.

During the '9th Assignment', series of discussions were made mainly on the comments from JICA on the draft Bidding Documents submitted in February. By reflecting results of the discussion, revised version of the Documents were consolidated, as the final for the Assignment in Egypt, and submitted to both RGBS and JICA on 24 April 2017

The contents of discussions during '8th Assignment' and '9th Assignment' on draft Bidding

Documents, including initial presentation from the team, comments from RGBS, information from JICA Egypt Office, conclusion as of 24 February and conclusion as of 24 April, are summarized in Table 2-2.1.

After the completion of '9th Assignment', comments were provided by RGBS on 10 May 2017 and by JICA on 19 May 2017. By reflecting these comments, draft Bidding Documents are finalized as part of the Final Report of the Study. The summary of said comments and reflection on the final Bidding Documents are summarized in Table 2-2.2.

2-3 Draft bidding documents (technical specifications)

As for the technical specifications, an integral part of draft Bidding Documents, discussions with RGBS were started on '8th Assignment' in February 2017. After the confirmation of structure and contents, actual works on the preparation of technical specifications were started.

The contents of technical specifications are as follows:

1) General Provisions

2) General Technical Specifications

- Civil Works
- Mechanical and Electrical Works

3) Particular Technical Specifications

- Civil Works
- Mechanical and Electrical Works

For the preparation of technical specifications, attentions were paid on the consideration of fair risk allocation among contract parties, and also consistency with contents of general conditions of contract.

The background of discussions with Egyptian side on the technical specifications are as follows:

1) On 7 February 2017, immediately after the start of the '8th Assignment', table of contents of the technical specifications was presented to RGBS and the items listed were discussed and confirmed.

2) Based on the results of a series of discussions with RGBS, 1st version of the technical specifications were prepared and submitted to RGBS on 24 February 2017, immediately before the end of the '8th Assignment'.

3) 1st version of the technical specifications were revised taking into consideration the comments from JICA and the results of the series of discussions with RGBS during the '9th Assignment', and the 2nd version was submitted to RGBS on 24 April 2017, immediately before the end of '9th Assignment'.

4) After the completion of the '9th Assignment', comments on the 2nd version of the technical specifications were provided by JICA on 30 April and 3 May 2017, and by RGBS on 10 May 2017. After that, the technical specifications was finalized taking into consideration those comments.

Table 2-2.1 Major issues discussed on draft bidding documents during 8th and 9th field surveys in Egypt

General Issue:

Issue	RGBS Comments	Draft Tender Documents (as of 24 February 2017)	JICA Comments (March – April)	Draft Tender Documents (as of Draft Final Report
PQ/Bidding shall be separated, or combined. .	Since when the bidding is to be made has not yet been decided, possibility of time saving by combining PQ and BD is uncertain. Thus, 2 patterns of documents shall be maintained.	2 patterns (PQ/BD separated, or PQ/BD combined) are made.		Combined type is attached as hard copy and soft copy, but separate type are submitted only in soft copies.

Specific Issues on Draft Bidding Documents:

Page	Items	Contents	Point of Discussion	RGBS Comments	Information from JICA Egypt Office (Feb)	Draft Tender Documents (as of 24 February 2017)	JICA Comments (March – April)	Draft Tender Documents (as of Draft Final Report
IFB-2	-	Price of Bid Documents	Minimum price to cover printing cost.	25,000 L.E. in Assiut Barrage. (approx. US$1,500)	In Metro project, it was $10,000. (5,000 pages of drawings and 1,000 pages of documents)	1,000 U.S.Dollars may be appropriate. (Approx.300 pages of drawings and 500 pages of documents.) However, it shall be blank in Draft Bidding Documents at this point of time.	Shall be $1,000	1,000 U.S.Dollars
IFB-2	-	Amount of Bid Security	About 2% of expected contract amount (as per JICA Guideline). This time, 48.8 Million USD is expected, thus 1 Million USD shall be adequate amount.	Between 0.5% to 2 %.	%It shall be in 2%	2% may be appropriate, however only range (between 0.5% to 2%) shall be indicated to Draft Bidding Documents at this point of time.	2%	Approximately 2% (1.1 Million US$)
IFB-2	-	Submission Deadline	Normally 60 days in JICA's Yen Loan projects, but longer time is necessary for large projects.	90 days in Assiut Barrage Project.	90 days in Metro Project	90 days	-	No change (90 days)
BDS-2	ITB 10.1	Language: English	As per JICA Guideline.	English but some part shall be Arabic.	-	English (some part will be translated to Arabic for internal process in MWRI). Bidder shall not be required to submit bids in Arabic.	English	English, however some part of draft bidding documents are translated and submitted to RGBS (not as part of Report) in soft copy.

Page	Items	Contents	Point of Discussion	RGBS Comments	Information from JICA Egypt Office	Draft Tender Documents (as of 24 February 2017)	JICA Comments (March – April)	Draft Tender Documents (as of Draft Final Report
BDS-3	ITB 18.1	Bid Validity	JICA Guideline recommends 120 days, however, DD team proposes 180 days for safety.	In Assiut Barrage Project, it was 270 days.	In Metro, Bid validity period shall be 120 days including the day of the latest submission date.	270 days (9 months)	120 days	Additional explanations were made to JICA to insist 270 days. Awaiting JICA's approval.
EQC -6	2.3.2	Required Annual Turn-Over	As per JICA Guideline (twice of annual average of expected contract amount.)	Depending on the project cost.	-	Temporarily 24 Million U.S. Dollar is set (twice of annual average of construction cost in Loan Agreement), however it shall be revised upon actual issuance of Bid Documents.	-	$26 Million, based on the modified expected contract amount.
EQC -9	2.4.2(b)	Required Similar Experience	JICA Guideline says about 80% of construction volumes expected by the subject Project. However, DD Team suggests 60%, to have more bidders.	Depending on the project cost.	-	Temporarily 60% of work volumes are set (earth works, concrete works, gate size and depth of sheep pile of coffer dam), however it shall be revised upon actual issuance of Bid Documents.	-	(no change)
EQC-11	2.5.1	Financial Resources	As per JICA Guideline (half of annual average of expected contract amount.)	Depending on the project cost.	-	Temporarily 6 Million U.S. Dollar is set (half of annual average of construction cost in Loan Agreement), however it shall be revised upon actual issuance of Bid Documents.		$6.7 Million based on the modified expected contract amount.
BF-57	Form of Bid Security	Bank Guarantee	This format is OK or not (shall strictly follow this form, or not.)	Bid Security shall be in the form of "Unconditional Letter of Credit".	In Metro Project, Bank Guarantee was used for bid security. Letter of Credit is opened in case of procurement goods.	Unconditional Bank Guarantee.	It is not accepted to limit form of bid security.	Additional explanations were made to JICA, showing same limitation in RFP of SV consultant selection. Awaiting JICA's consideration.
PC-4	20.3	Appointment (if not agreed) to be made by	Examples of other past projects are requested.	-	-	Cairo Regional Centre for International Commercial Arbitration	It shall not be in Egypt, in terms of fairness.	Awaiting result of MWRI-JICA discussion on the same issue for RFP of SV Consultant selection.

Table 2-2.2 Major Comments from JICA and RGBS on the Draft Bidding Documents, and reflection on the Final Version

No.	Items	Comments from RGBS (on 10 May 2007)	Comments from JICA (on 19 May 2007)	Notes/Descriptions on the Final Version of Draft Bidding Documents
1	General Comments	• Bidding Documents could be modified in the next stage under management of RGBS by S/V consultant with the concurrence of JICA) • RGBS requests to support the Japanese Contractor by Egyptian Contractor as a joint venture.	—	• Even after the submission of draft Bidding Documents as final product of DD Study this time, it shall be continuously revised by RGBS until the date of actual invitation (bidding). • This issue shall be also considered after the finalization of draft Bidding Documents as final product of DD Study.
2	In case of failure to agree on the composition of the DB, the appointing entity shall appoint this member of the DB.	Place of arbitration shall be in Cairo.	Considering the Contractor may be foreign, entity in Cairo is not adequate to make appointment in terms of neutrality. FIDIC is recommended.	The appointing entity to appoint this member of the DB shall be FIDIC.
3	Temporary Yard	The Contractor shall lease 3 Feddans (in the expense of the RGBS) for a period of three years.	—	Included this issue in Technical Specifications. However, lease shall be made by RGBS as per instructed by JICA.
4	Legal Review on the Contract by State Council	The Contract shall be subject to the legal review of Egyptian Council of State according to laws of the Arab Republic of Egypt.	(Accepted)	No change from bidding documents attached to the Draft Final Report. (as proposed by RGBS)
5	Bid Validity (JICA Guideline recommends 120 days)	(It shall be 270 days.)	(Accepted)	No change from bidding documents attached to the Draft Final Report. (as proposed by RGBS)
6	Eligibility of MWRI (not having been declared ineligible by NWRI) is included in 2.1.4 of “2.1 Eligibility” of qualification.	(Eligibility of MWRI shall be included in PQ criteria.)	Such additional ineligible condition that is not specified in the Guidelines is not permitted in principle, because of concerns to transparency and arbitrariness.	Followed descriptions in JICA’s Standard Bidding Documents.
7	In 19.2 of Instruction to Bidders, four (4) forms for demand guarantee are indicated as Bid Security.	(Only Unconditioned Guarantee shall be allowed.)	Note 3, Section 4.03 of the Guidelines states as below: "It is not acceptable to prohibit bidders from submitting their securities in internationally accepted forms, such as bank guarantees or letters of credit. Such requirements would discourage suitable bidders from participating".	Followed descriptions in JICA’s Standard Bidding Documents.

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Volume V – ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

1. Environmental and Social Considerations

1-1 Project components that impact environment and society

The NDGRs Project is to construct new regulators at 140m downstream of the existing DGRs, which are located almost at the center of Dirout city. More than 100 years ago, the DGRs were located at the edge of the city, however, the annual urban expansion brought the DGRs to the center of the city.

The DGRs consist of two large regulators, namely, Bahr Yusef regulator and Ibrahimia regulator, and three relatively small scale regulators, namely, Abo Gabal regulator, Badraman regulator and Sahelyia regulator. Due to the recent deterioration of the DGRs, they have not functioned well, however, the DGRS will be preserved as a road, a bridge and a historical monument even after the NDGR construction. New Bahr Yusef regulator and New Ibrahimia regulator will be constructed about 140 m downstream of the current site, while other small scale gate structures will be reconstructed beside the existing ones. Locations of canals concerned and existing/new regulators are illustrated in Figure 1-1.1.

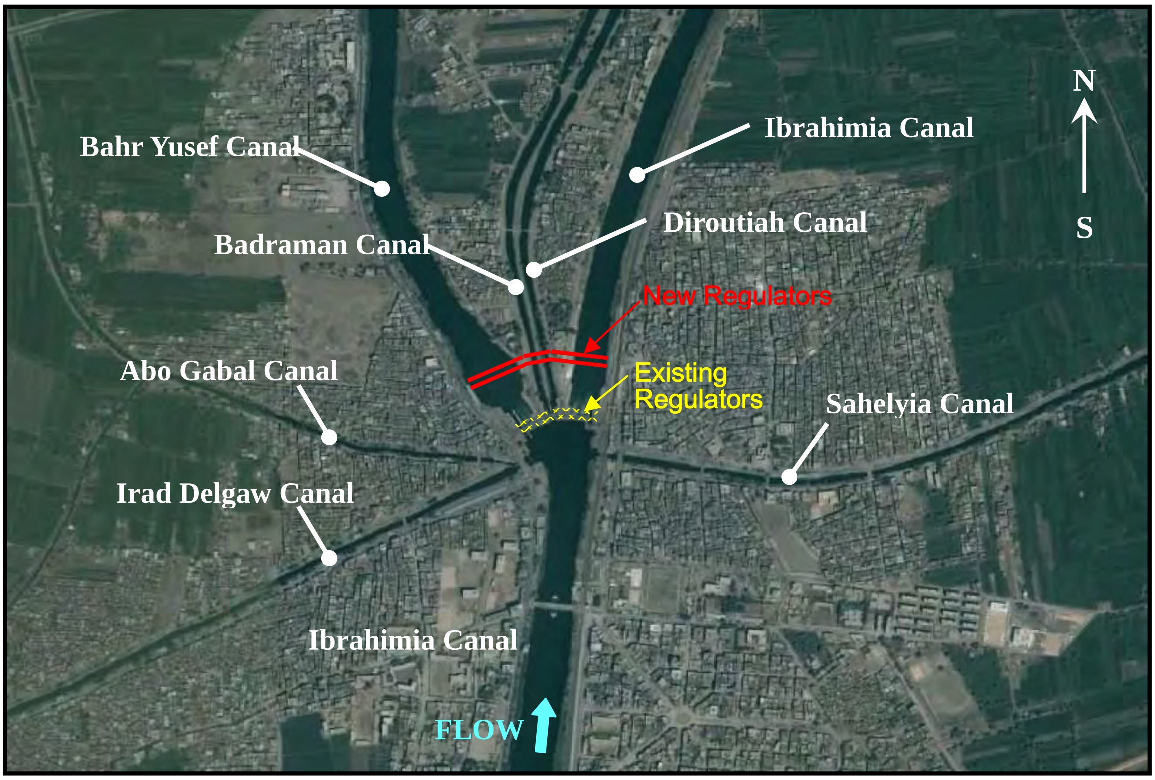


Figure 1-1.1 Location map of the regulators

1-2 Basic environmental and social conditions

(1) General conditions around the regulators

The regulators are located on the center of Dirout City, just beside of Dirout Railway Station, it is used as a bridge and a road by many people (See photo below). Also, there are many shops and buildings around the regulators. Farmlands stretch over the beneficial area and no virgin natural area such as marsh and forest is identified.

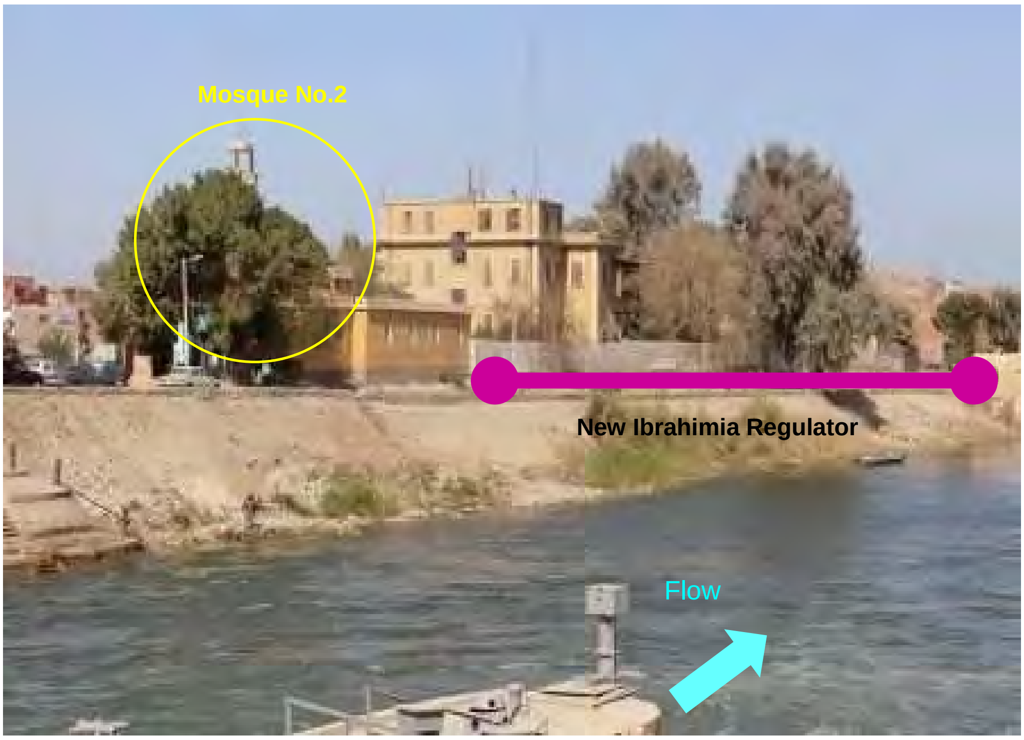
According to the law in Egypt, it is prohibited to construct any structures within the river bed, which means that there are no private lands to be affected by the project. However, there is an illegal café on upstream of Abo Gabal regulator as shown in following pictures, which was constructed after the F/S. Construction works can be done without the relocation of the café, it will be dusty and noisy for the café in the construction period, though.

Illegal Café (view from the Bahr Yusef regulators)

Entrance of the Illegal Café (“Lawyers Club”)

There are three mosques to be affected by the construction works of the NDGRs. The Mosque No.1 and Mosque No.2 are under the management of the Ministry of Awqaf of Egypt (Ministry of Awqaf), while the Mosque No.3 belongs to the MWRI, which means under the control of

MWRI. Apart from those structures, there are no buildings to be affected by the construction works.



(2) Social Status of the Command Area

1) Population

The Project covers five Governorates, namely, Beni Suef, Minia, Assuit, Fayoum and Giza. Still, beneficial area in Assuit Governorate is very small and negligible. Based on the population data on 2014[1], the total population in the beneficiary area of DGRs is estimated to be 18.25 million inhabiting an area of 6,828 km^2. The population density is, therefore, 2,673person/km^2. This figure is equivalent to 31 times of the national average one, which means the command area is very densely populated.

The population census in 2006 showed that the urban population in the beneficiary area was 4.78 million, while the rural population was 7.3 million. Based on the same data, the numbers of households in urban and rural areas are 1.18 million and 1.59 million, respectively. The family size of the urban and rural areas is 4.0 and 4.6 person/household, respectively.

2) Living conditions

According to the UNDP Human Development Report 2010, the average GDP per capita in the five Governorates, namely, Beni Suef, Minia, Assuit, Fayoum and Giza, is 8,482 LE equivalent to around 83% of the national average (10,246 LE/person). The national unemployment rate is 8.9%, while those are 11.7% and 7% are in urban and rural areas, respectively. However, the rates in the five Governorates are much lower, from 2.9% to 6.7%. On the other hand, the national poverty rate is 21.6%, while the rates are higher in the five Governorates, from 23.0% to 41.5%.

3) Meteorological Conditions

The project area is located in northern Egypt where annual rainfall is closed to zero. In the summer season, maximum daytime temperature sometimes can exceed 50^{o}C and drop to below 25 ^{o}C during night time. In the winter season, maximum daytime temperature reaches 20^{o}C at most, and drops from 6 to 8 ^{o}C during night time. During the hot season, any measures should be taken to prevent from heart attack those involved in construction works.

In this area, there is a constant north to north-westerly wind. In April and May, however, a southeasterly sand-storm usually attacks the area. It continues for 2 to 3 days, during which cars need head light even in the daytime. According to the inhabitants, sandstorms may occur several times a year. During that time, construction works are preferably stopped.

1-3 Institutional and legal frameworks of Environmental and Social Consideration in Egypt

(1) Institutional framework

In June 1997, Ministry of Environmental was established as stated in the Presidential Decree No. 275/1997. From thereon, the new Ministry has focused on defining environmental policies, preparing the necessary plans for environmental protection and environmental development projects, and implementing initiatives within a context of sustainable development. Egyptian Environment Environmental Affairs Agency (EEAA) is the highest authority in Egypt, which is

[1] source: CAPMAS Statistic Year Book 2014

responsible for promoting and protecting the environment, and coordinating adequate responses to environmental issues.

EEAA, established by virtue of Law No.4 in 1994, is to replace the Agency established by Presidential Decree No. 631 of the year 1982, in all its rights and obligations. At present, EEAA has many missions, for instance, prepares draft laws and decrees related to protection of the environment and implements studies on the state of the environment, formulate the national plan with the projects included for the protection of the environment, and prepare budgets for necessary activity. It also takes responsibility for classification of projects (screening), review and evaluate EIA reports prepared by proponents, and approve the EIA reports. Under the CEO Deputy Chairman of EEAA, there are five sectors including Environment Management Section as illustrated in Figure 1-3.1.

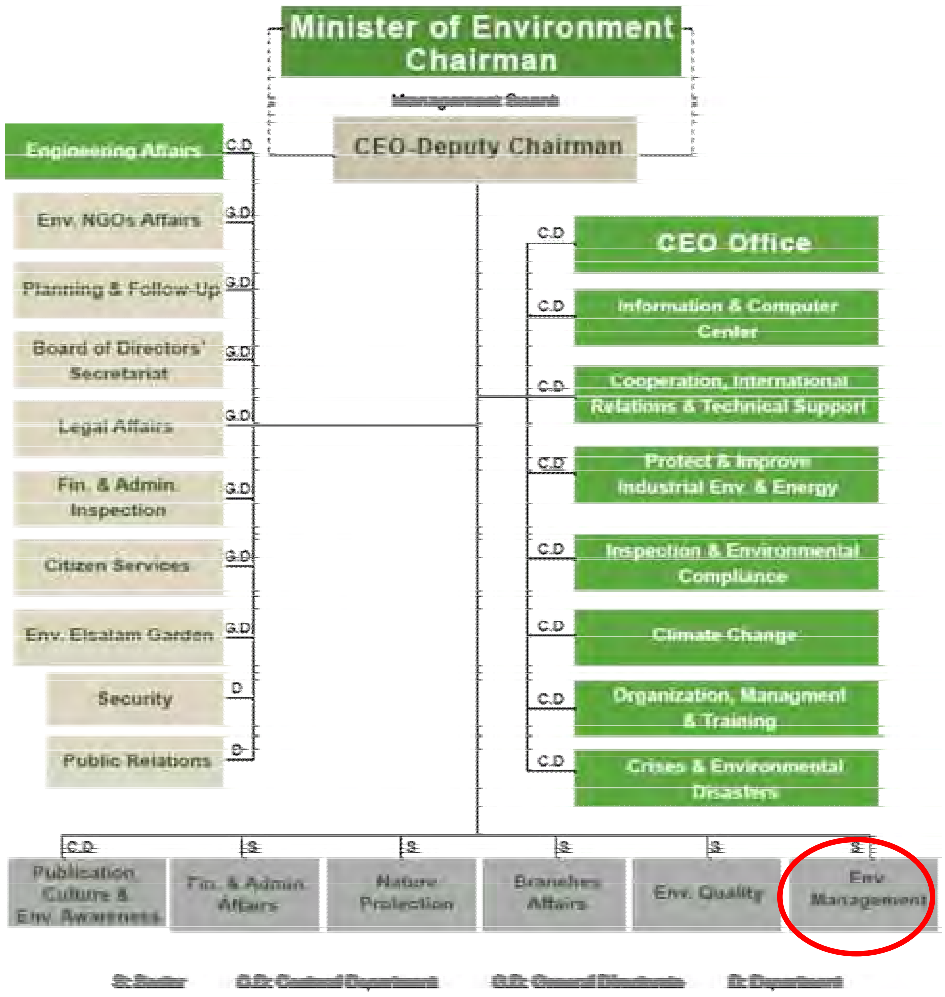


Figure 1-3.1 Organization chart of EEAA

Source: Homepage of Ministry of Environment (updated in January 2014)

EIA Central Department, under the Environmental Management Sector, is in charge of EIA review and has around 50 staff as of February 2017. There are five departments under the Central EIA Department as shown in Figure 1-3.2, Infrastructure Project Department is in charge of EIA for the project.

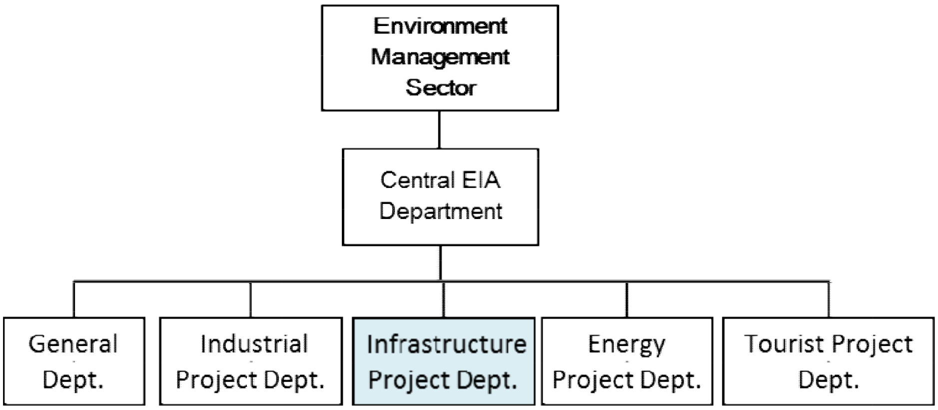


Figure 1-3.2 Departments in charge of EIA review

*Prepared through the hearing from the official personnel of Central EIA Department

(1) Legal Framework

Concerning EIA legal framework in Egypt, two main laws should be based, namely, Environmental Law No. 4, 1994, which was amended in 2009, and "Guidelines of Principles and Procedures for Environmental Impact Assessment", in 2001, that was revised in 2009.

1) Laws, regulations and guidelines related to environmental impact assessment

Law 4 (1994, revised in 2009)

Law No. 4 states that the environmental impact of certain establishments or projects must be evaluated before any construction works are initiated or a license is issued by the competent administrative authority or licensing authority.

Guidelines of Principles and Procedures for Environmental Impact Assessment (2001, revised in 2009)

Any projects are classified into three groups or classes reflecting different levels of necessary environmental impact assessment in accordance with severity of possible environmental impact as follows:

- The "A" list projects for establishments/projects with minor environmental impact.
- The "B" list projects for establishments/projects which may result in substantial environmental impact.
- The "C" list projects for establishments/projects which require complete EIA due to their potential impacts.

The Project of NDGRs is categorized into "C" requires EIA, therefore, the EIA report of the project was prepared in 2010, and it was approved on 9th September 2010 by EEAA. More than 6 years has passed after the EIA report approval, and there is no mention to the validity period of the EIA report in any laws. Moreover, there is no statement about necessary procedures in case of modification of approved EIA reports. Therefore, the meeting with official personnel of

EEAA was held on 28th February 2017 to confirm whether the approved EIA report should be revised on.

At the meeting, it was confirmed that it is not necessary to revise the EIA report for further approval from EEAA, as far as the project location, structure, scale and so on are not changed after the approval, and the EIA Report is still valid. Moreover, it is possible to modify some parts of monitoring items depending on the current conditions in and around the regulators without obtaining the approval from EEAA again.

EIA Source Book

The EIA Source Book was published by MWRI in October 2001 for aiming at guiding the process of EIA study for any projects by MWRI. The projects are classified into 1) New irrigation projects, 2) Irrigation improvement projects, 3) Drainage projects, 4) Dams, barrages, reservoirs and flash flood projects, and 5) Shore protection projects.

2) Other laws and regulations related to environmental consideration

Law 48 (Protection of the River Nile against Pollution & Drainage of Liquid Waste, 1982)

This law aims to protect the River Nile and waterways from pollution, and to ban dumping of wastes (solid, liquid or gaseous) from ships, commercial and industrial establishments, tourism, drains and municipal waste management in streams and other water without permission of MWRI.

Law No. 10 (Expropriation of Real Estate for Public Utility, 1990)

Law No.10 deals with the expropriation for public utilities, such as, energy, water, sanitation, construction, bridges, streets and transport projects. According to the Article 6, assessment of compensation is discussed by a committee formed in each governorate, consisting of representative of the survey authority (president), and other members from each of the directorate. The compensation amount will be decided based on the market prices at the time of the expropriation decision. The land owners who are to be expropriated can get all the compensation in kind or some of it according to the agreement of the owners.

Law No. 117 (Promulgating the Antiquities' Protection Law as Amended by Law No. 3 of 2010)

According to the Article 1 of the Law No.117, any creations on the Egyptian land which has been constructed more than 100 years before are considered as antiquities. Moreover, the owners shall be liable for preservation (Article 2) and cannot renovate the characteristics without license from the Minister of Culture (Item 4 of Article 13).

Environmental Standards

The Law 4 (1994) stipulates a series of tolerance limitations, for air quality, noise/vibration and so on. Maximum permissible limitation for ambient air quality in Egypt is as shown below:

Table 1-3.1 Maximum limits of outdoor air pollutants

(Unit: microgram per cubic meter)

Pollutant	Maximum Limit	Exposure Period
Sulphur Dioxide (SO_2)	350 150 60	1 hr 24 hrs 1 year
Carbon Monoxide (CO)	30 milligrams/cubic meter 10 milligrams/cubic meter	1 hr 8 hr
Nitrogen Dioxide (NO_2)	400 150	1 hr 24 hrs
Ozone	200 120	1 hr 8 hr
Suspended Particles Measured (SPM) as Black Smokes	150 60	24 hrs 1 year
Total Suspended Particles (TSP)	230 90	24 hrs 1 year
Respirable Particles (PM 10)	70	24 hrs
Lead	1	1 year

Source: Law 4 Annex (5)

Permissible limits of sound intensity and periods of safe exposure thereto in Egypt are as shown in following table:

Table 1-3.2 Maximum permissible limits for noise intensity in the different areas

Type of Area	Intensity Decibel (A)					
	Day		Evening		Night	
	From	To	From	To	From	To
Commercial, administrative and downtown areas	55	65	50	60	45	55
Residential areas in which can be found some workshops or commercial establishments or which are located on a main road	50	60	45	55	40	50
Residential areas in the city	45	55	40	50	35	45
Residential suburbs with low traffic	40	50	35	45	30	40
Residential rural areas, hospitals and gardens	35	45	30	40	25	35
Industrial areas (heavy industries)	60	70	55	65	50	60

*Day: from 7 a.m. to 6 p.m. Evening: from 6 p.m. to 10 p.m. Night: from 10 p.m. to 7 a.m.

Source: Law 4 Annex (6)

There are various water quality standards in Egypt depending on the environmental situations and project components. Given that the project can discharge mud water into the downstream in the canals in the construction stage, “Regulations, Standards and Specifications regarding the Draining of Processed Liquid Wastes into Waterways” of Article 60 in Law 48 is to be applied as the permissible surface water quality limitation. The maximum permissible limits are shown in following table:

Table 1-3.3 Maximum permissible limits for drained water quality into fresh water body

Statement	Standards and Specifications (milligram/liter unless otherwise mentioned)
Color	<100 degrees
Total Suspended Solid	<500 mg/l
Temperature	Five degrees above the average
DO (Dissolved Oxygen)	>5 mg/l
pH	7-8.5
BOD (Biological Oxygen Demand)	<6 mg/l
COD (Chemical Oxygen Demand)	<10 mg/l
Organic nitrogen	<1 mg/l
Ammonia	<0.5 mg/l
Grease and oils	<0.1 mg/l

Regarding water quality of groundwater, considering that some people use the groundwater for drinking in Dirout city, “Egyptian Standards for Drinking Water 2007” can be applied for the project. The maximum permissible level for drinking water is as shown below:

Table 1-3.4 Maximum permissible limits for drinking water

[General Specification]

Parameter	Minimum Permissible Limit	Maximum Permissible Limit
Color by cobalt platinum method	10 units	50 units
Turbidity by Jackson Candle method	5 units	25 units

[Chemical specification]

Parameter	Maximum Permissible Limit
Lead	0.05 mg/l
Selenium	0.2 mg/l
Arsenic	0.05 mg/l
Hexavalent chromium	0.01 mg/l
Fluoride	5 mg/l
Nitrates	40 mg/l

[Chemicals that affect the validity of the use of water]

Parameter	Minimum Permissible Limit	Maximum Permissible Limit
Dissolved solid	500 mg/l	1200 mg/l
Iron	0.3 mg/l	1 mg/l
Manganese	0.1 mg/l	1 mg/l
Copper	1 mg/l	1.5 mg/l
Zinc	5 mg/l	15 mg/l
Magnesium	50 mg/l	150 mg/l
Calcium	75 mg/l	200 mg/l
Sulphate	200 mg/l	400 mg/l
Chlorides	200 mg/l	600 mg/l
pH	7-8.5	6.5-9.2
Phenolic compounds	0.001 mg/l	0.002 mg/l

Bacteriological properties:

- It must not exceed the total coli in sterile water for 1/100ml
- It must not exceed the total coli in untreated water for 10/100ml

1-4 Examination of alternatives

Alternative plans for the location of new regulators were examined and evaluated. The alternative plans consist of: Plan-A (rehabilitation of the existing regulators at the original alignment); Plan-B (new regulator at upstream); and Plan-C (new regulators at downstream) as illustrated in Figure 1-4.1. As the examination result is shown in Table 1-4.1, Plan –C has the highest score among the alternatives in terms of various factors including cost, technical difficulties, stability and so on.

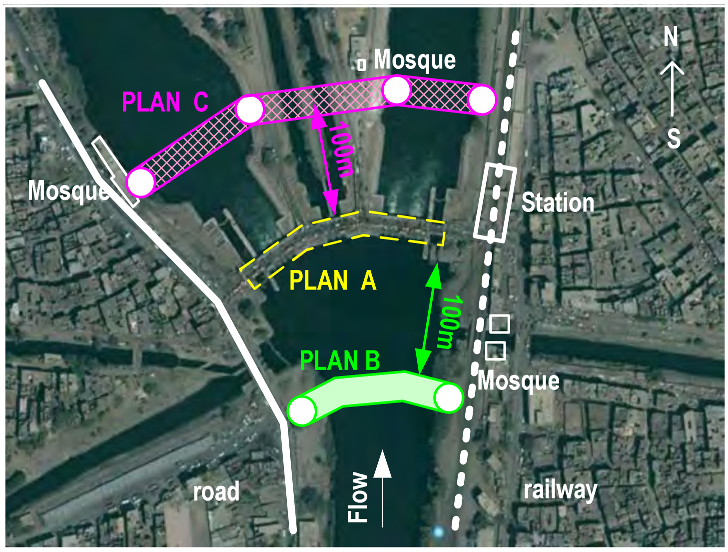


Figure 1-4.1 Preliminary layout of NDGRs' axis

Table 1-4.1 Examination of the alternative plans

Item	Plan-A	Plan-B	Plan-C
Hydraulic Performance	1	2	3
Stability of Structure	1	3	3
Ease of Construction	1	1	3
Operation & Maintenance	1	3	3
Heritage and View	1	1	2
Environmental	3	2	1
Comprehensive Evaluation	**8**	**12**	**15**
Working Life	40 yrs	100 yrs	100 yrs
Navigation Lock	Existing	Not possible	Possible
Hydropower Plant	Not possible	Not possible	Possible

Evaluation Category; 1:Low、2:Medium、3:High

The examination of three alternatives in view of environmental and social consideration is as shown in Table 1-4.2. Plan-A gets the highest scores in terms of that point, while Plan-C gets the highest scores for the other factors (engineering, project life and the rest). Taking into consideration various conditions, Plan-C was finally selected.

Table 1-4.2 Comparison of alternative plans for Environmental and Social Considerations

Item	Plan A	Plan B	Plan C
Heritage and View	In case of electrifying the existing gates, installation of switching devices on the existing structures will spoil the landscape of DGR. **Point:+1**	Since the new regulators are constructed at the upstream side and feeder canals are constructed from the new regulators to the existing DGR, the landscape of the upstream side of DGR will be drastically changed. **Point:+1**	Because the new regulators are constructed at the downstream side, the view of the downstream side of the existing DGR will be changed. **Point:+2**
Environment	There will be no land acquisition or relocation of houses/structures. **Point:+3**	There will be no land acquisition or relocation of houses/structures. However, if hydro-power plant and navigation lock are to be constructed, land acquisition for those facilities is necessary. **Point:+2**	There is a mosque on the left bank of Bahr Yusef. This mosque is requested to relocate in construction work **Point:+1**

2. Review of Environmental Impact Assessment

The EIA report on the project, which has been approved on 9th September 2010 by EEAA, was reviewed taking into consideration current conditions, focusing on mainly the environmental evaluation, environmental management plan and environmental monitoring plan. Environmental WG under the RGBS also participated in the process. Moreover, present progress of environmental monitoring as of February 2017 was also confirmed through discussion with ECRI which was in charge of the EIA report preparation in 2010.

2-1 Change of environmental conditions after the F/S

Given that there are some environmental changes in and around the construction sites between 2010 and 2016, it is needed to review the EIA report.

"JICA Guidelines for Environmental and Social Considerations" (hereinafter referred as to "JICA Guidelines") was revised in April 2010, and the new one mentions the necessity to minimize deviation between the international standards and laws of the recipient counties, if there is a significantly big gap. In Egypt, it is not necessary to provide compensation to illegal occupants/residents, if involuntary resettlement and land acquisition are caused and affected persons are illegal, there is a gap between the JICA Guidelines and Egyptian laws. On the other hand, there is no change of laws/regulations related to EIA and environmental standards in Egypt since 2010.

The largest changes in Egypt are democratization in 2011 and introduction of floating rate system in 2016 after the approval of the EIA report in September 2010. However, they are political and economic change, and not natural, industrial and demographic change in and around DGRs. Agriculture is still an important industry for the command area.

There are some minor changes of the surrounding conditions, such as construction of illegal café within the dry river bed at just upstream of the regulators, which refuses relocation for the project. Still, the construction works nearby the café can be implemented without the relocation; impacts such as dust and noise/vibration for the café are expected, though.

Concerning relocation of mosques, in the Minutes of Discussion (M/D) of this Loan, three mosques of them should be relocated to other sites, prior to the construction works. Parts of area around the construction sites, namely, spaces between Bahr Yusef Canal and Badraman canal, and Diroutiah canal and Ibrahimia canal, belong to the MWRI. Therefore, those three mosques can be shifted to neighboring areas as shown in Figure 2-1.1.

Originally, it was planned to set the stockyard including the batcher plant in the farmland 2-3 km upstream of the regulators at F/S stage. However, the farmland cannot be leased, since the consensus on the compensation rate with the land owners has not been obtained. Instead of that, the batcher plant will be constructed within the land owned by MWRI just downstream of the NDGRs. However, it is needed to secure additional site for the temporary stockyard, around 1 feddan (=0.42ha) for two years at longest. There are some available lands that the owners have willingness to rent, which are not far from the DGRs (see photos below). MWRI has a plan to apply bidding system for the land tenancy for the temporary yard. Based on the contract to be exchanged between MWRI and the land owner, the rental fee shall be paid, the rate has yet to be fixed, though.

Candidate for stockyard (1): app. 0.5ha
around 0.5km away from the construction site
Land is not used for any purposes as of Feb 2017.

Candidate for stockyard (2): app. 0.4ha
around 1 km away from the construction site
Land is used as a farmland as of Feb. 2017.

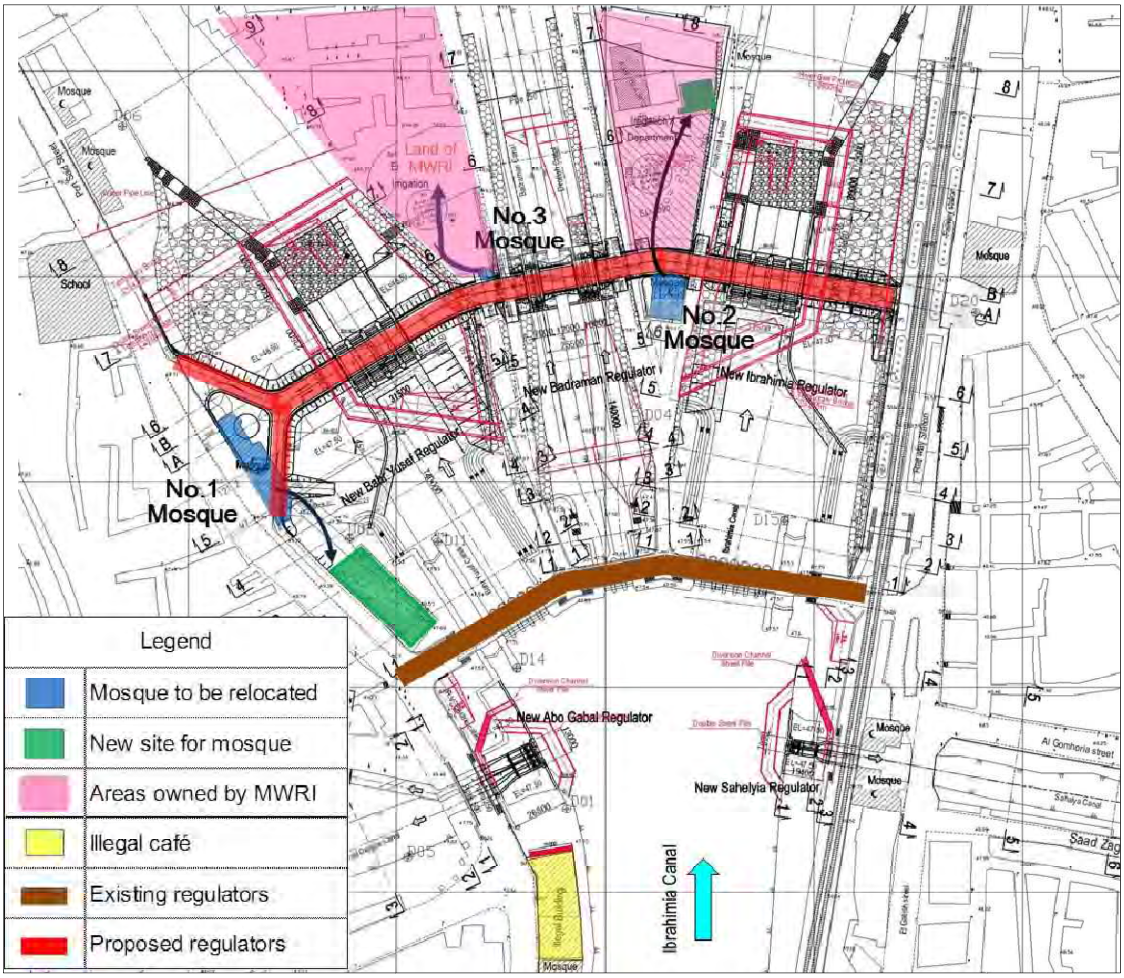


Figure 2-1.1 Location of mosques to be relocated and illegal café around the regulators

2-2 Progress of Environmental Management Plan and Environmental Monitoring Plan

The EIA report, which was approved by EEAA, stipulates environmental monitoring items for pre-construction stage, construction stage and operation stage. 16 items[2] including surface water quality, land use, noise, vibration, health, waste, growth of weed and so on are listed up as items. Actually, groundwater quality check and groundwater level measurement have been implemented in D/D stage, while other items have not been done. Moreover, it is not clear which organization is responsible for the monitoring, especially for pre-construction stage in the EIA Report. Therefore, this point was discussed at the 25th TAC meeting on 20th February 2017, and it was agreed that the S/V consultant will be responsible for the monitoring in pre-construction stage.

According to the official personnel of EEAA, it is surely needed to monitor groundwater level and groundwater quality according to the recommendation in the letter which approved the

2 Air emission is not listed up as one of monitoring items for pre-construction stage in the EIA Report. However, given that air pollution should be monitored in the construction stage, it is recommended to implement monitor air emission even pre-construction stage.

EIA report by the EEAA. On the other hand, if other monitoring items are judged as unpractical, it is possible to skip or change such items as far as the reasons are clearly mentioned in the motoring report. Moreover, it is not needed to take any procedures to get approval of the EIA report again.

Based on the consensus mentioned above, the existing Environmental Management Plan and Environmental Monitoring Plan are revised (refer to chapter 2-4).

2-3 Monitoring results of groundwater level and water quality check

The canal water level between DGRs and NDGRs will rise up to 2m after the construction of NDGRs. Moreover, canal water level will be controlled on EL.46.3m whereas the current maximum water level is approximately EL.46.0m. Those changes in canal water level will affect the groundwater head around those areas. As the current condition, some basements of houses located near the DGRs, have already shown signs of seepage; therefore, it is necessary to grasp the extent of the negative impact on those seepages. Moreover, groundwater is still utilized as the drinking water in some areas, when the tap water system is cut off; so that the impact on the groundwater quality also should be carefully assessed.

Groundwater monitoring aiming at recording the baseline of the hydrological data was carried out two to three times per month at thirteen piezometers from October 2015 to April 2017 for groundwater head and its quality (EC, pH and DO), and two times at two points (BH-N7 and BH-N10 beside the new axis line) for the detailed water quality test (refer to Figure 2-3.1). The detailed result of the groundwater monitoring is attached in the Appendix.

(1) Groundwater head

Groundwater head increased from June to August when the water demand is highest (the shallowest water level from the surface ground was 1.75m), and compared with the peak level, it decreased by 2.2m to 2.3m during the winter closure which shows the lowest canal water level. Those changes clearly indicate the groundwater head will correspond to the surface water level (refer to Figure 2.3-2 and Table 2-3.1).

Moreover, the aquifer can be partly recharged by the surface water because the groundwater head was basically higher at the piezometers close to the canals than the other piezometers, which also indicate the rise in canal water level will have the negative impact on the groundwater head (evaluation of the mitigation measures for the rise in groundwater head is discussed in the “Volume I Design of Regulators, ‘Chapter 20. Groundwater Simulation Analysis’).

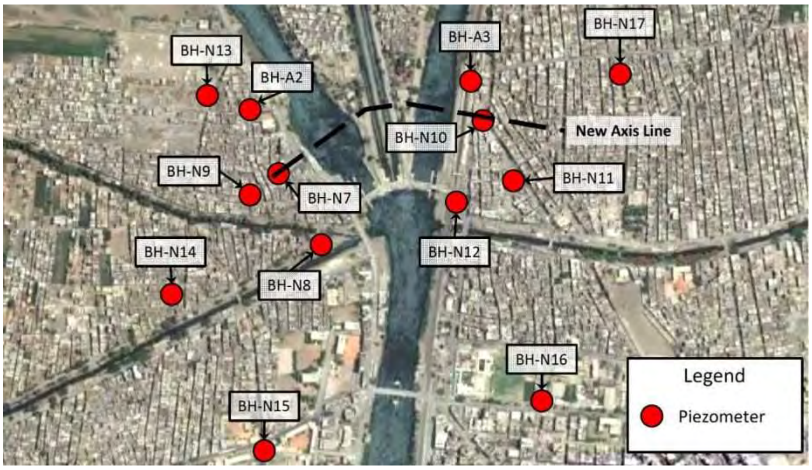


Figure 2-3.1 Location of the piezometers

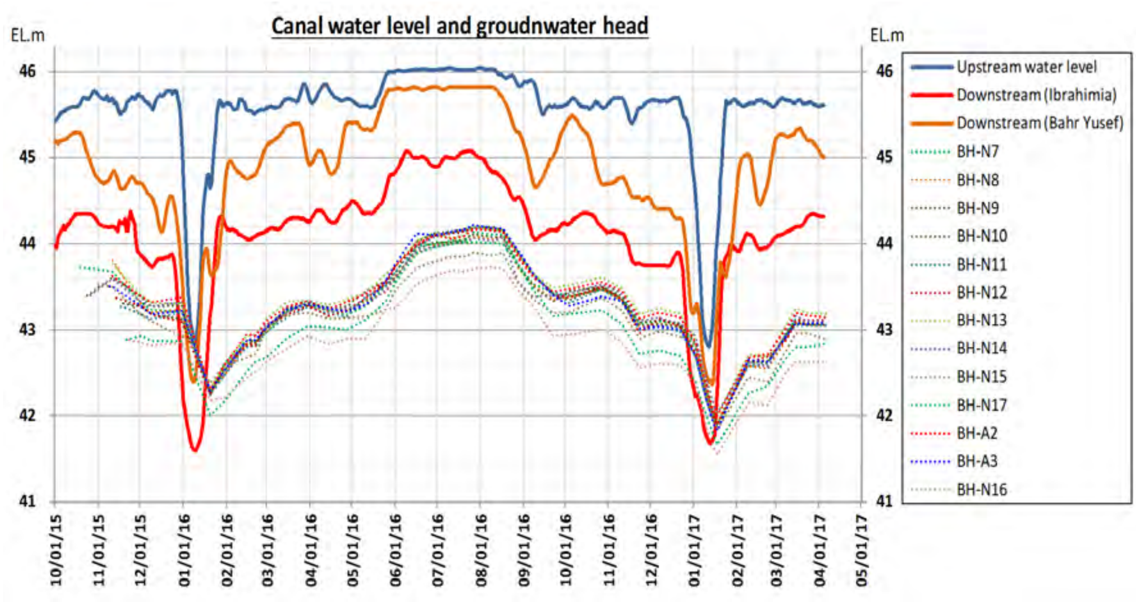


Figure 2-3.2 Seasonal change of groundwater head and canal water level
(Oct. 2015-Apr. 2017)

Table 2-3.1 Maximum/Minimum Groundwater Level/Depth (Oct. 2015- Apr.2017)

Monitoring Well / Canal	Max. Depth (m)	Min. WL (EL.m)	date		Min. Depth (m)	Max. WL (EL.m)	date
BH-N7	5.38	41.93	18/1/2017	～	3.17	44.14	27/7/2016
BH-N8	5.62	41.93	18/1/2017	～	3.46	44.09	17/8/2016
BH-N9	5.06	41.88	18/1/2017	～	2.83	44.11	27/7/2016
BH-N10	6.88	41.88	18/1/2017	～	4.56	44.20	27/7/2016
BH-N11	5.64	41.89	18/1/2017	～	3.34	44.19	27/7/2016
BH-N12	8.82	41.90	18/1/2017	～	6.54	44.18	27/7/2016
BH-N13	3.93	42.02	18/1/2017	～	1.75	44.20	27/7/2016
BH-N14	4.81	42.03	18/1/2017	～	2.77	44.07	17/8/2016
BH-N15	4.96	41.84	18/1/2017	～	2.90	43.90	10/8/2016
BH-N16	4.78	41.55	18/1/2017	～	2.60	43.71	10/8/2016
BH-N17	4.83	41.66	18/1/2017	～	2.47	44.02	27/7/2016
BH-A2	5.00	42.00	18/1/2017	～	2.83	44.17	27/7/2016
BH-A3	7.56	41.83	18/1/2017	～	5.17	44.22	27/7/2016
U/S Ibrahimia	-	46.08	23/6/2016	～	-	42.65	12/1/2016
D/S Ibrahimia	-	45.13	11/6/2016	～	-	41.60	12/1/2016
D/S Bahr Yusef	-	45.82	16/6/2016	～	-	42.17	18/1/2017

(2) Groundwater Quality

Figure 2-3.3 to Figure 2-3.5 show the trend of the groundwater quality. It can be evaluated that the impact on change of water level does not have direct relation with water quality, considering that the groundwater quality were not changed very much between the highest (Irrigation Season) and lowest (Winter Closure) water level periods. In regard to the Electric Conductivity, abrupt change was observed at certain sampling points and dates, which seems to be caused by the sewage intrusion to the aquifer. Figure 2-3.6 shows the EC values around Dirout, giving the followings; 1) high EC values were observed in the town area, and 2) low EC values on the right bank of the Ibrahimia regulator. Those facts indicate 1) sewage intrusion from the resident area, and 2) aquifer recharge from the canal water[3] on the right bank of the Ibrahimia regulator.

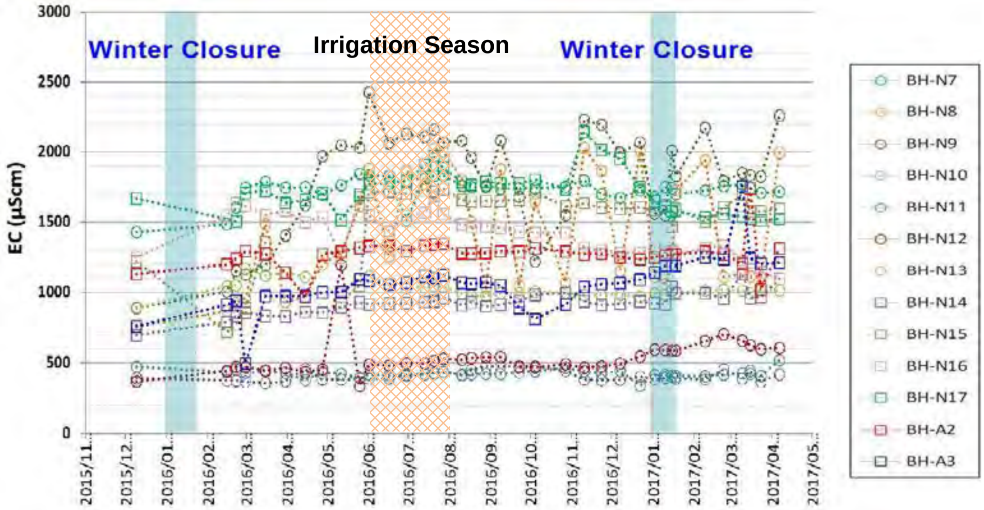


Figure 2-3.3 Seasonal Change of EC (Nov 2015-Apr.2017)

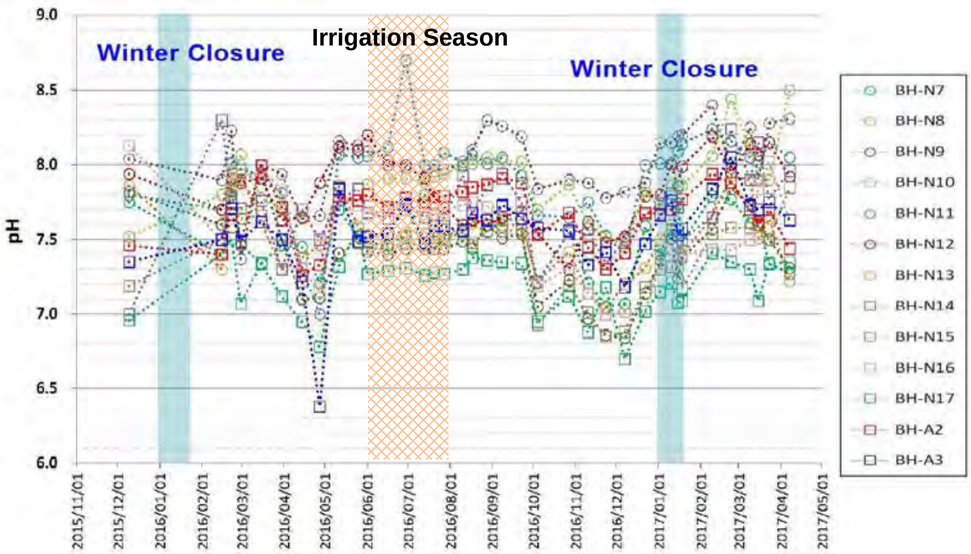


Figure 2-3.4 Seasonal Change of pH (Nov.2015-Apr.2017)

[3] EC of the canal water is approximately 300µS/cm, showing distinct difference in EC value of groundwater (1,000 to 2,000µS/cm)

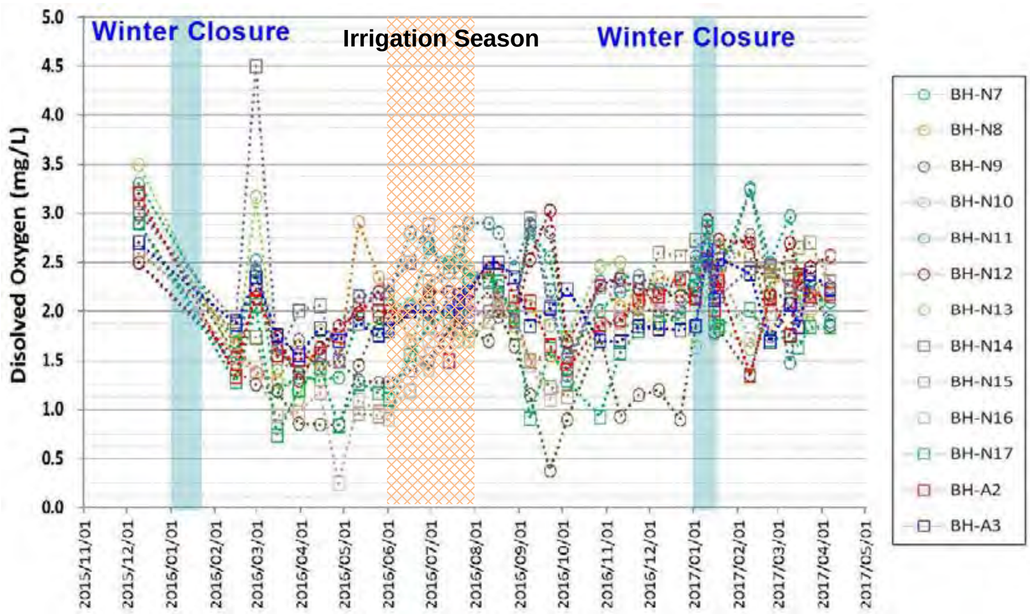


Figure 2-3.5 Seasonal Change of DO (Nov.2015-Apr.2017)

Figure 2-3.6 EC distribution trend (14th April 2016)

※Balloon symbols with W in the figure show the location of the hand pump well found by the inventory survey

Table 2-3.2 shows the result of the detailed water quality test at two sampling points (BH-N7 and BH-N10). Compared to the Egyptian standards for the drinking water, total (fecal) coliform and the excessive concentration of the manganese ion were detected. At BH-N7 (the left bank of the Bahr Yusef regulator), high concentrations of sodium and chloride ions were also detected, which can be considered as the sewage origin. The existence of the Sulfur which gives unpleasant odor to the groundwater was also identified, which also indicates aquifer is in a reduced state.

Given that those all results are seemingly caused by the sewage water, it is difficult to improve the groundwater quality unless the current sewage treatment system is improved. Therefore, not only from the aspect of prevention measures of the seepage, but also the aspect of the groundwater quality, the improvement in the sewage water treatment system is essential.

Table 2-3.2 Results of groundwater quality check

	Item	Unit	Egyptian Standard*	BH-N7		BH-N10		Remarks
				13 Jul. 2016	2 Jan. 2017	13 Jul. 2016	2 Jan. 2017	
Physical & Chemical Property								
1	Temperature	°C	-	25.0	23.5	24.6	22.9	-
2	pH	-	6.5 - 8.5	8.0	7.4	8.0	8.2	-
3	EC	mS/cm	-	1.714	1.68	0.424	0.383	Electiric Conductivity
4	Turbidity	NTU	1	5	8	13	3	-
5	TDS	mg/L	1000	1098	1175	271	258	Total Dissolved Solids
6	TSS	mg/L	-	2	3	2	3	Total Suspended Solids
7	COD	mg/L	-	110	138	40	53	Chemical Oxygen Demand
8	BOD	mg/L	-	160	200	63	80	Biological Oxygen Demand
9-1	CO_3	mg/L	-	0	0	0	0	Carbonate
9-2	HCO_3	mg/L	-	574	220	178	138	Bicarbonate
10	TA	mg/L	-	574	220	178	138	Total Alcalinity
Hydro-checmial Property								
11	Ca	mg/L	200	103	120	34	31	Calcium
12	Mg	mg/L	150	38	17	11	10	Magnesium
13	Na	mg/L	200	220	200	35	28	Sodium
14	K	mg/L	-	12	16	4	6	Potassium
15	Cl	mg/L	250	269	265	28	21	Chloride
16	SO_4	mg/L	250	20	210	13	21	Sulfate
Trace Element & Heavy Minerals								
17	NO_3	mg/L	44	0.71	0.3	3.47	< 0.2	Nitrate
18	NO_2	mg/L	0.02	< 0.2	< 0.2	0.91	< 0.2	Nitrite
19	PO_4	mg/L	-	< 0.2	< 0.2	< 0.2	< 0.2	Phosphate
20	S	mg/L	-	6.81	70	4.24	7	Sulfur
21	Cr	mg/L	0.050	0.001	0.004	0.001	< 0.001	Chromium
22	Cu	mg/L	2.0	0.031	0.020	0.027	0.015	Copper
23	Fe	mg/L	0.3	0.080	0.162	0.054	0.119	Iron
24	Mn	mg/L	0.4	0.163	1.515	0.238	0.445	Manganese
25	Ni	mg/L	-	0.033	0.012	0.004	< 0.001	Nickel
26	Pb	mg/L	0.01	< 0.001	< 0.001	< 0.001	< 0.001	Lead
27	Zn	mg/L	5.0	0.010	0.013	0.004	0.005	Zinc
Others								
-	Total Coliform	CFU/100ml	N/D	1.4E+05	4.4E+03	5.0E+04	1.2E+03	-
-	Fecal Coliform	CFU/100ml	N/D	2.0E+05	N/D	2.0E+04	N/D	-

* Egypt Standards according to the Minister of Health decree Number (108) for 1995 and (458) for 2007

2-4 Review of environmental evaluation

As mentioned before, it is not necessary to drastically modify the environmental evaluation of the EIA Report, which has been prepared at F/S stage, since there is no significant change in terms of environmental conditions in and around the regulators. Therefore, parts of description in the environmental evaluation were revised as shown in Table 2-4.1.

As for “No.5 Groundwater level” was described as “Groundwater quality” in the original report. However, it pays attention to rise of groundwater level, thus, the title is changed to “Groundwater level”, and “Groundwater quality” is newly added as No.6. Concerning “No.9 Land use and land tenure”, description of “reasons” is changed based on the current conditions. As for “No.18 Odor”, original evaluation was B, however, it is not caused by the Project, and it is re-evaluated as D. Moreover, regarding “No.17 Safety of the regulators”, it is possible to prevent from water inflow to the construction site by installation of sheet piles, which leads to no damage to soil and the regulators. Therefore, the evaluation for the item is also changed into D. The revised Environmental Evaluation is as shown below:

Table 2-4.1 Revised environmental evaluation

No	Items	Evaluation		Reasons
		Construction Stage	Operation Stage	
1	Topography and geology	D	D	The project scale is not very large to affect topographic and geological conditions.
2	Weather and climate	D	D	The Project does not cause any changes of weather and climate.
3	Air Emission	B	F	Construction stage Due to increase of vehicle numbers for the construction works, dust can be generated. Moreover, the batcher plant which processes concrete materials will generate powder dust. However, such situations are limited to only construction stage. Operation stage No air pollution is expected after the completion.
4	Surface Water Quality	B	D	Construction stage Effluent containing cement can be discharged from the batcher plant, and oil might get out of. Operation stage No effect of water quality is expected in operation period.
5	Groundwater Level	B	B	Construction stage Groundwater level can be increased by the construction works, however, it is acceptable level, which does not give damage to existing structures considering the groundwater level simulation result. Operation stage Groundwater level can be increased after completion of the construction works, however, it is acceptable level, which does not give damage to existing structures based on the groundwater simulation result.
6	Groundwater Quality	C	C	Construction stage According to the groundwater quality monitoring, sewage seems to intrude to groundwater. Since parts of people in

No	Items	Evaluation Construction Stage	Evaluation Operation Stage	Reasons
				Dirout city use groundwater as drinking water, it is needed to monitor groundwater quality continuously. Still, current issue is caused by improper sewage treatment system, and it is thought that the Project will not cause water quality deterioration directly. Operation stage As the same in the construction stage, continuous water quality check is necessary.
7	Water Flow and River Morphology	B	D	Construction stage Due to setting of the temporary cofferdam in the canals, water flow can be changed to some extent, however, the same water discharge will be kept for irrigation in downstream, and the period is limited to the construction period. Operation stage After the completion of construction works, no impact on the water flow is expected.
8	Archeological Treasure	D	D	It is proposed to preserve the current DRG as a historical monument and main structure of the DRG will not be spoiled. Therefore, the construction works does not give damage to the antiquities.
9	Land Use and Land Tenure	B	D	Construction stage It is needed to lease land for temporary stockyard from some private land owners under the contract after the bidding. In case of lease of farmland, the land shall be recovered to the original condition after the construction works. It is, thus, needed to avoid lease of farmland as much as possible. Operation stage After the completion of works, no impact is expected.
10	Fishery	B	D	Construction stage Fishermen who have license for fishing around the regulators have not been identified. In addition, due to the effluent containing cement from the batcher plant, fish larvae, benthic organism and planktons can be affected. However, a sedimentation pond at the plant can minimize the issue, and the impacts on the fishery will be very limited. In case there are any complaints by fishermen, RGBS staff in Dirout will receive and handle the complaints. Operation stage After the completion of works, no impact is expected.
11	Income	F	F	Construction stage The construction works will create the new job opportunities (e.g. restaurant, cafeteria, etc.), which will increase the income of some citizens, as well as workers coming from nearby villages. Operation stage After the completion of works, stable irrigation water can be supplied to the command area, which leads to income improvement of the beneficiaries.
12	Access to the	B	D	Construction stage

No	Items	Evaluation		Reasons
		Construction Stage	Operation Stage	
	Project Site			Transportation of the construction material by heavy machines might cause traffic jam. <u>Operation stage</u> After the completion of works, traffic jam by the NDGR is not expected.
13	Noise	B	D	<u>Construction stage</u> Using heavy equipment and increase of vehicle numbers may generate noise, however, it is temporary. <u>Operation stage</u> After the completion of works, noise is not expected.
14	Vibration	B	D	<u>Construction stage</u> Vibrations can be caused by the sheet pile installation and movements of heavy machines. However, it is limited to only construction stage. <u>Operation stage</u> After the completion of works, vibration is not expected.
15	Health and safety	B	D	<u>Construction stage</u> Accident by the construction works, traffic accident and infectious diseases can be caused due to use of construction vehicles, increase of number of vehicles and employment of many workers. <u>Operation stage</u> After the completion of works, no health and safety issue by the NDGR Project is expected.
16	Labor accommodation camps	D	D	No accommodation camp for the labors is to be constructed, since they will come from nearby villages.
17	Safety of the regulators	D	D	<u>Construction stage</u> A temporary cofferdam will be put by using of sheet piles, which prevents from water inflow. In such case, any damages to on soil and the regulators are not given. <u>Operation stage</u> After the completion of works, no impact on the safety of the regulators is expected.
18	Odor	D	D	The odor may be caused by accumulated algae and dead animals in the water ways. However, the odor is not generated by the construction works.
19	Sediment	D	D	A large quantity of sediment is not expected, since dredging is carried out regularly as a routine work.
20	Solid Waste	B	D	<u>Construction stage</u> Wastes materials are generated by the construction activities. Therefore, it is needed to <u>Operation stage</u> No impact is expected in operation stage.

Evaluation category:
A: Serious impact is expected
B: Some impact is expected
C: Extent of impact is unknown
D: No impact is expected. EIA is not necessary
F: Positive impact
*Highlighted cells show that negative impacts are expected in the parameters.

3. Environmental Management Plan and Monitoring

3-1 Environmental Management Plan and Cost

Based on the revised Environmental Evaluation discussed above, the original EMP in the EIA Report is also revised as shown in Table 3-1.1. The table shows mitigation measures for the items respectively which are evaluated as "B" and "C" in Table 2-4.1. Moreover, the mitigation cost is included in the construction cost in the construction stage in general, while the cost in operation stage is covered by the MWRI.

Table 3-1.1 Environmental Management Plan

No *1	Environmental Items	Mitigation measure	Implementation agency	Responsible agency	Cost
Pre-construction stage					
9	Land use and Land tenure	● To exchange land lease agreement on the temporary yard ● To avoid lease of farmland as much as possible since it is needed to recover the farmland to the original condition	MWRI*2	MWRI	Budget of MWRI*2
Construction stage					
3	Air Emission*3	● Installation of a dust extractor at the batcher plant ● Water spray around the construction site ● Regular maintenance of construction vehicles	Contractor	MWRI	Included in construction cost
4	Surface Water Quality	● Set-up of a sedimentation basin at the concrete batcher plant to prevent effluent containing cement from discharging to the downstream	Contractor	MWRI	Included in construction cost
5	Groundwater Level	● Regular monitoring of groundwater level	Contractor	MWRI	Included in construction cost
6	Groundwater quality	● Regular monitoring of groundwater quality ● Improvement of existing sewage system	Contractor Holding Company for Water & Waste water (HCWW)	MWRI MWRI	Included in construction cost Regular budget of HCWW
7	Water flow and river morphology	● Keeping the same discharge to the downstream as planned	Contractor	MWRI	Included in construction cost
9	Land use and land tenure	● Whether payment to the land owners has been done should be confirmed	MWRI*2	MWRI	Budget of MWRI*2
10	Fishery	● Setting of sedimentation basin at the concrete batcher plant to prevent effluent water to downstream ● Employ persons with high priority who depend on fishery for livelihood	Contractor	MWRI	Included in construction cost
12	Access to the Project Site	● Preparation of a vehicle operation schedule which deconcentrates utilization of vehicle	Contractor	MWRI	Included in construction cost
13	Noise	● To refrain from the construction works at night in the residential areas as much as	Contractor	MWRI	Included in construction

No *1	Environmental Items	Mitigation measure	Implementation agency	Responsible agency	Cost
		possible ● Silent piler machine is to be used for piling to minimize noise around densely populated area and railway while hydraulic hammer is used in other areas			cost
14	Vibration	● To refrain from the construction works at night in the residential areas as much as possible ● Silent piler machine is used for piling to minimize noise around densely populated area and railway while hydraulic hammer is used in other areas	Contractor	MWRI	Included in construction cost
15	Health and safety	● Paying attention to the workers' health condition, and if there is a possibility of incident of infectious diseases taking place, immediately inform the Ministry of Health. ● Request the Ministry of Health to carry out awareness creation on HIV/AIDS among the workers and recommend them to voluntary check the status of HIV/AIDS. ● To identify if there is too tight operation schedule or not, and if so rectify it. ● Place traffic control staff along the construction roads. ● To explain contents of the work to the workers with necessary care taking for their safety prior to the start of the work, and make daily confirming safe meeting before starting the work.	Contractor	MWRI	Included in construction cost
20	Solid waste	● Re-use excavated soils ● Disposal of waste generated from the construction site to the dumping site.	Contractor	MWRI	Included in construction cost
Operation stage					
5	Groundwater Level	● Monitoring of groundwater level	MWRI	MWRI	Included in regular budget of MWRI
6	Groundwater quality	● Monitoring of groundwater quality	MWRI	MWRI	Included in regular budget of MWRI

*1: Numbers in the table are the same ones which hare illustrated in Table 2-4.1.
*2: It is tentatively set as MWRI, however, it is to be discussed at biding and contract exchange.
*3: It is newly added as an environmental item, since EEAA recommended monitoring groundwater quality in 2010.

3-2 Environmental Monitoring Plan

As mentioned before, it is needed to re-examine existing monitoring items and to propose a new monitoring plan depending on the current conditions. Regarding "groundwater quality", it will not be influenced by the project; however, considering that high concentration of chloride, sodium, manganese were detected in the groundwater as mentioned in Table 2-3.2 and EEAA recommends to monitor the groundwater quality, this item is also included. The revised monitoring items by stage are as shown in from Table 3-2.1 to Table 3-2.3.

Table 3-2.1 Environmental monitoring items for pre-construction stage

(to be covered by the S/V Consultant)

Items (proposed in the EIA Report)	Decision of implementation	Reasons
1. Air emission	To be implemented	Air emission is not included in the monitoring items in the EIA Report. However, it is needed to include the item, since air pollution is expected in the construction period.
2. Surface water quality	To be implemented as planned	
3. Groundwater quality	To be implemented as planned	
4. Groundwater level	To be implemented as planned	
5. Noise	To be implemented as planned	
6. Vibration	To be implemented as planned	
7. Water flow and river morphology	Not to be implemented	Due to cofferdam, conditions of water flow would be changed, however, the same amount of water discharge to the downstream is kept, which will not result in damage to the farming in the downstream. Moreover, it is difficult to evaluate the change quantitatively.
8. Land use and land tenure	Progress of contract exchange of the 1) land lease and 2) transfer of mosques which are under control of the Ministry of Awqaf is to be checked.	
9. Fishery	Number of fishermen and legalities of them shall be identified.	
10. Income	Not to be implemented	Since negative impacts on incomes of neighboring people and beneficial farmers are not expected, monitoring of income is not necessary.
11. Access to the Project Site	Not to be implemented	There is no quantitative regulation/standard related to transportation, and monitoring of transportation is not necessary. Moreover, since there are no limitation of number of vehicles in the roads, “access to the Project site” cannot be assessed. It is noted that an operation schedule of construction vehicle should be prepared to avoid traffic jam in construction stage.
12. Health and safety	Not to be implemented	Since there is no infectious diseases or accidents before construction works, monitoring of the item is not needed.
13. Safety of regulators	Not to be implemented	Cofferdam is put by using pile sheets, and such construction works will not cause damage to the existing regulators. It is, thus, not necessary to monitor the safety, especially in pre-construction stage.
14. Solid waste	Not to be implemented	Since no waste is generated before construction works and quantitative measurement is difficult, monitoring of waste is not implemented.
15. Odor	Not to be implemented	Regardless of implementation of construction works, dead animal and solid waste are thrown

Items (proposed in the EIA Report)	Decision of implementation	Reasons
		away to the canal, which does not have direct relationship with the Project.
16. Sedimentation	Not to be implemented	Quantitative measurement and evaluation are difficult.
17. Growth of weeds	Not to be implemented	Quantitative measurement and evaluation are difficult. Moreover, there is no mention to the growth of weeds by the Project in the EIA Report, and there is no clear relation between the Project and growth of weeds.

Following table shows the monitoring items in construction stage. "Odor" will not be caused by the Project, sill, the problem could be caused by bad habitat such as throwing away garbage to the canals. However, it is mentioned that "Odor" is to be monitored in construction stage and monitoring stage in M/D in 2014. MWRI has a duty to dredge canals biannually as a routine work, and it can be assessed by confirmation of dredging implementation.

Table 3-2.2 Environmental monitoring items for construction stage

(to be covered by the contractor under the supervision of MWRI)

Items (proposed in the EIA Report)	Decision of implementation	Reasons
1. Climate and weather	Not to be implemented	Any impacts by the construction works are expected. According to the Checklist in the EIA Report, it is evaluated as "D" for this item.
2. Air emission	To be implemented as planned	
3. Surface water quality	To be implemented as planned	
4. Groundwater quality	To be implemented as planned	
5. Groundwater level	To be implemented	It is not included in the monitoring items in the EIA Report, however, it is to be monitored since it is recommended by EEAA in 2010.
6. Noise	To be implemented as planned	
7. Vibration	To be implemented as planned	
8. Water flow and river morphology	To be implemented as planned. It is needed to keep same discharge to the downstream for farming.	
9. Land use and land tenure	Whether payment to the land owners for the stockyard has done shall be checked.	
10. Fishery	Instead of impact on the fishery, whether mud water is treated is monitored. Surface water quality check can substitute.	Since there is a possibility that waste water containing cement form the batcher plant can give damage to ecosystem in the river, the monitoring focuses on the waste water treatment. In case of complaints from the fishermen, it can be managed by employment of them as construction labors.
11. Income	Not to be implemented	Since negative impacts on incomes of neighboring people and beneficial farmers are not expected, monitoring of income is not

Items (proposed in the EIA Report)	Decision of implementation	Reasons
		necessary.
12. Access to the Project Site	Whether the schedule management of construction vehicles for decentralization is prepared can be regarded as an indicator of monitoring for access to the project site.	
13. Health and safety	To be implemented as planned	
14. Safety of regulators	Not to be implemented	Cofferdam is put by using pile sheets, and such construction works will not cause damage to the existing regulators. It is, thus, not necessary to monitor the safety.
15. Solid waste	To be implemented as planned	
16. Odor	It can be assessed by frequency of canal dredging. It is done as a routine work of MWRI since odor will not be generated by the Project.	
17. Sedimentation	Not to be implemented	Quantitative measurement and evaluation are difficult.
18. Growth of weeds	Not to be implemented	Quantitative measurement and evaluation are difficult. Moreover, there is no mention to the growth of weeds by the Project in the EIA Report, and there is no clear relation between the Project and growth of weeds.
19. Complaints	To be implemented	

Following table illustrates monitoring items in operation stage. “Odor” and “Solid waste” are not caused by the Project directly, instead, those problems could be caused by bad habitat such as throwing away garbage to the canals as well as in construction stage. MWRI will dredge canals biannually as a routine work instead of as one of project works, and it can be assessed by confirmation of dredging implementation. Some items, namely, water flow and river morphology, surface water quality, noise, vibration are not included in the EMP. However, they are to be monitored in terms of Environmental Auditing.

Table 3-2.3 Environmental monitoring items for operation stage

(to be covered by MWRI)

Items (proposed in the EIA Report)	Decision of implementation	Reasons
1. Surface water quality	To be implemented	
2. Groundwater quality	To be implemented	
3. Groundwater level	To be implemented	
4. Noise	To be implemented	
5. Vibration	To be implemented	
6. Water flow and river morphology	To be implemented	
7. Fishery	Not to be implemented	Effluent water that can damage to fishery will not be generated after the completion of construction works, and impacts on the fishery is not expected.

Items (proposed in the EIA Report)	Decision of implementation	Reasons
8. Safety of the regulators	Not to be implemented	No concern about safety of the regulators is expected.
9. Solid waste	It is not implemented, since it is a routine works of MWRI, and out of scope of the Project.	Solid waste will not be generated after the completion of construction works, and it is difficult to evaluate quantitatively. Neighboring people sometimes throw away garbage to the canals, such waste is dredged as a routine work of MWRI.
10. Odor	It is not implemented within the Project. It can be done by frequency of canal dredging. However, it is a routine works of MWRI, and out of scope of the Project.	
11. Sedimentation	Not to be implemented	Quantitative measurement and evaluation are difficult.
12. Growth of weeds	Not to be implemented	Quantitative measurement and evaluation are difficult.
13. Complaints	Complaints will be handled, if any (as planned).	

Based on the proposed monitoring items, the actual monitoring activities shall be done. It is noted that implementation organizations of monitoring varies by stage. Monitoring cost in pre-construction stage is included in the fee of S/V consultant. On the other hand, that in construction stage is included in the construction cost, while it is covered by the general budget of MWRI in the operation stage. Any statements of dissatisfaction or complaints from the neighbor villagers are to be received by MWRI official personnel at the site. The documented reports related to the issues should be submitted RGBS in Cairo to be reviewed. Following table shows the recommended monitoring plan.

Table 3-2.4 Monitoring Plan (pre-construction stage)

Item	Parameter	Measurement Point	Done by	Responsible organization
1. Air emission	SO_2, NO_2, CO, SPM, CO_2	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1（Port Side Street） 4) In front of the Dirout Water Distribution office	S/V Consultant	MWRI
2. Surface water quality	One set*	1) Upstream of current regulators (just upstream of Abo Gabal Canal) 2) Just downstream of the new Ibrahimia regulator 3) Just downstream of the new Buhl Yusef Cana	S/V Consultant	MWRI
3. Groundwater quality	One set*1	BH-N7 and BH- N10 (2 points) in Figure 3-2.1 for covering one set of water quality check (EC, pH and DO are to be monitored at all of 13 points.)	S/V Consultant	MWRI
4. Groundwater	Water level	All 13 points in Figure 3-2.1	S/V	MWRI

Item	Parameter	Measurement Point	Done by	Responsible organization
level			Consultant	
5. Noise	Noise	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1（Port Side Street） 4) In front of the Dirout Water Distribution office	S/V Consultant	MWRI
6. Vibration	Vibration	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1（Port Side Street） 4) In front of the Dirout Water Distribution office	S/V Consultant	MWRI
7. Land use and land tenure	Securement of land for the temporary yard (confirmation of agreement with land owner) and confirmation of mosque transfer	―	MWRI*2	MWRI
8. Fishery	Number of fishermen and their legalities	The targets are those who catch fish from 300m upstream of DGRs to 500 m downstream of NDGRs (around 1,000m distance).	S/V Consultant	MWRI

*1: Water quality check parameters: pH, TDS, COD, BOD, DO, TSS, Turbidity, EC, CO_3, HCO_3, Total Alkalinity, Ca, Mg, Na, K, Cl. NO_3, NO_2, PO_4, S, SO_4 Temperature, Cr, Fe, Cu, Mn, Ni, Pb, Zn

*2: It is tentatively set as MWRI, however, it is to be discussed at the biding.

Table 3-2.5 Monitoring Plan (construction stage)

Item	Parameter	Measurement Point	Frequency	Done by	Responsible organization
1. Air emission	SO_2, NO_2, CO, SPM, CO_2	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1（Port Side Street） 4) In front of the Dirout Water Distribution office	Monthly	Contractor	MWRI
2. Surface water quality	One set*1	1) Upstream of current regulators (just upstream of Abo Gabal Canal) 2) Just downstream of the new Ibrahimia regulator 3) Just downstream of the new Buhl Yusef Cana	Once per 2 months	Contractor	MWRI
3. Groundwater quality	One set*1	BH-N7 and BH- N10（2 points）in Figure 3-2.1 for covering one set of water quality check (EC, pH and DO are to be monitored at all of 13 points.)	Once per 2 months	Contractor	MWRI
4. Groundwater level	Water level	All 13 points illustrated in Figure 3-2.1	Monthly	Contractor	MWRI

Item	Parameter	Measurement Point	Frequency	Done by	Responsible organization
5. Noise	Noise	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1 （Port Side Street） 4) In front of the Dirout Water Distribution office	Monthly	Contractor	MWRI
6. Vibration	Vibration	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1 （Port Side Street） 4) In front of the Dirout Water Distribution office	Monthly	Contractor	MWRI
7. Land use and land tenure		Confirmation of payment to the landowners	-	MWRI*2	MWRI
8. Water flow and river morphology	Water discharge	Regular water level measurement point of Ibrahimia Canal and Bahr Yusef Canal beside Dirout Office of Water Distribution Section	Every day	MWRI	MWRI
9. Fishery	Complaints from the fishermen	-	-	MWRI	MWRI
10. Access to the Project Site	Check of car arrangement schedule	-	Every day	Contractor	MWRI
11. Health and safety	- Health check - Assignment of traffic control - Proper car arrangement	-	Monthly Every day Every day	Contractor	MWRI
12. Waste	Frequency of waste management	Around the construction site	Weekly	Contractor	MWRI
13. Complaint	Frequency of complaint from the people	-	-	MWRI	MWRI

*1: Water quality check parameters: pH, TDS, COD, BOD, DO, TSS, Turbidity, EC, CO_3, HCO_3, Total Alkalinity, Ca, Mg, Na, K, Cl. NO_3, NO_2, PO_4, S, SO_4 Temperature, Cr, Fe, Cu, Mn, Ni, Pb, Zn

*2: It is tentatively set as MWRI, however, it is to be discussed at the biding.

Table 3-2.6 Monitoring Plan (operation stage)

Item	Parameter	Measurement Point	Frequency	Done by	Responsible organization
1. Groundwater level	Water level	All 13 points illustrated in Figure 3-2.1	Twice per year	MWRI	MWRI
2. Surface water quality	One set*	1) Upstream of current regulators (just upstream of Abo Gabal Canal)	Twice per year	MWRI	MWRI

Item	Parameter	Measurement Point	Frequency	Done by	Responsible organization
		2) Just downstream of the new Ibrahimia regulator Just downstream of the new Buhl Yusef Canal			
3. Groundwater quality	One set*	BH-N7 and BH- N10（2 points）in Figure 3-2.1 for covering one set of water quality check (EC, pH and DO are to be monitored at all of 13 points.)	Twice per year	MWRI	MWRI
4. Noise	Noise	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1（Port Side Street） 4) In front of the Dirout Water Distribution office	Twice per year	MWRI	MWRI
5. Vibration	Vibration	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1（Port Side Street） 4) In front of the Dirout Water Distribution office	Twice per year	MWRI	MWRI
6. Water flow and river morphology	Water discharge	Regular water level measurement point of Ibrahimia Canal and Bahr Yusef Canal beside Dirout Water Distribution Office	Twice per year	MWRI	MWRI
7. Complaint	Frequency of complaint from the people	-	-	MWRI	MWRI

Based on the M/D on 21st May 2014, the monitoring period is set at one year since the operation is started.

* One set of water quality check parameter: pH, TDS, COD, BOD, DO, TSS, Turbidity, EC, CO_3, HCO_3, Total Alkalinity, Ca, Mg, Na, K, Cl. NO_3, NO2, PO_4, S, SO_4 Temperature, Cr, Fe, Cu, Mn, Ni, Pb, Zn

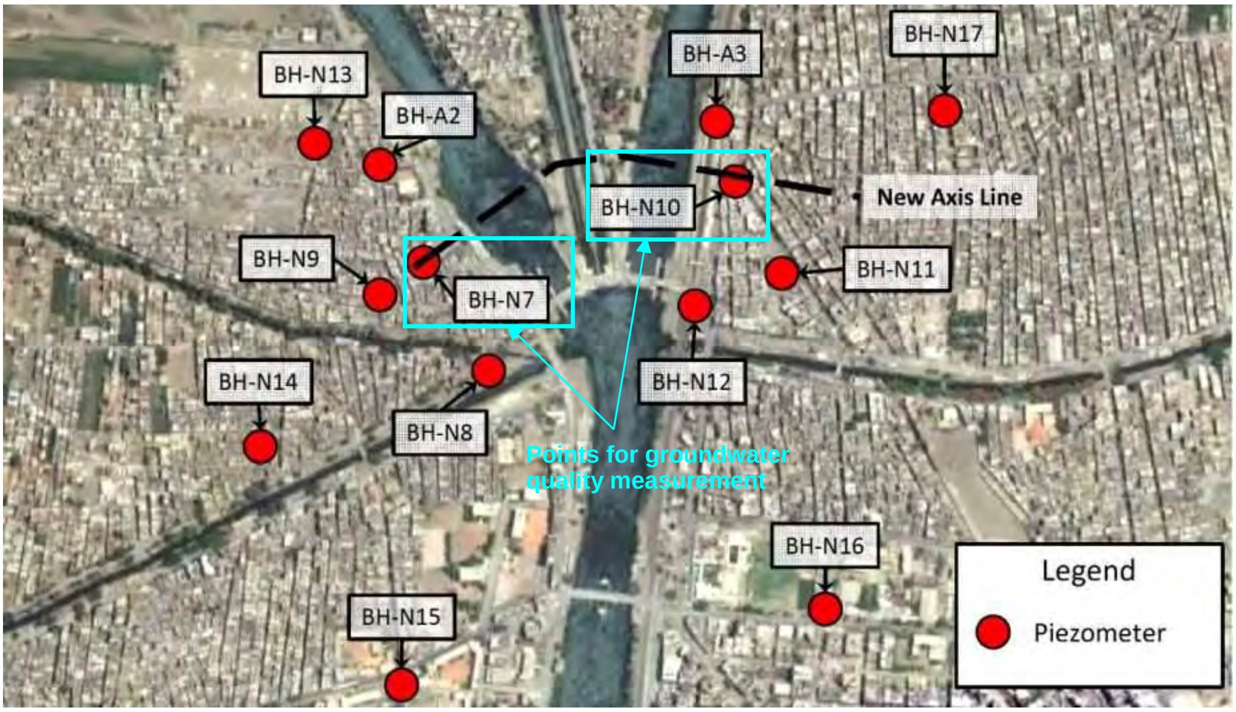


Figure 3-2.1 Location of the 13 piezometers for groundwater

Based on the monitoring plan mentioned above, actual monitoring is to be done. It is recommended to use the monitoring form as shown below:

(1) Pre-construction stage

1) Response and actions by the government

Monitoring Item	Monitoring Results in Report Period
Number and contents of responses from the people Actions taken by the government based on the complaints from the people	

2) Pollution

- Air Pollution

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred International Finance Cooperation (IFC) Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
SO_2	[μg/m^3] hr 24 hr			<350μg/m^3 <150μg/m^3	- <20μg/m^3	Once per month
NO_2	[μg/m^3] 1 hour 24 hours			<400μg/m^3 <150μg/m^3	<200μg/m^3 -	Once per month
CO	[mg/m^3] 1 hour 8 hours			<30mg/m^3 <10mg/m^3	20ppm/hr (Japanese standard) -	Once per month
SPM	[μg/m^3] 24hr			<150μg/m^3	<0.1mg/m^3(Japanese standard)	Once per month

- Noise / Vibration

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred IFC Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
Noise/ Vibration	dB			<65 (downtown in daytime) <55 (downtown in night)	<55 (daytime) <45 (night)	Once per month

*It is needed to pay consideration to minimize noise for the illegal café.

- Water pollution (surface water and groundwater)

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred IFC Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
One set of water quality parameters*						Once per 2 months

*Parameters of water quality check: pH, TDS, COD, BOD, DO, TSS, Turbidity, EC, CO_3, HCO_3, Total Alkalinity, Ca, Mg, Na, K, Cl. NO_3, NO_2, PO_4, S, SO_4 Temperature, Cr, Fe, Cu, Mn, Ni, Pb, Zn
Table 1-3.3 and Table 1.3.4 are to be referred as the standards for those water quality parameters.

3) Natural environment

Environmental parameter	Monitoring results	Measures taken	Monitoring date
Groundwater level	- Depth of groundwater level		

4) Social environment

Environmental parameter	Monitoring results	Measures taken
Number of complaint about land lease/completion of land lease contract and payment		

Environmental parameter	Monitoring results	Measures taken
Relocation of the mosques Number of fishermen and their legalities		

(2) Construction stage

1) Response and actions by the government

Monitoring Item	Monitoring Results in Report Period
Number and contents of responses from the people Actions taken by the government based on the complaints from the people	

2) Pollution

- Air Pollution

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred International Finance Cooperation (IFC) Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
SO_2	[μg/m^3] hr 24 hr			<350μg/m^3 <150μg/m^3	- <20μg/m^3	Once per month
NO_2	[μg/m^3] 1 hour 24 hours			<400μg/m^3 <150μg/m^3	<200μg/m^3 -	Once per month
CO	[mg/m^3] 1 hour 8 hours			<30mg/m^3 <10mg/m^3	20ppm/hr (Japanese standard) -	Once per month
SPM	[μg/m^3] 24hr			<150μg/m^3	<0.1mg/m^3(Japanese standard)	Once per month

- Noise / Vibration

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred IFC Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
Noise/ Vibration	dB			<65 (downtown in daytime) <55 (downtown in night)	<55 (daytime) <45 (night)	Once per month

*It is needed to pay consideration to minimize noise for the illegal café.

- Water pollution (surface water and groundwater)

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred IFC Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
One set of water quality parameters*						Once per 2 months

*Parameters of water quality check: pH, TDS, COD, BOD, DO, TSS, Turbidity, EC, CO_3, HCO_3, Total Alkalinity, Ca, Mg, Na, K, Cl. NO_3, NO_2, PO_4, S, SO_4 Temperature, Cr, Fe, Cu, Mn, Ni, Pb, Zn
Table 1-3.3 and Table 1.3.4 are to be referred as the standards for those water quality parameters.

3) Natural environment

Environmental parameter	Monitoring results	Measures taken	Monitoring date
Groundwater level Solid wastes Water flow and morphology Odor* Impact on ecosystem, if any	- Depth of groundwater level - Removal and disposal of waste - Measurement of water level of the canals and estimation of discharge - Confirmation of frequency of dredging by MWRI - Complaints about damage to ecosystem in the construction site		

*Based on the M/D in 2014, odor can be checked by means of confirmation of implementation of dredging.

4) Social environment

Environmental parameter	Monitoring results	Measures taken
Number of complaint about land lease and payment		
Number of complaint about traffic jam		
Number of complaint about noise/vibration		
Number of complaint about impact on fishery		

5) Working environment (Include working safety)/ Accident

Environmental parameter	Monitoring results	Measures taken	Monitoring date
Safety check for carrying the heavy machineries into the work area.			First time of the construction work
Safety check for refueling car accessing the work sites.			Everyday
Safety check for carrying-out of the heavy machineries from the work sites.			Last time of the construction work.
Assignment of traffic control staff			Everyday
Checking of the heavy machineries if keeping correct routes and speed.			Everyday
Installation of project sign board around the field.			First time of the construction work

6) Hazards (Risk) of Infectious diseases such as HIV/AIDS

Environmental parameter	Monitoring results	Measures taken	Monitoring date
Pay attention to the workers' health condition.			Every day
Arrange with the Local Unit office /Ministry of Health to carry out awareness creation on HIV/AIDS among the workers.			Once half a year

(3) Operation stage

1) Response and actions by the government

Monitoring Item	Monitoring Results in Report Period
Number and contents of responses from the people (including impacts on fishery) Actions taken by the government based on the complaints from the people	

2) Pollution

- Noise / Vibration

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred IFC Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
Noise/ Vibration	dB			<65 (downtown in daytime) <55 (downtown in night)	<55 (daytime) <45 (night)	Twice per year

*It is needed to pay consideration to minimize noise for the illegal café.

- Water pollution (surface water and groundwater)

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred IFC Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
One set of water quality parameters*						Twice per year

*Parameters of water quality check: pH, TDS, COD, BOD, DO, TSS, Turbidity, EC, CO_3, HCO_3, Total Alkalinity, Ca, Mg, Na, K, Cl. NO_3, NO_2, PO_4, S, SO_4 Temperature, Cr, Fe, Cu, Mn, Ni, Pb, Zn
Table 1-3.3 and Table 1.3.4 are to be referred as the standards for those water quality parameters.

3) Natural environment

Environmental parameter	Monitoring Item	Monitoring Results and Dates
Groundwater level	- Depth of groundwater level	
Water flow and morphology	- Measurement of water level of the canals and estimation of discharge	
Odor and Waste*1	- Confirmation of frequency of dredging by MWRI	
Impact on ecosystem, if any*2	- Complaints about damage to ecosystem in the construction site	

*1: Based on the M/D in 2014, odor and waste can be monitored through confirmation of implementation of dredging.

*2: Particular ecosystem in the construction site is not identified, therefore, just in case of any complaints from the residents.

3-3 Establishment of Security Management Committee (SMC)

For the duration of the Project, it is proposed to establish the Security Management Committee, which coordinates, assesses, approves various issues to maintain security of the project. The Committee meeting will be held monthly to share the monitoring results, and if some problems such as violation of the Egyptian environmental standard are identified, measures to be taken should be discussed at the meeting. Furthermore, the ad hoc SMC meetings will be organized according to necessity. Moreover, the committee will handle any complaints of the people during the Project period. Proposed constitute and roles of the committee are as follows:

1 Committee consists of RGBS staff of Dirout and Cairo, S/V consultant and Contractor.

2 Roles of the committee are as shown below:

(1) Supervision of monitoring and examination of monitoring result,

(2) Taking measures if some problems are identified during the monitoring activities, for instance, a result varies from the standard

(3) Handling of complaints from the people

(4) Identification and counting of those who catch fish around the DGRs regardless of with or without of license, and taking measurement as required

(5) Reporting, recording and information sharing, especially, any issues identified and measured taken

Volume VI MATHEMATICAL MODEL ANALYSIS

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Volume VI - MATHEMATICAL MODEL ANALYSIS

1. Water Surface Profile Analysis on NDGRs

1-1 Objective and method of analysis

(1) Analysis objective

The objective of the water surface profile analysis of the new regulator is to calculate the water surface profile impacted by the NDGRs associated with the inflow from the Assiut regulator intake. The analysis is conducted by one-dimensional unsteady flow analysis using the Ibrahimia canal cross-section, roughness coefficient, and boundary conditions given in measurement results, to identify whether or not there are locations at risk of overtopping the existing bank.

Two water surface profile analyses were carried out: (1) non-uniform flow analysis to determine the range of impact during the maximum design discharge, (2) unsteady flow analysis to determine the extent and range of impact of the water surface profile over time when a gate is closed under the maximum design discharge.

(2) Target of the analysis

The analysis targets is the 60km section of the Ibrahimia canal that stretches from the Assiut regulator intake to the NDGRs. The slope of the riverbed of the canal in this section is slight, about 1/25,000, the river width is about 60m, the water depth is about 6m, and the planned flow capacity of the canal at maximum discharge is 474m^3/s.

The upstream control water level of the existing DGRs will increase from the current maximum WL 46.1m to WL 46.3m with the construction of the new regulator. Therefore, the DGRs was taken as a starting point for the water surface profile analysis to check whether or not there was an effect on the water surface profile at the planned maximum discharge of 474m^3/s.

Unsteady flow analysis was also carried out under the planned design discharge of 474m^3/s after the construction of the new regulator, to determine the effect on the water surface profile when one gate is suddenly closed for any reason.

(3) Analysis method

a) Non-uniform flow analysis

1) Basic equations of non-uniform flow analysis

i) Basic equations

In open channel flow, flow varies depending on location; In non-uniform flow, the flow depth and flow velocity vary with time. Water surface in non-uniform flow is tracked using two basic equations of non-uniform flow: (1) stepwise calculations, or (2) the graphical method.

In both cases, calculations are carried out from a known starting point; towards the upstream side in the case of steady flow, and towards the downstream side in the case of rapid flow.

With the stepwise calculations, the water depths at successive points are deduced from a known point, and the calculations proceed verifying the energy by applying Bernoulli's theory. This method has many merits, (1) calculations can be carried out at any cross-section regardless of steadiness or rapidity of flow, (2) losses apart from those caused by friction can be calculated. By dividing the water channel into ideal calculation sections and applying boundary conditions at the nodes, the calculation gives the successive shapes of the water surface so that Bernoulli's equation is satisfied in each section. Applying Bernoulli's equation to cross-sections I and II in Figure 1-1.1 yields the following equations.

$$h_1 + \frac{\alpha \cdot Q^2}{2g \cdot {A_1}^2} + z_1 + h_f + \Delta h_p = h_2 + \frac{\alpha \cdot Q^2}{2g \cdot {A_2}^2} + z_2$$

$$h_f = \frac{Q^2 \cdot l}{2}\left(\frac{{n_1}^2}{R_1^{\frac{4}{3}}{A_1}^2} + \frac{{n_2}^2}{R_2^{\frac{4}{3}}{A_2}^2}\right)$$

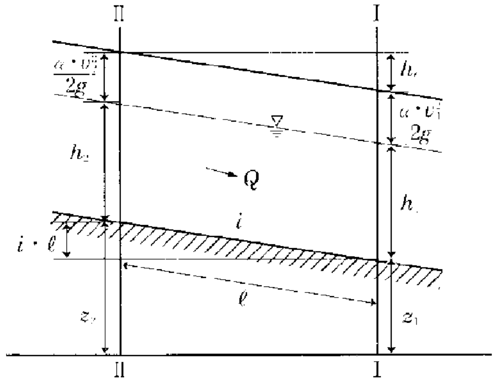

Figure 1-1.1 Explanation of non-uniform flow calculation

Source: "Canal Works." Land Improvement Project Program Design Standard. Agricultural Structure Improvement Bureau, Ministry of Agriculture, Forestry and Fisheries (2008).

Where,

z: Height from bedrock to bottom of water channel (m)

h : Water depth (m)

Q : Discharge (m^3/s)

v : Flow velocity (Q/A) (m/s)

i : Slope of the water channel bottom

h_f : Water head loss produced at cross-sections I, II (m)

Δh_p: Amount of change in water level due to bridge piers (m)

ℓ : Slope length between cross-sections I to II (m)

R : Hydraulic radius (m)

A : Area of cross-section of water (m^2)

n : Roughness coefficient

g: Gravitational acceleration 9.8 (m/s^2)

α : Energy correction function

Subscripts 1, 2: Indicate values at cross-sections 1 and 2 respectively.

When the energy at cross-section I is given, the water depth is calculated at cross-section II so that adding the hydraulic head loss between cross-sections I and II to the height of this energy line gives the height at cross-section II.

The following shows an example of non-uniform flow calculation arrived at by stepwise calculation.

Table 1-1.1 Example of water surface tracing calculation in case of non-uniform flow in water channel

Section name	Section XX	Starting point water depth	1.50m	Bottom width of trapezoidal cross-section water channel	2.0m
Detailed position	No. 18 to No. 20	Flow rate	6.00m³/s	Side slope	1-1
Starting point	(No. 20) bottom elevation 47.500m	n	0.013		

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12) Head loss			(13)	(14)	(15)	(16)
Measurement point	Section length (m)	Water depth h (m)	Water cross-sectional area A (m^2)	Flow velocity V (m/s)	Velocity head $V^{2\text{-}2}g$ (m)	Wetted perimeter P (m)	Hydraulic radius R (m)	$R^{4/3}$	Friction slope S_f	Friction slope S_f	Friction head loss (m)	Other head losses	Total (m)	Bottom elevation (m)	Height of total energy line (m)	Height of total energy line (m)	Error
No.20		1.500	5.250	1-143	0.067	6.242	0.841	0.794	0.00028					47.500	49.067		
										0.00032							
No.19	50.000	1.400	4.760	1.261	0.081	5.959	0.799	0.741	0.00036		0.016	0	0.016	47.550	49.031	49.083	- 0.052
										0.00029							
		1.490	5.200	1-154	0.068	61-14	0.837	0.789	0.00029		0.015	0	0.015	47.550	49.108	49.082	0.026
										0.00029							
		1.465	5.076	1-182	0.071	6.143	0.826	0.775	0.00030		0.015	0	0.015	47.550	49.086	49.082	0.004 ok
										0.00032							
No.18	50.000	1.440	4.954	1.211	0.075	6.072	0.816	0.763	0.00033		0.016	0	0.016	47.600	491-15	49.102	0.013
										0.00032							
		1.420	4.856	1.236	0.078	6.016	0.807	0.751	0.00034		0.016	0	0.016	47.600	49.098	49.102	- 0.004 ok

Notes) 1st line (1) to (9), (13): Enter the quantities for the given conditions at the starting point (10): Friction slope: $S_f = Q^2 \cdot n^2/A^2 \cdot R^{4/3} = (V^{2\text{-}2}g) \times 2gn^2/R^{4/3}$. When n is determined, (6) may be multiplied by the constant $2gn^2$ and divided by (9).
(14): (3) + (6) + (13)

2nd line (3): Enter assumed water depth. (4) to (10), (13), (14): Enter the various quantities for (3), (11): Average value of (10) on the 1st line and (10) on the 2nd line, (12): (11) × (2), (15): (14) on the 1st line + (12) on the 2nd line,
(16): Difference of (15) and (14) on each line, revise the assumed water depth until the error is within the allowable range (±0.01 or less), and repeat the calculation.

Source: "Canal Works." Land Improvement Project Program Design Standard. Agricultural Structure Improvement Bureau, Ministry of Agriculture, Forestry and Fisheries (2008).

ii) Friction loss

Manning's equation is used to calculate hydraulic head loss due to friction. Friction head loss in a section of length ℓ is obtained using the following equation.

$$h_f = \frac{Q^2 \cdot \ell}{2} \left(\frac{n_1{}^2}{R_1{}^{4/3} \cdot A_1{}^2} + \frac{n_2{}^2}{R_2{}^{4/3} \cdot A_2{}^2} \right) = \frac{1}{2} \left(\frac{n_1{}^2 \cdot V_1{}^2}{R_1{}^{4/3}} + \frac{n_2{}^2 \cdot V_2{}^2}{R_2{}^{4/3}} \right) \cdot \ell$$

Where,

Q : Discharge (m^3/s)

A : Water cross-sectional area (m^2)

h_f : Friction head loss (m)

ℓ : Distance between the sections (m)

R : Hydraulic radius (m)

n : Roughness coefficient

V : Average flow velocity (m/s)

(Subscripts indicate the starting point and the finishing point of the relevant section)

iii) Amount of change in water level at bridge

The amount of change in the water level due to bridge piers is obtained from the D'Aubuisson equation as follows.

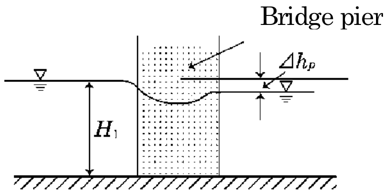

Figure 1-1.2 Amount of drawdown in water level due to bridge piers

$$\Delta h_p = \frac{Q^2}{2g}\left(\frac{1}{C^2 \cdot b_2^{\,2} \cdot (H_1 - \Delta h_p)^2} - \frac{1}{b_1^{\,2} \cdot H_1^{\,2}}\right)$$

Where,

Δh_p : Amount of change in water level due to bridge piers (m)

Q : Discharge (m^3/s)

C : Coefficient depending on the plane shape of the bridge pier (Figure 1-1.3)

b_1 : Water channel width immediately in front of the bridge pier (m)

b_2 : Net width after deducting the total width of the bridge piers from the water channel width

$(b_2 = b_1 - \sum t)$ (m)

t: Width of one bridge pier (m)

H_1 : Water depth on upstream side of bridge pier (m)

g : Gravitational acceleration 9.8 (m/s^2)

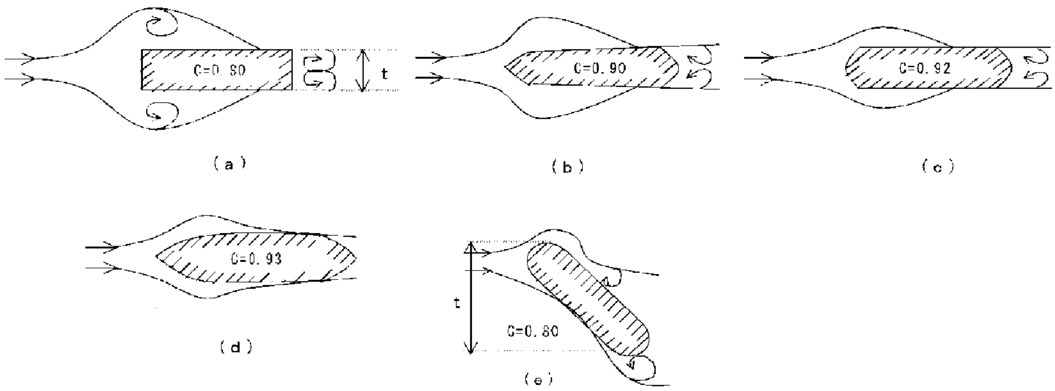

Figure 1-1.3 Coefficient for each shape of bridge pier

In the calculation, an approximate value $\Delta h_p'$ of Δh_p is obtained from the following equation, and based on the approximate value $\Delta h_p'$, a trial calculation is repeatedly carried out until the left side Δh_p of the above equation is equal to the right side Δh_p.

$$\Delta h_p' = \frac{Q^2}{2g \cdot b_1^2 \cdot H_1^2}\left[\frac{1}{C^2}\left(\frac{b_1}{b_2}\right)^2 - 1\right]$$

2) Analysis conditions

i) Water channel cross-section

The water channel cross-sections used in the water surface profile analysis were those obtained from the results of a separate survey carried out at a 50m pitch in the section 1,500m upstream of the existing DGRs, and at a 500m pitch from the 1,500m point upstream of the Ibrahimia Head regulator.

There are 168 sections including bridges, and the calculation section was about 60km in length. Figure 1-1.4 shows a longitudinal section of the water channel showing the elevation of the deepest riverbed.

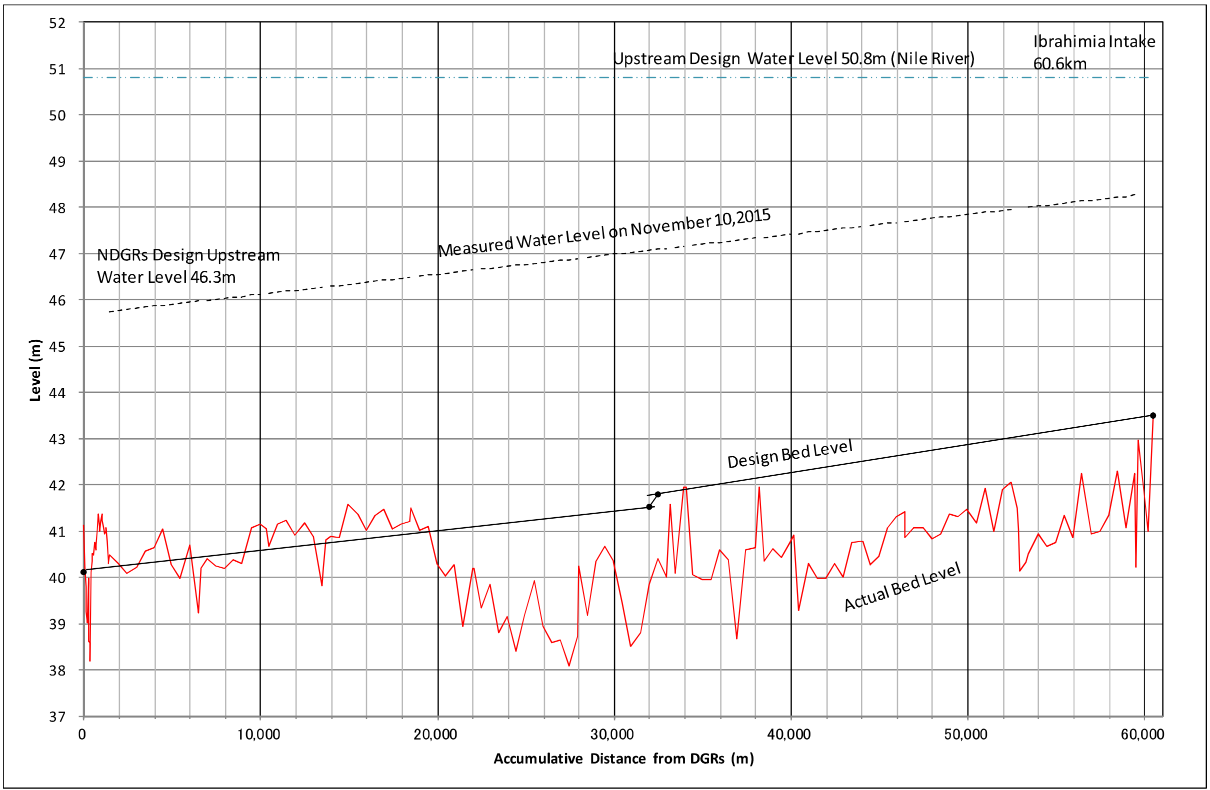

Figure 1-1.4 Longitudinal section of the Ibrahimia canal

In the section up to 20km upstream of the DGRs, the riverbed tends to be higher than the design bed level, but in the section from 20-60km upstream, the riverbed tends to be lower than the design bed level.

Because sedimentation moves 20km downstream this way, it is assumed that the canal loss of this section becomes quite big. Design canal bed level is shown in Figure 1-1.5.

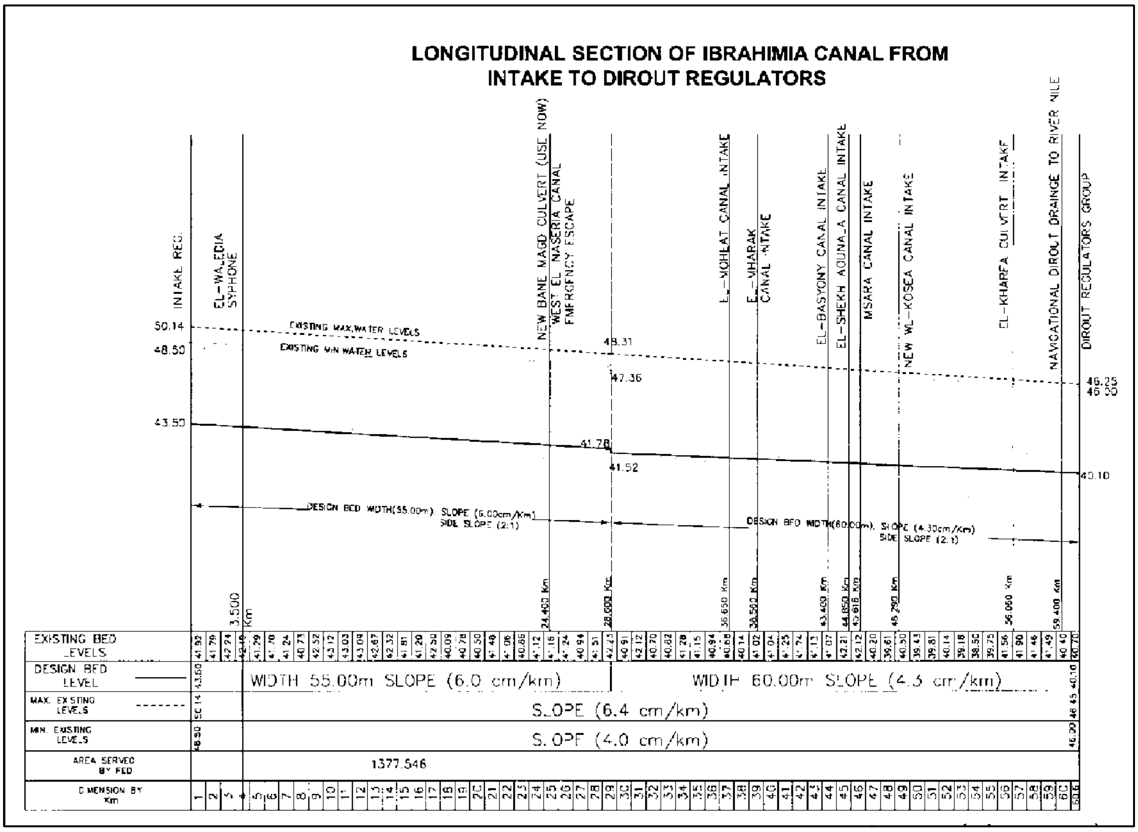

Figure 1-1.5 Longitudinal profile of the Ibrahimia canal (design bed level)

ii) Bridges

There are bridges at 21 locations along the calculation section. The measurement results for the shapes, widths, number of bridge piers, and water channel cross-sections were used.

The main parameters are as shown in the following table.

Table 1-1.2 Existing bridge parameters

No	Type	Pier		Coordinates at center of bridg		Distance from Ibrahimia Head Regulator (m)
		Number	Width (m)	E (m)	N (m)	
B1	R.C.	12	0.70	319884	3009297	348
B2	Steel	2	7.23	319328	3009142	884
B3	R.C.	3	1.40	319251	3009130	1,057
B4	Steel	2 [*1]	3.59	313431	3009132	7,264
		6	0.40			
B5	R.C. [*2]	18	0.40	313069	3009372	7,684
B6	R.C.	15	0.40	313038	3009397	7,729
B7	R.C. + Steel	14	0.40	308007	3013305	14,114
B8	R.C.	15	0.40	306267	3014926	16,500
B9	R.C. + Steel	14	0.35	303382	3017616	20,423
B10	R.C.	6 [*1]	3.30	301997	3018920	22,330
		18	0.40			
B11	R.C. + Steel	16	0.35	298954	3021751	26,500
B12	R.C.	6 [*1]	2.90	298287	3022385	27,409
		18	0.40			
B13	R.C.	14	0.70	295158	3026441	32,545
B14	R.C. + Steel	16	0.40	291529	3031177	38,500
B15	R.C.	14	0.60	289015	3033669	42,068
B16	Wood	10	0.15	285442	3036942	46,906
B17	R.C. + Steel	8 [*1]	2.05	285383	3037054	47,030
		16	0.40			
B18	R.C.	7 [*1]	3.03	284651	3040149	50,220
		21	0.40			
B19	R.C. + Steel	15	0.40	283712	3043769	53,945
B20	R.C.	15	0.70	283789	3048980	59,500
B21	R.C. + Steel	18	0.35	283904	3049825	60,322

Notes: 1) Upper section value of Pia colum is used when disherge volume is high.
2) R.C. : Reinforced Concrete

Figure 1-1.6 Upstream view of the existing bridge (No.B18)

iii) Water intake facilities

The positions and shapes of intake facilities along the calculation section were determined from the measurement results of the same survey. The planned maximum water intake amount was $19m^3/s$ for the total number of intake facilities in the section. This was determined by factors such as the scale of the intake facilities, and the area benefitting from each intake facility as provided by the Water Distribution Sector. The results are shown in the following table.

Table 1-1.3 Parameters of the water intake facilities

ID	Intake				Name of Canal	Distance from B.P (m)
	Width (m)	Depth (m)	Area (m^2)	Demand (m^3/s)		
L0	2.0	0.99	1.98	0.6		24094
L1	4.0	1.54	6.16	1.3	EL-Moheat	36547
L1-P1	D 0.9	0.90	0.64	0.2		36858
L2	5.0	1.93	9.65	2.7	EL-Maharak	38468
L2-P1	D 0.55	0.55	0.24	0.1		42116
L3	4.0	1.40	5.60	1.4	EL-Basuoni	42459
L4	D 3.0*2	1.40	6.79	1.5	EL-Shaekh Awnalla	44785
L4-1	D 0.75	0.75	0.44	0.1	Ganibia El sheakh Awmalla	44914
R1	5.0	1.32	6.60	2-2	Masara	45634
L5	6.0	2-23	13.38	5.9	EL-Kosia	48086
L7	D 1.0	1.00	0.79	0.1	Ganibia Morad	50533
L8	D 1.05	1.05	0.87	0.1	El Daer	52328
L9	2-8	1.77	4.43	0.4	Sanabo & Nazlet Zaher	53257
R3	1-1	0.63	1.32	0.4	EL-Kharfa	55956
L10	D 1.05	1.05	0.87	0.2		56970
L11	2.0	1.00	2.00	0.6		57851
L12	2.0	1.85	3.70	1.2	Ganibia Karsh & Banob	59778
Total			65.44	19.0		

Note: 'D' means diameter of pipe canal. Date of observation is 10 Nov. 2015.

Figure 1-1.7 Photograph of water intake facility

iv) Flow rates

At the upstream of the Ibrahimia canal, the water levels and intake amounts were measured every day at a point upstream of the Ibrahimia Head regulator (Ibrahimia inflow, Nile River water level), and downstream of the regulator. At the downstream DGRs, the upstream and downstream water levels were measured daily, as was the discharge from the downstream of the Bahr Yusef regulator, and the downstream of the Ibrahimia regulator.

The design maximum intake amount was determined as follows.

Table 1-1.4 Design discharge at each regulator

Regulator		Design Discharge: Discharge (m3/s)	Design Discharge: ratio (%)	Remark	
DGRs	Ibrahimia	186	39	455	96
	Bahr-Yusef	227	48		
	Sahelyia	5	1		
	Diroutiah	12	3		
	Badraman	9	2		
	Abo Gabal	7	1		
	Irad Delgaw	9	2		
Direct Intake		19	4	19	4
Total		474	100	474	100

v) Roughness coefficient

The roughness coefficient of the Ibrahimia Canal used in the water surface profile analysis was estimated from the results of flow rate measurements carried out at 12 cross-sections. It was also estimated by carrying out water surface profile analyses using verified values of actual measured water levels. The roughness coefficient used in this analysis was estimated by these two methods.

v-1) Estimation from measured flow velocity

The roughness coefficient of the Ibrahimia Canal was estimated using the two point method; by measuring the flow velocity at two cross-sections at the two ends of a 500m straight section on a 10km section with no water intake facilities and no obstructions. This was done within the 60km water channel section used as part of the Ibrahimia canal survey.

The measured flow velocities, flow rates, and estimated roughness coefficients are shown in Table 1-1.5.

Table 1-1.5 Results of estimated roughness coefficients from measured flow velocity

Section No.	Discharge Q (m^3/s)	$Q_{average}$ (m^3/s)	Cross section area A (m^2)	Velocity V(m/s)	P (m)	Hydraulic radius R (m)	Hydraulic gradient I (cm/km)	$I_{average}$ (cm/km)	$R^{2/3}$	$I^{1/2}$	Roughness coefficient n
Vel 1-1	296.5	295.7	389.1	0.760	77.17	5.04	6.93	5.07	2.940	0.0083	0.0322
Vel 1-2	295.0		414.8	0.713	75.90	5.47			3.103	0.0083	0.0362
Vel 2-1	293.1	291.1	422.8	0.689	84.39	5.01	5.14		2.928	0.0072	0.0305
Vel 2-2	289.1		435.8	0.668	84.00	5.19			2.997	0.0072	0.0322
Vel 3-1	290.2	289.5	376.7	0.769	72.41	5.20	6.32		3.003	0.0079	0.0310
Vel 3-2	288.8		386.8	0.749	74.22	5.21			3.006	0.0079	0.0319
Vel 4-1	284.5	285.7	443.8	0.644	83.28	5.33	3.21		3.051	0.0057	0.0269
Vel 4-2	286.9		408.1	0.700	78.62	5.19			2.998	0.0057	0.0243
Vel 5-1	287.6	287.3	390.1	0.737	93.32	4.18	4.68		2.595	0.0068	0.0241
Vel 5-2	287.0		424.8	0.676	103.94	4.09			2.556	0.0068	0.0259
Vel 6-1	278.9	278.1	408.2	0.681	97.06	4.21	4.12		2.606	0.0064	0.0245
Vel 6-2	277.3		422.3	0.658	100.55	4.20			2.603	0.0064	0.0254
										Average	0.0288

Roughness coefficient is calculated by the Manning formula as follows.

$V = (1/n)R^{2/3}I^{1/2}$ --> $n=(1/V) R^{2/3}I^{1/2}$

Where,

V: Velocity (m/s)

I: Canal bed gradient

R: Hydraulic mean depth (m) (=Hydraulic radius)

n: Roughness coefficient

Flow velocity produced a roughness coefficient 0.0288.

v-2) Estimates from actual measured water levels and discharges

Water surface profile analysis was carried out using previous Ibrahimia canal intake water levels and discharges, as well as the DGRs upstream water levels and discharges. To estimate the roughness coefficient, upstream and downstream water levels and discharge values under steady conditions (without fluctuation over two days) were used.

For the discharge scale, three discharges close to the design maximum intake were extracted, 400m^3/s, 300m^3/s, and 200m^3/s. These are shown in Table 1-1.6.

Total quantity of intake of the canal branch was calculated based on the distribution ratio of the design discharge calculated in Table 1-1.4.

The results of the intake distributions are shown in Tables 1-1.7 and 1-1.8.

Table 1-1.6 Selected results for observed discharge

Selected discharge (m^3/s)	Selected Date	Ibrahimia Head Regulator		DGRs			
		Observed discharge (m^3/s)	Observed DS WL (m)	Observed US WL (m)	Bahr-Yusef Discharge (m^3/s)	Ibrahimia Discharge (m^3/s)	Total Discharge (m^3/s)
400	2014/May/11	422.5	49.57	45.89	196.8	152.2	349.0
300	2014/July/18	300.9	48.52	45.62	156.3	130.2	286.5
200	2012/Dec/21	190.4	47.56	45.50	97.2	83.3	180.5

Table 1-1.7 Allocation of measured discharges based on the design allocation

Regulator		Design Discharge		Observed Dischage					
		Discharge (m3/s)	ratio (%)	400m3/s (2014/5/11)		300m3/s (2014/8/18)		200m3/s (2012/12/21)	
DGRs	Ibrahimia	186	39	405.6	96%	288.9	96%	182.8	96%
	Bahr-Yusef	227	48						
	Sahelyia	5	1						
	Diroutiah	12	3						
	Badraman	9	2						
	Abo Gabal	7	1						
	Irad Delgaw	9	2						
Direct Intake		19	4	16.9	4%	12.0	4%	7.6	4%
Total		474	100	422.5	100%	300.9	100%	190.4	100%

Table 1-1.8 Allocation of intake amounts based on the design allocation

ID	Name of	Demand(m^3/s)			
		Design	400m^3/s	300m^3/s	200m^3/s
L0		0.6	0.5	0.4	0.2
L1	EL-Moheat	1.3	1.1	0.8	0.5
L1-P1		0.2	0.2	0.1	0.1
L2	EL-Maharak	2.7	2.4	1.7	1.1
L2-P1		0.1	0.1	0.1	0.0
L3	EL-Basuoni	1.4	1.2	0.9	0.6
L4	EL-Sheakh Awnalla	1.5	1.3	0.9	0.6
L4-1	Ganibia El sheakh Awmalla	0.1	0.1	0.1	0.0
R1	Masara	2.2	2.0	1.4	0.9
L5	EL-Kosia	5.9	5.2	3.7	2.4
L7	Ganibia Morad	0.1	0.1	0.1	0.0
L8	El Daer	0.1	0.1	0.1	0.0
L9	Sanabo & Nazlet Zaher	0.4	0.4	0.2	0.2
R3	EL-Kharfa	0.4	0.4	0.2	0.2
L10		0.2	0.2	0.1	0.1
L11		0.6	0.5	0.4	0.2
L12	Ganibia Karsh & Banob	1.2	1.1	0.8	0.5
Total		19.0	16.9	12.0	7.6

The following tables calculated roughness coefficient as a parameter so that calculated water levels were consistent with observed water level at the Ibrahimia Head regulator. The calculations used non-uniform flow analysis arrived at by a stepwise calculation method that considered the influence of the bridge and intake.

The non-uniform flow analysis that started from the upstream DGRs set actual survey water levels at the Ibrahimia Head regulator downstream as targeted water levels. The roughness coefficient at the time of calculation assumes this is a temporary set value. As for the calculations, the roughness coefficient is calculated until calculated water levels at the Ibrahimia Head regulator downstream, accord with the targeted water level.

The estimated roughness coefficients are shown in Table 1-1.9.

The result of the water surface profile analysis and the calculated roughness coefficient at every discharge is shown in Figures 1-1.8 to 1-1.10.

Table 1-1.9 Results of roughness coefficient estimation based on measured water levels and discharges

Selected discharge (m^3/s)	Selected Date	DGRs	Ibrahimia Head Regulator		Result of calculation			
		Observed US WL (m)	Observed discharge (m^3/s)	Observed DS WL (m)	Compare	Ibrahimia Head Regulator DS WL (m)	Judge	Result of roughness coefiicient
400	2014/May/11	45.89	422.5	49.57	<	49.63	NG	0.0260
					=	49.57	OK	0.0256
					>	49.49	NG	0.0250
300	2014/July/18	45.62	300.9	48.52	<	48.55	NG	0.0270
					=	48.52	OK	0.0267
					>	48.45	NG	0.0260
200	2012/Dec/21	45.50	190.4	47.56	<	47.60	NG	0.0305
					=	47.56	OK	0.0300
					>	47.52	NG	0.0295

The calculation results reveal the tendency of the roughness coefficient to decrease when water level and discharge increase in the Ibrahimia canal (Ven Te Chow. Open-Channel Hydraulics. NY: McGraw-Hill, 1959).

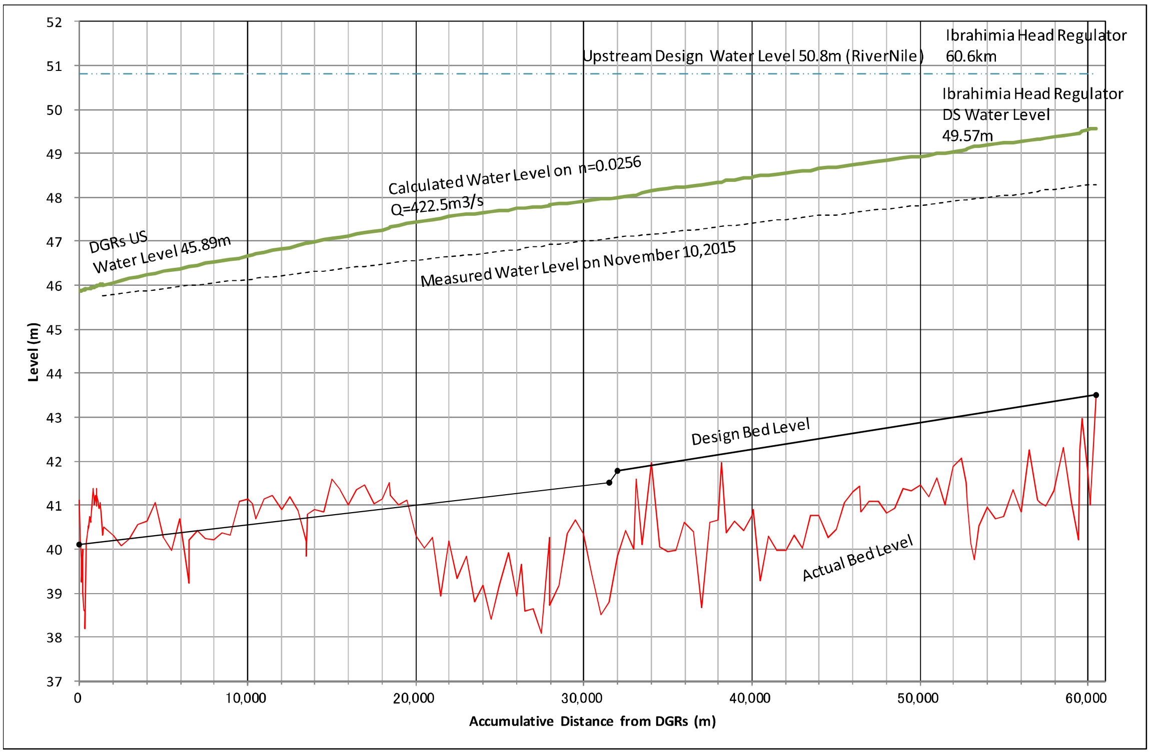

Figure 1-1.8 Result of roughness coefficient estimate from measured water levels and discharges (maximum discharge=422.5m^3/s, n=0.0256)

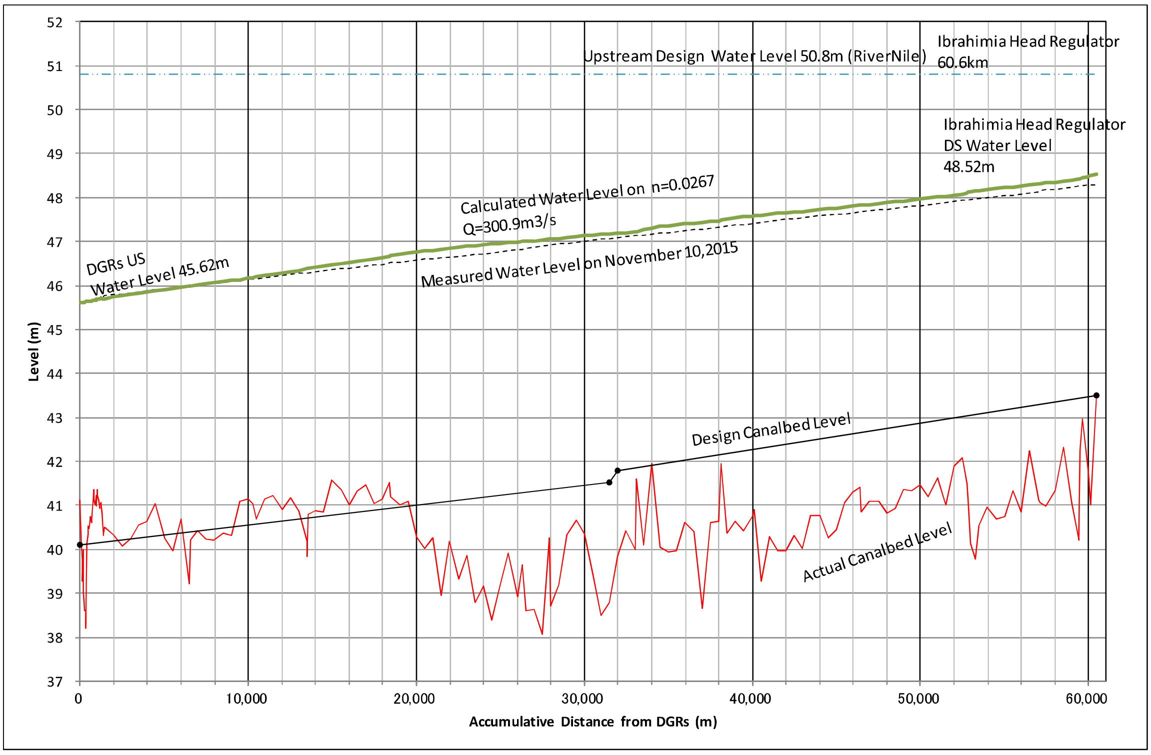

Figure 1-1.9 Result of roughness coefficient estimate from measured water levels and discharges (discharge=300.9m^3/s, n=0.0267)

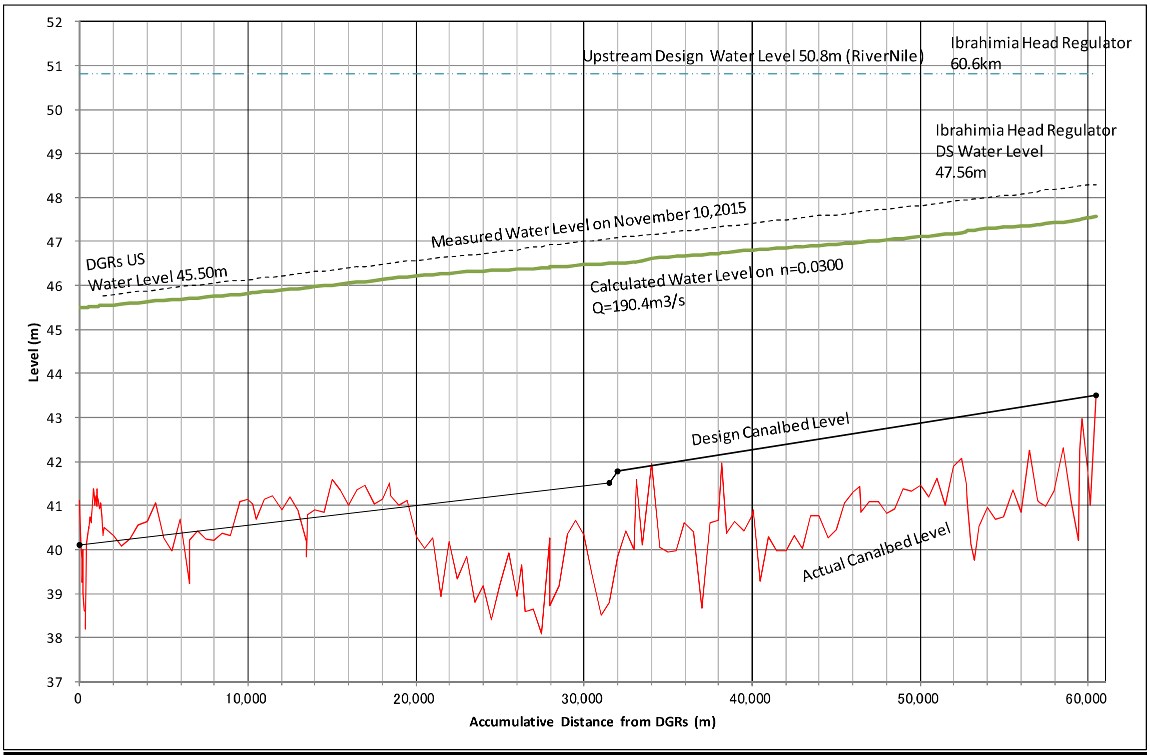

Figure 1-1.10 Result of roughness coefficient estimate from measured water levels and discharges (discharge=190.4m^3/s, n=0.0300)

v-3) Evaluation

According to version 4.0 of the Hydraulic Reference Manual published by the U.S. Army Corps of Engineers Institute for Water Resources Hydrologic Engineering Center, in March 2008, the roughness coefficient of an excavated dredged channel ranges from 0.025 to 0.030.

In addition, according to research conducted by the Water Research Center Egypt, the design roughness coefficient of Ibrahimia canal is 0.025, but the scattered garbage, raises the figure to 0.030 to 0.039.

A roughness coefficient of 0.0288 was provided at discharge of approximately 300m^3/s. This is only slightly greater than the roughness coefficient 0.0267 arrived at by inverse operations.

A roughness coefficient of 0.0256 resulted from calculations near the design discharge of 474m^3/s, and is considered a reasonable value for the analysis and can be applied to the design discharge.

The results of the roughness coefficient are as follows.

Table 1-1.10 Result of the roughness coefficient

Item	Discharge $Q(m^3/s)$	roughness coefficient n	Remarks
1.Measure Velocity	300	0.0288	May 2016
2.Estimation from actual measurement (inverse operation result)	400	0.0256	apply to design discharge
	300	0.0267	
	200	0.0300	
3.Hydraulic Reference Manual	-	0.025 – 0.030	Dredged Channel
4.Research paper by NWRC (Ibrahimia canal in Minya)	-	0.025	Design
	-	0.030 – 0.039	garbage

b) Unsteady flow analysis

1) Basic equations for unsteady flow calculation

Unsteady flow analysis was carried out to determine what would happen to the water surface profile if one gate suddenly closed for any reason, after the construction of the new regulator and under the design discharge $474m^3/s$.

Unsteady flow is mathematically calculated by simultaneously solving the equations of motion and the equations of continuity. The equations of motion and equations of continuity for unidirectional flow such as river flow, etc, are expressed as follows with the downstream end (river mouth) as the origin.

$$\frac{1}{g}\cdot\left(\frac{\partial v}{\partial t}\right)+\frac{1}{g}\cdot\frac{\partial}{\partial x}\left(\frac{v^2}{2}\right)+I+\frac{\partial h}{\partial x}+\frac{n^2|v|v}{R^{\frac{4}{3}}}=0 \quad \text{.......... (1)}$$

$$\frac{\partial A}{\partial t}+\frac{\partial Q}{\partial x}=q_x \quad \text{.......... (2)}$$

Where,

g: gravitational acceleration (m/s^2)

v: average flow velocity at the cross-section (m/s)

I: hydraulic gradient

h: water depth (m)

R: hydraulic radius (m)

n: Manning's roughness coefficient

A: water cross-sectional area (m^2)

Q: discharge (m^3/s)

q_x: lateral inflow rate per unit width per unit time (m^2/s)

x: distance (m)

t: time (s)

The most practical method of solving the partial differential equations described above (equations of motion and equations of continuity) for this type of mathematical calculation (for

the scale and accuracy of the calculation) is the first order central difference method.
In this method of solution, grid points are set with water level points and flow velocity points separated in time by ⊿t/2 and in distance by ⊿x/2 as shown in Figure 1-1.11. Initial values are given as the values at j = 1, 2, and using these values the water level at j = 3 is obtained from the continuity equations, next using the values at j = 2, 3 the flow velocity is obtained at j = 4 from the equations of motion, and this method is repeated successively.

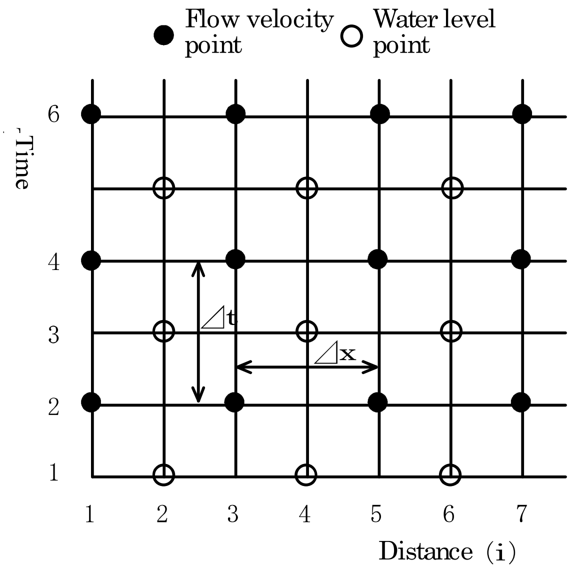

Figure 1-1.11 Calculation grid

2) Analysis conditions

i) Water channel cross-section, etc.

The water channel cross-sections and intake facilities in the unsteady flow analysis were the same as those in the non-uniform flow analysis previously described. However, the effect of the bridges, including the roughness coefficient was estimated in order to reproduce the steady conditions in the non-uniform flow analysis.
The analysis conditions such as discharge, water levels, etc., were as follows.
The design discharge 474m^3/s was taken at the Ibrahimia Head regulator, and the design 19m^3/s was taken at the Ibrahimia canal. At the upstream point of the DGRs, 455m^3/s was maintained at the design control water level 46.3m, and it was assumed that the water was divided into 7 channels. Then a scenario was envisaged where one of the Bahr Yusef regulator gates (4 gates, 227m^3/s) was closed for some reason, and it was not possible to distribute 57m^3/s. The variations over time in the upstream water levels of the regulator in this scenario were analyzed.

Table 1-1.11 Discharge and water level conditions

Ibrahimia Head Regulator design amount	474m^3/s
Ibrahimia Canal design intake	19m^3/s
Bahr Yusef Regulator upstream design discharge	455m^3/s
Bahr Yusef Regulator upstream design control water level	46.3m

1-2 Evaluation of analysis results

(1) Non-uniform flow analysis

a) Analysis results

With the construction of the new DGRs, the control water level upstream of the regulators will be increased from the previous maximum of 46.10m to 46.30m, an increase of 0.2 m. Therefore this analysis determined whether or not there was an effect associated with the construction of the new regulator group. The range and scale of the potential effect were then estimated. The applicable discharges were the Ibrahimia intake design discharge of 474m^3/s, Ibrahimia canal design intake discharge of 19m^3/s, and DGRs upstream discharge of 455m^3/s.

The results of the water surface profile analysis conducted at the present and in the design are shown in Table 1-2.1 and Figure 1-2.1 The increase in water level of the DGR upstream is 0.20m, which becomes 0.05m at a point downstream of the Ibrahimia intake, which is a small difference. It was found that the effect on the water surface profile extended downstream of the Ibrahimia Head regulator.

Table 1-2.1 Analysis result (n=0.0256)

Item	Ibrahimia Head regulator design discharge (m^3/s)	DGRs upstream water level (m)	Ibrahimia Head regulator downstream calculated water level (m)
Present status	474	46.10	50.16
Plan		46.30	50.21
Increase in water level (m)	-	0.20	0.05

The enlarged view of the water level is shown in Figure 1-2.2. In the upstream section where the elevation of the canal bed is relatively low, the water level rises mild. On the other hand, in the sections from DGRs until 20km upstream where the elevation of the canal bed is high, the water level rises relatively steep. This means that the sections until 20km from DGRs has a difficulty in flowing a result of sedimentation.

The difference in water levels between the present situation and the plans shrinks in the section 20km upstream of the Ibrahimia Head regulator. This phenomenon is likely due to sedimentation.

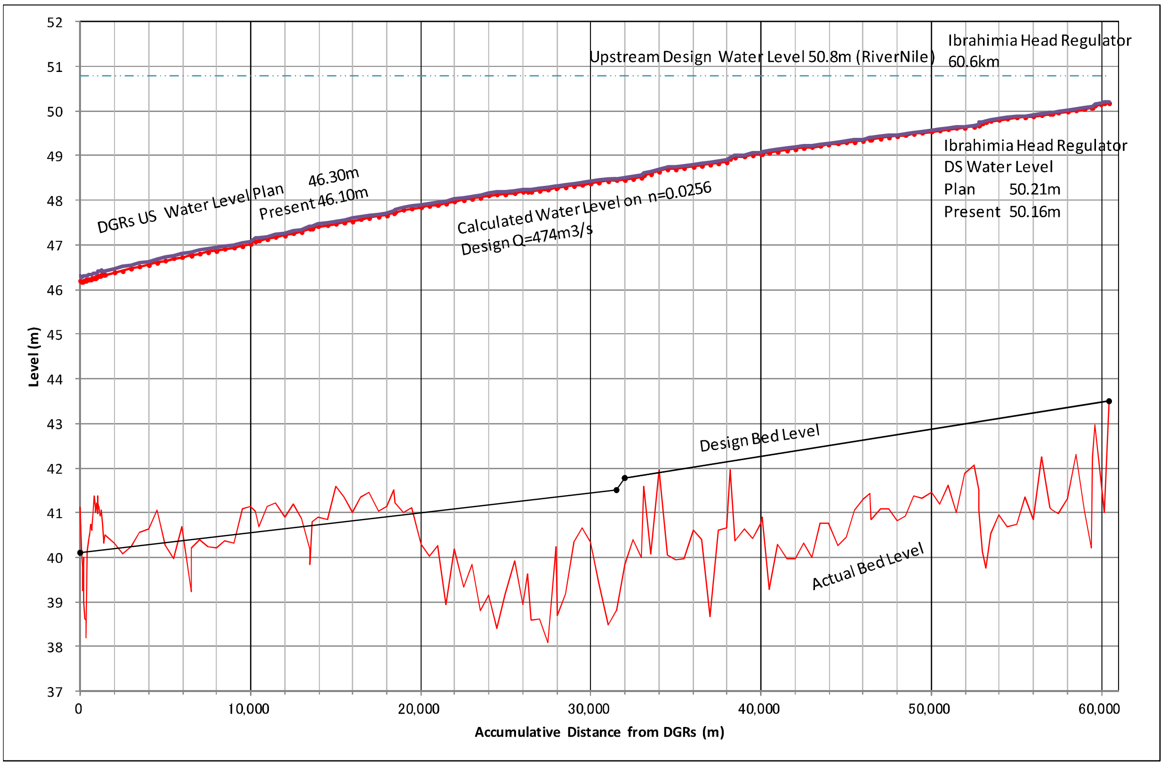

Figure 1-2.1 Water surface profile analysis in present situation and the design water level with the design discharge

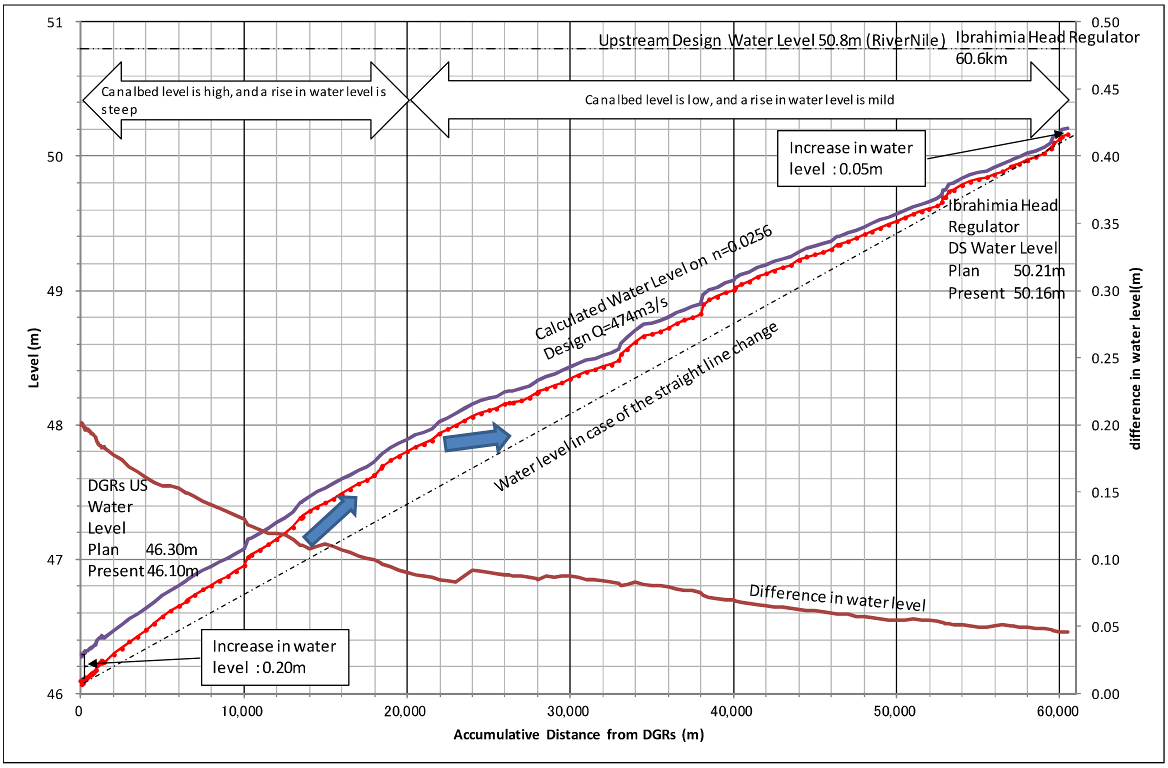

Figure 1-2.2 Water surface profile analysis in present situation and the design water level with the design discharge (enlarged view)

b) Evaluation

The difference in the water levels from the water surface profile, associated with the construction of the NDGRs is 0.20m upstream of the DGRs, but decreases to 0.05m at the downstream of the Ibrahimia Head regulator. Also, as shown in Figure 1-2.3, by comparing the water levels under design conditions with the elevation of the levees, it is found that there are no locations at risk of overtopping the current banks.

From the above, the construction of the NDGRs is considered to have almost no effect on the water surface profile.

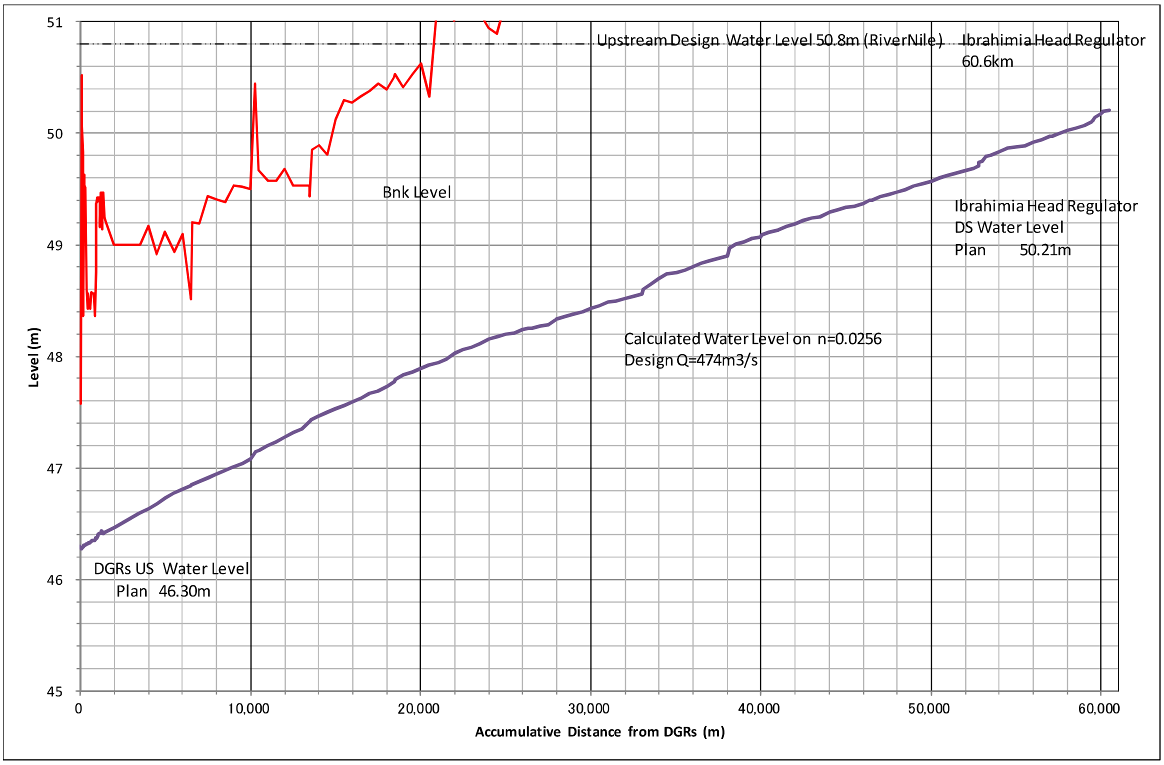

Figure 1-2.3 Comparison of the water surface profile under design conditions with the levee elevations

(2) Unsteady flow analysis

a) Analysis results

At design discharge distribution of 455m^3/s, when one gate of the Bahr Yusef regulator is closed, the 227m^3/s distribution drops to 170m^3/s, and the 57m^3/s difference is stored upstream of the regulator. As a result, the upstream water levels at the regulator increase, as does the quantity distributed to the other regulators.

Figure 1-2.4 shows the upstream water levels at the regulator: before the closure of the gate, 30 minutes, 1 hour, and 12 hours after the closure of the gate.

After the closure of one gate, the regulator upstream water level rises to EL.46.47m after 30 minutes, EL.46.53m after 1 hour, and EL.46.84m after 12 hours. These are rises in water level of 0.17 m, 0.23 m, and 0.54m respectively. The effect of the rise in water level after 12 hours extends downstream of the Ibrahimia Head regulator.

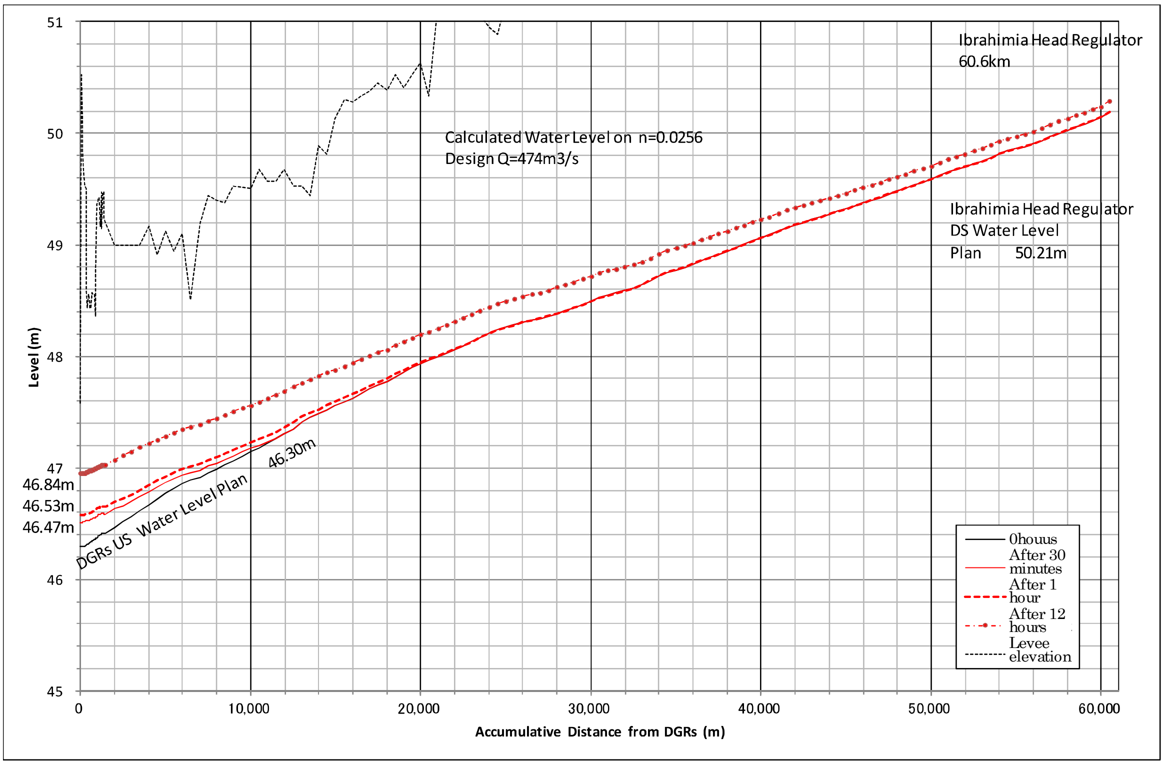

Figure 1-2.4 Water level profile at the upstream of the regulator after closure of one gate

b) Evaluation

One hour after one gate of the Bahr Yusef regulator is closed under the design discharge, there is a possibility of a 23cm rise in upstream water level at the regulator due to the impact of the water surface profile. After 12 hours this becomes 0.54m, and in both cases no overtopping of banks occurs.

It is therefore important that the initial response system be activated promptly after the closure of a gate. This includes the activation of the flood spillway located on the right bank 1.3km upstream of the regulator, and the reduction of the intake amount at the Ibrahimia intake.

Reference 1: Relationship between water surface profile level and canal shoulder level

Examining the relationship between the water surface profile level and the canal shoulder level identified one place (No.56 in the figure below) 14.5km upstream of the DGR where water level exceeds the canal shoulder level.

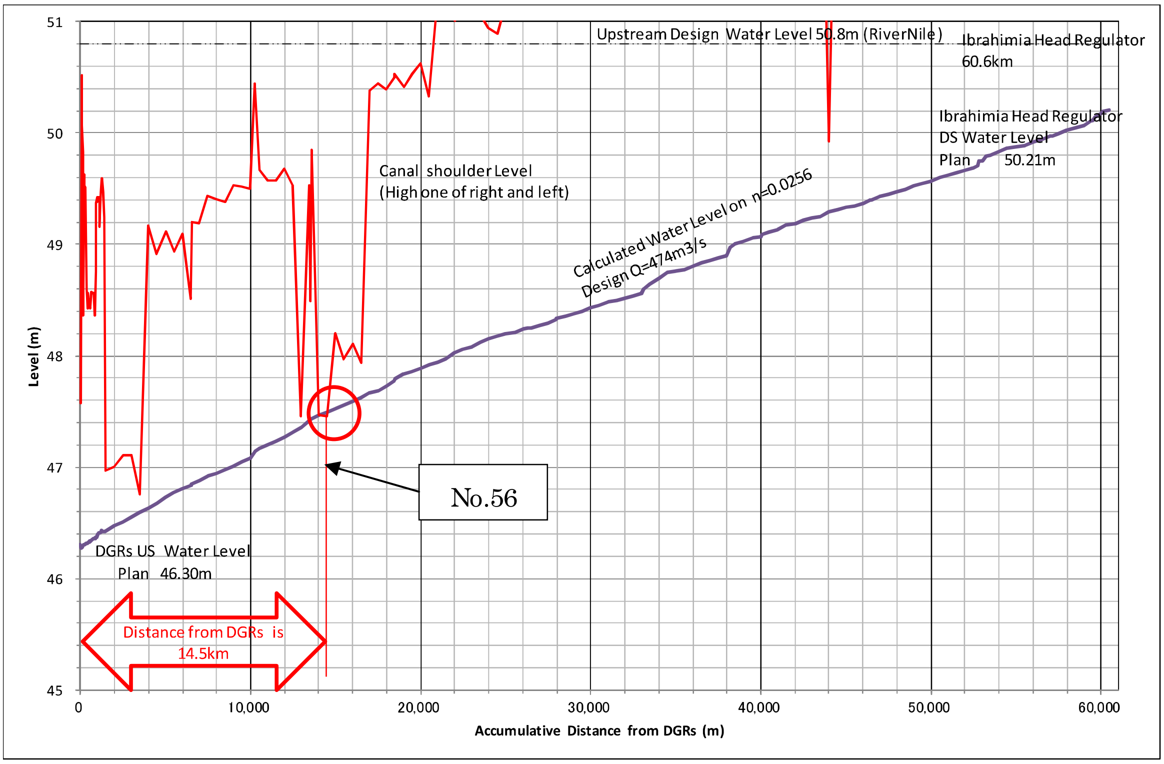

Figure 1-2.5 Critical point where water level exceeds canal shoulder

Estimated rise in water level is 11cm from the actual maximum water level after the construction of NDGRs, as shown in Figure 1-2.6.

Figure 1-2.6 Current maximum water level at the critical point

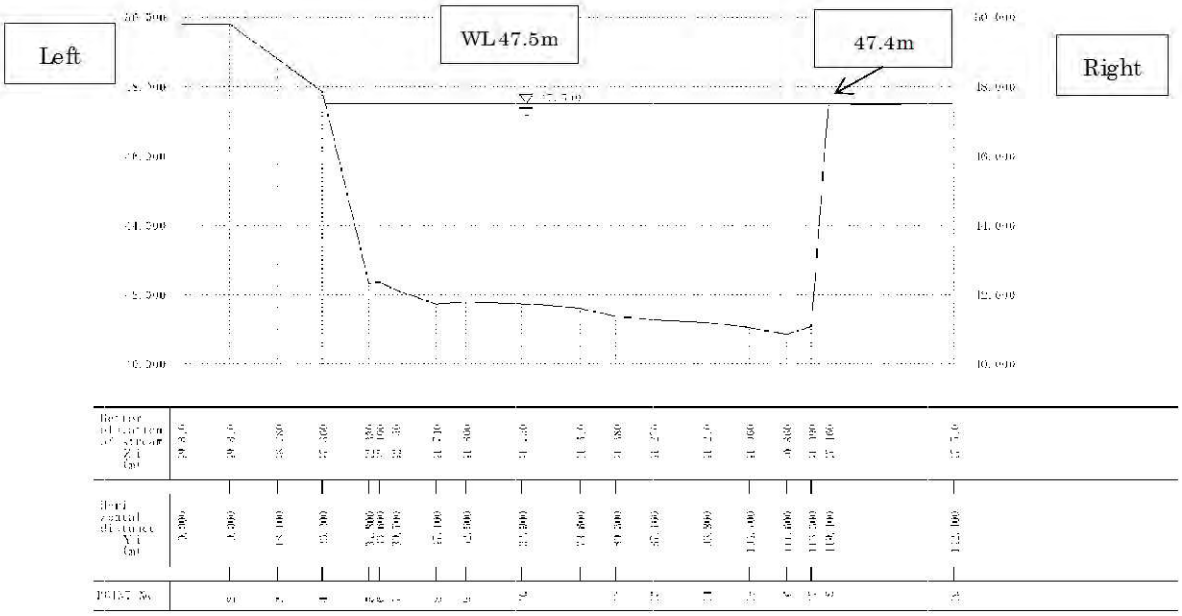

Figure 1-2.7 Maximum water level at cross section No.56 (14.5km U/S of DGRs)

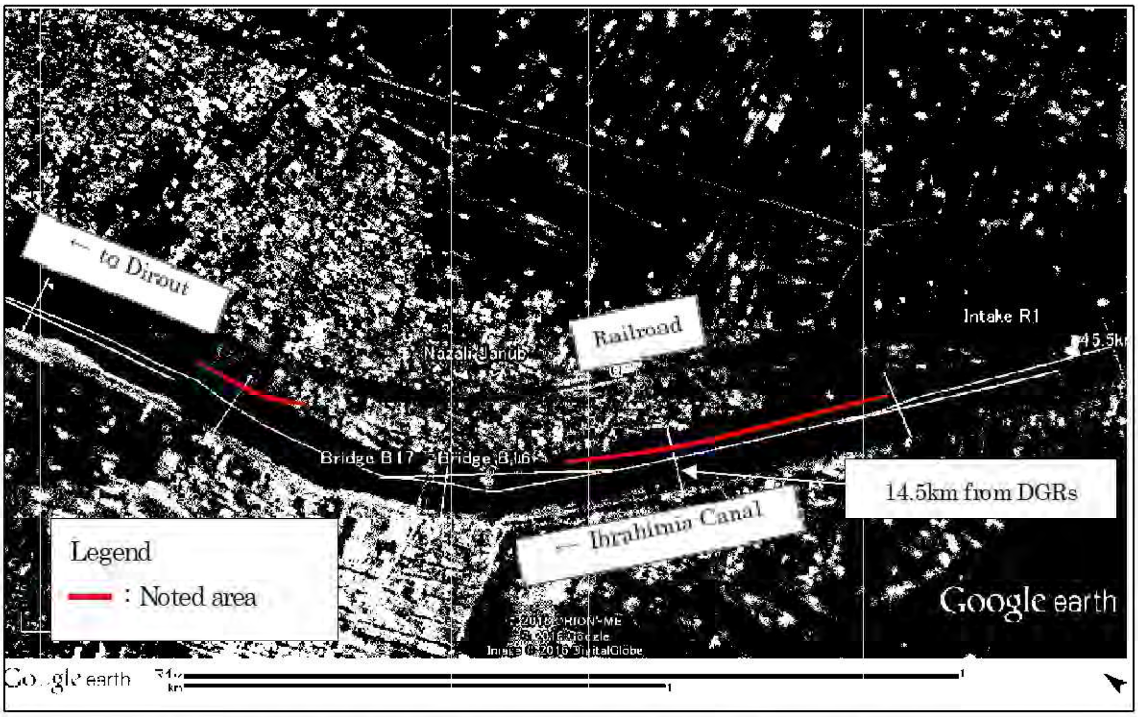

Figure 1-2.8 Critical point where water level exceeds canal shoulder