CHAPTER 6
OPERATION AND MAINTENANCE MANAGEMENT PLAN

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6.1 Introduction

6.1.1 Purposes of This Plan

The purposes of this plan are as follows:

- To describe a safe train operation system including a fire fighting and evacuation plan
- To describe a working system and number of staff during the operation stage
- To estimate operation and maintenance (O&M) cost at the operation stage
- To provide a training plan for Metro Line 4

First, the operation system will be discussed by category of works from the viewpoint of safety and efficiency. Then, the maintenance system will also be discussed from the viewpoint of safety and cost efficiency. The organization plan will be described and the number of staff and expenditure needed for O&M will be estimated. Finally, a training plan for the staff of Metro Line 4 will be discussed.

6.1.2 Concept of This Plan

Establishing a sustainable commuter rail system will be the ultimate target of this project. To attain this target, the following concepts will be adopted:

- Adopt a safe and efficient operation system
- Ensure consistency with the operation of the existing lines
- Adopt measures which have been successful throughout the world

Particular specifications of various equipment and rolling stock items will be provided in each chapter related to electrical and mechanical equipments.

6.1.3 Methodology of Study

This plan will be prepared through the following activities:

- Study the operation of the existing metro lines
- Study the systems design of Metro Line 4
- Study the operational experience of lines in other countries, especially in Japan

6.2 System Operations Plan

In this plan, the key personnel involved will be controllers in Central Control Point (CCP), as well as the train drivers and station staff.

The operation plan will be expressed in terms of categories of operating staff. In this chapter, safe operation will be emphasized. The plan will be based on careful study of an efficient working system for the operation staff. First, the general concept of safe train operation in urban railways will be discussed. Signals are the most important safety measures for all such railways. The required external specifications for signaling equipment are discussed in the section about drivers since such equipment is significantly related to driver operations.

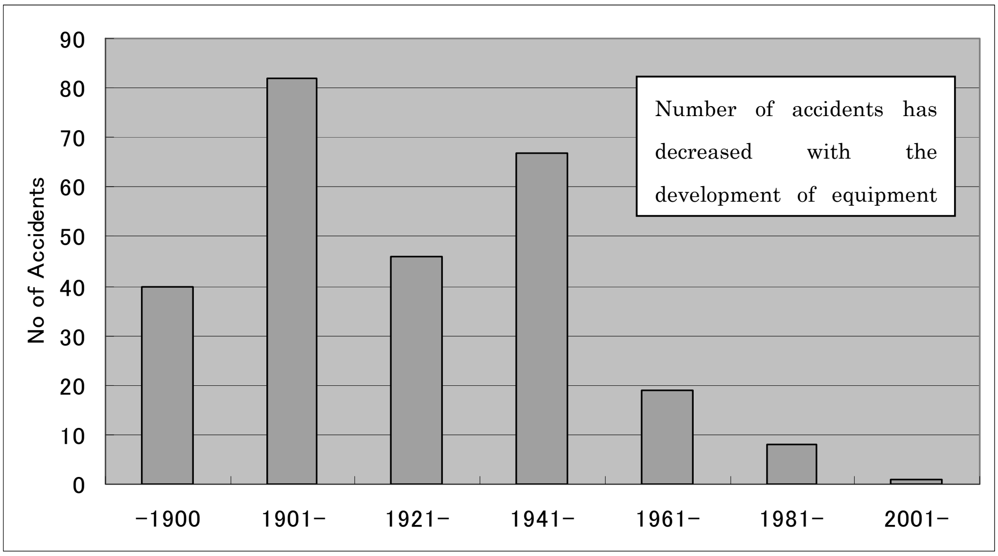
In this chapter, a fire fighting and evacuation plan will also be emphasized. This equipment is significantly related to station staff and operational controllers in the CCP. Hence this issue will be described after the section related to these staff.

Also in Section 6.5 "Estimation of Number of Staff", from the viewpoint of estimating the number of staff, the operation system for the existing lines of Cairo Metro and that provided for Metro Line 4 will be discussed.

6.2.1 General Concept of the Safety of Train Operation in Urban Railways

Basically railway accidents can be avoided through the use of modern safety equipment. It is realized that in order to maintain safety, staff should operate trains and equipment properly, and proper maintenance will be indispensable.

The following chart illustrates a tendency in which number of accidents has decreased with the development of equipment and rolling stock from the commencement of railway service in 1830. Most of these accidents shown in this chart occurred on intercity railways and during construction of urban railways implemented only in recent years. Nevertheless, the development of equipment and rolling stock in intercity railways has been utilized also for urban railways.



Source: New York Times from 1851 to 2002, JICA Study Team

Figure 6-1 Number of Serious Railway Accidents in the World (More than 20 Casualties)

Intercity railways have a long history, being constructed in the early stages of technology development. The route length of these lines is long. On the intercity lines, various types of passenger and freight trains are running. Therefore, the traffic and track layout of these lines is complicated. It has taken a lot of time and money to install modern safety equipment on various intercity lines in order to establish safe operations.

On the contrary, urban commuter lines have been constructed recently and their traffic and track layouts are simple. The route length of these lines is short. It seems comparatively easy to install modern safety equipment on the commuter lines. With modern safety equipment, most accidents can be avoided, but it should be noted that installation of such modern equipment can increase construction cost substantially.

It should also be realized that since urban trains carry a lot of passengers, any accident that may occur could involve significant loss of lives. Therefore, the establishment of an adequate safety system is vital for urban railways.

(1) Measures to secure safety

To secure safe action for train operation, the following will be required:

- Installation of equipment which will help avoid train accidents
- Execution of proper operation by the train operation staff
- Implementation of proper maintenance

Hence, from the operation view point, the requirement for the safety equipment will be discussed. Implementation of proper training and maintenance meanwhile will be discussed in a later section.

(2) Foreseeable accidents and concrete measures against them

On the Cairo Metro, there were no serious accidents since its opening, except for those that cause deaths of passengers on the platforms. Generally speaking, foreseeable accidents with fatalities on railways and concrete measures against them are expressed as follows:

1) Train collision

Collision of trains is usually due to faulty train driver operation in modern railways. These are discussed in Section 6.2.4. On the Washington DC metro, a train rear collision accident happened on 22nd June 2009. The cause of this accident has not been established, but it is possible that weaknesses in the safety system may have contributed to this accident. Provision of an excellent Automatic Train Protection (ATP) system will be the most effective measure to avoid a train collision.

2) Train fire

The civil structures of the station are provided with non-flammable materials and are designed to allow passengers to evacuate easily from the platform without getting hurt. Rolling stock is made of fire proof materials. Measures for fire fighting and evacuation during the operation stage are discussed in Section 6.2.3.

3) Derailment

Derailments are caused mainly by the following factors:

a) Incidents of trains running into wrong tracks due to signal passing at danger (SPAD)
b) Defective rolling stock parts
c) Some failures of tracks or signals
d) Collision with automobiles at level crossings

Countermeasures against the cause of factor “a” are discussed in Section 6.2.4. Countermeasures against the cause of factors “b” and “c” are discussed in the section related to maintenance. Accidents at level crossings can be avoided through grade separation of road and railway lines.

4) Passengers falling down from platforms;

For this project, installation of Platform Screen Door (PSD) will be planned at these stations for the safety of passengers. This type of accident will never happen at stations with PSD, but it must be noted that in the Cairo Metro, passenger falls occur infrequently, possibly attributed to religious practices (which avoid cause of suicides) and abstention from consumption of alcohol.

6.2.2 CCP Operation Plan

A CCP will be established on Metro Line 4 similar to other lines in Cairo. This section describes the role, equipment and detailed tasks of the CCP.

Even if some incidents occur on the urban railway system, it is important that it remains operational as much as possible since urban railways are indispensable transit systems to support urban life. In such cases, a degraded operation will be necessary and will be discussed in this section, since said operations will be conducted by the controllers in the CCP, although the drivers and station staff need to also be involved.

(1) Roles of the CCP

The following are the roles of the CCP. It can be seen that its central role is controlling train operations on urban commuter lines.

Train operations will be conducted through communication between the controllers in the CCP and the train drivers, with former being in charge of route control. Specifically, CCP controls routes in the following ways:

- Route control for trains is done normally by the Automatic Train Supervisor (ATS);
- Route control in a contingency operation is done by ATS under the instruction of the controller;
- Basically, route control of shunting inside the depot is done manually;
- Route control for maintenance vehicle at night time is done manually;
- Every morning, before the start of revenue operation, the operation of the routes will be checked through an ATS confirmation test;
- The SCADA system for power control will be operated at the CCP except in cases where maintenance staff will directly operate the SCADA;

When an incident happens, the CCP controls train traffic in consideration of the following issues:

- Keeping the safety of passengers and staff as a top priority;
- Reporting the occurrence of the incident to the relevant authorities as soon as possible;
- Maintaining system capacity as much as possible when an incident happens during peak time;
- Restoration of services to normal operation as soon as possible; and
- Provision of transport as much as possible for sections other than the affected section (Please see “2.5 Degraded Operation Plan”).

The CCP delivers information on traffic to the stations, the drivers’ depot, maintenance workshop and so on by the following means:

- Direct communication with stations or maintenance depot;
- Internal broadcasting when some incident happens;
- Train describers which, at minimum, display the location and delay of trains;

The CCP supports drivers, station staff and maintenance staff when they experience difficulties during operation as follows:

- Supports drivers in troubleshooting when their trains have malfunctioned;
- Support the safety of maintenance staff who are engaged in troubleshooting or urgent maintenance works. In particular, in these situations, the controller will stop the related trains or issue orders to reduce the train speed in order to assure the safety of maintenance staff.

(2) Location and Organization of the CCP

Location of the CCP

The CCP of Metro Lines 1 and 2 of the Cairo Metro is located at the Ramses complex. Ideally, it will be preferable for the CCP of all metro lines in Cairo to be centrally located, in order to enhance the network consolidation and facilitate communications among the metro lines.

From an operational point of view, the specification of the CCP facilities for a line need not have the same specifications as the other lines.

It is suggested that the CCP should be located adjacent to the headquarters of the Operation Department of Metro Line 4 in Cairo. In case of train contingency operations, the following activities will improve substantially:

- Communication with drivers and station staff
- Manual operation of the route control
- Supply of traffic information to the mass media

Back up from the headquarters will be indispensable during the contingency train operations. If the headquarters is not adjacent to the CCP, the CCP will have to maintain spare staff to deal with contingency operations. This however will not be efficient.

In reality it will be difficult to provide a large space for a consolidated CCP for all lines in Cairo and the operation headquarters for new lines at the headquarters of ECM in Ramses complex. The CCP of Metro Line 3 will be located at Attaba station since the operation headquarters of Metro Line 3 is required to be located at a central place of the line for the convenience of the station managers in visiting the operation department. Moreover, it should be near the Ramses complex for close communication with the headquarters. For Metro Line 4, the CCP and its operations headquarters may have to be located at El Malek

El Saleh Station. In such a case, provision of an advanced communication system among the CCPs will be needed.

Organization of the CCP

The major roles of controllers are expressed in the following table. It is assumed that route control inside the depot will be done from the CCP.

Table 6-1 Major Roles of Controllers

CCP Component	Major roles
Chief	• Management of the CCP • Decide on the operation policy or strategy during a contingency situation • Delivery of various information to the stations and public media during a contingency situation
Traffic	• Route control for trains • Drivers' operation planning during a contingency situation
Rolling stock and depot	• Provides drivers with instructions on troubleshooting failures occur on their train-sets • Facilitate route control in the depot
Equipment supervisor	• Delivery of information on facility trouble or problems to the related work sites • Operation of SCADA system • Facilitate route control for the facility maintenance work at night

Source: JICA Study Team

(3) Facilities Required at the CCP

The following facilities are required at the CCP.

Table 6-2 Facilities Required at the CCP

Facility	Required functions or system
Information collection	• Status of train operation (Automatic Train Supervisor) • Alarm from the disaster prevention system for underground stations • Status of facilities (Provided by Facility SCADA) • Pictures of the situation of each station through CCTV
Control	• Route control (Spare terminal of ATS should be provided for training) • Button for detention of trains at stations (by pushing this button, all the trains will be detained at stations) • Power supply control with Power SCADA
Communication with drivers and staff at sites	• Transmit radio communication between controllers and the drivers in the cabin of trains • Direct telephone communication to various sites • Utilize normal telephone system

Facility	Required functions or system
Documentation	• Records of communication with drivers and staff at sites • Record of the result diagram for the daily train operation (May be a part of the function of ATS)

Source: JICA Study Team

(4) Required Functions of Automatic Traffic Supervisor (ATS)

The basic principles and some important functions that should be provided in the ATS are described below.

Basic Segregation of Roles between ATS and Controllers

The ATS at CCP functions to reduce the controllers' work load as much as possible. Basically, its role is to carry out tasks that can be logically calculated/ estimated and to provide the reference data required by the controllers. By contrast, it is the role of controllers to do what ATS cannot carry out. The controllers make the decisions when alternatives are presented.

Daily Route Control

On this line, trains will be operated according to the train diagram. ATS selects the routes for each train according to the train diagram on behalf of the controllers.

Quick Recovery from the Contingency Operation

One of the most important roles of the controllers is to restore the contingency train operations to normal operations as soon as possible. Major roles required from the ATS for this operation are as follows:

- Provide proper information such as forecast train diagrams on various preconditions to the controllers;
- Report any identified discrepancy of controllers' instructions.

Maintenance of Uniform Headway

On urban railways, maintaining the interval of trains is more important than maintaining the time table as the stations will be crowded with passengers causing disorderliness at the station premises when train intervals are extended. When the operation schedule is disturbed even slightly, it is important to restore the headway to regular intervals on the urban railways. Even when there are trains that could be operated on schedule, it is common practice on urban railways to stop them temporarily to reduce the interval between the succeeding trains that are delayed. With this, rushing of passengers to board the succeeding trains can be avoided. Consequently, this will lead to the early recovery of the normal operation. ATS has the function of supporting the controllers in this respect.

Registration of Train Diagram

One of ATS functions is the registration of the timetable into the system, including the following features to ease the timetable preparation works:

- Displays needed various timetable patterns;
- Modification of functions of timetable to ease the entry works.

Recording of the Operation

ATS also provides the following functions:.

- Recording of operated trains on the diagram;
- Recording of communication between controllers and drivers or station staff;
- Provision of statistics such as train operation in kilometers and average train delay.

(5) Degraded Operation Plan

The aim of the degraded operation plan is to maintain a certain level of service even in situations where normal services cannot be provided, and as much as possible to ensure a fast, effective and efficient coordination of efforts for service recovery.

It should be noted that degraded operations are considered to be different from the emergency conditions as they do not represent a potential or actual threat to the safety of passengers.

Various Degraded Operation Mode

Different modes of degraded train operations can be selected when one or more tracks have been blocked for any reason. The implementation of these modes depends on different factors including the nature, extent and severity of the problem.

These different modes are summarized as follows:

- Operation with substitution block system
- Withdrawal of disabled trains from the main lines using refuge facilities
- Temporary speed restriction
- Turn back operation at an intermediate station
- Provide emergency bus service

Operation System of Each Degraded Operation Mode

1) Single track operation

In the Cairo Metro, bi- directional ATP is installed on the underground section of Metro Line 1 and on all sections of Metro Line 2. This system is utilized when a train-set cannot move between stations and operation in reverse direction is required for purposes of evacuation. However, the bi-directional ATP is not used when signals fail or are under maintenance. On Metro Line 1, single track operations occur once per month, owing to the failure of the aged rolling stock. On Metro Line 2, these operations are not carried out since train-set failure seldom happens.

Basically, the purpose of single track operation in degraded mode is to maintain the passenger transport even during recovery from equipment failure. On the commuter lines, the number of trains per direction will be large but the number of trains per hour at single track operation will be reduced drastically to one third or less of the double track operation. In such situations passengers crowd at stations and create disorderliness. In reality on Cairo Metro, such an operation is not carried out.

In intercity railways, maintenance works which need stopping of train can be done by adopting single track operations with bi-directional signal since on these lines, number of trains is limited. However, on urban railways, such maintenance work measures cannot be carried out even if single track signal systems are equipped since the number of trains is considerable that frequently, trains pass near the maintenance workers subjecting them to danger.

Thus utilization case of bi-directional ATP for single track operation will be limited.

2) Operation with substitution block system

For example, when the on board ATP fails, the train should be withdrawn to the refuge tracks or the depot. In such case, a substitution block system can be applied. Basically, maintenance of safety with this system will depend upon the attentiveness of the staff. Controllers in the CCP will apply this system based on the information on train location received from the ATS. Specifically, controller in the CCP will order the driver to start the targeted train when all the trains on its foregoing section up to the next station have been evacuated.

3) Withdrawal of trains from the main line

To minimize the disruptive effect on train services, any disabled train must be withdrawn to the nearest refuge track so that normal scheduled operation can be resumed as fast as possible from the moment the train fails.

To move a disabled train to the refuge tracks, the succeeding/preceding train-set can be utilized as a rescue train. The typical procedures are as follows.

- Before the rescue train goes to assist the disabled train, all the passengers on this train will alight from the rescue train.
- After all the passengers alighted, the rescue train can proceed under the assistance of ATO/ATP to the point where the disabled train is halted.
- When the train comes close to the disabled train, the ATP indicates a stop signal. Then the driver reports to the controller in the CCP and selects the emergency position of ATP under the order of the controller (Please see also “4.3 Operation with ATO/ATP”).
- After coupling of the rescue train with the disabled train, the trains can be restarted after checking if the functions are normal. If the operation cannot be carried out from the cabin of the disabled train, it should then be executed from the cabin of the rescue train.

If a disabled train can move in a reverse direction, the succeeding trains should be evacuated first between the stations, prior to executing the reverse direction operation. This function can be utilized for this operation if a bi-directional ATP is installed on the line.

4) Temporary speed restriction

When there is a fault, such as a rail crack, foreign objects on the catenaries, etc., that may cause unsafe operations under normal train speed, a temporary speed restriction may be imposed.

Subject to the actual condition and engineering assessment, trains are allowed to pass the defective area under a prescribed speed limit.

Operations under a temporary speed limit are controlled with some specific measures. In case of a conventional ATP, portable transponders will be used. The imposition and the withdrawal of the temporary speed restrictions must be clearly communicated to all involved parties. Dedicated signboards showing the temporary speed limit must be displayed at the site. Moreover, the temporary speed restriction shall be confirmed beforehand at the check-in meeting between the driver and the duty manager of drivers’ depot.

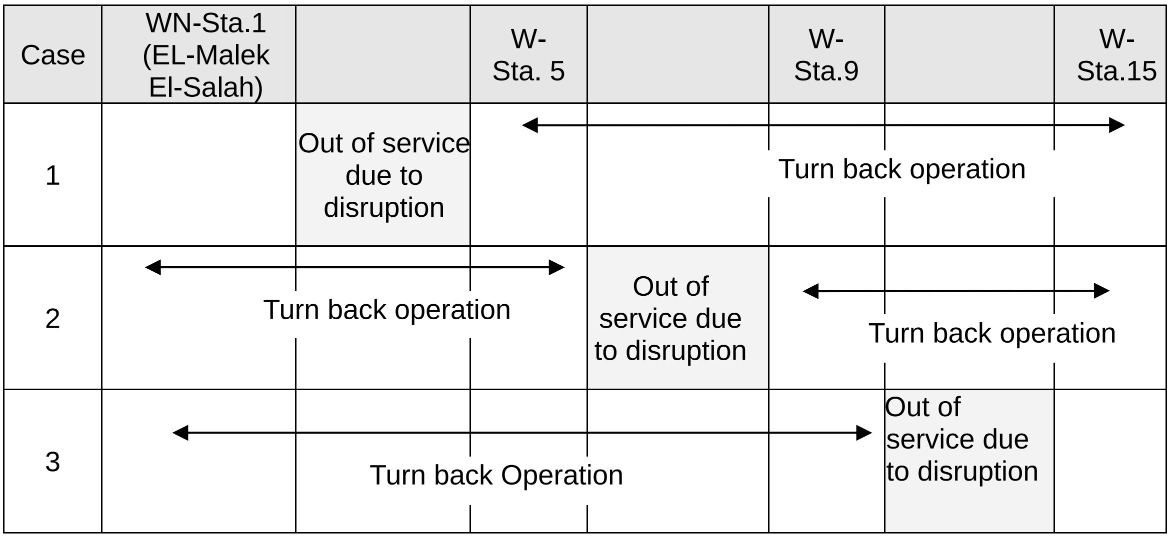
In case the signalling system fails, ATO/ATP automatically indicates a stop signal. The operation in this case is described in the section related to signaling (See “4.2.4.(3) Operation with ATO/ATP”).

5) Turn back operation

When a failure occurs on a section, all the trains will be stopped in cases where there is no equipment for degraded operation. Maintenance of the train operation as much as possible even during recovery from a failure will be required in order to not to disrupt services to passengers. With the installation of turnouts at some intermediate stations, turn back operations for degraded operation can be done. The more intermediate stations with turn outs are provided, the more the service level will be enhanced. However, installation of such turnouts at intermediate stations will be costly. Furthermore, there are some stations where installation of turnouts will be difficult. Hence it is identified that, turnouts for degraded operation will be planned at W-Sta.5 and W-Sta.9.

It should be noted that these facilities can be utilized also for maintenance gangs.

Figure 6-2 illustrates the turn back operation during contingency periods.



Source: JICA Study Team

Figure 6-2 Turn back Operation During Contingency Period

6.2.3 Fire Fighting & Emergency Plan

All the stations of Metro Line 4 to be constructed in the first phase will be underground. Fire accidents at underground stations will seldom occur but the potential for damage is enormous. Therefore, all the countermeasures against fire should be taken not only at the construction stage but also at the operation stage.

Basically, the civil structures of the station will be provided with non flammable materials and designed to enable passengers to easily evacuate from the platform without getting hurt. The interior of the cars will also be installed with non flammable material or fabric.

(1) Lessons from Accidents

Lessons from two serious accidents are discussed as follows. One is the most severe accident due to fire in Japan. Japan Railways received relevant lessons from this accident.

The other is the most severe fire accident at an underground station that occurred in the Republic of Korea.

Fire Accident inside the Hokuriku Tunnel in Japan

At midnight in 1972, a fire accident occurred on an express train running in the Hokuriku tunnel in Central Japan. The train was stopped inside the tunnel with emergency brake applied by the conductor on board. The force of the fire was so strong that it was necessary to detach the burning coach from the other coaches in the train. However, power supply was suddenly stopped and the detachment had to be stopped. The train could not proceed outside of the tunnel. This accident happened at midnight and most of passengers were asleep in sleeping coaches. It took a lot of time to evacuate the passengers. As a result, 30 passengers lost their lives and 714 passengers were injured.

The lessons learned from this accident were the following:

- Make the rolling stock inflammable,
- Reinforce lighting facilities in long tunnels,
- Establish a rule to keep trains running until they escape from tunnels when train fires have broken out

Figure 6-3 Picture at the Hokuriku Tunnel Fire Accident

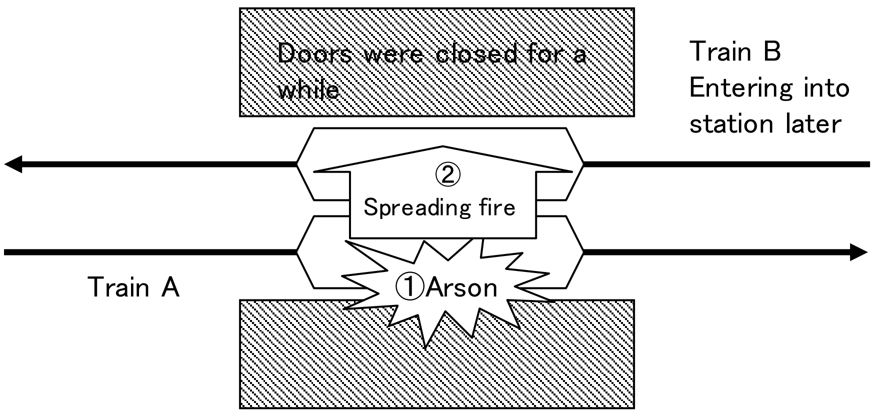
Fire Accident at Daegu Metro in Korea

In Feb 2003, a man attempted suicide by scattering petrol inside a coach of the metro and set it on fire. This train had just arrived at the central station of the subway in Daegu City in South Korea (referred to as Train A).

After the outbreak of the fire, the CCP of the subway systems was unaware of the situation of the fire accident and they did not immediately stop other trains entering this station. As a result, a train heading in the opposite direction, entered the station (referred to as Train B). The station has a side platform arrangement, and Train B stopped beside Train A, i.e., the burning train.

At first the controller of the CCP did not realize the situation. Curiously enough, the occurrence of the fire was only informed to the CCP by a fire station outside the station. Before an order could be issued by the CCP to start Train B or to open its doors, the power supply was stopped due to the fire and a black out occurred. Meanwhile, Train B also caught fire with the fire that spread from Train A.

The passengers inside Train B could not evacuate from the coaches since the doors of the train-set were closed. Hence, the driver of Train B exited the train without opening the doors, As a result, the number of fatalities was counted at 192 and the member of injured, including heavy injury, was 148. Of the 192 fatalities, 142 persons died inside Train B.



Source: JICA Study Team

Figure 6-4 Schematic Diagram of the Central Station in Daegu During the Fire Accident

The lessons learned from this accident were as follows.

1) Modification of train operation to control fire in tunnel sections

- Other trains at adjacent stations will be stopped and never permitted to enter the station where a burning train is stopped.
- In case that a burning train stops at a station or a station is in flames, the

arriving train will be stopped before reaching the station.

2) Major modification of rolling stock specification for fire prevention

- Adoption of materials with anti-melting/protection
- Equipment of doors at the connecting section between coaches for compartmentalization of each coach against fire

3) Providing clearer indications of the location of fire extinguishers and emergency handles for doors.

(2) Principles on Fire fighting and Evacuation in Case of Train Fire Accident

Fire Fighting

Based on above mentioned lessons, the following should be established as a principle for train operation in case of train fires.

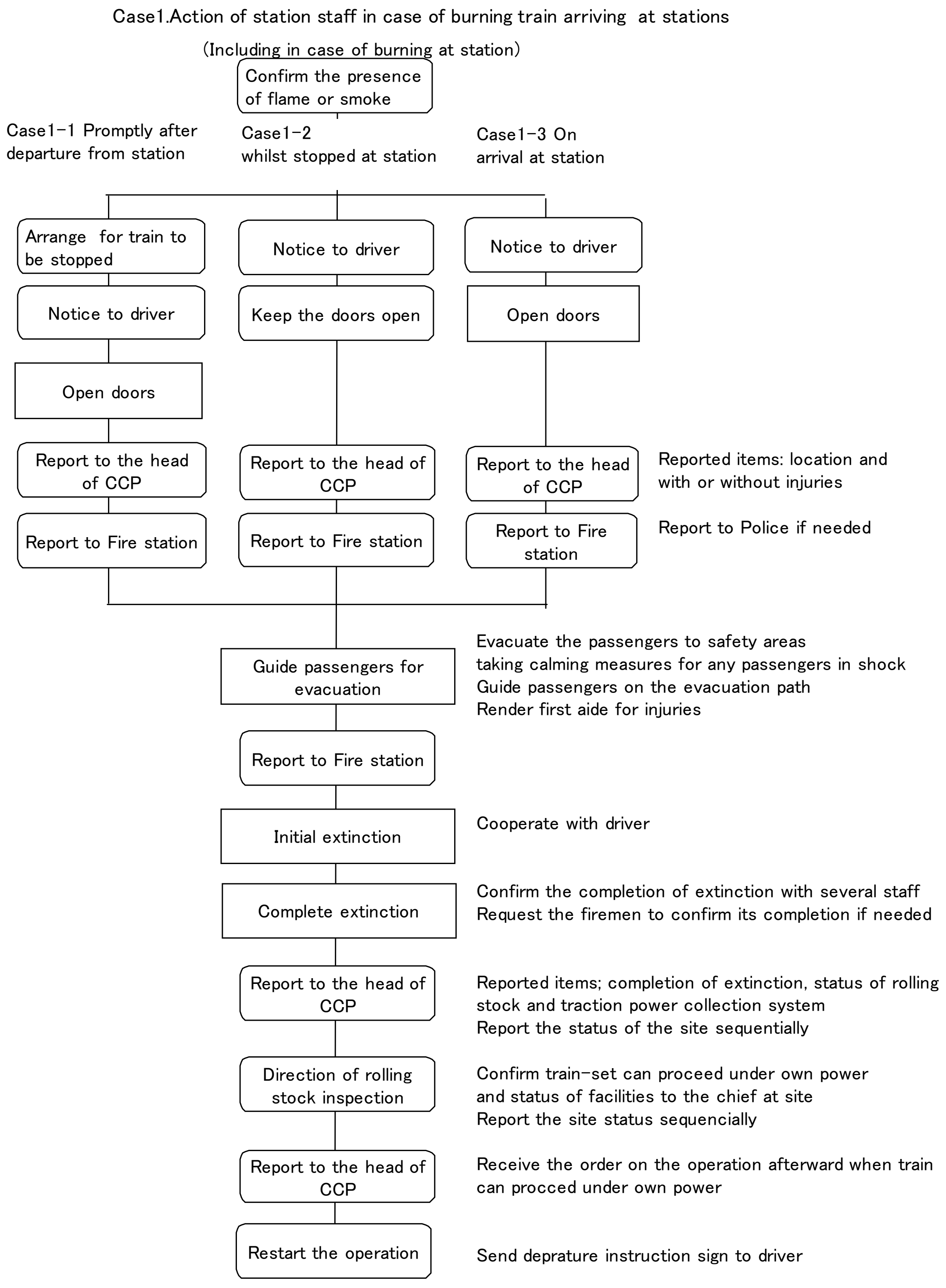
- When a train fire accident is reported to the driver while running in the underground section, the driver shall keep the train running until it reaches the next station without stopping. This is in spite of the common rule of immediately stopping the train operation when a trouble on board is realized.
- Controllers will stop other trains at adjacent stations and never start them to the station where the burning train is stopped.
- In case that a burning train stops at a station, or a station is burning, controllers will generally stop the arriving train in front of the station.

Fire fighting at the initial stage will be carried out by station staff. They will also operate the fire extinction and smoke extraction facilities from the station office. After the arrival of a fire fighting team, a full scale fire fighting operation should take place.

Evacuation of passengers

Basically, station staff will play a central role in evacuating passengers during fire situations.

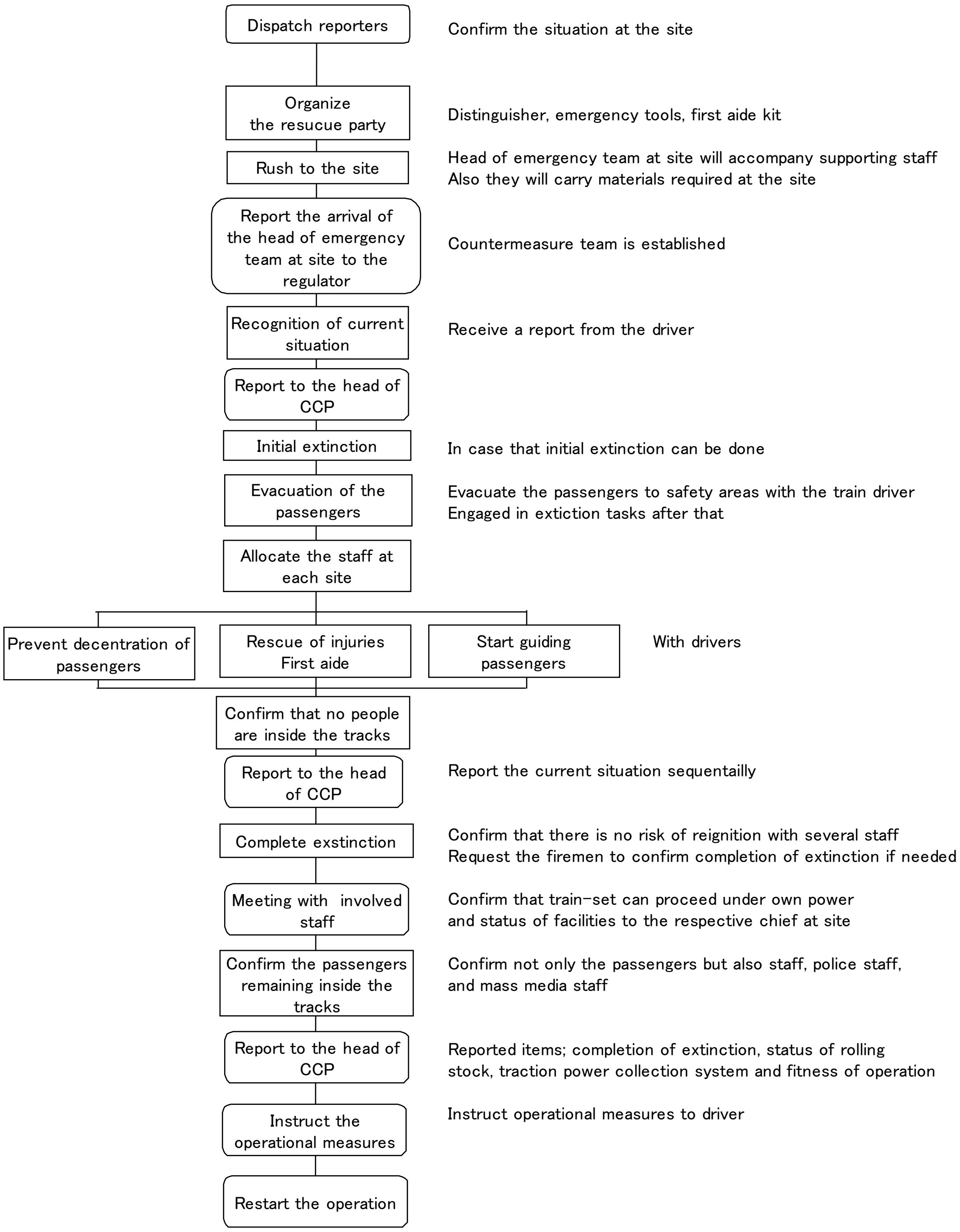
The typical action to be adopted when a train is on fire in the vicinity of stations is presented in the following chart.



Source: JICA Study Team

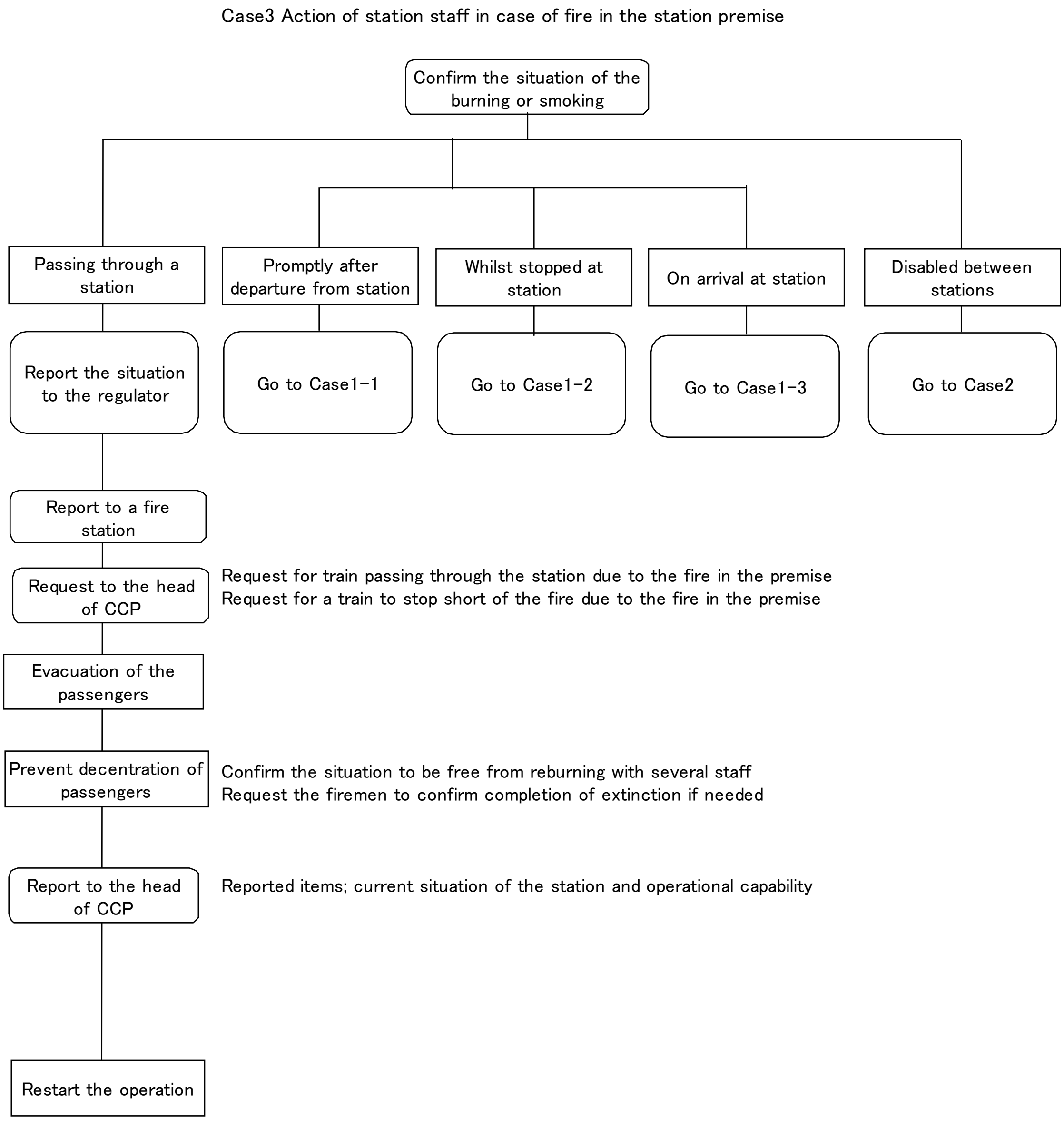
Figure 6-5 Action of Station Staff in Case of an Arriving Burning Train

Case 2 Action of station staff in case that a burning train stops between stations



Source: JICA Study Team

Figure 6-6 Action of Station Staff in Case of Burning Train Stopping Between Stations



Source: JICA Study Team

Figure 6-7 Action of Station Staff in Case of Fire in the Station Premises

6.2.4 Driver Operation Plan

It should be noted that this section is closely related to the section on the CCP, since on the modern railway, the train operation will be carried out based on close communication between the drivers and the controllers in the CCP.

(1) Single Driver Operation

On Metro Line 2 of Cairo Metro, trains are operated only by a single driver without an assistant driver. His functions are as follows;

- Closing/opening of the door for alighting /boarding of passengers at stations
- Operation of the train

- Stopping the train when he/she recognizes an abnormal situation

Closing /opening of train doors is carried out by the driver to maintain the security of passengers alighting /boarding on the platform. On Metro Lines 1 and 2, CCTV monitors that can provide the drivers a full view of the platform are installed on the platforms at stations. Full PSD will be installed on Metro Line 4. Hence, a CCTV monitor will be provided in the cabin since the driver cannot see the passengers on the platform from the cabin at stations with full PSD.

Basically, reverse operation is not allowed. When such operation is required, the driver must change the cabin for safety. Therefore a reverse operation is not needed except in cases when the back cabin is not functioning or a train-set does not have a back cabin in the depot. The switch is installed in such a way that it cannot be pushed accidentally to change driving direction.

Basically, the driver can carry out the troubleshooting and recovery action on board against failure or trouble on rolling stock.

(2) Driverless Operation

Normally it needs six months or more to train the drivers for the Cairo Metro. Repetitive instructions for drivers are also needed. Nowadays, ATO is installed on a standard basis on modern urban commuter lines. Therefore in some countries, to avoid labour problems or to reduce number of staff, a driverless operation is adopted.

When a driverless operation is to be implemented, consideration must be given to the following issues:

- When the ATO/ATP does not work, it will be necessary to dispatch a train operator to the train with ATO/ATP trouble. For these staff, some training on train operation will be required.
- When some incident occurs, it will be necessary to provide guidance information to passengers on board. Such information should be provided through a wireless communication system between the CCP and individual passenger coaches of the train-set.
- In case of single driver operation, single mode architecture of ATO system is normally enough since ATO on board is not a facility to secure safety and when it fails, a driver can operate the train manually without ATO. Where driverless operation is adopted, ATO should be upgraded to double mode to ensure high availability.

Technically driverless operation can be realized. In Singapore and Paris metros, driverless operation of mass rapid transit (MRT) has already been adopted. In Japan, driverless operation is not adopted considering the fact that such operation appears not sensible for commuter trains carrying more than one thousand passengers per train. Japanese commuters refuse to get on an MRT without a driver. In the ultimate sense, driverless operation is not a technical matter but a matter of culture.

The JICA Study Team interviewed a few officers of Cairo Metro. They suggested that a sophisticated working system is not preferred in Egypt. Therefore, the JICA Study Team is proposing a single driver operation for Metro Line 4.

(3) Operation with ATO/ATP

Considering safety for Metro Line 4, an ATP system will be installed. An ATO system will be also be installed to assist driver operation.

For ATO/ATP, three operation modes will be provided as shown in the following table.

Table 6-3 Operation Modes

<table>
<tr><th colspan="3">Mode</th><th>Note</th></tr>
<tr><td>1</td><td colspan="2">ATO</td><td>ATO will be adopted for normal operation</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">Manual</td><td>ATP</td><td>This mode will be adopted for operation during ATO failure and training for manual operation</td></tr>
<tr><td>Emergency</td><td>Operation when ATP on the ground fails. Maximum speed is limited to 25 km/h</td></tr>
<tr><td>Cut off</td><td>Operation when ATP on board fails or for trial running on the test track of the depot.
Maximum speed is ordered by the controller.</td></tr>
<tr><td>3</td><td colspan="2">Wayside Signal Mode</td><td>Operation with the way side signal in the depot area. Maximum speed is limited to 25 km/h except on test track</td></tr>
</table>

Source: JICA Study Team

Normally trains are operated with an ATO system. When ATO fails and ATP is active, the driver can operate the train in accordance with an ATP signal.

In the Cairo Metro, the dwell time at stations is designated as 30 seconds, but in reality during the morning peak hour, it frequently extends to 1 minute, since the volume of boarding and alighting passengers at stations is enormous. Therefore, ATO is not used during the peak period. Basically, the minimum travel time with modern ATO is same as that with a driver and such an issue can be solved by improving ATO functions.

When ATP on ground does not work, the driver has to stop the train and receive an order from the CCP to select the emergency operation mode of ATP. In this situation the maximum speed is limited to 25 km/h.

When ATP on board fails, the driver can select the ATP cut off mode and operate the train at the speed designated by the controller in the CCP (possibly 15 km/h) to the nearest station. There are two options for the operation from this station. One is to continue the train operation with the limited speed without ATP and the other is to operate the train with a substitute block mode. In the latter option, the driver can increase the train speed (for example, 40 km/h). However it should be noted that prior to the execution of the operation with the substitute block operation system, all the trains on the section where the substitute block system is adopted must be evacuated from these sections. All of these actions must be ordered by the controller.

(4) Shunting at Stations

Shunting at stations is usually carried out at the normal position of ATP.

When the ATP on ground does not work, the driver can select the emergency operation position of ATP based on orders from the controller.

When the ATP on board does not work, the driver can select the ATP cut off position based on orders from the controller. The controller must lead the train through radio communications after confirming it's the route with the operation staff of the station. Maximum speed for this operation will be 15 km/hr.

(5) Shunting at Depot

The ATP system is provided on the section between the main line and the stabling tracks and on the section between the stabling tracks and the turn back tracks in the depot.

On the section between the turn back tracks and inspection tracks in the depot, wayside signalling will be installed. On this section, the driver will select the wayside signal mode as the operation mode. With this mode, the train brake will be released and the maximum speed will be controlled to a 25 km/h limit.

When the ATP/wayside signal does not work, the controller will lead the train driver through radio communication after confirming its route with another driver dispatched from the drivers' depot. For this operation, the maximum speed is 15 km/hr.

6.2.5 Station Operation Plan

The following sections discuss the role of station staff and system on Metro Line 4 and a detailed description of train operational activities at stations.

(1) Role of Station Staff

The major role of station staff is assumed as follows.

1) Ticketing business

Currently on Metro Lines 1 and 2 of the Cairo Metro, passengers need tickets to pass through the ticketing gate machine. It is now planned to replace these gate machines with new ones, which are compatible with the smart fare card.

Therefore on Metro Line 4, it is proposed to adopt a ticket gate system compatible with both tickets and smart fare card.

At existing metro stations in Cairo, tickets are sold manually. Basically, it will be preferable to install ticket vending machines at stations from the viewpoint of establishment of a lean working system at stations. However, the condition of bank notes in Cairo is not suitable, while use of coins have only been introduced recently and is not yet adopted in wide circulation. Hence, it is assumed for this plan that all tickets will be sold manually, at least during the opening stage.

2) Gate Management

Problems will occur frequently at automatic ticketing gate even where a contactless smart card system is employed. Therefore, some gate management staff will be needed. For the existing lines of the Cairo Metro, the prevention of passengers without tickets from passing the gates is accorded high priority. With the introduction of new gate machines, establishment of a lean working system will be required for a sound financial management.

On the Cairo Metro, respect for senior passengers on board is generally observed..Hence, such public behaviour at the time of passing the gate with tickets can be expected. Courtesy in riding the metro with tickets can be further enhanced through public advertisements.

3) Train operation

Train operation at stations should be simple to decrease the number of station staff. Hence the JICA Study Team is proposing a system whereby train operation will be carried out by train drivers and controllers in the CCP without any station staff. Signal operation inside the depot will also be carried out in the CCP.

Therefore train operation functions at stations will be limited to cases where there is disruption of normal train operations and so on. Train operations at stations are discussed in more detail in 6.2.5(2) below.

In case of fire accidents, most of fire extinction and smoke ejecting tasks will have to be automatically activated. In case of fire accidents, station staff will have to be engaged in guiding the passengers during evacuation, initial extinction of fire, supervision of machines, announcement to passengers and reporting to the CCP.

4) Guidance of passengers

Assistance for passengers will be one of the major roles of station staff. Typical tasks are illustrated as follows.

- Foreigners or senior passengers who have limited chances to ride the Cairo Metro line will find it difficult to buy tickets or to pass the gates. Cairo has a lot of tourists from abroad every year who cannot read Arabian characters. Hence for Metro Line 4, it will be essential to allocate station staff who can speak English. Sufficient English language signages should also be provided.

- Handicapped passengers in wheel chairs will need assistance in riding the train.
- When train operations are disrupted, passenger guidance to alternative transport means, such as bus services along the line, will be needed.
- Station staff will have an important role during emergency evacuations. (See 6.3 for a description of the role of station staff in this respect.)

5) Management / administration inside the station

The typical roles of management/administration at stations are as follows.

- Staff management and administration
- Cash Management of fare revenue
- Administration of station premises
- Station premises are wide, and physical inspection of premises will be an important task of the station management.
- Keeping premises clean can be achieved only through frequent inspections by station management. Cleanliness of premises can be attained only by advising the concerned staff to clean daily. Such inspections will also involve identifying problems on station equipment, such as faulty lighting lamps.

6) Keeping security inside the station

People will avoid riding on the MRT when they feel that there are associated risks. Maintaining the security of the metro will therefore be important. Eliminating risks, whether related to terrorism/violence or merely to the presence of homeless people in the stations, will be indispensable for the maintenance of security. Close contact with the police will also be important. In the Cairo Metro, policemen are deployed throughout the station premises, providing safeguards against risks.

(2) Train Operation Tasks at Stations

Basically on Metro Line 4, there will be no train operation tasks to perform at stations when train operation is normal. PSD will be installed on the platform and no station staff will need to be allocated to supervise the boarding/alighting of passengers. It may however be necessary to assist the police in maintaining and providing protection against violent behaviour or illegal activities such as pick pocketing.

When some trouble or failure occurs in train operation, station staff will have to be involved in the following tasks.

Local Signal Control

When the central signal control system cannot determine the route at a station, route control may be done by a local signal control system. In such cases, station staff will have to identify routes based on orders from the controllers in the CCP. Display of departure signals to drivers and locking of turnouts may be the other tasks required of station staff.

Preparation of Logistics due to Service Disruption

In the case of normal service disruption, station staff will be required to organize the logistics of alternative transport.

6.2.6 Depot Operation Plan

On Metro Line 4, the depot will be located at the western end of the line. In this section, the basic functions, track layout and route control of the depot are discussed. It should be noted that in other countries the track layout at the depot is often planned without consideration of operational needs and as a result, shunting activities become inefficient.

(1) Function of Depot

Normally in the depot, the following three functions are provided.

- Stabling of train-sets
- Daily inspection/maintenance of rolling stock
- Overhaul inspection/maintenance of rolling stock

It should be noted that in some cases, inspection/ maintenance of infrastructure is carried out.

The stabling capacity required at the depot depends on the total capacity of the line. The extension of the Metro Line 4 is planned as part of the master plan of urban railways in Cairo and another stabling yard will be provided along the extended section. Therefore the stabling capacity required for this depot is the same as the ultimate number of the train-sets for the line.

In the depot, the two types of daily inspection (weekly and monthly), as well as overhaul maintenance, cleaning works and wheel profiling are carried out. Therefore, facilities for daily inspection, cleaning and wheel profiling are provided in the depot.

Other than the facilities for the stabling and maintenance of rolling stock, other maintenance facilities for tracks and system infrastructure will also be located at the depot site.

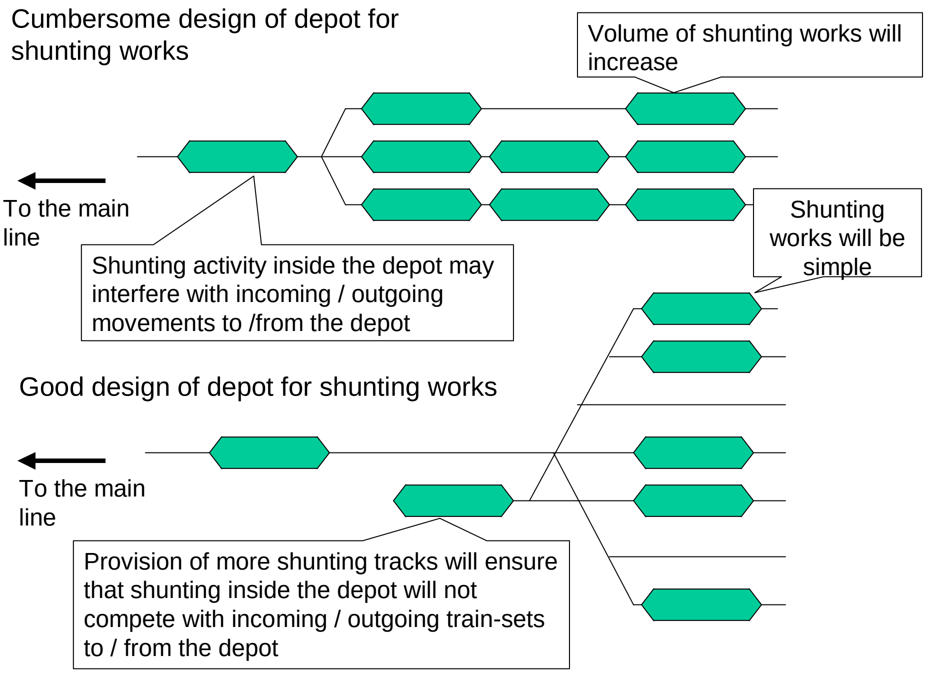
(2) Track Layout in the Depot

From an operational viewpoint, the basic design of the stabling yards should conform to the following two principles.

- One train-set on a single stabling track if train-set can go into/come from the stabling tracks only from one end; and
- Incoming/outgoing traffic from/to the depot should not affect shunting works inside the depot.

The signaling system will be designed so as to allow incoming train-sets to approach the depot, even if shunting activities are ongoing inside the depot.

The maximum stabling capacity at the depot in Phase1 is equal to or more than that of the number of train-sets at the ultimate stage, i.e., 35 in 2050 (The train-set number for Phase 1 + Phase 2 is estimated as 70 in 2050. Based on this, the depot in Phase 2 section should have a stabling capacity for 35 train-sets in the ultimate stage.).



Source: JICA Study Team

Figure 6-8 Design of Depot for Shunting Works

(3) Route Control and Shunting

Route control for the stabling yard in the depot is carried out at the signal cabin of each depot on the existing lines of the Cairo Metro. As already mentioned, the JICA Study Team will propose that these tasks should be done by the controller (rolling stock/depot) in the CCP. The reasons for this are as follows.

- The entrance/exit of trains to/from the depot needs close communication between the controller in the CCP and the signal operator in the depot.
- Normally the controller in charge of rolling stock in the CCP will not be busy and extra tasks will be needed to expand his tasks.

- Shunting activities in the depot will be small since shunting activities in the depot will be simple.

The drivers assigned to shunting activities in the depot will be dispatched to the depot from the drivers' depot. This will be same as for the existing system.

When the ATP does not work, route confirmation must be done by a driver dispatched from the driver's depot.

Planning of shunting for daily inspection and cleaning of cars will be done by the planning staff of the maintenance team. Said plan has to be sent to the controller in charge of the depot.

6.3 Maintenance Plan

Enhancement of work efficiency is discussed as the main theme of the maintenance plan for Metro Line 4. For enhancement of work efficiency, facilities without maintenance or with small maintenance work volume are basically indispensable, and hence, improvement of facilities is discussed first. Subsequently, some measures for enhancement of maintenance work efficiency are introduced. The specific working system in modern urban railways is then discussed. Finally, the topics on outsourcing of maintenance works are presented since such works is adopted in the existing Cairo Metro.

6.3.1 Target of Maintenance Work

The purposes of the maintenance tasks are as follows:

- To ensure safety
- To keep punctuality in operation
- To provide for passenger comfort
- To reduce adverse environmental effects, (such as noise or vibration) on the residents along the railway.

For railway companies, the target of maintenance work improvement will be to reduce the maintenance cost. It is noted that ensuring the safety of maintenance staff at work is also important for railway companies. Nowadays, based on the improvement of maintenance technology and management systems, it is possible to realize maintenance at a considerably lower cost.

6.3.2 Improvement of Facilities

Improvement of facilities and maintenance tools will be directly related to that of the maintenance working system. Hence, the improvement of facilities and maintenance tools is presented first. Then, as a typical example of improvement of working systems, the facilities adopted in Japan are introduced. The specific number of working staff for maintenance for Metro Line 4 is discussed in Section 6.5, which deals with the estimation of number of staff.

(1) Contents of facility improvements

Recently, urban railway technology has been dramatically improved. As a result, maintenance performance has been enhanced substantially. At the same time, technological improvements have allowed maintenance tasks to be carried out more easily and have reduced the volume of maintenance works.

Previously, most equipment was made up of mechanical parts, and a lot of workers were required to perform maintenance works, as the adjustment of mechanical parts was very complicated, that necessitate high skills and heavy work volume. Nowadays, from the maintenance viewpoint, railway equipment has been improved by utilizing modern technologies such as micro computers, various special materials such as stainless steel, and so on. The main principles for the improvement of maintenance works should be as follows.

- To adopt materials of high quality
- To adopt materials or systems which will not need maintenance
- To reduce the mechanical movement parts as much as possible

Typical examples of facility/equipment improvement are described for each department in the following table. As shown, a typical improvement in the department of electrical power is not found, though it is known that there have been cumulative small improvements in this field.

Table 6-4 Typical Examples of Facility Improvement

Department	Typical improvement of equipment	Effects on maintenance
Tracks	Tracks without ballast	Eliminate ballast tamping works
Signal/ telecom	Replacement of relays by micro–chips	Minimize inspection activities
Ticket equipment	Contactless card	Minimize inspection of mechanical movable parts
Electrical power		
Rolling stock/ Mechanical facilities	Replacement of DC motor with AC motor Stainless steel body	Eliminate commutator maintenance Eliminate painting works

Source: JICA Study Team

(2) Adoption of new technology and its risks

Rolling stock is a fundamental item of railway equipment and recent innovations have radically improved its performance. Adoption of new technology and its risks will be discussed in the following section by taking as an example the procurement of rolling stock.

Consideration of total Life Cycle Cost

In deciding on the selection of rolling stock, careful consideration must be given to the total cost including expenses for maintenance in addition to the initial investment cost. The cost and availability of spare parts are the important factors for the operation stage.

Selection of Stable Technology

Rolling stock incorporating new technology is subjected to repetitive testing in order to confirm its practical applicability. However, there is an infinite variety of conditions for rolling stock usage, and no test can cover every possible situation. Furthermore, practical tests can be undertaken only for a limited number of times.

Source: JR East
This rolling stock is representative of the type of rolling stock used for commuter services in Japan. It was conceptualized that enhancement of the total cost performance is the major target. Its IT specification is also state of the art, and its train-wire is digitalized.

Figure 6-9 Photo, E231 series of JR East

Newly developed rolling stock is desirable due to its technological advantages. However, if it is purchased at an early stage of its development, it could have been offered as trial for further improvement, which could bring about an increase of maintenance cost for the operator to bear. As a worst case, it could cause trouble to normal operation and many other inconveniences. It would be wise to select rolling stock of a type which has been produced in large quantities and is equipped with systems that have been fully improved. That is the key to less trouble and easy maintenance.

Source: JICA Study Team
This controller can contribute to a high running performance with an AC induction motor which needs only limited maintenance.

Figure 6-10 Photo of Modern IGBT Developed for Power Control

Coordination of New Technology with Conventional Specifications

Staff working on the maintenance of rolling stock incorporating different types of designs have more burden, as they are required to have a variety of knowledge on the structure and maintenance of each type. Lack of skills will lead to frequent breakdowns and inability to execute effective troubleshooting measures. In addition, a proliferation of various designs will require inventory of larger parts.

In the meantime, technologies are being continuously upgraded. If there is adherence to old technology for the sake of compatibility, a more efficient rolling stock would never be acquired. In time, old parts will no longer be available, leading to a lot of extra work, increase of costs, and so on. Although adopting new technology may contradict a policy of uniformity in technical specifications, a careful but radical judgment is sometimes encouraged according to need.

Importance of High Quality Parts

Usually, no one can imagine that wheels of rolling stock will be broken during normal operations, but in reality, these accidents have happened.

Basically, high quality wheels will not be broken during normal operations, but its unit price is high. To maintain high quality, suppliers of such parts have made strong efforts to develop special materials and manufacturing techniques, although they are not physically visible. To produce such high quality parts, suppliers have made significant investments.

If a railway operator wants to ensure safety, it should not purchase second-class products for the key safety parts.

(3) Improvement of Maintenance Tools

In railways, only improvement of facilities and rolling stock remains as the focus. However, maintenance tools/facilities have also been improved in coordination with the improvement of facilities and rolling stock. These have contributed to the enhancement of maintenance work efficiency. These improvements are discussed in the following sections.

Introduction of Monitoring System

As mentioned in the previous section, after a control system with relays is replaced with a micro- computer system, inspection works are not required.

Also, a monitoring system can be easily introduced with a micro-computer based control system. When a failure occurs in a micro-computer based control system, occurrence of the failure will be reported to the maintenance staff through the monitoring system. Replacement of the failed micro-computer can be done the next day since its function is taken over by a stand-by computer. Introduction of the micro-computer based control system will improve not only the efficiency of inspection activities but also the efficiency of repairing activities.

Introduction of New Maintenance Tools/Machines

For equipment maintenance at elevated sites, such as for inspection of catenaries, ladders used to be the only tools utilized., Nowadays, tower trolley cars are employed for such work. With the trolley cars, moving to another site can be done quickly and will prevent maintenance personnel from falling from high elevations. These trolleys have already been introduced on Cairo Metro Line 2 and will also be introduced on Metro Line 4.

Source: Photo taken by JICA Study Team

Figure 6-11 Trolleys for Working at Elevated Metro Line 2 of Cairo Metro

Normally, it seems desirable to delay maintenance in order to save costs. However in the case of track maintenance, there are cost-saving advantages to repair the damage with a rail grinding car in the early stages of damage. If rail damage is neglected until it becomes worse, its partial replacement is unavoidable which will involve hard work. Operating a rail grinding car periodically can be done easily and with this maintenance. The extent of rail wear per unit of time will decrease since the surface of rail will be kept in best condition at all times and damage on the smooth surface of the rail will not occur easily. Further, the noise from damaged rail will be reduced.

Introduction of new maintenance tools/machines, including robotic systems will enhance work efficiency and the safety of working staff.

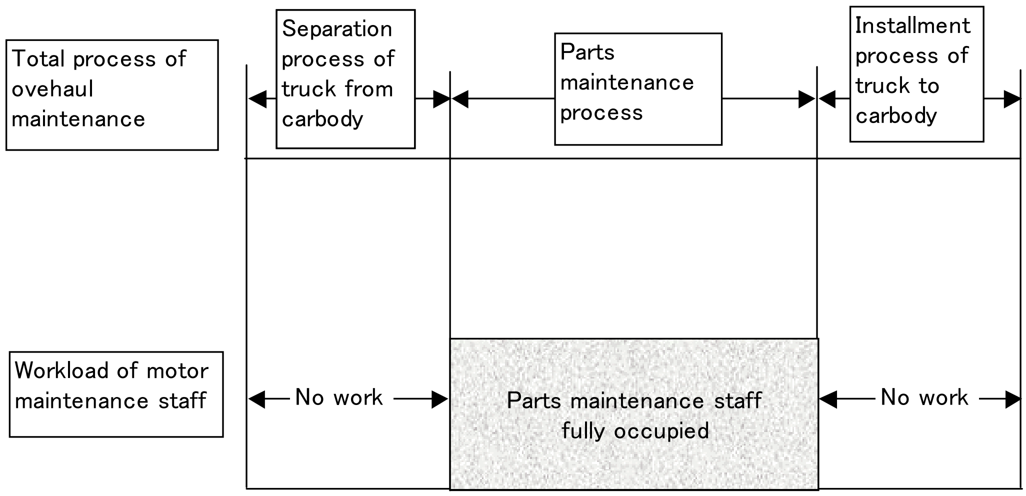
6.3.3 Improvement of Work System

The following are measures for the enhancement of maintenance work efficiency in urban railways. Some of them may have already been adopted in Cairo Metro.

(1) Introduction of multi-skilled workers

In railways, extensive skills are required for maintenance works, but in most cases, workers have only a single skill. Maintenance will not usually require full time use of individual skills. Therefore, work efficiency becomes low. If a worker has two or more skills, his work efficiency will be usually higher than that of a worker with a single skill.

There are cases when a single-skilled worker has no work in the process of overhaul maintenance works. (Please see the following chart.). On Metro Line 4, a multi-skilled worker policy should be adopted to enhance efficiency.



Source: JICA Study Team

Figure 6-12 Case of Single-skilled Workers

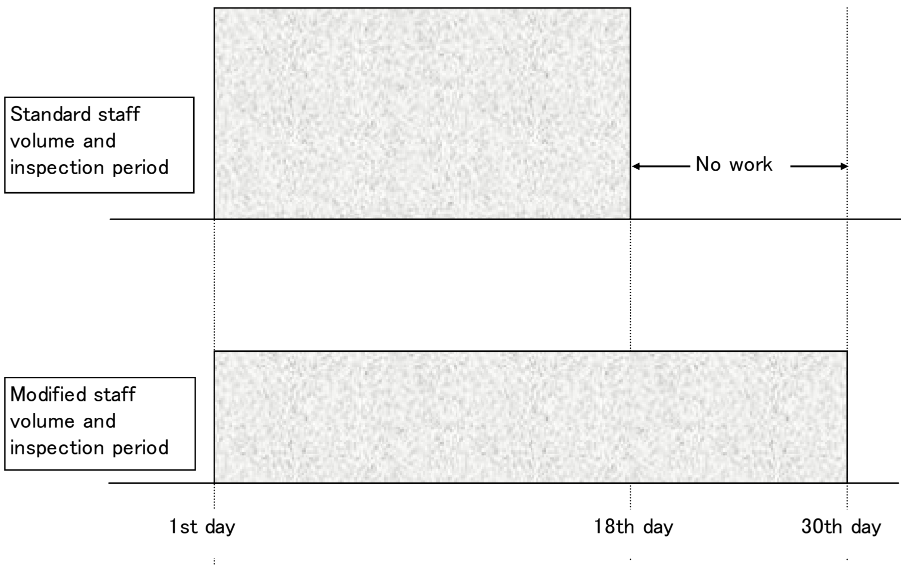
Controllers at the CCP of Metro Line 2 of the Cairo Metro are typical multi-skilled workers. They have knowledge in driving trains, signals, power supply and tracks. They can manage the traffic control and power supply with the assistance of ATS, power SCADA and facility SCADA. It can be noted that, as a result, the number of staff for Metro Line 2 is less than half that of Metro Line 1. Although this case is related to operations rather than maintenance, it illustrates the benefits of multi skilled workers.

(2) Leveling of Maintenance Workflow

In maintenance workshops, it is often observed that the volume of work done varies from day to day. On a particular day, workload may be very large, and may be very small or none at all on other days. In such a case, a leveling out of the workload will be needed for required number of staff may be reduced.

The standard period for inspection and a major overhaul of a train-set is 10-18 days. However in the Cairo Metro, this period is extended to a month and the number of working staff engaged in overhaul work is reduced as compared to a standard system. If the modification in overhaul work is not adopted, maintenance staff will have no work for half of the month (please see the following figure which shows the potential benefits of a levelling the workload).

From the operation viewpoint, the shorter the period of inspection, the greater the availability of rolling stock for traffic. Since spare train-sets have already been provided to allow for overhauls at any time, the spreading of the maintenance workload over the month will not affect the availability of sufficient train-sets for operation. A precise study will be required to determine whether a workload levelling policy should be adopted. However in principle, if it is adopted, there is a potential to bring about a substantial improvement of efficiency at no additional cost.



Source: JICA Study Team

Figure 6-13　Leveling of Work at Workshop of Metro Line 2

(3) Daily inspection in the daytime

In urban railways, maintenance work is done mainly at night since at daytime, a lot of trains are operated and any maintenance work subject the concerned staff to danger.

However, inspection of the rolling stock is normally done at the depot, where monthly inspection and overhaul maintenance is carried out at daytime. In the Cairo Metro, a part of the daily inspection is already carried out at daytime, but currently the daily inspection interval is extended to once every ten days maximum. By adopting Japanese practice, the inspection workload can possibly be reduced to two thirds of the workload of the existing system in the Cairo Metro. On Metro Line 4 of Cairo Metro, all daily inspections should be planned at daytime to enhance work efficiency.

Table 6-5 Number of Daily Inspections by Time Interval on Metro Line 2

Version	Daily inspection period	Inspection work load (minutes x staff)	Number of train-sets inspected		
			Total number per day	In the day time	In the evening
Current	Every 4 days	180	9	4	5
Modified	Every 6 days	120	4=(9 x4/6 x 120/180)	4	0

Source: ECM, JICA Study Team

(4) Securing long time interval for special maintenance works

On urban railways, replacement of rail or other equipment can be carried out only during the time intervals when there is no train operation. Such work should be planned to be completed within the maintenance time zone at midnight.

However in some cases, if the maintenance time zone is extended more than normal, work efficiency will increase substantially. In such cases, it may be necessary to secure the required time interval for maintenance/replacement works by reducing the train operation time interval, in a section where special maintenance or replacement works will be done. It is noted that when such measure is adopted, there should be careful selection of day for these works in order to reduce adverse effects on passengers.

On Metro Line 4, most of the track structure will be ballast-less and the maintenance work volume will therefore be small. Howeverm in the case of rail and signalling system replacement or improvements, this measure can be utilized.

6.3.4 Outsourcing of Maintenance Works

Outsourcing has been adopted as one of the main methods for undertaking maintenance on the Cairo Metro. In this section, the meaning of outsourcing, as well as the period and procurement of spare parts, is discussed. At the end of this section, maintenance management in a difficult financial situation is addressed.

(1) Outsourcing of Maintenance Works

Purpose of Outsourcing

In general, adoption of outsourcing aims to achieve the following two purposes.

- **Hiring of technology**
  Urban railway technology is predominantly not common, but is specific to individual systems. Therefore it will be necessary during the initial stages of urban railway development to hire engineers from the suppliers who can install the required technology.
  Suppliers will also be requested to take care of trouble shooting works that cannot be completed by the railway operator.

- **Reduction of cost**
  The metro O&M company can save costs by requesting the maintenance companies in the field to provide all maintenance services. The maintenance companies in the field have a lot of customers throughout Greater Cairo and can enhance work efficiency more easily than the metro O&M Company (Please see section "6.3.3(2) Levelling of maintenance workflow"). Outsourcing of escalator maintenance is a typical example of a category where such benefits can be realized.
  Even on a later stage when the metro O&M Company has fully acquired all the relevant technologies, maintenance works in some cases will still be outsourced to specialized companies. This is done in order to reduce average personnel costs, since most maintenance work is repetitive and, except for supervision and management, does not need high engineering skills.

Period of outsourcing

In the Cairo Metro, maintenance of rolling stock and the signalling system is outsourced. The outsourcing history of rolling stock maintenance for Metro Line 2 is as follows.

- For the initial two years, the guarantee period, suppliers were obliged to train local maintenance staff in maintenance procedures.
- For the following two years, Egyptian National Railways (ENR) conducted the maintenance works themselves under supervision of foreign experts assigned by the suppliers.
- For the next four years, maintenance works were outsourced to Misr Japan Alled Company for Rolling Stock Maintenance and Renewal (MJC).
- For the next three years, Egyptian Company for Metro (ECM) conducted all maintenance work by themselves again.
- From August 2008, maintenance work was outsourced again to MJC. Equipment suppliers are the major shareholders of this company.

Basically, maintenance work is one of the major activities of the metro O&M Company. It is appropriate for ENR or ECM to do the maintenance themselves, but history reveals that the outsourcing period was too short to perfectly acquire the maintenance knowledge.

It should be also noted that all the maintenance works cannot be carried out by the metro O&M Company. Even in case of Japanese railway companies, engineers from the suppliers are contacted when some difficult troubles occur.

In Bangkok, the urban railway O&M Company wants to do the maintenance works themselves but some ten years after the opening of the system, the company is still obliged to utilize its supplier for maintenance works. In the urban railways of Ho Chi Minh City, maintenance work for the initial five years is planned to be outsourced to the suppliers.

Based on these facts, the JICA Study Team proposes that the outsourcing period from the opening should be five years at minimum, and ideally ten years, for the maintenance outsourcing of Metro Line 4.

Supervision of outsourced work

In the Cairo Metro, a number of ECM supervision staff is allocated for the supervision of outsourced works. This may be essential for outsourcing involving contacts with private companies. If these works are to be done by ECM, these staff will not be needed.

In railways, the results of maintenance works can be evaluated with the data of train operation. The relationship between the data of train operation and the quality of maintenance works is statistical. Even without supervisors, the output of outsourcing contracts can be measured with statistical indicators, such as the availability of equipment.

The JICA Study Team will propose that for the outsourcing of maintenance works in Metro Line 4, statistical analysis should be adopted to replace direct intervention by the supervising staff of ECM so as to reduce the required number of such staff.

(2) Spare parts

In maintenance works, it is important that all spare parts will be available when needed. In this section, issues surrounding the procurement of spare parts will be discussed.

Procurement of Spare Parts

Procurement of spare parts for the maintenance of the Cairo Metro is carried out by ECM. It seems that ECM commits much effort to procurement activities since it is an organization of the state and must follow strict tender procedures.

In reality, however, the required volume of spare parts can be foreseen, since the wearing or failure ratio of rolling stock parts is based statistically on the law of large numbers.

Therefore, the JICA Study Team will propose that procurement of spare parts should be left to contractors and included in the maintenance contract of Metro Line 4.

Procurement lead time of maintenance parts

It is said that the lead time for procurement of maintenance parts is too long in the Cairo Metro. In some cases, it takes a year to deliver the required parts. Basically, the situation in Japan is also same as that in Cairo. Most spare parts especially for control equipment are a kind of special hand-made parts since their lot volume is very small. Most of the spare parts required for the maintenance are discontinued products, since equipment parts are improved year by year. To produce such parts, a production schedule should be arranged without interference to the current production schedule. After that, each required part will be gathered for input to the production work. Therefore the process takes a long time and cannot be changed easily. The procurement lead time of spare parts should be taken into consideration when the spare part inventories are planned for Metro Line 4.

Importance of statistics

In this section, it is suggested that railway activities may be monitored and controlled with assistance of statistical analysis. In railway business, the future perspectives can be foreseen since the activity of railway business may be measured statistically. Hence, preparation of the relevant statistics, such as the number of incidents, train running kilometres and consumption ratio of spare parts, will be indispensable for railway business.

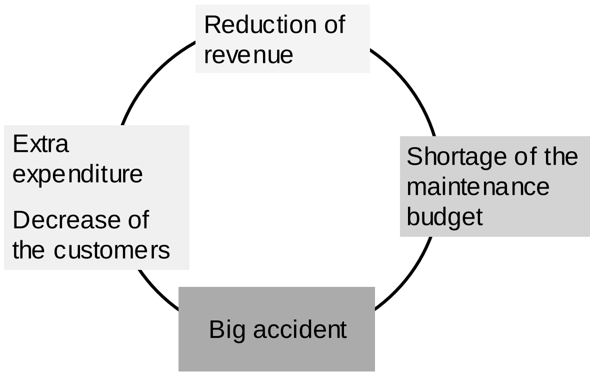
In compiling statistics, it is most important to report the occurrence of incidents correctly. If the causes of incidents are left without any countermeasures, these incidents will occur again. Frequently, incidents are due to staff's mistakes. In railways, when it is confirmed that such incidents occur, the staff involved will usually be subject to disciplinary action. Hence, a staff member who committed mistakes will make efforts to hide these incidents.

It must be noted that in railways, to clarify the cause of an incident is important in order to avoid reoccurrence of the same type of incident, but the damage of an incident cannot be compensated by punishment.

(3) Securing a sufficient budget for maintenance

Since there is a strong expectation of a high degree of punctuality, it is necessary to ensure a scheduled train operation on a daily basis by implementing preventative maintenance. Preparation of a sufficient budget for procurement of spare parts will be necessary to support this preventative maintenance. However, even when preventative maintenance is not carried out periodically, unfavourable consequences do not arise immediately. Because of this, when confronted with financial difficulties, railway companies tend to cut the budget for maintenance to reduce costs. However, this can only be done at the expense of providing a reliable railway. Figure 6-14 shows the consequences of an under-investment in rolling stock maintenance.

It should be noted that since the good management of an urban railway depends more or less the support of infrastructure development from the central and local governments, the above issue relates not only to the railway operator, but also to the railway policies of those governments.



Source: JICA Study Team

Figure 6-14 Vicious Circle of Management

6.4 Organization Plan

6.4.1 Existing Organization

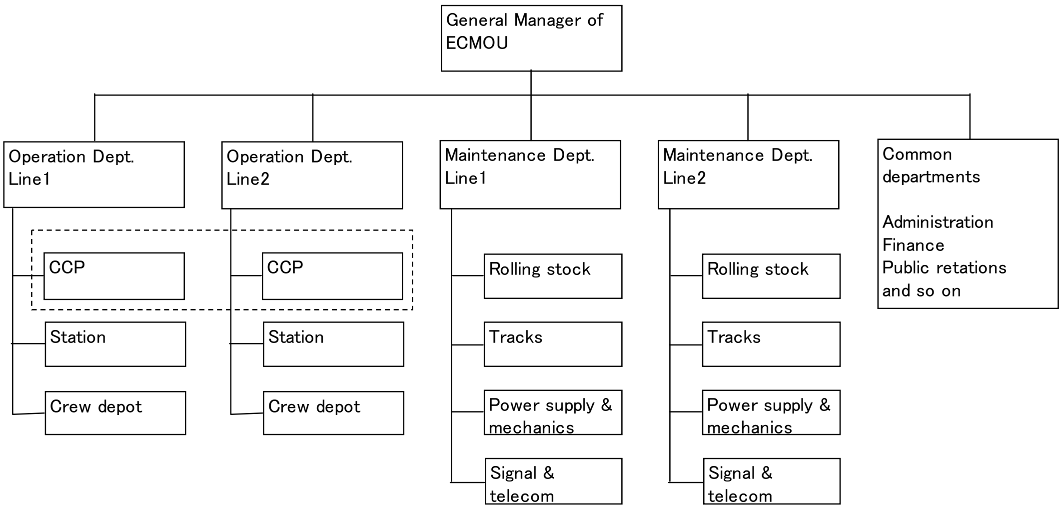
Currently the Cairo Metro lines are operated by ECM. Their management organization is shown on the following chart. Its special features are as follows:

Under the general manager of ECM, common departments, operations departments and maintenance departments are established. An operations department and a maintenance department are organized for respective lines. Since office space in the Ramses complex is limited, only directors of each department have offices. Basically, managers under the director of a department have their offices at stations or depots.

CCP's of Metro Lines 1 and 2 are located at the Ramses complex. These are consolidated under a manager in charge of CCP for Metro Line 1 and Metro Line 2.

Under each operation department, stations and a crew depot are established. Since the headquarters of the operation department is required to have close communication with stations, the general managers of operations departments must have offices in the centre area of the line(s) under their supervision. The general manager of Metro Line 1 has his office in the Ramses complex adjacent to Mubarak Station of Metro Line 1, and the general manager of Metro Line 2 has his office at Attaba Station of Metro Line 2.

Under each maintenance department, worksites for rolling stock, tracks, power supply and mechanics, and signal and telecom are established. Respective general managers have their offices in their main worksites.



Source: ECM

Figure 6-15 Existing Organization of ECM

6.4.2 Organization Plan for Metro Line 4

(1) Reconfiguration of Existing Organization

The Chairman of ECM was assigned to his present position six month ago. He intends to introduce modern management systems to ECM. He has already introduced a separate accounting system by individual metro line. He is planning to reconfigure the ECM organization to establish a new organization where the operation is designated as the core business of ECM. The concept is expressed as follows:

- Maintenance of rolling stock should be included in the operation group since rolling stock maintenance is closely related to the train operation.
- Each maintenance department of Metro Lines 1 and 2, except for rolling stock maintenance, will be consolidated to an infrastructure group since infrastructure should be managed by a unit for enhancement of efficiency.
- Refurbishment, upgrading and modernization will be carried out by the project department since these are significant for ECM for some years.
- A non-rail business department will also be established.

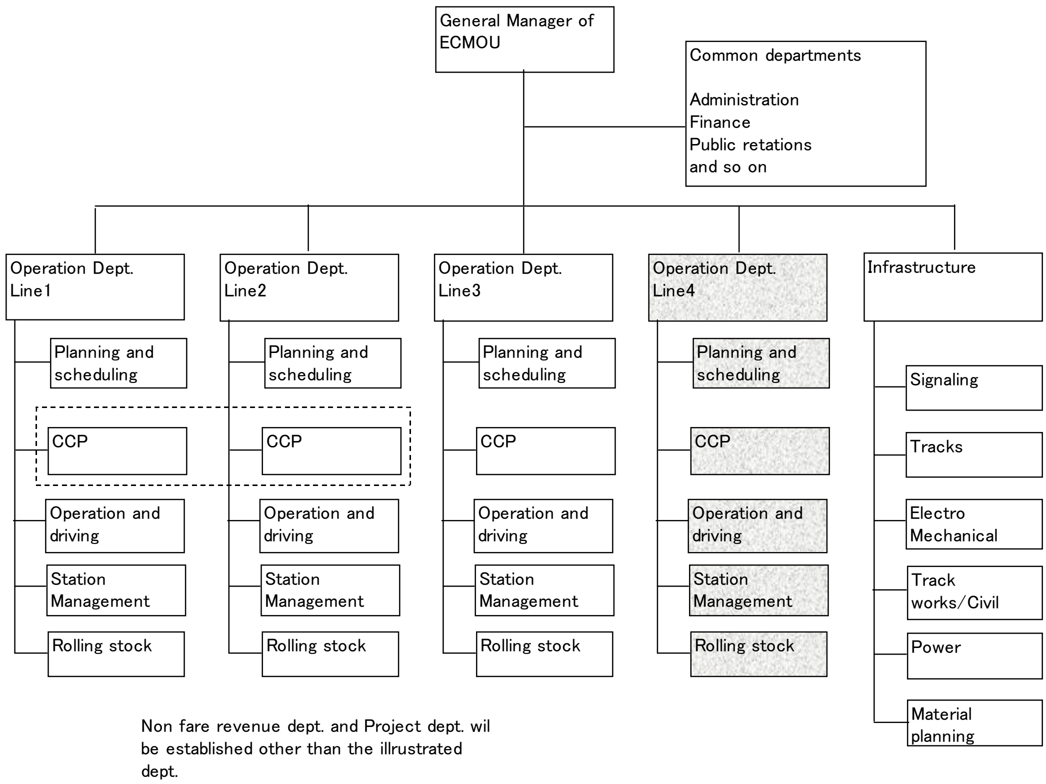
(2) Proposal of organization plan for Metro Line 4

Basically all the urban commuter lines in Cairo will be managed by ECM. Hence in this plan, it is assumed that Metro Line 4 will also be managed by ECM.

Basically, the urban commuter lines are managed by lines although the intercity railways are managed by zones. The operational organization of ECM is basically established by lines. This concept should be maintained in the organization plan for Metro Line 4.

By the time the organization for Metro Line 4 is established, the organization for Metro Line 3 will already be in place. The organization for Metro Line 3 will be established basically with the same concept as that for Metro Lines 1 and 2, except for the CCP. The CCP of Metro Line 3 will be located in Attaba Station, since there is no space in the existing CCP.

It is suggested that the new organization policy of ECM should be adopted as the model for the organization of Metro Line 4. The organization structure of ECM at the opening of Metro Line 4 is illustrated in the following figure, which will become more complex when Metro Line 5 or the subsequent lines start providing services. A kind of intermediate organization may be needed in the future to enable the consolidation of some of the functions for individual lines.



Source: JICA Study Team

Figure 6-16 Management Organization Plan of ECM at the Opening of Metro Line 4

6.5 Estimation of Number of Staff

6.5.1 Preface

Numbers of staff are estimated as a basis for calculating personnel cost which is a major element of O&M costs. By multiplying the average personnel cost with the number of staff, the total personnel cost can be calculated (Please see Chapter 7 "7.2 Estimation of O&M cost").

In Cairo, two metro lines are already in operation. ECM, as the operator of the two lines, has much information on the allocation and number of staff. In Japan, various data of the railway companies are published by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) as Annual Railway Statistics. Estimation of the number of staff for Metro Line 4 will be based on these two sets of data.

The existing Cairo Metro O&M system appears to have some redundancy in staff number and allocation. A comparison will be made between the two data sets in order to determine whether there is potential for improvement of staff efficiency in the planning for Metro Line 4. If there are no big differences, the unit number of the Cairo Metro will be adopted for purposes of estimation.

When a large difference is found between them, corresponding reasons will be assessed. Some reasons for variations may be explained by the specific work conditions applicable in Cairo. In such cases, it may be necessary to modify the unit cost data of the Cairo Metro in order to adopt its data for estimation. In other cases where the particular local work conditions do not affect the number of staff, the unit figures of the Japanese Metro organizations will be adopted for the estimation purposes.

6.5.2 Working conditions in Egypt

The working conditions in Egypt are the basic factors to be considered in making these estimates. In Egypt, working hours per week are 40–48, including lunch time. Working days per year are 261 for drivers and 273 for other staff.

Said working days per week exceed those in Japan by one day. The workload of special duties is considered in specifying working hours. Working hours per day for controllers in the CCP is five and that for drivers is six. In reality, the number of weekly working hours of the Cairo Metro drivers is smaller than that of Japan ((6hours x 6days)/(8hours x 5days)=0.9). For details, please see Table 6-6 below.

Table 6-6 Working Conditions of the Existing Metro Lines

<table>
<tr><th colspan="3">Items</th><th>Egypt</th><th>Japan</th></tr>
<tr><td colspan="2">Calendar days in a year</td><td>A</td><td>365</td><td>365</td></tr>
<tr><td colspan="2">Working hours per day</td><td>B</td><td>5-8</td><td>8</td></tr>
<tr><td rowspan="4">Non working days</td><td>Weekend</td><td>C</td><td>52</td><td>52 x 2=108</td></tr>
<tr><td>National holidays</td><td>D</td><td>20</td><td>15</td></tr>
<tr><td>Paid holidays</td><td>E</td><td>20</td><td>20</td></tr>
<tr><td>Training for drivers</td><td>F</td><td>6 days x 2=12 days per year</td><td>3 days per three years</td></tr>
<tr><td rowspan="2">Total of non working days</td><td>Drivers</td><td>G=C+D+E+F</td><td>104</td><td>152</td></tr>
<tr><td>Staff other than drivers</td><td>H=C+D+E</td><td>92</td><td>151</td></tr>
<tr><td rowspan="2">Working days</td><td>Drivers</td><td>I=A-G</td><td>261</td><td>214</td></tr>
<tr><td>Staff other than drivers</td><td>J=A-H</td><td>273</td><td>215</td></tr>
<tr><td rowspan="2">Working ratio</td><td>Drivers</td><td>K=I/A</td><td>0.71</td><td>0.59</td></tr>
<tr><td>Staff other than drivers</td><td>L=J/A</td><td>0.75</td><td>0.59</td></tr>
</table>

Source: JICA Study Team

6.5.3 Estimation of Number of Drivers

The number of drivers for Metro Line 4 has been estimated from an analysis of the current figures in Cairo and Japan.

Essentially, the work volume of drivers can be measured on the basis of travel time. On urban metro railways, the average speeds of different trains will be similar, if the average distance between stations is also similar. Hence, travel time can be replaced by travel distance, i.e., train km. “Train km per driver” is therefore the unit adopted for the measurement of driver’s work volume.

(1) Daily work volume per driver on existing lines of Cairo Metro

Based on the data from ECM, the daily train km per driver of the Cairo Metro is calculated as shown in Table 6-7. It should be noted that in real operation, this figure is much higher since the number of drivers should include those who take holiday rest.

Table 6-7 Yearly Train-km and Number of Drivers of Cairo Metro

Line	Yearly Train km (2008)	Number of Drivers	Daily Train km per Driver
	A	B	C=A/365/B
Metro Line 1	6,161,566	163	103.6
Metro Line 2	3,641,120	130	76.7

Source: ECM

There is some difference in the figures for Metro Lines 1 and 2 as shown in column (C) of the above table. One of the major reasons for this is likely to be the difference of distance between the stations on each line, as shown in Table 6-8. It is obvious that the section length in which trains can run at their maximum speed is longer on Metro Line 1 than on Metro Line 2.

Table 6-8 Distance between stations on each line of the Cairo Metro

Items		Metro Line 1	Metro Line 2
Route (km)	A	44.0	21.7
Number of stations	B	35	20
Average distance between stations (km)	C=A/(B-1)	1.3	1.1

Source: ECM

(2) Daily work volume per driver in Japan

Table 6-9 below provides details of the average daily work volume per driver on selected metro systems in Japan. These values are similar to those of Metro Line 2, thus it may be said that the work volume of drivers in Cairo Metro is at least as high as that of the Japanese metro systems. However, it should be noted that the weekly number of working hours of the Cairo Metro is smaller than that of the Japanese metro systems (See "Section 6.5.2 Working Conditions in Egypt"). In most cases, average distances between stations of the latter are shorter than those of the former. This means that the travelling time in the Japanese metro systems will on average be longer than that of Cairo Metro. From these two facts, it seems that the working efficiency of the Cairo Metro is almost the same as that of the Japanese metro systems.

Table 6-9 Work volume per driver in Japan

Metro	Total Route Length (km)	Number of Stations	Distance between stations (km)	Daily Train km per Driver (km/driver)
	A	B	C=A/B	D
Sendai Metro	14.8	17	0.87	83.0
Tokyo Metro	183.2	169	1.08	68.9
Yokohama Metro	40.4	32	1.26	76.4
Osaka Metro	129.9	133	0.98	69.3

Note; It should be noted that calculation method of distance between stations is approximated.
Source; JICA Study Team

(3) Estimation of driver numbers on Metro Line 4

Since it has been established that the working efficiency of drivers in the Cairo Metro is almost the same as that of the Japanese metro systems, it was decided to base the work volume per driver on the existing lines of the latter for estimating the number of driver numbers Metro Line 4.

Table 6-10 shows the planned distance between stations on Metro Line 4. From this table and Table 6-8 (which shows the distance between stations on Metro Line 2), it may be seen that the distance between stations on both lines will be similar. Hence, it makes sense to adopt the daily train-km per driver of Metro Line 2 as the basis for estimating the number of drivers for Metro Line 4.

Table 6-10 Distance between Stations of Each Line

Section		Ph1	Ph2	Remarks
Route km	A	16.1	17.6	
Number of stations	B	15	17	El Malek El Saleh station is counted in both sections
Average distance between stations (Km)	C=A/(B-1)	1.1	1.1	

Source: JICA Study Team

As indicated above, the number of drivers for Metro Line 4 will be estimated on the basis of the forecasted train-km. Forecasts of the annual train-km for Metro Line 4 were estimated as part of the train operations plan and are also set out in Table 6-11 below.

Table 6-11 Annual Train-km of Metro Line 4 (Unit: 000km)

Year 2020	Year 2023	Year 2027	Year 2050
2,202	7,994	8,240	8,559

Source: ECM

The number of drivers can be estimated by the following formula:

Required number of drivers=Annual train-km /365 /76.7km

The results of this calculation are given in Table 6-12 below.

Table 6-12 Estimated Number of Drivers for Metro Line 4

Year 2020	Year 2023	Year 2027	Year 2050
79	286	295	306

Source: JICA Study Team

6.5.4 Estimation of number of drivers for depot operation

The number of drivers for depot operation will be estimated on the basis of the following assumptions.

- Multiple shunting works will not be done simultaneously since only one shunting track will be provided.
- Two drivers will be needed for quick shunting, without the need to walk from one cabin to the cabin at the opposite end of the shunting track, in order to change direction of the train-set.

Major shunting tasks are given in Table 6-13.

Table 6-13 Two-driver Shunting System in the Depot

Task	Roles of Drivers	
	Driver 1	Driver 2
Coupling of rolling stock	Operation	Informing the distance between rolling stock to the driver on board. Checking the status of the coupling
In case of signal failure	Operation	Confirmation of the route
Operation without cabin in front end of train-set	Operation	Confirmation of the route
Quick shunting of train-set between stabling tracks and maintenance depot	Operation at the front end	Operation at the opposite end
Quick shunting of train-set between stabling tracks	Operation at the front end	Operation at the opposite end
Operation of train-set for machine washing	Operation at the front end	Operation at the opposite end

Source: JICA Study Team

The number of drivers required for shunting in the depot is estimated according to the following formula:

2 drivers x 4 shifts per day /working ratio (=0.71) =11.3 persons

The following will be the number of drivers for depot shunting.

Table 6-14 Number of Drivers in the Depot

Items		Y2020	Y2023	Y2027	Y2050
Number of Depot	A	1	2	2	2
Unit number of drivers per party	B	11.3	11.3	11.3	11.3
Number of parties	C	2	2	2	2
Number of drivers for depots	D=A x B x C	23	46	46	46

Source: JICA Study Team

6.5.5 Estimation of number of controllers in the CCP

Owing to the lack of any breakdown data for CCP's in the Japanese metro systems, estimation of the number of CCP staff for Metro Line 4 are based on that of the existing CCP of the Cairo Metro.

(1) Number of Controllers for the Existing Lines of Cairo Metro

Table 6-15 gives the staff allocation of the CCP of the Cairo Metro, from which it may be observed that the number of staff for Metro Line 2 is much less than that for Metro Line 1.

Basically, the CCP facilities of Metro Line 1 comprise the consolidated station signal facilities, without automatic route control system (ATS). By contrast, train route control on Metro Line 2 is carried out automatically with an ATS in place, and does not require operators for manual route setting. These differences in facilities explain the difference in numbers of staff between these two existing lines.

Table 6-15 Staff in the CCP of Cairo Metro

Lines	Position	Staff allocation	Staff for shifting	Number of staff	Remarks
		A	B	C=A x B	
Both	Chief of Operation	1	3	3	Common for both lines
Metro Line 1	Train controller	2	7	14	5 hours x 3 (day time)+ 9 hours at night (once a week per controller)
	Signal/points operator	3	4	12	
	Equipment supervisor (called “Centre for Commuting” in existing CCP)	2	3	6	Common for both lines
Metro Line 2	Train controller	2	7	14	Same as that of Metro Line 1
Total				49	

Source: ECM

(2) Estimation of controller number for CCP of Metro Line 4

The CCP of Metro Line 4 will be located at El Malek El Saleh, since no space remains in the Head Office Building at Ramses complex for a new CCP to be established.

On this assumption, the “Centre for Commuting” cannot be common with those for the CCP of the other lines. These staff will be called “equipment supervisors” in the CCP for Metro Line 4. The roles of train controllers were defined in Chapter 4 ”4.2 Train Operations Plan”. For the convenience of readers, this table is repeated here as Table 6-16.

Table 6-16 Major roles of train controllers

Category	Major roles
Management/supervision	Management of the CCP Decision of the operation policy or strategy during contingency operations Delivery of various types of information to the stations and to mass media in a contingency operation
Traffic	Route control for trains Driver operation planning in contingency situation
Rolling stock and depot	Instruction of troubleshooting to the drivers when there is trouble /failure on their train-set Route control in the depot
Equipment supervising	Delivery of information on facility trouble to the relevant work sites Operation of SCADA system Route control for facility maintenance works at night

Source: JICA Study Team

Although a good example cannot be provided from the experience of the Japanese metro systems, the JICA Study Team has an impression that the staff allocation of Metro Line 2 is suitable. Consequently, the JICA Study Team will apply the staffing concept of Metro Line 2 to Metro Line 4.

Table 6-17 gives estimates of the number of staff for the CCP on Metro Line 4. The staff allocation will be minimized, with the application of the smart ATS system. The number of staff will increase in 2023, owing to the opening of the Phase 2 section.

Table 6-17 Estimated Number of Staff at the CCP for Metro Line 4

Position		Number of Staff			
		Y2020	Y2023	Y2027	Y2050
Manager/supervisor		3	3	3	3
Train controllers	Traffic control on mainlines	7	14	14	14
	Rolling stock and route control in the depot	7	14	14	14
	Equipment supervising	7	7	7	7
Total		24	38	38	38

Source: JICA Study Team

6.5.6 Estimation of station number of staff

The number of station staff for Metro Line 4 was estimated on the basis of the current staff allocations for the Cairo Metro and the metro systems in Japan.

(1) Station staff allocation on the Cairo Metro

The current number of station staff of the Cairo Metro is given in Table 6-18. It should be noted that the number of labouring staff is not included in the total number of station staff. It should also be noted that the number of driver supervisory staff is included in the overall management staff.

The number of staff per station of Metro Line 2 is larger than that of Metro Line 1. ECM explained that this difference is due to the rather complicated structure of Metro Line 2 stations than that of Metro Line 1.

Table 6-18 Number of station staff on Cairo Metro

Lines	Station Number	Breakdown			Total	Staff per station
		Management	Operation	Ticketing		
Metro Line 1	35	72	408	551	1,031	29.5
Metro Line 2	20	52	298	398	748	37.4

Source: ECM

In Table 6-19, the breakdown of number of staff at typical stations on Metro Line 2 is given.

Table 6-19 Breakdown of number of staff at typical stations

Stations		Metro Line2		
		Ataba Station	Shubra Station	Opera Station
Features		Intermediate station; Passenger volume is large	Terminal station; Signal office for depot shunting is provided	Intermediate station; Passenger volume is not so large
Operation	Manager	1	1	1
	Assistant manager	4	6	4
	Operator	-	5	-
	Gate staff	13	6	3
Ticketing	Manager	3	3	2
	Ticket sellers (Seasons)	1	-	-
	Ticket sellers (Single)	18	27	5
	Number of ticketing machines	(6)	(9)	(2)
	Staff for ticket exchanges	6	-	-
Total		46	48	15

Source: ECM

(2) Number of station staff for metro systems in Japan

As observed in Table 6-20, the number of station staff for Japanese metro systems is much smaller than that of Cairo Metro. Driver supervisory staff of the Japanese metros is included in the management staff at headquarters similar to that of the Cairo Metro.

From these data, it can be seen that the staff per station of the Tokyo and Osaka metros is more than double that of the Sendai and Yokohama metros. Tokyo and Osaka are the largest and the second largest cities in Japan, respectively. The varying volume of passengers between these metros may explain the differences between the numbers of staff per station.

Table 6-20 Staff per Station of the Japanese Metro Systems

Metro	Number of Stations	Number of Station Staff		Staff per Station
		Management at Headquarters	At Sites	
	A	B	C	D=(B+C)/A
Sendai Metro	17	17	124	8.3
Tokyo Metro	169	195	2,734	17.3
Yokohama Metro	32	28	245	8.5
Osaka Metro	133	121	2,177	17.3

Source: Annual Railway Statistics 2007 MLIT Japan

(3) Estimation of number of station staff on Metro Line 4

Evaluation of number of staff of Cairo Metro

Comparing Table 6-18 and Table 6-20, it can be seen that there is a large difference between them in terms of staff per station. The staff per station on Metro Line 2 of Cairo Metro is more than double that of the Japanese metros, even if the Tokyo and Osaka metros are selected for comparison purposes.

This may be explained by the following reasons related to the Cairo Metro.

- Vending machines for tickets are not installed.
- There are a lot of passengers without tickets who force their way through the gates.
- Significant train operating tasks remain at Cairo Metro stations.

Proposed working plan for stations on Metro Line 4

Assuming the current situation of the Cairo Metro and the equipment plan for Metro Line 4, the basic conceptual plan for staff allocation on Metro Line 4 is proposed, as shown in Table 6-21. Table 6-22 gives the estimated number of staff required per station on Metro Line 4 by typical types of stations.

Table 6-21 Current Situation and Conceptual Plan for Metro Line 4

Issues		Current Situation	Conceptual Plan for Metro Line 4
(1)	Vending machines for tickets are not installed	Banknote condition is not suitable for the vending machines. Coins (particularly in larger denominations) are still not in wide circulation	At the initial stage, manual ticketing has to be adopted. In future, vending machines will be installed.
(2)	Passengers without tickets force their way through gates,	Allocation of security staff and railway police at gates provides an adequate countermeasure against these practices	Assuming that security staff and police will be allocated at gates, one station staff will be allocated for each location of entrance/exit gate. (basically the same as the current system)
(3)	Operational activities at stations	Basically, the CCP carries out all route control operations excluding route control at the depot. Operation staff and security police are allocated at platforms.	All route control functions, including those for the depot, will be performed from the CCP. PSD will be installed at the stations. Number of operating staff at stations will be kept to a minimum.

Source: JICA Study Team

Table 6-22 Breakdown of Number of Staff at Typical Stations on Metro Line 4

Stations		Interchange Station	Terminal Station	Intermediate station
Operation	Manager	1	1	1
	Assistant Manager	4	4	4
	Operator	-	-	-
	Gate staff	6	6	3
Ticketing	Manager	3	3	2
	Ticket (Seasons)	1	-	-
	Ticket (Single)	18	18	5
	Ticket (Exchange)	6	-	-
Total		39	32	15

Source; JICA Study Team

Estimation of station number of staff on Metro Line 4

Table 6-23 shows the daily number of passengers expected to board/alight at each station based on the demand forecast,. The categorization of the stations is indicated in the remarks column.

Table 6-23 Passenger Demand for Individual Stations on Metro Line 4

Section	Station Name	Number of Boarding and Alighting Passengers per day				Remarks
		Y2020	Y 2023	Y2027	Y2050	
Ph.2	N-Sta.17	0	26,740	32,070	35,700	Terminal station
	N-Sta.16	0	14,390	18,330	19,220	
	N-Sta.15	0	10,460	11,650	13,090	
	N-Sta.14	0	8,550	9,700	10,710	
	N-Sta.13	0	15,540	17,000	17,220	
	N-Sta.12	0	12,710	14,170	16,310	
	N-Sta.11	0	6,920	8,300	9,140	
	N-Sta.10	0	8,650	9,970	11,170	
	N-Sta.09	0	9,620	10,610	11,540	
	N-Sta.08	0	18,270	19,810	20,820	Interchange station with Metro Line 1
	N-Sta.07	0	6,900	7,250	8,760	
	N-Sta.06	0	4,370	4,580	4,830	Interchange station with Metro Line 3
	N-Sta.05	0	4,720	5,170	6,240	
	N-Sta.04	0	4,870	5,570	6,680	
	N-Sta.03	0	4,860	5,140	6,270	
	N-Sta.02	0	4,860	5,140	6,270	
Ph.1	WN-Sta.1	9,370	10,150	11,380	13,710	Terminal station till Y2022 Interchange station with Metro Line 1
	W-Sta.2	3,770	3,990	4,200	4,280	

Section	Station Name	Number of Boarding and Alighting Passengers per day				Remarks
		Y2020	Y 2023	Y2027	Y2050	
	W-Sta.3	13,970	14,660	15,410	19,310	
	W-Sta.4	12,570	13,330	14,430	18,130	Interchange station with Metro Line 2
	W-Sta.5	5,600	5,920	6,660	7,520	
	W-Sta.6	8,550	8,890	9,340	11,280	
	W-Sta.7	17,190	18,070	20,970	25,130	
	W-Sta.8	11,370	12,040	14,520	16,740	
	W-Sta.9	10,470	10,540	11,840	12,100	
	W-Sta.10	14,840	15,500	19,610	24,180	
	W-Sta.11	6,640	6,710	7,430	11,730	
	W-Sta.12	6,750	7,060	8,860	9,070	
	W-Sta.13	5,420	5,730	6,800	13,310	
	W-Sta.14	3,610	3,810	6,240	10,650	
	W-Sta.15	3,880	4,550	5,670	11,980	Terminal station

Source; JICA Study Team

Utilizing the station features in Table 6-23 and the average number of staff of typical station types in Table 6-22, the required number of station staff on Metro Line 4 was estimated. It should be noted that the Phase 2 section will be opened in Year 2023. WN-Sta.1 (El Malek El Saleh Station) will be the terminal station in 2020 and will be transformed into an intermediate station in 2023 with the opening of the Phase 2 section. Table 6-24 gives the estimates of the total number of station staff for Metro Line 4. These estimates include all categories of station staff (including management) and the staff at the drivers' depot.

Table 6-24 Required Number of Station Staff for Metro Line 4

Station Type	Number of Unit Staff	Section	Station Number	Y2020	Y2023	Y2027	Y2050
	A		B	C=A x B			
Interchange stations	39	Phase 1	2	78	78	78	78
		Phase 2	2	0	78	78	78
Terminal stations	32	Phase 1	1	32	32	32	32
		Phase 2	1	0	32	32	32
Intermediate stations	15	Phase 1	12	180	180	180	180
		Phase 2	13	0	195	195	195
Total		Phase 1	15	290	290	290	290
		Phase 2	16	0	305	305	305
		Grand Total	31	290	595	595	595

Source: JICA Study Team

6.5.7 Estimation of number of civil and track maintenance staff

Based on the current number of civil and track maintenance staff in Cairo and Japan that of Metro Line 4 was estimated.

The civil and track maintenance works volume will increase when the route km and traffic volume increase. The number of trains per day will be one of the representative figures for traffic volume. On urban railways, the number of trains per day per direction will be 200-300, which will not vary greatly. The route length will vary only when additional project phases come into service. Hence in this section, the number of staff per route km is adopted as the unit figure for estimating the overall staff requirement for civil and track maintenance on Metro Line 4.

(1) Civil and track maintenance staff on Cairo Metro

The current number of civil and track maintenance staff of the Cairo Metro is shown in Table 6-25. The track structure of Metro Line 2 is mostly comprised of concrete without ballast. This needs a smaller maintenance workload than ballasted track. However, Metro Line 1 with a ballasted track has a smaller number of staff per route-km, suggesting greater work efficiency than that of Metro Line 2. The JICA Study Team was unable to identify the reason for this issue.

Table 6-25 Civil and track maintenance staff on existing Cairo Metro

Lines	Route km	Number of Staff	Skilled staff per Route km	Artisans	Labour	Total	Staff per Route km
	A	B	C=B/A	D	E	F=B+D+E	G=F/A
Metro Line 1	44.0 km	100	2.27	188	46	334	7.59
Metro Line 2	21.7 km	117	5.39	78	17	212	9.77

Source: ECM

(2) Number of Civil and Track Maintenance Staff of Japanese Metro

The number of civil and track maintenance staff employed in Japanese metros is shown in Table 6-26. It can be seen that the number of civil and track maintenance staff per route-km in Japan is smaller than that of the Cairo Metro. The only exceptional case is that of Osaka Metro which has a higher engineering staff ratio than that of Cairo Metro Line 1.

The numbers of staff per route-km of the Tokyo and Osaka metros are quite different from those of the Sendai and Yokohama metros. The Tokyo and Osaka metros have long histories. Their infrastructures may need a lot of maintenance as compared to Sendai and Yokohama metros which were constructed more recently. This explains the difference in the maintenance staff ratios of the two metro groups.

In Japan, there are no artisans and labouring staff in the track maintenance work sites. Artisans and labourers are not counted in the calculation of the skilled staff ratios for the

Cairo Metro, (see Table 6-25). Therefore, the basic skilled staff allocation of the Cairo Metro is similar to that of Japanese Metro.

Table 6-26 Civil and Track Maintenance Staff in Japan

Metro	Total Route Length (km)	Management	Staff at Sites	Total	Staff per Route km
	A	B	C	D=A+B+C	E=D/A
Sendai Metro	14.8	0	21	21	1.42
Tokyo Metro	192.1	86	387	473	2.46
Yokohama Metro	40.4	15	64	79	1.96
Osaka Metro	129.9	71	405	476	3.66
Average of Tokyo and Osaka					3.06

Source: Annual Railway Statistics 2007 MLIT Japan

(3) Estimation of the number civil and track maintenance staff for Metro Line 4

Basically, the track structure of Metro Line 4 will be similar to that of Metro Line 2, but the work efficiency of Metro Line 2 is lower than that of Metro Line 1. Therefore, the skilled staff ratio for Metro Line 2 cannot be adopted for estimating the number of skilled staff for Metro Line 4. For this purpose and in order to provide a conservative estimated required number of staff, the skilled staff ratio for the Osaka Metro was used. Table 6-27 gives the estimation result.

Table 6-27 Required Number of Civil and Track Maintenance Staff for Metro Line 4

Section	Route km	Unit Figure	Number of Staff			
			Y2020	Y2023	Y2027	Y2050
Phase 1	16.1	3.06	50	50	50	50
Phase 2	17.6	3.06	0	54	54	54
Total			50	104	104	104

Source: JICA Study Team

6.5.8 Estimation of rolling stock maintenance staff

Based on the current number of rolling stock maintenance staff in Cairo and Japan that required for Metro Line 4 was estimated.

The rolling stock maintenance work volume will increase in proportion to the increase both in the number of metro car fleet and number of train-km run, although the two are closely related. However, train-km per rolling stock will not increase substantially by line since the enhancement of efficiency for the rolling stock operation is always required. Hence for purposes of estimating the requirement of rolling stock maintenance staff for Metro Line 4, the ratio of the number of staff to the number of cars in the rolling stock fleet has been used as a unit figure.

(1) Rolling stock maintenance staff on Cairo Metro

The current numbers of staff involved in rolling stock maintenance on the Cairo Metro is given in Table 6-28. The number of staff per metro car for Metro Line 2 is higher than that for Metro Line 1. On both lines, rolling stock maintenance is outsourced. In the case of Metro Line 2, the workers are dispatched from ECM and their number is counted as maintenance staff of Metro Line 2. In the case of Metro Line 1, the workers are understood to be dispatched from ENR and their number is not counted as maintenance staff of Metro Line 1. These facts explain the difference between the two lines in terms of the ratio of staff to car fleet number. It should be noted that maintenance supervisory staff are included in the numbers of staff shown in Table 6-28.

Table 6-28 Rolling Stock Maintenance Staff on Existing Cairo Metro

Line	Total Car Number	Number of Skilled staff	Skilled staff per car	Artisans	Labour	Total
	A	B	C=B/A	D	E	F=B+D+E
Metro Line 1	480	188	0.39	77	22	287
Metro Line 2	280	424	1.51	4	81	509

Source: ECM

(2) Rolling stock maintenance staff in Japan

Table 6-29 shows the number of staff engaged in rolling stock maintenance in relation to the car fleet on the Japanese metro systems. From this table, it can be seen that the number of maintenance staff per car for the Japanese metros is smaller than that of Metro Line 2.

The number of staff of Metro Line 2 seems to be more appropriate to a situation which would apply in the final stage of the line’s development, when the car fleet has reached its ultimate capacity. Therefore, the current staff to car ratio for Metro Line 2 does not reflect efficient staffing practices and therefore will not be a suitable basis for calculating the skilled staff requirements for Metro Line 4. Accordingly, the staff to car ratio of a Japanese metro was used for this estimation. It must be noted that no artisans and labouring staff are engaged in rolling stock maintenance on the Japanese metros.

Table 6-29 Rolling Stock Maintenance Staff in Japanese Metro Systems

Metro	Rolling Stock Number	Manage-ment	Staff at sites	Total	Staff per Rolling Stock
	A	B	C	D= B+C	E=D/A
Sendai Metro	84	0	32	32	0.38
Tokyo Metro	2,533	54	946	1,000	0.39
Yokohama Metro	222	5	84	89	0.40
Osaka Metro	1,280	48	703	751	0.59

Source: Annual Railway Statistics 2007 MLIT Japan

(3) Estimation of staff requirement for rolling stock maintenance on Metro Line 4

The unit figure of the Osaka Metro was used for estimating the number of rolling stock maintenance staff. Since the figure of Osaka Metro is the largest among the Japanese metros, this will provide a conservative basis for estimation.

The number of rolling stock is shown in the Train Operations Plan. Table 6-30 shows the estimated number of staff required for rolling stock maintenance on Metro Line 4. It should be noted that the number of management staff for rolling stock maintenance is included in these figures.

Table 6-30 Required Number of Rolling Stock Maintenance Staff on Metro Line 4

Items		Y2020	Y2023	Y2027	Y2050
Number of cars in a train-set	A	8	8	8	8
Train-set number	B	20	66	68	70
Number of rolling stock	C=A x B	160	528	544	560
Staff per rolling stock	D	0.59	0.59	0.59	0.59
Total	E=C x D	95	312	321	331

Source: JICA Study Team

6.5.9 Estimation of electrical equipment maintenance staff

Estimated number of staff required for electrical equipment/systems maintenance on Metro Line 4 were based on an analysis of the current number of staff for maintenance of signaling, ticket machines and power supply (hereinafter called “electrical equipment") in Cairo and Japan.

Basically, the electrical equipment maintenance works volume will increase when the route-km and traffic volume increase. The number of trains per day will be one of the representative figures for traffic volume. On urban railways, the number of trains per day per direction will be 200-300. This number will not vary greatly. The route length will vary only when additional project phases come into service. Hence in this section, the number of staff per route-km is adopted as the unit figure used for estimating the overall staff requirement for electrical equipment maintenance on Metro Line 4.

(1) Electrical equipment maintenance staff on Cairo Metro

Table 6-31 shows the number of staff currently engaged in the maintenance of electrical equipment on the Cairo Metro, while Table 6-32 provides a breakdown of the total number of staff by type of equipment. From the latter table, it can be seen that the major portion of electrical equipment maintenance is accounted for by the power supply system. This may be explained by the fact that two staff are allocated to every substation for the whole day.

Table 6-31 Electrical equipment Maintenance Staff for the Existing Cairo Metro

Line	Route km	Number of Skilled staff	Skilled staff per route-km	Artisans	Labour	Total
	A	B	C=B/A	D	E	F=B+D+E
Metro Line 1	44.0km	551	12.5	73	48	654
Metro Line 2	21.7km	594	27.4	22	23	588

Source: ECM

Table 6-32 Breakdown of Skilled Staff for Electrical Equipment Maintenance for the Cairo Metro

Line	Signaling	Telecommuni-cation	Ticket Machines	Power Supply	Total
Metro Line 1	129	33	34	355	551
Metro Line 2	79	27	60	428	594
Remarks	Signal maintenance of Metro Line 2 is outsourced			Substation number per route km of Metro Line 2 is larger than that of Metro Line 1	

Note: The number of artisans and labouring staff is not included.
Source: ECM

(2) Electrical equipment maintenance staff in Japan

Table 6-33 gives the number of staff engaged in electrical equipment maintenance on selected Japanese metro systems. It can be seen that the ratio of the number of electrical equipment maintenance staff to route-km in Japan is much smaller than that of Cairo Metro.

The staff per route-km of the Tokyo and Osaka metros are quite different from those of the Sendai and Yokohama metros. The Tokyo and Osaka metros have long histories. Their equipment may need a lot of maintenance, as compared to Sendai and Yokohama metros which were constructed more recently. This explains the difference in the maintenance staff ratios of the two metro groups.

In Japan, there are artisans and labouring staff in the electrical equipment maintenance work sites. For the calculation of the staff per route km of Cairo Metro in Table 6-31, artisans and labourers are not counted. Therefore the basic ground condition of Cairo Metro for staff allocation efficiency will be the same as that for the Japanese metro systems.

Table 6-33 Electrical Equipment Maintenance Staff in Japanese Metro Systems

Metro	Route km	Manage-ment	Staff at sites	Total	Staff per route-km
	A	B	C	D=A+B+C	E=D/A
Sendai Metro	14.8	0	40	40	2.70
Tokyo Metro	192.1	63	664	727	3.78
Yokohama Metro	40.4	6	79	85	2.10
Osaka Metro	129.9	65	539	604	4.65

Source: Annual Railway Statistics 2007 MLIT Japan

(3) Estimation of Required Number of Staff for Electrical Equipment Maintenance on Metro Line 4

Essentially, the electrical equipment structure of Metro Line 4 will be similar to that of Metro Line 2, except that the power supply system will utilize catenaries (as is the case with Metro Line 1) while Metro Line 2 utilizes a third rail system. However, the staff ratios of Metro Lines 1 and 2 are considerably higher than those of the Japanese metro systems. Since the electrical equipment of Metro Line 4 will be similar to that of the Japanese metro systems, the staff per route-km of the Japanese metro systems was adopted for estimating the electrical equipment maintenance staff for Metro Line 4.

For conservative estimation, the unit figure of the Osaka Metro was selected, since it has the largest number among the four metros. The result is given in Table 6-34.

Table 6-34 Required Number of Staff for Electrical Equipment Maintenance on Metro Line 4

Section	Route km	Unit Figure	Number of Staff			
			Y2020	Y2023	Y2027	Y2050
Phase 1	16.1	4.65	75	75	75	75
Phase 2	17.6	4.65	0	82	82	82
Total			75	157	157	157

Source: JICA Study Team

6.5.10 Management Staff

In this sub-section, the number of management staff common to the operations and maintenance departments is discussed.

(1) Management staff in the Cairo Metro

Table 6-35 gives the number of staff engaged in administration, financial and general labouring tasks on the Cairo Metro.

Table 6-35 Number of Administrative and Labouring Staff on the Existing Cairo Metro

Route km	Number of administrative staff	Administrative staff per route-km	Labourers	Total
A	B	C=B/A	D	E=B+D
65.7km	522	7.95	52	574

Source: ECM

(2) Management staff in the Japanese metros

Table 6-36 gives the number of staff engaged in administrative and financial tasks on the Japanese metro systems. The staff per route-km of the Japanese metros are different from each other. The management staff per route-km of the Japanese metros are much smaller than those of the Cairo metro.

Table 6-36 Administrative staff in Japanese metro systems

Metro	Route km	Administration staff	Staff per route km
	A	B	C=B/A
Sendai Metro	14.8	14	0.95
Tokyo Metro	192.1	360	1.87
Yokohama Metro	40.4	26	0.64
Osaka Metro	129.9	461	3.55
Average			1.75

Source: Annual Railway Statistics 2007 MLIT Japan

(3) Estimation of the number of management staff for Metro Line 4

The number of staff of the back office (financial section, administration, planning and so on) at the headquarters of the Cairo Metro seems to be so large that basically will not need to increase even after the commencement of Metro Lines 3 and 4.

The required number of staff for the management of Metro Line 4 can be estimated by the following two measures:

Table 6-37 Alternative Methods for Estimating the Number of Administrative Staff

Alternative	Method	Required staff
1	Acquired from the average administration number of staff per route-km of Japanese metro	59=1.75 staff/route km x 33.7 km
2	Acquired by dividing the number of management staff for the existing lines in the Cairo Metro with the line number	131=522 staff /4 lines

Source: JICA Study team

Since the number estimated by Alternative 1 is less than that by Alternative 2, the latter was used as a conservative basis for estimating the required number of staff for Metro Line 4.

6.5.11 Total number of staff for Metro Line 4

Based on Table 6-12, Table 6-14, Table 6-17, Table 6-24, Table 6-27 and Table 6-34, the total numbers of staff required for Metro Line 4 are summarized in Table 6-38.

The major assumptions underlying these estimates are as follows:

- In 2020, only the Phase 1 section will be open for service. The Phase 2 section will offer service in 2023.
- It is expected that a leanworking system will be adopted for Metro Line 4, but conservative data have been used for purposes of estimation.
- Trains will be operated with a single driver, similar to that of Metro Line 2.
- Operational tasks at stations will be few in number since nearly all of the operation, including selecting routes for shunting at the depot, will be done from the CCP.
- Ticket vending machines will not be installed at stations, at least not in the early stages of operation.
- The track infrastructure will be comprised of concrete without ballast, requiring relatively little maintenance, similar to that in Japan.
- For rolling stock, number of staff for inspection of outsourced works is included. (The total number excluding the staff dispatched to the maintenance outsourcing companies is presented on the last row of Table 6-38).
- For power supply maintenance, it is assumed that no staff will need to be allocated to individual sub-stations.

Since it is quite difficult to reduce the numbers staff once allocated to individual work sites, it is suggested that the initial operation of the new line should start with a minimum staff.

Table 6-38 Estimated Total Staff Requirement on Metro Line 4

Categories		Y2020	Y2023	Y2027	Y2050
Route km		16.1	33.7	33.7	33.7
Number of Stations		15	31	31	31
Number of Rolling Stock		160	528	544	560
Number of Staff Required					
Operation	Drivers	79	286	295	306
	Drivers in the depot	23	46	46	46
	CCP controllers	24	38	38	38
	Station Staff	290	595	595	595
	Sub total	416	965	974	985
Maintenance	Civil and Track	50	104	104	104
	Rolling Stock	95	312	321	331
	Electrical Equipment	75	157	157	157
	Sub total	220	573	582	591
Administrative staff		131	131	131	131
Total		767	1,669	1,687	1,708
Total number of staff without the staff dispatched to the maintenance outsourcing companies		647	1,305	1,687	1,708

Source: JICA Study Team

6.6 Training Plan

The training plan developed for Metro Line 4 draws upon experience with the planning of a training system for the existing lines of the Cairo Metro and for selected Japanese metro organizations.

6.6.1 Training system for existing lines of the Cairo Metro

The ECM has indicated major differences between the initial training scheme introduced at the time of the opening of Metro Line 2 and the current scheme in place for this line. The differences between these schemes are discussed in order to better understand the evolution of the current scheme.

(1) Current scheme for ab initio training on Metro Line 2

The current training period for new recruits to the Cairo Metro is given in

Table 6-39. This is the basic plan and if trainees cannot acquire enough skills and knowledge for the proper execution of their functions, the training period will be extended. Basically, the training system of Cairo Metro is similar to that of Japan (Please see section 6.6.2).

Table 6-39 Basic Initial Training Period by Staff Category

Unit: Month

Categories	Classroom Lessons	Practical training	Others	Total
Drivers	3	2	1	6
Station staff	1	2	-	3
Maintenance staff	-	3	-	3

Note: “Others” means the period of the test for drivers license and trial driving during waiting period issuance of drivers’ license.
Source: JICA Study Team

For drivers in the Cairo Metro, repetitive training is done after acquisition of driver certification, since they have to carry out emergency operation appropriately, without reading the manuals.

Basically, drivers will join the repetitive training twice per year. The period set for such training is one week, but in reality it is shortened to three days due to the shortage of drivers.

The JICA Study Team suggests that assignment of two weeks per year may be excessive for repetitive training. Three days in a six month period is considered to be sufficient. (similar to the case in Japan).

(2) Training at the Opening of Metro Line 2

Normally at the opening of a new urban railway line, the period secured for staff training is small, but the number of trainees is large. Ideally, a driver trainee should undergo practical training by operating a train under the supervision of an instructor in the same cab. If such a method is adopted, at least six months will be required for completion of training. Assuming that the number of drivers at the opening is fifty, the practical training period per trainee is one month, with eight instructors.

At the opening of Metro Line 2, the total period permitted for training, including classroom lessons, was only six months. The JICA Study Team considers that this period is too short to provide adequate practical in-cab training of drivers under instructor’s supervision.

6.6.2 Introduction of Japanese training system for drivers

In the following sections, the Japanese training system for drivers is introduced. Basically, the system itself is the same as that of the ECM. It should be noted that in Japan, the drivers' licensing system was established by the MLIT.

(1) Curriculum and duration of classroom lessons

The following table shows the curriculum and duration of classroom lessons in Japan.

Table 6-40 Curriculum and duration of classroom lessons

Requirements of the Ministry ordinance		Actual Curriculums	Total duration (Hours)
Related Ministry ordinance		Technical standards (Ministry of ordinance)	400 hours
		Security of safety on train operation (Ministry of ordinance)	
Structures and functions	Fundamental issues on securing safety	Outline of railway system	
		Operation rules	
		Safety works	
	Structures and functions of EMU	Structures of rolling stock	
		Troubleshooting	
		Electric facilities	
		Signals and tracks	
		Traffic control	
	Operation theory	Operation theory	

Source: JICA Study Team

(2) Curricula and duration of practical training on the mainline

The following table shows the curricula and duration of practical training in Japan.However, if it is deemed that a trainee cannot acquire enough skills within the set duration his/her training period will be extended.

Table 6-41 Curricula and duration of practical training on the mainline

Curricula	Duration
• Observation of speed • Observation of distance with eyes • Operation of brakes • Handling of equipments except brakes • Punctual driving • Operation in emergency	400 hours (This is the working hour basis and not the number of hours on board)

Source: MLIT of Japan

It should be noted that this system is based on the training syllabus of the Japanese National Railways. As can be seen in the following table, the operation experience and skills required for urban railways will be much less than that for intercity railways. These facts suggest that the practical training period on the mainlines of urban railways can be shortened from that of the existing one.

Table 6-42 Comparison Between Urban and Intercity Railways

Items	Intercity railways	Urban railways
Route length	Long	Short
Track layout	Complicated	Simple
ATP	So simple that accidents might occur in worst case	Perfect and no accident by SPAD will occur
Difficulty of training	Difficult	Easy
Training period	Existing training period in Japan is based on railways of this type	Can be shortened

Source: JICA Study Team

(3) Examination for Drivers' License

Examinations for obtaining drivers' licenses in Japan include tests for the following items. Aspiring drivers who have completed the training courses will take the tests, as shown in Table 6-43, at the training centre of each railway. If a trainee fails the examination, he/she has to repeat the training course.

Table 6-43 Examination for Obtaining Drivers' License

No	Broad test items	Detailed items
1	Medical checkup	• Visual performance • Audibility • Disease and disorder of body performance • Addiction
2	Aptitude Test	• Kraeplin test • Response rate test
3	Paper test on regulations of drivers' license, structure of rolling stock and functions	• Ministry ordinance • Rules for driving • Fundamental issues to keep safety • Structures and functions of rolling stock • Operation theory
4	Technical Examination on driving	• Observation of speed • Observation of distance with eyes • Operation of brakes • Handling of equipment, except brakes • Punctual driving • Operation in emergency

Note: Items 1 and 2 are tested at the time of selection of trainees
Source: MLIT of Japan

(4) Issuance of drivers' licenses by MLIT

Railway companies will submit the drivers' license application form for trainees who passed the examination and the Regional Transport Bureau of MLIT will issue the drivers' license to the successful applicants.

After acquisition of drivers' license, the new drivers can then operate a train. However, if there is spare number of drivers available, the new ones will have to be accompanied by experienced drivers until they have developed their driving capabilities.

(5) Repetitive training of drivers in Japan

In Japan, twenty four hours per year of repetitive training is conducted to all drivers. In this training session, repetitive learning of operation rules, learning from actual incidents and practical training in some cases will be provided. (Most of the actual incidents reviewed will be those which have occurred on other types of railways, since incidents seldom happen on urban railways). This training session is carried out at a drivers' depot.

Repetitive training at the training centre is carried out. The major curriculum is training for operation during emergencies, utilizing a train operation simulator.

6.6.3 Utilization of Human Resources of Existing Line

By the time Metro Line 4 is ready for service, there will already be three Cairo Metro lines in operation. Utilization of the staff of these three lines for the opening of Metro Line 4 will be most effective since they have enough knowledge and experience on the metro system. However, through the discussions with ECM officers, it was found that there is no plan to transfer the staff from the existing lines to the new ones, except for some management personnel. The reasons are as follows.

- On the existing lines, they will have to train new recruits also for their lines when some of their staff are transferred to Metro Line 4. The total workload for the new recruits to be trained for Metro Line 4 will be smaller than that of experienced staff of other lines, which will be transferred to Metro Line 4.
- The technology of Metro Line 4 will be different from that of existing lines. Hence, it is unlikely that the knowledge or experience from the existing lines can be utilized on Metro Line 4.

The advantages and disadvantages of the training and transfer alternatives are set out in Table 6-44.

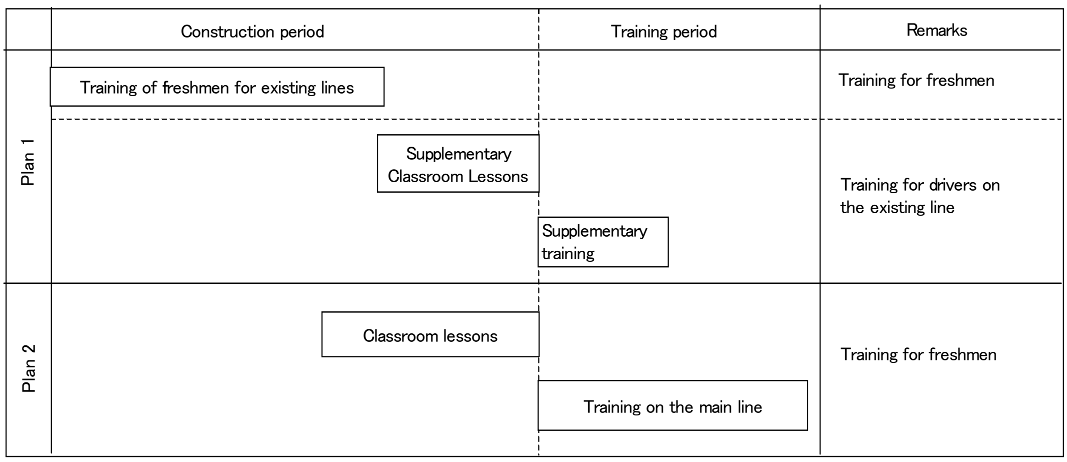
Table 6-44 Comparison of staff training plans

Plan		Advantage	Disadvantage
1	Transfer of staff from existing lines	Shortening of training period for the Metro Line 4 can be done since the experienced staff of the existing lines need only be trained in understanding the system differences between existing lines and Metro Line 4.	Extra training may be needed to cover the shortage of staff on existing lines
2	Training of new recruits	No extra training will be needed related to the existing lines	On Metro Line 4, the revenue operation will start without staff who have experience in urban railway operation

Source: JICA Study Team

The JICA Study Team recommends that the first alternative be adopted, since at the opening period, the duration allotted for training will be minimal. Prior to the opening of

Metro Line 4, extra training can be done on the existing lines to compensate for staff shortages.



Source: JICA Study Team

Figure 6-17 Comparison of Training Plans

6.6.4 Proposed Plan for Staff Training for the Opening of Metro Line 4

Based on above mentioned information, the JICA Study Team proposes the staff training plan for the opening of Metro Line 4 as shown in the following table.

At least for the training period prior to the opening, more than six months should be allotted. In this period, trial operation will not be included.

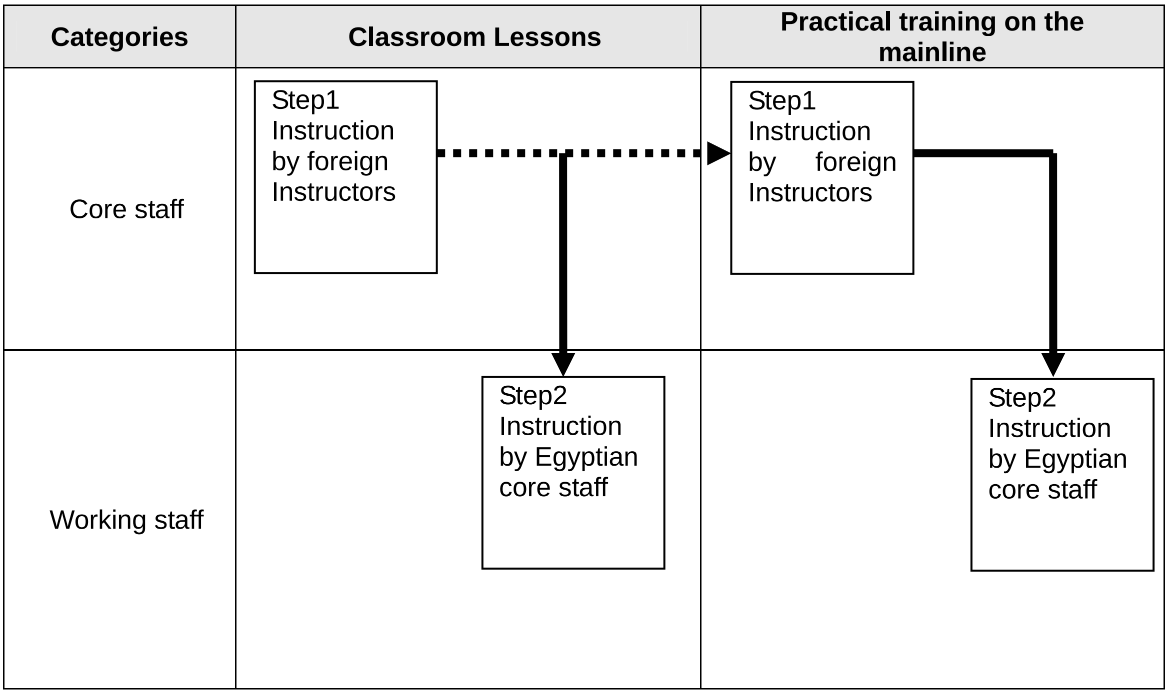
Basic training period or hours will be as follows:

Table 6-45 Proposed training period by staff category

Categories	Unit	Classroom Lessons	Practical training	Others	Total
Drivers(new recruits)	Hours	400	200	200	800
Drivers(skilled)	Hours	200	100	100	400
Station staff	Month	1	2		3
Maintenance staff	Month		3		3

Source: JICA Study Team

To reduce the cost for foreign instructors, classroom lessons will be carried out by a two-step instruction procedure as shown in the following figure. At first, core staff for Metro Line 4 will be trained by designated instructors from the general consultant or contractors team (Step 1). After that, core staff will instruct their working staff (Step 2). Practical training on the main line will be carried out in the same manner as classroom lessons.



Source: JICA Study Team

Figure 6-18 Two Steps Instruction

Classroom lessons should be completed before the start of the training period.

Transfer of skilled workers from existing lines should also be planned.

The total training schedule will be expressed as follows., The most conservative plan is presented among a number of possible alternatives.

Table 6-46 Total Proposed Schedule for Training

Training Method	Commencement schedule before the opening of the commercial operation	Remarks
Classroom lessons (three months) for core staff	Fifteen months before opening	
Classroom lessons (three months) for working staff	Twelve months before opening	Assuming that working staff will be newly employed
Training of drivers on the mainline (minimum six months)	Nine Months before opening	Including trial operation period

Source: JICA Study Team

CHAPTER 7
PROJECT COST AND PACKAGING

CHAPTER 7 PROJECT COST AND PACKAGING

The project cost consists of the initial capital cost and the O&M cost. It should be noted that initial capital costs include only the costs of infrastructure (civil works, track work and electrical and mechanical installations) and rolling stock provision, incurred during the construction period. Investments committed beyond this period in the purchase and refurbishment of rolling stock, as well as in the replacement of infrastructure and rolling stock assets, have been estimated for the purposes of the economic and financial appraisal. These estimates are described in Chapter 13 (Economic and Financial Analysis).

7.1 Initial Capital Cost

7.1.1 Basic Conditions of the Cost Estimation

The JICA Study Team has estimated the initial capital cost of the project based on the following conditions:

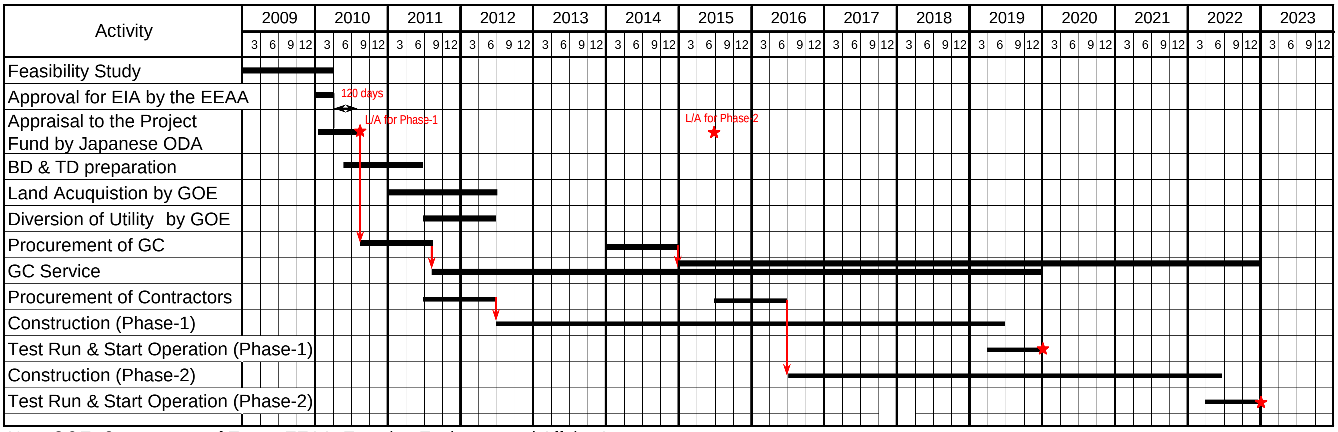
1) In this chapter, STEP loan and normal yen loan cases are considered. In case of the normal loan, the basic design of the project would be undertaken and financed by the Egyptian government under a tender let in accordance with international competitive bidding methods.
2) The unit prices are determined in consideration of unit prices for related projects in Cairo such as the Cairo Metro Line 3, metro projects conducted in other countries, and quotations obtained from makers/fabricators, etc.
3) Currency exchange rates were applied as per the following table:

Description	Exchange Rate*
JPY / EGP	17.28
EGP / USD	5.512
JPY / USD	95.25

* Rates current in August 2009

4) Import duty and tax are included in the cost items.
5) The project implementation schedules assumed as the basis for cost estimation are given in the following tables.

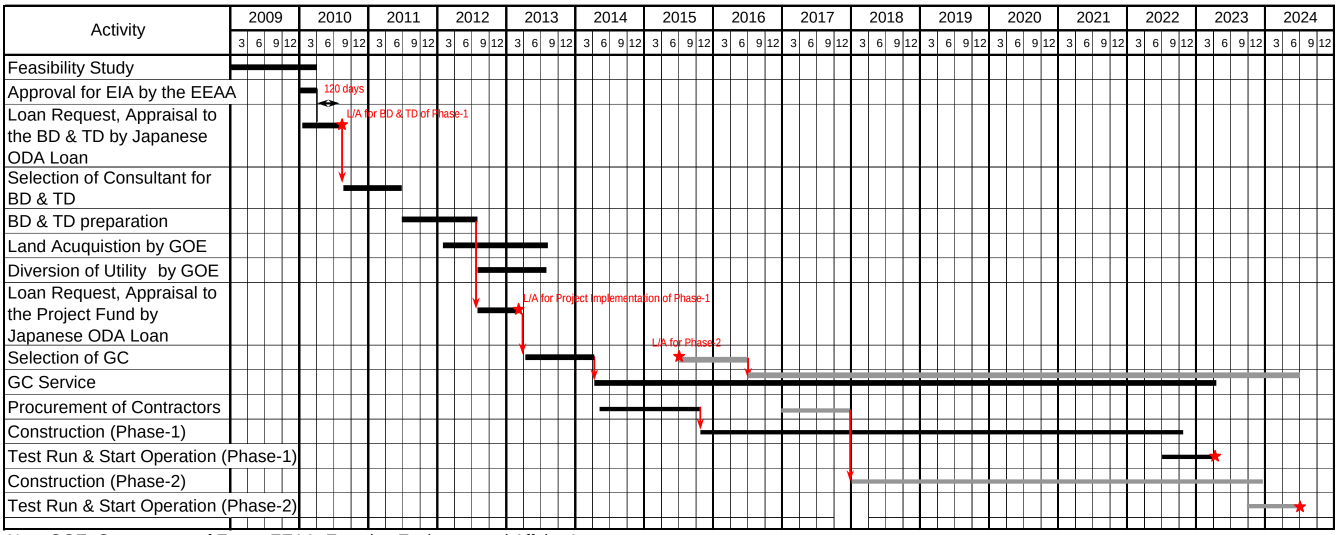
Table 7-1 Project Implementation Schedule (STEP Loan)



Note:GOE: Government of Egypt, EEAA: Egyptian Environmental Affairs Agency

Source: JICA Study Team

Table 7-2 Project Implementation Schedule (Normal Yen Loan)

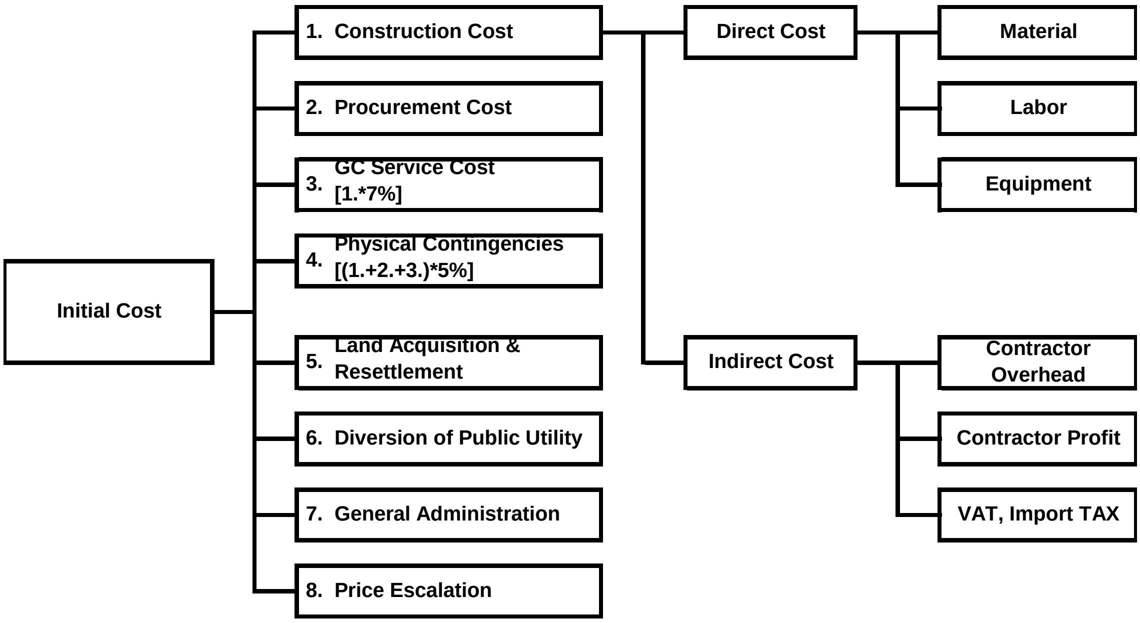


Note:GOE: Government of Egypt, EEAA: Egyptian Environmental Affairs Agency

Source: JICA Study Team

7.1.2 Composition of the Initial Capital Cost Estimate

The composition of the initial capital cost of the project is shown in Figure 7-1. This cost consists of the construction cost, procurement cost, General Consultancy (GC) service cost, land acquisition and compensation cost, physical contingencies, cost for diversion of public utility and price escalation as elaborated below:



Note) GC: General Consultant, VAT: Value-Added Tax)
Source: JICA Study Team

Figure 7-1 Composition of the Project Cost

(1) Construction Cost

As shown in Figure 7-1, the construction cost is divided into “direct cost” and “indirect cost”. The direct cost was estimated on the basis of the pay items of permanent and temporary works and quantities derived from the preliminary design (see Chapter 4). The indirect cost is composed of contractor(s) overhead, contractor(s) profit and taxes.

The sources and breakdown of the unit costs used for these estimates are shown in Table 7-3.

Table 7-3 Sources of Estimated Rates/Prices

Item		Source of Unit Cost	Included in Base Unit Cost
Civil Works (Tunnel)	Procurement cost related to Tunnel Boring Machine (TBM)	Estimated by Contractor.	DC, IDC
	Construction cost such as excavation, segment, soil improvement	GCM Line-3	DC, IDC, I-Tax, VAT
Civil Works (Elevated)	Construction cost for elevated route structures	Similar Projects	DC, IDC, I-Tax, VAT
Station (Civil)	Construction cost for stations except for road decking panel	GCM Line-3	DC, IDC, I-Tax, VAT
	Road decking panel	Similar projects	DC, IDC
Track work	Construction of non-ballasted track	Generally from GCM Line-3	DC, IDC, I-Tax, VAT
Depot / Workshop	Construction of buildings and installation of equipment	Similar projects	DC
Station Facilities	Installation of E&M equipment in stations	Similar projects	DC, IDC
Power Supply & Electrification	Installation of sub-stations, HVS, power distribution and control equipment	Similar projects	DC
Signals & Telecommunications	Installation of signalling, train control and telecommunications equipment	Similar projects	DC, IDC

Note) DC: Direct Cost, IDC: Indirect Cost, I-Tax: Import Tax, VAT: Value-Added Tax
Source: JICA Study Team

(2) Procurement Cost

The procurement cost relates to the purchase of rolling stock. It has been assumed that the rolling stock for Cairo Metro Line 4 will be imported from a supplier outside the country. Therefore, its cost is assumed to include shipping cost, import duty, value-added tax (VAT) or sales tax, and the cost of inland transport between the port of the importing country and Cairo.

(3) GC Service Cost

The GC Service Cost consists of the cost of basic design & tender preparation (only applicable for normal loan, other related GC services, or construction supervision service. The GC service fee is assumed to be 7% for STEP Loan and 7% plus USD 20 million for normal loan of the consolidated construction and rolling stock procurement cost.

(4) Physical Contingency

The physical contingency allows for the possibility of additional unexpected works. The physical contingency rate is assumed at 5% of the consolidated construction, procurement and GC service cost.

(5) Land Acquisition and Resettlement

The land acquisition and resettlement cost was estimated on the basis of the preliminary design (see Chapter 4). The cost of land acquisition was calculated in accordance with current market values for land, while the cost of resettlement is based on the rates approved by the relevant local government authorities.

(6) Diversion of Public Utilities

Diversion of public utilities, such as water and sewerage mains, electricity transmission lines, etc is often necessary before excavation work can commence. This is in preparation for the construction of the metro line and its stations. JICA Study Team understands that NAT will be responsible for executing the diversion of public utilities before the start of construction.

This cost is estimated on the basis of experience in the construction of Cairo Metro Line 3.

(7) General Administration Cost

The general administration cost is related to the cost of obtaining necessary government approvals and permits, and is calculated at 3% of the construction cost. It is included in the local cost portion.

(8) Price Escalation

Price escalation was assumed at the following rates based on Table 13-31 in Chapter 13:

Year	Foreign Portion	Local Portion
2010 – 2015	5%	5%
2016 – 2023	4%	4%
2024- 2050	3%	3%

Price escalation is applied at the above rates to the following cost items: construction, procurement, GC service, land acquisition and resettlement, and diversion of public utilities.

7.1.3 Initial Capital Cost Estimates

Table 7-4 provides the consolidated estimate of initial capital costs for the Metro Line 4 project. This estimate includes all the items described in the foregoing sub-sections and is summarised for each of the two construction phases, and in total for the entire route.

Table 7-4 Summary of Estimated Initial Cost (STEP Loan)

	Descriptions	Phase-1				Phase-2				TOTAL			
		F/P	L/P	Total		F/P	L/P	Total		F/P	L/P	Total	
		M. US$	M. US$	M. US$	(%)	M. US$	M. US$	M. US$	(%)	M. US$	M. US$	M. US$	(%)
1	Construction Cost												
	Civil Works (Tunnel)	124.1	157.9	281.9	8%	68.3	87.0	155.3	3%	192.4	244.8	437.2	5%
	Civil Works (Elevated)	0.0	0.0	0.0	0%	22.4	43.5	65.9	1%	22.4	43.5	65.9	1%
	Station (Civil)	269.9	524.0	794.0	22%	249.9	485.2	735.1	16%	519.9	1,009.2	1,529.1	18%
	Track	10.9	49.7	60.6	2%	7.9	35.8	43.7	1%	18.8	85.5	104.2	1%
	Depot / Workshop	48.2	85.7	133.8	4%	7.2	12.8	20.0	0%	55.4	98.5	153.8	2%
	Station Facilities	210.4	123.6	334.0	9%	202.6	119.0	321.7	7%	413.1	242.6	655.7	8%
	Power Supply & Electrification	73.8	60.4	134.2	4%	76.2	62.3	138.5	3%	150.0	122.7	272.7	3%
	Signal & Telecom.	115.7	45.0	160.7	4%	119.4	46.4	165.8	4%	235.1	91.4	326.5	4%
	Total Construction Cost (①) :	853.0	1,046.2	1,899.2	53%	754.0	892.0	1,646.0	35%	1,607.0	1,938.2	3,545.2	43%
2	Procurement Cost												
	Rolling Stock	428.7	0.0	428.7	12%	918.7	0.0	918.7	20%	1,347.5	0.0	1,347.5	16%
	Total Procurment Cost (②) :	428.7	0.0	428.7	12%	918.7	0.0	918.7	20%	1,347.5	0.0	1,347.5	16%
	Total of ①+②	1,281.8	1,046.2	2,328.0	64%	1,672.7	892.0	2,564.7	55%	2,954.5	1,938.2	4,892.7	59%
3	③Consultancy Service (① of 7%)	59.7	73.2	132.9	4%	52.8	62.4	115.2	2%	112.5	135.7	248.2	3%
4	Physical Contingency (①+②+③ of 5%)	67.1	56.0	123.0	3%	86.3	47.7	134.0	3%	153.3	103.7	257.0	3%
	Total-1(④):	126.8	129.2	256.0	7%	139.1	110.2	249.2	5%	265.8	239.4	505.2	6%
5	Land acquisition & Resettlement	0	30.8	30.8	1%	0	34.5	34.5	1%	0	65.3	65.3	1%
6	Diversion of Public Utility	0.4	41.4	41.8	1%	0.3	24.9	25.1	1%	0.7	66.3	67.0	1%
7	General Administration (① of 3%)	0	57.0	57.0	2%	0	49.4	49.4	1%	0.0	106.4	106.4	1%
8	Price Escalation	526.9	373.7	900.6	25%	1,127.5	606.6	1,734.1	37%	1,654.5	980.2	2,634.7	32%
	Total-2:	527.4	502.9	1,030.3	29%	1,127.8	715.3	1,843.1	40%	1,655.2	1,218.2	2,873.3	35%
	Grand Total:	1,935.9	1,678.3	3,614.2	100%	2,939.6	1,717.5	4,657.0	100%	4,875.5	3,395.8	8,271.3	100%

Note: F/P: Foreign Portion, L/P: Local Portion
Source: JICA Study Team

Table 7-5 Summary of Estimated Initial Cost (Normal Yen Loan)

	Descriptions	Phase-1				Phase-2				TOTAL			
		F/P	L/P	Total		F/P	L/P	Total		F/P	L/P	Total	
		M. US$	M. US$	M. US$	(%)	M. US$	M. US$	M. US$	(%)	M. US$	M. US$	M. US$	(%)
1	Construction Cost												
	Civil Works (Tunnel)	124.1	157.9	281.9	7%	68.3	87.0	155.3	3%	192.4	244.8	437.2	5%
	Civil Works (Elevated)	0.0	0.0	0.0	0%	22.4	43.5	65.9	1%	22.4	43.5	65.9	1%
	Station (Civil)	269.9	524.0	794.0	20%	249.9	485.2	735.1	15%	519.9	1,009.2	1,529.1	17%
	Track	10.9	49.7	60.6	2%	7.9	35.8	43.7	1%	18.8	85.5	104.2	1%
	Depot / Workshop	48.2	85.7	133.8	3%	7.2	12.8	20.0	0%	55.4	98.5	153.8	2%
	Station Facilities	210.4	123.6	334.0	8%	202.6	119.0	321.7	7%	413.1	242.6	655.7	7%
	Power Supply & Electrification	73.8	60.4	134.2	3%	76.2	62.3	138.5	3%	150.0	122.7	272.7	3%
	Signal & Telecom.	115.7	45.0	160.7	4%	119.4	46.4	165.8	3%	235.1	91.4	326.5	4%
	Total Construction Cost (①) :	853.0	1,046.2	1,899.2	48%	754.0	892.0	1,646.0	34%	1,607.0	1,938.2	3,545.2	40%
2	Procurement Cost												
	Rolling Stock	428.7	0.0	428.7	11%	918.7	0.0	918.7	19%	1,347.5	0.0	1,347.5	15%
	Total Procurment Cost (②) :	428.7	0.0	428.7	11%	918.7	0.0	918.7	19%	1,347.5	0.0	1,347.5	15%
	Total of ①+②	1,281.8	1,046.2	2,328.0	59%	1,672.7	892.0	2,564.7	53%	2,954.5	1,938.2	4,892.7	56%
3	③Cunsultancy Service	79.7	73.2	152.9	4%	72.8	62.4	135.2	3%	112.5	135.7	248.2	3%
4	Physical Contingency (①+②+③ of 5%)	68.1	56.0	124.0	3%	87.3	47.7	135.0	3%	153.3	103.7	257.0	3%
	Total-1(④):	147.8	129.2	277.0	7%	160.1	110.2	270.2	6%	265.8	239.4	505.2	6%
5	Land acquisition & Resettlement	0	30.8	30.8	1%	0	34.5	34.5	1%	0	65.3	65.3	1%
6	Diversion of Public Utility	0.4	41.4	41.8	1%	0.3	24.9	25.1	1%	0.7	66.3	67.0	1%
7	General Administration (① of 3%)	0	57.0	57.0	1%	0	49.4	49.4	1%	0.0	106.4	106.4	1%
8	Price Escalation	687.8	512.4	1,200.2	31%	1,290.0	645.2	1,935.2	40%	1,977.8	1,157.6	3,135.4	36%
	Total-2:	688.2	641.6	1,329.8	34%	1,290.3	753.9	2,044.2	42%	1,978.5	1,395.6	3,374.0	38%
	Grand Total:	2,117.7	1,817.1	3,934.8	100%	3,123.1	1,756.1	4,879.2	100%	5,198.8	3,573.2	8,771.9	100%

Note: F/P: Foreign Portion, L/P: Local Portion
Source: JICA Study Team

7.1.4 Estimated Cost of PSD

Installation of PSD represents one major design difference between Metro Line 4 and the existing metro lines. As mention in section 4.10.4 of this report, the benefits of PSD are as follows:

- To prevent collision with persons on tracks
- To realize fewer delays caused by safety incidents
- To reduce the energy costs caused by the loss of cooled air
- Minimize the number of station staff and train crew.

As also mentioned in said section, each type of PSD system will be introduced in the following stations

Type of PSD	Station Name
<Phase1>	
Full-height PSD system for 2 lines	M4W Sta. No.2 – No., 11, 13, and 14 (12 stations)
Full-height PSD system for 3 lines	M4W Sta. No.1 (El Malek El Saleh)
Full-height PSD system for 4 lines	M4W Sta. No.15
Half-height PSD system for 2lines	M4W Sta. No.12 (El Remayah)
<Phase2>	
Full-height PSD system for 2 lines	M4N Sta. No.2 – No.12 (11 stations)
Full-height PSD system for 4 lines	M4N Sta. No.13
Half-height PSD system for 2lines	M4N Sta. No.14 – No.17 (4 stations)

Based on the above list, the PSD cost is identified in Table 7-6 and Table 7-7. Said cost is already covered in the total construction cost presented in Table 7-4.

Table 7-6 Estimated Cost of PSD (Phase 1)

No.	Item	Decription	Unit	Quantity	Unit price (USD)	Amount (USD)	Import duty & TAX (USD)	Total (USD)
	PSD							97,822,268
1	Full-height PSD, 2lines	Sta No.2-11,13, 14	sta.	12	5,228,941	62,747,297	11,073,052	73,820,349
2	Full-height PSD, 3lines	Sta. No.1	sta.	1	7,641,470	7,641,470	1,348,495	8,989,964
3	Full-height PSD, 4lines	Sta. No.15	sta.	1	10,112,420	10,112,420	1,784,545	11,896,965
4	Half-height PSD, 2lines	Sta. No.12	sta.	1	2,647,741	2,647,741	467,248	3,114,989

Source: JICA Study Team

Table 7-7 Estimated Cost of PSD (Phase 2)

No.	Item	Description	Unit	Quantity	Unit cost USD	Amount (USD)	Import duty & TAX (USD)	Total USD
	PSD							92,025,576
1	Full-height PSD, 2lines	Sta. No. 2-12	Sta.	11	5,228,941	57,518,355	10,150,298	67,668,653
2	Full-height PSD, 4lines	Sta. No.13	Sta.	1	10,112,420	10,112,420	1,784,545	11,896,965
3	Half-height PSD, 2lines	Sta. No.14-17	Sta.	4	2,647,741	10,590,964	1,868,994	12,459,958

Source: JICA Study Team

7.2 Estimation of O&M Cost

7.2.1 Preface

(1) The purpose of this estimation is to provide the O&M cost for the calculation of the EIRR and FIRR in the economic and financial appraisals of the construction of Metro Line 4.

(2) In this report, a combination of three approaches has been adopted for cost estimation. The first is the direct estimation from the breakdown of overall costs provided by the “Egyptian Company for Metro” (ECM). The second is the estimation by imitation of Japanese metro costs through some indicators. The third is the direct estimation by the JICA Study Team using both the broad indicators of ECM and the indicators from the selected Japanese metro systems.

(3) When utilizing the cost data of foreign countries, the difference of commodity prices between two countries should be well noted. In this estimation, direct reference to costs in foreign countries was carefully avoided.

(4) Cost estimation was done without consideration of inflation.

(5) Structure of O&M cost is so complicated that its cost breakdown is displayed in the following table for better understanding.

Items			Related Table Number
Skilled Personnel cost			Table7-19
Power cost			Table7-11
Maintenance cost			
	Outsourcing cost		Table7-15
		Foreign engineers' cost	Table7-12 and 13
		Local working staff cost	Table7-14
		Management cost	Table7-15
		Profit of the outsourced company	Table7-15
	Miscellaneous cost		Table7-17
	Spare parts cost		Table7-23
	Cleaning cost		Table7-28
Other cost except depreciation and tax			
	Security cost		Table7-29
	Outsourcing cost (unskilled personnel cost)		Table7-31
	Other cost		Table7-32
Total cost			Table7-34

7.2.2 O&M Cost of Cairo Metro

Table 7-8 gives the breakdown of the total ECM cost for the financial year 2008-2009. It should be noted that this table excludes depreciation and tax.

Table 7-8 Breakdown of O&M Costs of ECM (2008-2009)

Category	Item	Amount (LE)	Distribution (%)	
Personnel costs	Wages and salaries plus allowances (such as medical expenses, pensions, etc)	81,753,687		35.4
Power cost	Electricity	47,812,303	20.7	21.0
	Power	590,124	0.3	
Maintenance cost	Maintenance	38,737,213	16.8	30.9
	Spare parts	27,075,132	11.7	
	Cleaning	5,524,748	2.4	
Other expenditures	Transportation	771,063	0.3	12.7
	Ambulance points	139,850	0.1	
	Safety	368,747	0.2	
	Security services	27,817,591	12.1	
Total		230,590,458	100.0	100.0

Source: ECMOU

7.2.3 O&M Cost of Japanese Metro Systems

(1) The O&M cost of a selection of Japanese metro systems is given in Table 7-9. In this table, depreciation and tax is not included, like that of Cairo Metro. It should be noted that power cost, other than traction power cost, is included in other expenditures in the Japanese case. In the Cairo Metro case, all the power supply cost is included in the combined categories, electricity and power".

(2) In the Japanese case, the percentage of personnel costs in the total cost is 59% while that of the Cairo Metro is 35%. This comparison shows that the breakdown of the Japanese Metro O&M cost is quite different from that of the Cairo Metro. This demonstrates the need for careful consideration when Japanese Metro data is used for the Metro Line 4 cost estimation.

Table 7-9 O & M Cost of Japanese Metro Systems 2007/2008

Lines	Personnel Costs	Traction Power Cost	Maintenance cost other than personnel costs	Other Expenditures	Total
Unit	**000Yen**	**000Yen**	**000Yen**	**000Yen**	**000Yen**
Sendai Metro	2,902,880	173,799	1,356,862	1,523,506	5,783,248
Tokyo Metro	85,139,237	6,255,021	17,476,345	53,517,916	156,133,498
Yokohama Metro	8,478,326	634,581	1,430,885	3,718,795	13,628,006
Osaka Metro	49,201,485	5,579,798	7,740,293	15,167,208	72,108,986
Total	145,721,928	12,643,199	28,004,385	73,927,425	247,653,738
Percentage (%)	59	5	11	30	100

Source; Annual Railway Statistics 2007 MLIT Japan

7.2.4 Estimation of Personnel Cost for Metro Line 4

The approximation process requires the estimation of the *average personnel cost*. The total personnel costs for Metro Line 4 are estimated by applying the estimated average personnel cost to the estimated number of personnel required (Please see, ” section 6.5 - Estimation of number of staff”).

(1) Average Personnel Cost

The average personnel cost for Metro Line 4 was estimated on the basis of data supplied by ECM for its total number of personnel and corresponding cost.

The working system of Metro Line 4 will be lean. From Table 7-10, it can be seen that the work efficiency ratio of Metro Line 4 will be higher than that of the existing lines by around 40 %. To establish such a high efficient working system, high performance equipment and staff with excellent abilities will be needed.

Table 7-10 Comparison of Work Efficiency between Metro Line 4 and Existing Lines

Items		Existing Lines	Metro Line 4 (2050)	Ratio of work efficiency
		1	2	C1/ C2
Route km	A	65.7	33.7	
Skilled staff number	B	4,773	1,708	
Skilled staff number per route km	C=B/A	72.6	50.6	
Ratio	D=C1/ C2			1.43

Source: JICA Study Team

It was assumed that higher wages and salaries will be needed to attract higher calibre staff. Thus for Metro Line 4, the average personnel cost was calculated by assuming that the contribution of human resources to efficiency enhancement represents half of the overall efficiency, and then multiplying the average personnel cost of ECM by the resulting factor of 120 % (=100%+ 40%/2) .

In calculating the average salaries for skilled staff (see Table 7-11), the wages of artisans and labour staff are assumed to be half those of for the skilled workers. Therefore, the number of artisans and labour staff is reduced to half of the current number.

After rounding off, LE19,000 per employee per year was derived as the average personnel cost for Metro Line 4.

It should be noted that this cost is estimated but in real operation, the actual number of staff can be increased within a fixed human resources budget.

Table 7-11 Estimation of Average Personnel Cost of Metro Line 4

Items		Figures	Unit	Remarks
Total personnel cost of ECMOU	A	81,753,687	LE	
Total number of staff	B	5,167	People	Number of artisans and labourers is reduced to a half
Average skilled personnel cost of ECMOU	C=A/B	15,822	LE	
Average skilled personnel cost of Metro Line 4	D=Cx1.2	19,144	LE	

Source; A , B=ECMOU, Others=JICA Study Team

(2) Estimation of the Total Personnel Costs

The number of staff of Metro Line 4 has already been estimated in section 6.5, “Estimation of number of staff”. Multiplying the average personnel cost with the estimated number of staff for Metro Line 4, gives the total personnel costs in every reference year of the forecast period, as shown in Table 7-12.

Table 7-12 Estimation of Total Skilled Personnel Costs for Metro Line 4

Year		Unit	Y2020	Y2023	Y2027	Y2050
Number of Staff	A		767	1,669	1,687	1,708
Average personnel cost	B	LE	19,000	19,000	19,000	19,000
Total skilled personnel costs	C=A x B	LE'000	14,573	31,711	32,053	32,452

Source: JICA Study Team

7.2.5 Power Cost for Metro Line 4

The electrical engineering specialist of the JICA Study Team estimated the power consumption volume and its cost as shown in Table 7-13.

Table 7-13 Power Cost for Metro Line 4 Operation

	Items	Unit	Y2020	Y2023	Y2027	Y2050
Station	Power consumption	Million KWh per year	147,279	288,553	288,553	288,553
	Electricity cost	LE million per year	10.01	19.62	19.62	19.62
Traction	Power consumption	Million KWh per year	51,745	187,876	193,642	201,137
	Electricity cost	LE million per year	3.52	12.78	13.17	13.68
Total	Power consumption	Million KWh per year	199,024	476,429	482,194	489,690
	Electricity cost	LE million per year	13.53	32.40	32.79	33.30

Source: JICA Study Team
Note: Electricity charge is assumed to be LE 0.068 per KWh

7.2.6 Maintenance Cost for Metro Line 4

Basically, maintenance cost consists of the items listed below. Further details of the composition of the maintenance cost estimates are provided in the respective sub-sections enclosed in parentheses.

- Outsourcing cost
  - Foreign engineers' cost (please see sub-section 7.2.6 (1))
  - Local working staff cost (please see sub-sections 7.2.6 (1)c))
  - Management cost (please see sub-section 7.2.6 (1)d))
  - Profit of the outsourcers (please see sub-section 7.2.6 (1)d))
- Miscellaneous cost (please see section 7.2.6 (3))
- Spare parts cost (please see section 7.2.7)

This section describes the basis of estimates of maintenance cost, other than the cost of spare parts.

(1) Foreign Engineers' Cost

This sub-section considers the foreign expert component of outsourcing cost, on the assumption that the maintenance of rolling stock and the signalling system will be outsourced for the initial five years.

a) Foreign Engineers' Cost in Rolling Stock Maintenance

a) Local workers will be assigned to work on Metro Line 4, similar to the case of Metro Line 2. The core staff of local workers will be assumed to have sufficient skills in rolling stock maintenance of the existing lines. It should be noted that training on the basic structures of the new rolling stock for Metro Line 4 and troubleshooting techniques will be provided by the rolling stock suppliers. The cost of this training will be included in the procurement cost of rolling stock.

b) The existing outsourcing payment is calculated by multiplying the train-km run with the unit price of the outsourcing contract. In the case of Metro Line 4, the number of train-sets at the opening will be much smaller than that of Line 2, but the required number of foreign engineers will be the same as that for Metro Line 2. Therefore, estimation of the payment should be based on costs related to the time commitment of the foreign engineers, rather than on train-km run.

c) Based on the above assumptions, Table 7-14 provides the estimates of the rolling stock foreign engineers' cost.

Table 7-14 Estimation of Foreign Engineers' Cost in Rolling Stock Outsourcing

Item	Unit	Y2020	Y2021	Y2022	Y2023	Y2024
Supervision	MM	24	24	24	24	24
Initial training	MM	24				
Instruction for heavy maintenance	MM				24	
Special instruction for parts maintenance	MM			5	5	5
Total	MM	48	24	29	53	29
Remuneration per man month	USD	30,000	30,000	30,000	30,000	30,000
Foreign engineers' cost	USD '000	1,440	720	870	1,590	870
	LE '000	7,937	3,969	4,795	8,764	4,795
Remarks		Guarantee period				

Note; USD=5.512 LE
Source; JICA Study Team

b) Foreign Engineers' Cost in Signal Maintenance

The foreign engineers' cost for signal maintenance is estimated in the same manner as the corresponding cost for rolling stock maintenance, as shown in Table 7-15 below.

Table 7-15 Estimation of Signal Maintenance Outsourcing Cost (Foreign Engineers)

Item	Unit	Y2020	Y2021	Y2022	Y2023	Y2024
Supervision	MM	24	24	24	24	24
Initial training	MM	12				
Unit remuneration	USD	30,000	30,000	30,000	30,000	30,000
Foreign engineers' cost	USD '000	1,080	720	720	720	720
	LE '000	5,953	3,969	3,969	3,969	3,969
Remarks		Guarantee period				

Note; USD1=L.E. 5.512 LE, Source: JICA Study Team

c) Yearly Local Staff Cost for Outsourcing

An estimate of yearly local staff cost in the overall outsourcing cost is given in Table 7-16. Assumptions for the calculation are as follows.

(1) The local staff number for signal maintenance is assumed to be one third of the electrical equipment maintenance staff.

(2) Regarding unit remuneration for local staff, the figure expressed in section 7.2.4(1), " Average personnel cost", is adopted.

(3) The number of local staff for the rolling stock maintenance is obtained by extending the number of staff in the years 2020 and 2023 by the forecast rate of growth in demand.

It should be noted that the number of local staff in Table 7-16 has to be subtracted from that of Metro Line 4, in order to avoid double counting the numbers of staff.

Table 7-16 Estimation of Local Staff Number and Cost in the Outsourcing of Maintenance

	Item	Unit	Y2020	Y2021	Y2022	Y2023	Y2024
Local staff number	Rolling stock	people	95	101	101	312	312
	Signal	people	25	25	25	52	52
	Total	people	120	126	126	364	364
Unit remuneration		LE	19,000	19,000	19,000	19,000	19,000
Local staff cost		LE '000	2,280	2,399	2,399	6,922	6,922

Source: JICA Study Team

d) Yearly Total Outsourcing Cost for the Initial Five Years

The yearly total outsourcing cost is given in Table 7-17. Assumptions for this estimation are as follows.

(1) Management percentage is assumed to be 20% of the direct cost.
(2) Profit percentage is assumed to be 10% of the total cost.

Table 7-17 Estimation of Yearly Total Outsourcing Cost (Unit; LE '000)

Category			Y2020	Y2021	Y2022	Y2023	Y2024
Local staff cost		A	2,280	2,399	2,399	6,922	6,922
Foreign expert cost	Rolling stock	B	7,937	3,969	4,795	8,764	4,795
	Signal	C	5,953	3,969	3,969	3,969	3,969
Total direct cost		D=A+B+C	16,170	10,337	11,163	19,655	15,686
Management cost		E=D x 0.2	3,234	2,067	2,233	3,931	3,137
Profit		F=(D+E) x0.1	1,940	1,240	13,396	2,359	1,882
Total cost		G=D+E+F	21,344	13,644	26,792	25,945	20,705

Source: JICA Study Team

(2) Miscellaneous Cost for Maintenance

Miscellaneous cost means indirect cost for maintenance. In reality, its components are different for each railway. At first, the miscellaneous cost of rolling stock in Japan was introduced. Then, utilizing these data, the miscellaneous maintenance cost for Metro Line 4 was estimated since no information from ECM was available for the estimation.

a) Miscellaneous Cost of Rolling Maintenance in Japan

Miscellaneous costs of the Japanese metro systems are given in the following table with the corresponding maintenance personnel costs. From this table, it can be seen that the average ratio of the miscellaneous maintenance cost to maintenance personnel costs (MMR) is 30%. Since this figure seems too high for Metro Line 4, the average ratio of the Tokyo and Osaka metros, i.e., 15% (≒(30%+11%)/2) was adopted for the estimation of miscellaneous cost for Metro Line 4.

Table 7-18 Miscellaneous Maintenance Cost of Japanese Metros

Lines	Maintenance personnel costs	Maintenance cost other than direct maintenance cost and power cost	MMR
	A	B	C=B/A
Unit	000Yen	000Yen	%
Sendai Metro	295,590	90,032	30
Tokyo Metro	9,995,342	2,950,758	30
Yokohama Metro	944,001	464,240	49
Osaka Metro	6,940,745	789,273	11
Average			30

Source: Annual Railway Statistics 2007 MLIT Japan

b) Estimation of Miscellaneous Maintenance Cost for Metro Line4

From the number of maintenance staff provided in section 6.5, "Estimation of staff number", average personnel cost (please see the section 7.2.4(1)) and MMR (please see 7.2.6 (2) a)), the miscellaneous maintenance cost for Metro Line 4 was estimated as shown in the following table.

Table 7-19 Estimation of Miscellaneous Maintenance Cost for Metro Line 4

Items		Unit	Y2020	Y2023	Y2027	Y2050
Maintenance staff number	A		220	573	582	592
Average personnel cost per staff	B	LE	19,000	19,000	19,000	19,000
Maintenance personnel costs	C=A x B	LE '000	4,180	10,887	11,058	11,229
MMR	D	%	15	15	15	15
Miscellaneous maintenance cost	E=C x D	LE '000	627	1,633	1,659	1,687

Source: JICA Study Team

(3) Total Outsourcing and Miscellaneous Maintenance Cost

From Table 7-17 and Table 7-19, total maintenance cost is summarised in the following table. Personnel costs for staff engaged in the direct maintenance by ECM and spare parts cost are not included in the total maintenance cost presented below.

Table 7-20 Total Outsourcing and Miscellaneous Maintenance Cost for Metro Line 4

Items		Unit	Y2020	Y2023	Y2027	Y2050
Outsourcing cost	A	LE ‘000	21,344	25,945	0	0
Miscellaneous maintenance cost	B	LE ‘000	627	1,633	1,659	1,687
Total	C=A+B	LE ‘000	21,971	27,578	1,659	1,687

Source: JICA Study Team

It should be noted that the local maintenance staff is dispatched from ECM to an outsourcing company. Hence, the number of the maintenance staff belonging to ECM for Metro Line 4 and the personnel cost for Metro Line 4 has to be modified. Figures after modification are given in the following table.

Table 7-21 Modified Estimation of Total Skilled Personnel Costs for Metro Line 4

Year		Unit	Y2020	Y2023	Y2027	Y2050
Number of Staff	A	People	767	1,669	1,687	1,708
Number of skilled maintenance staff dispatched to the outsourcing company	B	People	120	364	0	0
Modified number of skilled staff for Metro Line4	C=A-B	People	647	1,305	1,687	1,708
Average personnel cost	D	LE	19,000	19,000	19,000	19,000
Modified skilled personnel costs	E=C x D	LE ‘000	12,293	24,795	32,053	32,452

Source: JICA Study Team

7.2.7 Estimation of Parts Cost

ECM provided the yearly spare parts cost. The JICA Study Team deems that this figure is too small. Hence the spare parts cost was estimated on the basis of Japanese experience.

(1) Estimation of Rolling Stock Parts Cost

The spare parts cost of modern rolling stock in Japan is expressed in the following table. These figures have been arranged for an eight car train-set consisting of six motor cars and two trailer cars like that of Metro Line 4. Equipment installed on this rolling stock is similar to that of the train-sets planned in this study. The average ratio of spare parts cost to the rolling stock procurement cost applicable in Japan (1.5 %) is shown in the following table. This can be adopted for the purpose of estimating the rolling stock spare parts cost for Metro Line 4

Table 7-22 Spare Parts Cost for Modern Japanese EMU

Years after Procurement	Inspections	Percentage of Parts Cost with Procurement Cost of Rolling Stock
		%
Between 0-3.5years	Monthly inspections	0.9
3.5 year after commencement	Designated equipment maintenance	1.8
Between 3.5-7years	Monthly inspections	0.9
7 year after commencement	Function maintenance	2.8
Between 7-10.5years	Monthly inspections	0.9
10.5 year after commencement	Designated equipment maintenance	1.8
Between 10.5-14years	Monthly inspections	0.9
14 year after commencement	Overhaul maintenance	10.9
	Total	20.8
	Average per year	1.44

Source: JR East

Utilizing this average, the annual spare parts cost for rolling stock was estimated as shown in the following table.

Table 7-23 Yearly Spare Parts Cost of Rolling Stock

Items	Unit		Y2020	Y2023	Y2027	Y2050
Number of rolling stock		A	160	528	544	560
Unit price	USD'000	B	2,552	2,552	2,552	2,552
Parts cost per year ratio	%	C	1.5	1.5	1.5	1.5
Parts cost per year	USD'000	D=A x B x C	6,125	20,212	20,824	21,437
	LE'000	E=D x 5.512	33,761	111,406	114,782	118,161

Source: JICA Study Team

(2) Estimation of other spare parts cost

1) Based on the rolling stock spare parts cost, the spare parts cost for other equipment's maintenance was estimated. In this case, the yearly spare parts percentage of the initial asset cost was set to half of the rolling stock ratio, since other equipment, such as that related to track, signalling and power supply maintenance, is not movable and its structure is rather simple.

2) For this estimation, the initial capital costs of each type of equipment were used as the basis for estimating their respective spare parts cost, as shown in Table 7-24. The source of these base Initial capital cost estimates is section 7.1.

Table 7-24 Estimation of Other Spare Parts Cost for Equipment

Items		Unit	Tracks	Signal and Telecom and power supply	Depot/ workshop	Total
Ph1	A	USD' 000000	10.9	189.5	48.2	
Ph2	B	USD' 000000	7.9	195.6	7.2	
2020	C＝A x 0.75％	USD' 000	81.2	1,421.2	361.5	1,863．9
2027 2050	D=(A+B)x 0.75％	USD' 000	141.0	2,888.3	415.5	3，444.8

Source: JICA Study Team

(3) Estimation of total spare parts cost for Metro Line 4

Table 7-25 gives the total yearly parts cost in every reference year.

Table 7-25 Estimation of Yearly Parts Cost

Items		Unit	Y2020	Y2023	Y2027	Y2050
Parts cost of rolling stock	A	USD' 000	6,125	20,212	20,824	21,437
Parts cost for equipment	B	USD' 000	1,864	3,445	3,445	3,445
Total parts cost	C=A＋B	USD' 000	7,989	23,657	24,269	24,882
	D=C x 5.512	LE'000	44,035	130,397	133,771	137,150

Source; JICA Study Team

7.2.8 Estimation of Cleaning Cost

The cleaning cost of ECM is expended on the cleaning of both the rolling stock and stations, but its breakdown is not available. Hence, the unit cost of station cleaning was first estimated by the JICA Study Team. Consequently, the unit cost of rolling stock cleaning was estimated. Finally, the total cleaning cost for Metro Line 4 was estimated on the basis of these two components.

(1) Estimation of unit cleaning cost for stations

The unit cost for station cleaning on the existing lines was estimated as shown in the following table. The number of shifts and unit personnel cost, including a management fee, have been assumed by the JICA Study Team.

Table 7-26 Estimation of yearly cleaning cost per station

Items		Figures	Unit	Remarks
Number of staff	A	3	Shift	
Unit personnel costs per year	B	10,000	LE	Including management fee of the outsourcing company
Yearly cleaning cost per station	C=A x B	30,000	LE	

Source: JICA Study Team

(2) Estimation of unit rolling stock cleaning cost

The average cost for rolling stock cleaning on the existing lines was estimated as shown in Table 7-27.

Table 7-27 Estimation of Unit Cleaning Cost for rolling stock

Items		Figures	Unit
Number of rolling stock for Metro Line 1	A	480	
Number of rolling stock for Metro Line 2	B	280	
Total number of rolling stock	C=A+B	760	
Cleaning cost for Metro Line 1 and 2 (including both rolling stock and stations	E	5,524,748	LE
Cleaning cost for stations on Metro Line 1 and 2	F	1,650,000*	LE
Cleaning cost per rolling stock	G= (E – F) /C	5,098	LE

Source; JICA Study Team
* Calculated as 55 stations x 30,000 LE per station per year

(3) Estimation of cleaning cost for Metro Line 4

Utilizing the above unit costs, the annual cleaning cost was estimated separately for stations and rolling stock for Metro Line 4, as shown in Table 7-28 and Table 7-29, respectively below.

Table 7-28 Estimation of Yearly Cleaning Cost of Stations for Metro Line 4

Items		Unit	Y2020	Y2023	Y2027	Y2050
Number of stations	A		15	31	31	31
Unit cost of cleaning	B	LE	30,000	30,000	30,000	30,000
Cleaning cost	C=A x B	LE ‘000	450	930	930	930

Source; JICA Study Team

Table 7-29 Estimation of Yearly Cleaning Cost of Rolling Stock for Metro Line 4

Items		Unit	Y2020	Y2023	Y2027	Y2050
Number of rolling stock	A		160	528	544	560
Unit cost of cleaning	B	LE	5,098	5,098	5,098	5,098
Cleaning cost	C=A x B	LE’000	816	2,692	2,773	2,855

Source; JICA Study Team

The total cleaning cost for Metro Line 4 is summarised in Table 7-30 below.

Table 7-30 Estimation of Yearly Cleaning Cost for Metro Line 4

Items		Unit	Y2020	Y2023	Y2027	Y2050
For stations	A	LE’000	450	930	930	930
For rolling stock	B	LE’000	816	2,692	2,773	2,855
Total cleaning cost	C=A x B	LE’000	1,266	3,622	3,703	3,785

Source; JICA Study Team

7.2.9 The other costs excluding depreciation and tax

In this sub-section, security costs, as well as other miscellaneous costs, are estimated.

(1) Security Costs

This cost is the charge for police assigned to stations, thus, the JICA Study Team assumes that this cost is related to the number of stations. The security cost per station was estimated first for the existing metro lines, as shown in Table 7-31. The cost for Metro Line 4 is then estimated by multiplying this figure with the number of stations of Metro Line 4, as shown in Table 7-32.

Table 7-31 Estimation of Unit Security Cost for the Existing Lines

Items		Figures	Unit
Number of stations for Metro Line 1	A	35	
Number of stations for Metro Line 2	B	20	
Security services cost of ECMOU	C	27,817,591	LE
Security cost for station	D=C/(A+B)	505,774	LE

Source; JICA Study Team

Table 7-32 Estimation of Yearly Security Cost for Stations for Metro Line 4

Items		Unit	Y2020	Y2023	Y2027	Y2050
Number of stations	A		15	31	31	31
Unit price of security	B	LE	505,774	505,774	505,774	505,774
Total security cost	C=A x B	LE'000	7,587	15,679	15,679	15,679

Source; JICA Study Team

(2) Other Costs

a) Outsourcing cost (Artisans and labouring staff)

Regarding artisans and labouring staff, it is one idea that their tasks can be covered by employing multi-skilled workers with high salaries. In such scheme, no extra budget for the cost of artisans and labourers is needed. Outsourcing their tasks may also be considered as another idea. In this scheme, a budget for outsourcing has to be secured. Hence in this study, their cost is secured as a part of the other costs, adopting a conservative approach.

As already observed, their average wages are assumed to be half those of the skilled workers, calculated as follows.

Average wages for artisans and labourers =LE15,822 (from Table 7-11*) x 0.5= LE 7.911*

A rounded figure of 8,000LE is obtained as the average wage for artisans and labourers.

In the Cairo Metro, the number of skilled staff is 4,733 while that of artisans and labourers is 788. The number of artisans and labour for Metro Line 4 can be obtained by utilizing these figures and number of skilled staff for Metro Line 4.

Assumptions for outsourcing are as follows.

(1) Management percentage is assumed to be 20% of the direct cost.
(2) Profit percentage is assumed to be 10% of the total cost.

Table 7-33 Estimation of Outsourcing Cost for Artisans and Laborers for Metro Line 4

Year		Unit	Y2020	Y2023	Y2027	Y2050
Skilled staff number	A	People	767	1,669	1,687	1,708
Number of artisans and labourers	B=Ax788 /4,773	People	125	276	279	282
Unit personnel cost of artisans and labourers staff	C	LE	8,000	8,000	8,000	8,000
Total artisan and labourer costs	D=B x C	LE'000	1,016	2,208	2,232	2,256
Management cost	E=Dx0.2	LE'000	203	442	447	452
Profit	F=(D+E)x0.1	LE'000	122	265	268	271
Total	G=D+E+F	LE'000	1,341	2,915	2,947	2,979

Source; JICA Study team

b) Other costs

Other costs provided by ECM and not previously discussed in this chapter are shown in the following table. The total amount is so small that it was assumed that each cost is to be shared equally by Metro Line 1 and Metro Line 2. Hence the cost burden assumed for Metro Line 4 is the same as that for Metro Line 1 and Metro Line 2.

Table 7-34 Estimation of Other Costs for Metro Line 4

Items		Figures	Unit
Transportation	A	771,063	LE
Ambulance points	B	139,850	LE
Safety	C	368,747	LE
Total	D=A+B+C	1,279,660	LE
Cost for each Line	E=D/2	640	LE'000

Source; JICA Study Team

c) Consolidated "other cost"

From Table 7-33 and Table 7-34, the consolidated "other costs" is given in the following table.

Table 7-35 Estimation of Consolidated Other Costs

Items	Unit	Y2020	Y2023	Y2027	Y2050
Outsourcing of artisans and labor costs	LE'000	1,341	2,915	2,947	2,979
The other costs	LE'000	640	640	640	640
Total cost	LE'000	1,981	3,555	3,587	3,619

Source; JICA Study Team

7.2.10 Total O&M cost for Metro Line 4

Based on Table 7-12, Table 7-13, Table 7-20, Table 7-25, Table 7-30, Table 7-32 and Table 7-35, the total O&M cost is calculated and expressed in Table 7-36. The following is however noted:

1) In this cost, depreciation and tax are not included.

2) The O&M cost for each phase was estimated by multiplying the ratio of each phase's route length to the total route length, by the total O&M cost. The result is expressed in the Table 7-37.

Table 7-36 Total O&M Cost for Metro Line 4

Items	Unit	Y2020	Y2023	Y2027	Y2050
Personnel costs	LE'000	12,293	24,795	32,053	32,452
Power cost	LE'000	12,500	30,040	30,500	30,960
Maintenance cost					
Maintenance cost	LE'000	21,971	27,578	1,659	1,687
Parts cost	LE'000	44,035	130,397	133,771	137,150
Cleaning cost	LE'000	1,266	3,622	3,703	3,785
Other costs					
Security cost	LE'000	7,587	15,679	15,679	15,679
Other costs	LE'000	1,981	3,555	3,587	3,619
Total	LE'000	101,633	235,666	220,952	225,332

Source: JICA Study Team

Table 7-37 Breakdown of O&M Cost for Metro Line 4 by Phase

Items		Unit	Y2020	Y2023	Y2027	Y2050
Route length of Phase 1	A	Km	16.1	16.1	16.1	16.1
Route length of Phase 2	B	Km	0	17.6	17.6	17.6
Total O&M Cost	C	LE'000	101,633	235,666	220,952	225,332
Phase 1 O&M Cost	D=C x A/（A+B）	LE'000	101633	112,588	105,559	107,651
Phase 2 O&M Cost	E=C x B/（A+B）	LE'000	0	123,078	115,393	117,681

Source: JICA Study Team

7.3 Contract Packaging

7.3.1 Procurement of Contractors

Contractors should be selected through an international competitive bidding process, involving prequalification of tenderers.

(1) Design and Build Approach

The design and build approach is recommended for the construction works. This approach allows effective utilization of the experience and ingenuity of the contractors, in order to reduce the total project cost, and to alleviate road traffic disturbance under the very restricted conditions for the cut-and-cover construction of underground stations. The contractors can apply their engineering ingenuity in their detailed design. The duration for the pre-bid can be shortened through the design-build method.

7.3.2 Packaging for Construction Works

Conceivable contract packages are as follows:

- Scheme 1 1 package :	All-in-one package including civil works, electric works, other infrastructure works, and rolling stock.
- Scheme 2 2 packages :	One package for civil works, and one package for railway system which includes electric and mechanical works, including station facilities, depot/workshop facilities, and rolling stock.
- Scheme 3 3 packages 1 :	One package for civil works, one package for electric and mechanical works, and one package for rolling stock,
- Scheme 4 3 packages 2 :	Two packages for civil works and one package for railway system which includes electric and mechanical works, including station facilities, depot/workshop facilities, and rolling stock,
- Scheme 5 4 packages 1:	Three packages for civil works and one package for railway system which includes electric and mechanical works, including station facilities, depot/workshop facilities, and rolling stock.
- Scheme 6 4 packages 2 :	Two packages for civil works, one package for railway system which includes electric and mechanical works, including station facilities and depot/workshop facilities, and one package for rolling stock.
- Scheme 7 5 packages:	Three packages for civil works, one package for railway system which includes electric and mechanical works, including station facilities and depot/workshop facilities, and one package for rolling stock.

Table 7-38 Scheme of Packaging

<table>
<tr><th>Scheme 1
1 package</th><th>Scheme 2
2 package</th><th>Scheme 3
3 package</th><th>Scheme 4
3 package</th><th>Scheme 5
4 package</th><th>Scheme 6
4 package</th><th>Scheme 7
5 package</th><th>Item</th></tr>
<tr><td rowspan="5">1</td><td rowspan="3">1</td><td rowspan="3">1</td><td rowspan="2">1</td><td>1</td><td rowspan="2">1</td><td>1</td><td>Civil 1</td></tr>
<tr><td>1</td><td>1</td><td>Civil 2</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td><td>Civil 3</td></tr>
<tr><td rowspan="2">1</td><td>1</td><td rowspan="2">1</td><td rowspan="2">1</td><td>1</td><td>1</td><td>E&M</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>Rolling stock</td></tr>
</table>

Source: JICA Study Team

Table 7-39 Package Scope

Item	Sub item	Section	Scope
Civil 1		From station No.1 (El Malek El Saleh, including stabling track section) to station No.9 (including station No.9)	Construction of stations and tunnel by TBM, Construction of track.
			Station facility
Civil 2		From the end of station No.9 (not including station No.9) to station No.14 (including station No.14)	Construction of stations and tunnel by TBM, construction of track;
			Station facility
		All section for Phase 1	Procurement of track inspection vehicle and rail grinding machine.
Civil 3		From the end of station No.14 (not including station No.14) to depot/workshop	Construction of station and tunnel by cut-and-cover method; civil work of depot/workshop; construction of track in the tunnel and station area.
			Station facility
E&M	Signal	All section for Phase 1	Signal system including CCP, Train operation and control system, ATC/ATS, train detection system, system inspection and maintenance equipment, etc.
	Telecom	All section for Phase 1	Optical fibre telecommunications system, telecommunications system by LCX, telephone system, maintenance facilities, public announcement system, CCTV, radio system, inspection system, etc.
	Traction Power	All section for Phase 1	HVS with building, rectifier stations, over-head catenary system, switching system, power line, electric power system for station facilities, SCADA, inspection system, maintenance vehicles, etc.
	Depot Facilities	All section for Phase 1	Buildings, track, car sheds, jacking systems, pantograph inspection gantries, environmental systems, mobile access platforms, ground wheel lathe, car washing machine, pantograph repair equipment, repair and testing of air conditioning equipment, cranes, generator sets, lorry, ambulance, fire tender, pickup truck, electric power station, catenary, radio system, signalling system, lighting system, water supply system, compressed air supply system, forklifts, trucks
Rolling stock			8 car train with air-conditioning, on-board signalling system, motor car for depot and rail transportation

Source: JICA Study Team

Note: Station facility includes elevators, escalators, ventilation and air conditioning system, PSD, AFC, IC cards for AFC, lighting, tunnel ventilation system, signage, station water supply and drainage, etc.

Table 7-40 Assortment and Amount of Each Scheme

<table>
<tr><th>Scheme 1
1package
(mil.US$)</th><th>Scheme2
2package
(mil.US$)</th><th>Scheme 3
3package
(mil.US$)</th><th>Scheme 4
3package
(mil.US$)</th><th>Scheme 5
4package
(mil.US$)</th><th>Scheme 6
4package
(mil.US$)</th><th>Scheme7
5package
(mil.US$)</th><th>Item
(amount mil.US$)</th></tr>
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LC: 1,046.2</td><td rowspan="3">1
Total: 1,511.8
FC: 615.3
LC: 896.4</td><td rowspan="3">1
Total: 1,511.8
FC: 615.3
LC: 896.4</td><td>1
Total: 852.0
FC: 359.0
LC: 493.0</td><td>1
Total: 852.0
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Total: 852.0
FC: 359.0
LC: 493.0</td><td>Civil 1
Total: 852.0
FC: 359.0
LC: 493.0</td></tr>
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LC: 403.4</td><td>1
Total: 432.2
FC: 184.7
LC: 247.4</td><td rowspan="2">1
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FC: 256.3
LC: 403.4</td><td>1
Total: 432.2
FC: 184.7
LC: 247.4</td><td>Civil 2
Total: 432.2
FC: 184.7
LC: 247.4</td></tr>
<tr><td>1
Total: 227.5
FC: 71.6
LC: 155.9</td><td>1
Total: 227.5
FC: 71.6
LC: 155.9</td><td>Civil 3
Total: 227.5
FC: 71.6
LC: 155.9</td></tr>
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FC: 666.4
LC: 149.8</td><td>1
Total: 387.5
FC: 237.7
LC: 149.8</td><td rowspan="2">1
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FC: 666.4
LC: 149.8</td><td rowspan="2">1
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FC: 666.4
LC: 149.8</td><td>1
Total: 387.5
FC: 237.7
LC: 149.8</td><td>1
Total: 387.5
FC: 237.7
LC: 149.8</td><td>E&M
Total: 387.5
FC: 237.7
LC: 149.8</td></tr>
<tr><td>1
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FC: 428.7
LC: 0.0</td><td>1
Total: 428.7
FC: 428.7
LC: 0.0</td><td>1
Total: 428.7
FC: 428.7
LC: 0.0</td><td>Rolling stock
Total: 428.7
FC: 428.7
LC: 0.0</td></tr>
</table>

Source: JICA Study Team
Note: figures shown in table do not include price escalation and physical contingency

(1) Coordinated Construction of Tunnel Sections and underground stations

The pit for underground stations will also be used as the launching base for the TBMs, used in tunnel construction. Thus, the station works and tunnels works are conflicting tasks executed in the same location. The coordination of tunnelling works and station works is important for the fast and smooth execution of the construction works. Therefore, the JICA Study Team recommends that the construction works of one underground section including the stations and tunnels be executed under a single contract package, which includes track works and the interior finishing of stations.

Station No.14 will be used as the launching base for the TBM of the civil 2 section and Station No.9 will be used as the launching base for the TBM of the civil 3 section.

(2) Construction Works of Tunnel Section by Cut-and-Cover Method

A single contract for works of one tunnel section by the cut-and-cover method is desirable from the viewpoint of possession of the site, coordination of other works, and the acceleration of construction works. This section includes station No.15 and the civil work for the depot area.

(3) Railway System (Core System: Electrical and Mechanical Works)

The electrification, telecommunications, signalling, CCP, SCADA and other electrical (and electronic) station facilities are related electrical systems and require engineering consistency in the detailed design and construction works.

Technical consistency between rolling stock and the signalling system, telecommunication system, CCP and PSD at stations is essential for smooth, accurate and safe train operation.

Therefore, it is recommended that all the electric and mechanical systems be included in a single contract package. The detailed design and installation of station and depot facilities will also be included in this contract.

(4) Rolling Stock

The contract for the procurement of rolling stock will be in one package with the railway system (electric and mechanical works). This should include the spare parts for maintenance of the rolling stock for the first three years after its procurement. On-board signals will be combined with the control system of the rolling stock including the traction system.

(5) Utility Diversion and Relocation

The diversion and relocation of utilities such as water main pipe, electric cables, telephone cables, gas pipes, will be done by NAT before the start of construction.

This item is not included in the above mentioned packages.

(6) High Voltage Electric Line

The construction of a high voltage electric line from the electric trunk line to the high voltage station in the depot will be done by the electricity supply company while the finance will be prepared by NAT.

This item is not included in the above mentioned packages.

7.3.3 Comparison and Recommendation for Contract Packaging

(1) Comparison of Schemes

The comparison of individual schemes is given in the following table.

Table 7-41 Comparison of Contract Schemes

Scheme	No. of packages	Advantage	Disadvantage	Evaluation
1	1	Easiest coordination involved for each package. Easy management and control of construction.	Contract amount is too large. Different categories of technology are in one package and such capable contractors are very rare	Not recommended
2	2	Different category of technology, as civil works and E&M are separated. Number of acceptable contractors will be more than in the case of Scheme 1. One package of E&M including rolling stock allows easy coordination and well balanced design of core	Coordination work between civil work and E&M work is necessary. Size of civil work is too large and not many financially capable contractors are available.	Not recommended

Scheme	No. of packages	Advantage	Disadvantage	Evaluation
		system. Number of contract packages is easy for management and control.		
3	3	Technically different category works are separated. Number of contract packages is easy for management and control.	Size of civil works is too large and not many financially capable contractors available. Technical coordination between E&M and rolling stock is difficult.	Moderately suitable
4	3	Technical coordination between E&M and rolling stock is easy. Number of contract packages is easy for management and control.	Contract amount of E&M and rolling stock is large. The section of civil 1 and 2 is long and contract amount will be too large for one contractor.	Moderately suitable
5	4	Technical coordination between E&M and rolling stock is easy. Number of contract packages is manageable and controllable.	Contract amount of E&M and rolling stock is large.	Most suitable recommended
6	4	Number of contract packages is manageable and controllable.	Technical coordination between E&M and rolling stock is difficult.	Suitable
7	5	The size of contracts of each package is not too large and the number of bidders will be enough for each package. Amount of each package is well-balanced. There is a possibility of reducing the contract amount because of the higher number of contractors participating in the bid.	Technical coordination between each package will be difficult.	Suitable

Source: JICA Study Team
Note: Most suitable: recommended > Suitable > Moderately suitable > Not recommended

(2) Recommendation

The JICA Study Team recommends procurement according to Scheme 5, with four packages which includes: two packages for the construction of the underground section using a TBM, one package for the construction of the underground section by cut-and-cover method, and one package for the installation of electrical and mechanical systems, including rolling stock.

7.3.4 Procurement of Consultant for Management and Supervision of Construction Works

Consulting services are necessary to be part of the project implementation organization, because the construction of the Metro Line 4 will involve the application of new technology, such as the management and control system for tunnelling by TBM, underground station construction with cut-and-cover method using road deck and many new electronic systems for the railway core system, including signalling and telecommunications.

Engineering consulting service for management and supervision of construction aims to provide assistance in the construction of the metro system, which includes assistance in bidding and contract negotiations, and supervision of construction works.

(1) Terms of Reference (TOR) of Engineering Consulting Services for Construction Supervision

1) Tender assistance scope

- Assistance for pre-qualification and its evaluation
- Assistance for pre-bid orientation for tender process
- Assistance for evaluation of tender proposals
- Assistance for clarification/negotiation with selected tenderer(s)
- Preparation of contract agreement for prospective contractor(s)

2) Scope for management and supervision of construction works

- Assist the Client in monitoring the resettlement execution progress and any necessary procedures by the Client, as well as monitor the level of living of project affected people after resettlement
- Assist the Client in conducting the environment monitoring and management process
- Prepare all the arrangements and procedures for construction commencement, with necessary data points and locations for setting out the works
- Check, evaluate and approve contractor’s detailed design, drawings, work plans and the progress schedule for the most effective and expeditious method of carrying out the work
- Check, evaluate and approve the execution of the contractor to ensure that the work complies with the contract specifications and approved drawings; Issue necessary instructions to contractors.
- Assistance for preparatory arrangement of traffic management
- Any arrangement for the notification of road and traffic conditions to the concerned people
- Check and approve all arrangements for ensuring road traffic management made by the contractor during construction and the necessary arrangements for the safety and protection of road traffic
- Carry out safety inspection of all working areas and installations during the work execution

- Ascertain and approve for the contractor the work measurements and payment certificate, and certify these to the Client as being correct and within the terms of the contracts.
- Prepare and approve (or submit to the Client for approval) any contract change orders, together with related specifications and drawings
- Assist the Client during negotiations with the contractor on any price or rate change, and make any recommendations, as may be necessary
- Assist in any dispute which may arise with the contractor
- Inspection of materials, machinery and rolling stock
- Final Inspection for hand-over process of completed works and inspect repairs of defective works.

CHAPTER 8
PLANNING OF PROJECT IMPLEMENTATION PROGRAM

CHAPTER 8 PLANNING OF PROJECT IMPLEMENTATION PROGRAM

The main scope of the project is divided into pre-construction works and construction works.

The scope of the pre-construction works consists of the following:

- Preparation of tender documents including the owner's requirements, basic design, technical specifications, conditions of contract and other related documents.
- Tender process including invitation to tender, pre-bid meeting, tender evaluation, negotiation and contract award.

The scope of the construction works are composed of the following:

- Preparation of works including selection of and contract award to sub-contractors
- Procurement and mobilization of necessary machinery and materials.
- Preparation of site office and work field.
- Construction works
- Completion inspection and the test run

The implementation program is studied under the following assumptions:

- The project will be executed under Japanese Yen Loan (STEP)
- The basic design and tender documents preparation will be done by the consultant employed by JICA (The consultant will be approved by NAT and JICA)
- The tender for the construction works will be done through design and build method
- The tender for the construction works will have four packages which include three civil works packages and one electrical and mechanical works package including rolling stocks. The detail description of the packaging is in section 7.3.

The project is costly and involves a considerable loan amount. Hence, the JST assumed that the loan will be phased in two stages. The first loan agreement shall be signed before the announcement the request for proposal for the GC. The signing of the second loan agreement will be after the determination of the amount of all the contracts.

The sequence of pre-construction stage is as follows:

- Request for STEP Loan to the Japanese government by the Egyptian government
- Request for proposal for basic design and tender documents preparation by JICA
- Award of contract of consulting services
- Implementation of basic design and preparation of tender documents
- Appraisal of the project by JICA
- Loan agreement
- Procurement of supervision consultant (GC)
- Completion of basic design and tender documents
- Issue tender for the construction works
- Evaluation of tenders assisted by GC
- Negotiation with and contract award to the contractors

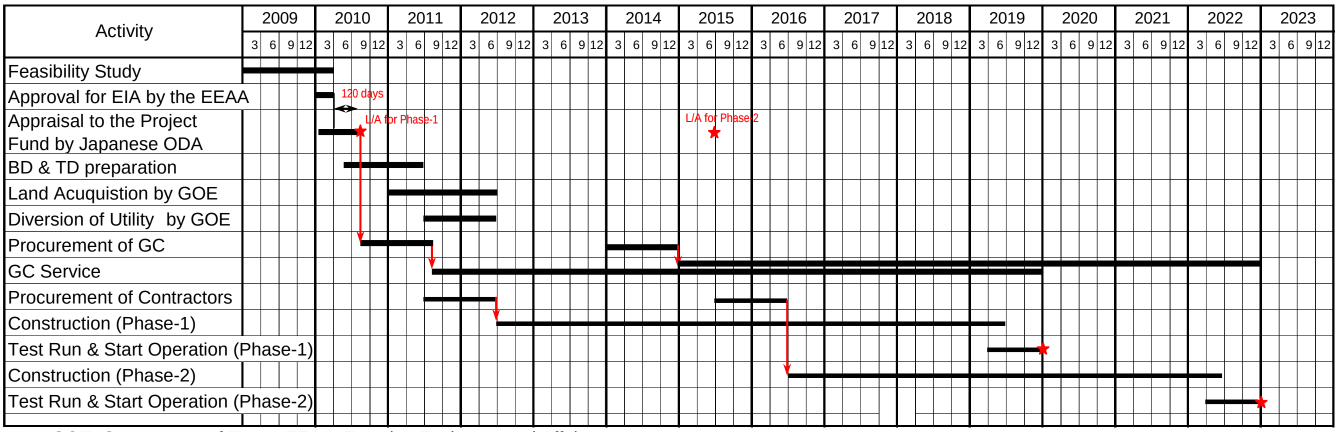
The following shall be noted with regards to the pre-construction activities:

- The works of basic design and preparation of tender documents need to be completed within 13 months, which include the pre-feasibility study, outline design and basic design of Phase 1B section and the approval of tender documents.
- The duration from the request for proposal to contract award to GC is assumed to be ten months.
- Preparation of tender documents for construction works is assumed to be 12 months.

The duration of construction will be seven years. Detailed explanation is in Section 4.7.6. Corresponding construction schedule is shown in Figure 4.260 to Figure 4.262. The following shall be noted with regards to construction works:

- After the completion of construction works, a trial run of rolling stocks and training operation will be done in six months. The expected completion for the preparation of the official operation of Metro Line 4 will be at the end of 2019.
- Diversion of utilities will be done by NAT before the start of construction works.
- Land acquisition shall be accomplished before the construction works.

The implementation schedule is shown in the following figure:



Note:GOE: Government of Egypt, EEAA: Egyptian Environmental Affairs Agency

Source: JICA Study Team

Figure 8.1 Project Implementation Schedule

CHAPTER 9
ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

CHAPTER 9 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

9.1 Introduction

The objectives of the Environmental Impact Assessment (EIA) for the Cairo Metro Line 4 (the project) are to examine the potential impacts during the construction and operation phase and to prepare appropriate mitigation measures for the expected adverse impacts, in order to avoid an unfavourable environmental and social situation. In the course of conducting the EIA, it is necessary to consider the Egyptian environmental regulations as well as the JICA Guideline for Environmental and Social Considerations, and ex-JBIC Guidelines for Confirmation of Environment and Social Considerations (hereinafter the Guidelines, or Guidelines of JICA and ex-JBIC) as donor policies.

In order to achieve the objectives under the Egyptian environmental legal framework and donor policies, the environmental and social study was conducted in two steps:

- An Initial Environmental Examination (IEE) through collecting available data and conducting preliminary site reconnaissance, and
- An EIA based on the result of the IEE. The EIA was conducted by site measurement of several environmental factors and preparation of an environmental management plan, including impact mitigation measures.

Preparation of an EIA for this project will be the first such experience for NAT, since the Egyptian guideline related to EIA study was only recently established. Therefore, close attention will be given to the preparation of the EIA proposal and results both during the project design, as well as during the construction and operation phase.

It is planned to implement the project in two phases, namely Phase 1 and Phase 2, as mentioned in previous chapters of this report. Phase 1 has been examined at the level of the preliminary-design, whereas Phase 2 has been studied at an outline design level, with due consideration to the available engineering data and project implementation schedule. Therefore, this chapter discusses the environmental and social considerations related to the examination of the two project phases as follows:

- An IEE was performed for both the Phase 1 and Phase 2, in order to assess the magnitude and extent of the environmental and social impacts likely to be caused by the project;
- An EIA was performed for the Phase 1 section, since it is about to proceed with the basic design stage, which will necessitate integrating of the environmental and social considerations into the project design; and
- Under certain assumptions concerning the alignment, station locations, etc., a preliminary EIA was prepared for the Phase 2 section and compiled in a volume separate from the Phase 1 EIA study.

9.2 Legislative System Related to Environmental Considerations in Egypt

9.2.1 Fundamental Laws and Regulations

The Egyptian laws and regulations related to environmental and social considerations are tabulated in *Annex 9-1*. Among these, two fundamental pieces of legislation in Egypt are identified, to which reference is made for environmental consideration of the project. One of these is Law No.4/1990, Law on Environment, the principal law on the environment. In addition, its derivatives, such as the Executive Regulations (ERs) of the Law No.4/1990 and Law No. 9/2009 (an amendment of Law No.4/2009) are also carefully considered.

The other legislation to which reference is made is the EEAA Guidelines of Principles and Procedures for EIA (prepared in 1996, updated in 2008, and put into effect in 2009), hereinafter called “the Egyptian EIA guidelines”. This regulates the procedure of the EIA approval system in Egypt.

9.2.2 EIA System in Egypt

(1) Overview of EIA System in Egypt

According to the Egyptian EIA guidelines, projects are to be categorized by type and by possible magnitude of likely impacts due to the project, in order to clarify the level of environment-related examination required, as well as the necessary procedure to be followed before the project implementation. The guidelines define three project categories as indicated below, and contains instructions and procedures for project proponents to follow.

a) List A Project

Projects with minor environmental impacts are classified under this category, and the project proponents are merely requested to fill in the Environmental Screening Form “A”.

b) List B Project

Projects with substantial environmental impacts are classified under this category based on activities and project size. A project proponent has to fill out Environmental Screening Form “B”. The procedure consists of two stages: (a) a screening (filling out Form B), possibly followed by (b) a scoped EIA on certain identified impacts/processes, if requested by the EEAA.

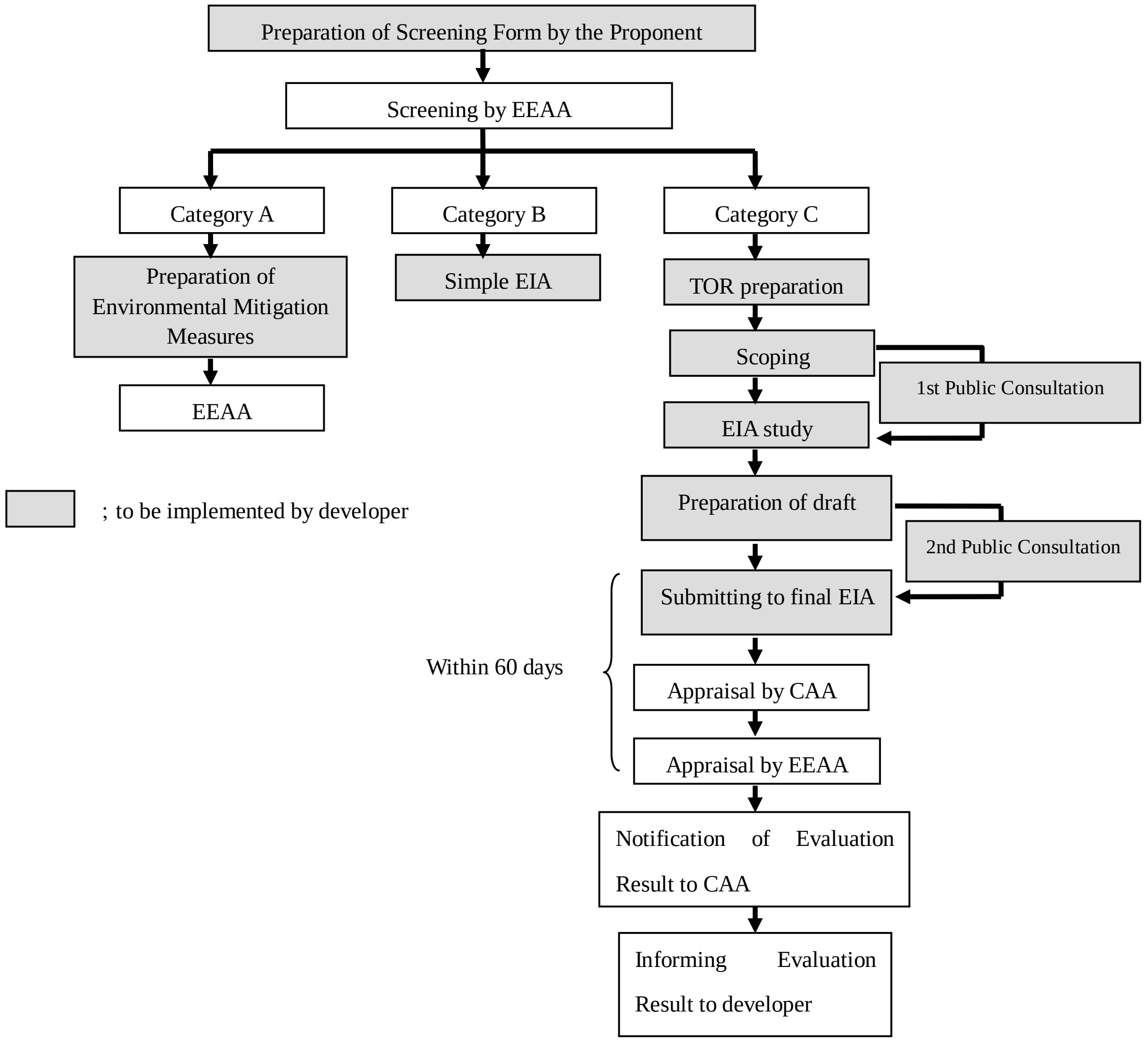
c) List C Project

Projects with high potential environmental impacts are classified under this category. Railway sector projects, including subways, are classified as List C projects according to Egyptian EIA guidelines. Proponents of List C projects are requested to conduct a full-scale EIA, and the approval procedure is summarised below.

- A project proponent submits an EIA report to the Competent Administrative

Authority (CAA).

- The CAA checks the reasonableness of the project classification and reviews the EIA report.
- The CAA submits the EIA report to the EEAA for review and evaluation.
- EEAA evaluates the EIA report and provides the appraisal result as well as comments on the EIA report, including mitigation measures, to the project proponent through the CAA within 60 days of EEAA's receipt of the completed documents.



Source: Prepared by JICA Study Team based on Egyptian EIA guidelines

Figure 9-1 EIA Approval Procedure under the Egyptian Legal Framework

d) Stakeholder Meetings

The Egyptian EIA guidelines request the conduct of stakeholder meetings twice: i) at the time of scoping and ii) at the time before compiling the final EIA report. With respect to the 2nd stakeholder meeting, its program including the project description will be announced in

Arabic through the newspaper at least two weeks before the meeting day. However, for List A and B projects, there is no obligation to conduct a stakeholder meeting.

9.2.3 Environmental Standards

Major environmental standards to be considered for the project are summarized as follows:

(1) Air Quality

Article 35 of Law 4/1994 and article 34 of its Executive Regulations (ERs), as amended by Decree 1741/2005, and Annex 5 of the ERs provide the maximum allowable limits for ambient air pollutants as shown in the following table.

Table 9-1 Maximum Limits of Outdoor Air Pollutants

(Unit: Microgram per Cubic Meter)

Pollutant	Maximum Limit	Period Of Exposure
Sulphur Dioxide	350 150 60	1 hr 24 hrs 1 year
Carbon Monoxide	30 Milligram/M3 10 Milligram/M3	1 hr 8 hrs
Nitrogen Dioxide	400 150	1 hr 24 hrs
Ozone	200 120	1 hr 8 hrs
Suspended Particles (Measured as black smoke)	150 60	24 hrs 1 year
Total suspending particles	230 90	24 hrs 1 year
Chest Particles (PM 10)	150 70	24 hrs 1 year
Lead	0.5 1.5	An average of 24 hours over 1 year in the urban areas An average of 24 hours over 6 months in the industrial zones

Source: Law No.4/1994

(2) Water Quality

Law 48/1982 concerning Protection of the Nile River and Water Streams provides the standard for water quality in bodies such as surface water streams and groundwater reservoirs, as shown below.

Table 9-2 Water Quality Standards for Fresh Water Bodies

(Unit: Milligram per Litter)

Parameter	Standard Value
Colour	100 NTU
Temperature	5 above normal temperature
Total Solids	500
Dissolved Oxygen	Not less than 5
pH	7 - 8.5
Biological Oxygen Demand (BOD)	6
Chemical Oxygen Demand (COD)	10

Parameter	Standard Value
Organic Nitrogen	1
Ammonia	0.5
Oil and Grease	0.1
Total Alkalinity	20 – 150
Sulphates	200
Mercury Compounds	0.001
Iron	1
Manganese	0.5
Copper	1
Zinc	1
Detergents	0.5
Nitrates	45
Fluorides	0.5
Phenol	0.02
Arsenic	0.05
Cadmium	0.01
Chromium	0.05
Lead	0.05
Selenium	0.01

Source: Law No.48/1982

(3) Noise

Article 42 of Law 4/1994 and Article 44 of the ERs give the maximum allowable limits for ambient noise intensity as presented in table below.

Table 9-3 Maximum Limit of Noise Intensity in Different Areas

Kind of area	Maximum limit of equivalent noise intensity LAeq in db(A)		
	Day time (7 am - 6 pm)	Evening time (6 pm - 10 pm)	Night time (10 pm - 7 am)
Rural residential areas, hospitals, and garden areas	45	40	35
Residential suburbs, with the existence of little movement	50	45	40
Town residential areas	55	50	45
Residential areas having some workshops or commercial activities, or on public roads	60	55	50
Trading and administrative areas, and downtown	65	60	55
Industrial zones (heavy industries)	70	65	60

Source: Law No.4/1994

(4) Other Standards

In addition to the above environmental quality standards, Law No.4/1990 also regulates the emission standards for sources of air pollution such as factories and vehicles, as well as , effluent standards for wastewater discharge from point sources. It also presents standard provisions for intermittent noise generated from heavy hammers, workplace standards on air and noise conditions, etc.

9.2.4 Consistency with the JICA and JBIC Guidelines

The guidelines of JICA and ex-JBIC aim at encouraging a recipient government to conduct appropriate environmental and social examinations at various stages of a feasibility study or project preparation. It also promotes appropriate participation of stakeholders to ensure transparent procedures and decision making. Adequate support and confirmation to be provided by JICA are also stipulated in the guidelines.

It has been requested that the study of this project should take the guidelines into consideration. Therefore, it is important for there to be an examination and understanding of the consistency and verification between the Egyptian regulations and donor policies.

a) Requirements of the Guidelines

The major requirements to be fulfilled by the recipient country can be summarised as follows:

- Integration of environmental and social considerations into the project planning and implementation decision-making process.
- Preparation of various EIA-related documents in official or familiar language in a host country as well as in understandable language and form for the local people.
- Transparency regarding EIA-related documents and availability for access and copying at any time by stakeholders.
- Conducting appropriate environmental and social monitoring.

The key points of the process of environmental and social examination in line with the guidelines are as follows:

- Categorization of each project to determine the required level of environmental and social examination.
- Examination, as early as possible in the project preparation and design stage, of various environmental and social impacts and measures, for both the main project design and multiple alternatives..
- Examination of environmental impacts, measures, and alternatives in close harmony with economic, financial, institutional, social and technical analysis of the project.
- Information disclosure to, and consultation with, stakeholders to have social acceptability.
- Appropriate consideration to be paid to socially vulnerable groups, such as indigenous people, those subject to involuntary resettlement, etc.
- Monitoring after project implementation to confirm the effectiveness of measures, as well as the occurrence of any unforeseen situations

b) Comparison and Verification between Egyptian System and Guidelines

The table below shows the consistency of the Egyptian EIA system with the JICA and ex-JBIC guidelines. The key points of the process of environmental and social examination in line with the guidelines are as follows:

Table 9-4 Comparison between Egyptian EIA System and JICA/ex JBIC Guidelines

Requirements/Key Points of Guidelines	Egyptian System
Integration of environmental and social considerations into planning and decision-making process	- Egyptian EIA Guidelines stipulate stakeholder involvement at an early stage of project planning, to the greatest extent possible.
Openness of EIA-related documents in understandable language	- EIA report is prepared in Arabic. As for documents for stakeholder meeting, it is also prepared in plain Arabic since meeting participants are not necessarily familiar with environmental issues.
Categorization of the proposed project	- Egyptian EIA Guidelines classify a project ,including subway projects, into three categories based on project type and scale.
Examination of various impacts and measures	- Egyptian EIA Guidelines provide the general scope for examination of impacts and measures, such as physical, biological and social-economic aspects. - Alternative analysis is also considered in EIA guidelines.
Information disclosure and stakeholder consultation	- Egyptian EIA Guidelines ensure information disclosure at two different stages during EIA study in order to reflect stakeholder's opinion in the EIA study as well as project design. - The first stage involves meetings during the scoping stage with individual stakeholders (e.g. representatives of communities, academics, relevant authorities). - The second stage involves a town style meeting at the time of the draft EIA report. Those who are interested in a project can participate in such a meeting.
Consideration for socially vulnerable groups, involuntary resettlement, etc.	- There is no system specifically for involuntary resettlement. However, the legal system for land acquisition and compensation is enacted separately from the IEE/EIA system.
Monitoring after project implementation	- Egyptian EIA Guidelines stipulate that an environmental management plan, including a monitoring plan, be included in the EIA.

Source: JICA Study Team, referring to Law 4/ 1994 and Egyptian EIA guidelines.

From the examination of consistency and verification, it may be concluded that the Egyptian EIA system almost satisfies the requirements stipulated in the JICA and ex-JBIC guidelines.

9.3 Initial Environmental Examination

9.3.1 Site Description

(1) Natural Environment

a) Meteorology

The project area located in the Greater Cairo region is in a dry climate zone. The summer season is generally from May to October, and the winter season from November to March. According to the Statistical Year Book issued in December 2008 by CAPMAS, the average monthly maximum temperature throughout 2006 was 28.0^{o}C, whereas during the period from July to August 2006 was 34.4^{o}C. On the other hand, the average monthly minimum temperature from July to August was 15.9^{o}C, whereas that from December to February was 9.8^{o}C.

The yearly total precipitation recorded in 2006 in the region was 37.5 mm, and the yearly average humidity was 56%.

b) Flora and Fauna

It was confirmed through preliminary site reconnaissance that the study area would have little ecological significance and low biodiversity since it is located in the urban area where the habitation of natural ecology is low. Previous studies confirmed that this area has minimal significance for biodiversity. In that area, none of the few species of plants and animals are globally or locally threatened.

An interview with personnel of the Nature Conservation Department of EEAA revealed that there are no species of flora and fauna listed in Red Data Book of IUCN in the project area. In addition, the distribution of Important Bird Areas in Egypt shows no such vital areas in the Greater Cairo study area.

c) Natural Protectorates

None of the studied alignment alternatives passes through or nearby natural protectorate areas. The natural protectorates in the whole of Egypt defined by Law No. 102/1983 for Natural Protectorates as shown in

Table 9-5 and Figure 9-2 the closest to the study area is Hassana Dome, which is a 1 km^2 geological protected area located more than 3 km away from the closest alignment alternative and at higher ground level. It is therefore not expected to be subject to any significant potential impact from project implementation. In addition, as shown in Table 9-6 and Figure 9-3 regarding the wildlife protection areas in the whole Egypt, there are no designated areas in and around the project area.

Table 9-5 List of Natural Protectorates in Egypt

Title	Region	Title	Region
Ras Mohamed	South Sinai	Nile River Islands Protected Area	Several gov.
Saint Catherine Protected Area		Zaraniq Protected Area and El Bardwaeel Marsh	North Sinai
Nabq Protected Area		Ahrash Protectorate	
Abu Gallum Protected Area		Saloga, Ghazal and The Amall Islands	Aswan
Taba Protected Area		Wadi Al- Alaqi	
Elba Natural Protected Area	Red Sea	Wadi El Rayan Protected Area	Fayoum
Red Sea Northern Islands		Quaron Lake Protected Area	
Wadi El Gamal – Hamata Protected Area		Wadi Al-Asioutty Protected Area	Assyut
Elomayed Natural Protected Area	Matrouh	El-Brolus Protected Area	Kafr El-Sheikh
Natural Siwa Protected Area		The Petrified Forest Area	Cairo
Natural White Desert Protected Area		Wadi Degla Protected Area	
El Gulf El Kebeer		Hassana Dome Protected Area	Giza
Ashtoom El-gamil and Tenis Island Protected Area	Port Said	El Dababya	Qena
Wadi Sanor Cave Protected Area	Beni Sueif		

Source: EEAA Webpage

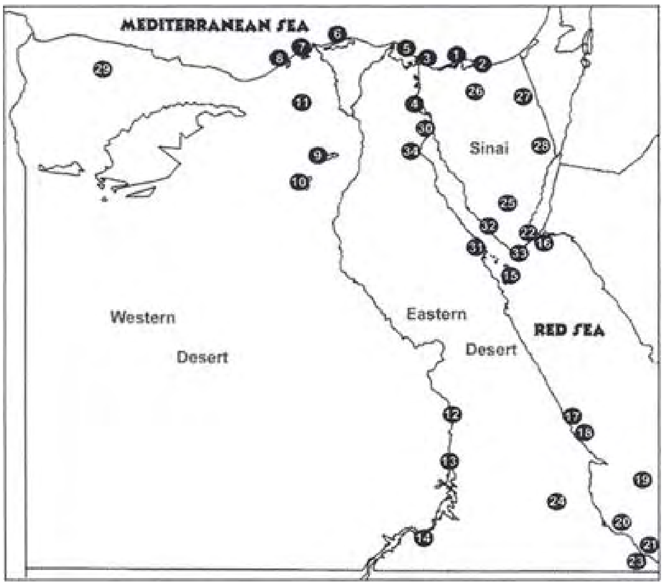
Source: EEAA Website

Figure 9-2 Location of Natural Protectorates in Egypt

Table 9-6 List of Wildlife Protection Areas in Egypt

1. Lake Bardawil	10. Wadi El Rayan	19. Zabargad Island	27. Quseima
2. Zaranik	11. Wadi El Naturn	20. Siyal Islands	28. Wadi Gerafi
3. El Malaha	12. Upper Nile	21. Rawabel Islands	29. El Qasr Desert
4. Bitter Lakes	13. Aswan Reservoir	22. Nabaq	30. Suez
5. Lake Manzalla	14. Lake Nasser	23. Gabel Elba	31. Gabel El Zeit
6. Lake Burullus	15. Hurghada Archipelago	24. The Abraq Area	32. El Qa Plain
7. Lake Idku	16. Tiran Island	25. St. Katherine	33. Ras Mohammed
8. Lake Maryut	17. Wadi Gimal Island	26. Gabel Maghara	34. Ain Sukhna
9. Lake Qarun	18. Qulan Island		

Source: EEAA Webpage

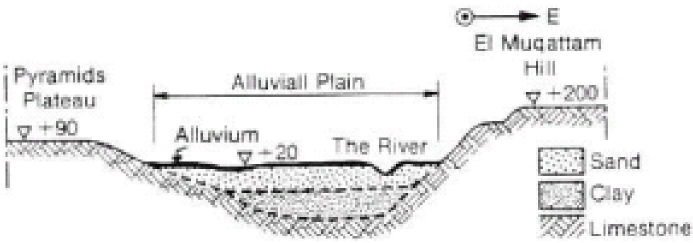


Source: EEAA Website (http://www.eeaa.gov.eg/English/main/protect_bird.asp)

Figure 9-3 Location of Wildlife Protection Areas in Egypt

d) Geological Features

Greater Cairo is spread out on the Nile alluvial plain. The alluvial stratum is composed of thick sediment up to the bed rock level. The pyramids plateau is situated on the left bank and El Muqattam hill on the right bank. Terrain suddenly changes from the border of the Nile alluvial plain. Taking into consideration the geological and terrain conditions in Greater Cairo, a study of the structures will be carried out.

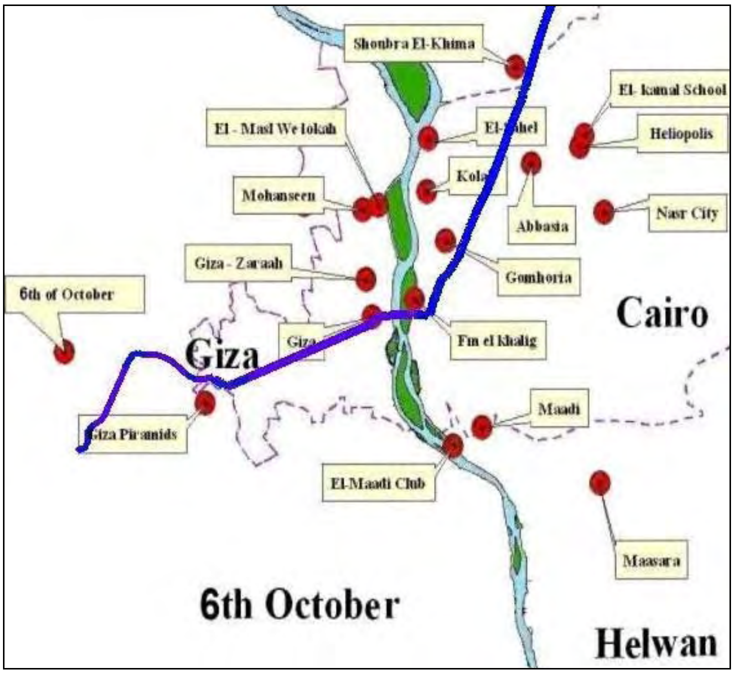


Source: El-Sohby and Mazen, 1985

Figure 9-4 Geological Cross Section of Greater Cairo

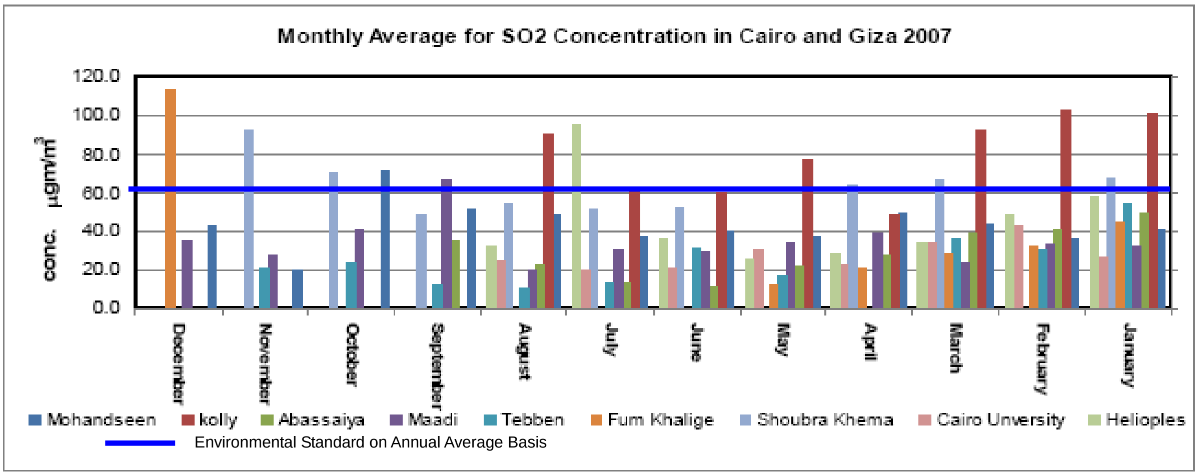
e) Air Quality

Monitoring of air quality is conducted by EEAA in the whole Egypt at 78 locations. Among these, 41 stations are distributed in the Greater Cairo region as shown in Figure 9-5. It shows that the monthly average level of SO_2 and PM_{10} is higher than the annual average of the environmental quality standard stipulated in Law 4/ 1994 of Egypt, as shown in Figure 9-6, Figure 9-7 and Figure 9-8.



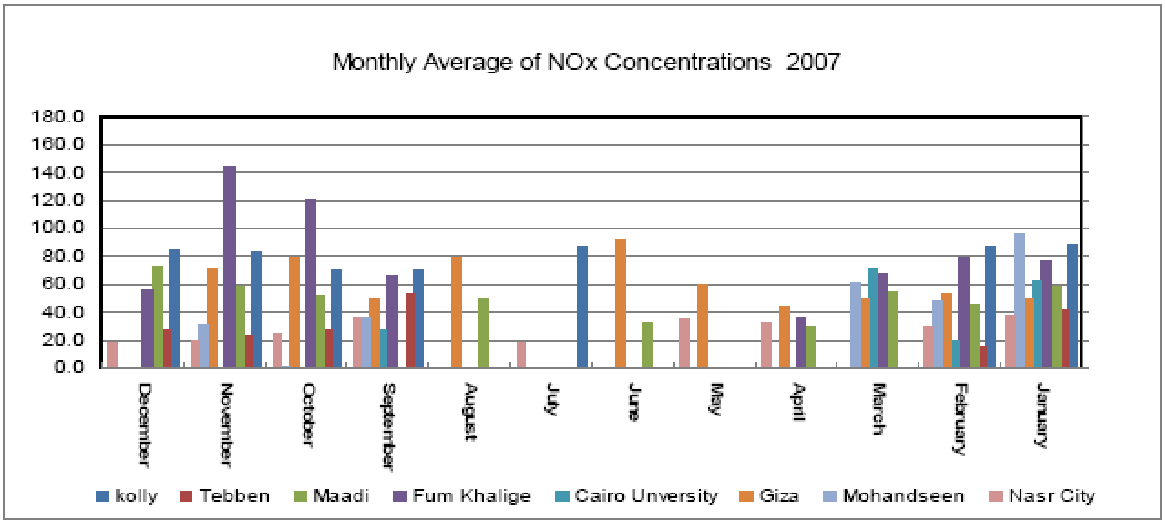
Source: Egypt State of Environment Report 2007, January 2008, EEAA

Figure 9-5 Air Quality Monitoring Stations in Greater Cairo Region



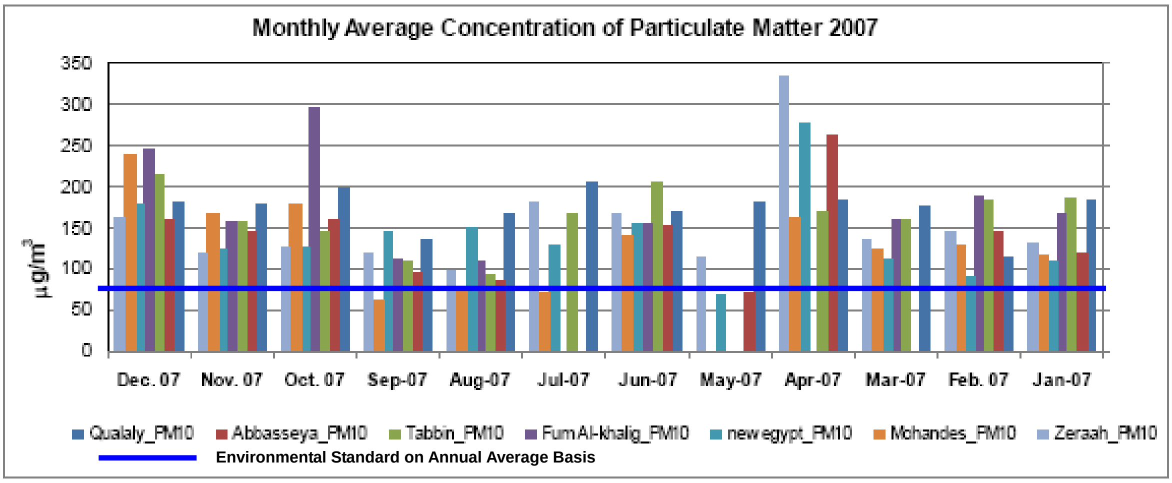
Source: Egypt State of Environment Report 2007, January 2008, EEAA

Figure 9-6 SO_2 Concentration Monitored in Cairo and Giza



Source: Egypt State of Environment Report 2007, January 2008, EEAA

Figure 9-7 NO_x Concentration Monitored in Cairo and Giza



Source: Egypt State of Environment Report 2007, January 2008, EEAA

Figure 9-8 PM_{10} Concentration Monitored in Cairo and Giza

f) Water Quality

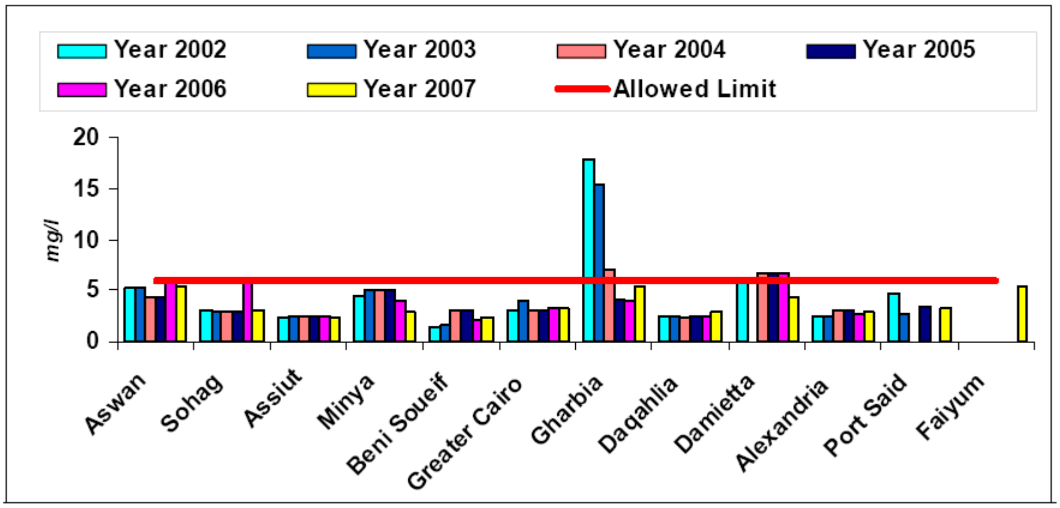
Water quality in Egypt is monitored jointly by EEAA, the Ministry of Water Resources and Irrigation, and the Ministry of Health. The mandate of the respective authorities is demarcated as shown in Table 9-7.

Table 9-7 Mandate Demarcation on Water Quality Monitoring in Egypt

Authority	Mandate of Water Quality Monitoring
EEAA	Inspection and monitoring of effluent of wastewater discharge by business establishments. Monitoring of coastal waters.
Ministry of Water Resources and Irrigation	Monitoring in inland water bodies including Nile river. Monitoring of irrigation water.
Ministry of Health	Monitoring of potable water resources.

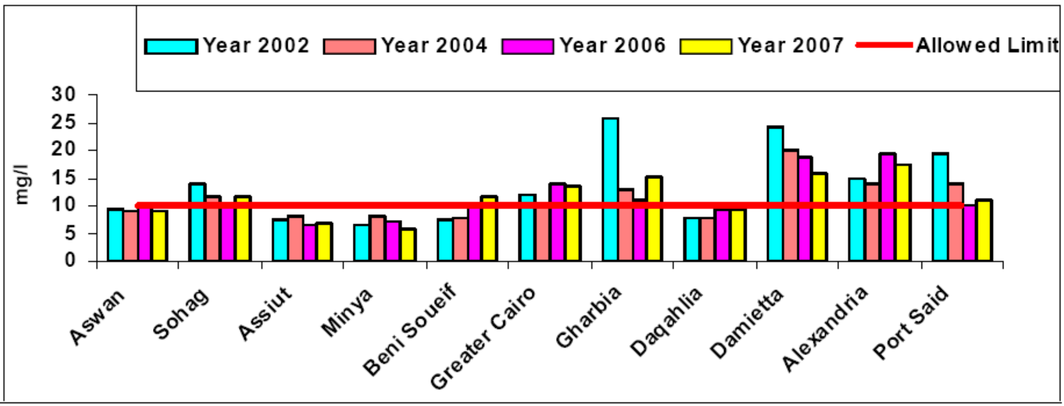
Source: JICA Study Team

A review of the available data, such as that of the Egypt State of Environment Report 2007, showed that the water quality of the Nile River in the Greater Cairo region (as compared with the upstream area) is considered deteriorated, due to effluence of domestic and industrial wastewater. However, the results of water quality monitoring also show that the level of deterioration is improving each year. The results of monitoring of the major parameters on an annual average basis on the Nile River are shown in Figure 9-9, Figure 9-10, and Figure 9-11.



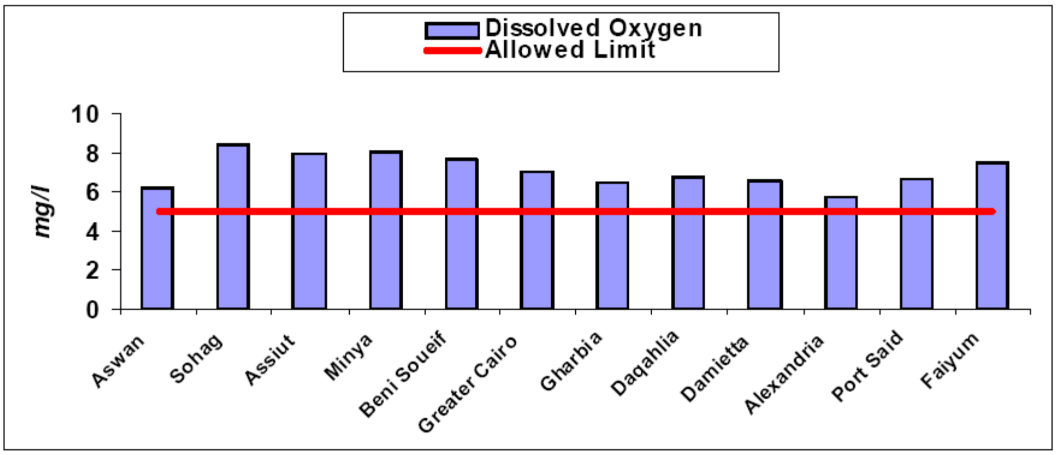
Source: Egypt State of Environment Report 2007, January 2008, EEAA

Figure 9-9 Monitoring Results in the Nile River (Biological Oxygen Demand)



Source: Egypt State of Environment Report 2007, January 2008, EEAA

Figure 9-10 Monitoring Results in the Nile River (Chemical Oxygen Demand)



Source: Egypt State of Environment Report 2007, January 2008, EEAA

Figure 9-11 Monitoring Results in the Nile River (DO)

g) Noise

Monitoring of noise is conducted by the EEAA at locations shown in Figure 9-12, and the related monitoring results are shown in Table 9-8. It is difficult to evaluate the results by comparison with the environmental standards because monitoring stations are set at the roadside and at intersections. However, it would be recognized that noise level around the project area would be high since it is located in an area with heavy traffic volume.

Source: Egypt State of Environment Report 2007, January 2008, EEAA

Figure 9-12 Noise Monitoring Locations

Table 9-8 Monitoring Results of Noise (dB)

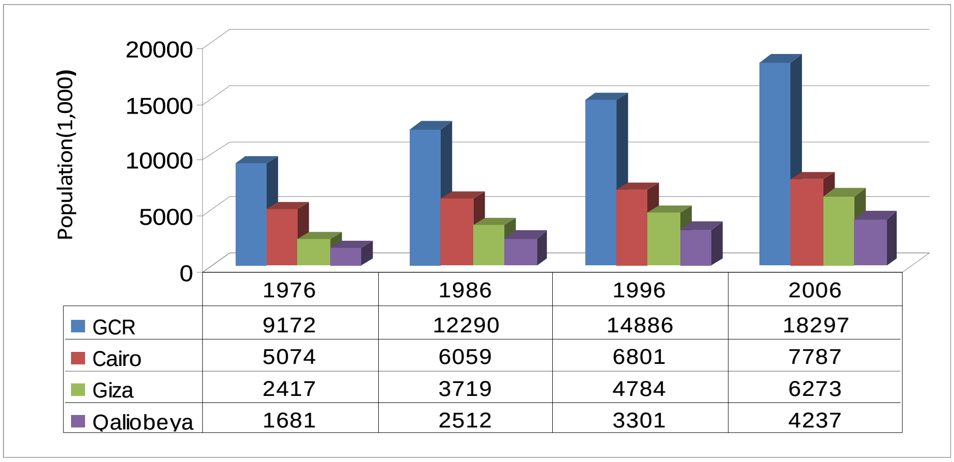
Monitoring Locations	Day time	Night Time
Opera Square	77	70
Ataba Square	62	65
Ramses Square	74	71
Roxy Square	75	70
Fom El-Khalig Square	80	75

Source: JICA Study Team

(2) Social Environment

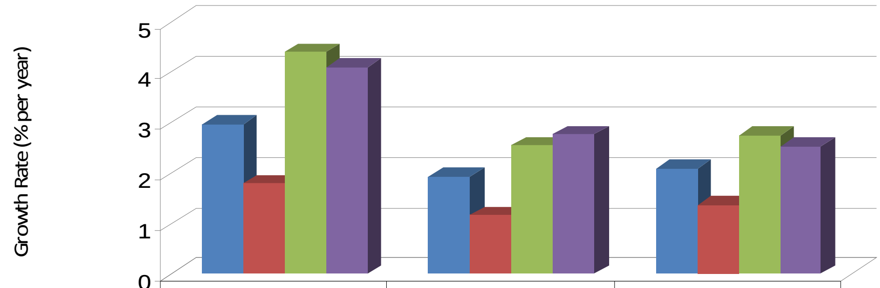
a) Population

According to the 2006 census, there has been a shift of population from Cairo to the governorates in the outlying areas of the Greater Cairo region, as shown in Figure 9-13 and Figure 9-14 . Data for the Sixth of October governorate is not included since it was only created in April 2008. According to the census data issued in December 2008, the population of the Sixth of October governorate is 2,581,056. Figure 9-15 shows the population density at the Greater Cairo Region.



Remark) GCR stands for Greater Cairo Region, which contains Cairo, Giza, and Qaliobeya governorates, since the data is refer to the 2006 census.
(Source: Census, CAMPAM, 2006)

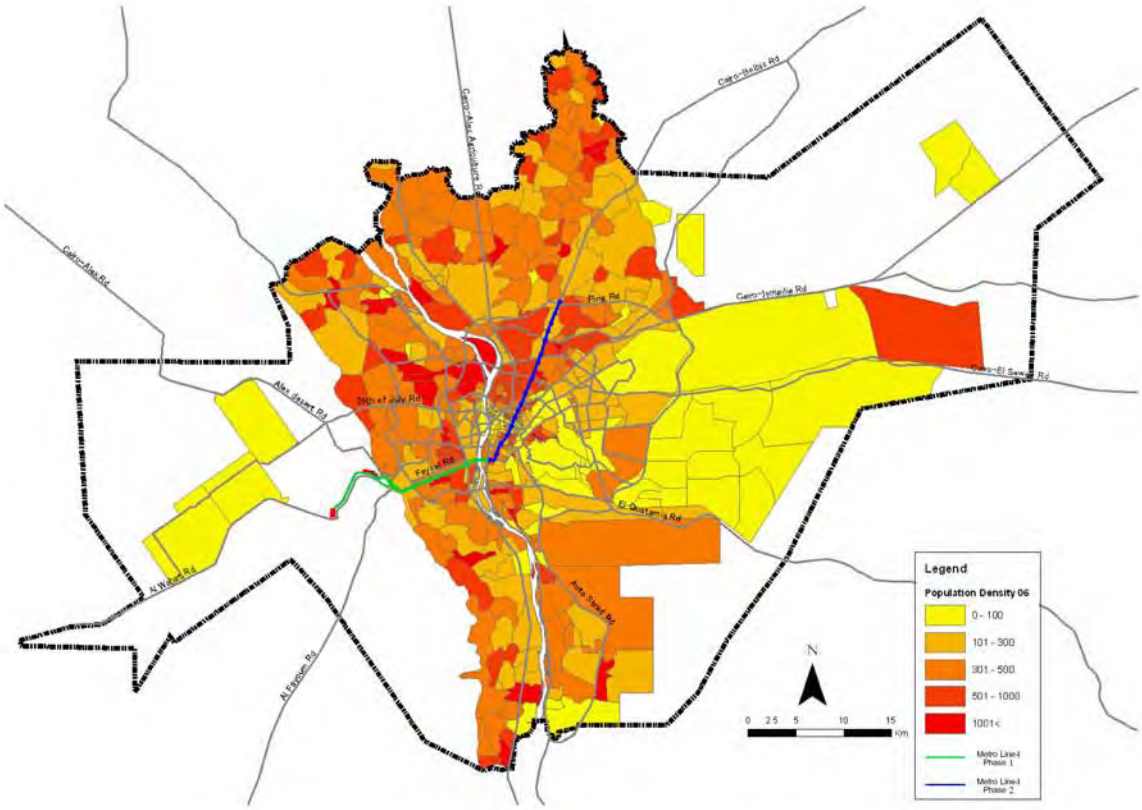
Figure 9-13 Population in the Study Area in Census Years 1976-2006



	1976-1986	1986-1996	1996-2006
GCR	2.969542627	1.934832396	2.08458964
Cairo	1.789984671	1.161947673	1.36306635
Giza	4.403474684	2.550197064	2.746825265
Qaliobeya	4.098672711	2.769108451	2.527718649

Remark) GCR stands for Greater Cairo Region, which contains Cairo, Giza, and Qaliobeya governorates, since the data refer to the 2006 census.
(Source: Census, CAMPAM, 2006)

Figure 9-14 Population Increase in the Study Area（1976-2006）



Source: SDMP

Figure 9-15 Population Density in Greater Cairo in 2006

b) Education, Unemployment, Literacy and Poverty

The education system in Egypt is divided into three stages excluding university: primary, preparatory, and secondary. In addition, there is a school which conducts religious lessons, namely El-Azhar. Table 9-9 shows the student population in 2006, and the forecasted student population up until 2050. Table 9-10 shows the unemployment, literacy and poverty situation in the study area in 2006.

Table 9-9 Actual and Forecasted Student Population in the Study Area

Year	Population	Primary and Preparatory students enrolled			Secondary and University students enrolled			Total students enrolled		
	(1,000 persons)	(1,000 students)	Annual growth rate	Student % of population	(1,000 students)	Annual growth rate	Student % of population	(1,000 students)	Annual growth rate	Student % of population
2006	16,101	2,305		14.32%	1,094		6.79%	3,399		21.11%
2007	16,464	2,328	1.00%	14.14%	1,132	3.47%	6.88%	3,460	1.79%	21.02%
2012	18,411	2,638	2.53%	14.33%	1,275	2.41%	6.93%	3,913	2.49%	21.25%
2017	20,369	2,922	2.07%	14.35%	1,560	4.12%	7.66%	4,482	2.75%	22.00%
2027	24,192	3,614	2.15%	14.94%	2,211	3.55%	9.14%	5,825	2.66%	24.08%
2030	25,387	3,854	2.16%	15.18%	2,361	2.21%	9.30%	6,215	2.18%	24.48%
2040	28,802	4,545	1.66%	15.78%	2,932	2.19%	10.18%	7,477	1.87%	25.96%
2050	31,815	5,249	1.45%	16.50%	3,531	1.88%	11.10%	8,781	1.62%	27.60%

(Source: SDMP and estimation by JICA Study Team)

Table 9-10 Literacy, Unemployment, and Poverty Rates in the Study Area

Governorate	Household	Population in a Household	Illiteracy (%)	Unemployment(%)	Poverty[1](%)
Qaliobeya	1,043,785	4.1	27.5	9.2	11.2
Cairo	1,783,335	3.8	19.3	10.8	4.6
Giza	802,402	3.9	19.7	10.8	13.1
Sixth of October	619,711	4.2	34.2	8.0	

(Source: Census, CAPMAS, 2006 and Egypt Human Development Report 2008, UNDP 2008)

c) Land Use

According to the analysis of land use in the study area as presented in the Strategic Urban Development Master Plan SDMP report, the urbanized land area increased by 12,600 ha between 2001 and 2007, while the area of desert and open space decreased by 13,100 ha and 1,100 ha, respectively.

One noticeable phenomenon was the loss of agricultural land in the study area. Between 2001 and 2007, there was a decrease of 2,000 ha in the area of agricultural land. This loss of agricultural land represents about 2.5% of the total area of agricultural land in the study area.

[1] Less than USD1 income per day

Table 9-11 Land Use in the Study Area from 2001 to 2007

Category	Area (ha)		Increase/ Decrease (ha)
	2001	2007	
Built-up Area	57,200	69,800	12,600
Agriculture	82,600	80,500	-2,100
Bare Area	1,400	5,100	3,700
Desert	285,700	272,600	-13,100
Water	3,400	3,400	0
Open Space	6,200	5,100	-1,100
Total	436,500	436,500	-

Remark：Build-up area includes urban area, airport, and cemetery.
Source：SDMP

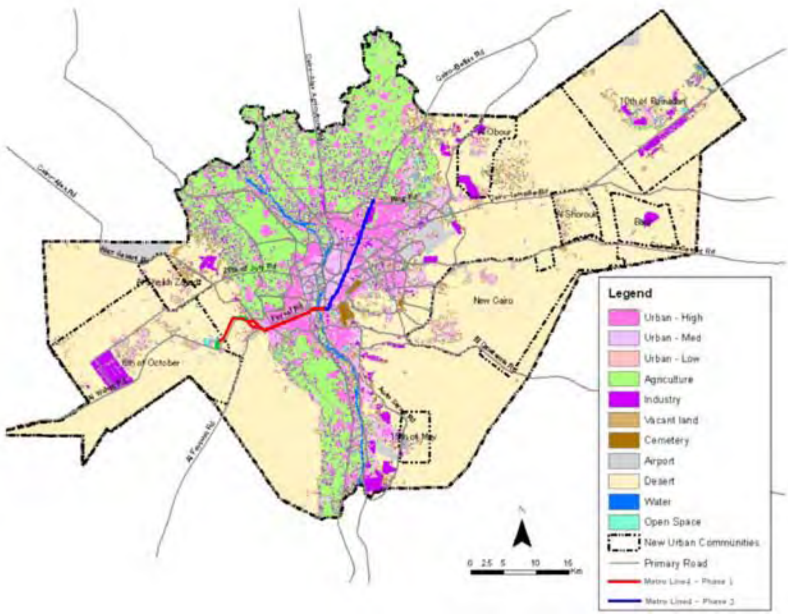
About half (53%) of the total increase in urban land area (12,600 ha) resulted from the conversion of desert, followed respectively by the conversion of open spaces (26%) and agricultural land (19%), as shown in Table 9-12.

Table 9-12 Area Which Was Converted Into Urban area in 2001-2007

Category	Area (ha)	Rate (%)
Agriculture	2,400	19.2
Bare Area	60	0.5
Desert	6,740	53.0
Water	100	0.8
Open Space	3,300	26.5
Total	12,600	100

Source：SDMP

Figure 9-16 shows the land use situation in the study area, as analyzed in the SDMP report. Most of the planned route pass through the urbanized area, but a part will pass through the desert area.



Source: SDMP

Figure 9-16 Land Use in Greater Cairo in 2006

(3) Cultural Aspects

Cairo is famous for its historical areas, and therefore the project area is expected to include cultural assets. Within the project area, the Giza Plateau, Matariya, and Heliopolis areas are especially regarded as important archaeological zones with an intensive distribution of cultural assets as well as a strong possibility of the existence of unrecognized cultural assets. Chapter 11 describes in detail the examination of cultural assets in the project area and the procedures necessary for protection of cultural assets discovered during the project construction.

9.3.2 Relevant Authorities Concerned with Environmental and Social Impacts

Table 9-13 lists the relevant authorities interested in the project.

Table 9-13 Authorities Concerned on Environmental and Social Considerations

Authority	Mandate/ Relation
National Authority for Tunnels; NAT	Project Proponent
Ministry of Transport	Competent Administrative Authority (CAA) in EIA Procedure
Egyptian Environmental Affairs Agency	Authority of EIA Approval
Supreme Council for Antiquities; SCA	Authority of Management and Supervision of Cultural Assets
Ministry of Irrigation and Water Resources	Authority responsible for Issue of decrees related to Land Acquisition and Resettlement
General Organization for Physical Planning; GOPP	Authority of Urban Planning
Egyptian General Survey Authority	Authority for Assessment of Resettlement
Qaliobeya Governorate	Local government authority in project area
Cairo Governorate	Local government authority in project area
Giza Governorate	Local government authority in project area
6th October Governorate	Local government authority in project area

Source: JICA Study Team

9.3.3 Screening and Categorization of the Project

Category A projects defined by the JICA and ex-JBIC Guidelines generally include i) vital sectors, such as transportation, having sensitive characteristics, or ii) projects located in/ around sensitive areas. Moreover, a project causing large-scale involuntary resettlement is classified under Category A project by the guidelines. Under this circumstance, there is a strong possibility that the Metro Line 4 project would be classified as a Category A project, since it belongs to the transportation sector, despite the low expected large-scale involuntary resettlement in the study area,.

As described in section 9.2.2, subway projects are automatically defined as List C projects under the Egyptian EIA guidelines, considering their potential impact on the environment due to project type and scale.

Accordingly, the project will need to proceed into the official procedure for EIA approval prescribed in Egyptian legislation. Hence, it is suggested that NAT, as the project proponent, should follow the necessary steps on the EIA before implementation of the project.

9.3.4 Examination of Potential Environmental Impact and Scoping

Potential impacts on the environment during the pre-construction, construction and operation stages of the project were initially identified using the environmental scoping list and matrices as shown in Table 9-14, Table 9-15, and Table 9-16 below.

Table 9-14 Results of Environmental Scoping

Item	Project Stage	Evaluation	Evaluation Basis
Social Environment			
Involuntary Resettlement	P	B-	Most of the sections of the project alignment are designed as underground structures beneath the exiting trunk roads, and other sections such as at-grade and viaduct structures are also designed along the existing trunk roads. It is expected that involuntary resettlement and land acquisition will be confined i) within the station construction areas where the method of cut-and-cover work will be employed, and ii) within the areas for other associated facilities to be installed on the surface if any. Although the magnitude of resettlement and land acquisition is not expected to be significant according to the project characteristics as abovementioned, further examination will be necessary.
	C,O	D	There is no project component or activity which would cause involuntary resettlement and land acquisition in the construction and operation stages.
Daily life of people in surrounding areas	P	D	No impact is expected in the pre-construction stage.
	C	B-	Some impact is expected on the people in the surrounding area due to noise and vibration caused by the construction activities.
	O	B- B+	The people resettled due to the project would be obliged to change their daily lives. On the other hand, some positive effect on the daily life of people is expected through the enhancement/ improvement by the project on the regional transportation condition.
Local economy such as employment and livelihood, etc.	P	D	No impact is expected in the pre-construction stage.
	C	B+	Some positive effect on the local economy is expected because of possible increment of business/ employment opportunity generated by construction activities of the project.
	O	B+	Some positive effect on the local economy is expected because of possible increment of business/ employment opportunity generated by the project operation. Further it is expected to improve the regional traffic condition through provision by the project for a convenient transportation mode.
Land use	P	D	No impact is expected in pre-construction stage.
	C	D	Extent of changing the land use condition during the construction stage is expected to be negligible, since i) the project alignment will generally be underground, and ii) the at-grade/ viaduct sections will be located along the existing trunk roads.
	O	C-	There is no project component or activity which would cause the change of land use condition during the operation stage. However, it is undeniable that the project will cause some secondary changes in land use, due to the operation of new stations. The negative extent of these secondary changes of land use will need to be examined further.
Physical community division	P	D	No impact is expected in pre-construction stage.
	C,O	C-	Extent of impact by physical community division would be small or negligible in general, since the project alignment of both underground and at-grade/ viaduct sections will mostly be located along the existing trunk roads. However, since a part of the at-grade sections would possibly be designed as cutting-and-embankment earth works, it will be necessary to further examine the possibility of physical community division along such

Item	Project Stage	Evaluation	Evaluation Basis
			sections.
Existing social infrastructure and services	P	D	No impact is expected in pre-construction stage.
	C	B-	Some negative impacts on the existing traffic conditions are expected, including air pollution, noise/ vibration, and increased risk of traffic accidents due to the traffic congestion caused by the construction activities, although the expected impacts will be temporary during the construction stage. The above would also cause temporary impacts on sensitive receptors such as schools and hospitals during the construction stage.
	O	B+	It is expected to improve the regional infrastructure through the project providing a convenient transportation mode.
The poor, indigenous, and ethnic people	P	C-	A part of the project alignment would possibly pass through the areas of social minorities (e.g. Coptic group) and/ or the areas where illegal occupants exist. Further examination and special considerations would be necessary in case that land acquisition and resettlement would be unavoidable in such areas due to the project.
	C,O	D	There is no project component or activity which would cause negative impacts additionally in construction and operation stages.
Misdistribution of benefit and damage	P,C,O	B-	Inequality among the stakeholders might be expected, since some would benefit from the project while others would be affected negatively.
Local conflict of interest	P,C,O	B-	It might be expected that inequality among stakeholders and inequalities in the distribution of benefit/ damage would cause local conflicts of interest.
Water use and water right	P,C,O	D	No impact on water use or water right is expected due to the project implementation.
Sanitation	P	D	No impact is expected in pre-construction stage.
	C	B-	Some negative impacts on the local sanitary condition are expected, due to the mobilization of construction work force and/ or workers' site camps, although the expected impacts will be temporary during the construction stage.
	O	D	The facilities associated with Metro Line 4 will be operated according to Egyptian regulations and guidelines related to maintaining sanitary conditions. Therefore, it is not expected to bring about serious impacts on sanitation in the operation stage.
Hazards (Risk), Infectious diseases	P	D	No impact is expected in pre-construction stage.
	C	B-	There is an increased risk due to infectious diseases among the construction work force and/ or in the workers' site camps, although the risk increment will be temporary during the construction stage.
	O	D	The facilities associated with Metro Line 4 will be operated according to Egyptian regulations and guidelines related to maintaining the sanitary conditions. Therefore, it is not expected to bring about a serious risk due to infectious diseases in the operation stage.
Accidents	P	D	No impact is expected in the pre-construction stage.
	C	B-	Increased risk of accidents is expected due to the operation of heavy equipment and heavy vehicles during the construction stage.
	O	B- B+	Increased risk of accidents is expected due to the train services in the operation stage, especially on the at-grade sections. On the other hand, it is expected that the risk of traffic accidents would be reduced due to the modal shift of transportation from passenger cars/ buses to the new metro.
Traffic condition	P	D	No impact is expected in the pre-construction stage.
	C	B-	Due to the cut-and-cover works for station construction on the existing roads, as well as due to the generation/ attraction of heavy vehicles at the construction site, some negative aspects are

Item	Project Stage	Evaluation	Evaluation Basis
			expected such as traffic accidents or traffic jams, although these expected impacts will be temporary during the construction stage.
	O	B+	It is expected that the risk of traffic accidents or frequency of traffic jam would be reduced due to the modal shift of transportation from passenger cars/ buses to the new metro.
Natural Environment and Pollution			
Topography and geological features	P,C,O	D	The project is not expected to cause significant changes or impacts on topography and geological features, since the project alignment will generally be located underground.
Soil erosion	P,C,O	D	The project is not expected to cause soil erosion, since the project alignment will generally be located underground.
Groundwater	C	C-	Some impacts on groundwater quality would be caused by the turbid water generated by shield tunnelling works for the route and cut-and-cover works for station construction. The probability and magnitude of impacts are unknown, so that further examination will be necessary.
	P,O	D	The project is not expected to cause serious impacts on groundwater artery/ quality in pre-construction and operation stages.
Hydrological situation	P,C,O	D	There is no project component or activity which would cause significant changes or impacts on hydrological conditions in and around the project area.
Coastal zone	P,C,O	D	There are no coastal zones in and around the project area.
Flora, fauna, and biodiversity	P,C,O	D	Negative impacts are not expected on the flora, fauna and biodiversity to be protected, since most of the project alignment will be located in developed urban and desert areas.
Meteorology	P,C,O	D	The project is not expected to cause significant changes in the regional meteorological conditions.
Landscape	P,C	D	The project is not expected to cause significant changes or impacts on the landscape during the pre-construction and construction stages.
	O	B-	Some change of landscape is expected due to the appearance of at-grade/ viaduct track sections and associated stations.
Global warming	P	D	No impact is expected in pre-construction stage.
	C	B-	Probability of increased GHG emission is expected due to the operation of heavy vehicles as well as traffic jams incidental to the construction works, although this impact will be temporary during the construction stage.
	O	B+	GHG emission is expected to be reduced due to the modal shift of transportation from passenger cars/ buses to the new metro.
Air pollution	P	D	No impact is expected in the pre-construction stage.
	C	B-	Some negative impacts on air quality are expected due to operation of heavy equipment/ vehicles as well as traffic jams incidental to construction works, although the expected impacts will be temporary during the construction stage
	O	B+	It is expected that emission of air pollutants will be reduced due to the modal shift of transportation from passenger cars/ buses to the new metro.
Water pollution	P	D	No impact is expected in pre-construction stage.
	C	B-	Some impacts on water quality would be caused by the turbid water generated from construction yards of cut-and-cover works as well as by the effluent generated from workers' camp sites, although the expected impacts will be temporary during construction stage.
	O	D	The facilities associated with Metro Line 4 will be operated according to the Egyptian regulations and guidelines related to proper management of wastewater or effluent. Therefore, it is not expected to bring about serious impacts on water quality in operation stage.

Item	Project Stage	Evaluation	Evaluation Basis
Soil contamination	C	C-	There are no project components or activities which cause soil contamination. However, in case the soil at the construction sites is already contaminated by other reasons, the construction activity of the project may cause negative impacts.
	P,O	D	There are no project components or activities which will cause soil contamination in pre-construction and operation stages.
Waste	P	D	No impact is expected in pre-construction stage.
	C	B-	The project is expected to generate construction waste in the construction stage.
	O	D	The waste generated from the facilities associated with Metro Line 4 will be managed according to the relevant Egyptian regulations and guidelines, thus it is not expected to cause serious impacts.
Noise and vibration	P	D	No impact is expected in pre-construction stage.
	C	B-	Some impacts of noise and vibration are expected due to the operation of heavy equipment/ vehicles, although the expected impacts will be temporary during the construction stage.
	O	B-	Some impacts of noise and vibration are expected due to train services in the operation stage, especially in the at-grade/ viaduct sections.
Ground subsidence	C	C-	The probability of ground subsidence is undeniable and dependent on the construction method to be employed, as well as on ground conditions. Further examination will be necessary according to the construction plan and findings on ground conditions.
	P,O	D	There are no project components or activities which may cause ground subsidence in pre-construction and operation stages.
Offensive odour	P,C,O	D	There are no project components or activities which may cause offensive odours.
Bottom sediment	P,C,O	D	There are no project components or activities which may cause negative impacts on bottom sediment.
Cultural Heritage			
Cultural heritage	P,C	C-	The possibility exists that buried/ undiscovered cultural assets may be found along the project alignment, since the Greater Cairo region is a well-known site for rich cultural heritage, including such assets as the Giza Pyramids. Further examination will be necessary for i) actions to be taken before the start of construction, and ii) countermeasures to be taken in case of unexpected discovery/ detection of cultural assets during construction stage.
	O	D	There are no project components or activities which may cause negative impacts on cultural heritage during the operation stage.

Legend of Project Stage

P: Pre-construction stage
C: Construction stage
O: Operation stage

Legend of Evaluation

A-: Serious impact is expected. A+: Positive effect is expected.
B-: Some impact is expected. B+: Positive effect is expected to a certain extent.
C-: Extent of impact is unknown. Further examination would be necessary. Impact may become clear as study progresses.
D: No or negligible impact is expected. Further examination is unnecessary in EIA study.

Source: JICA Study Team

Table 9-15 Scoping Matrix (1/2)

Name of Cooperation Project			JICA Preparatory Study on Greater Cairo Metro Line 4											
				Planning Phase		Construction Phase					Operation Phase			
	No	Likely Impacts	Overall Rating	Land acquisition	Change of Land use plan, Control of various activities by regulations for the construction	Setting a Camp for Construction Employees	Alteration to ground by cut land, filling, drilling, tunnel, etc.	Operation of Construction Equipment and Vehicles	Construction of Stations, Rail, other related facilities.	Limitation of transit in construction area	Increase of Through Trains	Appearance/ Occupancy of Stations, Rail, other related building structures	Operation of associated facilities	Boarding/ Alighting of passengers Generation/ Attraction of people
Social Environment	1	Involuntary Resettlement	B-	B-	D	D	D	D	D	D	D	D	D	D
Social Environment	2	Daily life of people in surrounding areas	B- B+	D	D	D	D	B-	B-	D	D	D	B+	B+
Social Environment	3	Local economy such as employment and livelihood, etc.	B+	D	D	B+	D	B+	B+	D	D	D	B+	B+
Social Environment	4	Land use and utilization of local resources	C-	D	D	D	D	D	D	D	D	D	C-	C-
Social Environment	5	Physical Community Division	C-	D	D	D	D	D	D	D	C-	C-	D	D
Social Environment	6	Existing social infrastructures and services	B- B+	D	D	D	D	B-	B-	D	B+	D	B+	D
Social Environment	7	The poor, indigenous and ethnic people	C-	C-	C-	D	D	D	D	D	D	D	D	D
Social Environment	8	Misdistribution of benefit and damage	B-	B-	B-	D	D	D	B-	B-	B-	D	B-	D
Social Environment	9	Local conflict of interests	B-	B-	B-	D	D	D	B-	B-	B-	D	B-	D
Social Environment	10	Water Usage or Water Rights and Rights of Common	D	D	D	D	D	D	D	D	D	D	D	D
Social Environment	11	Sanitation	B-	D	D	B-	D	D	D	D	D	D	D	D
Social Environment	12	Hazards (Risk) Infectious diseases such as HIV/AIDS	B-	D	D	B-	D	D	D	D	D	D	D	D
Social Environment	13	Accidents	B- B+	D	D	D	D	B-	B-	D	B- B+	D	D	D
Social Environment	14	Traffic Condition	B- B+	D	D	D	B-	B-	B-	D	B+	D	D	D

Rating:
A-: Serious impact is expected. A+: Positive effect is expected
B-: Some impact is expected. B+: Positive effect is expected to a certain extent.
C-: Extent of impact is unknown (Examination is needed. Impacts may become clear as study progresses.)
D: No impact is expected. IEE/EIA is not necessary.

Reference:
1) Japan International Cooperation Agency (1992) "IV Railways: Environmental Guidelines for Infrastructure Projects", Tokyo, Japan.
2) Norman Lee and Clive George (2002) "Environmental Assessment in Developing and Transitional Countries", JOHN WILEY & SONS, LTD., London, England.

Source: JICA Study Team

Table 9-16 Scoping Matrix (2/2)

Name of Cooperation Project			JICA Preparatory Study on Greater Cairo Metro Line No.4											
				Planning Phase		Construction Phase					Operation Phase			
	No	Likely Impacts	Overall Rating	Land acquisition	Change of Land use plan, Control of various activities by regulations for the construction	Setting a Camp for Construction Employees	Alteration to ground by cut land, filling, drilling, tunnel, etc.	Operation of Construction Equipment and Vehicles	Construction of Stations, Rail, other related facilities.	Limitation of transit in construction area	Increase of Through Trains	Appearance/ Occupancy of Stations, Rail, other related building structures	Operation of associated facilities	Boarding/ Alighting of passengers Generation/ Attraction of people
Natural Environment	15	Topography and Geographical features	D	D	D	D	D	D	D	D	D	D	D	D
Natural Environment	16	Soil Erosion	D	D	D	D	D	D	D	D	D	D	D	D
Natural Environment	17	Groundwater	C-	D	D	D	C-	D	C-	D	D	D	D	D
Natural Environment	18	Hydrological Situation	D	D	D	D	D	D	D	D	D	D	D	D
Natural Environment	19	Coastal Zone	D	D	D	D	D	D	D	D	D	D	D	D
Natural Environment	20	Flora, Fauna and Biodiversity	D	D	D	D	D	D	D	D	D	D	D	D
Natural Environment	21	Meteorology	D	D	D	D	D	D	D	D	D	D	D	D
Natural Environment	22	Landscape	B-	D	D	D	D	D	D	D	D	B-	D	D
Natural Environment	23	Global Warming	B- B+	D	D	D	D	B-	B-	D	B+	D	D	D
Pollution	24	Air Pollution	B- B+	D	D	D	D	B-	D	D	B+	D	D	D
Pollution	25	Water Pollution	B-	D	D	B-	B-	D	B-	D	D	D	D	D
Pollution	26	Soil Contamination	C-	D	D	D	D	D	C-	D	D	D	D	D
Pollution	27	Waste	B-	D	D	B-	B-	D	B-	D	D	D	D	D
Pollution	28	Noise and Vibration	B-	D	D	D	B-	B-	B-	D	B-	D	D	D
Pollution	29	Ground Subsidence	C-	D	D	D	C-	D	C-	D	D	D	D	D
Pollution	30	Offensive Odor	D	D	D	D	D	D	D	D	D	D	D	D
Pollution	31	Bottom sediment	D	D	D	D	D	D	D	D	D	D	D	D
	32	Cultural heritage	C-	D	C-	D	C-	D	C-	D	D	D	D	D

Rating:
A-: Serious impact is expected. A+: Positive effect is expected
B-: Some impact is expected. B+: Positive effect is expected to a certain extent.
C-: Extent of impact is unknown (Examination is needed. Impacts may become clear as study progresses.)
D: No impact is expected. IEE/EIA is not necessary.

Reference:
1) Japan International Cooperation Agency (1992) "IV Railways: Environmental Guidelines for Infrastructure Projects", Tokyo, Japan.
2) Norman Lee and Clive George (2002) "Environmental Assessment in Developing and Transitional Countries", JOHN WILEY & SONS, LTD., London, England.

Source: JICA Study Team

9.4 Alternative Analysis

Alternative analysis was conducted for both phase 1 and phase 2 in the course of the feasibility study of Cairo Metro Line 4. The outcomes and recommendations derived by the previous JICA studies, such as SDMP and Cairo Regional Area Transportation Study (CREATS), have been utilized as basis for setting the alternatives to be examined, since said studies proposed preferable alignments for future development of the transportation network in Greater Cairo. The outcomes of the previous SYSTRA study, which examined the future network of transport in the region, have also formed as basis for setting the alternatives.

In the case of Phase 1, alternative analysis was conducted on the basis of the following items:

- Route selection between El Malek El Saleh and El Remayah Square.
- Station locations between El Malek El Saleh and El Remayah Square.
- Type of structures and construction method for track.
- Location of Depot/ Workshop and access route from El Remayah Square to Depot/ Workshop.

On the other hand, in the case of Phase 2, the northern alignment along Port Said Street from El Malek El Saleh ending at Ring Road Exit No. 18 was proposed in CREATS, whereas the eastern route passing through Islamic Cairo and Nasr City ending at New Cairo was proposed in SYSTRA study. Therefore, these two alternatives were examined in the analysis of route options for Phase 2.

The basic concept, methodology, and conditions for alternative analysis were compiled in detail in Feasibility Study Report 2 issued in November 2009, including the optimum plan proposed for Phase 1 and Phase 2. The analysis incorporated not only technical/ engineering aspects, such as construction issues and transportation demand, but also environmental and social aspects, as a basis for proposing the optimum plan described in Feasibility Study Report 2.

9.5 Environmental Impact Assessment

The EIA study has been conducted for both Phase 1 and Phase 2 of the project, and the EIA reports has been compiled separately in each phase because of the following background.

The project feature of Phase 1 has been examined in a preliminary design level including integration of findings and data obtained through engineering surveys into the design work. Therefore, the project feature of this phase is considered sufficient for conducting the EIA study. Moreover, it is expected that Phase 1 will proceed to the implementation stage in the near future. Hence, the compilation of EIA report will be prerequisite for further procedure for approval to be obtained from Egyptian environmental authorities before implementation.

Accordingly, the EIA study and report for Phase 1 have been finalized and completed for the convenience of subsequent procedure for NAT and EEAA.

On the other hand, the project feature of Phase 2 has been examined at an outline design level. Moreover, it is planned to be implemented in about four years after the commencement of Phase 1. Considering the premature design progress of Phase 2 as well, the EIA study and report for this phase have been considered as preliminary. In this context, it can be said that the preliminary EIA report for Phase 2 should remain in the library of NAT for future preparedness of necessary procedure to be performed before Phase 2 implementation.

In this section therefore, essential points derived from EIA study especially for Phase 1 are summarized. Meanwhile, the results of preliminary EIA study for Phase 2 are compiled in a separate volume, and a brief explanation has been presented in this section.

9.5.1 Baseline of Environmental and Social Conditions

The following were surveyed as baseline data for the prediction of potential impacts as well as examination of corresponding mitigation measures. The surveys were conducted through the interpretation of existing information and data focused in and around the project area of Phase 1. Moreover, field survey and measurement were conducted in some of the vital environmental and social aspects with due considerations to both the findings of scoping and implications understood from the Egyptian EIA guideline.

Table 9-17 Environmental and Social Aspects Surveyed as Baseline

Item	Information Surveyed	Remarks
Physical Environment	Meteorology, air quality, noise, vibrations, topographic and geological conditions, soil, geologic hazards, water quality, hydrogeology, etc.	Field survey and measurement were conducted on air quality, noise, vibrations, water quality, and soil contamination, for understanding the current status of environmental pollution.
Biological Environment	Ecological geography and biodiversity, habitat type, nature protection, etc.	Site reconnaissance was applied in addition to the interpretation of existing information and satellite image.
Socio-economic Aspects	Socio-economic conditions in governorates concerned, health condition, transportation, land use status, historical and archaeological aspects, etc.	Household interview survey in the course of RAP framework study was conducted to grasp the overview of public perception of the project as well as general social-economic status through random sampling in and around the project area.

Source: JICA Study Team

Salient features of baseline conditions in and around the project area (Phase 1) are summarized hereinafter. Detail information and data including the results of field survey and measurement are compiled in the EIA report as a separate volume.

(1) Physical Environment

The results of field measurement of air quality along the project route show that total suspended particles (TSP) and particulate matter (PM_{10}) exceed Egyptian standards. Furthermore, SO_2 concentrations are also excessive in many locations of dense human activity and vehicle traffic. Other measured pollutants however do not show negative results. Noise readings were found to exceed Egyptian standards along the project route, also due to dense human activity and vehicle traffic. It can be said in general that the deterioration of living environment has been already induced along the project route as the areas are highly urbanized aggravated by the heavy traffic volume of vehicles as well as industrial activities condensed in certain local areas.

The project area and its surrounding consist of three geo-morphological units. The units are on two plateaus, namely Mokattam plateau at the east, Pyramids-Abu Rawash plateau at the west and the Nile Valley plain between them. The elevation levels at the Nile Valley plain are low and ranges from 15-20 m above sea level (asl) in the middle, and increases toward the two plateaus, reaching about 50 m to the east. The elevations at Mokattam and Pyramids-Abu Rawash plateaus reach about 200 and 180 m (asl) respectively.

The project route will predominantly run through deep alluvial plains on either side of the Nile River. Generally, the estimated thickness of the soil is about several hundred meters at the middle of the valley where the route is located, and gets thinner outward towards both sides (Pyramids-Abu Rawash and Mokattam Plateaus). The soil layers consist of over a few kilometres thick of sedimentary rocks similar to those presently exposed at Pyramids-Abu Rawash and Mokattam plateaus. Below these rocks, there are kilometres of thick layers of basement composed of igneous and metamorphic rocks similar to those exposed at the Eastern Desert. Location of the south-western part of the route consists of different types of soils.

There are three main surface water systems along the project route, namely: i) the Nile River as the main watercourse stem in the region, ii) three irrigation canals (Al Mansoriah and Al Zumur canals on the west side of the Nile River, and Ismailia Canal on the east side), and iii) one agriculture drain (Maryoutia Drain). The water quality in these water courses varies spatially and temporally according to the human activities alongside, and organic pollution is considered to be especially due to the highly dense domestic and industrial activities according to indicators such as the BOD measured. The results of water quality analysis have proven that the Maryoutia Drain has suffered from serious pollution, followed by the Nile River and the Ismailia Canal. However, heavy metals were not detected in any of the water ways in the course of site measurement.

Because of high accessibility to the Nile River water as sufficient resource for drinking, irrigation and industrial demands, groundwater utilization in the vicinity of the project route is marginal. The depth to the groundwater surface in the areas close to the Nile River is less than 5 m. On the other hand, away from the Nile River and close to the Nile Fringes, the depth to groundwater increases to more than 40 m due to the high topography of these areas. The results of groundwater quality analysis indicate that the value of TDS concentration seems slightly high, but the other polluting parameters including heavy metals are not significant n in and around the project area.

(2) Biological Environment

The areas in and around the project route mainly encompass man-made habitats which support common and widespread species of flora and fauna. No endangered or rare species were confirmed in the areas. All mammal and bird species recorded so far are abundant ones in many common ecosystems all over the Egyptian inland habitats, and are not threatened. The Nile River, Ismailia Canal and El Rauda Island could be considered as the most sensitive habitats encompassed by the route. However, El Rauda Island is heavily urbanized and has lost most of its natural features, and the waterways in and around the route pass thoroughly in the urban areas. Accordingly, the values in both terrestrial and aquatic ecosystem in and around the project route can be concluded to be considerably low.

(3) Socio-economic Aspects

The project route of phase 1 is planned to pass mainly through Giza Governorate, and the small sections in Cairo Governorate (Old Cairo area), as well as near the border of 6th October Governorate. The route passes through four districts under Giza Governorate (El Giza, El Omraneya, El Haram, and Hadeek Al-Ahram), and one district under Cairo Governorate (El Qadeema). The general features of socio-economic status, governorate wise, were enumerated in section 9.3, including the Phase 2 area. The following table shows the district wise features especially for phase 1. It is noted however that the following information are not consistent with the concerned districts abovementioned, since the administrative re-formation up to 2008 in both governorate and district levels have inconsistent statistics data according to the current administrative jurisdictions.

Table 9-18 Basic Socio-economic Information of Concerned Districts

Governorate and District/ Item	Giza Gov.			Cairo Gov.
	El Giza Dis.	El Omraneya Dis.	El Haram Dis.	El Qadeema Dis.
Population	251,596	726,384	172,655	217,390
No. of Households	64,366	187,707	43,684	61,615
Ave. size of Household (person)	3.9	3.9	4.0	3.5
Illiteracy Rate (%)	25.0	14.8	20.6	29.0
Unemployment Rate (%)	12.0	11.1	10.5	9.6
No. of Business Establishments	13,012	32,391	6,881	1,540

Source: CAPMAS 2006

Other notes on socio-economic aspects are itemized below.

- The accessible rates to the public services in Giza Governorate such as potable water network, sanitation, electricity and natural gas are about 88.5%, 43.2%, 92.8% and 6.9%, respectively. These figures are generally higher than those of national averages. Meanwhile, above rates in Cairo Governorates show the higher values than those of Giza, except for electricity.
- As for telecommunication and internet services in Giza Governorate, number

of telephone lines reached 910 per 1000 households, while number of internet subscribers reached 92.1 per 1000 households, as of 2008. The figures in Cairo Governorate meanwhile show slightly higher values.

- There is one industrial complex in the northwestern area of the depot/workshop for Phase 1, which is Abou Rawash in 6th October Governorate. Other industrial activities neighbouring Phase 1 are generally small and household scale, although scattered.
- As for medical services, there is one Ministry of Health (MOH) general hospital, located near station 10 of the Phase 1 route. Some other general hospitals are also found along said route. Besides, there are seven specialized, 14 public and central and about 227 private hospitals in Giza Governorate based on the available information in 2006. It can be said that the accessibility to health care and medical services in Giza and Cairo governorates are better compared with the national average. This is justified by the infant and maternal mortality rate which is lower than the average national level.
- Giza is well known because of many historical sites that make tourism an important sector contributing to the development of its economy. The governorate hosts the famous Giza pyramids, the Sphinx, Sakara Pyramid, etc., as well as various tourist spots such as handicraft villages and oasis entertainment in desert areas, although some of them are part of the 6th October Governorate. Giza and Cairo governorates are also accommodating a number of tourists at above locations and at other tourist attractions including museums, old Cairo, Citadel, etc.
- Road network in Greater Cairo region has been expansively developed, founded by the vital trunk roads such as the Ring Road, Cairo-Alexandria Agricultural and Desert Roads, Cairo-Ismailia Agricultural Road, etc. Many of secondary roads and streets are also merged another, leading to the trunk roads. However, the heavy traffic congestions can be ordinarily found in many places in the urban areas. Moreover, roads accidents recognized by the authorities formally reach to approximately 20,000 cases in the whole country although such cases shows tendency of gradual decrease in the recent years.
- The railways network has also developed such as the Egyptian National Railway. Specifically in Greater Cairo region, Metro Lines 1 and 2 are providing services and play an important role as internal urban transportation, accommodating around three million passengers daily. On the other hand, fluvial navigation exist in the Nile River mainly for the cruising purposes.
- The land use status along Phase 1 is generally classified in the following three sections. The western section of Phase 1 located between Depot and El Remayah square is lined in the newly developing areas. There are vacant land plots found in many places of which some are owned by the military and residential quarters, and are under rapid development. The land in the middle section along Al Haram street (Pyramid Road) are dominantly used for

residential purpose, followed by commercial activities including the tourists' accommodation as these are close to the vicinity of Giza Pyramids. The eastern section of Phase 1 located between El Giza Station and El Malek El Saleh Station is passing through the central area of Giza Governorate toward the urbanized areas at the side of Old Cairo.

- There are several sites found along Phase 1 route which are of historical and archaeological importance. However, these are located with enough distance from the route alignment. On the other hand, the precise information on buried cultural assets along the route is not available at this feasibility study stage. Furthermore, there may be possibility of discovering buried cultural assets unexpectedly before or during the construction. The findings so far and proposed risk management on buried cultural assets are discussed in Chapter 11 of this report as well as the archaeological study report separately prepared.

9.5.2 Impact Identification and Mitigation Measures Proposed

Impact identification due to implementing the project (especially phase 1) was conducted based on the analysis of the project characteristics and associated activities, as well as baseline information collected in the course of literature review, key informants, and site surveys and measurements. The findings obtained from scoping as well as in a series of stakeholder meetings are also referred to, and integrated as necessary. A quantitative prediction was exercised when applicable, or qualitative examination was made for impact identification purposes. Archaeological issues and issues on resettlement and land acquisition are separately discussed in detail in subsequent chapters.

The Table 9-19 shows the impact identified and mitigation measures proposed, including the environmental and social considerations in planning and preliminary design stages to further reduce the significance of negative impacts.

As summarized in the table, it is predicted that the key issues on which the attention should be paid will be mostly induced during the pre-construction and construction stages. On the other hand, the issues that would be induced during the O&M stage are basically predicted as secondary ones, since most of the main facilities such as the track and stations of Phase 1 will be underground and will not bring about environmental impacts such as noise, landscape, physical community division, etc. The key issues of secondary impacts during the O&M stage of the project (Phase 1) are summarized below:

- Air pollution around the new stations would also be induced due to the possible increment of vehicle emission by other transportation modes routing near the new stations such as taxis and mini buses. Noise level and traffic congestions in the vicinity of the new stations would also become worse due to the same scenario.
- Unregulated land use would be expected around the new stations due to the increment of commercial opportunities generated by boarding/alighting

passengers. Furthermore, lots of street stalls would be developed around the new stations which may serve as obstacle to the smooth operation of stations, based on the experiences of Metro Lines 1 and 2.

The above issues should be managed in coordination with related ministries and local authorities, including examination of land use plan, design of parking lots to accommodate transportation services, etc.

Besides, in the EIA study, impact identification during O&M stage includes i) occupational health and safety of workers of the metro operating company, and ii) public health and safety for passengers of the metro, which are directed to be examined under the Egyptian EIA guideline.

Table 9-19 (1/2): Impact Identification and Mitigation Measures Proposed (Pre-Construction Stage)

Type of Impact	Impact Identification (including considerations in planning/ designing)	Mitigation Measures
Involuntary Resettlement and Land Acquisition	- The magnitude of involuntary resettlement has been minimized in Phase 1 as far as the stations' design and construction method will be applied as proposed in this study, especially at planned Stations No.1, 2, 3, 4, and 13. - Therefore, estimated number of displaced person in Phase 1 has been minimized and will be less than 100 due to resettlement as of December 2009. Private land to be acquired is estimated to be less than 2,000 m^2 in total in Phase 1, mainly for construction of entrance and annexed facilities of stations. - The socially vulnerable groups such as very poor and minority have not been identified, to whom special attention and care should be paid. However, small shops including street stalls will be necessary to be relocated.	- It is proposed to put the continuous considerations to minimize the magnitude of resettlement and land actions in further basic design stage when applicable. - The detailed survey to identify the precise magnitude will be necessary after delineation of the areas affected by the project. - Compensation and/or other measures to restore the livelihood of project-affected persons (PAPs) should be provided according to the Egyptian law/regulations concerned, donor policies, and the recommendations from RAP framework study. - Consultation with PAPs should be planned and conducted at the appropriate timing in line with the progress of project planning and designing, in order to not only secure the livelihood restoration of PAPs but also to eliminate the local conflicts in theearly stage of the project.
Impact on Utilities	- The utilities such as power distribution and communication lines are possibly installed under the road. The construction works for tunnelling may damage these utilities.	- Before commencement of Phase 1 construction, relocation of the utilities underneath the road should be designed and implemented in order to avoid any negative impacts on daily life of surrounding areas.
Impact on Cultural Heritage	- Possibility that buried/ undiscovered cultural assets exist along the Phase 1 route, especially the areas around El Remayah square with middle-high probability.	- It is proposed to have preliminary surveys such as non-destructive investigation, trench investigation, etc. in basic design stage boring survey should be considered specifically for identifying the existence of buried assets.

Source: JICA Study Team

Table 9-19 (2/2): Impact Identification and Mitigation Measures Proposed (Construction Stage)

Type of Impact	Impact Identification (including considerations in planning/ designing)	Mitigation Measures
Air Pollution	- The current air quality in and around the Project area has deteriorated in general due to heavy traffic mainly. Moreover, the air pollution due to the construction activities will be confined in stations' construction sites where cut-and-cover method will be applied. However, the local residents near the	- Water spraying at the soil excavation work should be done to reduce dust whenever applicable. - Excavated soil and other construction materials should be covered with sheets to avoid diffusion of dust. - Proper maintenance and regular checking of heavy equipment and

Type of Impact	Impact Identification (including considerations in planning/ designing)	Mitigation Measures
	station construction sites of Metro Line 3 sometimes suffer from dust and gaseous pollution generated by heavy equipment and vehicles. The negative impact on air is similarly expected in the project.	vehicles utilized for construction should be performed. - The operation of heavy equipment and vehicles should be well scheduled, and shared with neighbouring areas.
Noise and Vibrations	- The current noise level in and around the project area is high in general due to heavy traffic mainly. However, the noise as well as vibrations, are expected to be generated additionally due to the construction activities, although the expected impacts will be confined in the stations construction sites.	- Proper maintenance and regular checking of heavy equipment and vehicles for construction should be performed. - Avoidance or minimization of construction works during night time should be considered in the course of planning the detailed construction schedule. - The operation of heavy equipment and vehicles should be well scheduled, and shared with neighbouring areas.
Water Quality and Groundwater Quality	- Tunnelling works by TBM as well as stations construction works will generate the turbid water. Although the sites of construction works in vicinity of the existing water courses are limited, there is a possibility to induce temporarily negative impacts on water quality.	- Treatment plants should be installed for turbid water generated from construction sites, similarly to Metro Line 3 construction. - Direct discharge of wastewater from construction site to the surface water ways should be avoided.
Traffic Condition	- Traffic congestion is expected to become worse than the current conditions due to the temporary occupation of roads' width for stations construction. - Possibility of risk increment of traffic accidents is expected due to generation/attraction of heavy vehicles near the construction sites.	- Duration of traffic obstruction due to construction activities on the roads should be reduced by applying road decking for maintaining the traffic lane, in addition to a well planned construction schedule. - Operation of heavy vehicles should comply with the traffic rules. Moreover, instruction for safety driving should be provided to the vehicle operators whenever necessary. - Coordination with traffic regulating authorities should be enhanced.
Sanitation and Health Hazard Risk	- Some negative impacts on local sanitary conditions are expected due to the mobilization of work force and workers' site camp. - The construction workers will be exposed to risk of workers' accidents as well as possible diseases due to poor sanitary conditions.	- The sanitary facilities in construction sites and camps should be maintained properly, and checked regularly. - First aid kits against accidents as well as regular health check ups of workers should be considered wherever applicable. Primary protective devices should be secured for workers, such as helmet, boots, grabs, etc.
Impact on Cultural Heritage	- It is not expected that negative impacts will be induced on the existing cultural assets along the Phase 1 route. - Despite the preliminary survey in the basic stage, unexpected discovery of buried cultural assets might still be possible during construction.	- Close coordination should be facilitated with SCA and other related authorities for data recovery and rescue, in case unexpected discovery occurs. Transportation and storage of movable artifacts should also be secured in cooperation with authorities.
Other Miscellaneous	- Soil contamination might be induced even in limited areas of	- Proper management of the site work and waste should be made

Type of Impact	Impact Identification (including considerations in planning/ designing)	Mitigation Measures
Impacts Conceivable	construction sites if oil spills, waste disposal, etc. would occur at the site.	during construction. - Construction wastes such as surplus soil should be disposed properly.
	- It is not planned to extract a huge volume of groundwater for the construction activities. However saturated soil removal by tunnelling may induce lowering of groundwater level in the vicinity.	- Groundwater level should be monitored to confirm the equilibrium in the vicinity.
	- The construction works especially at the sites of cut-and-cover method will induce physical division of local areas or communities in the vicinity, although the impacts will be limited in the construction stage.	- Close coordination especially with local authorities should be made, related to measures such as temporary pedestrian crossings, temporary entrance for existing shops' services near the sites, etc, together with sharing the construction schedule to neighbouring areas.
	- Landscape near the cut-and-cover construction sites will change, although the impacts will be limited in construction stage.	- The construction yards should be confined as much as possible, and fencing should be installed.

Source: JICA Study Team

9.5.3 Direction of Environmental Monitoring

The main purposes of the environmental monitoring are to provide a continuous feedback on the project implementation so as to identify actual or potential successes/problems, and to execute timely adjustments to the project works. Monitoring should be an integrated part of good environment management in every stage of the project implementation. The results of monitoring should be examined from the viewpoints of evaluating the effectiveness of the mitigation measures and other efforts provided to the project.

In this context, the following table shows the monitoring items and their directions proposed. Detailed plan of environmental monitoring is proposed in the EIA report prepared separately, including the parameters, methods, frequency, locations, institutional arrangement, etc.

Table 9-20 Monitoring Items and Directions Proposed

Items	Directions
Resettlement and Land Acquisition	- Monitoring of the level of restoring the livelihood and other impacts through comparison with the socio-economic information of PAPs to be obtained in census and surveys in the project design stage. (See Chapter 10).
Air Quality	- Periodic monitoring at major construction sites especially for stations during construction stage. - Monitoring of the secondary impacts likely caused by transportation modes routing the new stations at identified hot spots during O&M stage.
Noise and Vibrations	- Periodic monitoring at the major construction sites especially for stations during construction stage. - Monitoring of the secondary impacts likely caused by transportation modes routing the new stations at identified hot spots during OM stage.
Groundwater	- Regular monitoring of groundwater level and quality at the existing wells near the project route during construction stage. - Regular monitoring of groundwater level to ensure a minimal impact and equilibrium during O&M stage.
Waste Management	- Monitoring and recording of construction waste stream during the construction stage. - Monitoring and recording of utilization/control of oils and other chemicals if any, during construction stage.
Traffic Condition	- Observation of traffic conditions in and around the construction sites to be ready for necessary actions in case of identifying significance during construction stage. - Observation of traffic conditions in and around the new stations to be ready for necessary coordination with related authorities during O&M stage.
Sanitation and Health Hazard Risk	- Observation of sanitary conditions at the construction sites as well as workers camps during construction stage. - Recording of health checks of workers as well as risk response to health hazard during construction stage, if any.
Other Miscellaneous Items	- Observation of significance of land use change in the vicinity of new stations to be ready for necessary coordination with related authorities during O&M stage. - Monitoring and recording of occupational health and safety conditions of workers in the metro operating company according to legislative requirements of Egypt. - Monitoring and recording of public health and safety conditions of passengers of the metro according to the legislative requirements of Egypt.

Source: JICA Study Team

9.6 Stakeholder Meetings

Interagency coordination and stakeholder involvement are important components of both project planning and the EIA process itself. Based on this understanding, Egyptian EIA guidelines stipulate the necessity of initiation of stakeholder meetings in the course of the EIA study, especially for List C projects. Furthermore, guidelines of JICA and ex-JBIC recommend stakeholder involvement for realizing the integration of environmental and social considerations into the process of project' planning and design, to the maximum extent possible.

Considering the above as well as the procedure stipulated in the Egyptian EIA guidelines, two types of stakeholder meeting were planned, with the following aims and outlines.

- The 1st stakeholder meetings were held during the scoping stage from June to August 2009, in the form of individual meetings with key stakeholders.
- The 2nd stakeholder meeting for Phase 1 was held on 28th December 2009 during the disclosure stage of the draft EIA. This meeting was held in the form of a town meeting. On the other hand, the 2nd stakeholder meeting for Phase 2 is planned to take place at the time of compiling the draft EIA for Phase 2, after finalization of the detailed route for this phase.

Table 9-21 Outlines of Stakeholder Meetings

Stage	Main Contents	Remarks
1st Meeting at Scoping Stage	- Outline of the Project. - Sharing and discussing the draft scoping. - Methodology for EIA study and issues to be considered in the study. - Opinion exchange on resettlement and land acquisition including the procedural issues.	- June ~ August 2009. - Individual meeting with key stakeholders
2nd Meeting at Disclosure Stage [Phase 1 only]	- Sharing the Project description. - Sharing the specific components of the Project. - Sharing and discussing the outcomes of EIA study conducted. - Sharing and discussing the issues concerned to resettlement and land acquisition.	- 28th December 2009 - Town meeting style.

Source: JICA Study Team

In addition to the planned meetings mentioned above, ad-hoc interviews and consultations have been conducted with key persons and entities related to the project, such as NAT (project proponent), ECM, contractors of Metro Line 3, etc., whenever opportunities were available.

The findings and issues arising from the abovementioned stakeholder meetings have been considered and integrated into the EIA study, as well as in the project plan and design. The summary of both types stakeholder meeting is presented in the following sections.

9.6.1 First Stakeholder Meeting at Scoping Stage

Based on discussions with NAT and EEAA, the targets for the 1st stakeholder meetings (individual meetings) were examined among the relevant central ministries and governmental organizations, local government authorities and their specific departments in and around the project area, representatives of local communities such as council members, NGOs, universities and academic persons, etc. The list of entities contacted to participate in the 1st stakeholder meetings are tabulated in Table 9-22.

Table 9-22 Summary of 1st Stakeholder Meetings

Entity	Place	Date
EEAA Central Department for EIA	EEAA	Tuesday, 5th May 2009
EEAA Cairo Regional Branch Office (RBO)	RBO Greater Cairo office at Tamouh	Monday, 6th June 2009
Cairo Environmental Management Unit	RBO Greater Cairo office at Tamouh	Monday, 6th June 2009
Giza Environmental Management Unit	RBO Greater Cairo office at Tamouh	Monday, 6th June 2009
6th October Environmental Management Unit	RBO Greater Cairo office at Tamouh	Monday, 6th June 2009
Helwan Environmental Management Unit	RBO Greater Cairo office at Tamouh	Monday, 6th June 2009
Supreme Council of Antiquities (SCA)	Giza Plateau Administrative Offices, Giza Pyramids Premises.	Monday,11th May 2009
National Organization for Urban Harmony (NOUH)	National Organization for Urban Harmony (NOUH), ElKallah	Thursday, 2nd July 2009
Al-Azbakia Book Vendors	Conference Room of the French University in Egypt (FUE), Mohandeseen Branch, Cairo.	Tuesday, 7th July 2009
Students in Free Enterprise NGO (SIFE) - UFE	Conference Room of the French University in Egypt (FUE), Mohandeseen Branch, Cairo.	Tuesday, 7th July 2009
Giza Traffic - Ministry of Interior	Giza Traffic Station	Tuesday, 14th July 2009
Nile Company for Road Constructions	Nile Company for Road Constructions, El Tayaran st. Nasr City, Cairo.	Thursday, 16th July 2009
Academic community - Professor of Transportation & Traffic Engineering	NAMAT for Engineering Consultancy	Tuesday, 28th July 2009.
Nile Research Institute	Telephone Call	Tuesday, 4th August 2009
Roads and Transport Authority (Giza Governorate)	Giza Governorate EMU	Wednesday, 12th August 2009
Giza Local Council and NGOs	Giza Governorate	Monday, 17th August 2009
Ministry of Housing, Utilities, and Urban Development General Organization for Physical Planning	General Organization for Physical Planning 1 Ismail Abaza St. El Kasr El Eini	Monday, 31st August 2009
GESR NGO and Cairo Local Council Representatives	GESR NGO, at intersection of Sekket El-Waily and Mid-way of Port Said Street	Monday, 31st August 2009

Source: JICA Study Team

During the 1st stakeholder meetings, various issues, including the project features as well as expected environmental and social impacts, were raised and discussed. The topics raised in the meetings are summarized in Table 9-23, and key issues on every topic are enumerated in *Annex 9-2* with compiled records of each of meetings.

Table 9-23 Topics Raised in First Series of Stakeholder Meetings

Project-related Issues	Alternative examination, route selection, station location, construction method, etc.
Environmental Aspects	Air pollution, noise, waste management, landscape, impact on Nile river, etc.
Social Aspects	Resettlement, land acquisition, impact on utilities, impact on road traffic, health issues, economic issues, archaeological issues, etc.
Procedural and Managerial Issues	Consultation concept, Information dissemination in construction stage, emergency response plan, etc.

Source: JICA Study Team

9.6.2 Second Stakeholder Meeting at Disclosure Stage of Draft EIA

The 2nd stakeholder meeting was held from 11 am on 28th December 2009 at Agriculturalist Club in Dokki, Giza. The meeting was hosted by NAT as the project proponent, and announcement of holding the meeting was made beforehand through newspaper advertisements, posters pasted at the offices of local authorities in the project area, and individual invitation letters sent to related authorities, NGOs, academic persons, etc.

EIA summary in Arabic was distributed to the attendees at the registration of the meeting, together with a comment form and envelop for the purpose of obtaining attendees' comments after the meeting.

The meeting was opened with a speech and overall introduction of NAT by its Chairman, followed by the remarks from representatives of local authorities, ECM, and JICA Egypt Office. After the explanation of the Project description of phase 1 as well as results of EIA study, an open forum with questions and answers was initiated. EEAA gave the closing remark at the end of the meeting and appreciated the efforts and expected further processing of EIA.

It is noted that the meeting was open to all who intend to participate. Hence, opportunity for consultation was provided to the potential PAPs due to the project implantation. Furthermore, compensation policy for people who intend to clarify resettlement or land acquisition issues brought by the project was also shared in the course of explaining the EIA results at the meeting.

The attendees to the meeting as well as the major topics raised in the meeting are summarized in Table 9-24 and Table 9-25, respectively. Key issues discussed in the meeting are enumerated in *Annex 9-3*, and all the records of the meeting are compiled in a separate report (Report of Second Stakeholder Meeting at EIA Disclosure of the Phase 1 Project), including discussion records, materials distributed at the meeting, presentation materials, newspaper announcement, individual invitation letter and invitee list, attendance list, etc.

Table 9-24 Summary of Attendees of the 2nd Stakeholder Meeting on EIA

Governmental bodies	NAT (host of the meeting), EEAA, Greater Cairo RBO of EEAA, Giza governorate, Giza EMU, Cairo EMU, 6th October EMU, Giza district, Cairo district, GOPP, ECM, ENR, Transport authority, Cairo traffic department, SCA, NOUH, JICA Egypt Office, etc.
Other bodies and attendees	Academic community, Universities, Research centers, NGOs, Parliament members, Local council members, Political party members, Local communities and people, Media, consultants, private sectors, etc.

Source: JICA Study Team

Table 9-25 Major Topics Raised in the 2nd Stakeholder Meeting on EIA

Project-related Issues	Planning and design of the Project, propsosed route and alignment, facilities and design of stations, financial aspect, emrgency response, etc.
Environmental Aspects	Air pollution, noise and vibrations, waste management, groundwater, etc.
Social Aspects	Resettlement, land acquisition, impact on road traffic, health issues, archaeological issues, etc.
Procedural and Managerial Issues	Integration of the 1st stakeholder meetings, coordination with other entities concerned, etc.

Source: JICA Study Team

9.7 Proposed Outline for Implementing System for Environmental and Social Considerations of Phase 1

According to the series of study on environmental and social issues above, including EIA and RAP framework, an outline for implementing the environmental and social considerations are proposed in *Annex 9-4*. The outline shows the key entities and its key departments, organizational setup, human resource requirements, etc, which are concerned in the environmental and social considerations such as mitigation measures and monitoring to be performed in different stages of the implementation of phase 1 project. The outline proposed will be necessary for further development and design along with the project implantation stage.