### (2) Station with the Spine Wastewater Tunnel (SWWT)

Some stations are planned to be located where the SWWT runs. The station could be constructed without diverting or relocating the SWWT if suitable method is applied. The cut and cover method with road decks is applied similar to the standard station. The SWWT would be hanged with a wire during excavation and construction of the concrete slab. After the concrete slab is cast, the SWWT is borne by its concrete base on the concrete slab. The SWWT is put and operated permanently in the station. The practice of this method in Japan is shown in Figure 4-14 and the procedure for construction is illustrated in Figure 4-15.

In case the ground around the station is made up of very soft soil, it is realized that the shear force on the SWWT occurs at the interface between soil and concrete wall of the station due to the difference of the stiffness around the SWWT when earthquake or similar incidence happens. As a countermeasure, the space between the SWWT and the concrete wall is filled with elastic seal and the SWWT is wrapped with a seismic isolation material such as rubber, foamed polystyrene, etc. The space around the SWWT in the station is then filled with fluid soil cement which has less drying shrinkage and less permeability. The outline of the proposed method based on experience and practice in Japan is illustrated in Figure 4-16.

Source: Kumagai Co., Ltd.

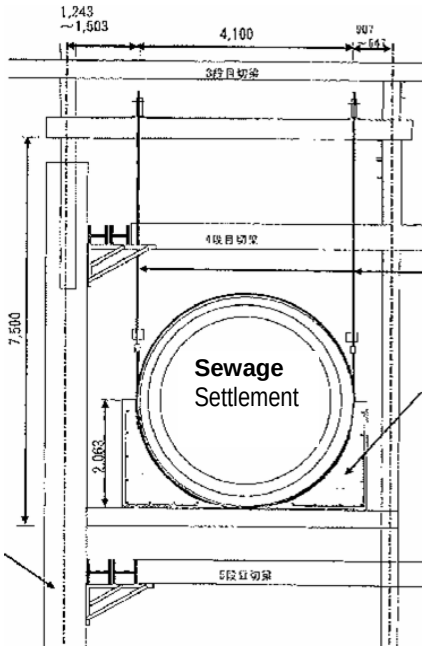
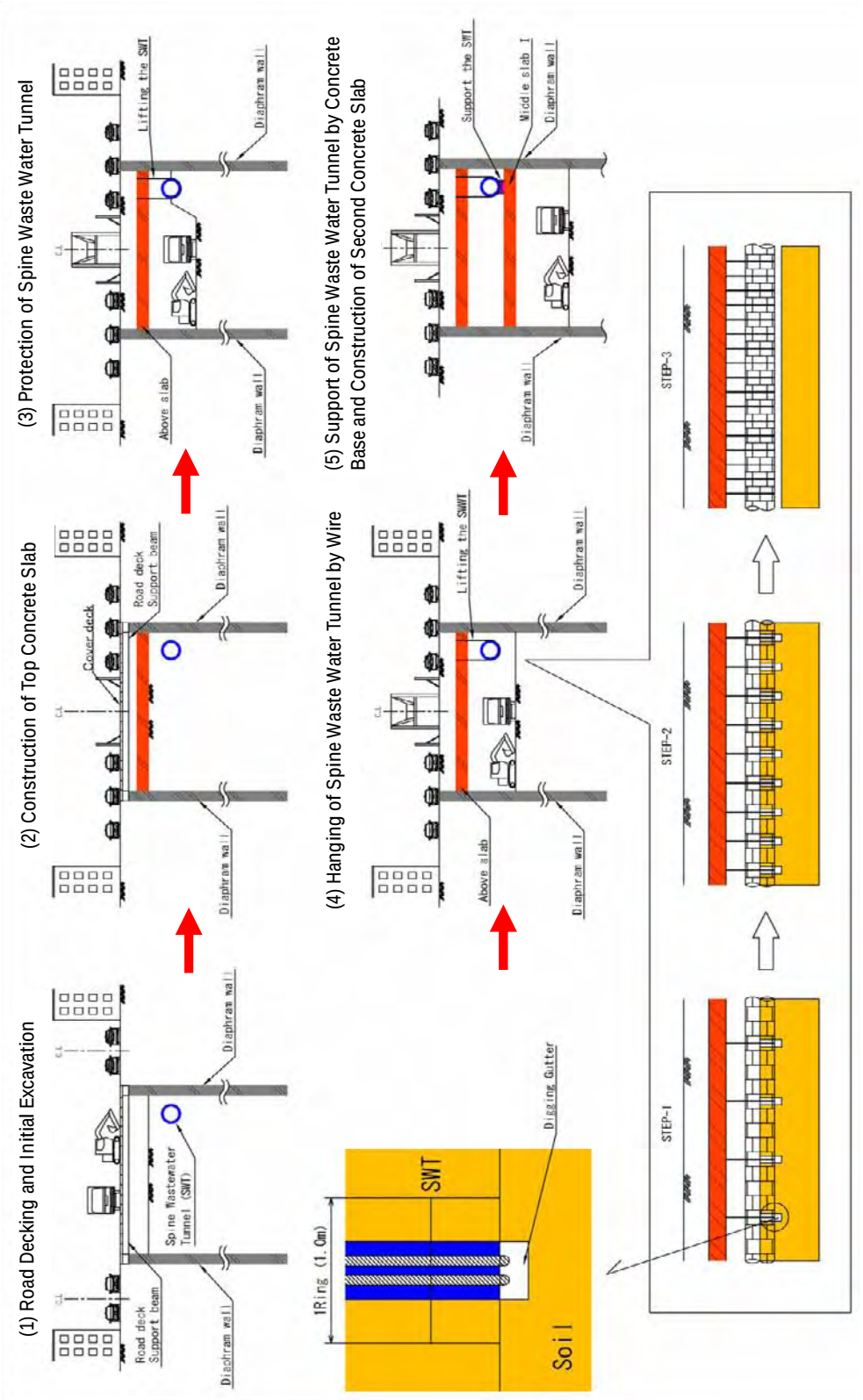
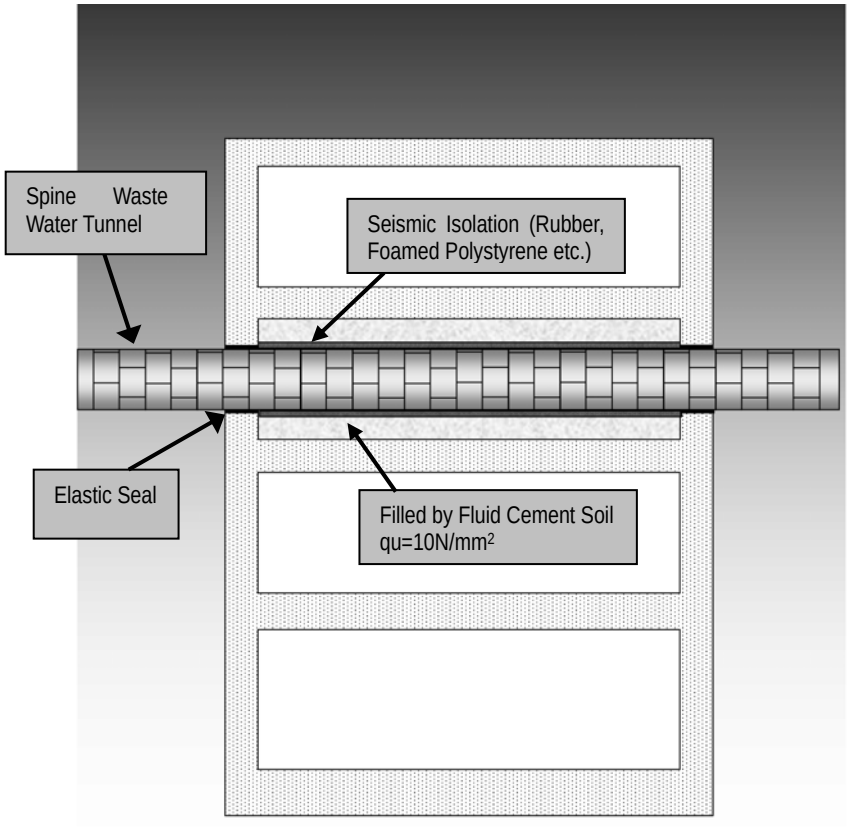



**Figure 4-14 Procedure of the Road Deck Method during Station Construction**




Source: JICA Study Team

**Figure 4-15 Procedure of Hanging Spine Wastewater Tunnel in Station Construction**

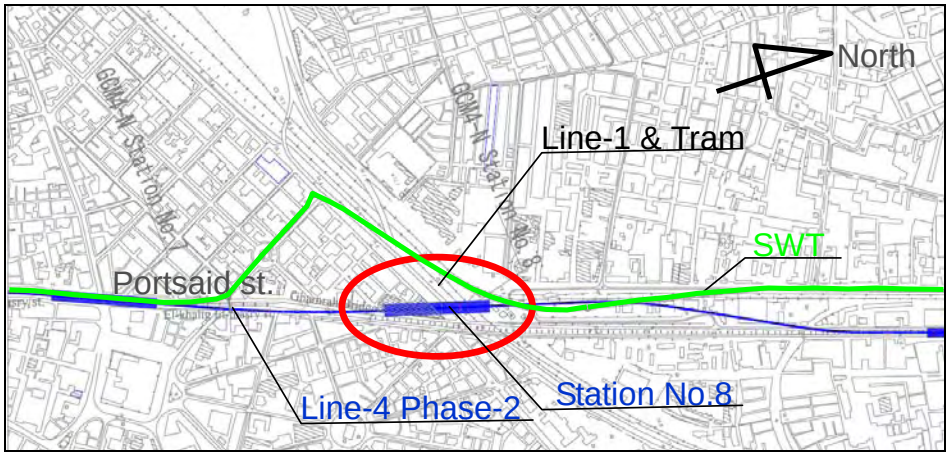



Source: JICA Study Team

**Figure 4-16 Seismic Countermeasure for the SWWT in Station**

### (3) Station No. 8 under an Existing Railway (Ghamrah)

Station No.8 at Ghamrah is planned to be located under the existing Metro Line 1 and tram. It is noted however that the viaduct of the highway crosses the intersection. The station could not be constructed by cut and cover method and thus, it is necessary to apply the crossing under railway method which will enable passing through the existing railway and highway. The plan of Station No.8 in Ghamrah station is shown in Figure 4-17.



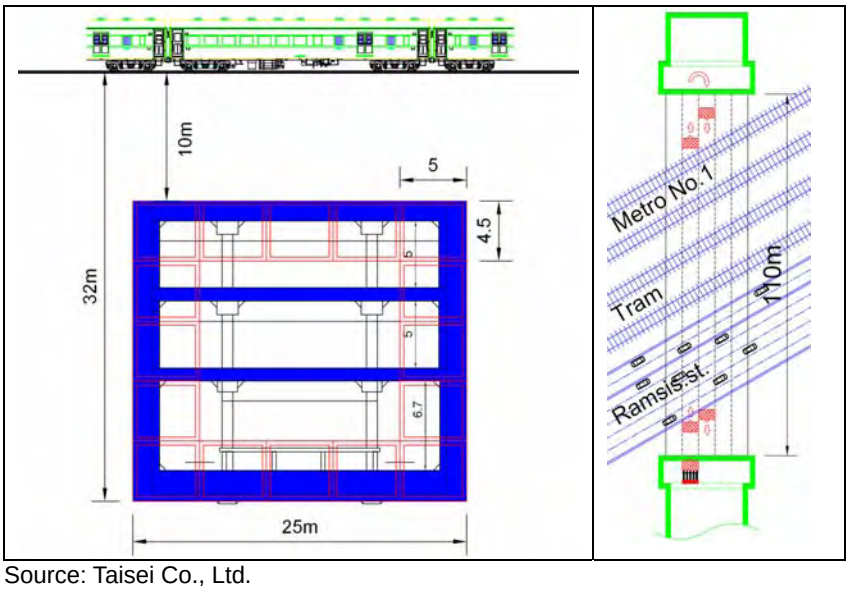

Source: JICA Study Team

**Figure 4-17 Plan at Station No. 8 (Ghamrah)**

There are various methods of crossing under railways. The following two methods could be adopted:

**a) Multi Box Jacking Method**

A small box shaped called the Earth Pressure Balanced Machine (EPBM) excavates under the existing railway while steel temporary segments are pushed by thrust jacking. The EPBM launches from the departure shaft and reaches the arrival shaft. After that, the EPBM returns to the departure shaft. This procedure is repeated until temporary box made from small steel boxes is constructed. The permanent concrete is cast for column, slab and wall, and temporary steel is then removed. The ground surface settlement is strictly controlled and the station could be constructed without stopping existing railway and highway operations.




Source: Taisei Co., Ltd.

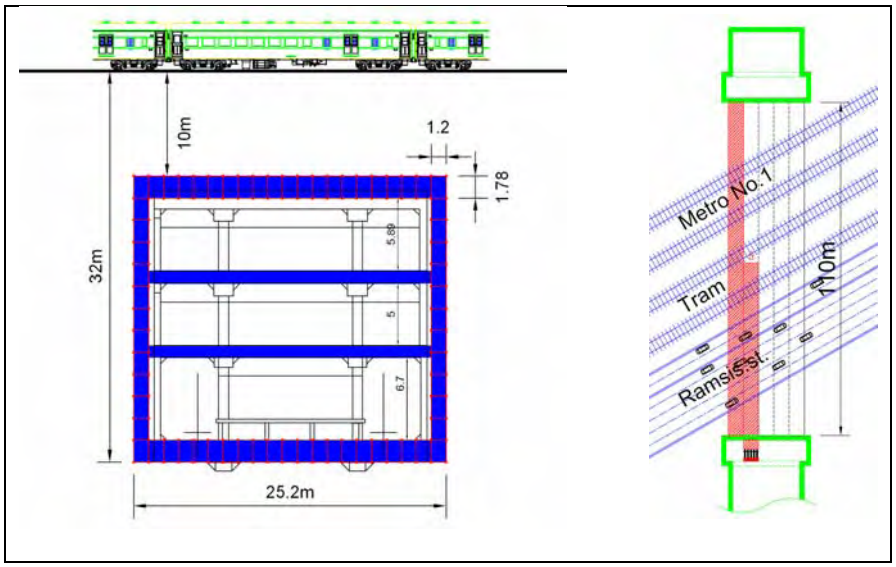
**Figure 4-18 Image of Station No. 8 (Ghamrah) Constructed Using the Multi Box Jacking**

Source: Taisei Co., Ltd.

**Figure 4-19 Photo of Multi Box Jacking Machine and Image of Construction**

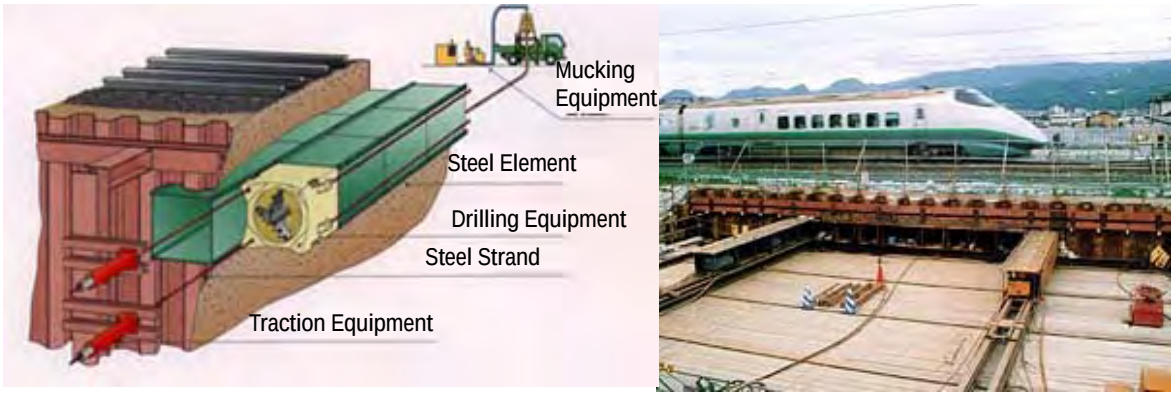
### b) HEP & JES Method

This method involves drilling of small horizontal bore holes and inserting of steel wire strand through bore holes. At the end of the bore holes, the traction equipment is fixed and the drilling equipment and steel structure elements is pulled using the steel wire strand. Installed small steel structure elements are connected to each other and combined to act as columns and beams. The steel structure elements are filled with concrete and could be used as part of the permanent structure. The station could be constructed without stopping existing railway and highway operations. However, the ground surface settlement is relatively large compared with the multi box jacking method, and it is necessary to study carefully the influence to the existing highway.




Source: Tekken Co., Ltd.

**Figure 4-20 Image of Station No. 8 (Ghamrah) constructed Using HEP and JES Method**



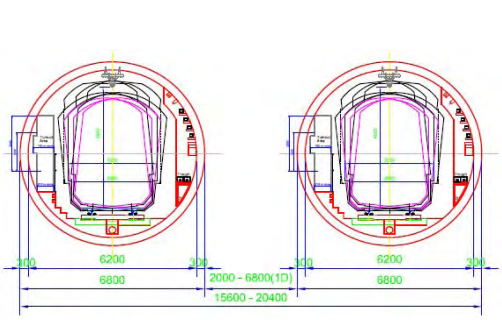
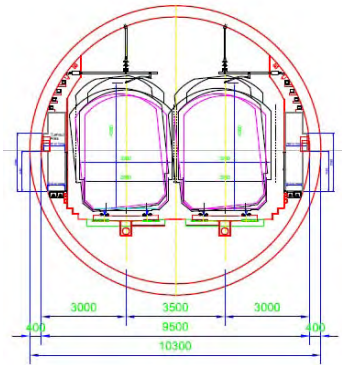

Source: Tekken Co., Ltd.

**Figure 4-21 Photo and Image of HEP and JES Construction Method**

### 4.4.3 Tunnel Construction Methodology

The city tunnel is usually constructed by cut and cover method or shield TBM. The alignment of tunnel passes under the road of the residential area and directly below some part of the dwelling places. Taking into account the influence to the structure and houses at ground level, the shield TBM is applied for the whole tunnel section. There are foundations and piles of buildings and flyovers/viaducts. Besides, there is a narrow space for the tunnels to pass under the existing underpass at road intersections. Therefore, the two single track tunnels by shield TBMs are selected to pass through shallower area as much as possible. In addition, the cost for two machines of the single track double tube is cheaper than one machine for double track tube. Comparing the speed of constructing the tunnel, the single track double tube tends to be faster because its cutting face has higher stability (smaller cross section). Thus, the single track double tube is more advantageous.

**Table 4-4 Single Track Double Tube and Double Tracks Tubel**

| | Single Track Double Tube (STDT) | Double Track Tube (DTT) |
|---|---|---|
| Typical Tunnel Cross Section |  |  |
| Type of Machine | Earth Pressure Balanced Shield TBM | |
| Outer Diameter | 6.8m x 2 Tube | 10.3m |
| Sectional Area | A=72.64m$^2$ | A=83.32m$^2$ |
| Overburden | Smaller than DTT | Larger than STDT |
| Avoiding of Obstacle | Easier (Flexible Location) than DTT | More Difficult than STDT |
| Construction Period | Little Bit Faster than DTT | Little Bit Slower than STDT |
| Cost of Machine | USD12-14 million for Two Machine | USD14-15 million or higher |

Source: JICA Study Team

In order to launch the shield TBM, the construction yard is required and the station where the shield TBM could launch is limited due to constraints caused by obstructions and land use. The time schedule of the subway construction is usually dominated and controlled by the construction of the station, and the schedule of the shield TBM is not critical to pass in most cases. Therefore, the installation of many shield TBMs is disadvantageous in terms

of cost. Taking into consideration these conditions, the tunnel construction methodology for Phase 2 is assumed as follows. The detailed condition need to be studied furthermore.

1. Two shield TBMs are installed for each alternative.

2. Shield TBM for single track

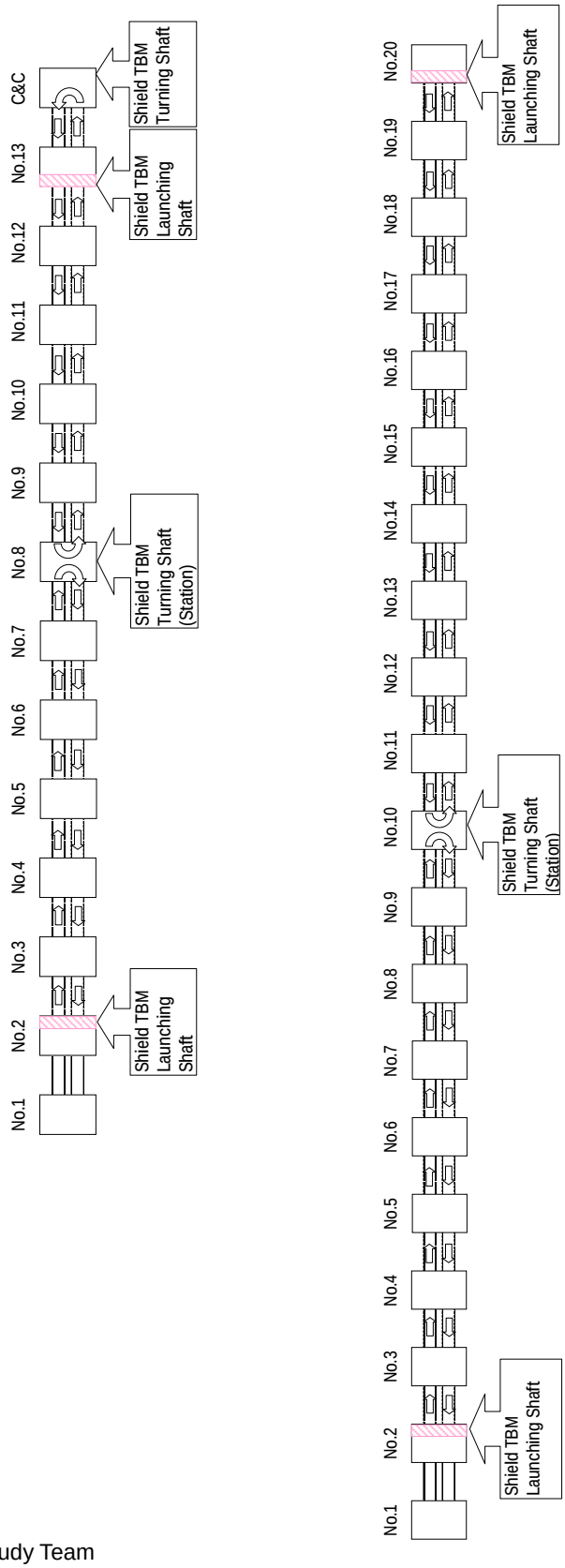
3. Station for shield TBM launching (possible station)

   Northern Route: Station No. 2 and Station No. 13
   Eastern Route: Station No. 2 and Station No. 20

4. Shield TBM would pass through stations under construction.

5. Shield TBM would turn around (U-turn) at the following station after launching.

   Northern Route: No. 8 Station
   Eastern Route: No. 10 Station




Source: JICA Study Team

**Figure 4-22 TBM Excavation Procedure Plan (Left: Northern Route, Right: Eastern Route)**

### 4.4.4 Use of the Two Liquid Type Backfill Material for the Tail Void

The conventional one liquid type backfill material was commonly used before in Japan. However, it has been replaced with two liquid type backfill material to minimize settlement.

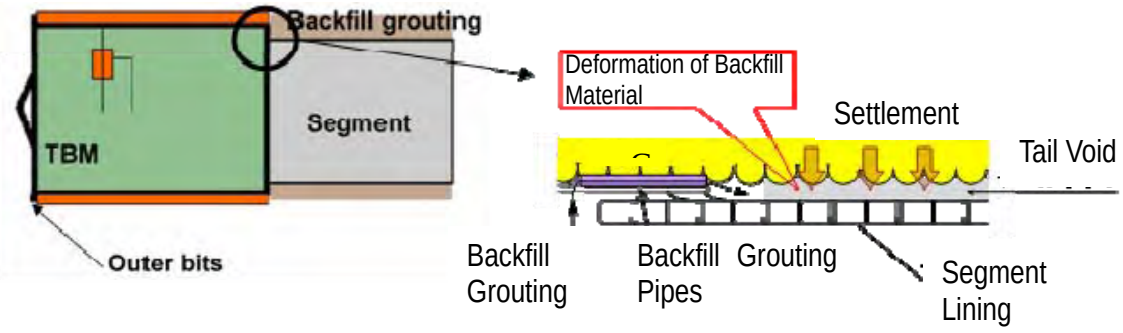
The Phase 2 alternatives are anticipated to encounter neighbouring construction. In order to execute these without any problem, the settlement caused by the excavation of the shield TBM must be minimized.

One of the significant reasons for the occurrence of large settlement is the hardening time of the back fill material. The conventional back fill material of liquid type requires 10 to 12 hours or more to harden and achieve initial strength. Thus, the stiffness of the backfill material is quite low and deformed by earth pressure above during hardening time. Consequently, the ground above the tunnel lining and tail void deforms and generates settlement.

In order to minimize the settlement which is caused by the deformation of backfill material, it is very effective to use a backfill material that rapidly hardens. The advanced two liquid type backfill material hardens within 30 minutes and achieves enough strength to resist earth pressure above. Moreover, it is re-softened and fluidized due to the pressure of the loaded backfill grouting. Then, the tail void is filled properly and the backfill material rapidly hardens after the grouting pressure is lightly loaded.

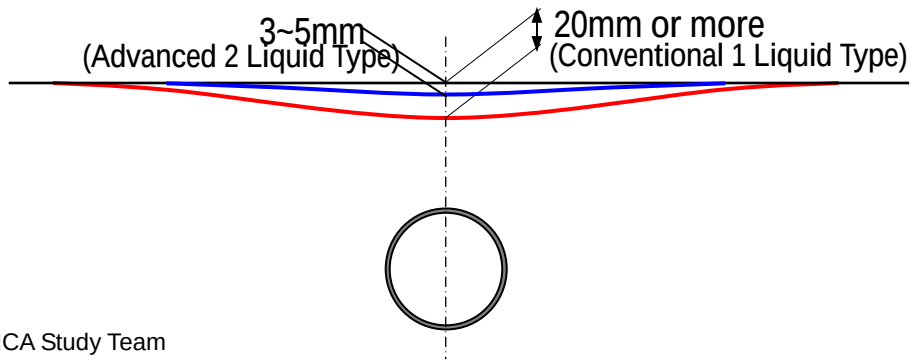
In Section 4.3.1 (1)-c), the practices and experiences of the neighbouring construction without any countermeasure is introduced. These methods were successfully carried out with advanced technology such as the two liquid type backfill material.

The conventional liquid type backfill material is a unique method in Egypt and in some European countries. Therefore, it is strongly recommended to introduce advanced material types to mitigate the settlement problem and neighbouring construction.




Source: JICA Study Team

**Figure 4-23 Mechanism of the Settlement by the Deformation of Backfill Material**

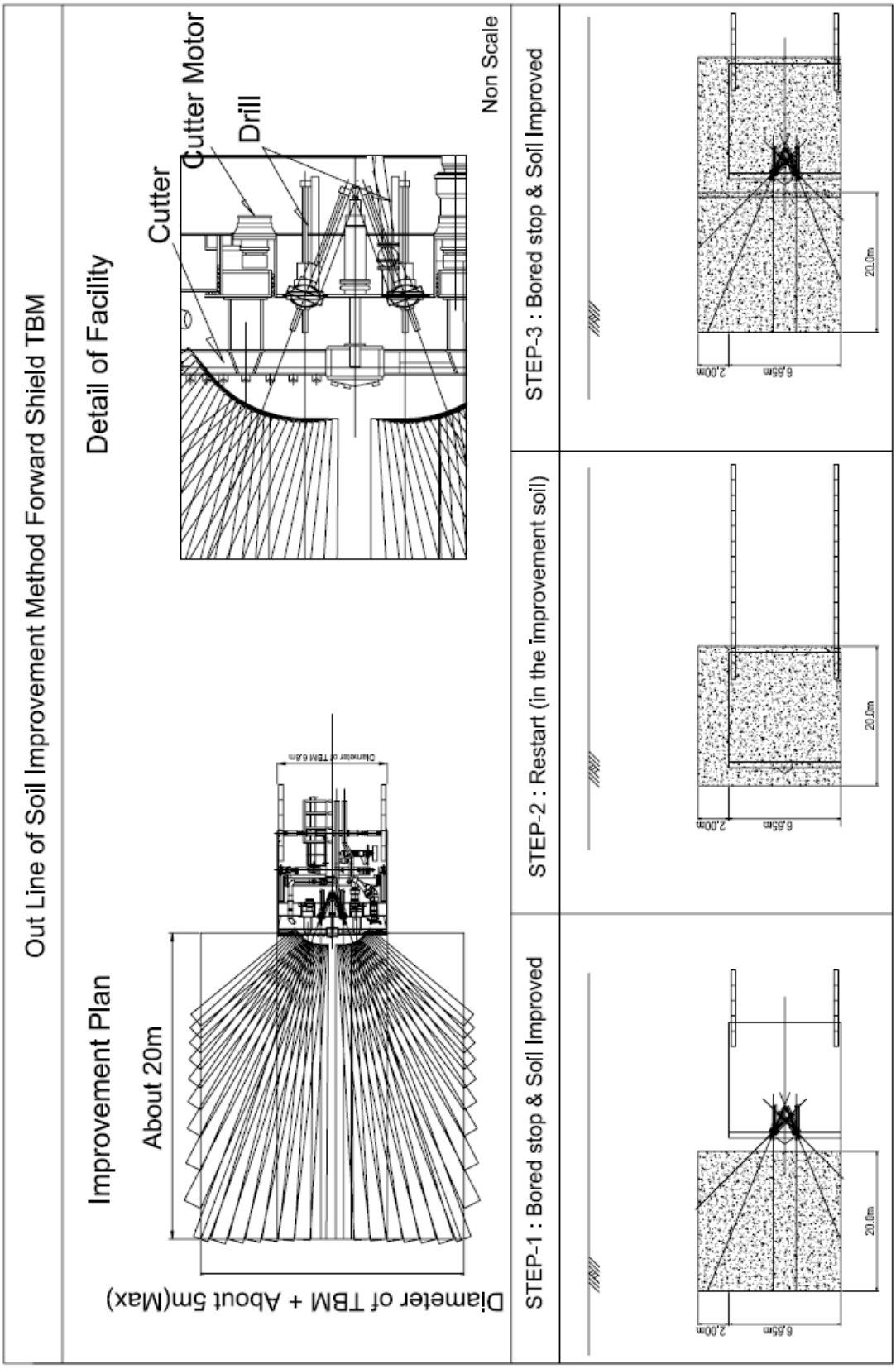



Source: JICA Study Team

**Figure 4-24 Ground Surface Settlement with Different Backfill Materials**

### 4.4.5 Soil Improvement from the Cutting Face and Under the Azhar Road Tunnel and Metro Line 3 Tunnel

The northern route is planned to pass under the existing Azhar Road Tunnel and the Metro Line 3 which is under construction. In principle, it is planned to keep enough distance that will not cause any problems when the Metro Line 4 passes beneath these tunnels. However, equipment should be attached for the improvement of the soil from the cutting face of the shield TBM, in case problems occur, as countermeasure to be considered. Besides, the soil improvement through the special hole of the fabricated segmental lining should also be considered and prepared. In order to determine appropriate construction method, it is necessary to measure the settlement of the ground and collect the data of deformation of adjacent structure during excavation. The data collection during construction and feedback to the methodology is very important. The image of the soil improvement from the cutting face of the shield TBM is illustrated in Figure 4-25.




Source: JICA Study Team

**Figure 4-25 Image of Soil Improvement from the Cutting Face of the Shield TBM**

## 4.5 Construction Schedule

### 4.5.1 Study Condition

The construction schedule is planned based on the following conditions:

1. Tunnel Cross Section: Two Single Track Tunnels

2. Number of Shield TBM: Two for both routes

3. Piles are used for the foundation of the viaduct section

### 4.5.2 Schedule

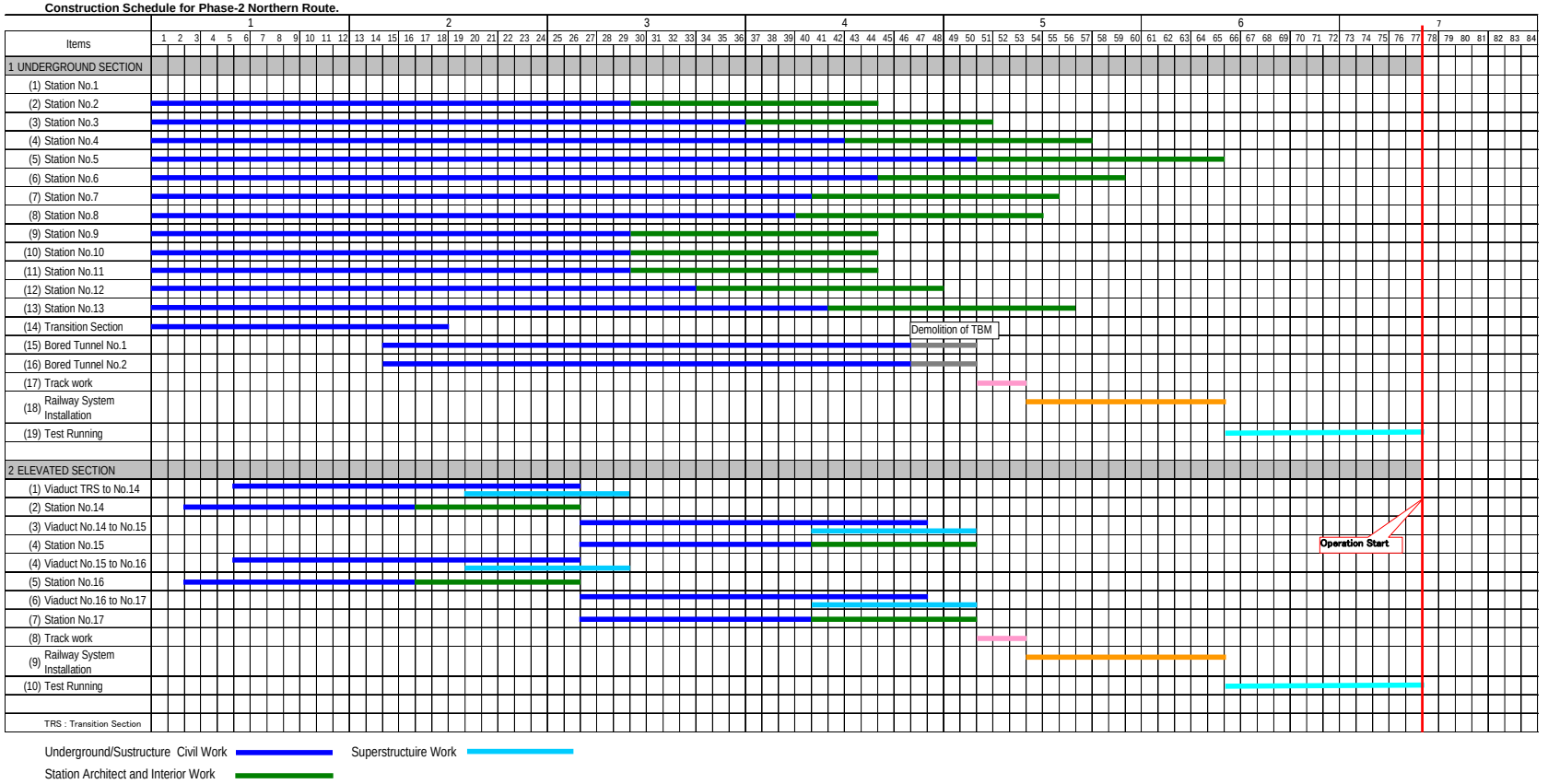
The preliminary construction period is studied as shown in Table 4-5. The construction period covers the commencement of the construction work to the start of operation of the metro.

The outline of the construction schedule is shown in Figure 4-26 and Figure 4-27.

**Table 4-5 Construction Period**

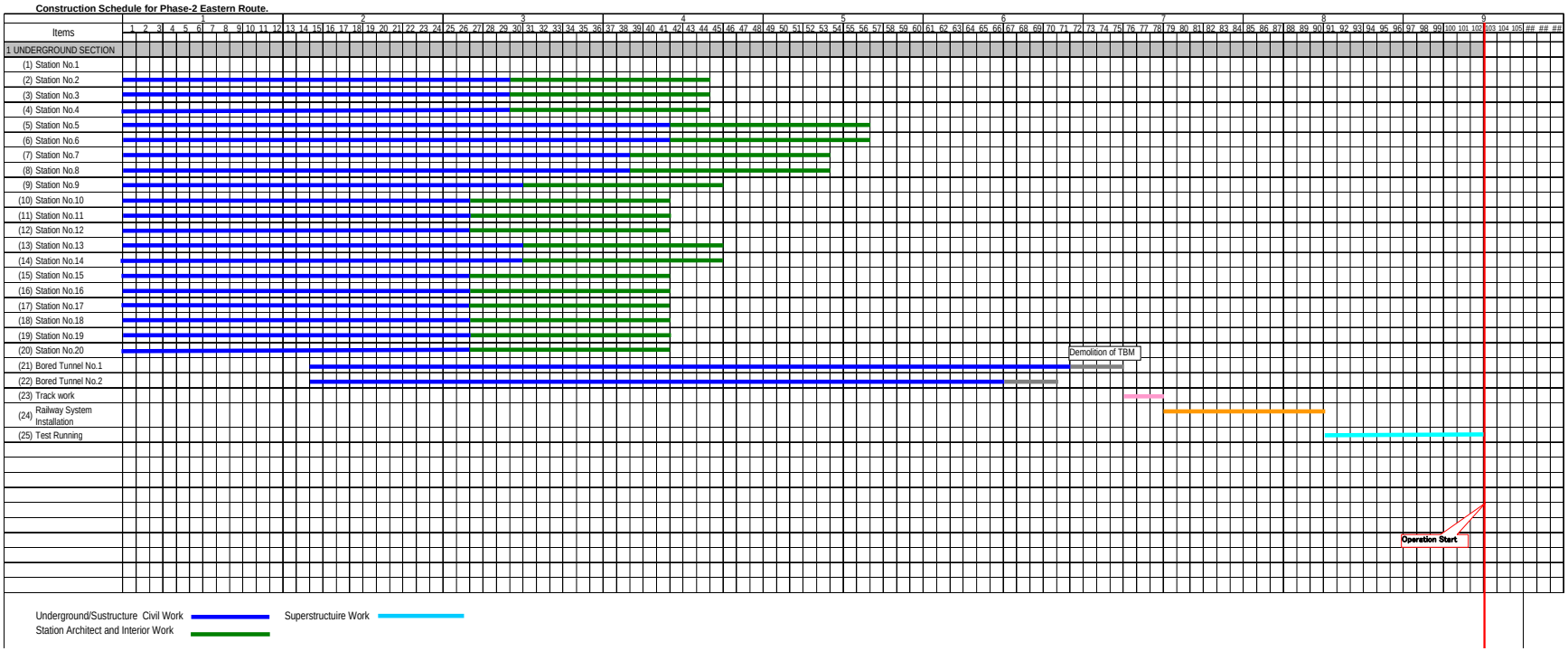
| Route | Period | Remarks |
|---|---|---|
| Northern Route | 6.5 Years | 2 TBMs are used. |
| Eastern Route | 8.5 Years | 2 TBMs are used. |

Source: JICA Study Team




Source: JICA Study Team

**Figure 4-26 Construction Schedule of Phase 2 (Northern Route)**




Source: JICA Study Team

**Figure 4-27 Construction Schedule of Phase-2 Eastern Route**

## 4.6 Construction Cost

For calculating the construction and procurement costs, items in Table 4-6 and Table 4-7 were taken into consideration.

**Table 4-6 Conditions for Cost Estimate**

| Category | Description |
|---|---|
| Pre-conditions | • The price is valid as at 2009.<br>• The foreign exchange rate used was USD1 = 5.512 LE.<br>• The construction cost calculation includes a local currency portion and a foreign currency portion.<br>• The construction cost of power generation plants is not included in the project cost.<br>• Price escalation rate is 10% per year. |

Source: JICA Study Team

**Table 4-7 Conditions for Each Corridor for Phase 2**

| | **North Corridor (CREATS Route)** | **East Corridor (SYSTRA Study Route)** |
|---|---|---|
| **1. Route** | El Malek El Saleh - El Azhar - Ghamrah - El Sawaha - El Khosos (Ring Road Exit #18) | El Malek El Saleh - Citadel - Nasr City - Ring Road Crossing |
| Total Length | 18 km | 23.5 km |
| Underground section | 12.5 km | 23.5 km |
| Elevated section | 5.5 km | 0 km |
| **2. Station** (except El Malek El Saleh Sta.) | 16 stations (Underground 12, Elevated 4) | 19 stations (Underground 19) |
| **3. Structures** | | |
| Tunnel Section | TBM – Two Single Track Tunnels Dia. 6.8 m (outside) | |
| Underground station (Common) | Cut and Cover: 220 m x 25 m | |
| Underground station (Particular) | Special Techniques for 2 Station | - |
| Elevated station | Viaduct Platform length 170 m | - |
| **4. No. of Train** | 352 car | 400 car |
| **5. Required No. of Depot for Phase 2** | 1 | 1 |

Source: JICA Study Team

The following table shows the basic unit cost considered for calculating the outline of construction and procurement costs.

Basic unit costs are estimated from related previous projects over the world such as “Cairo Metro Line 3”, ”Delhi Metro in India”, “Jakarta MRT in Indonesia”, “Ho Chi Minh MRT in Vietnam”, etc…

However, related previous project cost is estimated in a different year. Therefore, the basic unit price is based on 2009 costs, including price escalation.

**Table 4-8 Basic Unit Cost as of 2009**

| Items | Unit | Unit Cost (million USD) | Remarks |
|---|---|---|---|
| Underground Civil Works | km | 45 | Tunnel: Two Single Track Tunnels |
| Elevated Civil Work | km | 10 | |
| Track | km | 3.3 | |
| Signal and Telecom, Power Supply | km | 16 | |
| Underground Station (Depth*: Approx. 20 m) | Unit | 40 | |
| Underground Station (2 island platform 4 tracks sta.) | Unit | 80 | |
| Underground Station (Depth*: Approx. 30 m) | Unit | 60 | |
| Underground Station (Depth*: Approx. 40 m) | Unit | 80 | |
| Underground Station (HEP & JES ) | Unit | 80 | |
| Hard point for Sewage pipe | Unit | 2 | |
| Hard point for Manhole | Unit | 5 | |
| Elevated Station | Unit | 13 | |
| Rolling Stock | Car | 2 | |
| Depot | Unit | 20 | |

*: Depth is up to bottom of cut and cover
Source: JICA Study Team

The summary of construction cost in each route is shown in the following Table 4-9.

**Table 4-9 Construction and Procurement Cost for Phase 2 as of 2009**

| Items | Northern Route (CREATS Route) | | Eastern Route (SYSTRA Study Route) | |
|---|---|---|---|---|
| | Million USD | Million LE | Million USD | Million LE |
| Underground Civil Works | 444 | 2,469 | 869 | 4,838 |
| Elevated Civil Work | 48 | 268 | - | - |
| Track | 63 | 349 | 79 | 441 |
| Signal and Telecom, Power Supply | 288 | 1,603 | 376 | 2,092 |
| Underground Station (Depth*: Approx. 20 m) | 200 | 1,113 | 760 | 4,229 |
| Undergrand Station (2 island platform 4 tracks sta.) | 80 | 445 | - | - |
| Underground Station (Depth*: Approx. 30 m) | 180 | 1002 | - | - |
| Underground Station (Depth*: Approx. 40 m) | 160 | 890 | - | - |
| Underground Station | 80 | 445 | - | - |

| | | | | |
|---|---|---|---|---|
| (HEP & JES ) | | | | |
| Hard point for Sewage pipe | 8 | 45 | - | - |
| Hard point for Manhole | 5 | 28 | - | - |
| Elevated Station | 52 | 289 | - | - |
| Rolling Stock | 704 | 3,918 | 800 | 4,452 |
| Depot | 20 | 111 | 20 | 111 |
| **Total** | **2,332** | **12,975** | **2,904** | **16,163** |

Source: JICA Study Team, 2009

Please refer to “4.7 Environmental, Social and Archaeological Aspects” for Cost of Land Acquisition.

## 4.7 Environmental, Social and Archaeological Aspects

### 4.7.1 Methodology of Comparison

The comparison between Alternatives 1 and 2 for Phase 2 on the environmental, social and archaeological aspects was made based on the findings obtained through the field reconnaissance, secondary literature review and key informants. The findings were interpreted qualitatively together with the available Project features of the two alternatives such as the alignments, major track types designed section-wide (underground, at-grade, viaduct), locations of stations, etc. Quantitative comparison was employed if applicable through interpretation of satellite image and the Project features.

The comparison was made according to the Project stages, namely, pre-construction, construction, and operation stages, for each alternative. The conceivable negative impacts as well as positive effects of each alternative at every Project stage were interpreted from the viewpoints of acceptability for the purpose of comparison. The significance or magnitude of negative impacts was not examined/predicted in the environmental, social, and archaeological comparison of the two alternatives.

### 4.7.2 Comparison Results and Key Notes

Table 4-11 shows the results of comparison between Alternatives 1 and 2 for Phase 2 from the environmental, social and archaeological aspects. The points to be noted are summarized below, through the comparison between the two alternatives.

| Alternative 1 | Alternative 2 |
|---|---|
| - Total length passing underneath private/public lands: Approximately 2.5 km.<br>- Major areas to be acquired: the land in front of Child Cancer Hospital: Approximately 14,000 $m^2$.<br>- High potential for positive socio-economic effects for local community especially in the poor and densely populated areas.<br>- Potential negative impacts on water quality in Ismamailia Canal due to the turbid water discharge from the construction sites during construction stage. | - Total length passing underneath private/public lands: Approximately 2.5 km.<br>- Major areas to be acquired: the land adjacent to the Citadel: Approximately 17,000 $m^2$<br>- Higher risk of impact on cultural heritage especially in Islamic Cairo due to alignment adjacent to Citadel, etc. |

Table 4-10 shows the comparison of magnitude of land acquisition and resettlement between Alternatives 1 and 2 for Phase 2.

**Table 4-10 Comparison of Magnitude of Land Acquisition and Resettlement**

| Parameters | Alternative 1 | Alternative 2 |
|---|---|---|
| Necessary Area | 14,000 $m^2$ | 17,000 $m^2$ |
| Number of Resettlement Buildings | 11 | 15 |
| Cost for Land Acquisition | 138,629,000 LE | 204,000,000 LE |

Source: JICA Study Team

Remarks:

1: Unit price for land acquisition for alternatives 1 and 2 is based on interview survey at some local real estate and residence.

2: All acquired property is based on the prerequisite condition of owned flat.

3: Cost for land acquisition is calculated based on the maximum price of owned flat which includes land and property.

The above estimation just involves the acquisition price of land and properties based on the available data, and does not include other necessary compensation cost such as financial support for livelihood stabilization and transaction cost. Other necessary financial support such as compensation cost and number of potential Project Affected Persons (PAPs) are under examination, and will be available in the RAP framework report.

## Table 4-11 Comparison of Social, Environmental and Archaeological Aspects

| | Alternative 1 | Alternative 2 | Comparison |
|---|---|---|---|
| Social Environment | *Pre-construction Stage* | | |
| | >Stations and surface structures are all almost entirely planned within the right-of-way of the existing roads, therefore, expected negative impact due to involuntary resettlement is minimal.<br>>Key note 1: The length passing through underneath the private/ public lands outside of the right-of-way of the existing roads is roughly estimated 2.5km in total.<br>>Key note 2: One of the major areas to be acquired for the Alternative 1 is conceived the land in front of the Child Cancer Hospital, with approximately 14,000 m2. | >Stations and surface structures are all almost entirely planned within the right-of-way, therefore, expected negative impact due to involuntary resettlement is minimal.<br>>Key note 1: The length passing through underneath the private/ public lands outside of the right-of-way of the existing roads is roughly estimated 2.5km in total.<br>>Key note 2: One of the major areas to be acquired for the Alternative 2 is conceived the land adjacent to the western border of Citadel area, with approximately 17,000 m2. | >The characteristics of negative impacts in the pre-construction stage is considered to be similar between 2 alternatives.<br>>However, the negative impacts of the Alternative 1 is considered to be more acceptable due to the less pecuriality compared with the Alternative 2. |
| | *Construction Stage* | | |
| | >Negative local impact is conceivable on businesses adjacent to construction sites and vulnerable informal settlers and vendors.<br>>Traffic congestion is conceivable.<br>>Negative impact is conceivable on quality of daily lives of surrounding community | >Negative local impact is conceivable on businesses adjacent to construction sites and vulnerable informal settlers and vendors.<br>>Traffic congestion is conceivable.<br>>Negative impact is conceivable on quality of daily lives of surrounding community | >Impact of traffic congestion in Alternative 2 is considered to be less acceptable due to the higher importance of major arterial roads of Cairo (Salah Salem and Nasr roads) as compared to Alternative 1. |
| | *Operation Stage* | | |
| | >Physical community division is not expected since the at-grade section is limieted along the Ismailia Canal, which is an existing natural barrier already.<br>>Significant positive socio-eonomic effect is expected on the local community, and on small businesses and vendors in the poor and densely populated neighborhood of the stations.<br>>Positive effect on daily lives of local community is expected due to congestion relief after modal shifting. | >Physical community division is not expected since there are no at-grade sections of the alignment planned so far.<br>>Positive socio-economic effect is expected on local community.<br>>Positive effect on daily lives of local community is expected due to congestion relief after modal shifting. | >The characteristics of negative impacts as well as positive effects are considered to be similar between 2 alternatives.<br>>However, Alternative 1 is expected to contribute higher positive effects as compared with Alternative 2, since Alternative 1 is designed to pass through poorer and more densely populated communities, some of which are slums. |
| Natural Environment & Pollution | *Pre-construction Stage* | | |
| | >No Significant Impact | >No Significant Impact | > Similar |
| | *Construction Stage* | | |
| | >Air pollution and noise pollution are expected due to construction works and operation of heavy equipment/ vehicles.<br>>Potential impact on Ismailia Canal from construction debris and risks of other solid and liquid waste leakage, but minimal due to already existing road construction works throughout most of this section. | >Air pollution and noise pollution are expected due to construction works and operation of heavy equipment/ vehicles. | >The potential impact of Alternative 1 on Ismailia Canal is considered, although it is mitigatable. |
| | *Operation Stage* | | |
| | >Noise & vibrations from rolling stock traffic are expected especially along the at-grade/ viaduct sections.<br>>Positive effect is expected on the beautification of the environment, since the present status of regional landscape environment along some sections is significantly deteriorated (mainly from Al-Amiria Bridge to the terminal station). | >Noise & vibrations from rolling stock traffic are expected especially along the viaduct sections. | >The characteristics of conceivable negative impacts are almost similar between 2 alternatives.<br>>Alternative 1 is likely to contribute a more relative upgrade to the aesthetics of the local environment as compared with the current situation. |
| Cultural Heritage | *Pre-construction Stage* | | |
| | >No Significant Impact | >No Significant Impact | > Similar |
| | *Construction Stage* | | |
| | >Risk of impact is expected on unknown underground cultural heritage during tunneling and construction of stations through. | >Risk of impact on cultural heritage is expected in Islamic Cairo due to alignment adjacent to the Citadel, historical mosques, and passage under the historic wall of Cairo. | >Both alternatives are expected to bear the risk of impact on cultural heritage.<br>>However, Alternative 2 would pose a higher risk to cause negative impact on cultural heritage due to its distinctiveness compared with Alternative 1. |
| | *Operation Stage* | | |
| | >No Significant Impact | >No Significant Impact | > Similar |

Source: JICA Study Team

## 4.8 Comparison Results by Multi-Criteria Analysis and Recommendation

### 4.8.1 Multi-Criteria Analysis (MCA)

#### (1) The Purpose and Methodology of MCA

MCA is a decision-making tool developed for complex multi-faceted problems that include qualitative and/or quantitative aspects of the problem in the decision-making process.

MCA is a tool that can help evaluate the relative importance of all criteria involved, and reflect their importance in the final decision-making process.

RANKING AND RATING

The two simplest MCA methodologies that can be used in a Criteria and Indicators (C&I) assessment are ranking and rating.

Ranking involves assigning each decision element a rank that reflects its perceived degree of importance relative to the decision being made. The decision elements can then be ordered according to their rank (first, second. etc.). This methodology is not used in this report.

Rating is similar to ranking, except that the decision elements are assigned with ‘scores’ between 0 and 10. The scores for all elements being compared must add up to 10. Thus, to give a high score to one element means that a lower score is given to a different element. This methodology is applied in this report.

#### (2) Summarized Condition of Two Alternative Routes

The proposed routes to be compared are “Alternative 1 (Northern Route)”, the route studied and proposed by CREATS, and “Alternative 2 (Eastern Route)”, the route studied and proposed in the “Greater Cairo Public Transport Study, Report 2, Integrated Public Transport Network Scenarios” by SYSTRA. (Figure 8.1.5 and more detailed route is shown in Report 3, Evaluation of the Third Metro Line Alignment Options, Figure 6.2.1).

The proposed routes for selection must be provided with accompanying information and data.

The summarized main characteristics of both lines are shown in Table 4-12.

**Table 4-12 Summarized Main Characteristics**

| | Alternative 1 (Northern Route) | Alternative 2 (Eastern Route) |
|---|---|---|
| Section | El Malek El Saleh – El Azhar – Ghamrah – El Sawaha – El Khosos (Ring Road Exit No.18) | El Malek El Saleh – Citadel – Nasr City – Ring Road Crossing |
| Length | 18 km | 23.5 km |
| Underground section | 12.5 km | 23.5 km |
| Elevated section | 5.5 km | 0 km |
| Number of stations | 16 (except El Malek El Saleh) | 19 (except El Malek El Saleh) |
| Structures/construction method | | |
| Tunnel section | 2 single track tunnels | 2 single track tunnels |
| Underground station | Cut and cover method | Cut and cover method |
| Elevated station | Viaduct | - |
| No. of train sets | 44 sets (352 cars) | 50 sets (400 cars) |

Source: JICA Study Team

The information required will be mixed qualitative and quantitative elements.

The objectives are incorporated in the following list of criteria:

**a) Transportation Demand in the Near Future: 2022 and Far Future: 2050**

As mentioned in Section 4.1.3, the predicted population and number of passengers along Alternative 1 (Northern Route) and Alternative 2 (Eastern Route) shown in Table 4-13 are used for the scoring. The population covered is within a 2,000 m radius from the metro line.

**Table 4-13 The Predicted Population and Number of Passengers**

| | Alternative 1 (Northern Route) | | Alternative 2 (Eastern Route) | |
|---|---|---|---|---|
| Year | No. of passengers | Population | No. of passengers | Population |
| 2022 | 1,124,000 | 4,799,000 | 714,000 | 3,451,000 |
| 2027 | 1,181,000 | 4,916.000 | 946,000 | 3,645,000 |
| 2050 | 1,278,000 | 5,779,000 | 1,208,000 | 4,294,000 |

Source: JICA Study Team

The above table shows that Alternative 1 (Northern Route) has higher priority than Alternative 2 (Eastern Route) in the near future. However, after a long period, the population and transport demand of both routes become the same. Therefore, both routes are necessary to be constructed in order to meet the transportation demands in future.

**b) Cost**

The results of cost estimation for the comparison of the routes are shown in Table 4-14.

**Table 4-14 Comparison of Cost Estimation**

Unit: million LE

| | Alternative 1 (Northern Route) | Alternative 2 (Eastern Route) |
|---|---|---|
| Construction cost | | |
| Tunnel | 2,469 | 4,838 |
| Viaduct | 268 | - |
| Track | 349 | 441 |
| Station | 4,257 | 4,229 |
| Depot | 111 | 111 |
| Procurement cost | | |
| Rolling stock | 3,918 | 4,452 |
| Signal, telecom, power supply and other electro-mechanical cost | 1,603 | 2,092 |
| Total | 12,975 | 16,163 |

Source: JICA Study Team

**c) Hard Points and Construction Easiness**

< Alternative 1 (Northern Route) >

Six stations under Port Side Street, with a total length of 1,320 m, needs protection of the SWWT at stations. Moreover, underpinning for the foundation of flyover and deep excavation will be necessary to protect the existing tunnel and flyovers.

< Alternative 2 (Eastern Route) >

Since it requires passing under the foundation of the flyover and high-rise buildings, the foundation should rest on a rock layer and the construction of tunnel should utilize single track TBM as this will be less problematic.

**d) Construction Schedule**

The construction period of the north route is expected to be 6.5 years, including the construction of the station. Meanwhile, the construction period of the east route is expected to be 8.5 years, including the construction of tunnels with two sets of TBM.

**e) Environment**

The length passing underneath private/public lands for both lines is the same, which is approximately 2.5 km.

- Necessary land acquisition for Alternative 1 (Northern Route) covers the land in front of the Child Cancer Hospital: Approximately 14,000 $m^2$ + Ghamrah Station: Approximately 4,000$m^2$.

- Necessary land acquisition for the east line covers the land adjacent to the Citadel: Approximately 17,000 $m^2$, including the temporary bus-terminal during construction.

- Alternative 1 (Northern Route) has high potential in terms of positive socio-economic contribution to local community especially for the poor and densely populated areas.

**f) Archaeological Assets**

< Alternative 1 (Northern Route) >

- Passes close to the Matariya district where some archaeological remains have been found including Heliopolis, one of the ancient main cities.

- The planned route runs along Port Said Street beside the Ismailiya Canal, which has enough distance from the archaeological area in Matariya District.

- There is no high possibility of crossing the archaeological property during construction.

< Alternative 2 (Eastern Route) >

- Regarded as the world's oldest Islamic city, “Historic Cairo” is among UNESCO’s World Heritage. This area encompasses the famous mosques, citadel, madrasas, hammams and fountains, with outstanding universal value.

- JICA Study Team’s current plan considers the route line passing through the core zone as well as the buffer zone registered with the World Heritage area. It also includes the planned station located between the Citadel and the Ibn Tulun Mosque, although the whole line runs underground and intends to avoid the area just under the historical buildings. This aims to consider the landscape and direct damage of the World Heritage.

- Although the landscape features are taken into account by passing underground, there is a concern that slight subsidence and vibration during construction and while in service would affect these historic monuments. In addition, construction in the historic Cairo area highly increases the potential for finding cultural remains.

### (3) Analysis of Two Alternative Routes

The transportation demand for 2027 and 2050, construction cost, hard point, construction easiness, construction schedule, environmental issues and archaeological issues have been assessed for Alternative 1 (Northern Route) and Alternative 2 (Eastern Route).

The following table shows the guidelines for scoring each criterion.

**Table 4-15 Criteria for scoring**

| Criteria/Assessment | Higher score | Moderate score | Lower score |
|---|---|---|---|
| Score (Max. = 10, Min. = 0) | 10 to 7 | 7 to 4 | 4 to 0 |
| Transportation Demand Near Future: 2022 | d> 1 million | 1>d>0.8 million | 0.8>d |
| Transportation Demand Far Future: 2050 | d> 1 million | 1>d>0.8 million | 0.8>d |
| Cost | 10>c | 15>c>10 | c>15 |
| Hard points (Number) | 1>h | 5>h>1 | h>5 |
| Construction Easiness | easy | moderate | hard |
| Construction Schedule | Longer | moderate | shorter |
| Environment | no negative impact | low negative impact | high negative impact |
| Archaeological Assets | No | Possibly | Exist |

Source: JICA Study Team

Criteria can either be unweighted or weighted. Unweighted criteria are assumed to have the same importance. However, some criteria are considered to be more important than others. Thus, they should be weighted accordingly. The following table shows the proposed weighting of criteria.

**Table 4-16 Weighting of Criteria**

| Proposed weighting of criteria | Weighting<br>Average per criteria=1 |
|---|---|
| Transportation Demand Near Future: 2022 | 1.7 |
| Transportation Demand Far Future: 2050 | 1.2 |
| Cost | 1.2 |
| Hard Points | 0.8 |
| Construction Easiness | 0.7 |
| Construction Schedule | 0.8 |
| Environment | 0.8 |
| Archaeological Assets | 0.9 |

Source: JICA Study Team

Note: The above table indicates that a weighting of less than 1.0 means that a criteria is valued less than the average, a weight of 1.0 is at the average and a weight of more than 1.0 means it is valued above the average.

The weights of Hard point and construction easiness are lower compared to cost and construction schedule, because the former criteria are reflected in the cost, construction of the tunnel and underground structure at Hard points, requiring special construction method and higher construction cost. Thus, construction easiness means low cost and short construction schedule.

The following table shows the comparison of the two routes, including near and far future transportation demands.

**Table 4-17 Comparison of Two Routes**

| Multi Criteria Analysis | Alternative 1 (Northern Route) | | | | Alternative 2 (Eastern Route) | | | |
|---|---|---|---|---|---|---|---|---|
| | Score in words | Score | Weight | Score x Weight | Score in words | Score | Weight | Score x Weight |
| Transportation Demand Near Future: 2022 | High | 8.6 | 1.7 | 14.5 | Mod | 4.2 | 1.7 | 7.1 |
| Transportation Demand Far Future: 2050 | High | 9.4 | 1.2 | 11.5 | High | 8.9 | 1.2 | 10.9 |
| Cost | Mod | 5.4 | 1.2 | 6.5 | Mod | 4.6 | 1.2 | 5.5 |
| Hard Points | Low | 3.2 | 0.8 | 2.4 | High | 8.6 | 0.8 | 6.5 |
| Construction Easiness | Mod | 5.0 | 0.7 | 3.4 | High | 7.8 | 0.7 | 5.3 |
| Construction Schedule | Mod | 6.9 | 0.8 | 5.4 | Mod | 5.7 | 0.8 | 4.5 |
| Environment | Mod | 6.9 | 0.8 | 5.6 | High | 5.3 | 0.8 | 4.3 |
| Archaeological Assets | High | 7.4 | 0.9 | 6.3 | Low | 3.2 | 0.9 | 2.7 |
| Total/Average/Total | | 52.8 | 1.0 | 55.7 | | 48.3 | 1.0 | 46.8 |

Source: JICA Study Team

In case of only far future (2050) transportation demand.

**Table 4-18 Comparison Considering Transportation Demands in 2050**

| Multi-Criteria Analysis | Alternative 1 (Northern Route) | | | | Alternative 2 (Eastern Route) | | | |
|---|---|---|---|---|---|---|---|---|
| | Score in words | Score | Weight | Score x Weight | Score in words | Score | Weight | Score x Weight |
| Transportation Demand in the Far Future:2050 | High | 9.4 | 1.2 | 11.5 | High | 8.9 | 1.2 | 10.9 |
| Cost | Mod | 5.4 | 1.2 | 6.5 | Mod | 4.6 | 1.2 | 5.5 |
| Hard points | Low | 3.2 | 0.8 | 2.4 | High | 8.6 | 0.8 | 6.5 |
| Construction Easiness | Mod | 5.0 | 0.7 | 3.4 | High | 7.8 | 0.7 | 5.3 |
| Construction Schedule | Mod | 6.9 | 0.8 | 5.4 | Mod | 5.7 | 0.8 | 4.5 |
| Environment | Mod | 6.9 | 0.8 | 5.6 | High | 5.3 | 0.8 | 4.3 |
| Archaeological Assets | High | 7.4 | 0.9 | 6.3 | Low | 3.2 | 0.9 | 2.7 |
| Total/Average/Total | | 44.2 | 1.0 | 41.1 | | 44.1 | 1.0 | 39.7 |

Source: JICA Study Team

These tables show that both lines, Alternative 1 (Northern Route) and Alternative 2 (Eastern Route), have enough transportation demands that require construction of the metro. However, Alternative 1 (Northern Route) has higher transport demand at the earlier stage.

### 4.8.2 Recommendation

JICA Study Team recommends the construction of both alternative routes of the metro, considering the future transportation demands.

The 2022 transportation demands of both lines are large enough to require the construction of the metro.

However, the 2022 transportation demand of Alternative 1 is larger than that of Alternative 2.

The rehabilitation of the tramway line from Abbasia to Nasr City to efficiently connect Nasr City with the Metro Line 3 was recommended in the “Greater Cairo Public Transport Study, Report 2, Integrated Public Transport Network Scenarios” prepared by SYSTRA. Moreover, the study for the rehabilitation of this tramway as a Super Tram has already started with the financial support from World Bank.

The construction of stations on Port Side Street has some conflicts with SWWT. However, the recent underground construction technology and experience show that such conflict can be solved with limited additional cost.

Therefore, JICA Study Team recommends to give priority to Alternative 1 (Northern Route) and to implement the feasibility study. The comparison table for Phase 2 route is shown in Table 4-19.

# Table 4-19 Comparison Table for Phase 2 Route

***Comparison Table for Phase2 Route***

22 Jul. 2009

| | North Corridor (CREATS Route) | | | East Corridor (SYSTRA Study Route) | | | Remarks |
|---|---|---|---|---|---|---|---|
| ***[A] PROJECT OUTLINE*** | | | | | | | |
| **1. Route** | El Malek El Saleh - El Azhar - Ghamra - El Sawah - El Khosos (Ring Road Exit #18) | | | El Malek El Saleh - Citadel - Nasr City - Ring Road Crossing | | | |
| Total Length | 18km | | | 23.5km | | | |
| Underground section | 12.5km | | | 23.5km | | | Underground section is applied for all Residential/Commercial area |
| Elevated section | 5.5km | | | 0km | | | Elevated sections is applied for Industrial area along Ismailiya canal |
| **2. Station** | 16 stations | (except El Malek El Saleh Sta.) | | 19 stations | (except El Malek El Saleh Sta.) | | |
| | Underground 12, Elevated 4 | | | Underground 19 | | | |
| **3. Structures** | | | | | | | |
| Tunnel Section | TBM - Single Track W-Tube *(note: Example)* | | Dia. 6.8m (outside) | TBM - Single Track W-Tube *(note: Example)* | | Dia. 6.8m (outside) | |
| Station | | | | | | | |
| Underground station (Common) | Cut & Cover | | 220m x 25m | Cut & Cover | | 220m x 25m | |
| Underground station (Particular) | Special Techniques | | for 2 Station | - | | - | |
| Eleveted station | Viaduct | | Platform length 170m | - | | - | |
| **4. No. of Train** | No. of Train Set (inc spare sets) | | No. of Car | No. of Train Set (inc spare sets) | | No. of Car | |
| | 44 set | | 352 car | 50 set | | 400 car | 8 cars per train |
| **5. Required No. of Depot/Workshop for Phase2** | 1 | | | 1 | | | |
| ***[B] COMPARISON FACTOR*** | | | | | | | |
| ***1. Demand Forecast*** | ***Excellent (High Demand in Near Future)*** | | | ***Good (High Demand in Far Future)*** | | | |
| | No. of Pax. | PHPDT | Population within Radius 2000m | No. of Pax.* | PHPDT* | Population within Radius 2000m | *: with Super Tram condition |
| 2022 (Starting service Phase2) | 1,124,000 | 50,690 | 4,799,000 | 714,000 | 28,930 | 3,451,000 | |
| 2027 (5years later) | 1,181,000 | 53,090 | 4,916,000 | 946,000 | 34,080 | 3,645,000 | |
| 2050 (In the future) | 1,278,000 | 55,750 | 5,779,000 | 1,208,000 | 43,540 | 4,294,000 | |
| ***2. Outline of Hard Points*** | ***Fair (Many)*** | | | ***Good (Few)*** | | | |
| - The Number of Hard Point | 6 (Stations) | | | 0 | | | |
| - Total Length | 1320 m | | | 0 | | | |
| - Difficulty for construction | Spine Waste Water Tunnel Protection at Stations / Underpinning for Foundation of Flyover / Deep Excavation | | | Foundation of Flyover and Buildings | | | |
| ***3. Outline of Construction Methodlogy for Hard Points*** | ***Fair (Normal)*** | | | ***Good (Easy)*** | | | |
| - Spine Waste Water Tunnel Protection at Underground Stations | - Station is constructed by Cut & Cover method of top down basically. Then Spine Waste Water Tunnel (SWWT) at STATIONs is protected by the following procedure.<br>[Step 1.] Hang SWWT from upper slab.<br>[Step 2.] Support SWWT on the below slab.<br>[Step 3.] Install SWWT in the station structure. | | | - | | | |
| - Foundation of Flyover | - Foundation of Flyover is protected by ***Underpinning Method.*** (Note: Underpinning is the countermeasure to protect existing structures and its function. The foundations/piles are fully or partially constructed or replaced to bear the load of structure and the displacement and settlement which deteriorate the structure are controlled and minimized in allowable range.) | | | There are some points that tunnel pass under the foundations of the flyover and buildings. However, no countermeasure will be required for the work, because (1) the foundation might be not so deep hence the ground condition of the area are rock layer, and (2) the tunnel can pass in the rock layer under the bottom of the foundations/piles. | | | |
| - Other: Tunnel Construction Work along the Spine Waste Water Tunnel under Port Said St | - Tunnel construction work along the Spine Waste Water Tunnel (SWWT) under Port Said St. is ***NOT*** difficult according to the many experiences in Japan. Some example of the experiences are introduced as follows.<br>[Example 1] A road tunnel (Diameter:12m) was constructed under and along the existing road tunnel (Diameter:12m) , whose distance between both outside of tunnels is ***only 2 to 3meter*** . The work was carried out ***without countermeasue and any extra cost*** .<br>[Example 2] There are many examples of ***neighboring construction without any countermeasure and any extra cos t*** (included tunnel and underground station, other foundations, etc). The distances between structures are ***less than 1 meter*** . | | | - | | | |
| ***4. Outline of Construction Period*** | ***Fair (Shorter)*** | | | ***Poor (Longer)*** | | | |
| | 6.5 years<br>(From Site Clearance till Operation Start, 2 TBM) | | | 8.5 years<br>(From Site Clearance till Operation Start , 2 TBM) | | | |
| ***5. Outline of Construction & Procurement Cost*** | ***Good (Lower Cost)*** | | | ***Fair (Higher Cost)*** | | | |
| **Construction cost** | | | | | | | |
| Tunnel | 2,469 million EGP | | | 4,838 million EGP | | | |
| Viaduct | 268 million EGP | | | - | | | |
| Track | 349 million EGP | | | 441 million EGP | | | |
| Station | 4,257 million EGP | | | 4,229 million EGP | | | |
| Depot | 111 million EGP | | | 111 million EGP | | | |
| **Procurement cost** | | | | | | | |
| Rolling Stock | 3,918 million EGP | | | 4,452 million EGP | | | |
| Signal & Telecom, Power Supply | 1,603 million EGP | | | 2,092 million EGP | | | |
| **Total cost** | **12,975 million EGP** | | | **16,163 million EGP** | | | |
| **6. Social & Environmental Issues** | ***Good (Some Negative Impact+Some Positive Impact)*** | | | ***Fair (Some Negative Impact)*** | | | |
| Length passing through underneath Private/ Public Lands | - Approx. 2.5km | | | - Approx. 2.5km | | | |
| Major Areas to be Acquired | - Land in front of Child Cancer Hospital: Approx. 14,000 m2. + Ghamra station: Approx.4000m2. | | | - Land adjacent to the Citadel: Approx. 17,000 m2. | | | |
| Other Issues | - High potential of positive socio-economic effect for local community especially in the poor and densely populated areas. | | | | | | |
| **7. Archaeological Issues** | ***Excellent (Few)*** | | | ***Poor (Many)*** | | | ***< Legend >***<br>Each Compaarison Factors are evaluated by the following Ranking.<br>[Rank A]: **Excellent**<br>[Rank B]: **Good**<br>[Rank C]: **Fair**<br>[Rank D]: **Poor**<br>[Rank E]: **Very Poor** |
| Property | - Passing close to the Matariya district where some archaeological remains have been found including Heliopolis, one of the ancient main cities. | | | - Going through the world's oldest Islamic city, "Historic Cairo" which is one of the UNESCO World Heritage. This area encompasses the famous mosques, citadel, madrasas, hammams and fountains, considered as having outstanding universal value. | | | |
| Route | - Our planned route runs along the Port Said Street beside the Ismailiya Canal, which keeps enough distance from the Archaeological area in Matariya district. | | | - Our current plan is that the route line passes through the Core Zone as well as the Buffer zone registered into the World Heritage area, and the planed station is located between the Citadel and the Ibn Tulun Mosque, although the whole line runs underground and intends to avoid the area just under the historical buildings in order to consider the Landscape and direct damage of the World Heritage. | | | |
| Impact | - There is no highly possibility to come across the archaeological property during the construction. | | | - Even taking into account the Landscape by passing underground, there is concern that slight subsidence and vibration during construction and in service would affect these historic monuments. in addition, the construction in the historic Cairo area highly increases the potential for finding the cultural remains. | | | |
| **Conclusion** | | | | | | | |
| | ***Recommended to be constructed AS PHASE 2*** | | | ***Recommended to be constructed AS PHASE 3 (in the future)*** | | | |

Source: JICA Study Team

# APPENDIX 1
# TRAFFIC COUNT LOCATIONS

# Appendix 1

# Traffic Count Locations

**LT - 1**

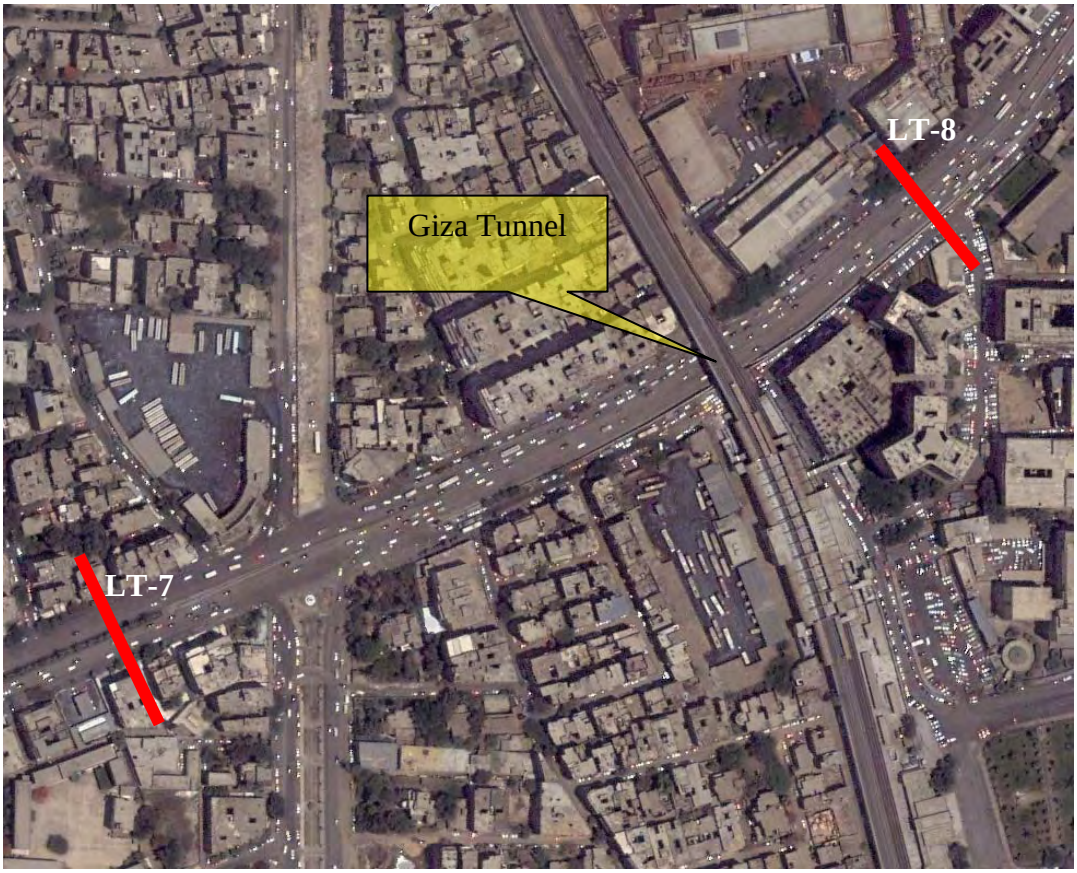

**LT - 3**


**LT - 4**

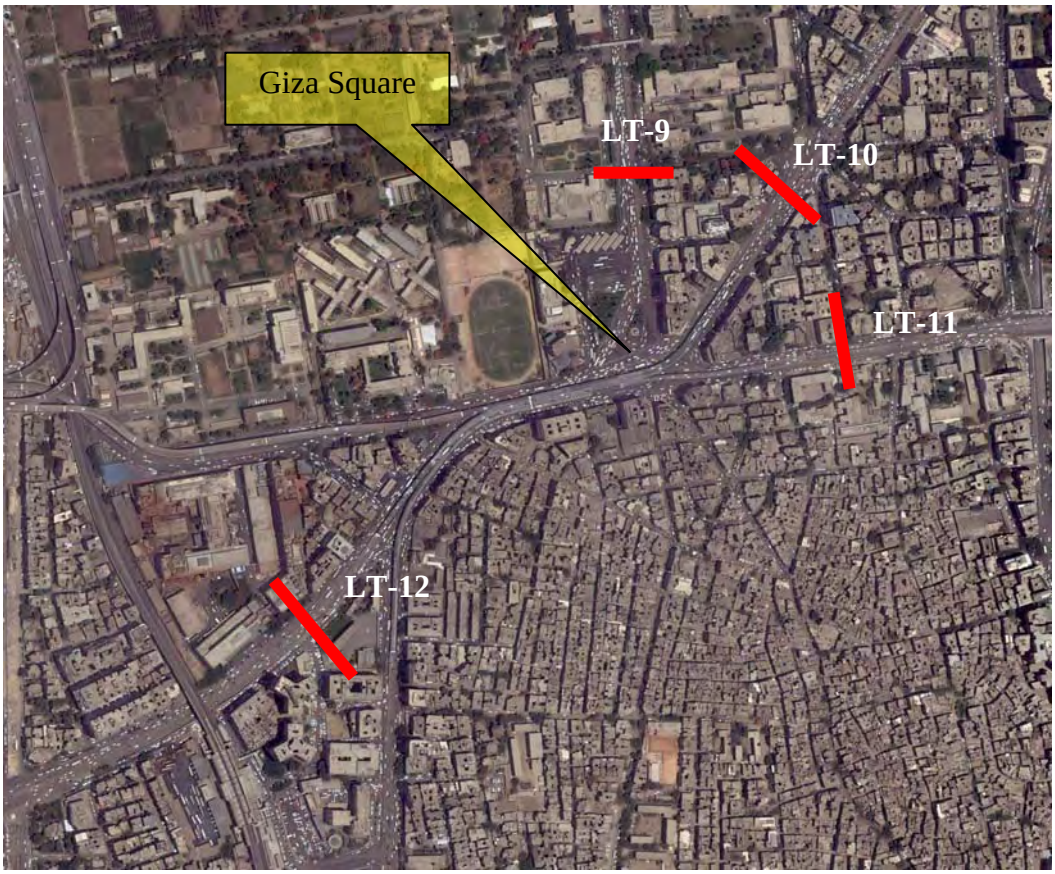
**LT - 5**


**LT - 6**

**LT-7 -8**




**LT - 9- 10- 11 - 12**



# APPENDIX 2
# TRAFFIC COUNT LOCATIONS AT PORT-SAID STREET

# Appendix 2

# Traffic Count Locations

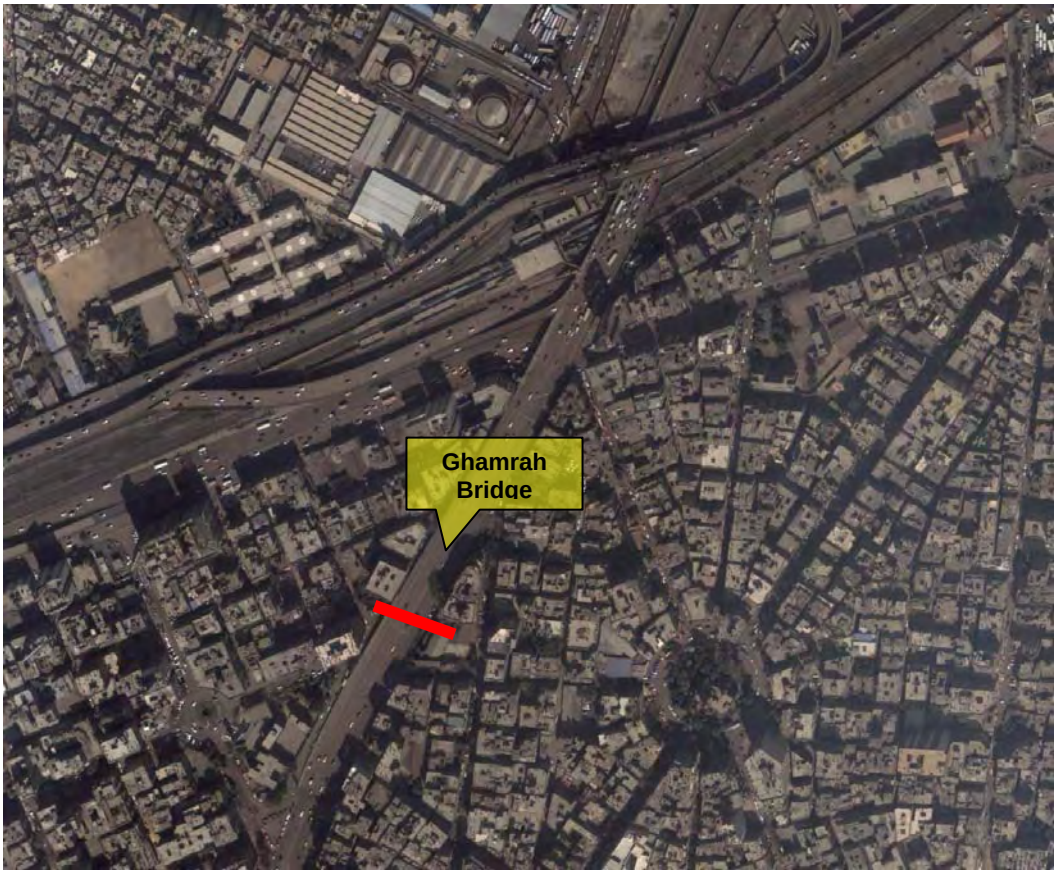
# at Port-Said Street

**LT - 13**

**LT - 14**

**LT - 15**


**LT - 16**



**LT - 17**

**LT - 18**

**LT - 19**


**LT - 20**

## LT - 21


## LT - 22