CHAPTER 5 PROJECT SCOPE

5.1 DESIGN CRITERIA AND POLICY FOR CIVIL WORKS

Following design policy is established and applied for the project design of civil works, based on the site reconnaissance and discussions with SPTrans.

5.1.1 Route alignments

- Connect with beginning point, end point and transfer stations required by the demand forecast and transport planning
- Avoid removal of established cemetery, university, school, important churches which have negative impacts in social environment
- Design flexible alignment, utilizing steep slope and small radius (advantage of Monorail) if necessary to match with the terrain condition of São Paulo
- Take into account existing development plans
- Minimize relocation/removal of utility structures such as buried pipes, high voltage lines, grade separated crossing structures, elevated structures
- Evaluate carefully the possibility of the relocation of number of houses particularly illegal occupation because São Paulo city is implementing restructuring of land use in parallel with other development projects such as transport
- Consider landscape aspects
- Evaluate possibility of repercussion during the construction work

5.1.2 Civil structures

- Generally the design shall be done in accordance with ABNT (ASSOCIACAO BRASILEIRA DE NORMAS TECNICA) standard in Brazil
- Provide access-friendly stations for all the uses.
- Provide attractive appearance for users and society.

5.1.3 Applicable design standards

(1) Geometric Design

- MLIT - Structure design standard for urban monorail

(2) Geo Technical Investigation

- ABNT NBR 6484 -Sondagens de simples reconhecimento com SPT - Metodo de ensaio (Soil -Standard penetration test - SPT - Soil sampling and classification - Test method)

(3) Earthworks

- ABNT NBR 7182 - Solo - Ensaio de compactacao (Soil . Compaction Test Method)
- ABNT NBR 7185 Solo - Determinacao da massa especifica aparente, “in situ”, com emprego dofrasco de areia (Soil. Determination of apparent specific mass, on site, with the application of sand bottle)
- ABNT NBR8044 - Projeto geotecnico (Geotechnical Design)
- ABNT NBR9061 - Seguranca de escavacao a ceu aberto (Open Excavation Safety)
- ABNT NBR11682 - Estabilidade de taludes (Slope stability).

(4) Foundations

- ABNT NBR6122 - Projeto e execucao de fundacoes (Foundations - Design and construction -Procedure)
- ABNT NBR12131- Estacas - Prova de carga estatica - Metodo de ensaio (Piles - Static Load
- ABNT NBR12655 Concreto de cimento Portland - Preparo, controle e recebimento - Procedimento Test - Procedure)
- ABNT NBR13208 - Estacas - Ensaio de carregamento dinamico (Dynamic testing piles - Methodof test);

(5) Concrete Structure

- ABNT NBR6118 - Projeto de Estruturas de Concreto Procedimento (Design of structural concrete - Procedure)
- ABNT NBR6489 - Prova de carga direta sobre terreno de fundacao (Foundation Ground Direct Load Test);
- ABNT NBR9062 Projeto e execucao de estruturas de concreto pre-moldado (Project of execution of pre-stressed concrete elements)
- ABNT NBR12654 - Controle Tecnologico de Materiais Componentes do Concreto .Procedimento (Technological Control of Concrete Component Materials - Procedure);
- ABNT NBR12655 Concreto de cimento Portland - Preparo, Controle e Recebimento .Procedimento (Portland Cement Concrete . preparation, control and acceptance -Procedure);
- ABNT NBR14931- Execucao de Estruturas de Concreto - Procedimento (Execution of concrete structures - Procedure)
- ABNT NBR15200 - Projeto de estruturas de concreto em situacao de incendio- Fire design of concrete structures

(6) Steel Structure

- ABNT NBR-8800 Projeto de estruturas de aco e de estruturas mistas de aco e concreto de edificios (Project of structures made of steel and concrete-steel mixed structures)
- ABNT NBR-6123 Forcas devidas ao vento em edificacoes (Forces due to wind on buildings)
- ASTM, JIS shall be supplementary applied.

(7) Fire Prevention

- ABNT NBR6135 Chuveiros automaticos para extincao de incendio (Showers, automatic extingishing)
- ABNT NBR8681 Acoes e seguranca nas estruturas – Procedimento (Actions and security structures - Procedure)
- ABNT NBR9077 Saidas de emergencia em edificios (Emergency exits of buildings)
- ABNT NBR11742 Porta corta-fogo para saida de emergencia (Fire doors)
- ABNT NBR11785 Barra antipanico - Requisitos
- ABNT NBR13435 Sinalizacao de seguranca contra incendio e panico
- ABNT NBR13768 Acessorios destinados a porta corta-fogo para saida de emergencia - Requisitos
- ABNT NBR14880 Saidas de emergencia em edificios - Escadas de seguranca - Controle de fumaca- Procedimento
- ABNT NBR14432 Exigencias de resistencia ao fogo de elementos construtivos de edificacoes –Procedimento

(8) Station design (Barrier free design)

- DECRETO No 5.296 DE 2 DE DEZEMBRO DE 2004 (Barrier Free low in Brazil)
- ABNT NBR-9050 Acessibilidade a edificacoes, mobiliario, espacos e equipamentos urbanos (Accessibility to buildings, furniture, spaces and urban equipment)
- ABNT NBR-13994
- NBRNM313 Elevadores de passageiros - Requisitos de seguranca para construcao e instalacao - Requisitos particulares para a acessibilidade das pessoas, incluindo pessoas com deficiencia (Passenger lifts - Safety requirements for construction and installation - Particular requirements for accessibility for persons including persons with disabilities)
- Japanese barrier free standard shall be supplementary applied.

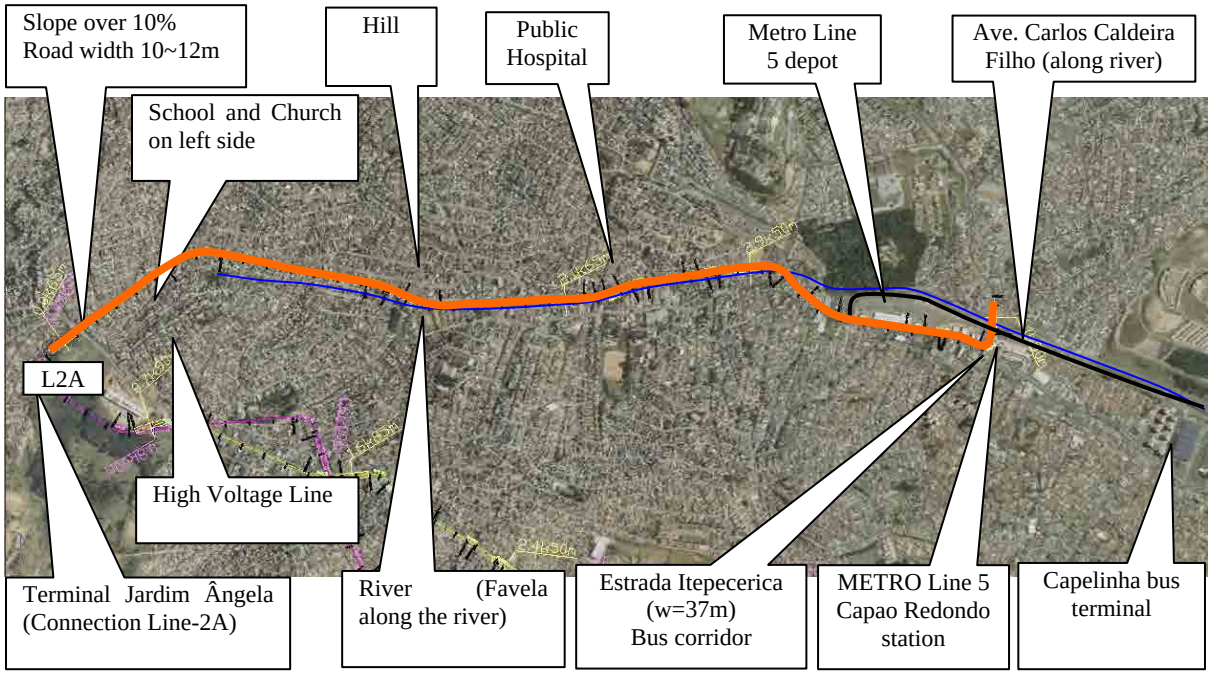
5.1.4 Design controls of route alignment

Major design controls are identified through the site visits of each route. Following tables show identified design controls by route. Line-2A is divided into two sub-sections in order to make a comparison of two route alternatives namely Original (M'boi corridor) route and Area development route. Orange lines are the selected alignments.

Table 5-1 List of Design Controls (1) (Line-1)

No.	Location	Item	Description/Counter measures
1	Km0+000	Connection with Line-2A	Connect smoothly with Line-2A (certain length of tangent should be provided for operation purpose)
2	Km0+000	Location of Terminal	Connect smoothly with Jardim Ângela terminal
3	Km0+020	M Boi Mirim	Avoid influence in the existing traffic
4	Km0+000~Km0+300	Steep slope	Existing road has approximately 10% down slope. Underground structure is designated together with Jardim Angela terminal. Vertical alignment should be less than maximum slope established in design criteria
5	Km0+000~Km0+600	Narrow road	Existing road width is 10-12m. Try to acquire only one side of road to avoid total removal of the existing commercial Take into consideration a road project planned by DERSA
6	Km0+600~Km1+850	Narrow road	Existing road width is 10-12m. Minimize the land acquisition. Try to acquire only one side of road to avoid total removal of the existing commercial
7	Km0+750	School and Church (left)	Avoid
8	Km1+000	High Voltage Line	Avoid
9	Km1+200~Km3+200	River	Try to utilize river space
10	Km1+800~Km2+150	Hill	Compare with option to use river
11	Km2+400	Hospital (AMA)	Avoid
12	Km3+200~Km4+100	Ave. Ellis Maas	Busy road
13	Km3+200~EP	Ave. Carlos Caldeira Filho (River)	Spacious road
14	Km3+550~Km4+100	Line 5 depot	Avoid
15	Km4+100~EP	Estrada Itapecerica	Busy road (bus corridor) W=37.0
16	Km4+100	Metro Line 5 Capao Redondo Station	Provide easy transfer to the Metro line
17	EP (Km4+200)	Estrada Itapecerica	Consider further extension of monorail line to Campo Limpo and Vila Sonia
18		Capelinha bus terminal	Consider connection by bus operation

Source: JICA Study Team



Source: JICA Study Team

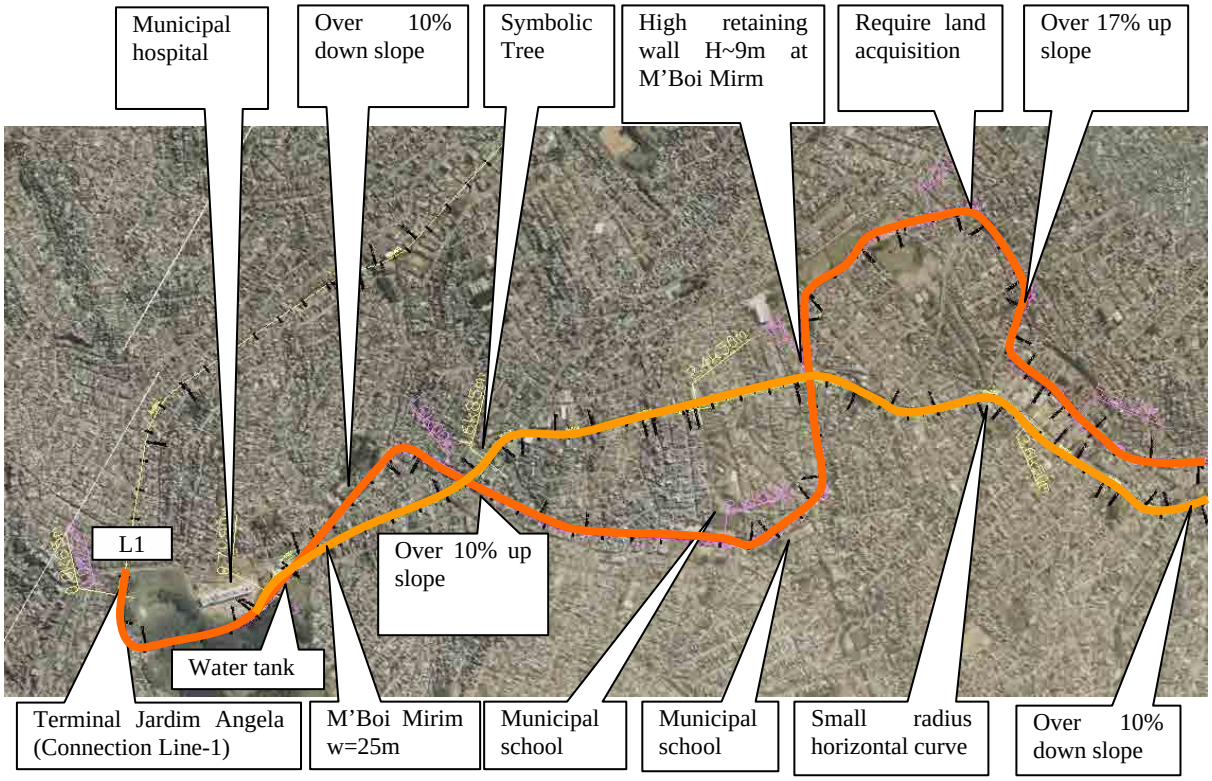
Figure 5-1 Design Control of Line-1

Table 5-2 List of Design Controls (2) (Line-2A – 1/2)

No.	Location	Item	Description/Counter measures
Option 1 (Original Route: Along Estrada M'Boi Mirim)			
1	Km0+000	Location of Terminal	Connect smoothly with Jardim Ângela terminal
2	Km0+000	Hospital Jardim Ângela	Secure distance
3	Km0+600	Water tank	Avoid
4	Km0+000~Km0+800	Hill	Minimize the impact
4	Km0+900~Km5+300	Estrada M'Boi Mirim	W=25m average (refer to the typical cross section)
5	Km0+800	Estacion de Transferencia Jardim Angela	High demand/ Provide station at appropriate location
6	Km1+750	Symbolic tree	Avoid
7	Km2+500	Municipal School	C.E.E Clube da Turma Avoid / Provide station at appropriate location
8	Km2+800	High retaining wall for M'Boi Mirim	H=9m with earth anchors. Avoid modification
9	Km3+500	Small radius of curve	Employ horizontal curve in accordance with design criteria
10	Km4+000~Km4+250	Steep slope	Existing road has over 10% down slope. / Limit the gradient under the maximum gradient by changing the height of piers.
11	Km4+200	Small radius of curve	Employ horizontal curve in accordance with design criteria
Option 2 (Area development route)			
1	Km0+000	Location of Terminal	Connect smoothly with Jardim Ângela terminal
2	Km0+000	Hospital Jardim Angera	Secure distance
3	Km0+800	Water tank	Avoid
4	Km1+000~Km1+400	Steep slope	Existing road has over 10% down slope. / Limit the gradient under the maximum gradient by changing the height of piers.
5	Km1+000~Km1+550	Land acquisition	Alignment does not follow existing road, which require large number of land acquisition (type of houses and procedures for land acquisition is discussed in environment section)
6	Km1+400~Km1+600	Steep slope	Existing road has over 12% up slope. / Limit the gradient under the maximum gradient by changing the height of piers.
7	Km1+650~Km2+600	Land acquisition	Alignment does not follow existing road, which require large number of land acquisition (type of houses and procedures for land acquisition is discussed in environment section)
8	Km2+600	Municipal School	C.E.E Clube da Turma

			Avoid / Provide station at appropriate location
9	Km2+600~Km3+350	Land acquisition	Alignment does not follow existing road, which require large number of land acquisition (type of houses and procedures for land acquisition is discussed in environment section)
10	Km3+200~Km3+300	Steep slope	Existing road has over 17% up slope/ Very toll piers will be necessary to keep the route under the maximum gradient.
11	Km3+400	Estrada M'Boi Mirim	Grade separation (H=9m) with M'Boi Mirim (detailed comparison is shown in separate sub chapter) Tunnel is considered
12	Km3+400~Km3+700	Land acquisition	Alignment does not follow existing road, which require large number of land acquisition (type of houses and procedures for land acquisition is discussed in environment section)
13	Km4+100~Km5+000	Land acquisition	Alignment does not follow existing road, which require large number of land acquisition (type of houses and procedures for land acquisition is discussed in environment section)
14	Km4+650~Km4+900	Steep slope	Existing road has over 17% up slope. / Employ vertical alignments in accordance with design criteria
15	Km5+000~Km5+350	Residential complex	Avoid

Source: JICA Study Team



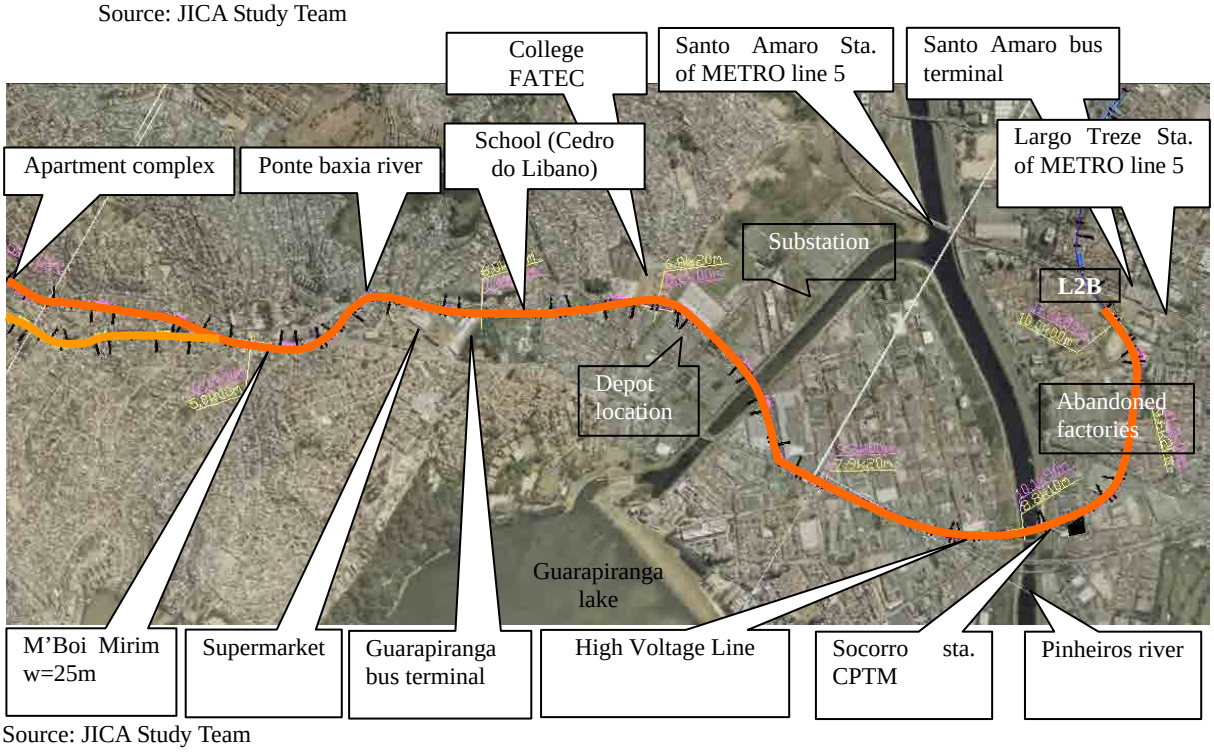
Source: JICA Study Team

Figure 5-2 Design Controls of Line-2A (1/2)

Table 5-3 List of Design Controls (3) (Line-2A – 2/2)

No.	Location	Item	Description/Counter measures
Option 1 (Original Route: Along Estrada M'Boi Mirim)			
1	Km4+200~5+300	Estrada M'Boi Mirim	W=25m average (refer to the typical cross section)
Option 2 (Area development route)			
1	Km5+350~Km5+700	Residential area	Minimize number of land acquisition
2	Km5+700~Km6+100	River Ponte Baixa	Minimize the impact for the existing river protection
3	Km6+100~Km6+200	Residential area	Minimize number of land acquisition
4	Km6+200~Km6+700	Estrada M'Boi Mirim	W=25m average (refer to the typical cross section)
Common by stations of Option2 and (Option 1)			
1	Km6+900~Km8+200 (Km5+500~Km6+800)	River Ponte Baixa	Coordination with SIURBI river protection project
2	Km7+300 (Km5+900)	Supermarket	Avoid
3	Km7+400 (Km6+000)	Guarapiranga bus terminal	Provide easy transfer from/to the bus service
4	Km7+500~Km7+700 (Km6+100~Km6+300)	School	Associacao Cedro Do Libano de Protecao A Infancia Avoid
5	Km8+200 (Km6+800)	School	FATEC, Avoid
6	Km8+200 (Km6+800)	Depot	Provide appropriate access
7	Km8+600 (Km7+200)	Substation	Avoid
8	Km8+700 (Km7+300)	Channel to Guarapiranga	Require longer span bridge
9	Km10+100 (Km8+700)	High Voltage Line	Avoid / Minimize the influence
10	Km10+200 (Km8+800)	Pinheiros river	Require longer span bridge
11	Km10+300 (Km8+900)	Socorro Station	CPTM, Provide easy access
12	Km10+300 (Km8+900)	CPTM Line (Line 9)	Avoid
13	Km10+300 (Km8+900)	Av. Nacoes Unidas	Secure enough clearance and require attention for construction
14	Km10+600~Km11+400 (Km9+200~Km10+000)	Abandoned factories	Check availability for acquisition
15	Km11+400 (Km10+000)	Santo Amaro terminal	SPTrans bus terminal, provide access
17	Km11+400 (Km10+000)	Largo Treze Station	Metro station, provide access

Source: JICA Study Team



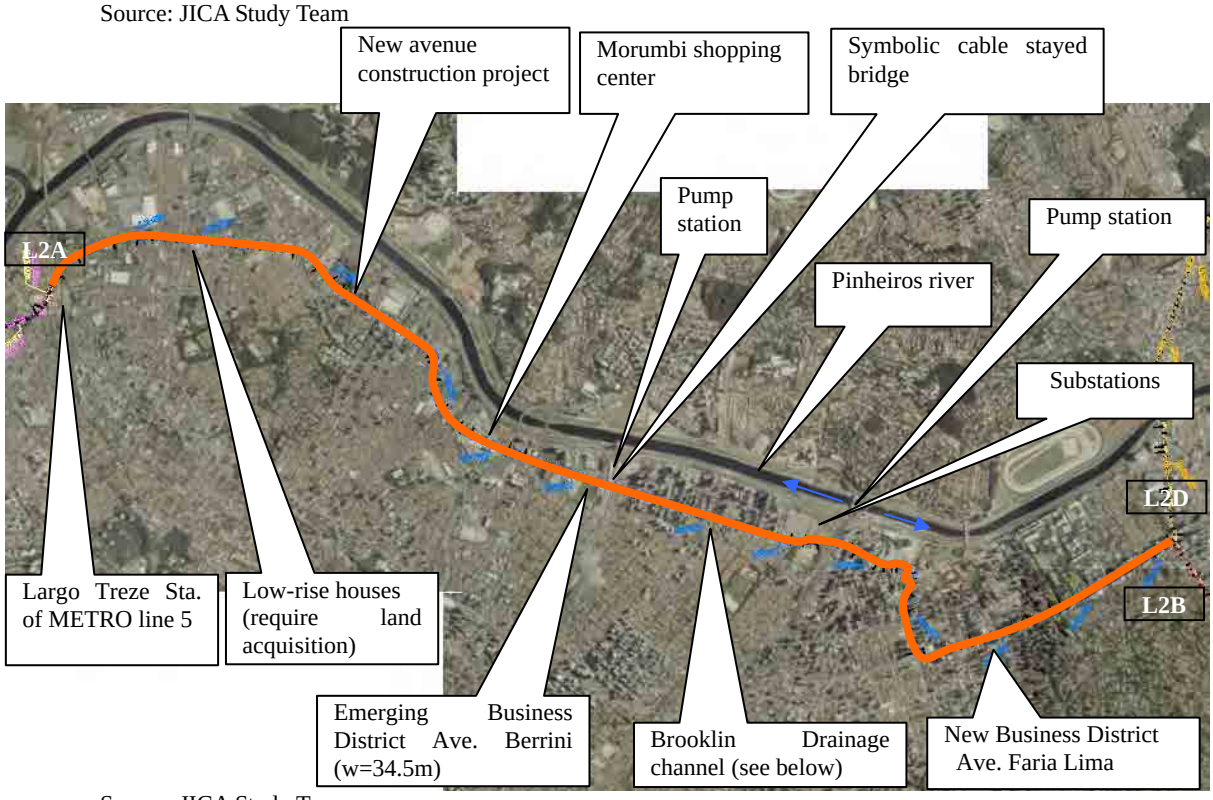
Source: JICA Study Team

Figure 5-3 Design Controls of Line-2A (2/2)

Table 5-4 List of Design Controls (4) (Line-2B)

No.	Location	Item	Description/Counter measures
1	Km0+000~Km3+000	Houses	Minimize the resettlement
2	Km3+000~Km5+100	New Avenue Project	Consider monorail structure into the avenue cross section
3	Km5+100~Km8+300	New business district	Ave. Berrini (L=34.5m), provide easy access
4	Km5+100~Km8+300	River Channel in median	Along Ave. Berrini
5	Km6+400	Aguas Espraiadas Bridge	Conideration for landscape of suspension bridge
6	Km7+900~8+100	Substation	Avoid
7	Km8+300	Grade separated road	Require longer span bridge
8	Km9+800~Km12+000	New business district	Ave. Faria Lima, provide easy access

Source: JICA Study Team



Source: JICA Study Team

Figure 5-4 Design Control of Line-2B

Brooklin Drainage Channel (Dreno do Brooklin)

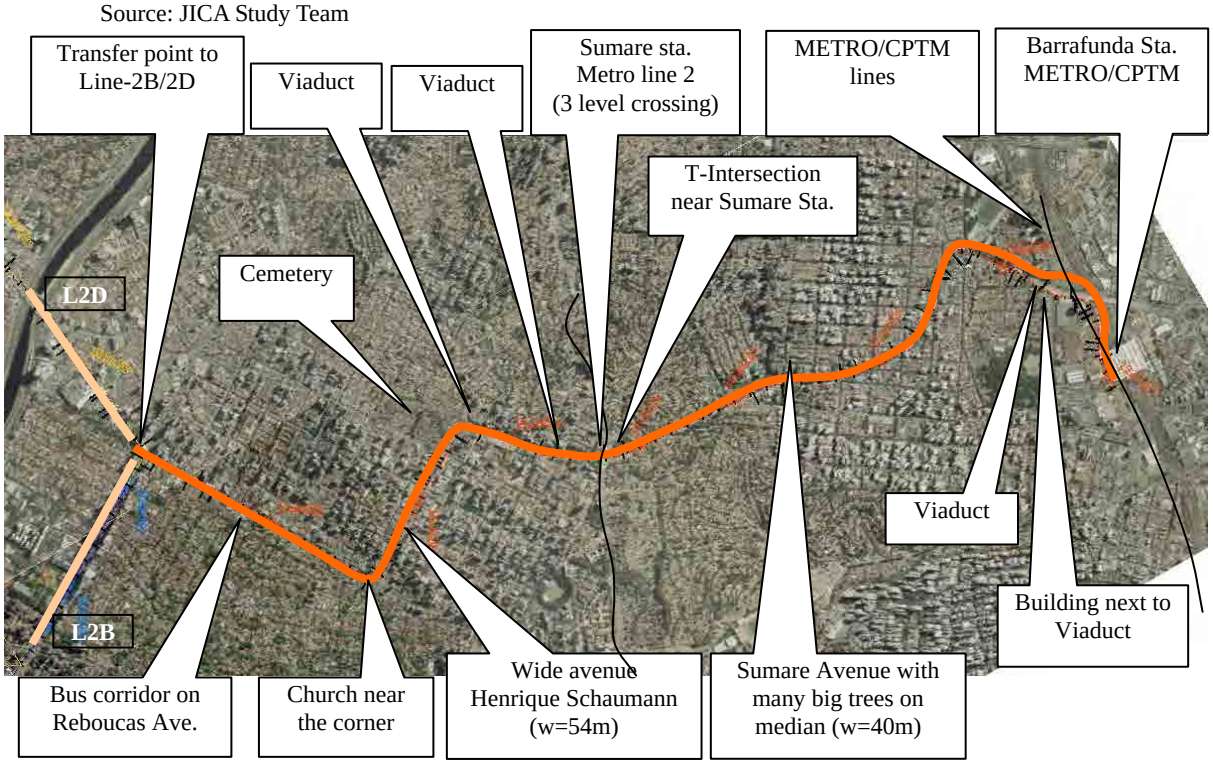
Brooklin drainage channel was constructed along Berrini Ave. in order to carry the outlets of existing streams into Pinheiros river. This channel became necessary when Henry Borden Hydro Power Plant was constructed utilizing the water of billings lake. In order to assure the water level for hydro generation, it was necessary to reverse the flow of Pinheiros river at Ari Torres Bridge/Bandeirantes Avenue (near to Vila Olimpia CPTM's Station), constructing a pumping station in the main cause of the river. An auxiliary pump station is also constructed at the end of Aguas Espraiadas Avenue for the emergency cases to avoid flooding. Special attention should be given in order to avoid interference of water flow by columns.

Table 5-5 List of Design Controls (5) (Line-2C)

No.	Location	Item	Description/Counter measures
1	Km12+000~Km12+200	Transfer point	Provide easy connection with Line-2D
2	Km12+200~Km13+600	Ave. Reboucas	Parallel to Bus Corridor/ Avoid interference
3	Km12+950	Transfer point	Provide easy connection with Metro Linea Amarela
4	Km13+500	Church	Avoid

5	Km13+600~14+600	Wide Road	Ave. Henrique Schaumann (w=54m)
6	Km14+500	Cemetery	Avoid/ Minimize influence
7	Km14+800	Viaduct	Avoid (alignment goes along the viaduct)
8	Km15+300	Viaduct	Grade separated
9	Km15+400	Viaduct and Metro	Actually 3 levels, grade separated
10	Km15+550	Intersection	May require modification of vertical alignment
11	Km15+600~Km17+900	Ave. Sumare	W=40, Big trees in median
12	Km18+300~Km18+700	Viaduct	Avoid
13	Km18+700	Building	Avoid
14	Km18+700~EP	CPTM	Avoid
15	EP	Barra Funda Station	Provide easy transfer from/to the CPTM/Metro service

Source: JICA Study Team



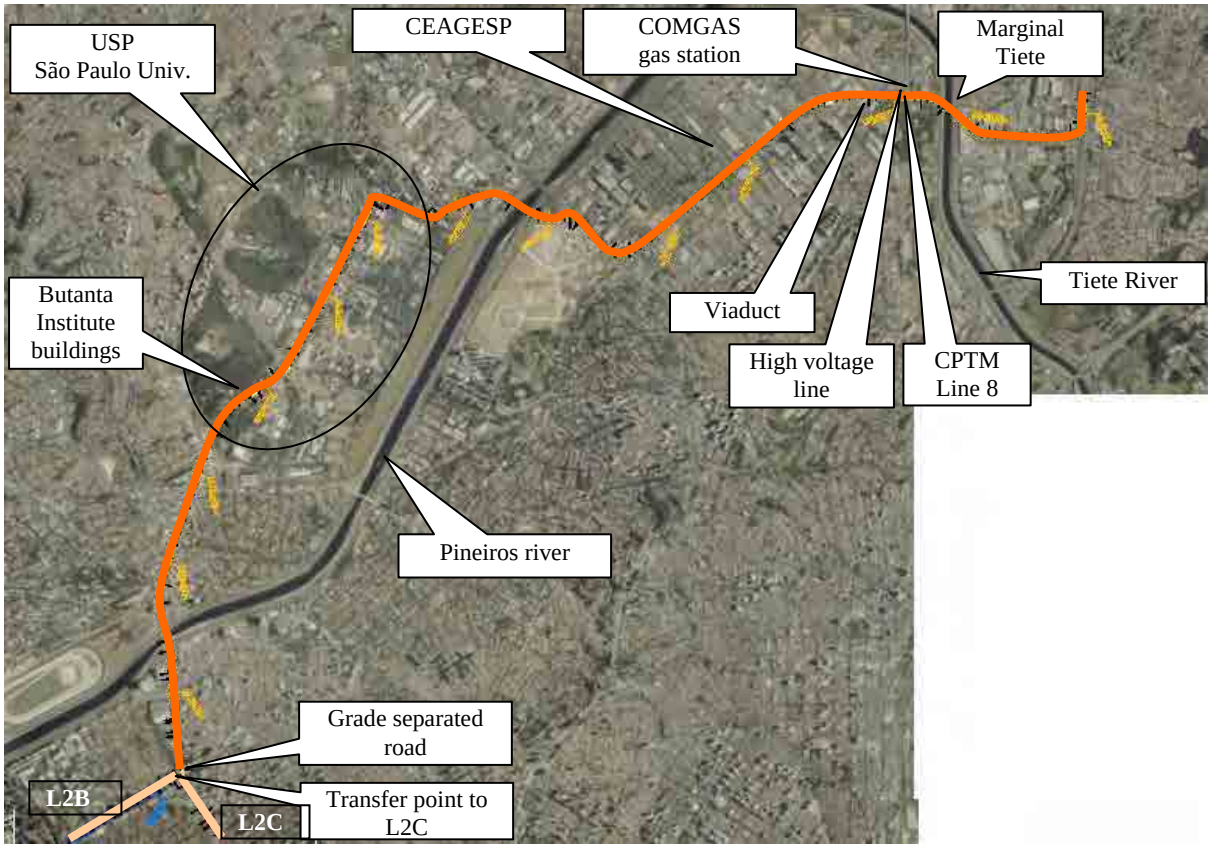
Source: JICA Study Team

Figure 5-5 Design Controls of Line-2C

Table 5-6 List of Design Controls (6) (Line-2D)

No.	Location	Item	Description/Counter measures
1	Km12+200~Km12+500	Two level road	Ave. Eusebio Matoso, requires special consideration
2	Km13+200	Pinheiros river	Requires long span bridge
3	Km13+600~Km14+800	Av. Dr Vital Brasil	Accommodate structures in the medium
4	Km15+100	Steep slope	Steep slope at instituto Butanta, comply with the design standard
5	Km14+800~Km15+500	Buildings in Butanta	Avoid
6	Km15+500~Km17+700	USP	Harmonize with university's installation
7	Km18+300	Pinheiros river	Requires long span bridge
8	Km19+400~Km20+900	CEAGESP	Avoid, provide easy access for the users
9	Km21+000~Km21+500	Viaduct Miguel Morarrej	Avoid
10	Km21+200	CPTM line 8	Cross
11	Km21+300	HVL	Avoid/ minimize the influence
12	Km21+600	COMGAS	Identify to include in the relocation plan
13	Km22+100	Marginal Tiete	Require long span bridge
14	Km22+200	Tiete River	Require long span bridge
15	Km23+300	Anhanguera	Avoid
16	EP	Terminal	Provide easy access

Source: JICA Study Team



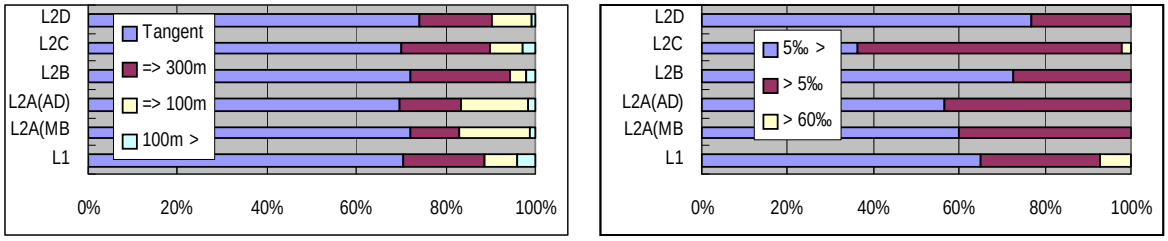
Source: JICA Study Team

Figure 5-6 Design Controls of Line-2D

5.2 ROUTE ALIGNMENT

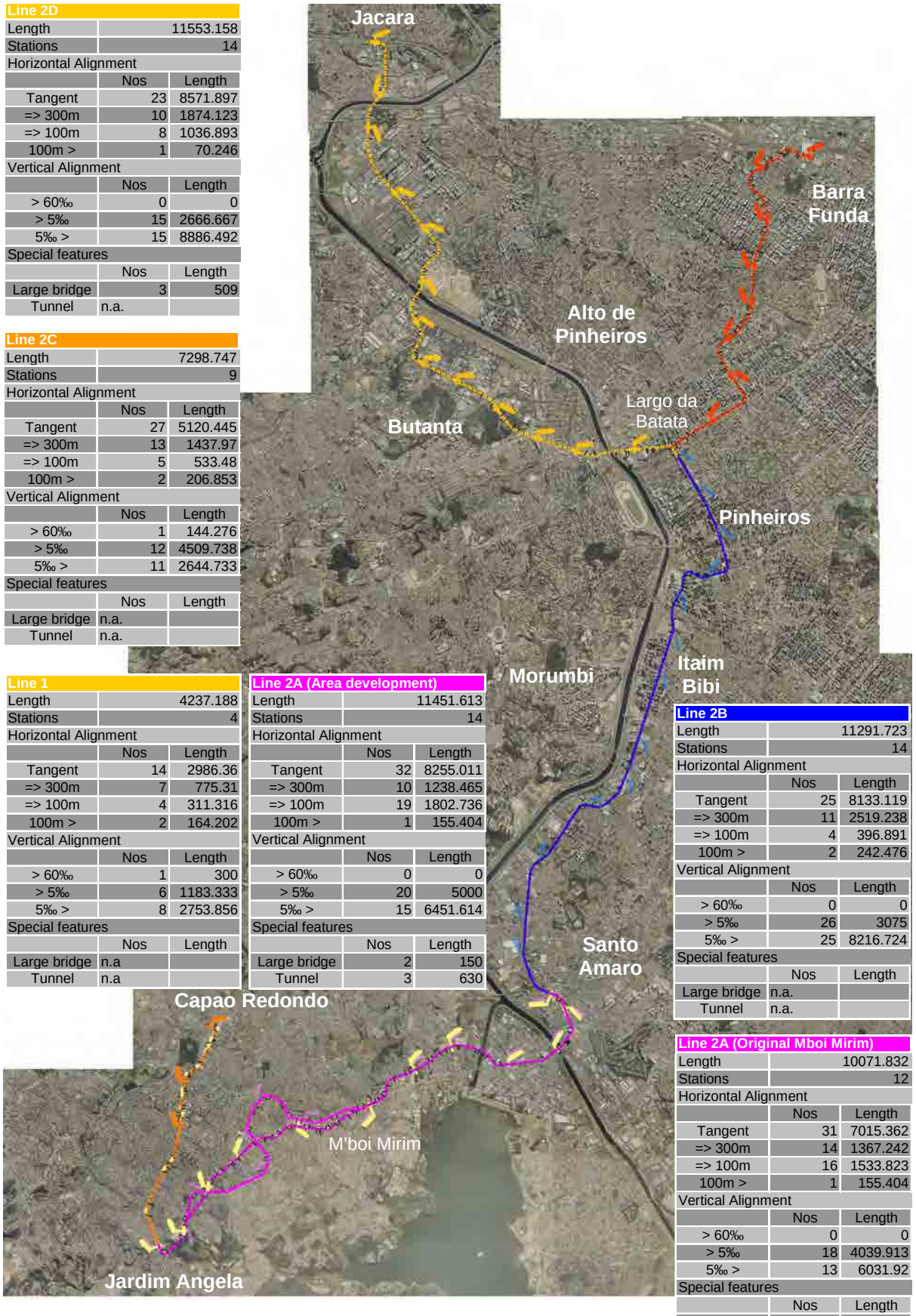
Based on the comparative analysis, final alignment of the project is set as shown in the Figure 5-8, together with its main characteristics. Further evaluation is required in the next phase of the project to determine the feasibility of land acquisitions and environmental evaluations. Adjustments should be introduced in accordance with further studies. Some stretches such as Line-1, Line-2A area development route and Line-2B south part, new road projects along the monorail alignment. The coordination with state or municipal responsible entity has to be done to adequate both the roads and monorail system infrastructures.

Nearly 90% of horizontal alignment is composed of tangent or curves larger than R=300m that the trains are able to operate without velocity limits. Smaller curves were applied in some places where the alignment should follow existing right of ways for example at ninety-degree intersection. Less than 5‰ longitudinal slope was applied at all of the station locations and other applicable sections. Larger than 60‰ slopes ware applied in two locations within acceptable length limit. Following Figure 5-7 shows the share of each element in length for horizontal and vertical alignment.



Source: JICA Study Team

Figure 5-7 Summary of Horizontal and Vertical Alignment



Line 2D		
Length		11553.158
Stations		14
Horizontal Alignment		
	Nos	Length
Tangent	23	8571.897
=> 300m	10	1874.123
=> 100m	8	1036.893
100m >	1	70.246
Vertical Alignment		
	Nos	Length
> 60‰	0	0
> 5‰	15	2666.667
5‰ >	15	8886.492
Special features		
	Nos	Length
Large bridge	3	509
Tunnel	n.a.	

Line 2C		
Length		7298.747
Stations		9
Horizontal Alignment		
	Nos	Length
Tangent	27	5120.445
=> 300m	13	1437.97
=> 100m	5	533.48
100m >	2	206.853
Vertical Alignment		
	Nos	Length
> 60‰	1	144.276
> 5‰	12	4509.738
5‰ >	11	2644.733
Special features		
	Nos	Length
Large bridge	n.a.	
Tunnel	n.a.	

Line 1		
Length		4237.188
Stations		4
Horizontal Alignment		
	Nos	Length
Tangent	14	2986.36
=> 300m	7	775.31
=> 100m	4	311.316
100m >	2	164.202
Vertical Alignment		
	Nos	Length
> 60‰	1	300
> 5‰	6	1183.333
5‰ >	8	2753.856
Special features		
	Nos	Length
Large bridge	n.a	
Tunnel	n.a	

Line 2A (Area development)		
Length		11451.613
Stations		14
Horizontal Alignment		
	Nos	Length
Tangent	32	8255.011
=> 300m	10	1238.465
=> 100m	19	1802.736
100m >	1	155.404
Vertical Alignment		
	Nos	Length
> 60‰	0	0
> 5‰	20	5000
5‰ >	15	6451.614
Special features		
	Nos	Length
Large bridge	2	150
Tunnel	3	630

Line 2B		
Length		11291.723
Stations		14
Horizontal Alignment		
	Nos	Length
Tangent	25	8133.119
=> 300m	11	2519.238
=> 100m	4	396.891
100m >	2	242.476
Vertical Alignment		
	Nos	Length
> 60‰	0	0
> 5‰	26	3075
5‰ >	25	8216.724
Special features		
	Nos	Length
Large bridge	n.a.	
Tunnel	n.a.	

Line 2A (Original Mboi Mirim)		
Length		10071.832
Stations		12
Horizontal Alignment		
	Nos	Length
Tangent	31	7015.362
=> 300m	14	1367.242
=> 100m	16	1533.823
100m >	1	155.404
Vertical Alignment		
	Nos	Length
> 60‰	0	0
> 5‰	18	4039.913
5‰ >	13	6031.92
Special features		
	Nos	Length
Large bridge	2	150
Tunnel	1	240

Figure 5-8 Route Alignments of the Project

5.3 STATION

5.3.1 Station geometry

The size of the stations for the monorail system will be determined by train length and passenger volume, and they will be arranged by taking into account the convenience of passengers.

The conditions which shall be taken into consideration for station design are as follows:

(1) For all the passenger's convenience, Barrier Free design and Universal Design shall be applied.

(2) By providing greater width in the central road reservation, wider roads will provide ideal station locations, by avoiding the need for land acquisition for the station;

The required spaces for stations are as follows.

(1) The minimum length of a platform will include the train length and 10 metres of margin. When 6-car train with a length of 90m is applied, the minimum platform length is 100m. For a 8-car train with a length of 120 metres, a total platform length of 130 metres will be required, station drawings show the case of 8 car-train.

(2) The effective width of a platform will be estimated on the basis of the expected passenger volume from the transport demand forecast.

(3) A 6 m width from the outside of a station building is required in order to allow fire fighting activity in the vicinity of the station. It is desirable to allow a gap of 10 m or more between the outside wall of stations and the nearest buildings in order to avoid the feeling of oppression by existence of the station building over a road.

5.3.2 Barrier free and Universal design

(1) Barrier free standards in Brazil

In Brazil, the standard ABNT 9050 "Accessibility to Buildings and Urban Equipment" July, 2004 specifies the details of the roads and buildings for handicapped users. Through the survey in São Paulo City, a lot of barrier free facilities have been observed such as slopes for wheel chair, kerb lamps, elevators, escalators, signboards, priority sheets, space for wheelchair in the train/ bus and etc.

Pedestrian bridge with slope

Slope for wheel chair in metro station

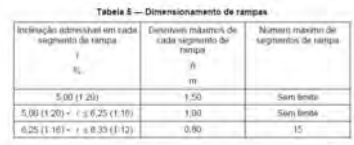
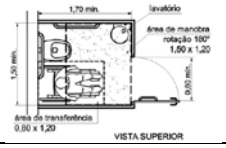
Source: JICA Study team

Figure 5-9 Barrier free facilities in São Paulo City

(2) Study of the standards

Table5-7 shows the summarized comparison of barrier free standards between Brazil and Japan which also has advanced standards of barrier free design.

Table 5-7 Comparison of the Barrier free standards

Item	Standards in Brazil	Standards in Japan
1.Law and Guideline	Law: DERECT No 5.296 DE 2 DE DEZEMBRO DE 2004 Guideline:ABNT NBR 9050 Acessibilidade a edificacoes, mobiliario,espacos e equipamentos urbanos	Law: Law on Promotion of Smooth Transportation, etc. of Elderly Persons, Disabled Persons, etc. (2006, Japan) Guideline for vehicles and Passenger Service Facility for Smooth Transportation (2007, Japan)
2. General	All spaces, buildings, urban furniture and equipment have to be designed, constructed, assembled or deployed, as well as renovate and expand buildings and street furniture must meet the requirements of :ABNT NBR 9050 to be considered accessible.	All public spaces shall be designed in accordance with the above mentioned Law and Guideline.
Passage way	Slopes and passageways are appropriately specified in NBR 9050. 	Slopes and passageways are specified in the Guideline. - Minimum width: 80cm - Hand rail shall be installed. - Anti slip floor
Toilet	Designs for Toilets are appropriately specified in NBR 9050. 	Designs for Toilets are specified in the Guideline.
Signboards	Signboards are appropriately specified in NBR 9050. 	Signboards are specified in the Guideline.
Platform of the station	-	The gap between train and platform shall be minimized and the elevation shall be flat.
	-	In order to avoid accident, Platform Screen Door (PSD) shall be installed for station platform if available.
Voice information and Notification Display	-	Voice announcement services and Notification Displays in the train and station are recommended
Elevator	-	-The buttons has to be set within the reach of the wheel chair passengers. - Voice information for blind passengers is recommended.

Escalator	-	The edge of the step shall be clearly distinguishable.
Obese Users	Priority seats for obese users shall be installed in the stations and trains.	-
Facility layout map of the station	-	At the main entrance and/or near the ticket gate, facility layout map of the station shall be displayed.

Source: JICA Study team and ABNT 9050

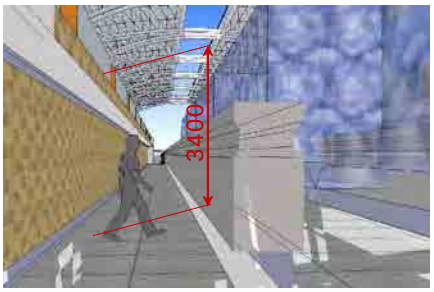
(3) Design standard to be applied for the station design

Through the study, ABNT 9050 "Accessibility to Buildings and Urban Equipment" widely specifies the barrier free design and it shall be applied for the station design. However, JICA study team recommends some advanced items in Japanese standard shall be supplementary referred to improve the accessibility of the monorail stations.

(4) Recommendations

1) Platform Screen Doors

In Japan, installation of platform doors to prevent accidents is recommended. Because the gap between the platform level and the slab level for monorail is bigger than ordinary train, it is recommended to install platform doors on the platform.



Source: JICA Study team and Tama Monorail

Figure 5-10 Platform screen doors of Tama Monorail station in Japan

2) Smooth transition of the train and platform

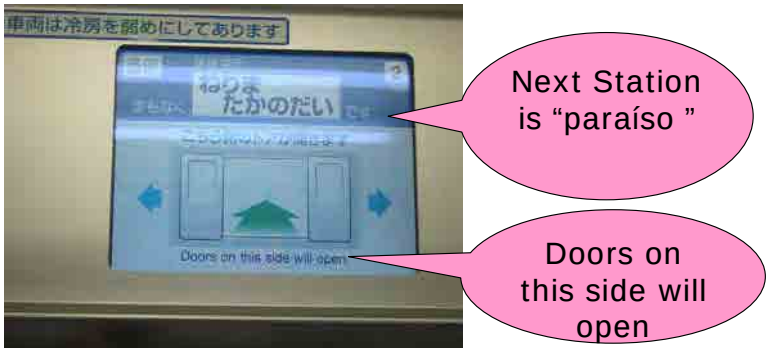
In Japanese standard, the horizontal and vertical gap between train and platform shall be minimized. Smooth transition is recommended.

Source: JICA Study team

Figure 5-11 Smooth transition of the train and platform

3) Voice information and notification display

Voice and monitor information of operation for handicapped users are recommended.



Source: JICA Study team and Toei Subway, Japan

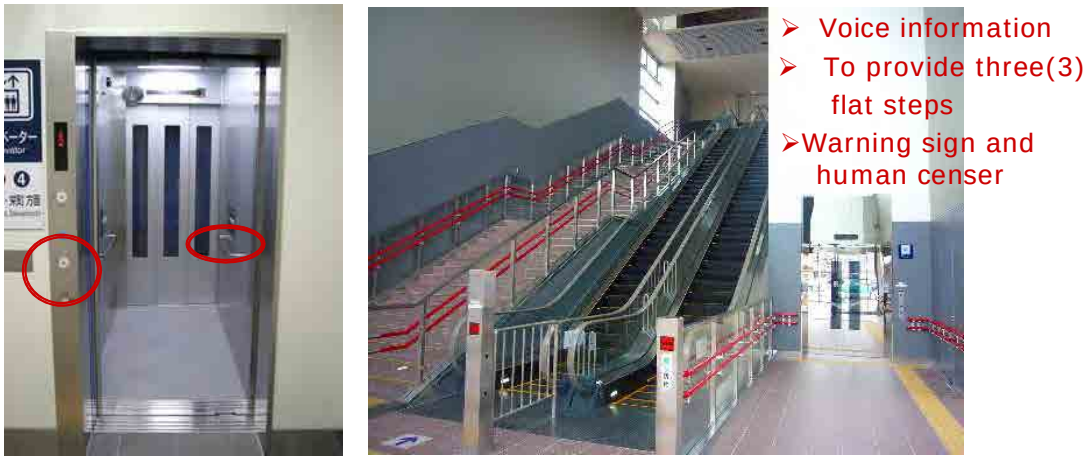
Figure 5-12 Notification LCD Display in the train

4) User-friendly elevators and escalators

In Japan, elevators and escalator in the public space are designed to be user friendly.

-The buttons of the elevators are set within the reach of the wheel chair passengers

- Handrail of the elevators for handicapped users
- Voice information for blind passengers
- Easily viewable edge of the steps of the escalators
- To provide three flat steps of the escalators for handicapped users



Source: JICA Study team

Figure 5-13 User-friendly elevators and escalators

5) Station layout map of the facilities for handicapped users

Station layout map of the facilities for handicapped users is recommended. Figure 5-14 shows the example station layout map in Japan, Osaka Monorail.

Source: Osaka Monorail, Japan

Figure 5-14 Station layout map of the facilities for handicapped users

5.3.3 Structure of the stations

Generally, it is proposed to adopt as the general design of the elevated stations of the urban transport system a design for a three storey building which has a platform level, a concourse level and a ground level (road level).

At the platform level, passengers wait and board trains. Also, passengers alight from trains to the platform and move to the concourse level.

At the concourse level, passengers who will board trains buy tickets and pass through the gate. If a passenger needs some information with regard to train operation, station staff in the station office located on concourse level will assist the passenger.

Since the most of the monorail stations are elevated and located over the roads, access ways such as a pedestrian bridge and stairs are provided to connect from the road level to the concourse. Since the access way connects both sides of the road via the concourse, it can also be used as a pedestrian bridge for non-users of the monorail to cross the road.

5.3.4 Platform type

Two types of platform are proposed as the typical type of the station. One is the Island type and another is the Separated type. Table 5-8 shows a comparison of the two types of platform to be adopted in the design of the monorail system.

In this project, Separated type platform is basically applied for the intermediate station and Island type is applied for the terminal station.

Table 5-8 Comparison of Station platform type

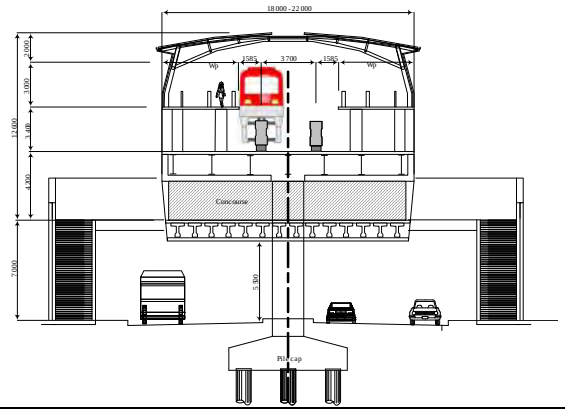
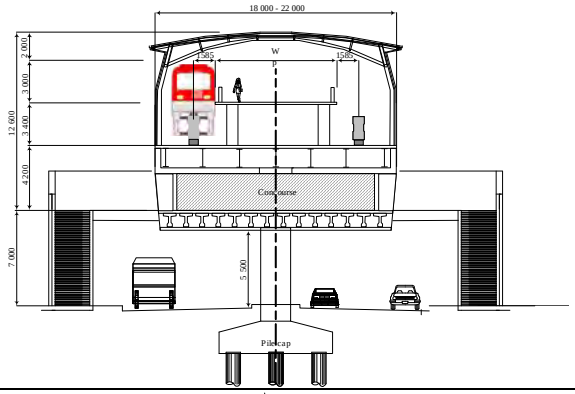
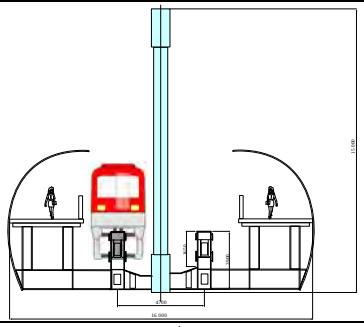
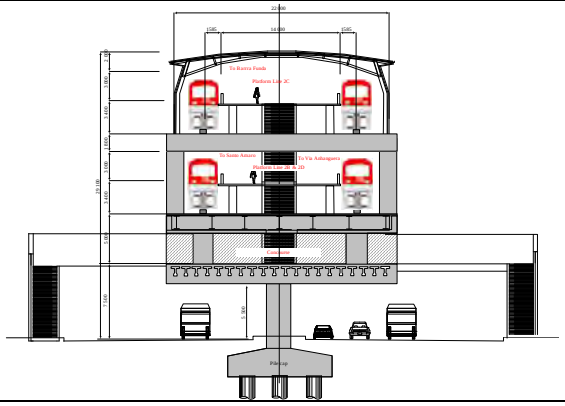
Item	Island type	Separated type
Image view		
Description	In the approach section of stations, the tracks are spreading like a "funnel shape" and the platform is located between the tracks.	The platforms are separated by the tracks. The distance between tracks is kept in the approach section of station as the same as normal section.
Alignment	Train running performance and comfort are inferior to the separated type platform because of a "funnel shape" alignment.	The distance between tracks is not spreading in the approach section of station. (+)
Station Facility	Compared with the separated type platform, the number of facilities such as elevators and escalators can be reduced. (+)	Facilities such as stairs, elevators and escalators are required for each platform.
Width of the structure	Total width will narrower than the Separated Type. (+)	Total width will be slightly wider than the Island Type.
Guide-way Structures	Guide-way structure has to be widened and construction costs shall be more than the Separated Type.	Continuous and parallel guide ways. (+)
Maintenance	Station staff can perform duties for both directions of travel owing to the single platform. (+)	Necessary to dispatch staffs for each platform.
Train Operation	The train has to reduce its speed in front of the curve and the average speed shall be less than the Separated Type.	There is no curve in front of station. (+)
Others	In view of operation, the type of the platform is frequently standardized on one line. (Separated type :Tokyo Monorail, Tama Monorail / Island Type: Osaka Monorail , Mixed Type: Okinawa Monorail)	

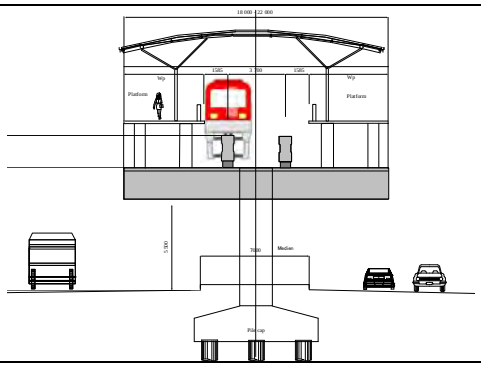
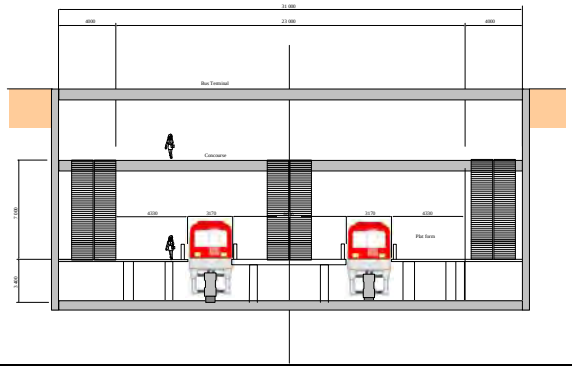
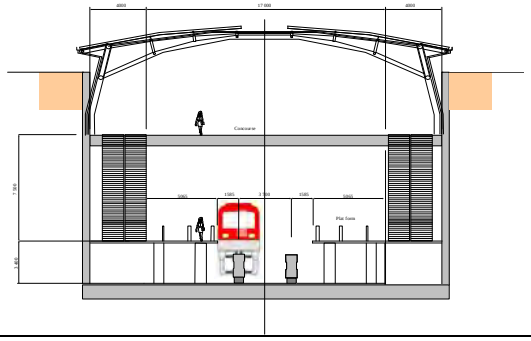
* (+) shows the advantage
Source: JICA Study team

5.3.5 Type of the Stations

Proposed types of the stations are summarized on the Table 5-9.

Table 5-9 Type of the Stations

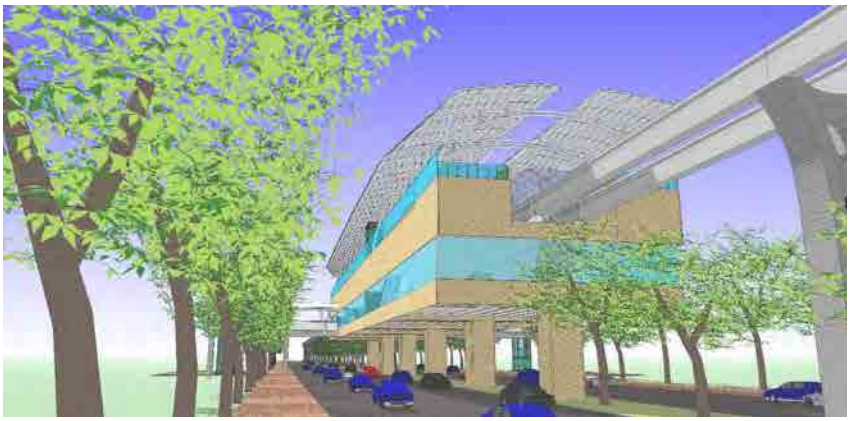
Type of the stations	Cross section	Notes
Type A		Separated Type Station Applied for intermediate station
Type B		Island Type Station Applied for the Terminal Station of reach line such as Capao Redondo, Sta. Amaro, Barra Funda and Via Anhanguera
Type C		Socorro Station On the river. Platform is on the trussed arch bridge.
Type D		Island Type Station with 4 stories. Faria Lima Station Junction station of Line-2B, 2C and 2D.

Type E		Sumare Station Separated Type Station with 2 stories.
Type F		Jardim Angela station Island type Under ground station with 3 platforms.
Type G		No. 2 and No. 4 station of the Line-2A Development route. Separated type, Under-ground station.

Source: JICA Study Team

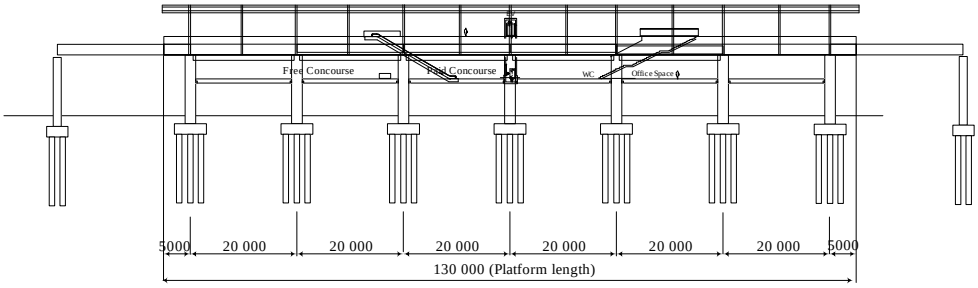
1) Type A station

Type A station is the most general structure for a three story station to be built over the median strip of a road. The platform is located on the 2nd floor and the concourse is on the 1st floor. The concourse and sidewalks of both sides of road are connected by the access way (pedestrian bridge). Passengers and pedestrians can safely use the station and/or cross the road. Road traffic is not affected by passengers and pedestrians.



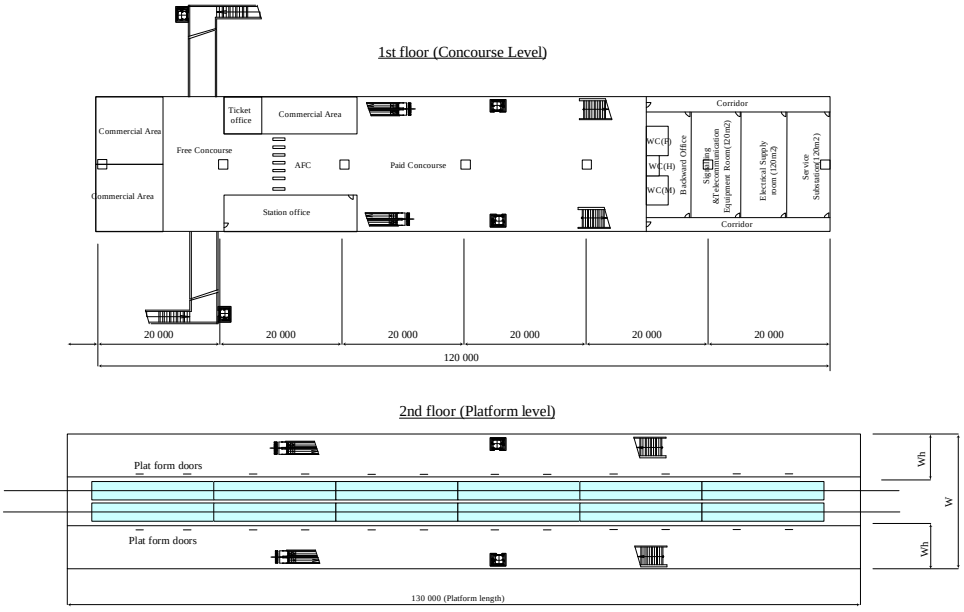
Source: JICA Study Team

Figure 5-15 Perspective view of Type A station



Source: JICA Study Team

Figure 5-16 Profile of Type A station



Source: JICA Study Team

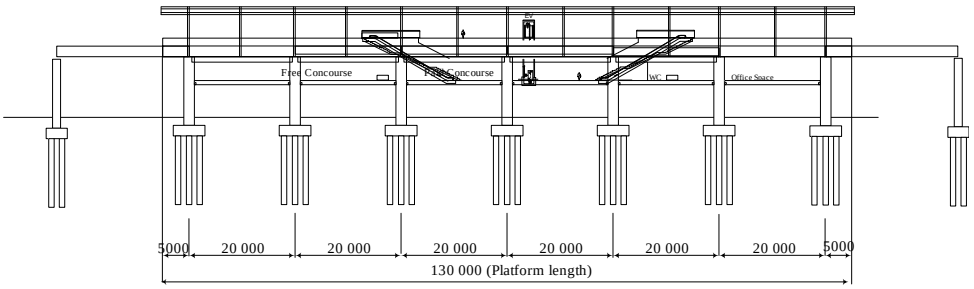
Figure 5-17 Plan of Type A station

2) Type B station

Type B station is Island type Station, three stories to be built over the median strip of a road. The platform is located on the 2nd floor and the concourse is on the 1st floor. The concourse and sidewalks of both sides of road are connected by the access way (pedestrian bridge). Passengers and pedestrians can safely use the station and/or cross the road. Road traffic is not affected by passengers and pedestrians.

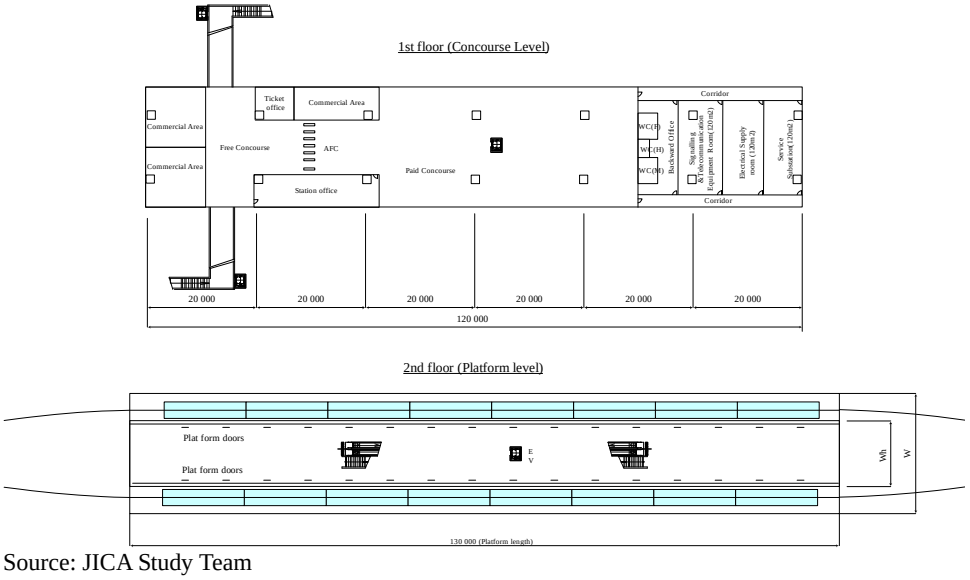
Source: JICA Study Team

Figure 5-18 Perspective view of Type B station



Source: JICA Study Team

Figure 5-19 Profile of Type B station

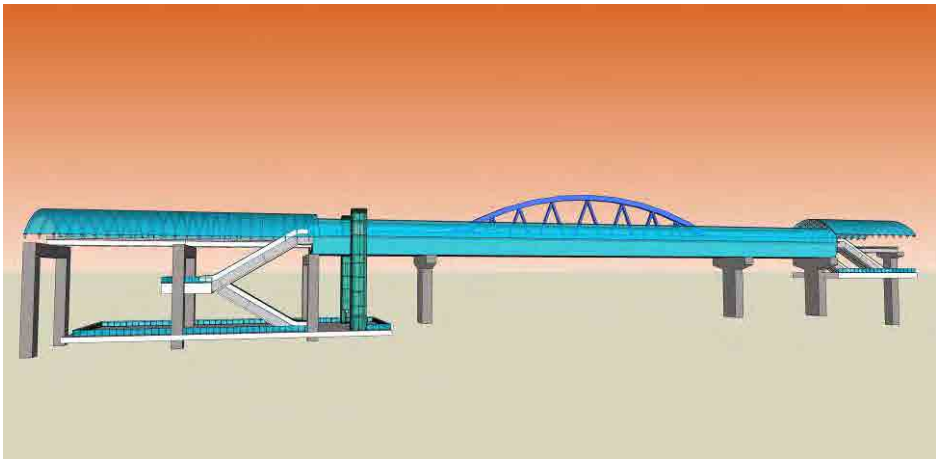


Source: JICA Study Team

Figure 5-20 Plan of Type B station

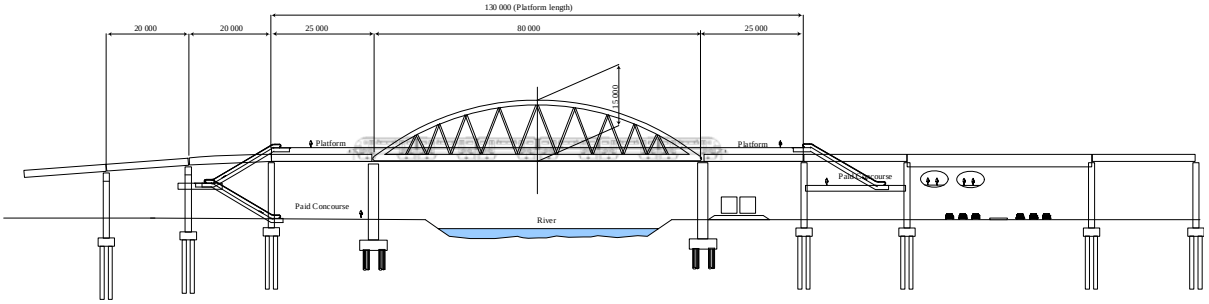
3) Type C station (SOCORRO Station)

SOCORRO Station is located on the Pinheiros River and connecting the SOCORRO station of CPTM. The platform will be constructed on the river and the passengers can safely access the both sides of the river. The main bridge structure is Trussed Langer Bridge and the span length is 80m.



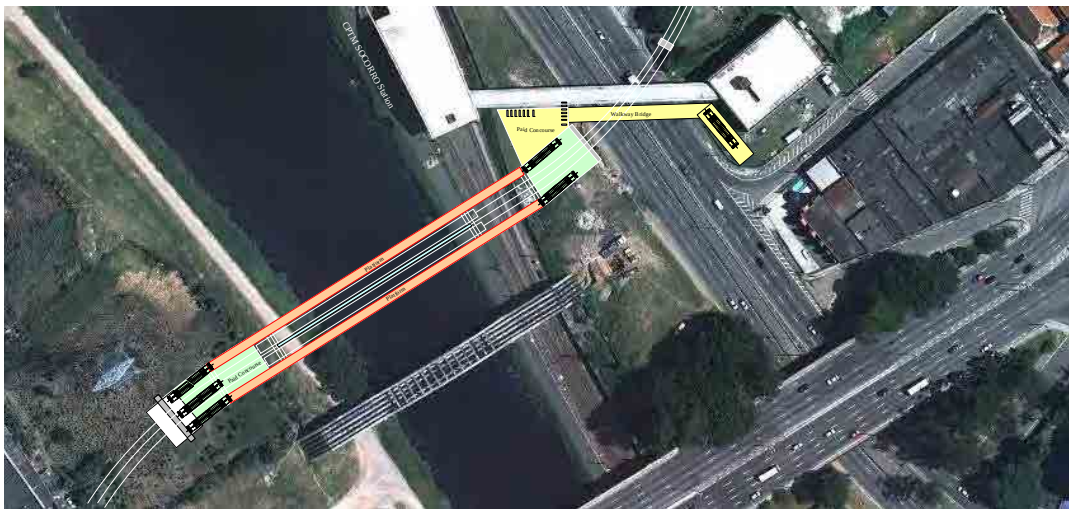
Source: JICA Study Team

Figure 5-21 Perspective view of Socorro station



Source: JICA Study Team

Figure 5-22 Profile of Socorro station



Source: JICA Study Team

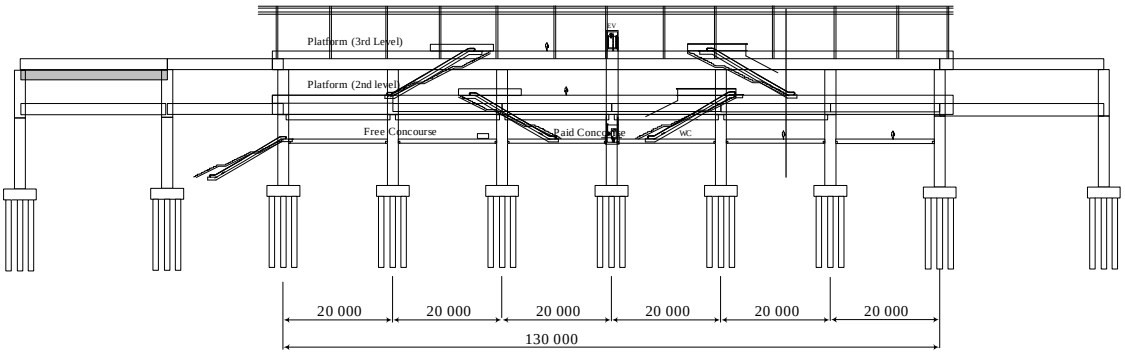
Figure 5-23 Plan of Socorro station

4) Type D station (Faria Lima Station, No. 2B-14 station)

Faria Lima Station is an interchange station of Line-2B, 2C and 2D. Four story station to be built over the median strip of a road. The platform of Line-2C is located on the 3rd level and the platform of Line-2B-2D is located on the 2nd level. The concourse is on the 1st floor.

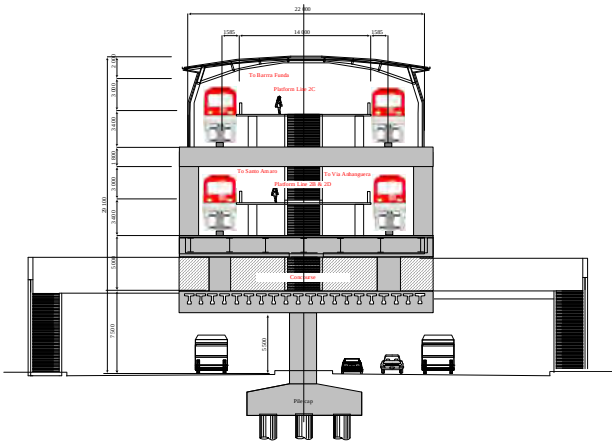
Source: JICA Study Team

Figure 5-24 Perspective view of Faria Lima Station



Source: JICA Study Team

Figure 5-25 Profile of Faria Lima Station



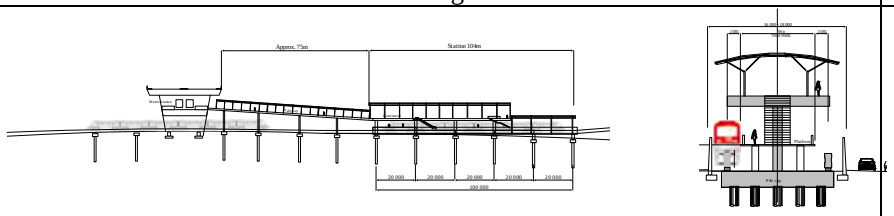
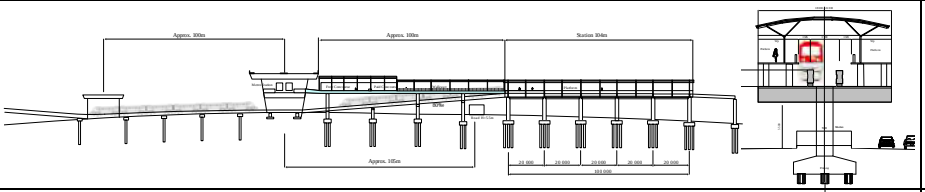
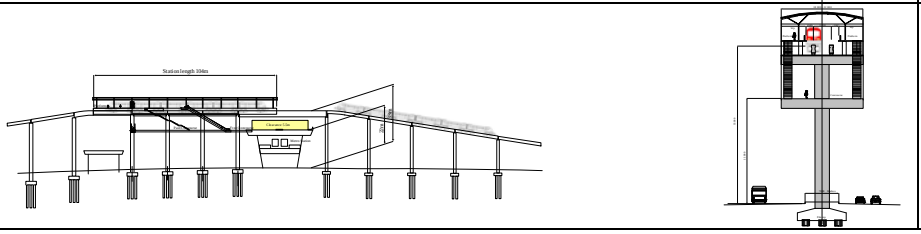
Source: JICA Study Team

Figure 5-26 Cross Section of Faria Lima Station

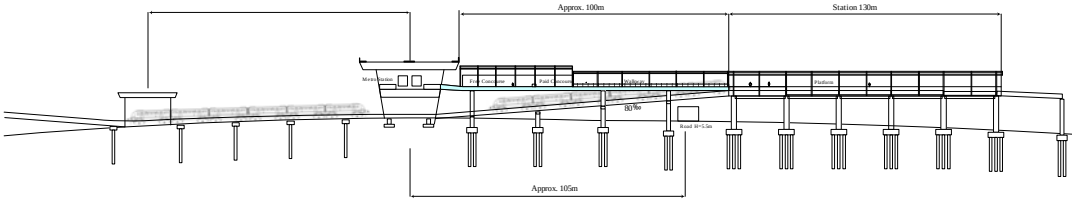
5) Type E station (Sumare Station)

Sumare Station is a connecting station of the Metro station. Three types of station structures for Sumare station were studied. From the view of construction costs and accessibility for the passenger, the Option No. 2 was selected.

Table 5-10 Comparison table of Sumare Station

Option	Drawing	Notes
Option 1 Rail level on the Ground		
Option 2 Rail level on the 1st level		selected
Option 3 Rail level above the road Bridge		

Source:JICA Study Team

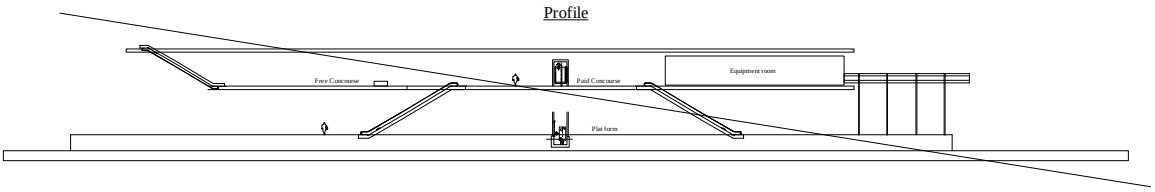


Source: JICA Study Team

Figure 5-27 Profile of Sumare station (Option2)

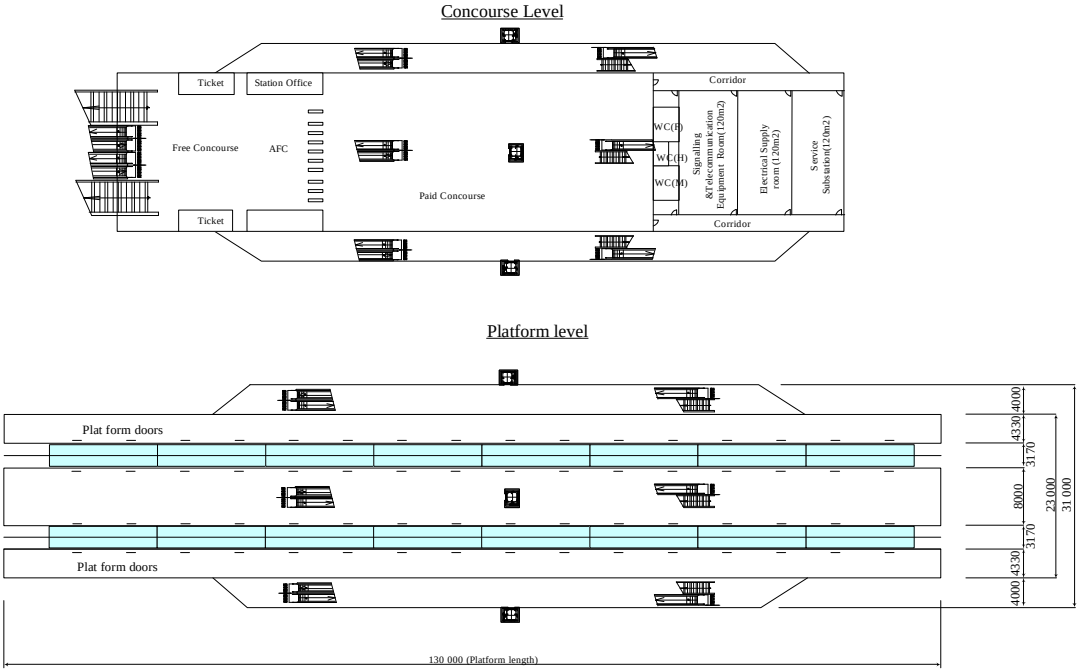
6) Type F station (Jardim Angela Station)

Jardim Angela Station is located at the beginning of the Line-2A and shall be constructed under the bus terminal.



Source: JICA Study Team

Figure 5-28 Profile of Jardim Angela Station

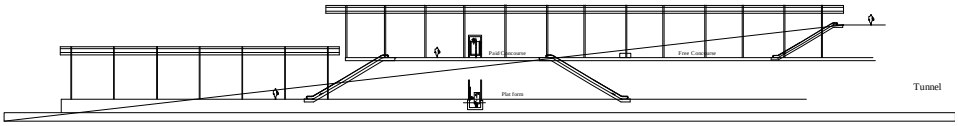


Source: JICA Study Team

Figure 5-29 Plan of Jardim Angela Station

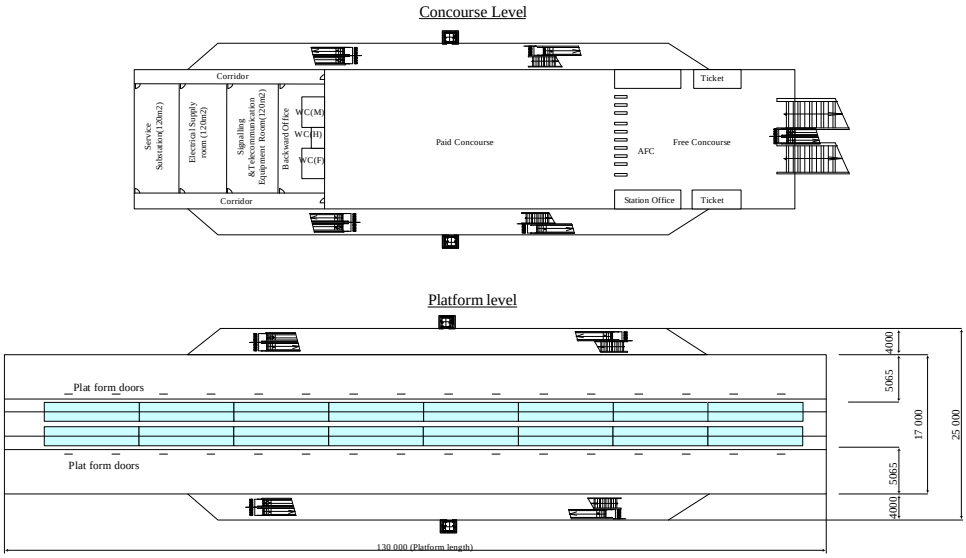
7) Type F station (No.2 and 4 Station of Line-2A, Urban development route)

No.2 and 4 Station of Line-2A, Urban development route are located in front of the tunnel under M'boi Milim.



Source: JICA Study Team

Figure 5-30 Profile of Type F Station



Source: JICA Study Team

Figure 5-31 Plan of Type F Station

5.3.6 Platform

A Platform Screen Doors (PSD) with a height of 1.20m or more will need to be installed at the edge of the platform in order to prevent passengers from falling on the guideway. It is not planned to install an air conditioner and artificial ventilation.

The required widths of platforms are calculated from the expected passenger volume during the peak hour.

A calculation formula which is generally used in São Paulo Metro shall be applied for calculation of the platform width.

According to the "Manual De Engenharia metroviaria", the formula to decide the width of the platform of the stations are as follows;

Width of the separated type station platform:

$$L = 0.6 + 0.25 + \frac{Ne + NT}{(C - 2 * 0.25) * 3}$$

Where: L = platform width (m) >4.6m
0.60 = security range (m)
0.25 =distance to the wall (m)
C = platform´s length (m)
3.0 = maximum adopted density (passengers/ m2)
NE = numbers of shipments expected between trains (head way) in peak time (passengers)
NT = 2/3 of one train capacity (passengers)

Width of the Island type station platform:

$$L = 2 * 0.6 + \frac{Ne + 2 * NT}{(C - 2 * 0.25) * 3}$$

Where: L = platform width (m)
2 * 0.60 = security range (m)
0.25 =distance to the wall (m)
C = platform´s length (m)
3.0 = maximum adopted density (passengers/ m2)
NE = numbers of shipments expected between trains (head way) in peak time(passengers)
NT = 2/3 of one train capacity (passengers)

Table 5-11 Platform width

Name of the station		Type	Width of PF(m)
Line-1			
No.1-1 (No.2A-1)	Jardim Angela	Semi-Underground, Island (Type F)	4+8+4
No.1-2 ~ No.1-5		Separated (Type A)	4+4
No.1-6	Capao Redondo	Island (TypeB)	10
Line-2A			
No.2A-1 (No.1-1)	Jardim Angela	Semi-Underground, Island (Type F)	4+8+4
No.2A-2		Semi-Underground, separated (Type G)	4+4
No.2A-3		Separated (Type A)	4+4
No.2A-4		Semi-Underground, separated (Type G)	4+4
No.2A-5 ~ No.2A-8		Separated (Type A)	4+4
No.2A-9	Guarapiranga	Separated (Type A)	4+4
No.2A-10	Depot	Separated (Type A)	4+4
No.2A-11		Separated (Type A)	4+4
No.2A-12	Socorro	Separated (Type C)	4+4
No.2A-13	Future station	Separated (Type A)	4+4
No.2A-14	Santo Amaro	Island (TypeB)	10
Line-2B			
No.2B-1 (2A-14)	Santo Amaro	Island (TypeB)	10
No.2B-2 ~ No.2B-4		Separated (Type A)	4+4
No.2B-5	Morumbi Mall	Separated (Type A)	4+4
No.2B-6 ~ No.2B-11		Separated (Type A)	4+4
No.2B-12	Faria Lima	4 stories, Island type (Type D)	10
Line-2C			
No.2C-1 (2B-12, 2D-1)	Faria Lima	4 stories, Island type (Type D)	10
No.2C-2 ~ No.2C-3		Separated (Type A)	4+4
No.2C-4	Sumare	Separated (Type E)	4+4
No.2C-5 ~ No.2C-7		Separated (Type A)	4+4
No.2C-8	Barra Funda	Island (TypeB)	10
Line-2D			
No.2D-1 (2B-12, 2C-1)	Faria Lima	4 stories, Island type (Type D)	10
No.2D-2 ~ No.2D-11		Separated (Type A)	4+4
No.2D-12	Via Anhanguera	Island (TypeB)	10

5.3.7 Station equipment

1) Ticket window	Tickets are sold at ticket offices by station staff. The size of the ticket window to be constructed will be sufficient to accommodate an automatic ticket vending machine in future.
2) Ticket gate	Ticket gates are installed. A fare adjustment office is not required since a flat rate fare structure is to be applied. Ticket gates will have a width of 90cm in order to allow passengers in wheelchairs or those with large bags to pass through easily.
3) Station office and ticket room	A station office is installed near the entrance for station staff to work, take a rest or for standby persons. Next to the station office, a ticket room will be installed, this containing both the ticket window and passenger information displays. However, at small stations, a minimum sized ticket room is installed, to serve only for ticket selling and provision of passenger information.

4) Electric and mechanical (E&M) room and signaling and telecommunication equipments (S&C) room	An electric and mechanical (E&M) room and a signaling and telecommunication equipments (S&C) room are installed at the concourse floor. The E&M room contains electrical equipments to distribute electric power to station facilities and lighting. The S&C room contains signaling and telecommunication equipment. A minimum sized room is installed next to the ticket room to house minimum E&M equipment.
5) Rest room	Rest rooms shall be installed for all the stations.
6) Ascending facilities (Lift and Escalator)	In addition to stairs, lifts and Escalators shall be installed to all types of platform.
7) Platform screen door	Platform screen doors with a height of 1.20m or more will need to be installed at the edge of the platform in order to prevent passengers from falling on the guideway. It is not planned to install an air conditioner and artificial ventilation.
8) Air conditioner and Ventilation	Not installed for platforms

5.4 GUIDEWAY STRUCTURES

5.4.1 Super Structure

(1) Application of the Superstructure

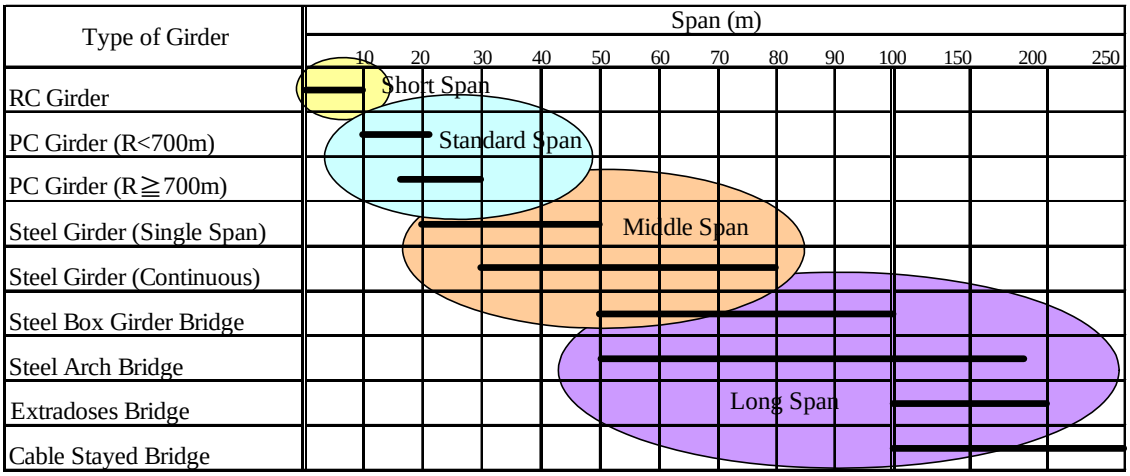
Monorail girders are classified in the following four types. The appropriate girder structure for each span type will be applied as per following figure.

1) Short Span (Span length: ~10m) : Reinforced concrete girder

2) Standard Span (Span length: 22~30m) : pre-stressed concrete girder

3) Middle Span (Span length: 30m~80m) : Steel Girder Bridge

4) Long Span (Span length: 80m~) : Steel Arch Bridge and etc.



Source: JICA Study Team

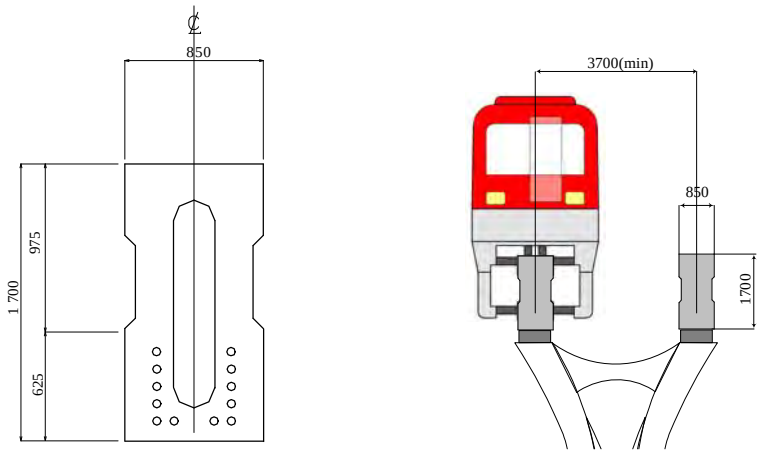
Figure 5-32 Application of Superstructure

(2) Selection of the type of the Girder

1) Short Span (Span length: ~10m): Reinforced concrete girder

The reinforced concrete girder will be applied to the tracks in the storage line in the depot and the span length would be less than 10m.

2) Standard Span (Span length: 22~30m) : pre-stressed concrete girder

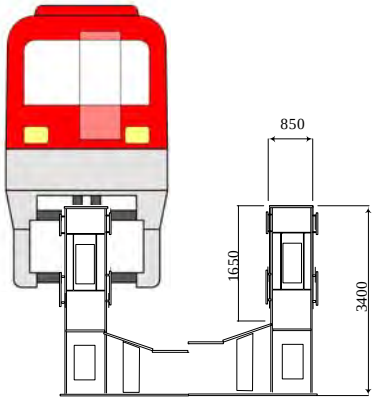


Source: JICA Study Team

Figure 5-33 Cross Section of pre-stressed concrete girder (L=25m)

For the standard pre-stressed concrete girder, single span and continuous span girder are possible. In case of the single span girder, the maximum span length will be 25 m as the standard. The girder will be pre-cast at a factory, transported to the erection point and launched on the bearings. In case of the continuous span girder, the span length will be extended up to approximate 30m because of the structural advantage. However, at the construction stage, reinforcement-bar arrangement, formwork and concrete pouring between the girders at site are required and the construction period will be longer than for the single span girder.

3) Middle Span (Span length: 30m~80m) : Steel Girder Bridge

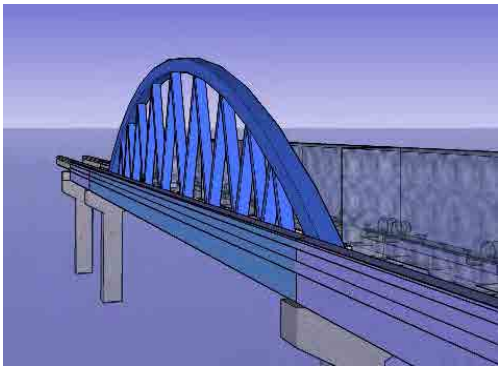


Source: JICA Study Team

Figure 5-34 Cross Section of Steel Girder Bridge (L=50m)

Steel girders are applied for crossing points over roads where the span length will be 30m~80m, in case the standard pre-stressed concrete girder cannot be applied.

4) Long Span (Span length: 80m~) : Steel Arch Bridge and etc.



Source: JICA Study Team

Trussed Rangar Bridge (L=80m) **Steel Arch Bridge (L=120m)**

Figure 5-35 Views of Steel Bridges

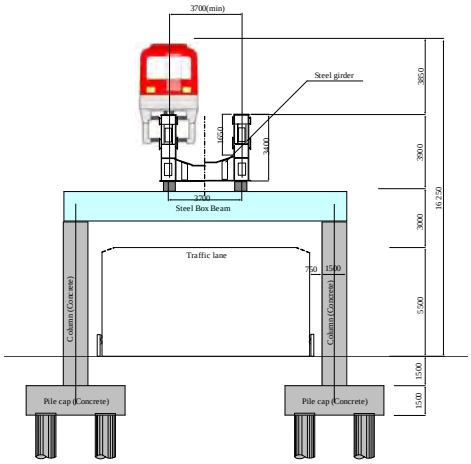
For the bridge over Tiete River and Pinheiros River, span length will be more than 80m. Therefore, long span bridges are applied. In view of the proven structure for monorail system, Trussed Rangar Bridge and steel arch bridge was applied in this study.

5.4.2 Substructures

Structural requirement of columns of monorail is about 1.5m diameter in case of circular piers, which are accommodated easily on the central median of the road. The shape of the piers is to be designed to follow the flow of forces. For tall/ slender pier columns, a higher strength concrete is to be used. The pier cap is shaped in such a manner, so that it will provide a minimum vertical clearance of 5.5 m over the finished road surface. The pier cap is sized to accommodate the pedestals supporting the bearings. Space for jacks for lifting of girders is planned between the bearing pedestals. For draining out of water, the top of the pier cap will be sloping outwards with a slope of 1:200. Elevated monorail systems do not occupy any space on the road surface .except abovementioned columns. Typical cross sections of monorail pier are shown in Figure 5-36, Figure 5-37 and Figure 5-38.

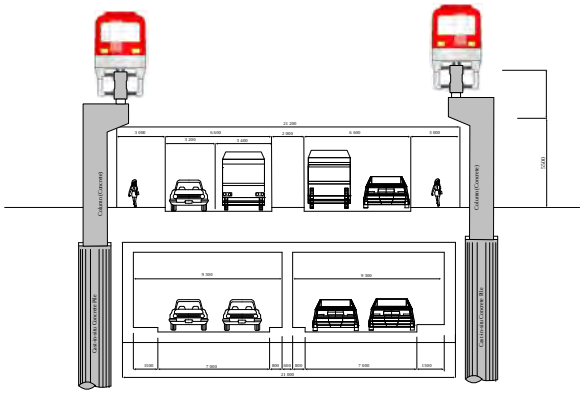
Source: JICA Study Team

Figure 5-36 Typical Cross Section of Monorail Pier



Source: JICA Study Team

Figure 5-37 Typical Cross Section of Monorail Viaduct Portal Type Pier



Source: JICA Study Team

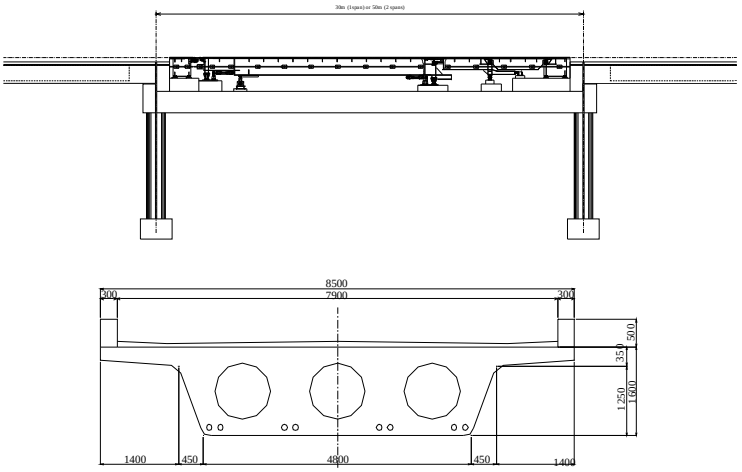
Figure 5-38 Cross Section of Monorail Viaduct Separated Type Pier

5.4.3 Foundation

To decide the type of the foundation and its depth, geotechnical investigation for 25 locations along the route alignment was conducted. According to the result of the soil investigation, all structure needs to be supported by pile foundation. The depth of the bearing layer from the ground level is in between 10m and 30m, its average is 20m. It is proposed to provide 1000/1200/1500 mm dia. bored cast in situ vertical piles. Pile cap of 1.5 to 2 m (approx) thick will be cast over the piles. The pile cap will be kept minimum 1500mm below the road level or ground level.

5.4.4 Switch Bridges

Switches and its equipment are installed on the switch bridges. Pre-stressed concrete slab structure shall be applied for the switch bridge.



Source: JICA STUDY TEAM

Figure 5-39 Profile and Cross Section of Monorail switch bridge

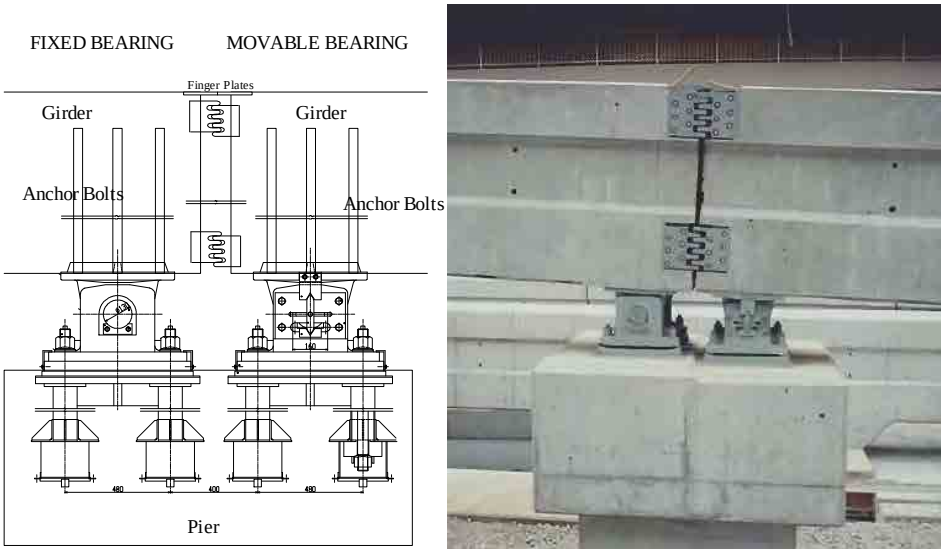
5.4.5 Other facilities on the track

(1) Anti-slip surface on the girder

On the surface of the steel girder, anti-slip material will be applied to prevent the tyres from slipping.

(2) Bearing system and expansion joints

The bearing system for the track beam will be resistant to vertical, horizontal and torsional reactions. Moreover, it will work smoothly against movement due to temperature differences and angular movement due to live load. The bearing design will be suitable to allow for easy future replacement of track girders and will be adjustable for girder positioning. To provide for a smooth and comfortable ride, steel finger joints will be applied at the ends of girders.



Source: JICA STUDY TEAM

Figure 5-40 Bearings and Expansion Joints (Example)

(3) Stoppers

At the end of the girder of the line, stoppers on the beam/ pier shall be installed to prevent from over-run accident.

Source: JICA STUDY TEAM

Figure 5-41 Photo of the stoppers, End of TAMA MONORAIL

5.4.6 Design Loads

(1) Design Loads

The following loads shall be considered for the analysis of the superstructure.

Primary loads:	Secondary loads:
a) Dead load (D) b) Live load (L) c) Impact load (I) d) Pre-stressed force (PS) [if required] e) Influence of Creep of Concrete (CR) [if required] f) Influence of Dryness/Shrink of Concrete (SH) [if required] g) Centrifugal force (CF) h) Earth pressure (E) [if required] i) Water pressure (HP) [if required] j) Buoyancy (U) [if required] k) Influence of Support Down (SD) [if required] l) Force to Handrail (HF) [if required] m) Transversal live load effect (LF)	a) Longitudinal live load effects (BK) b) Wind load (W) c) Overall temperature variation d) Seismic effect e) Collision force (CO) [if required] f) Erection force (ER) [if required] g) Friction of Bearing (F) [if required] h) Buffer stop effect (ST) [if required]

Table 5-12 Combination of Design Load

	Load											Factor a
	D	L	I	LF	CF	T	W	BK	EQ	ER	ST	
1	O	O	O	O	O							1.00
2	O	O	O		O	O						1.15
3	O	O	O		O		O					1.25
4	O	O	O		O			O				1.25
5	O	O	O		O		O	O			O	1.35
6	O	O										1.60
7	O						O					1.25
8	O	O			O	O			O			1.60
9										O		1.25

Source: JICA Study Team

(2) Vertical Effects of Live Load

Structures will be checked for the more severe of the following loading

1) Axle arrangement

Axle arrangement is shown in the figure below.

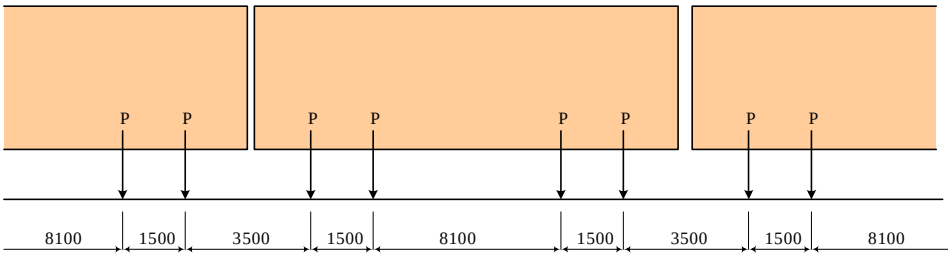


Figure 5-42 Axle arrangement

2) The center of gravity

The center of gravity shall be 1300mm above the rail level.

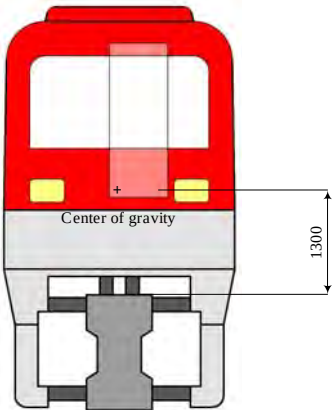


Figure 5-43 The center of gravity

3) Axle Loads

The Axle Loads are shown on the Table 5-13 below.

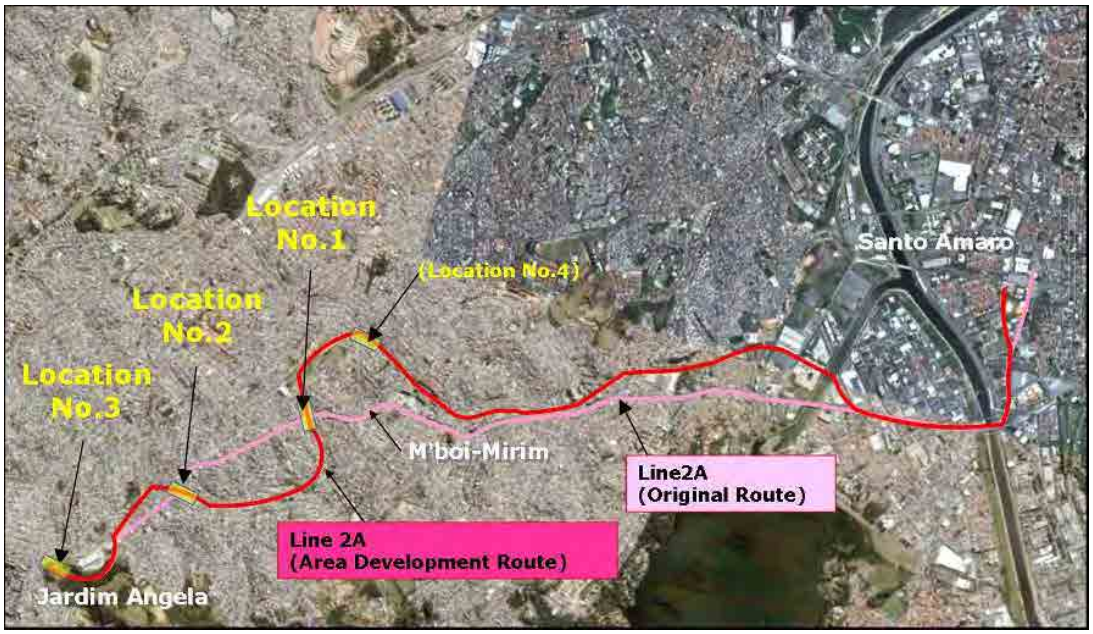
Table 5-13 Axle Loads

Description	P (t)	Remarks
Crush load	11.0	= 44.0 / 4
Nominal load	9.0	= 35.2 / 4 (Table 4-32)
Tare	7.0	= 27.6 / 4 (Table 4-32)

Source: JICA Study Team

5.5 TUNNEL

Line-2A (Area Development Route) has four tunnels are shown in Figure 5-44, while the original route of Line-2A has one of them. Comparative study has carried out for those tunnels that cross M'Boi Mirim Road. A viaduct was selected for No.4 after the Study.

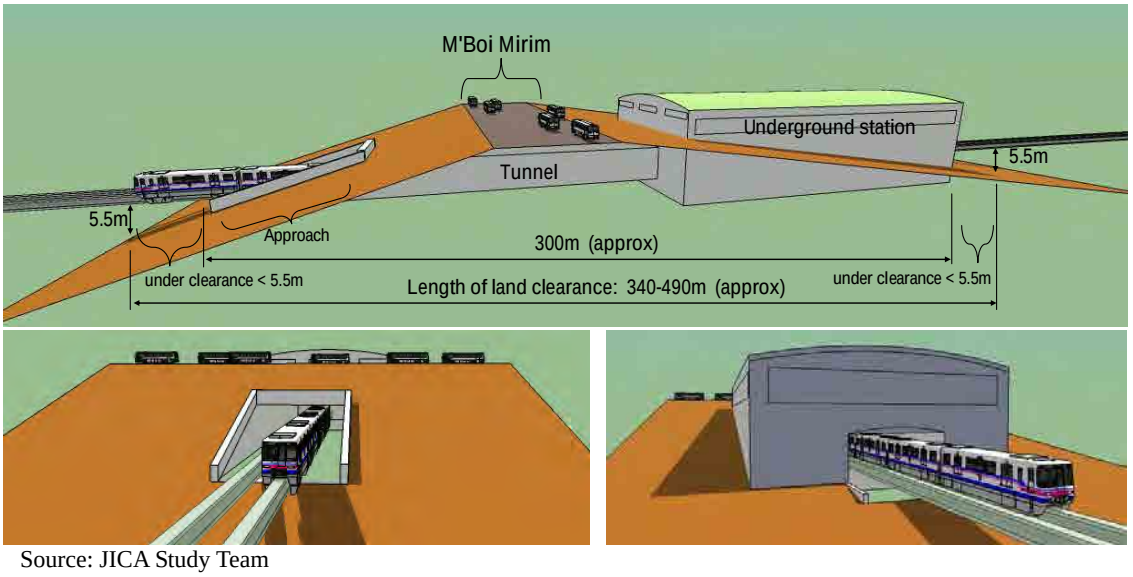


Source: JICA Study Team

Figure 5-44 Location of tunnels

5.5.1 3D image of tunnel

Figure 5-45 shows 3D image of tunnels (No.1 - No.3) which cross M'Boi Mirim. The length of underground structure is approximately 300m each including approaches and the length of land clearance is approximately 340 – 490m, including areas of under clearance less than 5.5m.

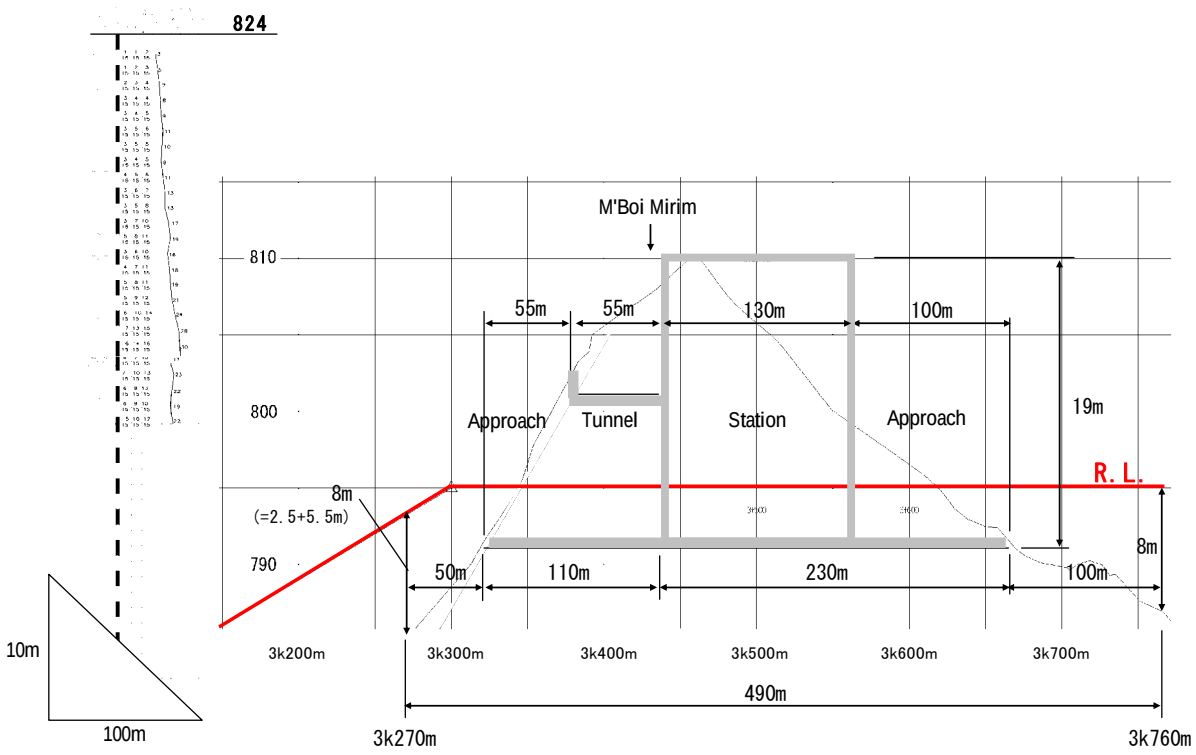


Source: JICA Study Team

Figure 5-45 3D image of tunnels

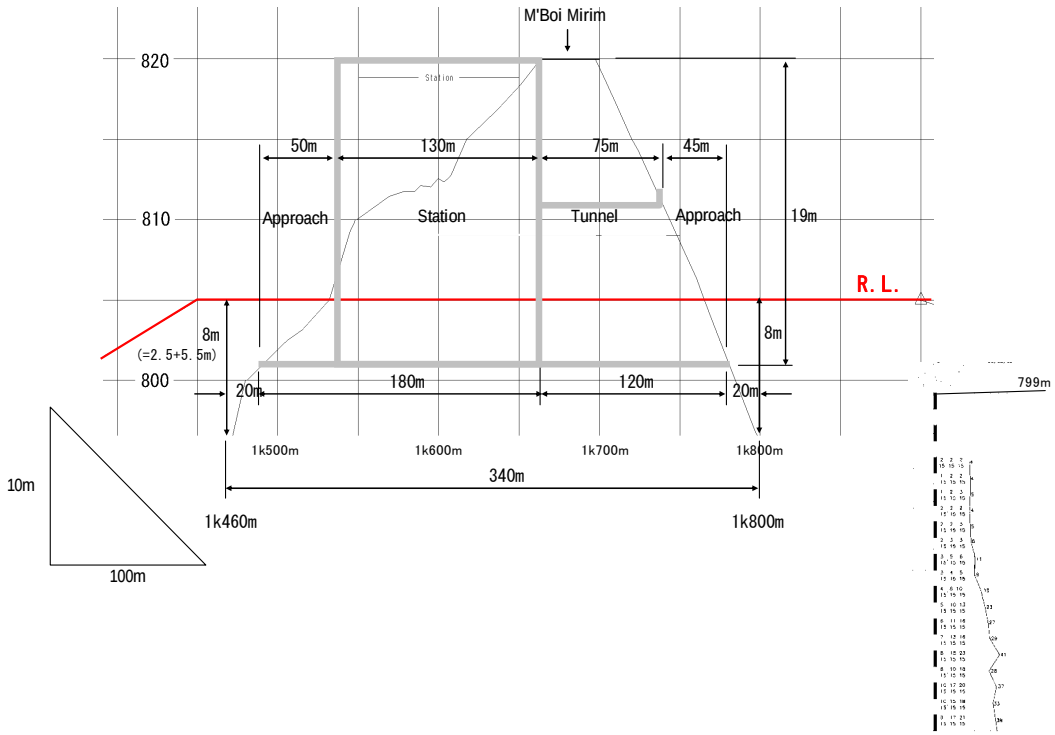
5.5.2 Profile of tunnel

Profiles of the four locations in case of cut and cover method were studied, as shown in the following figures.



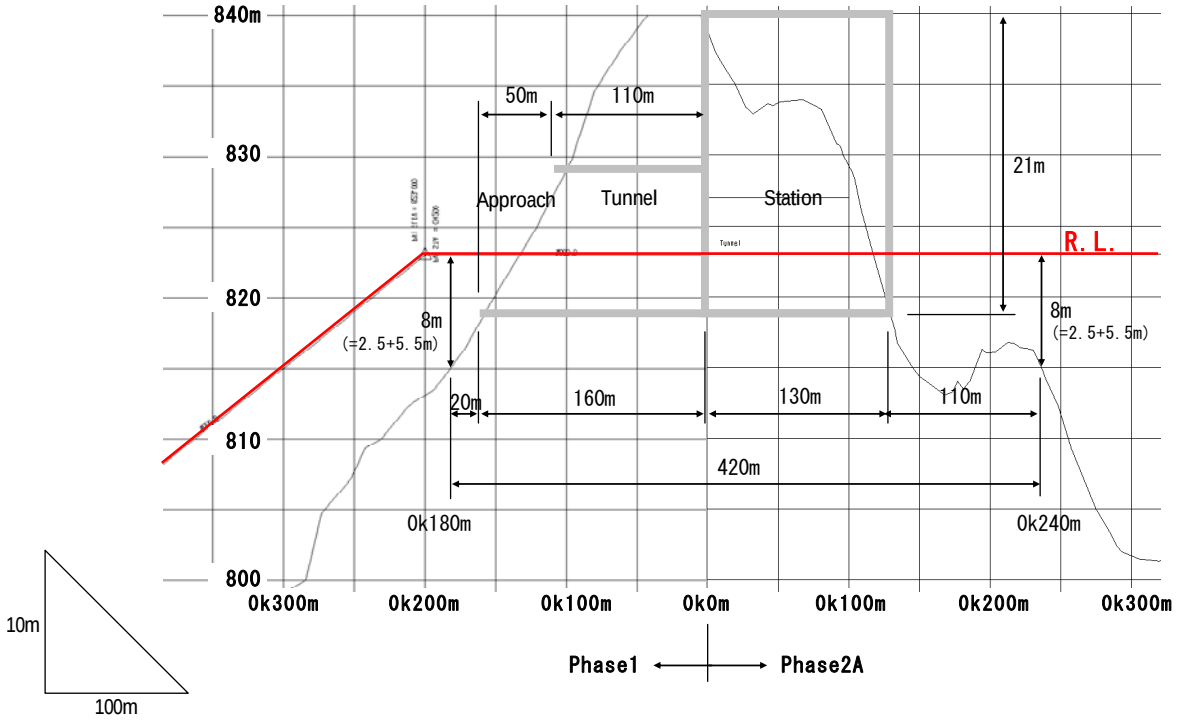
Source: JICA Study Team

Figure 5-46 Profile of location No.1



Source: JICA Study Team

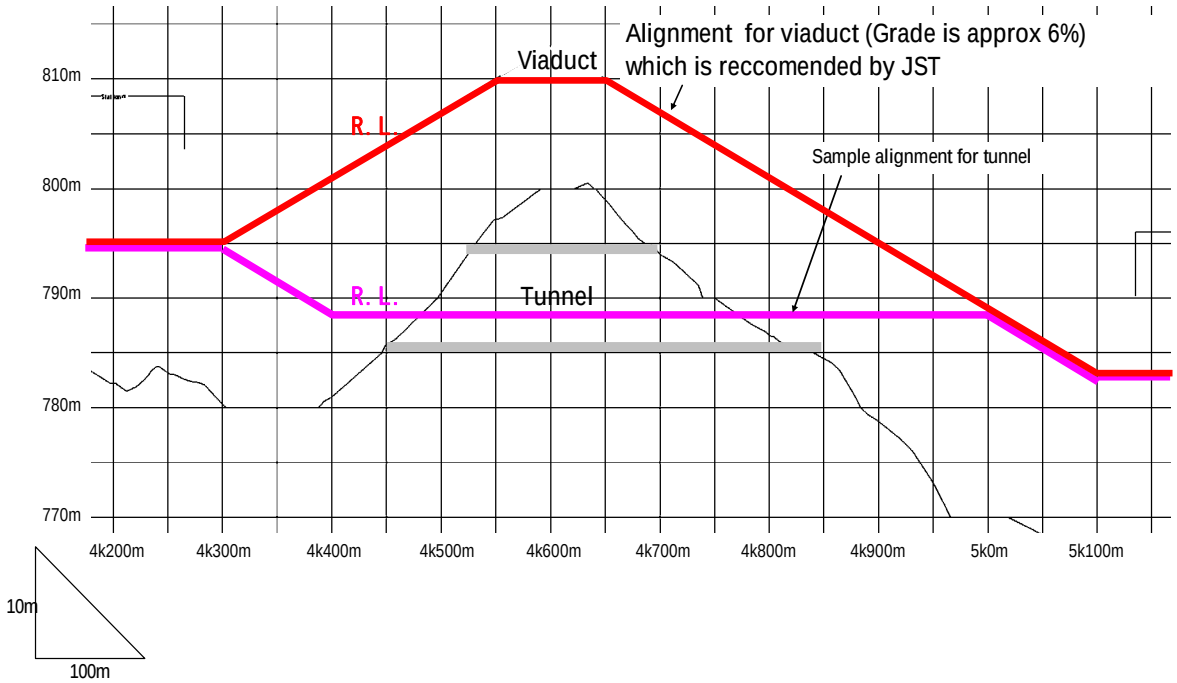
Figure 5-47 Profile of location No.2



Source: JICA Study Team

Figure 5-48 Profile of location No.3

For location No.4, an alternative of viaduct structure was selected based on the alignment study and topographic survey as shown in Figure 5-49, because the construction cost of viaduct structure is less than that of tunnel in general.

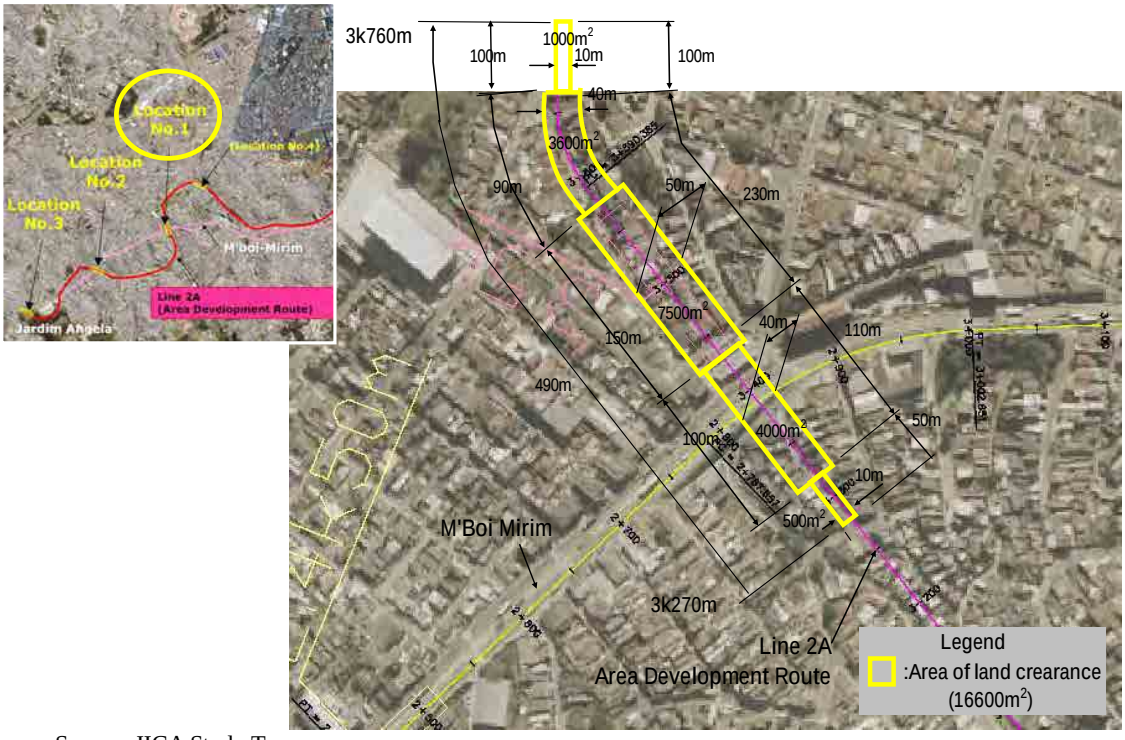


Source: JICA Study Team

Figure 5-49 Profile of location No.4

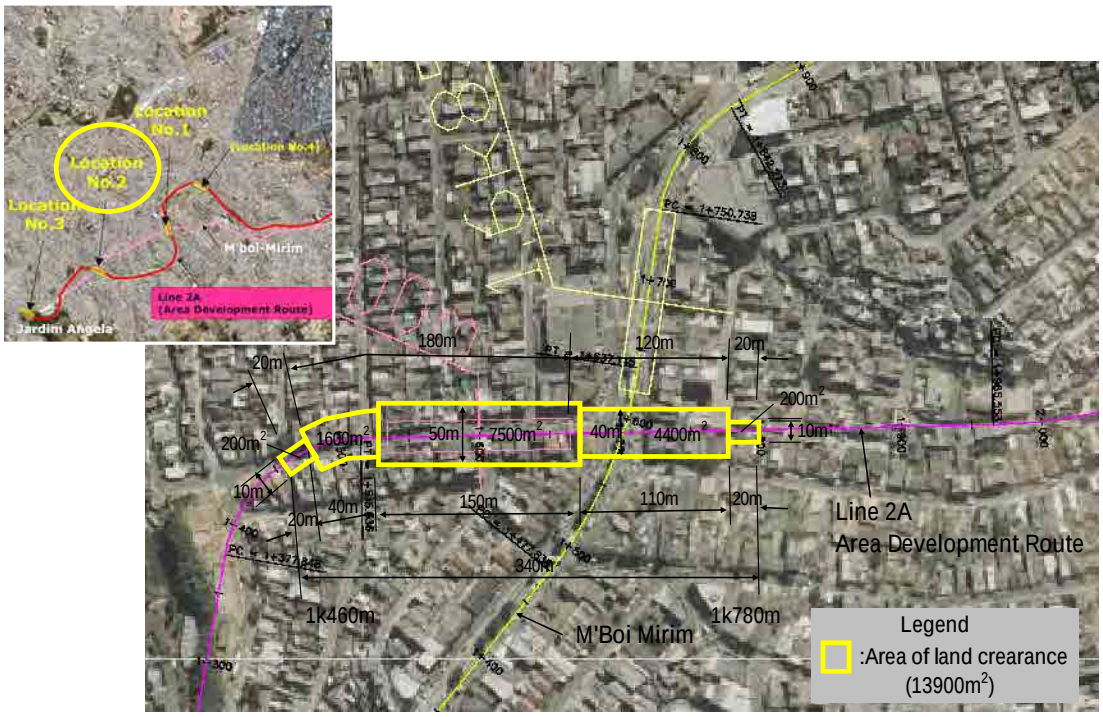
5.5.3 Land clearance for construction of tunnel

The tunnel construction will require a large scale of land acquisition and resettlement. The following figures show the necessary area for the tunnels at each location, and the area per location will be approximately 14000-16000m^2.



Source: JICA Study Team

Figure 5-50 Area of land clearance of location No.1



Source: JICA Study Team

Figure 5-51 Area of land clearance of location No.2

Source: JICA Study Team

Figure 5-52 Area of land clearance of location No.3

5.5.4 Selection of tunnelling method

There are three methods for the construction of urban tunnels in general, namely 1) shield method, 2) mountain tunnelling method, and 3) cut and cover method. The outline of each tunnelling method is shown in Table 5-14.

In selecting a tunnelling method, it is necessary to consider site conditions, conditions of obstacles, ground conditions, work influence to surrounding area, construction period, and the economic viability of the methods to be employed.

In addition, tunnels should be constructed safely and economically following the design works based on appropriate investigation and planning.

Based on the above-mentioned policy, tunnel methods are compared and the cut and cover method is selected as the most suitable tunnelling method for all of three tunnels No.1 – No.3 as shown in Table 5-15.

Table 5-14 Outline of each tunnelling method

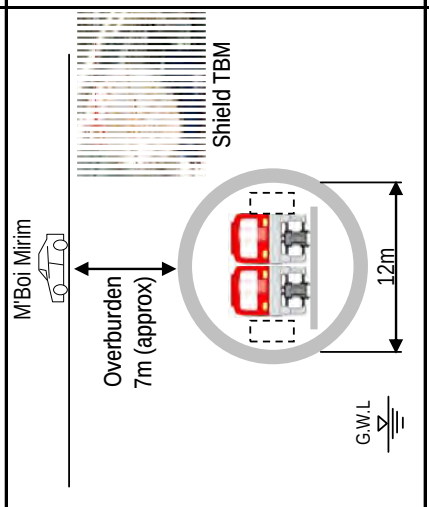
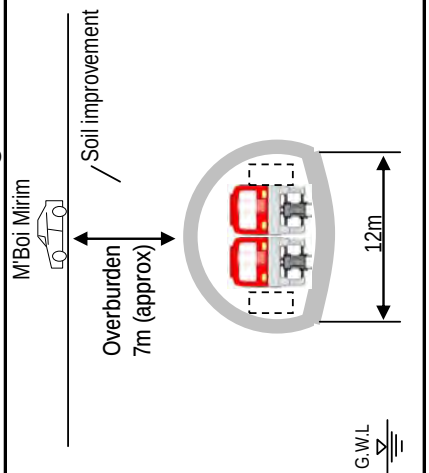
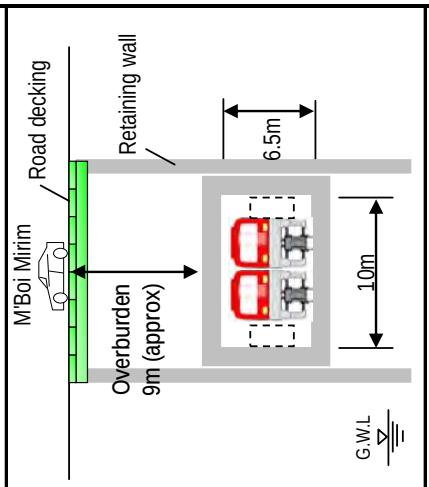
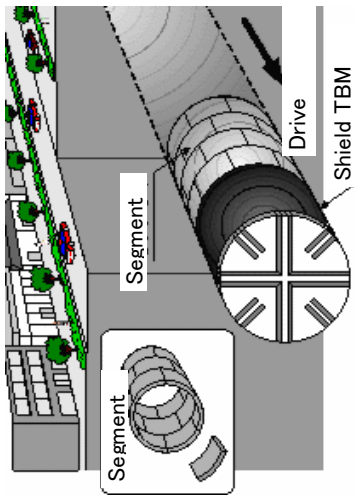
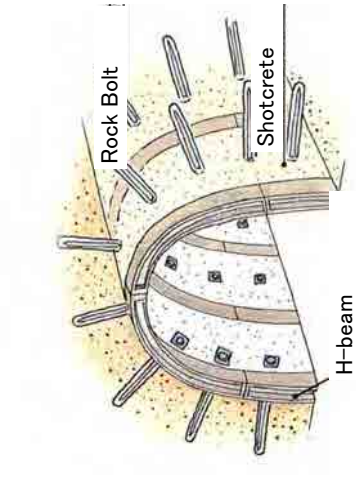
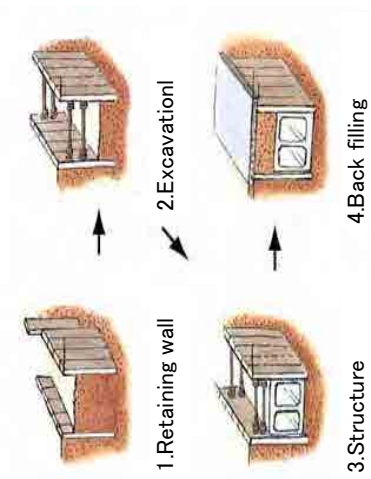
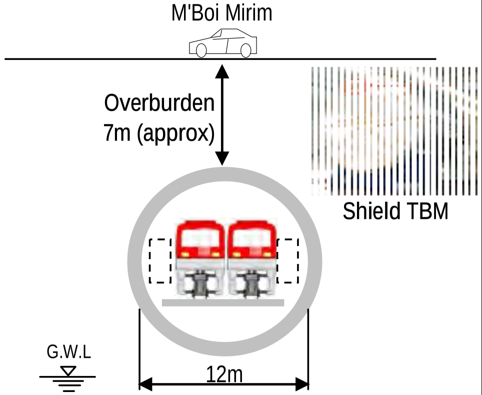
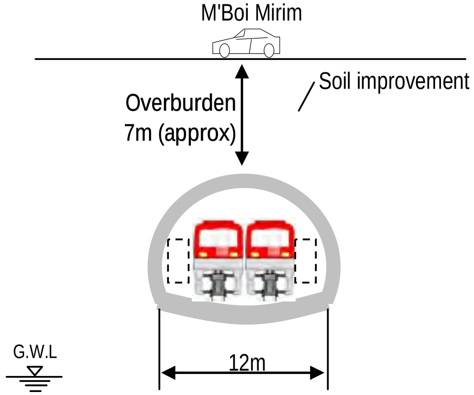
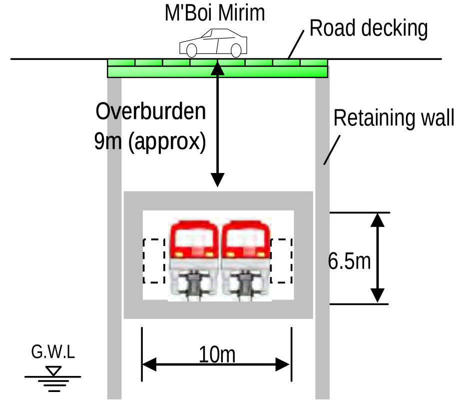
	Shield method	Mountain tunneling method	Cut and cover method
Section in this site			
Outline of method	 A Shield is thrust in the ground to make a tunnel. Outer layer of the shield and segment support the walls of the tunnel. Closed-type shield stabilizes the face using earth or slurry to bear the earth and hydraulic pressures. Open-type shield is only usable when the face remains standing. Otherwise, countermeasures are neccessary.	 Makes full use of natural support function of surrounding ground. The ground is stabilized during excavation with shotcrete, rock bolts, steel supports etc. Prerequisite condition that a 'ground arch' is formed and that the face remains standing when excavated. Otherwaise, countermeasure are neccessary.	 Ground is excavated from the surface using earth retaining wall system to build a tunnel at the desired depth. Then the excavated earth is brought back to restore the surface.

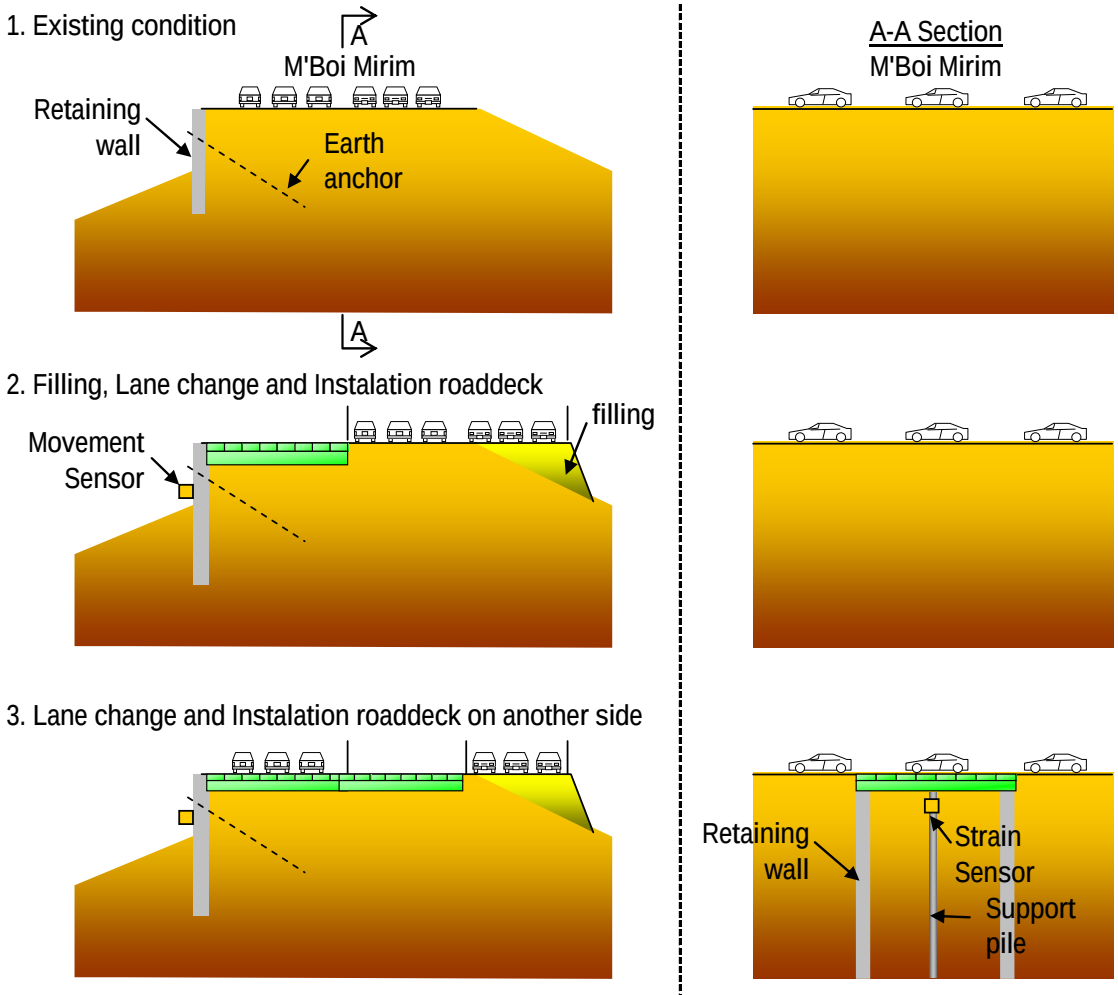
Table 5-15 Comparison table of tunneling method

	Shield method	Mountain tunneling method	Cut and cover method
Section (Approx)			
Safety	Ground settlement of M'Boi Mirim will be large because overburden is less than 1D. (1D: diameter of tunnel)	Ground settlement of M'Boi Mirim will be very large because overberden is less than 1D. Soil improvement as countermeasure will be necessity.	Ground settlement of M'Boi Mirim will be comparativery small. Observation method will be necessary.
Difficulty	Countermeasure to the exsisting retaining wall etc will be difficult.	Countermeasure to the exsisting retaining wall etc will be difficult.	Countermeasure to the exsisting retaining wall etc will not be difficult.
Experience	Construction of urban large tunnel in little overburden like this is few.	Construction of urban large tunnel in little overburden like this is very few.	There are many similar constructions.
Precondition	Land acquisition and removal of obstacle houses for construction are necessity. The area per location will be approximately 14000-16000m^2.	Land acquisition and removal of obstacle houses for construction are necessity. The area per location will be approximately 14000-16000m^2.	Land acquisition and removal of obstacle houses for construction are necessity. The area per location will be approximately 14000-16000m^2.
Construction Cost	170%	150%	100%
Construction Period	140%	100%	100%
Evaluation	Unsuitable to this site	Unsuitable to this site	Comparativery suitable to this site

5.5.5 Procedure of tunnel construction

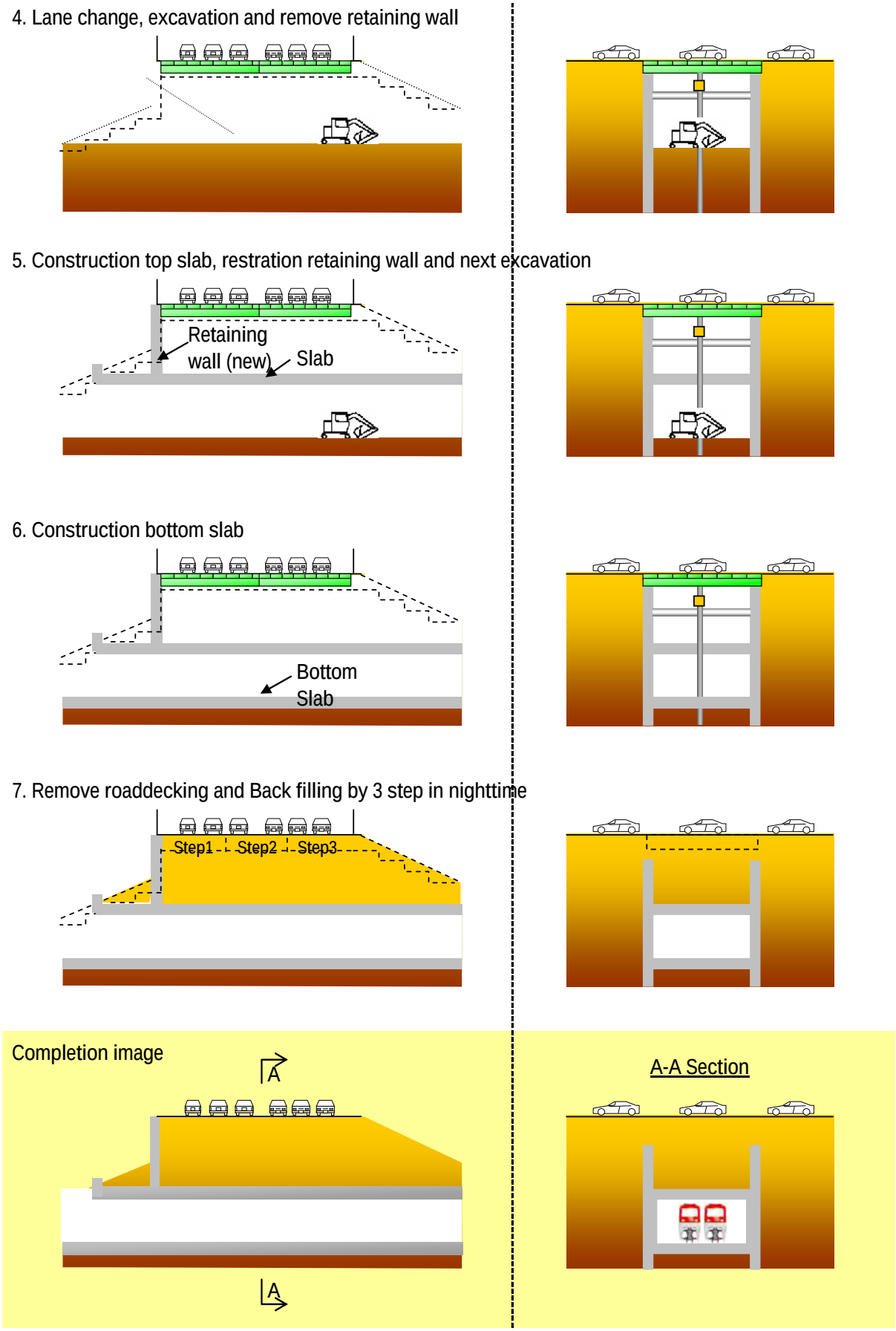
The procedure of the tunnel construction was studied for the location No.1, where the construction condition is the harshest due to the existing retaining wall (photo below). Subsequent figures illustrate the procedure of construction of tunnel with provision of detours for the existing traffic.

Source: JICA Study team



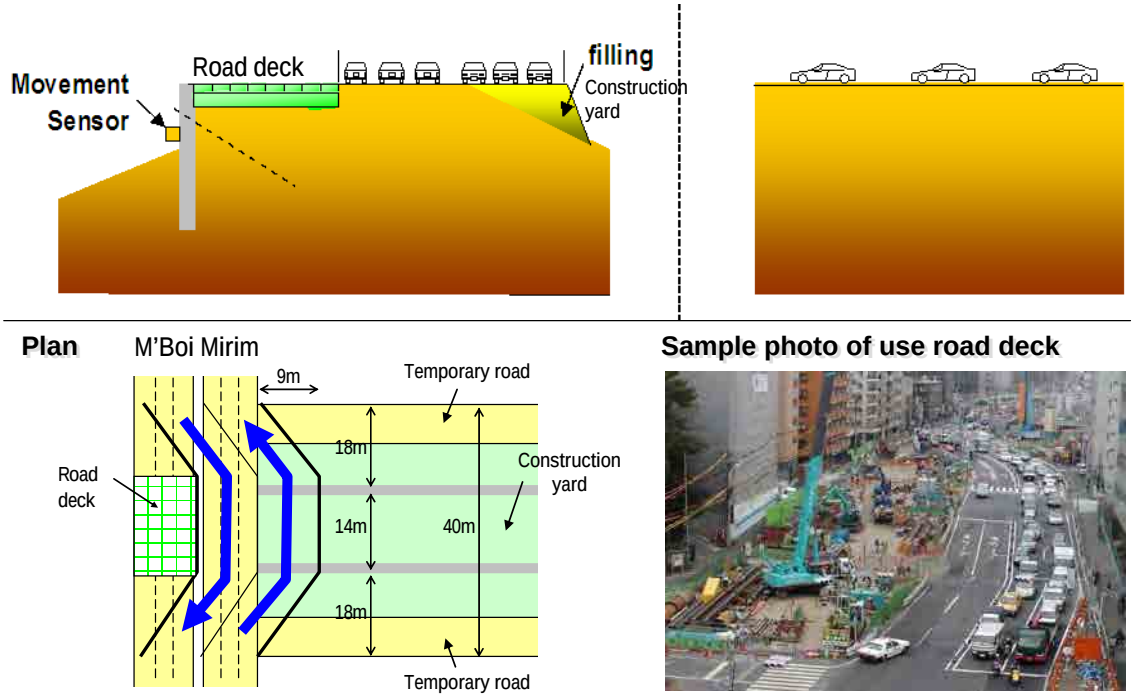
Source: JICA Study Team

Figure 5-53 Procedure of tunnel construction (1/2)



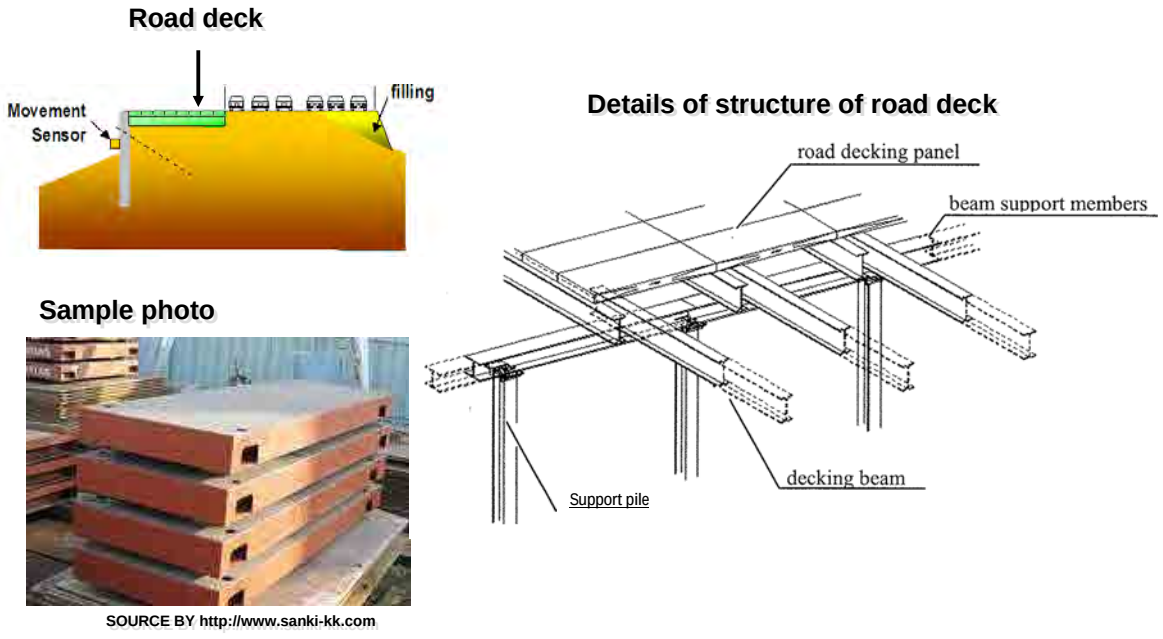
Source: JICA Study team

Figure 5-54 Procedure of tunnel construction (2/2)



Source: JICA Study team

Figure 5-55 Sample photo of use road deck



Source: JICA Study Team

Figure 5-56 Detail of structure of road deck

5.5.6 Result of comparison

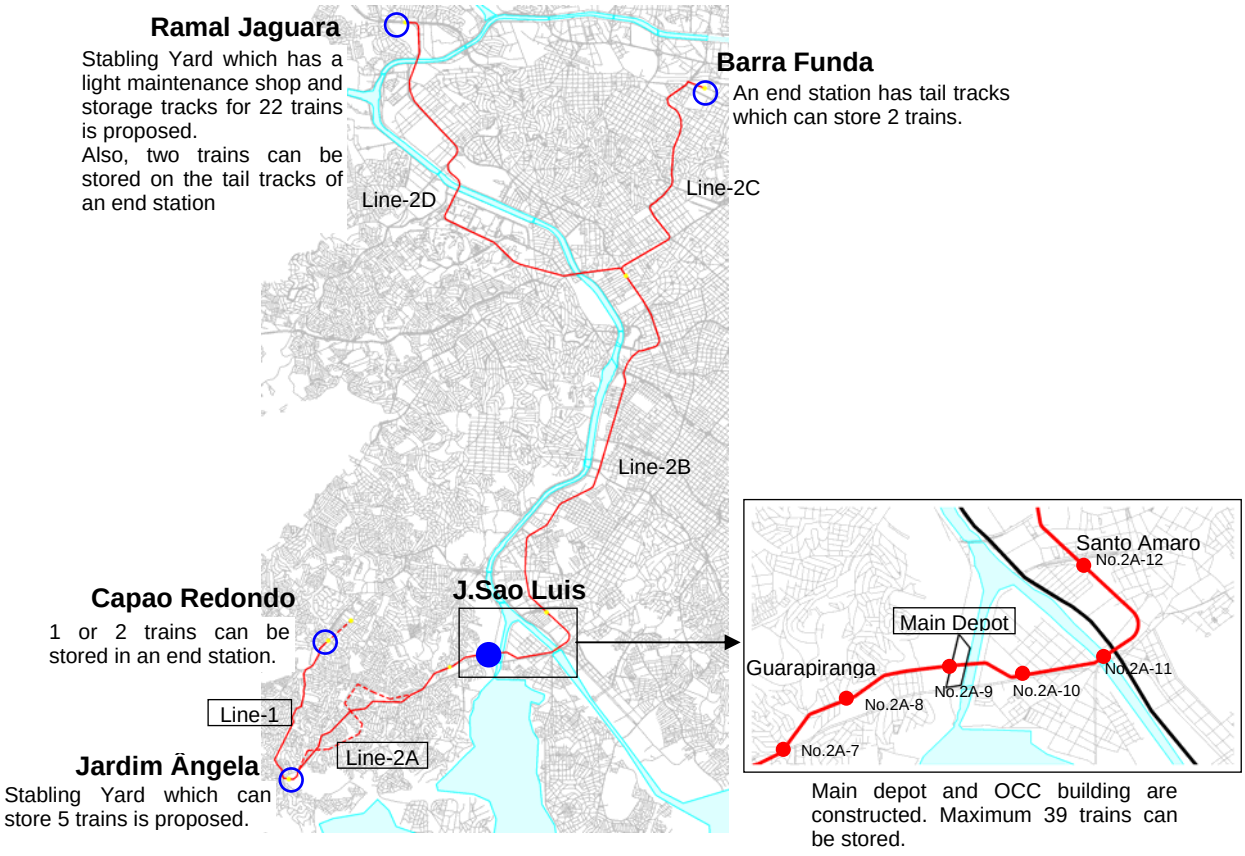
It is judged that the constructions of tunnels are technically possible in all the evaluated locations. Cut & Cover method is the most suitable at locations No.1, No.2 and No.3. The cost impact to construct tunnels No.1 and No.2 along Area Development route is evaluated as double of its cost of viaducts. A 20% increase in the construction time is anticipated to construct the tunnel in stead of viaducts.

5.6 DEPOT

5.6.1 Locations of main depot and stabling yards

A main depot is constructed in an idle land along the Guarapiranga River in Jardim Sao Luis. As shown in Figure 5-57, this area is located along the Line-2A, between 2A-9 and 2A-10 stations. Spread of this area is 11ha by length of approximately 600m and a width of 200m.

In addition, when Phase 2 is commenced and the number of trains is increased, stabling yards are constructed in Jardim Angela and Ramal Jaguara. Moreover, if Line-1B is extended in phase 3, an additional depot for the trains which will be added for Line-1B operation is required at the location adjacently to Line-1B.



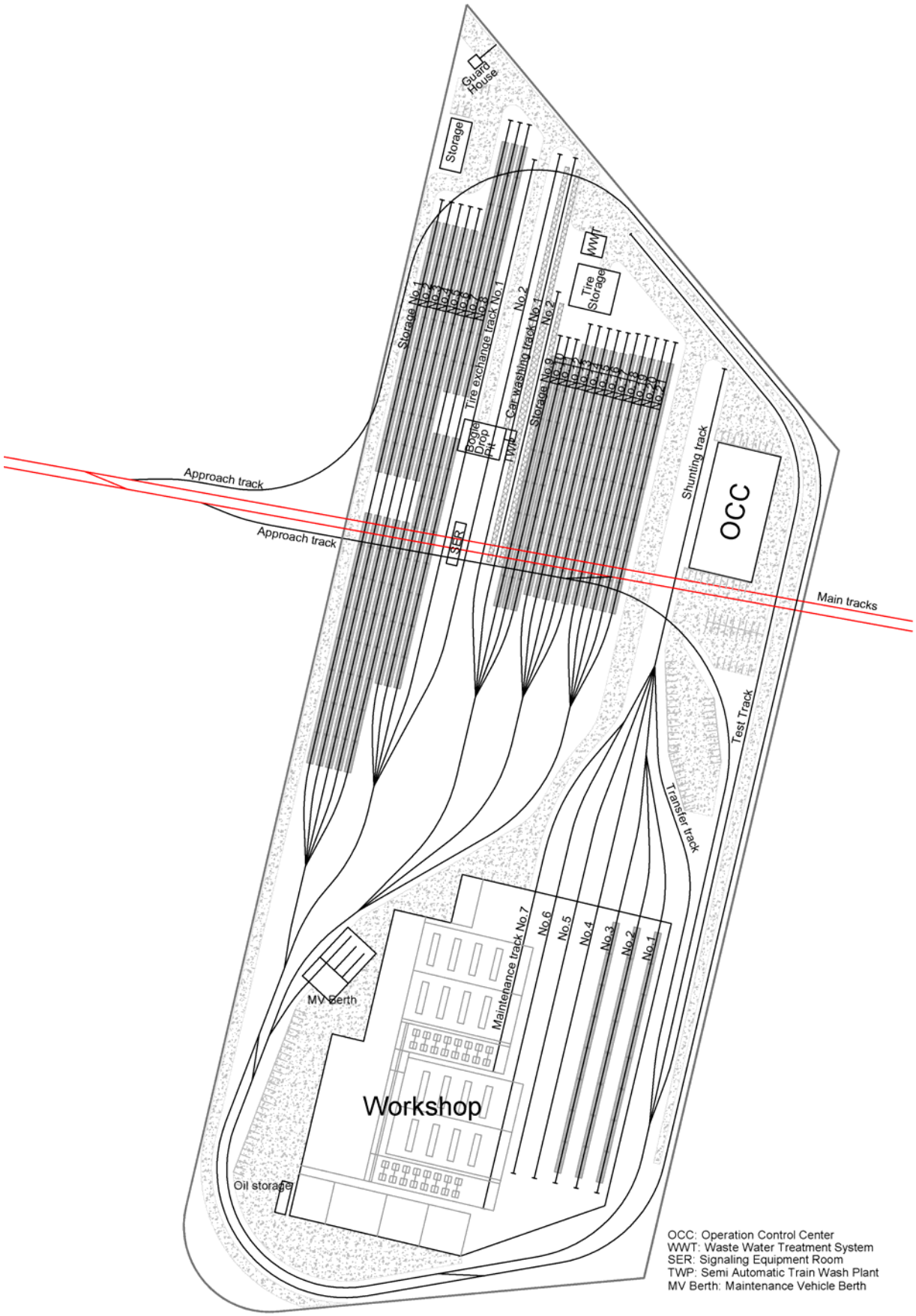
Source: JICA Study Team

Figure 5-57 Locations of Main Depot and Stabling Yards

5.6.2 Main Depot

(1) Layout

Storage tracks, maintenance tracks, workshop and OCC building, etc. are constructed in a main depot area. Since the maximum gradient of storage tracks and maintenance tracks is 0.5%, depot is made on level ground. Also, in order to facilitate the visual inspection of trains, it is preferable that the train is stored in the straight section in the storage tracks and maintenance tracks. As for horizontal curve radius of the track in depot area, the minimum curve radius must be more than 50m. Layout of main depot is shown in Figure 5-58.



Source: JICA Study Team

Figure 5-58 Main Depot Layout

(2) Function and/or role of each track in main depot

1) Approach tracks (2 tracks):

The monorail train passes the approach track separated from the main tracks and enters into the depot. In order to realize frequent operation, the approach track is designed as the double tracks. An approach track which separates from eastbound main track descends to ground level after crossing the storage tracks. Another approach track which connects westbound main track also descends and passes through under the main tracks. The maximum gradient of the approach tracks must be less than 6%.

2) Storage tracks (21 tracks):

The storage tracks from No.1 to No.8 can store each 2 trains, and the tracks from No.9 to No.21 can store each 1 train. Of them, tracks from No.1 to No.5 are constructed in Phase 2. Storage capacity by the storage tracks is 19 trains in Phase 1 and it increases to 29 trains in phase 2.

3) Tire exchange tracks (2 tracks):

The tire exchange tracks are used to replace rubber tires of monorail cars. In the middle of the tracks, a tire replacement workroom is provided to inspect wear and damage of the tire and replace tires, as necessary. Each track has a “bogie drop pit” in a tire replacement workroom, respectively. Near the tire exchange tracks, a tire storage is provided. During the night time, two trains can be stored in two tire exchange tracks since tire replacement work will not be carried out.

4) Car washing tracks (2 tracks):

2 tracks are provided for car cleaning and washing purpose. In No.1 car washing track, a semi automatic train wash plant is equipped. And in both of No.1 and No.2 track, platforms for hand-washing are provided. Two trains can be stored in the car washing tracks, if necessary.

5) Transfer track and shunting track:

A transfer track and a shunting track are used to move the train between the storage tracks and a workshop. No train can be stored on these tracks.

6) Test track (1 track):

A test track is used for the test run after train maintenance.

(3) Workshop and maintenance tracks

The workshop is divided into two areas. One is daily and monthly inspection area and another is heavy maintenance area. The daily and monthly inspection area is containing the maintenance tracks from No.1 to No.4

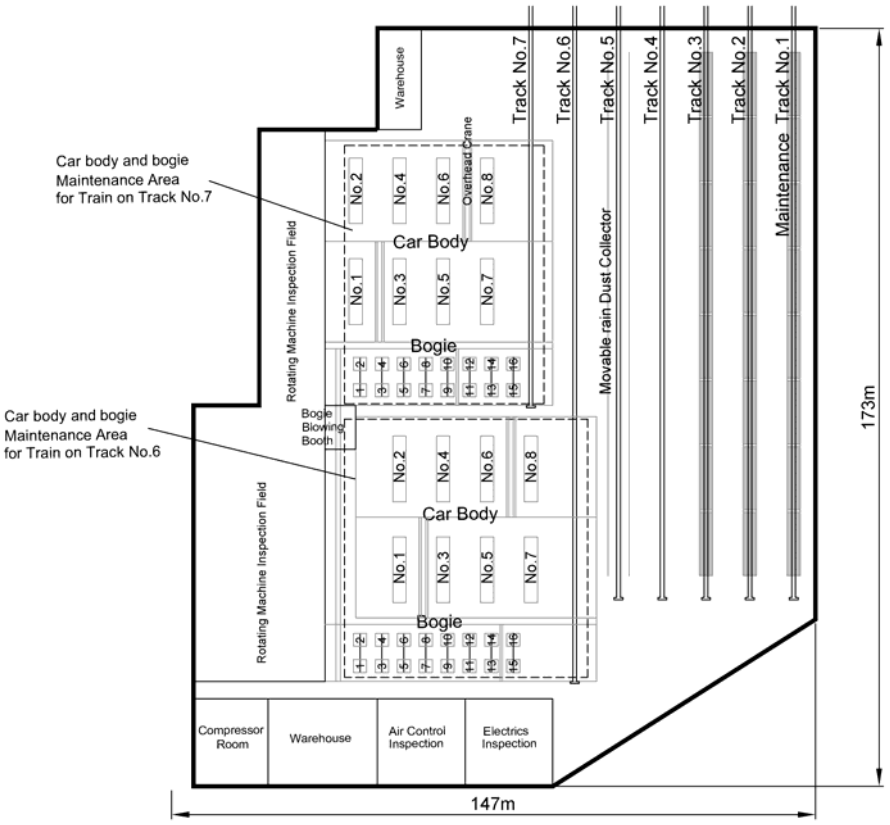
Prior to the monthly and heavy maintenance, dust inside the skirt of the train is removed by using the movable train dust collector which is equipped on No.5 track.

Maintenance tracks No.6 and No.7 are contained in the heavy maintenance area. At each track of No.6 and No.7, a pair of the overhead crane is equipped to hoist the car body, and other overhead crane is provided to hoist the bogie. No.7 maintenance track and relevant

maintenance area is installed in Phase 2 and on and after Phase 2, two trains can be overhauled simultaneously.

As for the train stabling of nighttime, 6 trains can be stored on the maintenance track from No.1 to No.6 in maximum.

The layout of workshop building is shown in Figure 5-59.



Source: JICA Study Team

Figure 5-59 Layout of Workshop

(4) Operation Control Center (OCC)

At the OCC, the total train operation management of the whole monorail lines and the depot is conducted. In the OCC building, the following offices and rooms are arranged.

a) Operation and Control Center
b) Administration office
c) Operation department office
d) Car maintenance department office
e) Track maintenance department office
f) Electric facilities maintenance department office
g) Signaling and Communication maintenance department office
h) Guard's room
i) Conference room
j) Visitors' room
k) Canteen

(5) Other Facilities

1) Maintenance vehicle berth:

The maintenance vehicle berth is used to park the maintenance vehicles used for the maintenance of the guideway and traction power facilities. Maintenance vehicle will depart from the depot at night, after the last revenue service, to maintain the facilities. Four maintenance vehicles can be parked in this berth, a traverser is provided in front of the berth.

2) Storage:

Beside the entrance, parts storage for main track and station facilities is located.

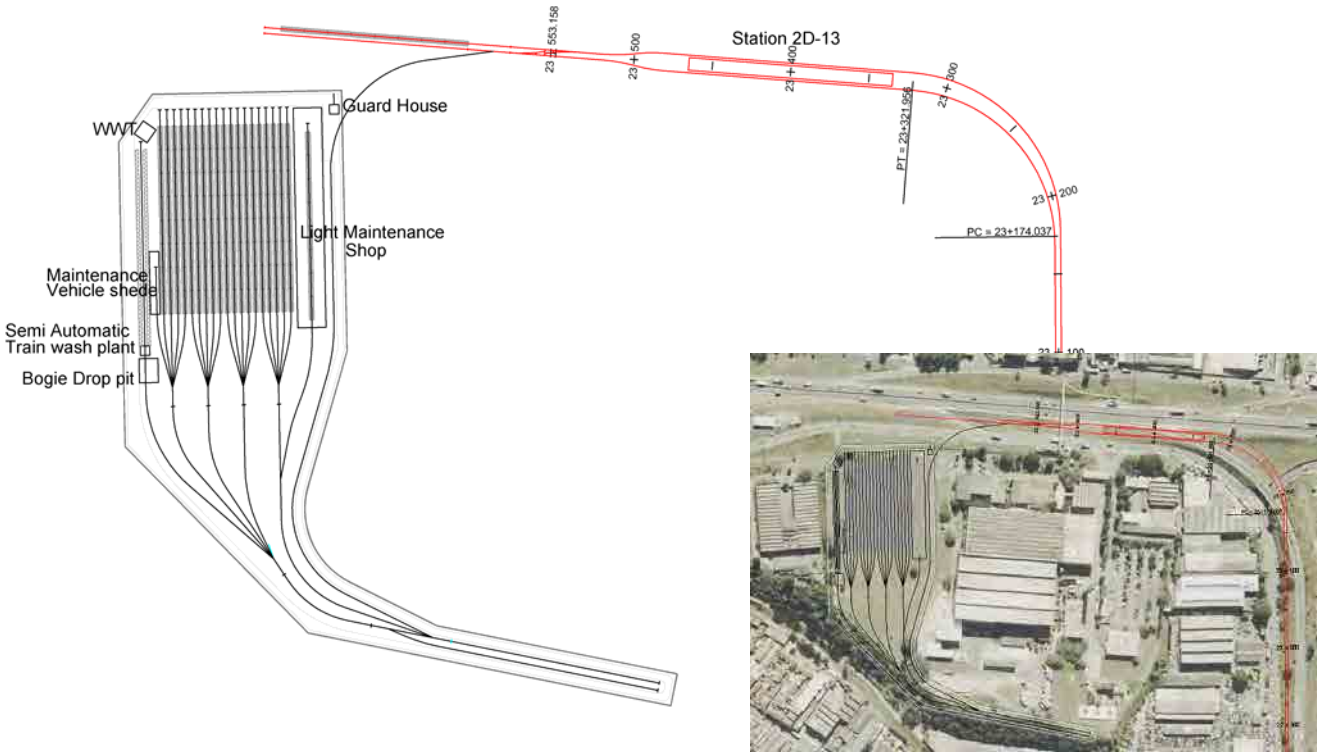
3) Others:

A waste water treatment facility, oil storage, parking lot for emergency vehicles, etc. are provided.

5.6.3 Stabling yard in Ramal Jaguara

On and after Phase 2, in order to operate the southbound train from the end station of Line-2D from the early morning hours, a stabling yard is required in Ramal Jaguara.

Figure 5-60 shows the proposal of the stabling yard in Ramal Jaguara. An approach track connects the tail track of the end station of Line-2D. Area is 4.4ha and the facilities described in Table 5-16 are provided.



Source: JICA Study Team

Figure 5-60 Layout of Ramal Jaguara Stabling Yard

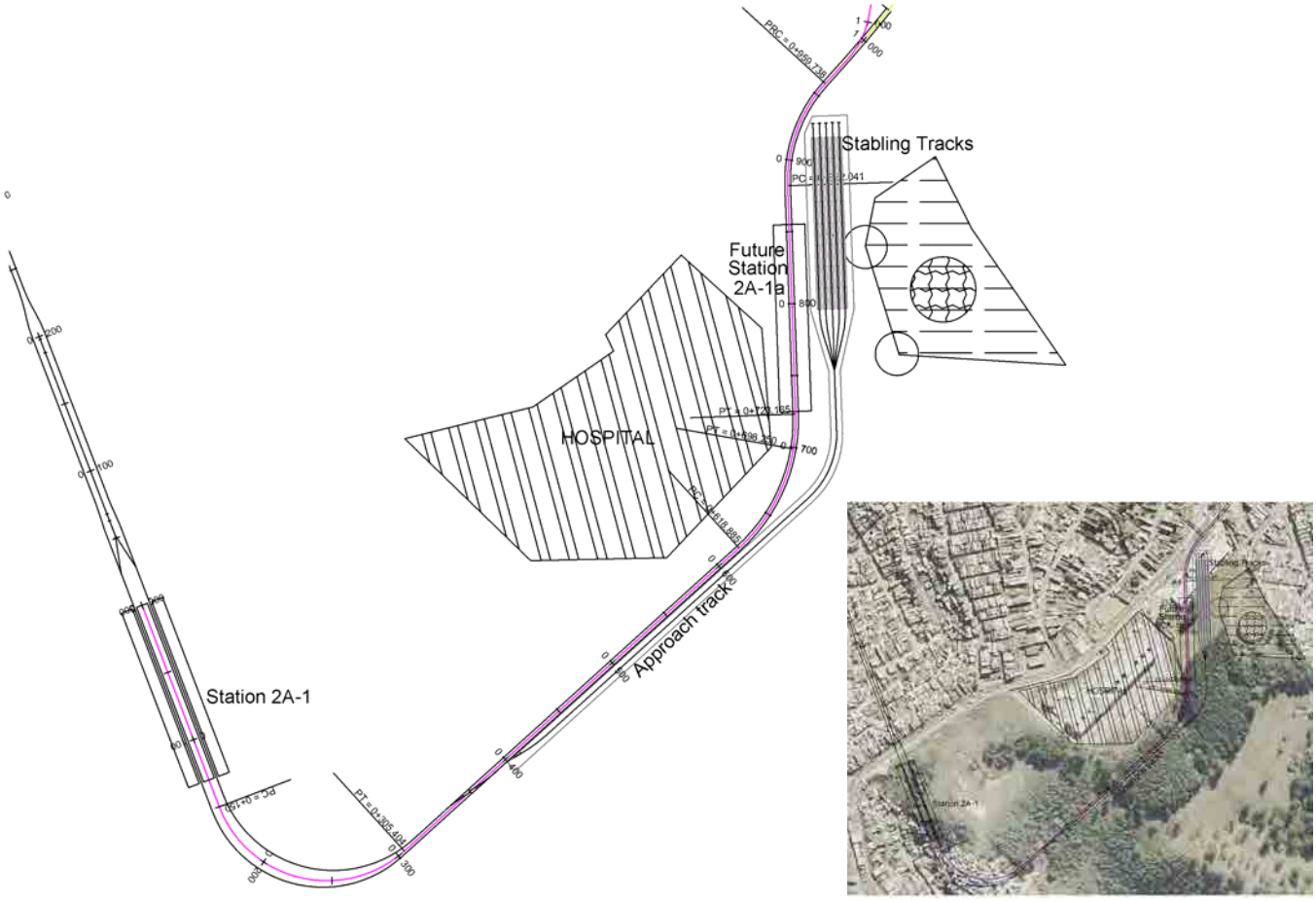
Table 5-16 Facilities of Ramal Jaguara Stabling Yard

Facilities	Nos.	Description	Capacity*
Storage tracks	19	Each Track has a length for 8-car train.	19
Approach track	1	Approach track descends to ground level after passing the public road.	0
Shunting track	2	This is used to shunt trains in the stabling yard.	1
Car washing track	1	Semi automatic train wash plant and platform for hand-wash are equipped.	1
Light maintenance shop	1	A capability for the daily and monthly inspection to be provided.	1
Tire replacement facility	1	A workroom and a bogie drop pit are equipped. The facility is installed at the car washer track.	--
Maintenance vehicle shade	1	2 of Maintenance vehicles can be parked.	--
WWT	1	Waste water treatment facility	--

Note *) Storage capacity of Monorail in nighttime
Source: JICA Study Team

5.6.4 Stabling yard in Jardim Angela

In order to achieve the frequent operation in Phase 2, installation of the stabling yard near Jardim Angela is also recommendable. Figure 5-61 shows the proposal of the stabling yard in Jardim Angela. The stabling yard is constructed beside the future station 2A-1a, and above the existing bus terminal. Required area of this stabling yard is 0.8ha including approach track.



Source: JICA Study Team

Figure 5-61 Stabling Yard in Jardim Angela

Table 5-17 Facilities of Jardim Angela Stabling Yard

Facilities	Nos.	Description	Capacity*
Storage tracks	5	Each Track has a length for 8-car train.	5
Approach track	1	Single track	0

Note *) Storage capacity of Monorail in nighttime
Source: JICA Study Team

5.6.5 Maintenance Facilities in Depot

Main maintenance facilities and its application are summarized in Table 5-18.

Table 5-18 Major maintenance equipments in Main Depot

Area	Field	Main Equipment	Unit	Q'ty	Note
Workshop	Train inspection Field	Automatic Train Inspection Device	set	1	
		Moving Dust Collection Device(1set = 2 unit)	set	1	Maintenance track #5
		High Elevation Work Car (Scissor Lift)	set	4	
		Access Platform(Staircase)	set	4	
		Scaffolding for Train Roof Maintenance	set	1	by Building works
		AC Argon Arc Welding Device	set	1	
		Battery Charge & Discharging Device	set	1	
		Forklift	Car	2	
		Bogie Skirt Dismantling Unit	set	64	
	Car Body Maintenance Field	Overhead Crane (1 set = 10tons x 2 unit)	set	4	
		Car Body Stand (1 set = 4 stand)	set	16	
		Underfloor Equipment Detaching Device	set	2	
		High Elevation Work Car (Scissor Lift)	set	6	
		Cargo Lift Trolley	set	2	
		Hand Lifter	set	2	
		Bogie Lifting Beam	beam	2	By Civil works
		Air Conditioner Stand	set	4	
		Shunting Unit	car	2	
		Jigs and Special Tools	lot	1	
	Bogie Maintenance Field	Overhead Crane (5 tons)	set	2	
		Bogie Maintenance Stand (2 bogies/stand)	set	4	
		Bogie Stand (2 bogies/stand)	set	12	
		Guide/Stabilizer wheel Changer	set	1	
		Bogie Air Blowing Booth	set	1	
		Jigs and Special Tools	set	1	
	Air Control Inspection	Pneumatic Control Valve	set	1	
		Pressure Gage Standard	set	1	
		Ultrasonic Cleaner	set	1	
		Parts Cleaner	set	1	
	Electronics Inspection	Electronics Equipment Testing Device	set	1	
		CBTC-Trans & Receiving Testing Device	set	1	
		CBTC-Control Assembly Testing Device	set	1	
	Rotating Machine Inspection	Over Head Crane (1 ton)	set	1	
		Rotating Machine Testing Device	set	1	
		Electric Compressor Testing Device	set	1	
		Parts Air Blowing Device	set	1	
	Parts Maintenance Room	Driving Equipment Cleaning Device	set	1	
		Magnetic Flaw Detector	set	1	
		Oil Pressure Device	set	1	
		Small parts washing & Air Blowing Unit	set	1	
	Air Compressor Room	Air Compressor for Motive Power	lot	1	Including conduits, facilities
	Electric Room	Incoming & Distribution Panel	lot	1	
Car Washing Track		Semi-Automatic Car body Wash Plant	set	1	
		Scaffolding for Monorail Car Hand Wash	set	2	
Tire Exchange Track	Tire replacement workroom	Bogie Drop Pit and Machine	set	1	
		Car Body Support Stand	set	2	
		Running Tire Changer	set	1	
		Overhead Crane (500kg)	set	1	
	Tire Storage	Tire Rack	lot	1	
Maintenance Vehicle Berth		Maintenance Vehicle	car	3	
		Traverser	set	1	
		Lorry Crane	car	1	
		AC Arc Welding Device	set	2	
WWT		Waste Water Treatment System	set	1	By Building works

Source: JICA Study Team

Table 5-19 Major maintenance equipment in Ramal Jaguara Stabling Yard

Area	Field	Main Equipment	Unit	Q'ty	Note
Light Maintenance Shop		Automatic Train Inspection Device	set	1	
		High Elevation Work Car (Scissor Lift)	set	1	by Building works
		Access Platform(Staircase)	set	1	
		Hand Lifter	set	1	
		Forklift	car	1	
		Jigs and Special Tools	lot	1	
Car Washing Track		Semi-Automatic Car body Wash Plant	set	1	
		Scaffolding for Monorail Car Hand Wash	set	1	
	Tire Replacement Workroom	Bogie Drop Pit and Machine	set	1	
		Car Body Support Stand	set	2	
		Running Tire Changer	set	1	
		Overhead Crane (500kg)	set	1	
		Hoisting Tool for Running Tire	set	1	
		Tire Rack	lot	1	
Maintenance Vehicle Shade		Maintenance Vehicle	car	1	
		Lorry Crane	car	1	
		AC Arc Welding Device	set	1	
WWT		Waste Water Treatment System	set	1	By Building works

Source: JICA Study Team

5.7 ELECTRIC POWER FEEDING SYSTEM

5.7.1 Current situation of electric power supply in São Paulo

(1) Power supply structure in São Paulo

In Brazil, the responsible companies for the power supply are divided into three areas, namely generation, transmission, and distribution companies. In São Paulo, the major companies in each area are as follows.

1) Major electric generation companies: ITAIPU, Eletrobras, FURNAS and CPFL
2) Major electric transmission companies: Eletrobras and CTEEP
3) Major electric distribution company: Eletropaulo

At present trolley bus system of SPTrans is receiving the electric power from Eletropaulo in an acceptable condition. Therefore for the monorail operation plan, it was considered an alternative to receive the electric power directly from Eletropaulo from the viewpoint of effective use of the present substations.

The outage time of Eletropaulo was as long as 8.9 hours per year and the number of outages per consumer was as often as 6.4 times per year, according to Associacao Brasileira de Distribuidores de Energia Eletrica (ABRADEE).

(2) Current situation of Power Supply

Hydraulic power accounts for 83.2% of electric power source of Brazil (2006 year data by the federation of electric power companies of Japan), which makes the electric power supply tends to become unstable under abnormal weather. Furthermore, the recent rapid industry development is likely to threaten the stability of power supply.

As of October 2009, 22 dams in Brazil are at low water level due to dry weather. In addition, the power transmission breakdown of the metro has occurred three times in the last year.

Especially a very serious outage occurred in the large part of Brazil at the night on Nov 11, 2009. These fundamental causes would be considered the lack of the redundancy of the mutual electric power plants and the transmission gird, by the reason that the few super-big electric power plants have been supplying electric power. Therefore the possibility of outage at large area would be considered very high.

5.7.2 Power supply system for the monorail system

(1) Power supply system

In general, there two kinds of electric power supply system for feeding electricity to trains as;

1) Each traction substation receives electric power from an electric power company directly.
2) Big AC substations receive electric power from an electric power company through electric transmission lines, and feed the electric power to each traction substation.

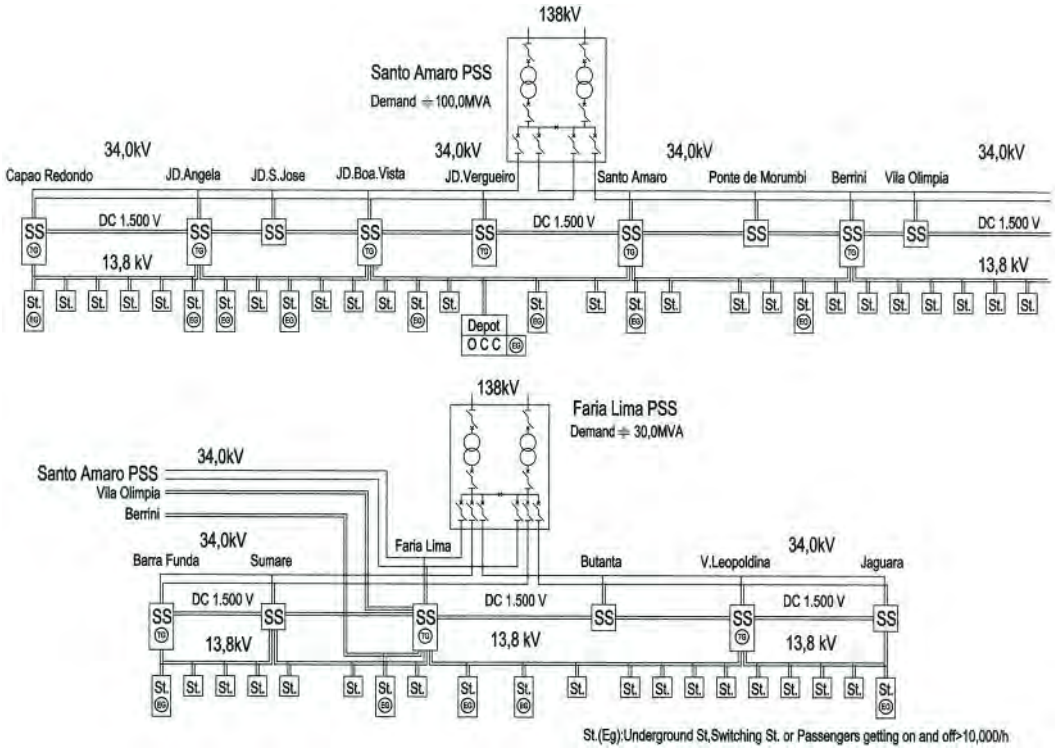
The first type of system is suitable when the electric power company has many stable transmission lines, because the capital investment cost is lower than the second type of system and the system is more flexible for the future expansion. On the other hand, the second type system is suitable when there are many outages.

However, under the above mentioned unstable situation of power supply with high possibility that a wide area outage occurs, it is necessary to supply electric power to the train in an emergency by in-house generation system.

Therefore, about the stability of power supply, there is no difference between the first type and second type. Rather the first system of high extendibility and low cost is more advantageous.

And the second type of power supply system should be adopted when the redundancy of transmission grid will be obtained sufficiently in the future.

The proposed power supply total system layout is as shown in the figure below.



Source: JICA Study Team

Figure 5-62 Electric power supply system

(2) Outline of power supply system

The power supply to monorail cars is converted from AC 60Hz into DC 1500V. The variation range in the monorail power supply shall be in accordance with IEC standard; the highest voltage is 1800V and the lowest voltage is 1000V.

The general electric power is converted into AC13.8kV in suitable traction substation, and supplied to each station and the depot etc by double distribution lines.

When one substation is fail, the electric power is supplied from the adjoining substation. And even in that case the locations of substations have been designed to obtain the almost normal train running.

When serial traction substations fail by the outage of a power supply company, the monorail cars will stop in that section. As a counter measure, turbine generators are installed in the traction substations, to make the trains arrive at the nearest station. The installation interval of the turbo generator is from 10 to 15Km, as shown in Table 5-20.

Therefore it will be better not to construct the primary substation system until the electric power supply system of electric companies will become stable in the future. And it will be better to receive the electric power at traction substations directly from the electric company by the reason of construction cost and flexibility of construction period and construction range.

In the case of constructing the primary substation, the primary substation receives by AC 138kV double transmission lines and it is better to adopt the double transformer system from the viewpoints of safety, and the traction substation is supplied by AC 34KV double transmission lines. Then it is converted into DC 1500V and AC 13.8 kV in the traction substation.

Table 5-20 Interval of turbine generator

Interval of turbine generator	Center of interval	Contact line resistance	Current/train	Voltage	Rectifier Capacity	Regulation of rectfier	No load Voltage	Inner Resistance	Minimum Feed Voltage
(km)	(km)	(Ω/km)	(A)	(V)	(kW)	(%)	(V)	(Ω)	(V)
0	0.0	0.03605	1300	1500	1950	10	1,667	0.128	1,500
1	0.5	0.03605	1300	1500	1950	10	1,667	0.128	1,477
2	1.0	0.03605	1300	1500	1950	10	1,667	0.128	1,453
3	1.5	0.03605	1300	1500	1950	10	1,667	0.128	1,430
4	2.0	0.03605	1300	1500	1950	10	1,667	0.128	1,406
5	2.5	0.03605	1300	1500	1950	10	1,667	0.128	1,383
6	3.0	0.03605	1300	1500	1950	10	1,667	0.128	1,359
7	3.5	0.03605	1300	1500	1950	10	1,667	0.128	1,336
8	4.0	0.03605	1300	1500	1950	10	1,667	0.128	1,313
9	4.5	0.03605	1300	1500	1950	10	1,667	0.128	1,289
10	5.0	0.03605	1300	1500	1950	10	1,667	0.128	1,266
11	5.5	0.03605	1300	1500	1950	10	1,667	0.128	1,242
12	6.0	0.03605	1300	1500	1950	10	1,667	0.128	1,219
13	6.5	0.03605	1300	1500	1950	10	1,667	0.128	1,195
14	7.0	0.03605	1300	1500	1950	10	1,667	0.128	1,172
15	7.5	0.03605	1300	1500	1950	10	1,667	0.128	1,149
16	8.0	0.03605	1300	1500	1950	10	1,667	0.128	1,125
17	8.5	0.03605	1300	1500	1950	10	1,667	0.128	1,102
18	9.0	0.03605	1300	1500	1950	10	1,667	0.128	1,078
19	9.5	0.03605	1300	1500	1950	10	1,667	0.128	1,055
20	10.0	0.03605	1300	1500	1950	10	1,667	0.128	1,031
21	10.5	0.03605	1300	1500	1950	10	1,667	0.128	1,008

Source: JICA Study Team

5.7.3 Location and function of the traction substation

(1) Location

For the purpose of consumption calculation, headway of 120 sec and 240sec are used for the section Jardim Angela - Faria Lima and other sections respectively.

In this case, the location of traction substation, the capacity of substation, and the voltage drop are as shown in Table 5-21, Table 5-22, Table 5-23, Table 5-24 and Figure 5-63.

Table 5-21 Rectifier Capacity by Electric Power Consumption (8 Car)

Line	Station			Train Operation				Weight					Value of Traffic	Electric Power Consumption	Location of Traction SS					
				Cars/Train		Headway of a Peak Hour	Train-km/hour of a Direction	Weight of a train	Weight of a perspon	Passenger/H		Weight of Passengers	ton-km/hour in Section		Name	Interval	Section	SS Section	Load of SS	SS Capacity
										Inbound	Outbound									
	k m	Name	Interval (km)	Mc	M	sec	km/h	ton	ton	number	number	ton	t-km/hour	kwh/1000t-km		km	kwh	kwh	kwh	kwh
	0.000	No6-Capao Redondo	0.000	2	6	300	0.000	222.000	0.070	0		0.000	0	70			0			
	1.200	No5	1.200	2	6	300	14.400	222.000	0.070	16,878	4,382	1,488.200	8,179	70	Capao Redondo		573		1,012	1,012
	2.000	No4	0.800	2	6	300	9.600	222.000	0.070	16,866	5,333	1,553.930	5,506	70			385			
Line-1	2.100		0.100	2	6	300	1.200	222.000	0.070	15,894	4,529	1,429.610	676	70			47			
	2.100		0.000	2	6	300	0.000	222.000	0.070	15,894	4,529	1,429.610	0	70		4.200	0	2,023		
	2.700	No3	0.600	2	6	300	7.200	222.000	0.070	15,894	4,529	1,429.610	4,055	70			284			
	3.340	No2	0.640	2	6	300	7.680	222.000	0.070	13,700	6,908	1,442.560	4,333	70			303		1,012	
	4.150	No1-JD.Angela	0.810	2	6	300	9.720	222.000	0.070	10,837	8,619	1,361.920	5,419	70	Jardim Angela		379			2,452
	4.200		0.050	2	6	120	1.500	222.000	0.070	15,108	4,412	1,366.400	734	70			51			
	4.200		0.000	2	6	120	0.000	222.000	0.070	15,108	4,412	1,366.400	0	70			0		1,440	
	5.750	No2	1.550	2	6	120	46.500	222.000	0.070	15,108	4,412	1,366.400	22,764	70		2.800	1,593	2,881		
	6.760	No3	1.010	2	6	120	30.300	222.000	0.070	17,987	1,397	1,356.880	14,824	70			1,038		1,440	
	7.000		0.240	2	6	120	7.200	222.000	0.070	20,682	1,386	1,544.760	3,568	70			250			
	7.000		0.000	2	6	120	0.000	222.000	0.070	20,682	1,386	1,544.760	0	70	JD.S.Jose		0			2,852
	7.650	No4	0.650	2	6	120	19.500	222.000	0.070	20,682	1,386	1,544.760	9,662	70			676		1,412	
	8.350	No5	0.700	2	6	120	21.000	222.000	0.070	21,072	1,386	1,572.060	10,424	70		2.700	730	2,824		
	9.350	No6	1.000	2	6	120	30.000	222.000	0.070	21,072	1,386	1,572.060	14,892	70			1,042		1,412	
Line-2A	9.700		0.350	2	6	120	10.500	222.000	0.070	27,208	1,383	2,001.370	5,362	70	JD.Boa.Vista		375			2,940
	9.700		0.000	2	6	120	0.000	222.000	0.070	27,208	1,383	2,001.370	0	70			0		1,528	
	10.500	No7	0.800	2	6	120	24.000	222.000	0.070	27,208	1,383	2,001.370	12,257	70		2.800	858	3,055		
	11.600	No8-Guarapira	1.100	2	6	120	33.000	222.000	0.070	29,759	2,397	2,250.920	17,128	70			1,199		1,528	
	12.500	No9	0.900	2	6	120	27.000	222.000	0.070	33,730	2,397	2,528.890	14,264	70	JD.Vergueiro		998			3,206
	12.500	Depot,OCC	0.000	2	6	120	0.000	222.000	0.070	34,446	3,366	2,646.840	0	70			0		1,679	
	13.550	No10	1.050	2	6	120	31.500	222.000	0.070	34,446	3,366	2,646.840	16,765	70		3.000	1,174	3,357		
	14.450	Socorro(No11)	0.900	2	6	120	27.000	222.000	0.070	30,792	5,134	2,514.820	14,251	70			998		1,679	
	15.500		1.050	2	6	120	31.500	222.000	0.070	34,770	5,438	2,814.560	16,941	70			1,186			
	15.500		0.000	2	6	120	0.000	222.000	0.070	34,770	5,438	2,814.560	0	70	Santo Amaro		0			3,320
	15.640	Sant Amaro(No12-No1)	0.140	2	6	120	4.200	222.000	0.070	34,770	5,438	2,814.560	2,259	70			158		1,642	
	16.540	No2	0.900	2	6	120	27.000	222.000	0.070	29,624	2,974	2,281.860	14,042	70		3.000	983	3,283		
	17.090	No3	0.550	2	6	120	16.500	222.000	0.070	30,155	2,991	2,320.220	8,602	70			602			
	18.190	No4	1.100	2	6	120	33.000	222.000	0.070	30,155	2,991	2,320.220	17,204	70			1,204		1,642	
	18.500		0.310	2	6	120	9.300	222.000	0.070	27,149	3,513	2,146.340	4,795	70	Ponte de Morumbi		336			3,260
	18.500		0.000	2	6	120	0.000	222.000	0.070	27,149	3,513	2,146.340	0	70			0		1,618	
	19.440	No5	0.940	2	6	120	28.200	222.000	0.070	27,149	3,513	2,146.340	14,538	70			1,018			
	20.390	Morumbi(No6)	0.950	2	6	120	28.500	222.000	0.070	26,359	3,513	2,091.040	14,640	70		3.000	1,025	3,236		
	21.400	No7	1.010	2	6	120	30.300	222.000	0.070	26,007	3,414	2,059.470	15,533	70			1,087		1,618	
	21.500		0.100	2	6	120	3.000	222.000	0.070	22,888	4,151	1,892.730	1,521	70	Berrini		106			2,682
	21.500		0.000	2	6	120	0.000	222.000	0.070	22,888	4,136	1,891.680	0	70			0		1,064	
Line-2B	22.240	No8	0.740	2	6	120	22.200	222.000	0.070	22,888	4,136	1,891.680	11,257	70		2.000	788	2,127		
	22.890	No9	0.650	2	6	120	19.500	222.000	0.070	22,878	4,136	1,890.980	9,887	70			692		1,064	
	23.500		0.610	2	6	120	18.300	222.000	0.070	22,145	4,146	1,840.370	9,248	70			647			
	23.500		0.000	2	6	120	0.000	222.000	0.070	22,145	4,146	1,840.370	0	70	Vila Olimpia		0			2,924
	23.590	No10	0.090	2	6	120	2.700	222.000	0.070	22,145	4,146	1,840.370	1,364	70			96		1,860	
	24.490	No11	0.900	2	6	120	27.000	222.000	0.070	21,275	7,222	1,994.790	13,783	70			965			
	25.340	No12	0.850	2	6	120	25.500	222.000	0.070	20,827	7,223	1,963.500	12,991	70		3.500	909	3,720		
	26.240	No13	0.900	2	6	120	27.000	222.000	0.070	19,721	10,005	2,080.820	13,861	70			970			
	26.930	Faria Lima(No14-No1)	0.690	2	6	120	20.700	222.000	0.070	16,501	12,035	1,997.520	10,569	70			740		1,860	
	27.000		0.070	2	6	240	1.050	222.000	0.070	9,051	12,969	1,541.400	574	70	Faria Lima		40			3,221
	27.000		0.000	2	6	240	0.000	222.000	0.070	9,051	12,969	1,541.400	0	70			0			
	27.760	No2	0.760	2	6	240	11.400	222.000	0.070	9,051	12,969	1,541.400	6,233	70			436		865	
	28.780	No3	1.020	2	6	240	15.300	222.000	0.070	8,310	12,899	1,484.630	8,308	70		3.000	582	1,730		
	29.480	No4	0.700	2	6	240	10.500	222.000	0.070	10,580	14,600	1,762.600	5,896	70			413		865	
	30.000		0.520	2	6	240	7.800	222.000	0.070	9,310	13,068	1,566.460	4,278	70			299			
	30.000		0.000	2	6	240	0.000	222.000	0.070	9,310	13,068	1,566.460	0	70	Butanta		0			2,142
	30.380	USP(No5)	0.380	2	6	240	5.700	222.000	0.070	9,310	13,068	1,566.460	3,126	70			219		1,277	
	31.180	USP(No6)	0.800	2	6	240	12.000	222.000	0.070	9,042	13,013	1,543.850	6,563	70		4.500	459	2,553		
Line-2D	31.880	USP(No7)	0.700	2	6	240	10.500	222.000	0.070	9,042	13,013	1,543.850	5,743	70			402			
	33.500	No8	1.620	2	6	240	24.300	222.000	0.070	4,918	13,794	1,309.840	12,911	70			904		1,277	
	34.500		1.000	2	6	240	15.000	222.000	0.070	5,509	15,486	1,469.650	8,130	70			569			
	34.500		0.000	2	6	240	0.000	222.000	0.070	5,509	15,486	1,469.650	0	70	V.Leopoldina		0			2,375
	34.620	No9	0.120	2	6	240	1.800	222.000	0.070	5,509	15,486	1,469.650	976	70			68		1,099	
	35.410	No10	0.790	2	6	240	11.850	222.000	0.070	5,398	18,927	1,702.750	6,607	70		3.805	462	2,198		
	36.730	No11	1.320	2	6	240	19.800	222.000	0.070	3,195	19,976	1,621.970	10,932	70	Jaguara		765		1,099	1,099
	38.305	Jaguara(No12)	1.575	2	6	240	23.625	222.000	0.070	1,396	20,318	1,519.980	12,883	70			902			
	27.930	No2	0.930	2	4	360	9.300	166.800	0.070	5,626	4,287	693.910	3,748	70	Faria Lima		262		496	
	29.030	No3	1.100	2	4	360	11.000	166.800	0.070	6,096	4,466	739.340	4,483	70		3.500	314	991		
	29.880	No4	0.850	2	4	360	8.500	166.800	0.070	5,513	4,470	698.810	3,430	70			240		496	
	30.500		0.620	2	4	360	6.200	166.800	0.070	5,513	4,470	698.810	2,502	70			175			
	30.500		0.000	2	4	360	0.000	166.800	0.070	5,513	4,470	698.810	0	70	Sumare		0			997
Line-2C	30.630	Sumare(No5)	0.130	2	4	360	1.300	166.800	0.070	5,513	4,470	698.810	525	70			37		502	
	31.280	No6	0.650	2	4	360	6.500	166.800	0.070	4,895	4,524	659.330	2,597	70		3.655	182	1,004		
	32.130	No7	0.850	2	4	360	8.500	166.800	0.070	4,895	5,323	715.260	3,444	70			241			
	33.180	No8	1.050	2	4	360	10.500	166.800	0.070	4,395	5,208	672.210	4,209	70	Barra Funda		295		502	502
	34.155	Barra Funda(No9)	0.975	2	4	360	9.750	166.800	0.070	3,841	722	319.410	3,564	70			249			
Total			45.460				975.375									45.460	34,983	34,983	34,983	34,983

Source: JICA Study Team

Table 5-22 Rectifier capacity by maximum electric power (8 Car)

Substation	Section	Distance (km)	Cars/Train		Headway (sec)	Schedule Speed (km/h)	No. of Trains in Section	Max Current of Train		Max Power by Calculation(kW)		Consumption Power (k Wh/h)	Max 2hr-Power by Simulation (kW)	Demand Peak Power (kVA)	Rectifier
			Mc	M				Motor (A)	Auxiliary (A)		Total				
Capao Redondo	~Capelinha	0.00	2	6	300	30.0	0.0	2,600.0	186.6	0	3,933	1,012	3,812	4,200	3,000kW*（1+1）
	Capao Redondo~Jardim Angela/2	2.10	2	6	300	30.0	1.7	2,600.0	186.6	3,933					
Jardim Angela	Capao Redondo~Jardim Angela/2	2.10	2	6	300	30.0	1.7	2,600.0	186.6	3,933	10,487	2,452	8,452	9,300	3,000kW*（2+1）
	Jardim Angela~JD.S.Jose/2	1.40	2	6	120	30.0	2.8	2,600.0	186.6	6,554					
JD.S.Jose	Jardim Angela~JD.S.Jose/2	1.40	2	6	120	30.0	2.8	2,600.0	186.6	6,554	12,874	2,852	9,852	10,900	3,000kW*（3+1）
	JD.S.Jose~JD.Boa Vista/2	1.35	2	6	120	30.0	2.7	2,600.0	186.6	6,320					
JD.Boa Vista	JD.S.Jose~JD.Boa Vista/2	1.35	2	6	120	30.0	2.7	2,600.0	186.6	6,320	12,874	2,940	9,940	11,000	3,000kW*（3+1）
	JD.Boa Vista~JD.Vergueiro/2	1.40	2	6	120	30.0	2.8	2,600.0	186.6	6,554					
JD.Vergueiro	JD.Boa Vista~JD.Vergueiro/2	1.40	2	6	120	30.0	2.8	2,600.0	186.6	6,554	13,577	3,206	10,206	14,000	3,000kW*（3+1）
	JD.Verguiro~Santo Amaro/2	1.50	2	6	120	30.0	3.0	2,600.0	186.6	7,022					
	Depot									0			2,500		
Santo Amaro	JD.Verguiro~Santo Amaro/2	1.50	2	6	120	30.0	3.0	2,600.0	186.6	7,022	14,045	3,320	10,320	11,400	3,000kW*（3+1）
	Santo Amaro~Ponte de Morumbi/2	1.50	2	6	120	30.0	3.0	2,600.0	186.6	7,022					
Ponte de Morumbi	Santo Amaro~Ponte de Morumbi/2	1.50	2	6	120	30.0	3.0	2,600.0	186.6	7,022	14,045	3,260	10,260	11,300	3,000kW*（3+1）
	Ponte de Morumbi~Berrini/2	1.50	2	6	120	30.0	3.0	2,600.0	186.6	7,022					
Berrini	Ponte de Morumbi~Berrini/2	1.50	2	6	120	30.0	3.0	2,600.0	186.6	7,022	11,704	2,682	9,682	10,700	3,000kW*（3+1）
	Berrini~Vila Olimpia/2	1.00	2	6	120	30.0	2.0	2,600.0	186.6	4,682					
Vila Olimpia	Berrini~Vila Olimpia/2	1.00	2	6	120	30.0	2.0	2,600.0	186.6	4,682	12,874	2,924	9,924	11,000	3,000kW*（3+1）
	Vila Olimpia~Faria Lima/2	1.75	2	6	120	30.0	3.5	2,600.0	186.6	8,193					
Faria Lima	Vila Olimpia~Faria Lima/2	1.75	2	6	120	30.0	3.5	2,600.0	186.6	8,193	13,801	3,221	10,221	11,300	3,000kW*(3+1)
	Faria Lima~Butanta/2	1.50	2	6	240	30.0	1.5	2,600.0	186.6	3,511					
	Faria Lima~Sumare/2	1.75	2	4	360	30.0	1.2	2,000.0	140.0	2,097					
Butanta	Faria Lima~Butanta/2	1.50	2	6	240	30.0	1.5	2,600.0	186.6	3,511	8,778	2,142	7,142	7,900	3,000kW*（2+1）
	Butanta~V.Leopoldina/2	2.25	2	6	240	30.0	2.3	2,600.0	186.6	5,267					
V.Leopoldina	Butanta~V.Leopoldina/2	2.25	2	6	240	30.0	2.3	2,600.0	186.6	5,267	9,784	2,375	7,375	8,200	3,000kW*（2+1）
	V.Leopoldina~Jaguara/2	1.93	2	6	240	30.0	1.9	2,600.0	186.6	4,518					
Jaguara	V.Leopoldina~Jaguara/2	1.93	2	6	240	30.0	1.9	2,600.0	186.6	4,518	4,518	1,099	4,599	5,100	3,000kW*（1+1）
	~Jaguara	0.00	2	6	240	30.0	0.0	2,600.0	186.6	0					
Sumare	Faria Lima~Sumare/2	1.75	2	4	360	30.0	1.2	2,000.0	140.0	2,097	4,290	997	3,564	4,000	3,000kW*（1+1）
	Sumare~Barra Funda/2	1.83	2	4	360	30.0	1.2	2,000.0	140.0	2,193					
Barra Funda	Sumare~Barra Funda/2	1.83	2	4	360	30.0	1.2	2,000.0	140.0	2,193	2,193	502	2,299	2,600	2,000kW*（1+1）
	~Barra Funda	0.00	2	4	360	30.0	0.0	2,000.0	140.0	0					
Total		45.52										34,984	120,147	132,900	

Note: No. of Trains in Serction=60/Headway*Distance/Schedule Speed*2
Maximum Moter Current= 400A:*4M+200A*2Mc=2000 A:400A*5M+200A*1M+200A*2Mc=2600 A
Auxiliary Current of a Car=(20kW*2(Air Conditioner)/1.5kV+10kW/1.5kV)*0.7(Load Factor)=23.33A
Max Power by Calculation= No. of Trains in Section*Max Current of Train*1.2kV*0.7
Rectifier Capacity=150%(2Hours),300%(1Minutes)
Dimand Peak Power(kVA)=Maximum Power(kW)*1.1

Source: JICA Study Team

Table 5-23 Voltage drop in normal time (8 Car)

Substation	Section	Distance (km)	Feeding Resistnce		Cars/Train		Headway (sec)	Schedule Speed (km/h)	No. of Trains in Section of Direction	Max Current of a Train (A)	Maximum Current of SS (A)		Rectifier Capacity (kW)	Voltage Regulation (%)	Voltage (V)		Inner Resistance (Ω)	Feeding Voltage (V)
			Ω/km	Ω	Mc	M						Total			Standard	No Load		
Capao Redondo	~Capao Redondo	0.00	0.03605	0.00000	2	6	300	30.0	0.00	2,787	0	3,277	6,000	6	1,500	1,596	0.0239	1,517
	Capao Redondo~Jardim Angela/2	2.10	0.03605	0.07571	2	6	300	30.0	0.84	2,787	3,277							1,517
Jardim Angela	Capao Redondo~Jardim Angela/2	2.10	0.03605	0.07571	2	6	300	30.0	0.84	2,787	3,277	8,739	9,000	6	1,500	1,596	0.0160	1,456
	Jardim Angela~JD.S.Jose/2	1.40	0.03605	0.05047	2	6	120	30.0	1.40	2,787	5,462							1,456
JD.S.Jose	Jardim Angela~JD.S.Jose/2	1.40	0.03605	0.05047	2	6	120	30.0	1.40	2,787	5,462	10,728	12,000	6	1,500	1,596	0.0120	1,467
	JD.S.Jose~JD.Boa Vista/2	1.35	0.03605	0.04867	2	6	120	30.0	1.35	2,787	5,267							1,467
JD.Boa Vista	JD.S.Jose~JD.Boa Vista/2	1.35	0.03605	0.04867	2	6	120	30.0	1.35	2,787	5,267	10,728	12,000	6	1,500	1,596	0.0120	1,467
	JD.Boa Vista~JD.Vergueiro/2	1.40	0.03605	0.05047	2	6	120	30.0	1.40	2,787	5,462							1,467
JD.Vergueiro	JD.Boa Vista~JD.Vergueiro/2	1.40	0.03605	0.05047	2	6	120	30.0	1.40	2,787	5,462	11,314	12,000	6	1,500	1,596	0.0120	1,460
	JD.Verguiro~Santo Amaro/2	1.50	0.03605	0.05408	2	6	120	30.0	1.50	2,787	5,852							1,460
Santo Amaro	JD.Verguiro~Santo Amaro/2	1.50	0.03605	0.05408	2	6	120	30.0	1.50	2,787	5,852	11,704	12,000	6	1,500	1,596	0.0120	1,456
	Santo Amaro~Ponte de Morumbi/2	1.50	0.03605	0.05408	2	6	120	30.0	1.50	2,787	5,852							1,456
Ponte de Morumbi	Santo Amaro~Ponte de Morumbi/2	1.50	0.03605	0.05408	2	6	120	30.0	1.50	2,787	5,852	11,704	12,000	6	1,500	1,596	0.0120	1,456
	Ponte de Morumbi~Berrini/2	1.50	0.03605	0.05408	2	6	120	30.0	1.50	2,787	5,852							1,456
Berrini	Ponte de Morumbi~Berrini/2	1.50	0.03605	0.05408	2	6	120	30.0	1.50	2,787	5,852	9,753	12,000	6	1,500	1,596	0.0120	1,479
	Berrini~Vila Olimpia/2	1.00	0.03605	0.03605	2	6	120	30.0	1.00	2,787	3,901							1,479
Vila Olimpia	Berrini~Vila Olimpia/2	1.00	0.03605	0.03605	2	6	120	30.0	1.00	2,787	3,901	10,728	12,000	6	1,500	1,596	0.0120	1,467
	Vila Olimpia~Faria Lima/2	1.75	0.03605	0.06309	2	6	120	30.0	1.75	2,787	6,827							1,467
Faria Lima	Vila Olimpia~Faria Lima/2	1.75	0.03605	0.06309	2	6	120	30.0	1.75	2,787	6,827	12,029	12,000	6	1,500	1,596	0.0120	1,452
	Faria Lima~Butanta/2	1.50	0.03605	0.05408	2	6	240	30.0	0.75	2,787	2,926							1,452
	Faria Lima~Sumare/2	1.75	0.03605	0.06309	2	6	360	30.0	0.58	2,787	2,276							1,452
Butanta	Faria Lima~Butanta/2	1.50	0.03605	0.05408	2	6	240	30.0	0.75	2,787	2,926	7,315	9,000	6	1,500	1,596	0.0160	1,479
	Butanta~V.Leopoldina/2	2.25	0.03605	0.08111	2	6	240	30.0	1.13	2,787	4,389							1,479
V.Leopoldina	Butanta~V.Leopoldina/2	2.25	0.03605	0.08111	2	6	240	30.0	1.13	2,787	4,389	8,154	9,000	6	1,500	1,596	0.0160	1,466
	V.Leopoldina~Jaguara/2	1.93	0.03605	0.06958	2	6	240	30.0	0.97	2,787	3,765							1,466
Jaguara	V.Leopoldina~Jaguara/2	1.93	0.03605	0.06958	2	6	240	30.0	0.97	2,787	3,765	3,765	6,000	6	1,500	1,596	0.0239	1,506
	~Jaguara	0.00	0.03605	0.00000	2	6	240	30.0	0.00	2,787	0							1,506
Sumare	Faria Lima~Sumare/2	1.75	0.03605	0.06309	2	4	360	30.0	0.58	2,140	1,748	3,575	6,000	6	1,500	1,596	0.0239	1,510
	Sumare~Barra Funda/2	1.83	0.03605	0.06597	2	4	360	30.0	0.61	2,140	1,828							1,510
Barra Funda	Sumare~Barra Funda/2	1.83	0.03605	0.06597	2	4	360	30.0	0.61	2,140	1,828	1,828	4,000	6	1,500	1,596	0.0359	1,530
	~Barra Funda	0.00	0.03605	0.00000	2	4	360	30.0	0.00	2,140	0							1,530
Total		45.52											145,000					

Note: No. of Trains in Oneway Serction=3600/Headway*Distance/Schedule Speed
Maximum Current of SS= No. of Trains in Serction of Direction*Max Current of a Train*0.7*2
Inner Resistance=Standard V*(No Load V-Standard V)/Rectifier Capacity/1000
Feeding Voltage=No Load V-Max Current of SS*Inner Resistance
Minimum Voltage=Feeding Voltage-No. of Trains in Section of Direction*Max Current of a Train*0.7*Feeding Resistance*0.5

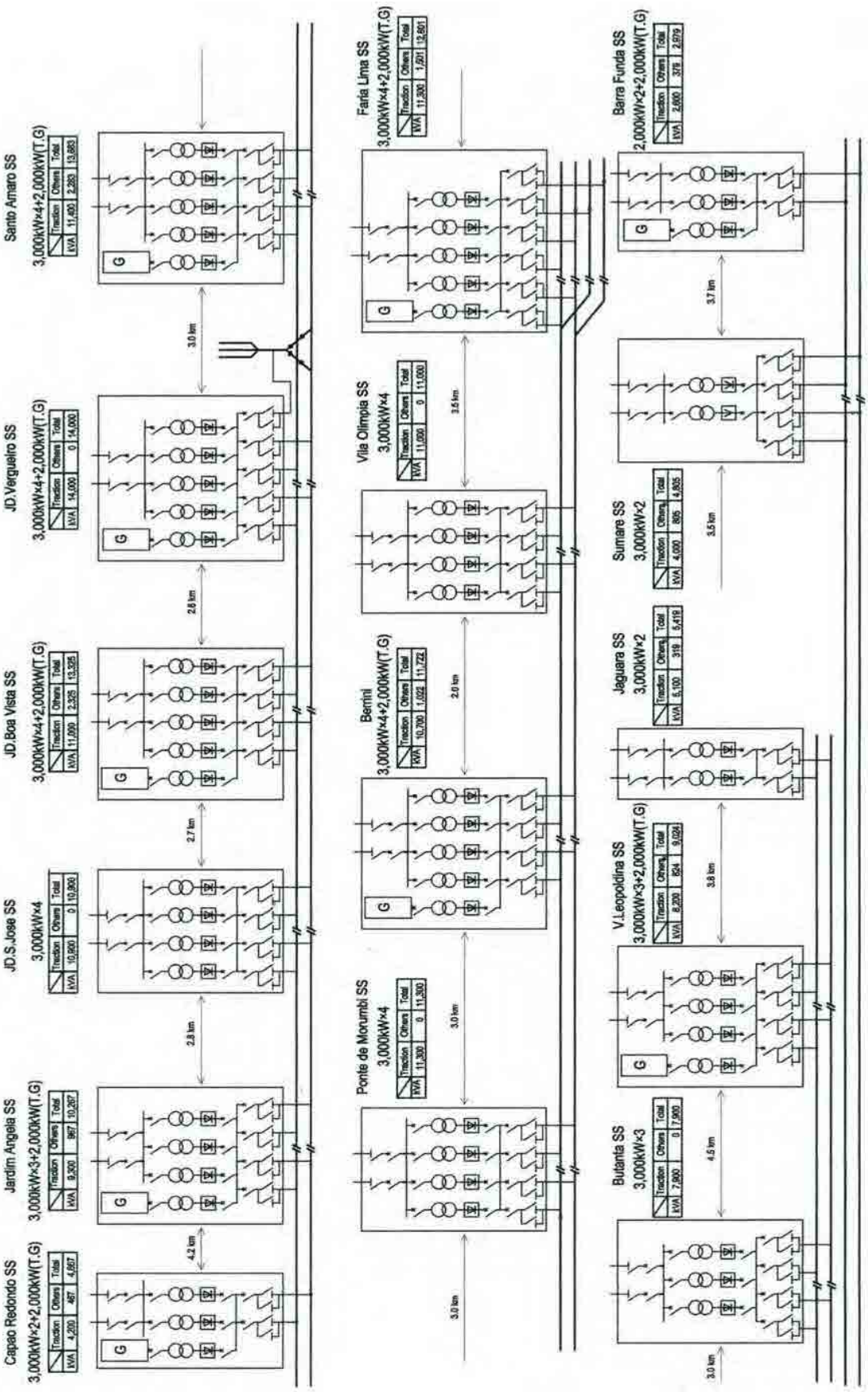
Source: JICA Study Team

Table 5-24 Voltage drop in failure time (8 Car)

Substation	Break Down Substation	Section	Distance (km)	Feeding Resistance		Cars/Train		Headway (sec)	Schedule Speed (km/h)	NO. of Trains in Section	Max Current of a Train (A)	Maximum Current of SS(A)		Rectifier Capacity (kW)	Voltage Regulation (%)	Voltage (V)		Inner Resistance (Ω)	Feeding Voltage (V)	Minimum Voltage (V)
				Ω/km	Ω	Mc	M						Total			Standard	No Load			
Capao Redondo	Jardim Angela	~Capao Redondo	0.00	0.03605	0.00000	2	6	300	30.0	0.00	2,787	0	7,804	6,000	6	1,500	1,596	0.0239	1,409	1,409
		Capao Redondo~JD.S.Jose/2	3.50	0.03605	0.12618	2	6	210	30.0	2.00	2,787	7,804							1,409	1,163
Jardim Angela	Capao Redondo	Capao Redondo~Jardim Angela	4.20	0.03605	0.15141	2	6	300	30.0	1.68	2,787	6,555	12,018	9,000	6	1,500	1,596	0.0160	1,404	1,156
		Jardim Angela~JD.S.Jose/2	1.40	0.03605	0.05047	2	6	120	30.0	1.40	2,787	5,463							1,404	1,335
	JD.S.Jose	Capao Redondo~Jardim Angela/2	2.10	0.03605	0.07571	2	6	300	30.0	0.84	2,787	3,278	14,007	9,000	6	1,500	1,596	0.0160	1,372	1,298
		Jardim Angela~JD.Boa Vista/2	2.75	0.03605	0.09914	2	6	120	30.0	2.75	2,787	10,730							1,372	1,106
JD.S.Jose	Jardim Angela	Capao Redondo~JD.S.Jose/2	3.50	0.03605	0.12618	2	6	210	30.0	2.00	2,787	7,804	13,071	12,000	6	1,500	1,596	0.0120	1,439	1,193
		JD.S.Jose~JD.Boa Vista/2	1.35	0.03605	0.04867	2	6	120	30.0	1.35	2,787	5,267							1,439	1,375
	JD.Boa Vista	Jardim Angela~JD.S.Jose/2	1.40	0.03605	0.05047	2	6	120	30.0	1.40	2,787	5,463	12,291	12,000	6	1,500	1,596	0.0120	1,449	1,380
		JD.S.Jose~JD.Vergueiro/2	1.75	0.03605	0.06309	2	6	120	30.0	1.75	2,787	6,828							1,449	1,341
JD.Boa Vista	JD.S.Jose	Jardim Angela~JD.Boa Vista/2	2.75	0.03605	0.09914	2	6	120	30.0	2.75	2,787	10,730	16,192	12,000	6	1,500	1,596	0.0120	1,402	1,136
		JD.Boa Vista~JD.Vergueiro/2	1.40	0.03605	0.05047	2	6	120	30.0	1.40	2,787	5,463							1,402	1,333
	JD.Vergueiro	JD.S.Jose~JD.Boa Vista/2	1.35	0.03605	0.04867	2	6	120	30.0	1.35	2,787	5,267	16,583	12,000	6	1,500	1,596	0.0120	1,397	1,333
		JD.Boa Vista~Santo Amaro/2	2.90	0.03605	0.10455	2	6	120	30.0	2.90	2,787	11,315							1,397	1,102
JD.Vergueiro	JD.Boa Vista	JD.S.Jose~JD.Vergueiro/2	1.75	0.03605	0.06309	2	6	120	30.0	1.75	2,787	6,828	12,681	12,000	6	1,500	1,596	0.0120	1,444	1,336
		JD.Vergueiro~Santo Amaro/2	1.50	0.03605	0.05408	2	6	120	30.0	1.50	2,787	5,853							1,444	1,365
	Santo Amaro	JD.Boa Vista~JD.Vergueiro/2	1.40	0.03605	0.05047	2	6	120	30.0	1.40	2,787	5,463	17,168	12,000	6	1,500	1,596	0.0120	1,390	1,321
		JD.Vergueiro~Ponte de Morumbi/2	3.00	0.03605	0.10815	2	6	120	30.0	3.00	2,787	11,705							1,390	1,074
Santo Amaro	JD.Vergueiro	JD.Boa Vista~Santo Amaro/2	2.90	0.03605	0.10455	2	6	120	30.0	2.90	2,787	11,315	17,168	12,000	6	1,500	1,596	0.0120	1,390	1,095
		Santo Amaro~Ponde de Morumbi/2	1.50	0.03605	0.05408	2	6	120	30.0	1.50	2,787	5,853							1,390	1,311
	Ponte de Morumbi	JD.Vergueiro~Santo Amaro/2	1.50	0.03605	0.05408	2	6	120	30.0	1.50	2,787	5,853	17,558	12,000	6	1,500	1,596	0.0120	1,386	1,306
		Santo Amaro~Berrini/2	3.00	0.03605	0.10815	2	6	120	30.0	3.00	2,787	11,705							1,386	1,069
Ponte de Morumbi	Santo Amaro	JD.Vergueiro~Ponte de Morumbi/2	3.00	0.03605	0.10815	2	6	120	30.0	3.00	2,787	11,705	17,558	12,000	6	1,500	1,596	0.0120	1,386	1,069
		Ponte de Morumbi~Berrini/2	1.50	0.03605	0.05408	2	6	120	30.0	1.50	2,787	5,853							1,386	1,306
	Berrini	Santo Amaro~Ponte de Morumbi/2	1.50	0.03605	0.05408	2	6	120	30.0	1.50	2,787	5,853	15,607	12,000	6	1,500	1,596	0.0120	1,409	1,330
		Ponte de Morumbi~Vila Olimpia/2	2.50	0.03605	0.09013	2	6	120	30.0	2.50	2,787	9,755							1,409	1,189
Berrini	Ponte de Morumbi	Santo Amaro~Berrini/2	3.00	0.03605	0.10815	2	6	120	30.0	3.00	2,787	11,705	15,607	12,000	6	1,500	1,596	0.0120	1,409	1,092
		Berrini~Vila Olimpia/2	1.00	0.03605	0.03605	2	6	120	30.0	1.00	2,787	3,902							1,409	1,374
	Vila Olimpia	Ponte de Morumbi~Berrini/2	1.50	0.03605	0.05408	2	6	120	30.0	1.50	2,787	5,853	16,583	12,000	6	1,500	1,596	0.0120	1,397	1,318
		Berrini~Faria Lima/2	2.75	0.03605	0.09914	2	6	120	30.0	2.75	2,787	10,730							1,397	1,131
Vila Olimpia	Berrini	Ponte de Morumbi~Vila Olimpia/2	2.50	0.03605	0.09013	2	6	120	30.0	2.50	2,787	9,755	16,583	12,000	6	1,500	1,596	0.0120	1,397	1,178
		Vila Olimpia~Faria Lima/2	1.75	0.03605	0.06309	2	6	120	30.0	1.75	2,787	6,828							1,397	1,290
	Faria Lima	Berrini~Vila Olimpia/2	1.00	0.03605	0.03605	2	6	120	30.0	1.00	2,787	3,902	7,179	12,000	6	1,500	1,596	0.0120	1,510	1,475
		Vila Olimpia~Sumare,Butanta/2	1.68	0.03605	0.06056	2	6	240	30.0	0.84	2,787	3,278							1,510	1,451
Faria Lima	Vila Olimpia	Berrini~Faria Lima/2	2.75	0.03605	0.09914	2	6	120	30.0	2.75	2,787	10,730	15,404	12,000	6	1,500	1,596	0.0120	1,411	1,145
		Faria Lima~Butanta/2	1.50	0.03605	0.05408	2	6	240	30.0	0.75	2,787	2,926							1,411	1,359
		Faria Rima~Sumare/2	1.75	0.03605	0.06309	2	4	360	30.0	0.58	2,140	1,748							1,411	1,364
	Butanta	Vila Olimpia~Faria Lima/2	1.75	0.03605	0.06309	2	6	120	30.0	1.75	2,667	6,534	15,283	12,000	6	1,500	1,596	0.0120	1,413	1,310
		Faria Lima~V.Leopoldia/2	3.75	0.03605	0.13519	2	6	240	30.0	1.88	2,667	7,001							1,413	1,176
		Faria Lima~Sumare/2	1.75	0.03605	0.06309	2	4	360	30.0	0.58	2,140	1,748							1,413	1,366
	Sumare	Vila Olimpia~Faria Lima/2	1.75	0.03605	0.06309	2	6	120	30.0	1.75	2,667	6,534	12,910	12,000	6	1,500	1,596	0.0120	1,441	1,338
		Faria Lima~Butanta/2	1.50	0.03605	0.05408	2	6	240	30.0	0.75	2,667	2,800							1,441	1,391
		Faria Lima~Barra Funda/2	3.58	0.03605	0.12906	2	4	360	30.0	1.19	2,140	3,575							1,441	1,326
Butanta	Faria Lima	Vila Olimpia, Sumare~Butanta/2	2.38	0.03605	0.08580	2	6	240	30.0	1.19	2,667	4,443	8,644	9,000	6	1,500	1,596	0.0160	1,458	1,363
		Butanta~V.Leopoldia	2.25	0.03605	0.08111	2	6	240	30.0	1.13	2,667	4,201							1,458	1,373
	V.Leopoldia	Faria Lima~Butanta/2	1.50	0.03605	0.05408	2	6	240	30.0	0.75	2,667	2,800	10,548	9,000	6	1,500	1,596	0.0160	1,427	1,377
		Butanta~Jaguara/2	4.15	0.03605	0.14961	2	6	240	30.0	2.08	2,667	7,748							1,427	1,138
V.Leopoldia	Butanta	V.Leopoldia~Faria Lima/2	3.75	0.03605	0.13519	2	6	240	30.0	1.88	2,667	7,001	10,548	9,000	6	1,500	1,596	0.0160	1,427	1,191
		V.Leopoldia~Jaguara/2	1.90	0.03605	0.06850	2	6	240	30.0	0.95	2,667	3,547							1,427	1,363
	Jaguara	Butanta~V.Leopoldia/2	2.25	0.03605	0.08111	2	6	240	30.0	1.13	2,667	4,201	11,295	6,000	6	1,500	1,596	0.0239	1,325	1,240
		V.Leopoldia~Jaguara	3.80	0.03605	0.13699	2	6	240	30.0	1.90	2,667	7,094							1,325	1,082
Jaguara	V.Leopoldia	Butanta~Jaguara/2	4.15	0.03605	0.14961	2	6	240	30.0	2.08	2,667	7,748	7,748	6,000	6	1,500	1,596	0.0239	1,410	1,121
		~Jaguara	0.00	0.03605	0.00000	2	6	240	30.0	0.00	2,667	0							1,410	1,410
Sumare	Faria Lima	Vila Olimpia,Butanta~Sumare/2	2.57	0.03605	0.09265	2	6	240	30.0	1.29	2,667	4,798	6,625	6,000	6	1,500	1,596	0.0239	1,437	1,326
		Sumare~Barra Funda/2	1.83	0.03605	0.06597	2	4	360	30.0	0.61	2,140	1,828							1,437	1,388
	Barra Funda	Faria Lima~Sumare/2	1.75	0.03605	0.06309	2	4	360	30.0	0.58	2,140	1,748	5,403	6,000	6	1,500	1,596	0.0239	1,466	1,419
		Samare~Barra Funda	3.66	0.03605	0.13194	2	4	360	30.0	1.22	2,140	3,655							1,466	1,346
Barra Funda	Samare	Faria Lima~Barra Funda/2	3.75	0.03605	0.13519	2	4	360	30.0	1.25	2,140	3,745	3,745	6,000	6	1,500	1,596	0.0239	1,506	1,380
		~Barra Funda	0.00	0.03605	0.00000	2	4	360	30.0	0.00	2,140	0							1,506	1,506
Total																				

Note: No. of Trains in Oneway Serction=60/Headway*Distance/Schedule Speed
Maximum Current of SS= No. of Trains in Serction of Direction*Max Current of a Train*0.7*2
Inner Resistance=Standard V*(No Load V-Standard V)/Rectifier Capacity/1000
Feeding Voltage=No Load V-Max Current of SS*Inner Resistance
Minimum Voltage=Feeding Voltage-No. of Trains in Section of Direction*Max Current of a Train*0.7*Feeding Resistance*0.5

Source: JICA Study Team



Source: JICA Study Team

Figure 5-63 Single Line of Power Feeding

(2) Feeding circuit

The parallel feeding system is adequate to save the voltage drop and raise the efficiency of regenerating system as shown in Figure 5-63.

To prevent the earth or short-circuit accident, it is necessary to set up the interlinked breaking equipments for DC high speed circuit breaker of mutual substation.

The main functions of substation are controlled by the remote supervisory control system of OCC.

(3) Equipment of substation

The recommendable main equipments of traction substation are as follows.

1) House of substation	Type: Indoor type
2) Scale of Substation	Floor are:1000~1300m2
3) Receiving equipment	Type: Cubicle type Equipment: Vacuum circuit-breaker, Electrically operated disconnecting switch, MOF panel and AC high voltage arrester.
4) Rectifier transformer	Type: SF6 gas charging type Connection: Delta or Star Neutral grounding system: Isolated neutral system
5) Silicon rectifier	Type Boiling Self-cooing type Rectifier system: 12 Pulses system
6) Feeding equipment	Type: Cubicle type Equipment: DC high speed circuit breaker, Disconnecting switch and DC arrester.
7) Power filter	

(4) Remark

- Unifying the capacity of transformer and rectifier as much as possible in consideration of interchangeability
- Installing a preliminary transformer and rectifier in consideration of maintenance. In the substation.
- Applying double three phase full wave rectification for reducing of radio wave trouble
- Installing the filter at DC side
- Installing the thyristor chopper resistance for the reliability of regenerative brake.

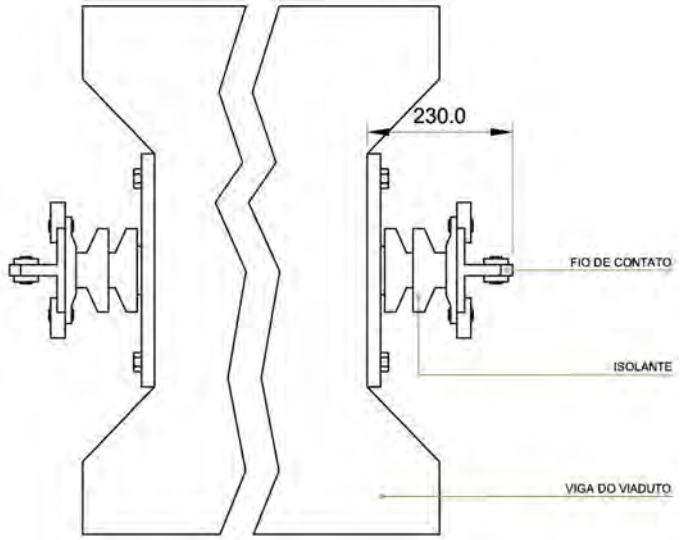
5.7.4 Contact line system for monorail

(1) The contact line system

The contact line is designed based on the train operation planning and the rolling stock planning, enduring the current capacity and the voltage drop. Considering the high demand, a double type rigid contact line system is adopted in this project.

(2) The structure of contact line

The contact line is laid at the both sides of girder of viaduct. The contact line is composed with the aluminum trestle and copper contact wire, because the aluminum and the copper are excellent in the weather resistance and the electric conductivity. To support the normal train running of the planned operation, it is necessary to adjust the resistance of contact line to about 0.036 Ω/km or less, and therefore the wear rate of contact wire becomes 60%. The concept figure of contact line structure is as shown in Figure 5-64.



Source: JICA Study Team

Figure 5-64 Structure of Contact line

(3) Composition and parameter of contract line

1) Contact wire and the trestle

As shown in Table 5-25, it is necessary that the section area of copper contact wire is more than 200mm^2 and the section area of aluminum trestle is more than 1722mm^2 to satisfy the required condition. And the parameters of member are as shown in Table 5-26.

An example of structure design is as shown in Figure 5-65 which is composed of the material with the following quality.

a) Trapezoid grooved hard copper contact wire with the nominal section area of 200mm^2

b) Corrosion resistively alloyed aluminum trestle

Table 5-25 Section area of Contact Line

Piece		Q'ty	Material		Section Area (㎟)	Conductivity >%	Weight		Resistance			Current Capacity (A)	Expansion Coefficient (1/℃*10^{-6})	Elastic Modules (kg/㎠*10^6)
							Gravity	(kg/m)	Ω/㎝*10^{-6} (20℃)	Ω/km (20℃)	Ω/Operating km (20℃)			
Aluminum Trestle	T Type	1	JIS H4100	A6063-T5	1,722	51.0	2.72	4.684	3.380	0.01963	0.03926		23.4	0.63
Contact Wire	GT-M-200	1	JIS E2101		200	70.0	8.73	1.745	1.768	0.08840	0.17680		17.0	1.20
	60% Wear	1			80	70.0	8.73	0.698	1.768	0.22100	0.44200		17.0	1.20
Aluminum Ear	Long Ear	2	JIS H4100	A6063-T6	115	51.0	2.72	0.313					23.4	0.70
Composite Value	Initial							6.742		0.01606	0.03212	2,300		
	60% Wear							5.695		0.01803	0.03605			

Note:
Requested Line Resistance=0.03605/2=0.01803 (Ω/km(20 ^{o}C))
Line Resistance of Contact Wire(GT-M-200) at 60% Wear=1.768*10-6*100/(200*0.4)*105= 0.221(Ω/km(20^{o}C))
Line Resistance of Aluminum Trestle=(0.22100*0.01803)/(0.22100-0.01803)=0.01963(Ω/km(20^{o}C))
Required section area of Aluminum Trestle=3.380*10/0.01963=1,722 ㎟

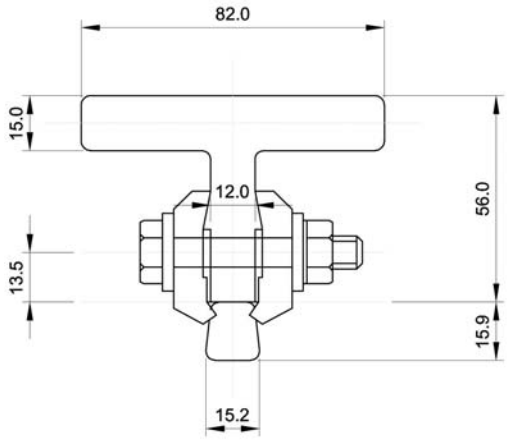
Source: JICA Study Team

Table 5-26 Parameters of member

Y		A	B	C	D	S	Note
Scale(㎜)	All	15	82	12	56		
Area(㎜^{2})						1,722	A*B+(D-A)*C
S(㎜^{3})=Moment of Area						-861	A/2*A*B-(D-A)/2*(D-A)*C
Gravity Center(㎜)						16	A-S/Area
Moment of Inercia of Area(㎜^{4})						23,063	B*A^3/12
E＝Difference of Center						8	Gravity Center-A/2
Area						1,230	A*B
Moment of Inercia of Area(㎜^{4})						68,921	C*(D-A)^3/12
E＝Difference of Center						20	(D-A)/2-(Gravity Center-A)
Area						492	C*(D-A)
Moment of Inercia of Area(㎜^{4})						101,783	B*A^3/12+E^2*A*B
						265,721	C*(D-A)^3/12+E^2*C*(D-A)
	All					367,504	Sum Up

X		A	B	C	D	S	Note
Scale(mm)	All	15	82	12	56		
Area(mm^2)						1,722	A*B+(D-A)*C
S(mm^3)=Moment of Area						0	
Gravity Center(mm)						0	
Moment of Inercia of Area(mm^4)						689,210	A*B^3/12
E						0	
Area						1,230	A*B
Moment of Inercia of Area(mm^4)						5,904	(D-A)*C^3/12
E						0	
Area						492	C*(D-A)
Moment of Inercia of Area(mm^4)						689,210	A*B^3/12
						5,904	(D-A)*C3/12
	All					695,114	Sum Up

Source: JICA Study Team



Source: JICA Study Team

Figure 5-65 Design of trestle

2) Ear

Corrosion resistively alloyed aluminum ear with the nominal section area of 250mm^2

3) Electric resistance of contact line

Direct current composed resistance: 0.03605 Ω/km(20^{o}C)

4) Specification of support Insulator

DC 1,500V: Line post insulator

Diameter: 175φ

60Hz fire-flow withstand voltage: 24kV

Torsion breaking load: 588Nm

Tensile braking load: 9,800N

Bending breaking load: 5,300N

Surface leakage current length: 275mm

5) Interval of support insulator

From the material and the shape of contact line, the relation between the interval of support insulator and the stress of contact line by self weight is calculated as shown in the Table 5-27.

According to the table, the nominal required interval is about 5m. The maximum interval is recommended as 4m taking the workers and tools weight into consideration that may get on the contact line during the construction addition to the safety factor. At the locations of track switch, the intervals shall be shorter.

Table 5-27 Interval of support insulators

(B)	Moment of Inertia of Area B(㎜⁴)	695,114.00
(C)	Distance from Center C (㎜)	41.00
(X)=(B)/(C)	Section Modulus X(㎜³)=B/C	16,954.00

Span	Self Weight		Weight of Worker	Bending Moment	Stress	Permanent Set Stress
A(m):	D(Kg/m)	E(Kg)=A*D	F(kg)	G(kg*㎜)=(E+F)*A/4*1000	S(kg/㎟)=G/X	of Aluminium(kg/㎟)
2.50	6.742	16.855	95.00	69,909.38	4.12	11
2.60	6.742	17.529	95.00	73,143.98	4.31	11
2.70	6.742	18.203	95.00	76,412.30	4.51	11
2.80	6.742	18.878	95.00	79,714.32	4.70	11
2.90	6.742	19.552	95.00	83,050.06	4.90	11
3.00	6.742	20.226	95.00	86,419.50	5.10	11
3.10	6.742	20.900	95.00	89,822.66	5.30	11
3.20	6.742	21.574	95.00	93,259.52	5.50	11
3.30	6.742	22.249	95.00	96,730.10	5.71	11
3.40	6.742	22.923	95.00	100,234.38	5.91	11
3.50	6.742	23.597	95.00	103,772.38	6.12	11
3.60	6.742	24.271	95.00	107,344.08	6.33	11
3.70	6.742	24.945	95.00	110,949.50	6.54	11
3.80	6.742	25.620	95.00	114,588.62	6.76	11
3.90	6.742	26.294	95.00	118,261.46	6.98	11
4.00	6.742	26.968	95.00	121,968.00	7.19	11
4.10	6.742	27.642	95.00	125,708.26	7.41	11
4.20	6.742	28.316	95.00	129,482.22	7.64	11
4.30	6.742	28.991	95.00	133,289.90	7.86	11
4.40	6.742	29.665	95.00	137,131.28	8.09	11
4.50	6.742	30.339	95.00	141,006.38	8.32	11
4.60	6.742	31.013	95.00	144,915.18	8.55	11
4.70	6.742	31.687	95.00	148,857.70	8.78	11
4.80	6.742	32.362	95.00	152,833.92	9.01	11
4.90	6.742	33.036	95.00	156,843.86	9.25	11
5.00	6.742	33.710	95.00	160,887.50	9.49	11
5.10	6.742	34.384	95.00	164,964.86	9.73	11
5.20	6.742	35.058	95.00	169,075.92	9.97	11
5.30	6.742	35.733	95.00	173,220.70	10.22	11
5.40	6.742	36.407	95.00	177,399.18	10.46	11
5.50	6.742	37.081	95.00	181,611.38	10.71	11
5.60	6.742	37.755	95.00	185,857.28	10.96	11
5.70	6.742	38.429	95.00	190,136.90	11.21	11

Note:
Worker's Weight=70kg (Average in Brazil) +25kg(Others)
Allowance of 30% for Weight = 5.6m*70%=3.8m
Source: JICA Study Team

6) Length of contact line

It is designated to locate the 400mm joint equipment at each 100m line length. The values are calculated based on the function of expansion/ contraction length and material's characteristic to absorb the length change of contact lines by temperature as shown in the Table 5-28.

The thermal expansion coefficient of aluminum is $23.4/^{o}C\times10^{-6}$. Climate temperature change is assumed between 0 ^{o}C and 35 ^{o}C. And the temperature change of contact line is assumed to be 100 ^{o}C because the maximum temperature of aluminum is 100 ^{o}C.

Table 5-28 Length of Contact Line

Temperature Difference(℃)	Thermal Expansion Coefficient(1/℃*10⁻⁶)	Expansion Length of Contact Line(mm)			
		100m	125m	150m	175m
5	23.4	11.7	14.6	17.6	20.5
10	23.4	23.4	29.3	35.1	41.0
15	23.4	35.1	43.9	52.7	61.4
20	23.4	46.8	58.5	70.2	81.9
25	23.4	58.5	73.1	87.8	102.4
30	23.4	70.2	87.8	105.3	122.9
35	23.4	81.9	102.4	122.9	143.3
40	23.4	93.6	117.0	140.4	163.8
45	23.4	105.3	131.6	158.0	184.3
50	23.4	117.0	146.3	175.5	204.8
55	23.4	128.7	160.9	193.1	225.2
60	23.4	140.4	175.5	210.6	245.7
65	23.4	152.1	190.1	228.2	266.2
70	23.4	163.8	204.8	245.7	286.7
75	23.4	175.5	219.4	263.3	307.1
80	23.4	187.2	234.0	280.8	327.6
85	23.4	198.9	248.6	298.4	348.1
90	23.4	210.6	263.3	315.9	368.6
95	23.4	222.3	277.9	333.5	389.0
100	23.4	234.0	292.5	351.0	409.5
105	23.4	245.7	307.1	368.6	430.0
110	23.4	257.4	321.8	386.1	450.5
115	23.4	269.1	336.4	403.7	470.9
120	23.4	280.8	351.0	421.2	491.4
125	23.4	292.5	365.6	438.8	511.9
130	23.4	304.2	380.3	456.3	532.4
135	23.4	315.9	394.9	473.9	552.8
140	23.4	327.6	409.5	491.4	573.3
145	23.4	339.3	424.1	509.0	593.8
150	23.4	351.0	438.8	526.5	614.3
155	23.4	362.7	453.4	544.1	634.7
160	23.4	374.4	468.0	561.6	655.2
165	23.4	386.1	482.6	579.2	675.7
170	23.4	397.8	497.3	596.7	696.2
175	23.4	409.5	511.9	614.3	716.6

Note: Dark gray shows range of temp. change, light gray shows range of permissible expansion (Δ<300mm)
Source: JICA Study Team

7) Deflection of contact line

The deflection of contact line for wearing the contact shoe is about 60mm.

8) Other pieces

a) Expansion joint

The expansion joint has function of absorbing the expansion/ contraction of contact line due to temperature change. The terminal part of contact line is connected with an enough electric current capacity cable.

Generally, the parallel length of contact line is 400mm and the isolation between contact lines is 50mm.

b) Section

The section is equipped in the connection part of the feeder of substation.

Additionally, it is equipped in the cross part of track and the sectioning part of contact line etc.

c) Anchor ring

Anchor ring is the equipment that prevents the movement of contact line by the temperature change.

Anchor ring is equipped at the center of length of contact line, and the upper and lower deflection is set up.

d) Protection board

The protection board is equipped at the part that faced platform in plus contact line and is equipped at the part of contact line of ground height 5m or less.

e) Ground board for train

About the monorail the static electricity is charged in the car body easily by the reason of insulating at rubber tire and it requires the installation of discharging to prevent electric shock Ground board is equipped at the platform and at the storage track.

f) Arrester

The arrester is equipped at interval of 500m generally.

5.7.5 Distribution of general electric power

(1) The Constitution of distribution line

About the constitution of distribution circuit, electric power is converted into AC13.8kV from receiving voltage of traction substation, and supplied to each station or depot respectively by double lines.

The transformer needs sufficient capacity to cover an adjacent failure substation.

It is necessary to set up the electric generator at the main station that has the switching gears, the underground station and also OCC.

And the main distribution functions of substation are controlled by the remote supervisory control system of OCC.

(2) Distribution Load

The equipments of station have been becoming very important lately according to development and diversity of automation and information. Therefore it is important to separate the load by their roles. For example they are the load for driving operation, the load for information, the load for passenger leading and the load for emergency lighting etc.

And about the switching gear introduced by this plan, the starting current is more than five times of switching current. Therefore be careful enough at the designing of low voltage cable.

The distribution load of stations and total load of substations in this plan is as shown in Table 5-29 and Table 5-30.

Table 5-29 Distribution Load of stations

Line	Traction SS Location			Distribution S.S Location		Station Capacity								SS:Normal			S S :Adjoining Failure	SS Transformer
	km	Name	Interval (km)	Name	Interval (km)	Name	Type	OD/h	EG	No	Station(kVA)	Yard Switch(kVA)	Capacity(kVA)	Capacity (kVA)	Ratio(kVA)	Capacity(kVA)	Capacity(kVA)	kVA
	0.000					No6-Capao Redondo	B	15,179	1	1	175	22	197					
	1.200	Capao Redondo		Capao Redondo		No5	A	964		1	152		152		474	474	939	1,000
Line-1	2.000					No4	A	1,958		1	152		152					
	2.700		4.200		4.2	No3	A	4,574		1	152		152	1,083				
	3.340					No2	A	4,573		1	152		152					
	4.150	Jardim Angela				No1-JD.Angela	F	24,746	1	1	256	22	278		609			
	4.200			Jardim Angela							0		0			929	2,070	2,000
	4.200										0		0					
	5.750		2.800			No2	G	1,353	1	1	176		176		320			
	6.760					No3	A	1,607		1	152		152					
	7.000										0		0					
	7.000	JD.S.Jose			5.500						0		0	808				
	7.650					No4	G	1,607	1	1	176		176					
	8.350		2.700			No5	A	1,607		1	152		152		488			
	9.350					No6	A	3,074		1	152		152					
Line-2A	9.700			JD.Boa Vista							0		0			2,281	3,367	3,000
	9.700	JD.Boa.Vista									0		0					
	10.500					No7	A	3,566		1	152		152					
	11.600		2.800			No8-Guarapira	A	4,106	1	1	152	22	174		1,793			
	12.500					No9	A	1,685		1	152		152					
	12.500	JD.Vergueiro			5.800	Depot,OCC					2,666		2,666	3,477				
	13.550					No10	A	6,254	1	1	152	22	174		1,684			
	14.450		3.000			Socorro(No11)	C	9,105		1	159		159					
	15.500										0		0					
	15.500	Santo Amaro									0		0			2,173	3,313	3,000
	15.640			Santo Amaro		Sant Amaro(No12-No1)	B	7,774	1	1	175	22	197					
	16.540					No2	A	6,579		1	152		152					
	17.090		3.000			No3				0	0		0		489			
	18.190					No4	A	3,700		1	152		152					
	18.500	Ponte de Morumbi			6.000						0		0	979				
	18.500										0		0					
	19.440					No5	A	790		1	152		152					
	20.390		3.000			Morumbi(No6)	A	452	1	1	152	22	174		490			
	21.400					No7	A	3,854		1	152		152					
	21.500	Berrini		Berrini							0		0			968	2,055	2,000
	21.500										0		0					
Line-2B	22.240					No8	A	364		1	152		152					
	22.890		2.000			No9	A	744		1	152		152		478			
	23.500										0		0					
	23.500	Vila Olimpia									0		0					
	23.590				5.500	No10	A	5,124		1	152		152	1,098				
	24.490					No11	A	449		1	152		152					
	25.340		3.500			No12	A	4,996		1	152		152		620			
	26.240					No13	A	5,889		1	152		152					
	26.930			Faria Lima		Faria Lima(No14-No1)	D	25,201	1	1	164	22	186			1,365	1,849	2,000
	27.000										0		0					
	27.000	Faria Lima									0		0					
	27.760					No2	A	1,756	1	1	152	22	174					
	28.780		3.000			No3	A	13,748	1	1	152		152		598			
	29.480					No4	A	2,802		1	152		152					
	30.000										0		0					
	30.000	Butanta			7.500						0		0	1,086				
	30.380					USP(No5)	A	323		1	152		152					
	31.180		4.500			USP(No7)	A	3,288		1	152		152		488			
Line-2D	31.880					USP(No7a)	A	2,550		1	152		152					
	33.500			V.Leopoldina		No8	A	4,085		1	152		152			814	1,496	1,500
	34.500										0		0					
	34.500	V.Leopoldina									0		0					
	34.620					No9	A	4,160		1	152		152		326			
	35.410		3.805		3.805	No10	A	3,611		1	152		152	653				
	36.730	Jaguara		Jaguara		No11	A	2,359		1	152		152		327	327	734	1,000
	38.305					Jaguara(No12)	B	21,714	1	1	175	22	197					
	27.930	Faria Lima		Faria Lima		No2	A	650		1	127		127		147			
	29.030		3.500		3.500	No3	A	597		1	127		127	254				
	29.880					No4				0	0		0		107			
	30.500										0		0					
Line-2C	30.500	Sumare		Sumare							0		0			420	594	1,000
	30.630					Sumare(No5)	E	746		1	112		112		312			
	31.280		3.655		3.655	No6	A	799		1	127		127	661				
	32.130					No7	A	643		1	127		127					
	33.180	Barra Funda		Barra Funda		No8	A	6,296		1	127		127		349	349	559	1,000
	34.155					Barra Funda(No9)	B	4,563	1	1	146	22	168					
Total			45.460		45.460			226,564	13	47			10,099	10,099	10,099	10,099		

Source: JICA Study Team

Table 5-30 Total load of substations

Route	Substation	No. of Incoming Circuits	Traction				Excluding Traction		Total	Primary Substation		
			Rectifire Capacity (kWh/h)		Maximum Power (kW)	Demand Peak Power (kVA)	Capacity of Transformer (kVA)	Demand Power (kVA)	Demand Power (kVA)	Name	Subtotal of Demand	Capacity of Transformer
01	Capao Redondo	2	3,000kW*2	6,000	3,812	4,200	1,000	474	4,674	PSS-1	66,657	100,000kVA*2
	Jardim Angela	2	3,000kW*3	9,000	8,452	9,300	2,000	929	10,229			
02A	JD.S.Jose	2	3,000kW*4	12,000	9,852	10,900			10,900			
	JD.Boa Vista	2	3,000kW*4	12,000	9,940	11,000	3,000	2,281	13,281			
	JD.Vergueiro	2	3,000kW*4	12,000	12,706	14,000			14,000			
	Santo Amaro	2	3,000kW*4	12,000	10,320	11,400	3,000	2,173	13,573			
02B	Ponte de Morumbi	2	3,000kW*4	12,000	10,260	11,300			11,300		46,633	
	Berrini	2	3,000kW*4	12,000	9,682	10,700	2,000	968	11,668			
	Vila Olimpia	2	3,000kW*4	12,000	9,924	11,000			11,000			
	Faria Lima	2	3,000kW*4	12,000	10,221	11,300	2,000	1,365	12,665			
02D	Butanta	2	3,000kW*3	9,000	7,142	7,900			7,900	PSS-2	22,341	30,000kVA*2
	V.Leopoldia	2	3,000kW*3	9,000	7,375	8,200	1,500	814	9,014			
	Jaguara	2	3,000kW*2	6,000	4,599	5,100	1,000	327	5,427			
02C	Sumare	2	3,000kW*2	6,000	3,564	4,000	1,000	420	4,420		7,369	
	Barra Funda	2	2,000kW*2	4,000	2,299	2,600	1,000	349	2,949			
	Total			145,000	120,148	132,900	17,500	10,100	143,000			

Note:Rectifier Transformer Capacity=150%(2Hours),300%(1Minute)
: It is possible to stop one rectifier of substation by maintenance
: As for the traction, if one substation should be failure,adjoining substations will cover that about 2 hours in peak time
: As for the excluding traction, if one substation should be failure,adjoining substations will cover that all day long

Source: JICA Study Team

5.8 SIGNALING AND TELECOMMUNICATIONS

5.8.1 General

Monorail is one of the new traffic systems belonging to Medium Capacity Transit using rubber tires instead of conventional iron wheels used by MRT. On the other hand, signaling and telecommunication system of monorail is as same as that of MRT. From this point of view, the signaling and telecommunication system of São Paulo Metro can be used as reference for the monorail system. Introduction of CBTC as new signaling system for São Paulo Metro is underway since the latter half of 2008.

CBTC is one of the signaling systems based on the new principle that is detecting locations on-board itself and moving block system without fixed block system depending on the conventional train detection system using inductive loop antenna.

CBTC is possible to minimize the interval safe length between trains ahead and following in accordance with their speed and also it is possible to increase the traffic density without modifying signaling system.

For this project it is strongly recommended applying CBTC for the signaling system, because CBTC for monorail is also able to meet increasing traffic demand in future without modifying signaling system.

There are several manufacturers who produce CBTC products in the world, and it can be said that their safety, reliability, availability and maintainability are high.

5.8.2 Signaling system

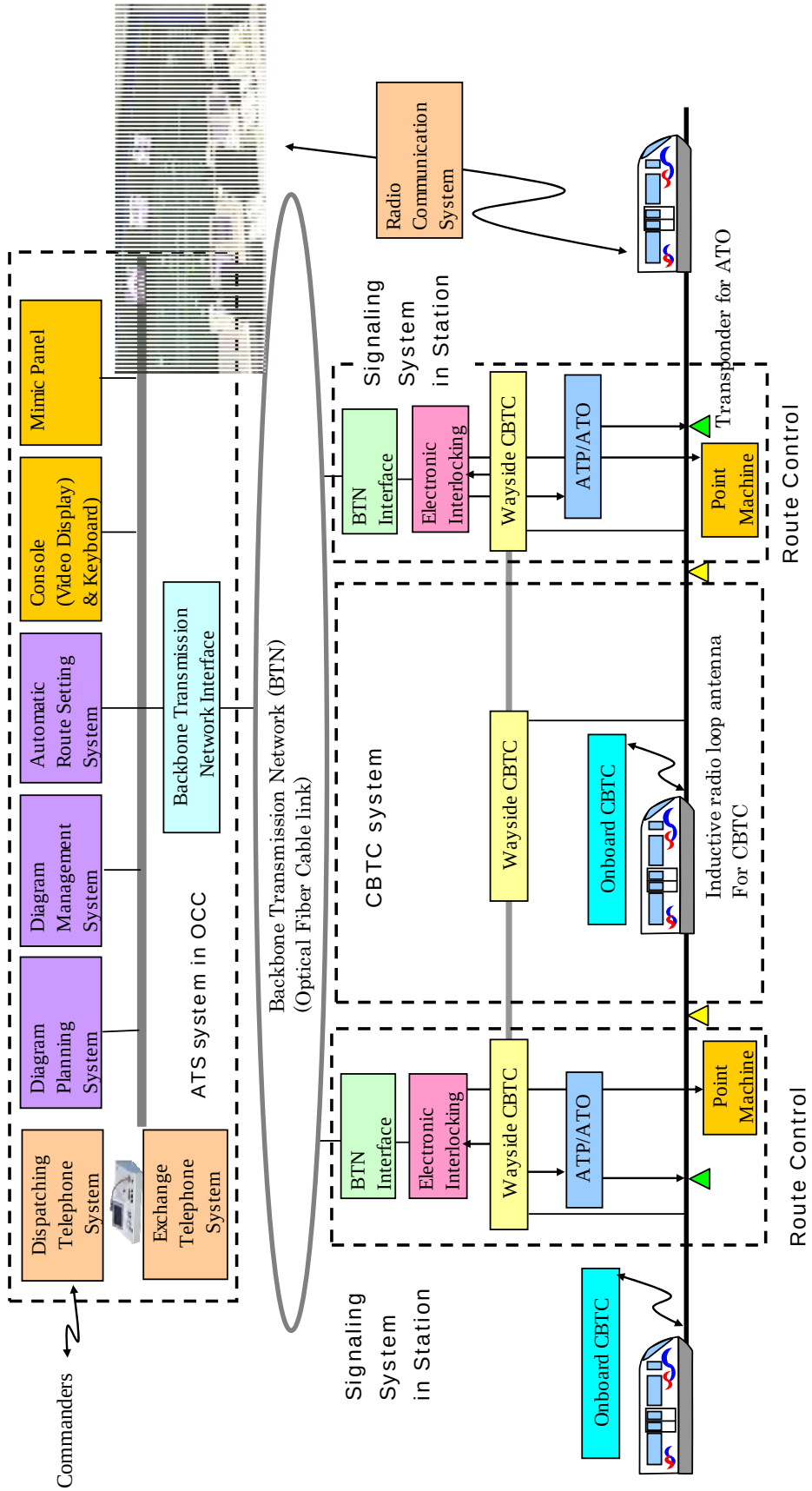
(1) Outline of signaling system

Schematic configuration of signaling system for monorail is shown in Figure 5-66.

1) Operation Method and Signaling System

It is proposed to introduce Automatic Train Operation system (ATO) with a train driver. The trains will be operated automatically by ATO in the main line and cab signal with Communication Based Train Control System (CBTC) will be used. The train driver just monitors the ATO and makes sure ahead safety visually and in case of failure or emergency, he operates manually after changing from ATO mode to manual mode. On the other hand, the shunting in station yard and depot access line will be operated manually. Automatic Train Protection system (ATP) will be used between the main line and the depot storage line, while wayside signal will be used between the storage line and the workshop. These are summarized as:

Line	Operation method	Signaling
Main line	ATO with a train driver	Cab signal with CBTC
Between main line and depot storage line	Manual	ATP
Between storage line and workshop	Manual	Wayside signal



Source: JICA Study Team

Figure 5-66 Schematic Configuration of Signaling System

2) Traffic management

Operation Control Center (OCC) will be provided in Depot for the centralized traffic management of the monorail lines. Automatic Traffic Supervision system (ATS) and Tel-communication system will be installed in OCC for the automatic control of trains in accordance with train schedule.

3) Provision against accident

Rescue trains will be operated in case of accident with ATP for both directions.

4) Provision for signaling system failure

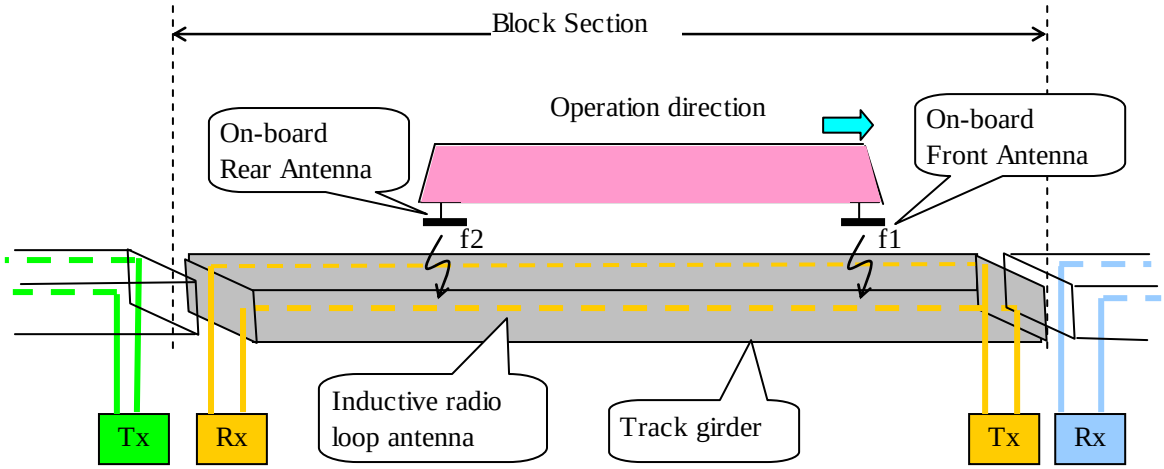
a) Block system between stations with wayside signal will be used if CBTC failure occurs.

b) Manual route setting function and manual point machine control function will be provided if ATS system failure occurs.

(2) Conventional signaling system for monorail

1) Train Detection system

Track circuits, which are largely used for railways to detect the presence of a train, can not be applied to monorails which use rubber tires. The principle of train detection for a monorail is that inductive radio loop antennas buried in track girder receive train detecting information from on-board antennas as shown in Figure 5-67.



Source: JICA Study Team

Figure 5-67 Principle of Train Detection

A train is equipped with two sets of a transmitter at front and rear of the train, transmitting a signal of f1 and f2, respectively.

The train is detected when ground loop antenna receives frequency f1 from front side of train and become clear when frequency f2 comes out after receiving f2 from rear side of train.

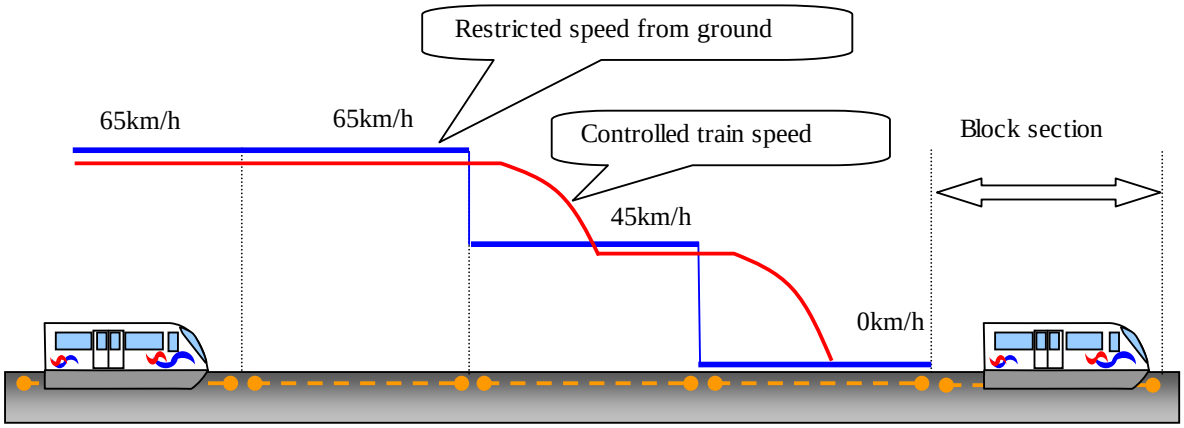
A loop antenna is provided to each block section, permitting only one train to occupy the block section. The block length is decided considering brake distance of a train and the safety marginal distance.

2) ATP system

Restricted speed data is given through loop antennas from track girders to on-board equipment in accordance to the block location where ahead train is occupying.

These data is transmitted to each block section step by step to enable multi-step speed control. The concept of the multi-step speed control is shown in Figure 5-68.

The train speed does not decrease gradually but discontinuously because of the nature of the stepping speed control system. The train headway depends on the block length. This method is called a fixed block system.



Source: JICA Study Team

Figure 5-68 Multi-step speed control of traditional ATP

(3) CBTC system for monorail

Provision of CBTC system will be recommended as applicable signaling system for São Paulo Monorail because of following two reasons.

- This system is available to obtain the minimum train head way.
- This system is lower cost than conventional fixed block system.

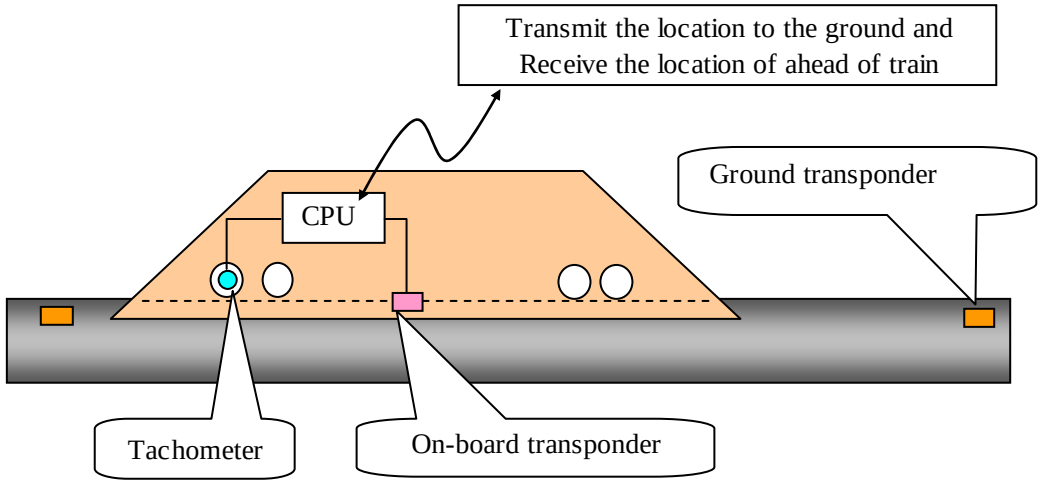
The outline of CBTC system is as follows.

1) Train detection system

The characteristic of CBTC system is that a train detects its location by itself. The principle of train location is the calculation of running distance from tachometer attached to a tire wheel and beacon or transponder which transmits the absolute location.

On wayside passive transponder will be installed. The necessary equipments of CBTC for train detection are less than that of conventional signaling system.

The principal of the train detection is shown in Figure 5-69.



Source: JICA Study Team

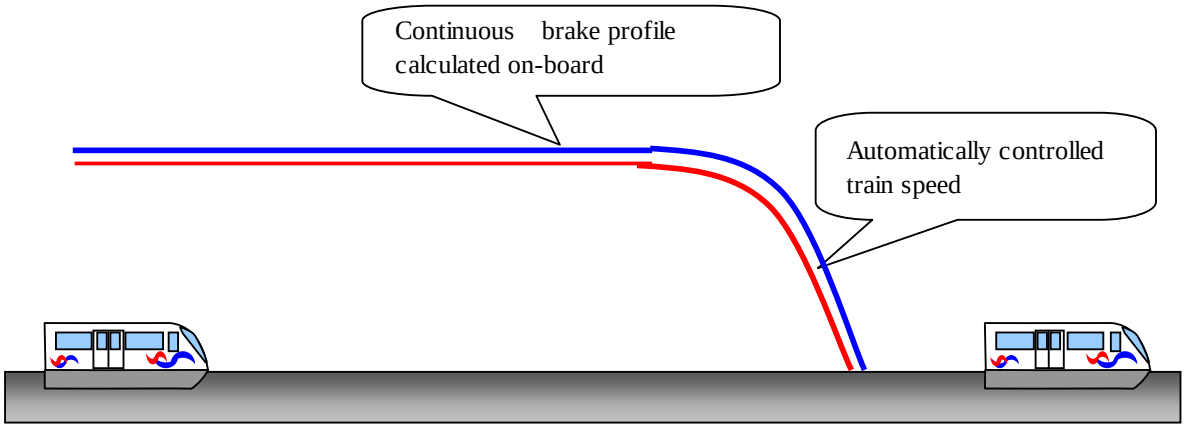
Figure 5-69 Principle of Train Detection

2) ATP function

ATP on-board system automatically calculates the brake profile in accordance with the distance to the preceding train, and continuously controls the speed of the train on which the ATP is installed. This block system is called 'Moving Block system'.

The train headway of a conventional ATP depends on the block length but the headway of CBTC system does not depend on the block length and safety interval distance is moving according with the movement of the preceding train.

Continuous brake profile of CBTC is shown in Figure 5-70.



Source: JICA Study Team

Figure 5-70 Continuous brake profile of CBTC system

3) Communication between train and ground

There are various methods for communication between train and ground. Various methods and feature is shown in Table 5-31.

We recommend Inductive radio loop method for communication of CBTC because of following reasons.

- Induction radio communication uses only weak electro-magnet field and low frequency not more than several 10kHz frequency, therefore the wave authority

approval is not required.

- On board antenna and loop antenna at ground is always coupled keeping constant gap. Therefore this method is steady against the outer wave noise. It is better to select this method because the monorail route is passing through the noisy environment for airplane communication.
- Induction radio method is already using as train detection and ATP system of conventional signaling system for monorail and is matured communication technology.
- Before all steady communication between train and ground is obtained with this method.
- This system dose not mar the monorail landscape so that loop antenna is buried in track girder.

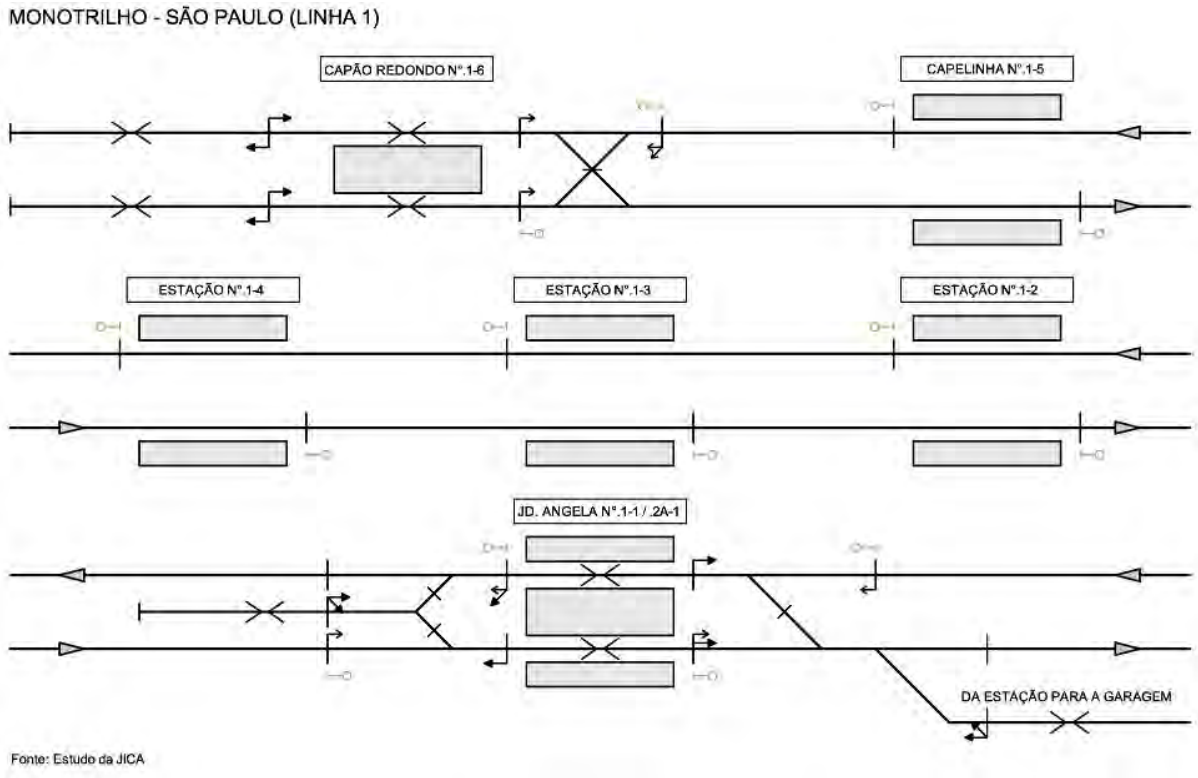
Table 5-31 Communication Method and Feature

Communication Method	Feature	Practical example
Inductive radio loop antenna	Steady communication is expected. Suitable for Monorail	Detroit APM Rubber tire New York JFK Airport San Francisco SF Muni LRT
Radio space wave using ISM band 2.45GHz or 5.2GHz	Authority approval is not needed. Provision against wave disturbance. Radio station interval is about 300m - 500m.	Many
Radio antenna using special frequency band for public service	Authority approval using frequency is required. Radio station interval is large. (about 3km) immune against wave disturbance	JR East is planning practical use at Senseki Line in 2010. (170-220MHz) called ATACS Sweden regional traffic RBS (450MHz band) Deutshe Bahn regional line SIMIS FFBsystem (900MHz band)
Micro wave Wave guide	Steady communication is expected. Installation cost is very high.	Singapore NE

Source: JICA Study Team

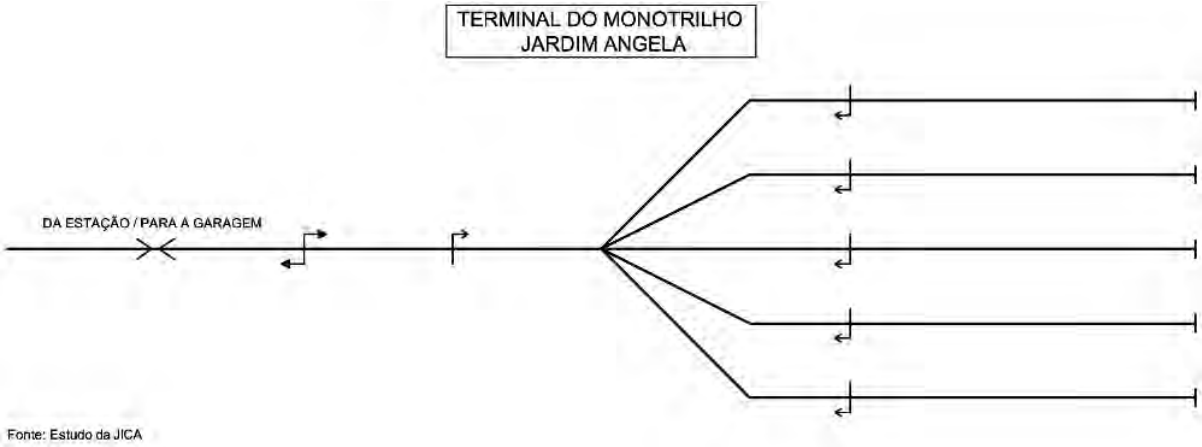
(4) Track layout and signaling arrangement

Track layout and signaling arrangement of Line-1, Line-2A, Line-2B, Line-2C and Line-2D is shown in following drawings.



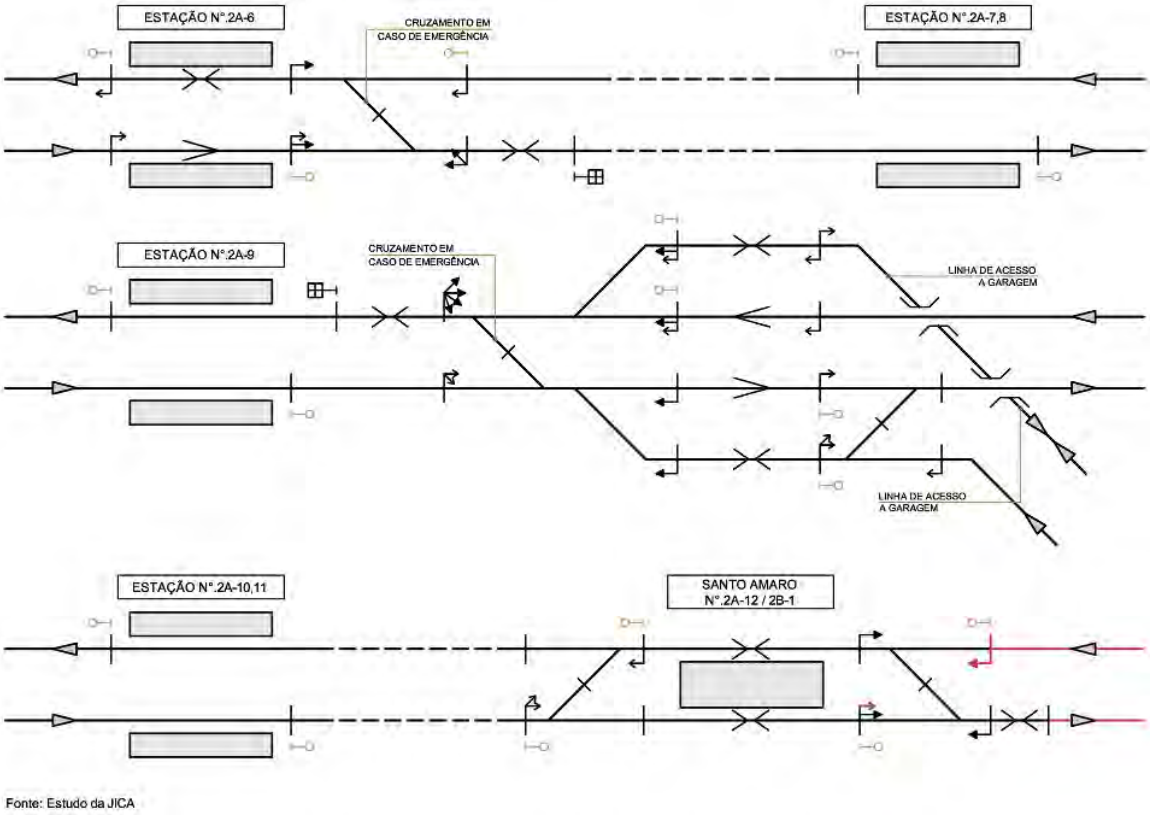
Source: JICA Study Team

Figure 5-71 Track Layout and Signaling Arrangement of Line-1A



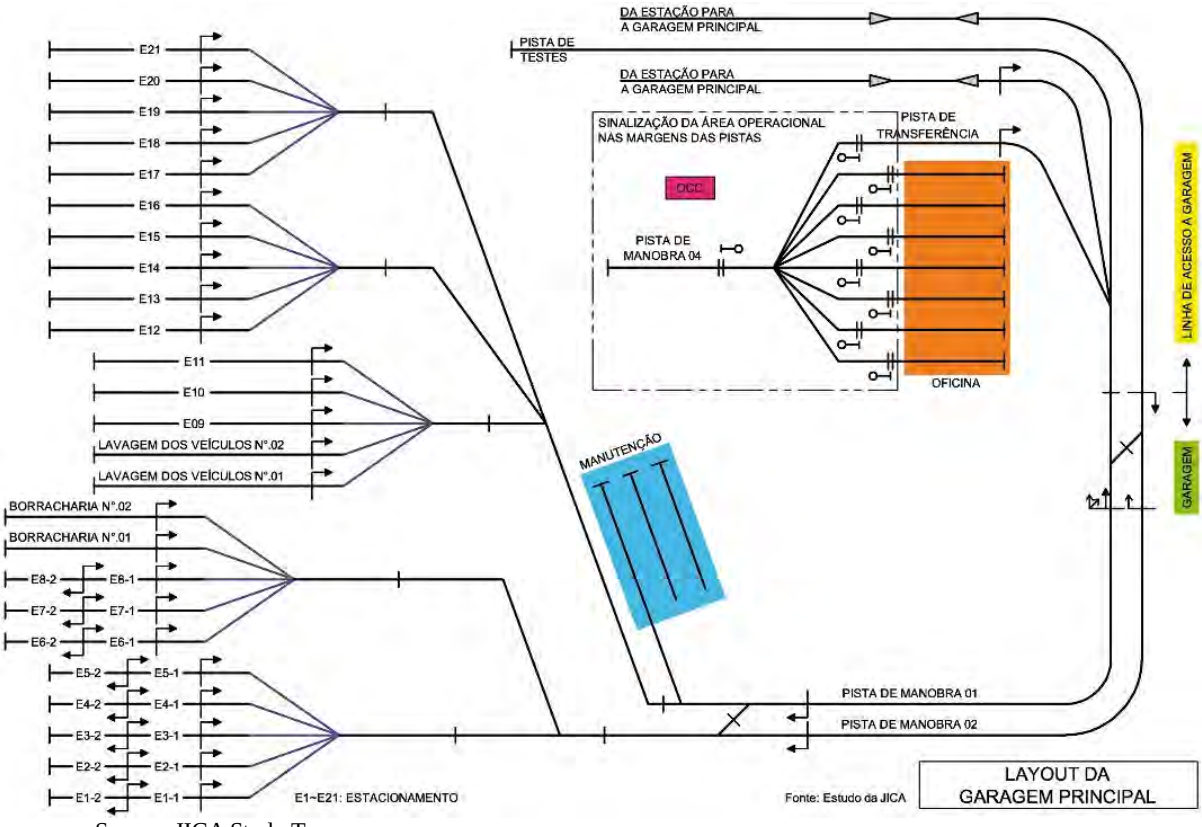
Source: JICA Study Team

Figure 5-72 Track Layout and Signaling Arrangement of Jardim Angela Yard



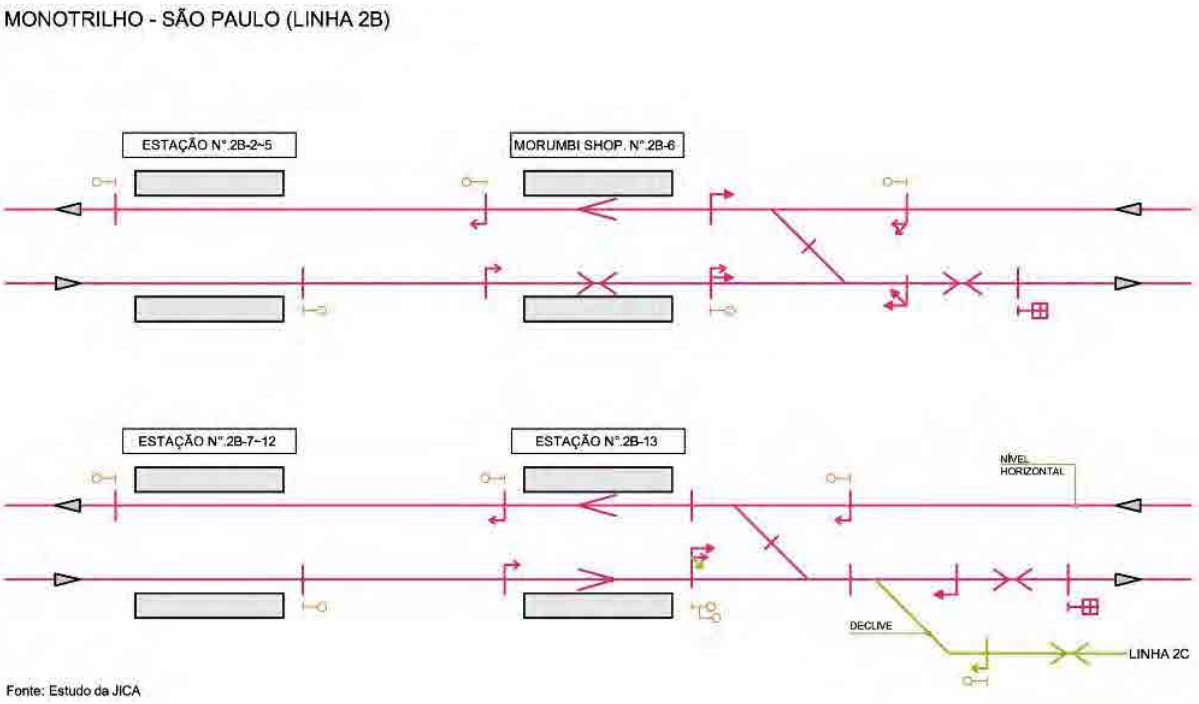
Source: JICA Study Team

Figure 5-73 Track Layout and Signaling Arrangement of Line-2A



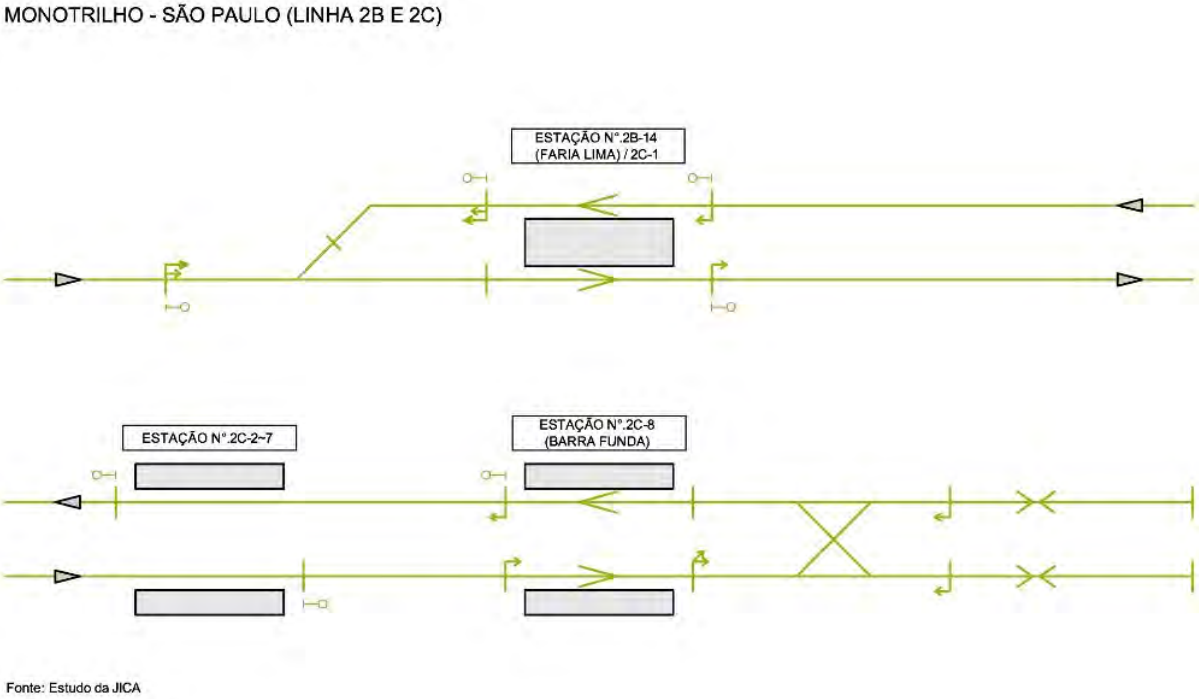
Source: JICA Study Team

Figure 5-74 Track Layout and Signaling Arrangement of Depot



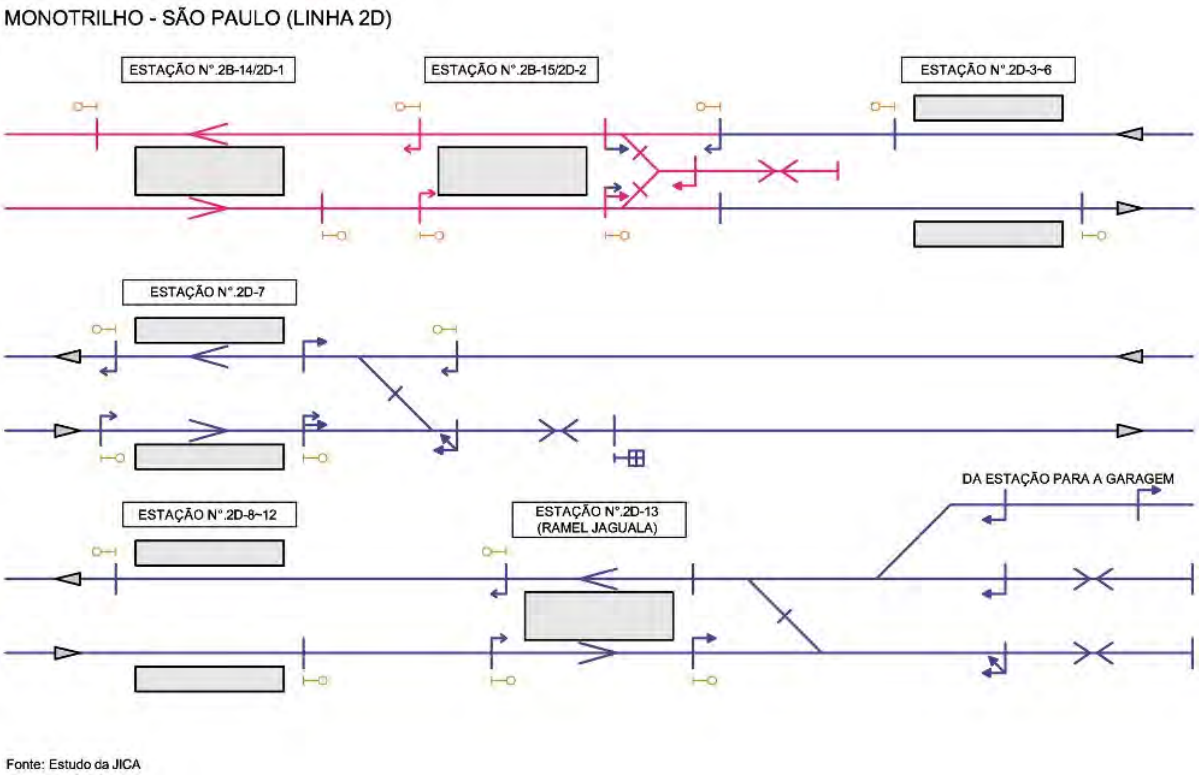
Source: JICA Study Team

Figure 5-75 Track Layout and Signaling Arrangement of Line-2B



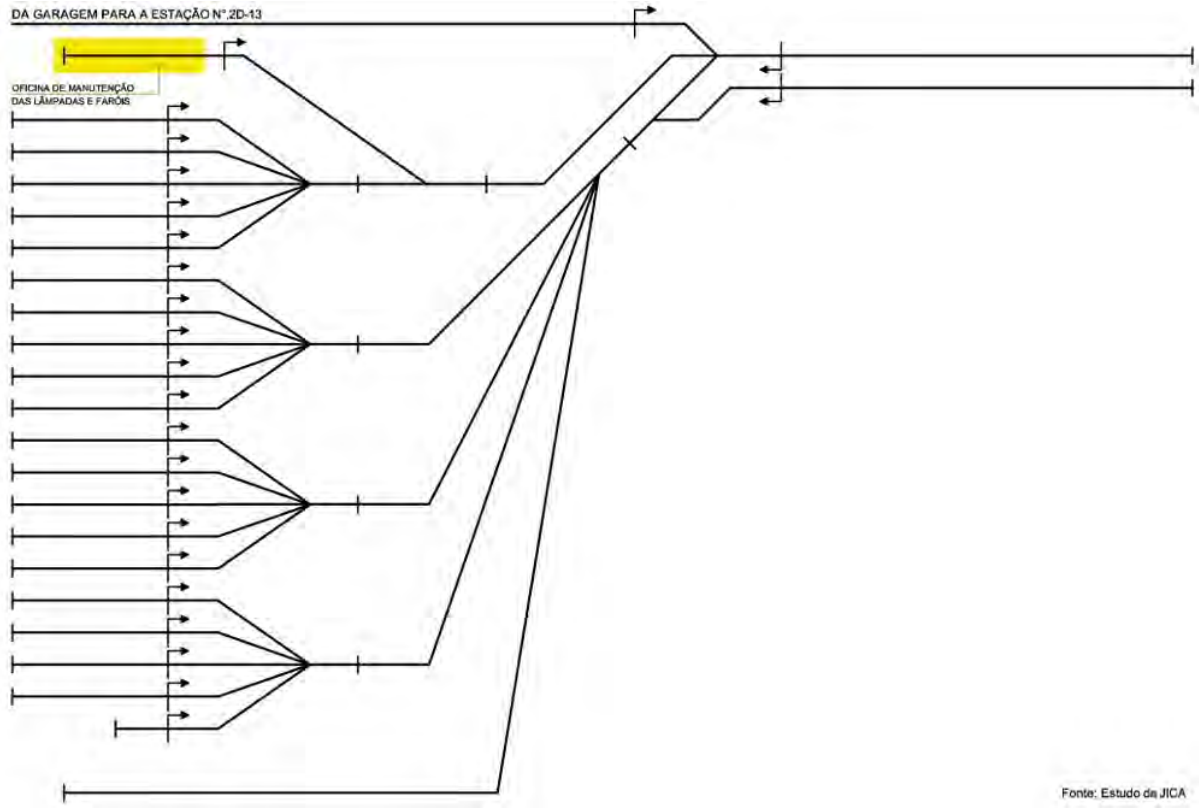
Source: JICA Study Team

Figure 5-76 Track Layout and Signaling Arrangement of Line-2C



Source: JICA Study Team

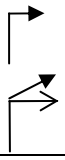
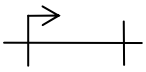
Figure 5-77 Track Layout and Signaling Arrangement of Line-2D



Source: JICA Study Team

Figure 5-78 Track Layout and Signaling Arrangement of Line-2D Yard

Table 5-32 Symbol Illustration

Symbol	Significance	Note
	ATP entrance or home route or departure route for station yard. 2 arrows mean 2 different routes. Turnout is open to different direction.	The route is setting with Interlocking equipment at the station existing turnout. The route information is transmitting through CBTC system to the train and the restricted train speed is decided in accordance to the location of the precede train.
	ATP Shunting route This symbol means 2 kinds routes, one is ATP Shunting route and other ATP departure route.	When shunting route is setting the shunting operation speed is restricted 30km/h. Shunt route setting information is transmitting to the train through CBTC.
	Wayside signal for backup in case of CBTC failure. Normally signal is lit off and when route is set signal aspect become green and when the route is occupied the aspect become red.	Option. When CBTC failure, one block operation between stations is executed. Train density is reduced than normally. When CBTC failure, train is detected with photo sensor.
	Operation direction between stations. Operation keeps to the right.	Normally reverse direction operation with ATP is not permitted. But in accidental condition bi-directional ATP operation is permitted with the special working.
	Operation direction in the station existing turnout.	Where two arrows on one track, ATP bi-directional ATP operation is permitted.
	One loop antenna is installed where enclosing vertical lines between stations. In the station yard this symbol means train detection section also.	The communication between on-board and ground is executed through inductive loop antenna.
	Shunting car stopping indicator	Shunting car cannot go over this indicator.

Source: JICA Study Team

5.8.3 Telecommunication system

Telecommunication system has a feature that can be commonly utilized for every transportation mode such as MRT, LRT and monorail. This chapter deals with the required service of telecommunication system, required function and performance.

(1) Objectives and required telecommunication service

The objective of telecommunications system is to assist safe and efficient train operation and business environment. To achieve this, the following three telecommunication services are required for the Project

1) Telecommunication service for safety

Telecommunication system offers voice and data communication services among persons in charge and related sections for the purpose of ensuring to assist safe and smooth train operation.

2) Telecommunication service for passenger

Telecommunication system offers the accurate and valuable information to the passengers in order to increase user service level and supports smooth operation.

3) Telecommunication service as common network infrastructure

Telecommunication system offers common network services not only for safety purposes but also various business sectors in railway business operation for the purpose of making efficient business environment.

(2) Requirement of telecommunication system

1) Required function and system

In order to realize previous mentioned telecommunication services, following functions and system are generally required.

Table 5-33 Required telecommunication functions and systems

Required service	Required function	Required system
Telecommunication service for safety	Dispatching control Emergency protection	Radio communication system Closed Circuit Television (CCTV) system
Telecommunication service for passenger service	Monitoring of passenger Information dissemination to the passenger	Passenger Information System (PIS) that consist of Public Addressing System (PIS) and Passenger Information Display System (PIDS) Clock System
Administrative and common service	Communication among related parties Common network service	Telephone system Backbone Transmission Network (BTN)

Source: JICA Study Team

(3) System redundancy

In order to secure redundancy, core communication system such as Backbone Transmission Network (BTN) should have redundant functions that ensure continuous system operation

when some of facilities break down. In order to maintain the system function, doubling of system (operation and standby) or facilities (unit redundancy) are generally utilized. The outline of the redundancy of a system is shown below.

Table 5-34 Comparison of redundancy method

Method	Description	Implications
Full duplex system	Even if the function of equipment stops, it can be made to perform maintenance of the function with other equipment. There are two systems; a parallel reserve and Standby Reserve.	It is most strong to the trouble In this three options, highest reliability Installation cost is the highest in three options
Half duplex system	Only applied for some of vital facilities.	Half duplex system is applied when the minimum function should be protected at the time of abnormal condition
Simplex system	There are no back up system. Therefore, when the function of equipment stops, it becomes impossible to maintain services	Unsuitable for an important communication circuit In three options, lowest reliability

Source: JICA Study Team

In view of system security level, full duplex system is recommended for the dispatching system and trunk communication system.

(4) Network configuration and protocol

It is proposed to introduce the optimal network system, in order to reduce unnecessary traffic and to minimize the influence range of trouble at the time of failure. The network configuration includes following three configurations;

1) The “Star” network system which concentrated all of facilities at the Operation Control Center (OCC)
2) The “Ring” networks system which connects terminal facilities with the ring network line
3) The “Independent” network system. Each system is completely independent

Table 5-35 Comparison of network configuration

Option	Description	Implications
Ring network	The system which has connects network terminals in the shape of a ring	It is most strong against the network trouble such as cut off the network cable or circuit In this three options, highest reliability. Commonly utilized for the Reliable Backbone Optical Fiber Cable (OFC) network
Star network	The system which each system has a network independently and combines at one place	Since the number of together joining points is one, failure of a together joining point influences the whole. Since it is a gathering to an independent network, failure of other networks does not influence others. It is easy to expand network system

Independent network	The system which each system has a network independently and does not combine with other networks	Since it is a gathering to an independent network, it is not dependent on failure of other networks. Exchange of the information between networks cannot be performed.

Source: JICA Study Team

In view of system reliability, ring network is recommended for the Backbone Transmission Network.

As for the communication protocol, it is desirable to utilize common and standardized protocols in order to ensure compatibility of facilities. There are several protocols for networking. In these network protocols, Internet Protocol (IP) is a one of common and famous protocols as user level. In order to ensure expandability and compatibilities of telecommunication system, it is desirable that the networking facilities like traffic monitor or maintenance monitor especially for user service level should equip with Internet Protocol (IP) interface as a minimum requirement. In view of system reliability, ring network is recommended for the Backbone Transmission Network.

(5) Type of telecommunication systems

The telecommunication system consists of 7 sub-systems:

1) Radio communication system.
2) Telephone system
3) Closed Circuit Television (CCTV) System
4) Passenger Information System (PIS)
5) Clock System
6) Backbone Transmission Network (BTN)
7) OA & IT system which consists of OA network and client PC

Radio communication system mainly deals with telecommunication system for safety that consists of dispatching telephone, emergency protection and related data transmission between Operation Control Center (OCC) and trains. Telephone system is divided into 1) Administrative & general telephone system and 2) Dispatching telephone system. Passenger Information System (PIS) consists of 2 systems; 1) Public Addressing System (PA) and Passenger Information Display System (PIDS).

The type of telecommunication system is shown in bellow.

Table 5-36 Type of telecommunication system

1. Radio communication system		
	Dispatching telephone	: between OCC and train
	Emergency protection	: from train to OCC
	Train status data	: from train to OCC
	Control data	: from OCC to train
2. Telephone system		
	Administrative & general telephone with PABX	
	Dispatching telephone	
	Operation & Maintenance telephone	
3. Closed Circuit Television (CCTV) system		
4. Passenger Information System (PIS)		
5. Clock System		
6. Backbone Transmission Network (BTN)		

Source: JICA Study Team

As mentioned in the above, radio communication system is indispensable for securing safe and efficient train operation. For the selection the radio communication system, several matters such as interval of base transceiver station, external noise strength, characteristics of radio wave propagation, etc. should be considered. Following table shows the general comparison of radio communication system.

Table 5-37 General comparison of radio systems

Item	Inductive Radio (IR)	Space Wave Radio (SR)	Leakage Coaxial Cable (LCX)
Method	Electromagnetic induction	Radio Wave	Radio Wave
Frequency	LF Band (30kHz-300kHz)	UHF/VHF band (150MHz, 400MHz, 800MHz band)	UHF/VHF band (150MHz, 400MHz, 800MHz band)
General applicable location	Underground	Open space	Underground or Open space
Interval of Base Transceiver Station	Approx. 1km	Approx. 2km	Approx. 2km
Digitalization	Difficult	Easy	Easy
Transmission speed	Low	High	High
External noise strength	Weak	Weak	Strong
Applicability for urban new transport system	Low	High	High

Source: JICA Study Team

In view of radio characteristic which is mentioned above, LCX radio communication system is proposed for the Project.

CHAPTER 6 PROJECT IMPLEMENTATION

6.1 METHOD STATEMENT

6.1.1 Method statement for civil structure

(1) Track structure

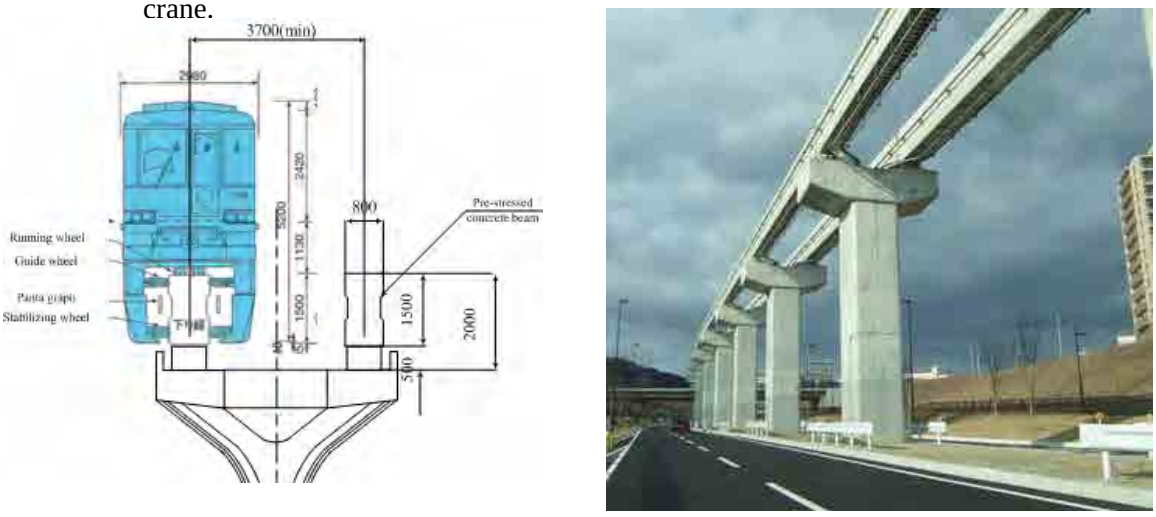
Monorail, which has been selected as a suitable medium capacity transit system for São Paulo is the system to run on an elevated track girder built above the road space. This track work will be carried out within the road space of the major street. Construction in a road space, not only monorail construction, has a possibility to affect the road traffic. Therefore, the construction method which can shorten the construction period, and can mitigate the impact to road traffic is recommendable.

1) Track girder

Track girder of the Monorail supposed to be adopted in this project is classified into two types, prestressed concrete track girder and steel track girder.

a) Typical span: Prestressed concrete (PC) track girder (PC girder)

The PC girder will be used in the typical span. Length of girder is designed between 22m and 30m. In order to shorten the construction period, PC girder is fabricated in the PC yard which is specialized facility for PC girder fabrication. Track girder will be transferred to the installation site during the nighttime when the road traffic volume becomes lower. Subsequently, erection of girder will be carried out by crane.

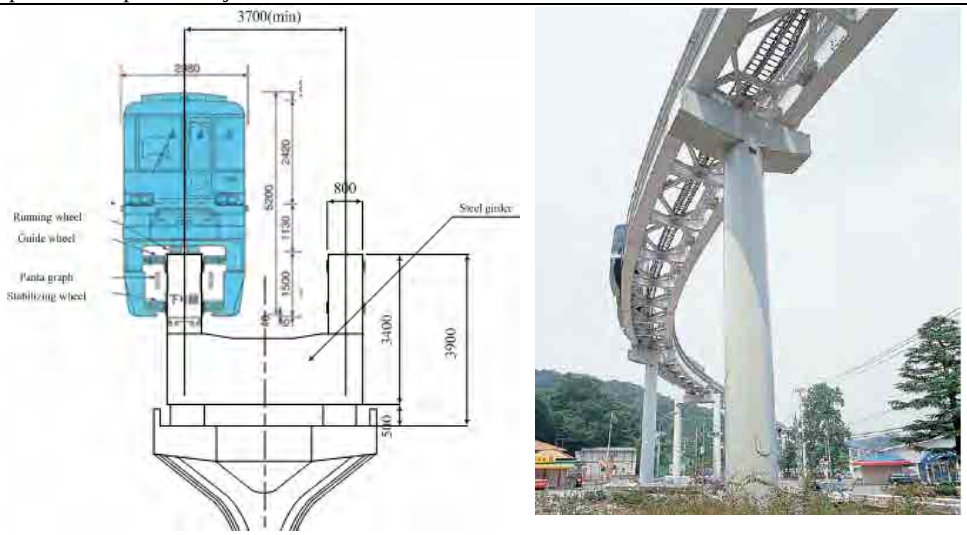


Source: JICA Study Team

Figure 6-1 Typical Section Drawing and Photo of PC Girder

b) Long span: steel girder

This type of track girder will be adopted for the section where typical pre-stressed concrete girder cannot be used, such as intersections of road, bridges spanned over rivers and so on. Bridge length is designed between 30m and 100m. Each member of steel girder will be fabricated in the factory, delivered to the site and installed. The steel supporting or other temporary supporting strut is supposed to be used at site for installation of steel girder. A high-tension bolt will be used for girder joint.



Source: JICA Study Team

Figure 6-2 Typical Section Drawing and Photo of Steel Girder

2) PC-Yard

As the Monorail runs straddled on a track girder, the PC track girder plays a role as the track in conventional railway. The shape of track girder shall be designed based on the conditions of span length, horizontal alignment, vertical alignment and super elevation of each section where each girder is installed. In short, the shape of each girder is unique.

For the fabrication of PC girder, high accuracy is required in order to ensure passenger's ride comfort. Therefore, PC yard which is specialized facility for PC girder fabrication is established. And in this yard, the mould unit which is the specialized formwork to fabricate the various shapes of the girders and accurately is set.

PC yard requires approximately 30,000m^2, as facilities for fabrication and a store area for storage of the PC girders.

If PC girder is fabricated at the site, ensuring of high accuracy is difficult. Moreover, this construction occupies public road space for a long time. Therefore, establishment of PC yard is required.

3) Erection of PC girder

According to Japanese Monorail construction manner, the PC girders are not placed temporarily in the site of working zone for the installation work. The PC girders are fabricated in the PC-Yard and stored in the store area of the PC-yard. When the installation work is carried out, the PC girders of working numbers for the day (normally two girders) are delivered by the exclusive trailers in the midnight to the installation site directly and installed to extend the working zone by the morning.

The reasons why the girders are not placed temporarily are as follows.

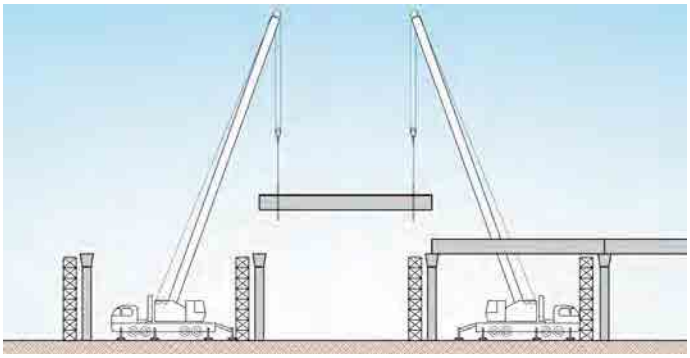
i) The PC girders can not be placed temporarily between the substructures in the working zone because the girder has the same length of the substructure interval. Therefore, in case of placing the PC girders temporarily in the working zone, it is necessary to extend both sides of the substructure for placing the PC girders with the measure to prevent turnover and the temporary fence. As a result, the road traffic is greatly affected due to decrease the road lane.

ii) Since the PC girder weighs more than 40 tons, when the girders are placed temporarily, two set of heavy cranes and their working space are needed additionally for loading and unloading the girder.

The procedure for erection of the girder is as follows;

a) Setting up of working zone on the street (traffic regulation).
b) Mobilization and installation of the crane.
c) Mobilization of the trailer for transport of the PC girder.
d) Installation of the PC girder (Considering the weight of the PC girder, two numbers of 200 tons-capacity cranes will be used.)
e) Demobilization of the trailer and the crane.
f) Clearance of working zone.

In such a case that the site location is confined or where public traffic is difficult to regulate, considering the operating radius, a 300-500 tone-capacity crane will be mobilized. In cases that public traffic cannot be regulated or that installation of crane is impracticable, erection girder will be used.



Source: JICA Study Team

Figure 6-3 Erection of PC Girder

(2) Substructure

No Special construction method or structure style is needed for substructure of the Monorail as it is the same as normal support structure.

Cast-in-site pile or precast concrete pile is used for foundations of general buildings and civil structures in São Paulo, as conditions of ground around São Paulo city are relatively good. Taking into account of urban construction works, cast-in-site pile, which has less impact on vibration and vocal noise, will be adopted. The pile diameter will be 1.0-1.5m. After piling, pile caps with 1.5-1.8m thickness will be built. Thickness of earth covering over pile caps will be 0.5m. After excavation work to the predefined point is done by all-casing-excavator, rebar cage will be installed and then concrete will be cast.

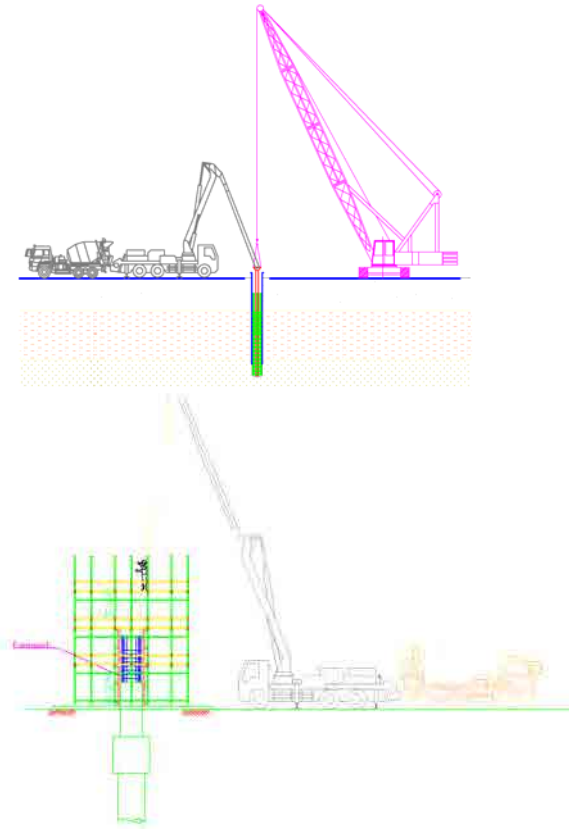
As construction machineries take possession of approximately 8.0m width of public road including median strip during the construction work, works will be carried out at nighttime with an adequate traffic regulation.

1) Procedure for pile construction

a) Install Guide Casing
b) Drill Borehole
c) Remove slime
d) Install rebar cage
e) Insert tremie pipe
f) Place concrete
g) Backfill
h) Draw out guide casing

2) Procedure for pier construction

a) Erect the scaffolding for column
b) Assemble the rebar for column
c) Install casing for column
d) Place the concrete for column
e) Erect the scaffolding for pier head
f) Install casing for pier head
g) Assemble the rebar for pier head
h) Place the concrete for pier head



Source: JICA Study Team

Figure 6-4 Place Concrete in Pile and Pier Construction

(3) Construction procedure of structures crossing river

1) Construction method of long span bridges

Required span length for the long span bridges over the River would be approximately one hundred meters and steel arch bridge (Trussed Langer or Nielsen-Lohse Type) will be suitable for this span length. In this project, four numbers of long span bridges are designed on the route. The location, span length and type of long span bridge are shown on the table below.

Table 6-1 List of long span bridges

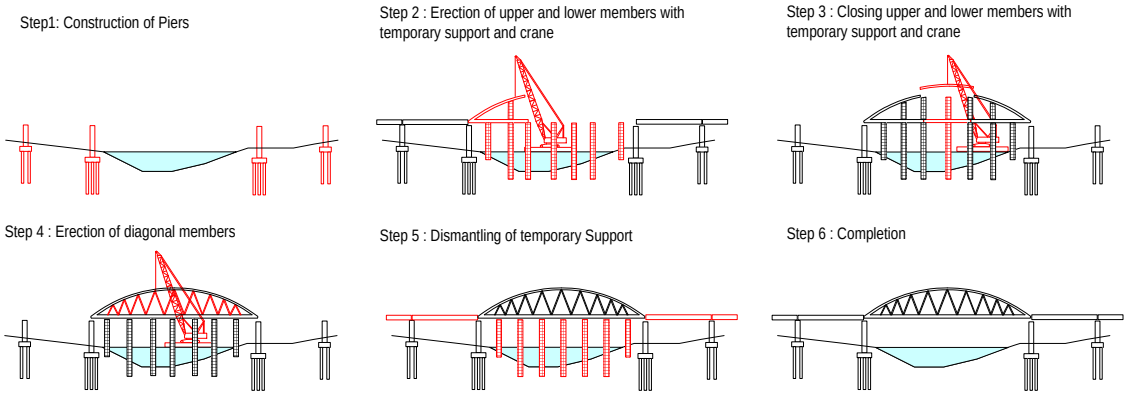
	Location	Crossing River	Span length	Selected Type of the bridge	Remarks
1	Line-2A	Canal do Guarapiranga	120m	Nielsen-Lohse	
2	Line-2A	Pinheiros River	80m	Trussed Ranger	Socorro station
3	Line 2D	Pinheiros River	100m	Trussed Ranger	
4	Line 2D	Rio Tiete	120m	Nielsen-Lohse	

Source: JICA Study Team

The site conditions of the long span bridges are summarized as below;

1) The bridges are constructed in urban area
2) Serious traffic congestion of the road occurs near the site.
3) No need to consider a navigation channel for big ship
4) No access way of large scale barge on waterway

The sequence of erection for long span bridge (Trussed Ranger bridge) is shown on the figure below. In view of the site conditions, the erection would be carried out using crane and temporary support.

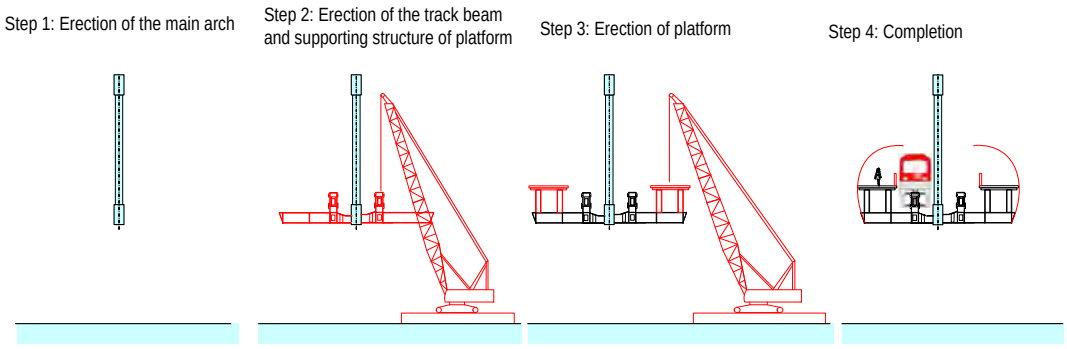


Source: JICA Study Team

Figure 6-5 Sequence of erection for long span bridges

2) Construction method of the station on the long span bridge

Socorro Station is located on the Pinheiros River. The main bridge structure is Trussed Langer Bridge (Arch Bridge) and the span length is 80m. The sequence of erection is shown on the Figure 6-6. The track beam and supporting structure of platform shall be erected by crane.



Source: JICA Study Team

Figure 6-6 Sequence of erection of the station structure on the river

6.1.2 Works for installation of the Electric, Signaling and Telecommunication system

Different from other transportation system, the Monorail is characterized by installation of contact line, communication and signal system, and electrical cable on its track girder. Except works for track girders, it is similar to the normal construction.

Source: JICA Study Team

Figure 6-7 Contact Wire and Cable Tray

Signal and communication cables and electrical cables are arranged on the trays set under the track girder, and contact lines are installed in both side of the track girder. Installation of the cables and contact line is carried out in high places as it is elevated bridge. Generally, this installation works are carried out on the scaffold assembled on public road under track girder. However, it affects public road traffic for a long term due to the scaffold set on public road. And it's a hazardous work.

In the construction works of the Monorail in Japan, a self-propelled service vehicle is used instead of assembling scaffold.

The service vehicle, which is driven by battery equipped or internal-combustion engine, and is straddled on track girder, can transport the materials, equipments and workers to the place where installation works are done.

The service vehicle is designed to enable works to be done upside, lateral side and downside of track girder in safety.

As the self-propelled service vehicle is able to work sliding on track girder, no scaffold work is required and it has no impact on public traffic, in addition, it's advantageous to the construction schedule.

6.2 PROCUREMENT OF MATERIAL AND EQUIPMENT

6.2.1 Present conditions of São Paulo city

Brazil has accomplished remarkable development as one of the BRICs in recent years, having applied high technology and advanced manufacturing capabilities to produce many kinds of industrial and agricultural products.

As for São Paulo city, many projects such as a subway, BRT, and several road construction works have been executed, and the construction market is active.

6.2.2 Construction materials and equipment

Brazilian industry produces many construction materials, primary and secondary steel products, machinery, electric products and so on, which are supplied not only to the domestic market, but also to foreign markets. Therefore, it can be considered that many construction materials and machinery for the Monorail can be procured domestically in future.

The construction materials and equipment for the Monorail system are classified into three following categories according to the procurement plan.

(1) Materials and Equipments procured from domestic sources.

1) Construction materials for civil structures and building works:

Cement, Aggregate, Concrete, Wooden material, Reinforced bar, PC cable, Steel products, Stone materials, Glass products, Furnishings, Piping materials, Drainage materials, Elevator, Escalator, Compressor, etc.

2) Construction machines:

Truck crane, Excavator, Dump-truck, Trailer, Automobile, etc.

3) Electrical and electronic products:

Electric wire and cable, General electric appliances, Communication equipment, Computer, etc.

4) The general equipment and facilities for workshop:

Overhead crane, Forklifts, High elevation work car, Cargo lifter trolley and so on.

(2) Materials and Equipment procured from foreign sources.

These are special materials and equipments relating to monorail system.

1) Onboard Signaling equipment and OCC system

Onboard equipment and the OCC system will be procured from foreign factories because they are closely related to unification of the system and vehicle design.

Electric wires, cables and apparatus related to the signaling and telecommunication system can be supplied from domestic sources.

2) Traction power supply system (electric power lines and attachments):

Electric power lines, insulators and attachments for the traction power supply system will be procured from foreign countries, due to special facilities of the Monorail system which are not manufactured domestically.

3) Transformer system of bulk substation and rectifier of transformer

The transformer system of bulk substations and rectifiers of transformers will need to be procured from foreign factories with reliability and results.

4) Maintenance facilities in workshop

Special equipment for the Monorail system will be manufactured in foreign factories, because domestic suppliers have no experience in their manufacture and no design documents. Such facilities are: bogie drop machine, moving dust collection device, shunting unit, maintenance vehicles, traverser, and so on.

The general equipment and facilities for the workshop to be procured from domestic factories, include overhead cranes, forklifts, high elevation work cars, cargo lifter trollies, and so on.

(3) Procurement from foreign factory of prototype and assembly of remainder in domestic factory

1) Rolling stock and Switches

Initially, prototypes of the rolling stock and switches will be procured from foreign factories and the remainder of the order will be assembled in local factories using parts imported from foreign suppliers.

Since there is substantial manufacturing capacity in Brazil, a reduction in costs and technical transfer will in the longer term enable much of this equipment to be manufactured in Brazil.

It may be expected that the success of the Monorail system in São Paulo will lead to the development of monorail systems elsewhere in Brazil.

6.2.3 Construction Machinery

There are many kinds of construction machinery for the project in and around São Paulo city, such as excavators, mobile crane trucks etc. due to many the many construction projects underway in the city at present. Therefore, it is easy to procure such machinery near the project site.

6.2.4 Construction Labour

In Brazil, there are many big construction companies which have advanced technology and good achievements. As for the manpower, there are many engineers, foremen, skilled workers, common workers, etc. in São Paulo city.

It is easy to procure the construction companies and manpower in São Paulo city for the Monorail system construction project.

However, in the case of special technology for the Monorail system, advanced technical knowledge and experienced experts will be required to provide technical assistance for the development of the Monorail system, essentially because it is a new system for Brazil.

The following work activities will need to be undertaken by foreign technical experts.

(1) Pre-stressed Concrete (PC) girder of Guideway

Workmanship of the PC girder has a significant effect on the ride comfort of the Monorail

because the Monorail vehicle runs directly on the girder as its guideway. Consequently, the PC girder must be manufactured more precisely and installed with greater accuracy than in the case with a road bridge girder.

The foreign technical experts will instruct the manufacturing, installation and adjustment of the PC girder.

(2) Signaling and Power supply system work

Signaling and telecommunication cables and electrical power cables are installed under the guideway and power rails are attached to both sides of the guideway and in this respect differ from other transit systems. In Japan, above installation work is generally carried out using the service vehicle which is special self-propelled working wagons.

Foreign technical experts will instruct how to perform the installation work because the work using the self-propelled elevated working stages is the first such application in São Paulo city.

(3) Test running and commissioning

Foreign technical experts will coordinate, instruct and confirm various performance tests in relation to individual and integrated tests, trial runs, test running and so on. After the confirmation of various tests, the experts will certify system commissioning in the presence of the employer.

6.2.5 Delivery period

Estimation of the delivery periods for foreign equipment, will be based on the assumption that the manufacturing source will be located in Japan. Shipment of such equipment from Japan to Santos Port (the main unloading port located about 60 km away from São Paulo city) normally needs 30 to 45 days. The period needed for unloading and customs clearance is uncertain owing to congestion in the port. With allowance for unseen problems, a period of two months is likely to be required for shipment, unloading, customs clearance and inland transportation.

6.2.6 Consultant

This project is the first project in Brazil introducing the Monorail. And the project will be subject to an international competitive tendering process. Effective implementation of the project therefore requires selection of a consultant who has sufficient international technical experience and can demonstrate success in the construction of monorail systems worldwide.

The consultant will prepare a basic design, a construction program, tender documents and selection of the contractor by tender. After the award of the contract, he will execute reviews and approve detailed designs and specifications, supervision of the construction and verification of the system.

6.3 PROJECT COST ESTIMATES

6.3.1 General

The proposed routes of the monorail system are composed of Line-1, 2A, 2B, 2C and 2D. It is difficult to construct the whole proposed lines at the same time from an aspect of the finance and the procurement of construction materials and machines. Therefore, the construction is executed by dividing into three phases.

Among these, for Line-2A included in Phase 1, there are two alternatives of the Original Route plan and the Area Development Route plan. The route length of the Area Development Route plan is 1.4km longer than that of the Original Route plan. Two more underground stations are also added in the Area Development Route plan. Moreover, the Area Development Route plan is accompanied by the demolition work of existing houses and the construction work of new road in order that the Monorail route passes through the existing residential district.

Furthermore, since some power supply equipment and rolling stock will be added in future, year 2025 with the increase of demand, it is shown as Phase 3-2.

The construction terms and lines is shown in Table 6-2.

Table 6-2 Construction terms and lines

	Contract	Completion	Construction period (month)	Lines
Phase 1 Original Route Plan	Aug, 2011	Sep, 2014	38	Line-1and 2A
Phase 1 Area Development Route Plan	Aug, 2011	Feb, 2015	43	Line-1and 2A
Phase 2	Mar, 2013	Jun, 2016	40	Line-2B and 2D
Phase 3	Jan, 2015	Mar, 2018	39	Line-2C
Phase 3-2		Year 2025		Increase power supply system and rolling stock

Source: JICA Study Team

6.3.2 Condition of cost estimation

The conditions of cost estimation are as follows.

(1) Implementation cost

The components of the implementation cost are: the construction and procurement cost; a consulting services fee; and a land acquisition cost, which are classified into foreign and local costs. Those costs are applied the various rates, exchange rates, price escalation, physical contingency, administration cost, value-added tax (VAT) and import tax. Incidentally, phase 3-2 which will be executed in year 2025 is shown a procurement cost at basic year for cost estimation excluding the escalation price and incidental costs, because the accumulation of the price escalation becomes large amount to pass through the many years from basic year and it is not realistic.

1) Construction costs

This comprises the direct capital costs to construct the Monorail system, including the costs of mobilization, sub-structure, superstructure, switches, station buildings, power supply system, signaling and telecommunication system, procurement of rolling stock,

depot and so on.

2) Consulting service fee

This fee relates to the consulting service necessary to assist the management unit to implement the project.

3) Land acquisition cost

This is the cost of acquiring land and re-settling local communities to allow project construction to proceed. Estimates of these costs have been made with reference to present day costs in São Paulo city.

(2) Exchange rate

Japanese Yen /US dollar	USD 1.00 = JPY 89.55
Brazil Reais / US dollar	USD 1.00 = BRL 1.75
Japanese Yen/ Brazil Reais	BRL 1.00 = JPY 51.171

(3) Price Escalation

Foreign currency (FC)	1.5% p.a.
Local currency (LC):	4.5% p.a. (in reference to Inflation Targeting in Brazil by Brazil Central Bank, for year 2005 to 2011)

(4) Physical Contingency

Construction:	5%
Consulting Services:	5 %

(5) Base Year for Cost Estimation

The reference month and year for cost estimation is January, 2010.

(6) Project Implementation Schedule

The schedule is considered from the commencement of the loan procedure to the completion of the construction of each phase respectively. The implementation schedules of each Phase are referred in section 6.4 Implementation Schedule.

(7) Rate of Tax

VAT:	18%	Standard rate in São Paulo is referenced from www.worldwide-tax.com.
VAT:	5%	Consulting services

(8) Import Tax

Import Tax:	0 %	The case that the importation is performed by the name of Sao Paulo state government and all duties and/or taxes concerning an import material can be exempted is assumed.

(9) Rate of Administration Cost

Rate of Administration cost: 3%

(10) Foreign cost and Local cost

The classification of foreign and local costs is referred to section 6-2 “Procurement of material and equipment”.

(11) Annual distribution of cost

Annual distribution of cost for each item is basically distributed based on the rate of working-months in each year. As for rolling stock and depot equipment, since these are mostly delivered and installed at the latter period of construction, annual distribution of these costs are comparatively distributed to the latter period.

Among the various rates, Exchange Rates, Price Escalation, Physical Contingency, and the Billing Rates of Consultants which have been surveyed as the present values for the cost estimate, those rates may be revised by JICA at the time of Loan negotiation.

6.3.3 Result of cost estimate

The implementation cost of whole project is shown in Table 6-3. Furthermore, the construction costs, implementation costs and annual distribution of costs for each phase are shown in Table 6-4 to Table 6-16.

Table 6-3 Implementation Cost of Whole Project

	Item	Phase 1 Orginal route			Phase 1 Area Development route			Phase 2			Phase 3			Phase 3-2		
		FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
		million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY
A. ELIGIBLE PORTION																
I	Procurement / Construction	22,160	2,330	141,411	22,587	2,588	155,040	20,588	3,484	198,848	3,948	938	51,964	1,003	172	9,784
	Mobilization	0	53	2,708	0	62	3,161	0	71	3,622	0	22	1,124			
	Relocation of Public Utilities	0	27	1,394	0	33	1,683	0	39	1,989	0	13	655			
	Substructure	0	153	7,835	0	168	8,595	0	221	11,310	0	81	4,123			
	Superstructure	0	299	15,288	0	322	16,470	0	460	23,559	0	152	7,779			
	New Road Construction	0	0	0	0	17	856	0	0	0	0	0	0			
	Station Building	0	360	18,444	0	360	18,444	0	614	31,440	0	194	9,916			
	Station with Tunnel section	0	96	4,909	0	229	11,733	0	0	0	0	0	0			
	Switch	855	47	3,282	855	47	3,282	0	36	1,848	0	8	417			
	Depot	1,145	135	8,078	1,145	135	8,078	755	90	5,335	0	0	0			
	Rolling stock	5,257	577	34,793	5,257	577	34,793	0	897	45,891	0	130	6,656	0	164	8,408
	Power Supply system	8,831	164	17,225	9,054	172	17,845	10,226	208	20,893	2,516	59	5,526	1,003	7	1,376
	Signalling and Telecommunication system	4,247	75	8,100	4,364	80	8,451	7,474	131	14,164	928	28	2,366			
	Automatic Fare Collection system	0	8	384	0	9	435	0	12	614	0	4	205			
	Environmental Mitigation and Compensation	0	0	25	0	1	30	0	7	336	0	3	147			
	Base cost	20,335	1,996	122,466	20,675	2,212	133,855	18,455	2,786	161,002	3,444	693	38,913	1,003	172	9,784
	Price escalation	770	224	12,212	837	253	13,802	1,153	532	28,377	316	201	10,577			
	Physical contingency	1,055	111	6,734	1,076	123	7,383	980	166	9,469	188	45	2,474			
II	Consulting services	4,188	96	9,094	4,462	105	9,816	4,346	99	9,423	3,456	75	7,305			
	Base cost	3,841	82	8,012	4,086	88	8,614	3,892	79	7,910	3,009	55	5,813			
	Price escalation	147	10	649	163	11	735	248	16	1,065	282	17	1,144			
	Physical contingency	199	5	433	212	5	467	207	5	449	165	4	348			
Total A=（ I + II ）		26,348	2,426	150,506	27,049	2,693	164,856	24,935	3,583	208,271	7,403	1,014	59,269			
B. NON ELIGIBLE PORTION																
a	Land Acquisition	0	96	4,895	0	164	8,415	0	62	3,179	0	2	114			
	Base cost	0	87	4,477	0	152	7,758	0	53	2,696	0	2	87			
	Price escalation	0	4	185	0	5	256	0	6	331	0	0	21			
	Physical contingency	0	5	233	0	8	401	0	3	151	0	0	5			
b	Administration cost 3%	0	91	4,662	0	102	5,198	0	124	6,343	0	35	1,781			
c	VAT	0	506	25,909	0	555	28,398	0	709	36,264	0	191	9,763			
	VAT 18% for Procurement /Construction	0	497	25,454		545	27,907		699	35,793	0	183	9,354			
	VAT 5% for Consulting Service	0	9	455		10	491		9	471	0	7	365			
d	Import Tax	0	0	0	0	0	0	0	0	0	0	0	0			
Total B = (a+b+c+d)		0	693	35,465	0	821	42,011	0	895	45,786	0	228	11,658	0	0	0
TOTAL (A+B)		26,348	3,119	185,971	27,049	3,514	206,867	24,935	4,478	254,057	7,403	1,241	70,928	1,003	172	9,784

Source: JICA Study Team

Table 6-4 Construction Cost of Original Route Plan of Phase 1

Item	Unit	Line-1						Line-2A (Original Route)						Total Phase 1 L2A(MB)
		Quantity	Unit Price		Cost		Total	Quantity	Unit Price		Cost		Total	
			FC	LC	FC	LC			FC	LC	FC	LC		
			1000 JPY	BRL	1000 JPY	BRL	1000 JPY		1000 JPY	BRL	1000 JPY	BRL	1000 JPY	1000 JPY
Mobilization														-
Mobilization	LS	1		13,115,799	-	13,115,799	671,149	1		39,807,392	-	39,807,392	2,036,984	2,708,133
Relocation of Public Utilities						-								-
Relocation of Public Utilities	LS	1		7,640,271	0	7,640,271	390,960	1		19,607,530		19,607,530	1,003,337	1,394,297
Substructure					-	-						-		-
Substructure	nos	154		290,000	-	44,660,000	2,285,297	374		290,000		108,460,000	5,550,007	7,835,304
Superstructure work					-	-						-		-
PC Girder	nos	288		200,000	-	57,600,000	2,947,450	704		200,000		140,800,000	7,204,877	10,152,326
Steel Girder	Ton	2,100		12,000	-	25,200,000	1,289,509	4,980		12,000		59,760,000	3,057,979	4,347,488
Switch Bridge	LS	1			-	2,400,000	122,810	1				13,010,000	665,735	788,545
Total					-	85,200,000	4,359,769				-	213,570,000	10,928,590	15,288,360
New Road Construction														
Road Construction	km													-
Demolition	km													
Total														
Switch work					-	-	-						-	-
Total	LS	1			500,000	-	500,000	1			355,000	47,420,000	2,781,529	3,281,529
Station Building work					-	-								-
Type A Station (Standard station)	station	4		24,872,240	-	99,488,960	5,090,950	7		24,872,240	-	174,105,680	8,909,162	14,000,111
Type B Station (Terminal station)	station	1		25,326,740	-	25,326,740	1,295,995	1		25,326,740	-	25,326,740	1,295,995	2,591,989
Type C Station (Socorro station 2A-11)	station				-	-	-	1		36,181,900	-	36,181,900	1,851,464	1,851,464
Type D Station (Faria Lima station 2B-14)	station				-	-	-							-
Type E Station (Sumare station 2C-5)	station				-	-	-							-
Type F Station (Jardim Angela station with Tunnel)	station				-	-	-	1		95,940,000	-	95,940,000	4,909,346	4,909,346
Type G Station (Underground stations with Tunnel)	station				-	-	-							-
Total		5				124,815,700	6,386,944	10				331,554,320	16,965,966	23,352,910
Depot Construction					-									-
Civil works	LS	1						1		12,000,000	-	12,000,000	614,052	614,052
Track works	LS	1						1		47,056,000		47,056,000	2,407,903	2,407,903
Buildings and workshops	LS	1					-	1		63,900,000	-	63,900,000	3,269,827	3,269,827
Total												122,956,000	6,291,781	6,291,781
Depot Facilities procurement							-						-	-
Depot Facilities	LS						-	1	1,145,000	12,540,000	1,145,000	12,540,000	1,786,684	1,786,684
Rolling stock procurement							-						-	-
Rolling stock (Import)	nos						-	18	200,000		3,600,000		3,600,000	3,600,000
Rolling stock (Domestic 1st lot)	nos							156		3,700,000	-	577,200,000	29,535,901	29,535,901
Rolling stock (Domestic 2nd lot)	nos												-	-
Spare parts	LS							1	1,656,795		1,656,795		1,656,795	1,656,795
Total											5,256,795	577,200,000	34,792,696	34,792,696
Electric Power Supply system							-						-	-
Primary Substation (1000MVA & 30MVA)	LS	1	-		-	-	-	1	352,000	4,226,200	352,000	4,226,200	568,259	568,259
Transmission Line (34 kV, 2 Circuit)	LS	1		9,000,427	-	9,000,427	460,561	1		21,263,553		21,263,553	1,088,077	1,548,638
Power Supply Substation (15 SS)	LS	1	777,075	11,295,164	777,075	11,295,164	1,355,060	1	4,488,600	64,677,710	4,488,600	64,677,710	7,798,223	9,153,283
Contact Line (1,500V) Main line	LS	1	697,645	8,525,368	697,645	8,525,368	1,133,897	1	1,665,970	20,358,500	1,665,970	20,358,500	2,707,735	3,841,630
Contact Line (1,500V) Depot	LS	1	-	-	-	-	-	1	849,916	8,205,768	849,916	8,205,768	1,269,813	1,269,813
Distribution Line (13.8kV, 2 Circuit)	LS	1	-	1,513,935	-	1,513,935	77,470	1		4,217,678		4,217,678	215,823	293,292
Power Facilities Station	LS	1.000	-	2,485,380	-	2,485,380	127,179	1		5,649,950		5,649,950	289,114	416,293
Power Facilities Depot	LS	1.000	-		-	-	-	1		1,166,560		1,166,560	59,694	59,694
Power Facilities OCC	LS	1.000	-		-	-	-	1		1,455,095		1,455,095	74,459	74,459
Total					1,474,720	32,820,274	3,154,166				7,356,486	131,221,014	14,071,197	17,225,363
Signalling &Telecomm. system							-						-	-
Main Line Signalling system	LS	1	289,480	2,496,809	289,480	2,496,809	417,244	1	788,660	6,345,580	788,660	6,345,580	1,113,370	1,530,614
Depot Siganlling system	LS	1	-	-	-	-	-	1	250,850	885,100	250,850	885,100	296,141	296,141
ATS system	LS	1	152,000	539,070	152,000	539,070	179,585	1	227,000	557,470	227,000	557,470	255,526	435,111
Onboard Signalling system	LS	1	867,200	-	867,200	-	867,200	1	1,086,000	-	1,086,000	-	1,086,000	1,953,200
Commissioning and O & M Manual	LS	1	79,000	186,000	79,000	186,000	88,518	1	142,000	479,000	142,000	479,000	166,511	255,029
Spare parts for Signalling system	LS	1	130,000	301,000	130,000	301,000	145,402	1	235,000	773,000	235,000	773,000	274,555	419,958
Telecommunication system	LS	1	-	15,598,270	-	15,598,270	798,179	1	-	38,431,404	-	38,431,404	1,966,573	2,764,752
Commissioning and O & M Manual		1	-	960,000	-	960,000	49,124	1		2,365,000		2,365,000	121,019	170,144
Spare parts of Telecommunication system		1		1,550,000	-	1,550,000	79,315	1		3,816,000		3,816,000	195,269	274,584
Total					1,517,680	21,631,149	2,624,568				2,729,510	53,652,554	5,474,965	8,099,532
							-						-	-
AFC system							-						-	-
AFC system	station	5		500,000	-	2,500,000	127,928	10		500,000	-	5,000,000	255,855	383,783
							-						-	-
Environmental Mitigation and Compensation							-						-	-
Removal works of roadside trees	LS	1		273,150		273,150	13,977	1		221,701		221,701	11,345	25,322
							-						-	-
Total					3,492,400	332,656,343	20,514,758				16,842,791	1,663,210,511	101,950,936	122,465,694

Source: JICA Study Team

Table 6-5 Implementation Cost of Original Route Plan of Phase 1

Item	Total			2010			2011			2012			2013			2014		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
A. ELIGIBLE PORTION	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY
Ⅰ) Procurement / Construction	22,160	2,330	141,411	0	0	0	1,827	253	14,794	9,175	1,047	62,741	9,401	813	50,984	1,758	218	12,893
Mobilization	0	53	2,708	0	0	0	0	33	1,706	0	20	1,002	0	0	0	0	0	0
Relocation of Public Utilities	0	27	1,394	0	0	0	0	17	871	0	10	523	0	0	0	0	0	0
Substructure	0	153	7,835	0	0	0	0	17	871	0	102	5,224	0	34	1,741	0	0	0
Superstructure	0	299	15,288	0	0	0	0	33	1,699	0	199	10,192	0	66	3,397	0	0	0
Station Building	0	360	18,444	0	0	0	0	29	1,475	0	173	8,853	0	159	8,115	0	0	0
Station with Tunnel section	0	96	4,909	0	0	0	0	8	409	0	48	2,455	0	40	2,046	0	0	0
Switch	855	47	3,282	0	0	0	68	4	263	410	23	1,575	376	21	1,444	0	0	0
Depot	1,145	135	8,078	0	0	0	115	14	808	458	54	3,231	573	68	4,039	0	0	0
Rolling stock	5,257	577	34,793	0	0	0	526	58	3,479	1,577	173	10,438	1,577	173	10,438	1,577	173	10,438
Power Supply system	8,831	164	17,225	0	0	0	679	13	1,325	4,076	76	7,950	4,076	76	7,950	0	0	0
Signalling and Telecommunication system	4,247	75	8,100	0	0	0	327	6	623	1,960	35	3,738	1,960	35	3,738	0	0	0
Automatic Fare Collection system	0	8	384	0	0	0	0	0	0	0	0	0	0	7	352	0	1	32
Environmental Mitigation and Compensation	0	0	25	0	0	0	0	0	3	0	0	17	0	0	6	0	0	0
Base cost for JICA financing	20,335	1,996	122,466	0	0	0	1,715	231	13,532	8,482	913	55,198	8,562	678	43,266	1,577	174	10,470
Price escalation	770	224	12,212	0	0	0	26	10	558	256	84	4,555	391	96	5,290	97	33	1,809
Physical contingency	1,055	111	6,734	0	0	0	87	12	704	437	50	2,988	448	39	2,428	84	10	614
Ⅱ) Consulting services	4,188	96	9,094	0	0	0	394	6	689	1,873	42	4,011	1,218	34	2,957	702	14	1,437
Base cost	3,841	82	8,012	0	0	0	370	5	639	1,732	36	3,596	1,109	28	2,561	630	11	1,217
Price escalation	147	10	649	0	0	0	6	0	18	52	3	224	51	4	256	39	2	152
Physical contingency	199	5	433	0	0	0	19	0	33	89	2	191	58	2	141	33	1	68
Total (Ⅰ + Ⅱ)	26,348	2,426	150,506	0	0	0	2,222	259	15,483	11,048	1,089	66,752	10,618	847	53,941	2,460	232	14,329
B. NON ELIGIBLE PORTION																		
a Procurement / Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Base cost for JICA financing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Price escalation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physical contingency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
b Land Acquisition	0	96	4,895	0	8	392	0	88	4,503	0	0	0	0	0	0	0	0	0
Base cost	0	87	4,477	0	7	373	0	80	4,104	0	0	0	0	0	0	0	0	0
Price escalation	0	4	185	0	0	0	0	4	185	0	0	0	0	0	0	0	0	0
Physical contingency	0	5	233	0	0	19	0	4	214	0	0	0	0	0	0	0	0	0
c Administration cost	0	91	4,662	0	0	12	0	12	600	0	39	2,003	0	32	1,618	0	8	430
d VAT	0	506	25,909	0	0	0	0	53	2,697	0	225	11,494	0	182	9,325	0	47	2,392
VAT 18% for Procurement /Construction	0	497	25,454	0	0	0	0	52	2,663	0	221	11,293	0	179	9,177	0	45	2,321
VAT 5% for Consulting Service	0	9	455	0	0	0	0	1	34	0	4	201	0	3	148	0	1	72
e Import Tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total (a+b+c+d+e)	0	693	35,465	0	8	403	0	152	7,800	0	264	13,497	0	214	10,943	0	55	2,822
TOTAL (A+B)	26,348	3,119	185,971	0	8	403	2,222	412	23,283	11,048	1,352	80,249	10,618	1,060	64,884	2,460	287	17,151
C. Interest during Construction	6,256	0	6,256	0	0	0	252	0	252	1,323	0	1,323	2,212	0	2,212	2,469	0	2,469
Interest during Construction(Const.)	6,254	0	6,254	0	0	0	251	0	251	1,322	0	1,322	2,212	0	2,212	2,468	0	2,468
Interest during Construction (Consul.)	2	0	2	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1
D. Commitment Charge	784	0	784	157	0	157	157	0	157	157	0	157	157	0	157	157	0	157
GRAND TOTAL (A+B+C+D)	33,388	3,119	193,011	157	8	560	2,630	412	23,691	12,528	1,352	81,729	12,987	1,060	67,253	5,086	287	19,778
E. JICA finance portion incl. IDC (A + C + D)	33,388	2,426	157,545	157	0	157	2,630	259	15,891	12,528	1,089	68,232	12,987	847	56,310	5,086	232	16,955

Source: JICA Study Team

Table 6-6 Annual Distribution of Cost of Original Route Plan of Phase 1

Item	Total			2010			2011			2012			2013			2014		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
Mobilization	100%	100%	0%	0%	0%		63%	63%		37%	37%		0%	0%		0%	0%	
Relocation of Public Utilities	100%	100%	0%	0%	0%		63%	63%		38%	38%		0%	0%		0%	0%	
Substructure	100%	100%	0%	0%	0%		11%	11%		67%	67%		22%	22%		0%	0%	
Superstructure	100%	100%	0%	0%	0%		11%	11%		67%	67%		22%	22%		0%	0%	
Station Building	100%	100%	0%	0%	0%		8%	8%		48%	48%		44%	44%		0%	0%	
Station with Tunnel section	100%	100%	0%	0%	0%		8%	8%		50%	50%		42%	42%		0%	0%	
Switch	100%	100%	0%	0%	0%		8%	8%		48%	48%		44%	44%		0%	0%	
Depot	100%	100%	0%	0%	0%		10%	10%		40%	40%		50%	50%		0%	0%	
Rolling stock	100%	100%	0%	0%	0%		10%	10%		30%	30%		30%	30%		30%	30%	
Power Supply system	100%	100%	0%	0%	0%		8%	8%		46%	46%		46%	46%		0%	0%	
Signalling and Telecommunication system	100%	100%	0%	0%	0%		8%	8%		46%	46%		46%	46%		0%	0%	
Automatic Fare Collection system	100%	100%	0%	0%	0%		0%	0%		0%	0%		92%	92%		8%	8%	
Environmental Mitigation and Compensation	100%	100%	0%	0%	0%		11%	11%		67%	67%		22%	22%		0%	0%	
Land Acquisition					8%			92%			0%			0%			0%	
Consultant	100%	100%	0%	0%	0%	0%	8%	7%	0%	45%	45%	0%	31%	34%	0%	16%	14%	0%

Source: JICA Study Team

Table 6-7 Construction Cost of Area Development Route of Phase 1

Item	Unit	Line-1 Quantity	Line-1 Unit Price FC (1000 JPY)	Line-1 Unit Price LC (BRL)	Line-1 Cost FC (1000 JPY)	Line-1 Cost LC (BRL)	Line-1 Total (1000 JPY)	Line-2A (Development Route) Quantity	Line-2A Unit Price FC (1000 JPY)	Line-2A Unit Price LC (BRL)	Line-2A Cost FC (1000 JPY)	Line-2A Cost LC (BRL)	Line-2A Total (1000 JPY)	Total Phase 1 L2A (AD)) (1000 JPY)
Mobilization														-
Mobilization	LS	1		13,115,799	-	13,115,799	671,149	1		48,654,025	-	48,654,025	2,489,675	3,160,824
Relocation of Public Utilities						-						-		-
Relocation of Public Utilities	LS	1		7,640,271	0	7,640,271	390,960	1		25,248,190		25,248,190	1,291,975	1,682,935
Substructure					-	-						-		-
Substructure	nos	154		290,000	-	44,660,000	2,285,297	411		300,000		123,300,000	6,309,384	8,594,681
Superstructure work					-	-						-		-
PC Girder	nos	288		200,000	-	57,600,000	2,947,450	806		200,000		161,200,000	8,248,765	11,196,215
Steel Girder	Ton	2,100		12,000	-	25,200,000	1,289,509	5,205		12,000		62,460,000	3,196,141	4,485,650
Switch Bridge	LS	1			-	2,400,000	122,810	1				13,010,000	665,735	788,545
Total					-	85,200,000	4,359,769				-	236,670,000	12,110,641	16,470,410
New Road Construction														
Road Construction	km							7		1,950,000		13,650,000	698,484	698,484
Demolition	km							7		440,000		3,080,000	157,607	157,607
Total												16,730,000	856,091	856,091
Switch work					-	-	-						-	-
Total	LS	1			500,000	-	500,000	1			355,000	47,420,000	2,781,529	3,281,529
Station Building work					-	-								-
Type A Station (Standard station)	station	4		24,872,240	-	99,488,960	5,090,950	7		24,872,240	-	174,105,680	8,909,162	14,000,111
Type B Station (Terminal station)	station	1		25,326,740	-	25,326,740	1,295,995	1		25,326,740	-	25,326,740	1,295,995	2,591,989
Type C Station (Socorro station 2A-11)	station				-	-	-	1		36,181,900	-	36,181,900	1,851,464	1,851,464
Type D Station (Faria Lima station 2B-14)	station				-	-	-						-	-
Type E Station (Sumare station 2C-5)	station				-	-	-						-	-
Type F Station (Jardim Angela station with Tunnel)	station				-	-	-	1		95,940,000	-	95,940,000	4,909,346	4,909,346
Type G Station (Underground stations with Tunnel	station				-	-	-	2		66,676,000	-	133,352,000	6,823,755	6,823,755
Total		5				124,815,700	6,386,944	12				464,906,320	23,789,721	30,176,665
Depot Construction					-									-
Civil works	LS	1						1		12,000,000	-	12,000,000	614,052	614,052
Track works	LS	1						1		47,056,000		47,056,000	2,407,903	2,407,903
Buildings and workshops	LS	1					-	1		63,900,000	-	63,900,000	3,269,827	3,269,827
Total												122,956,000	6,291,781	6,291,781
Depot Facilities procurement							-						-	-
Depot Facilities	LS						-	1	1,145,000	12,540,000	1,145,000	12,540,000	1,786,684	1,786,684
Rolling stock procurement							-						-	-
Rolling stock (Import)	nos						-	18	200,000		3,600,000	-	3,600,000	3,600,000
Rolling stock (Domestic 1st lot)	nos							156		3,700,000		577,200,000	29,535,901	29,535,901
Rolling stock (Domestic 2nd lot)	nos												-	-
Spare parts	LS							1	1,656,795		1,656,795		1,656,795	1,656,795
Total											5,256,795	577,200,000	34,792,696	34,792,696
Electric Power Supply system							-						-	-
Primary Substation (1000MVA & 30MVA)	LS	1	-		-	-	-	1	352,000	4,226,200	352,000	4,226,200	568,259	568,259
Transmission Line (34 kV, 2 Circuit)	LS	1		9,000,427	-	9,000,427	460,561	1		24,226,765		24,226,765	1,239,708	1,700,269
Power Supply Substation (15 SS)	LS	1	777,075	11,295,164	777,075	11,295,164	1,355,060	1	4,488,600	64,677,710	4,488,600	64,677,710	7,798,223	9,153,283
Contact Line (1,500V) Main line	LS	1	697,645	8,525,368	697,645	8,525,368	1,133,897	1	1,888,314	23,075,592	1,888,314	23,075,592	3,069,115	4,203,012
Contact Line (1,500V) Depot	LS	1	-	-	-	-	-	1	849,916	8,205,768	849,916	8,205,768	1,269,813	1,269,813
Distribution Line (13.8kV, 2 Circuit)	LS	1	-	1,513,935	-	1,513,935	77,470	1		4,779,647		4,779,647	244,579	322,049
Power Facilities Station	LS	1	-	2,485,380	-	2,485,380	127,179	1		7,168,870		7,168,870	366,838	494,018
Power Facilities Depot	LS	1	-		-	-	-	1		1,166,560		1,166,560	59,694	59,694
Power Facilities OCC	LS	1	-		-	-	-	1		1,455,095		1,455,095	74,459	74,459
Total					1,474,720	32,820,274	3,154,166				7,578,830	138,982,207	14,690,689	17,844,855
Signalling &Telecomm. system							-						-	-
Main Line Signalling system	LS	1	289,480	2,496,809	289,480	2,496,809	417,244	1	891,676	7,278,823	891,676	7,278,823	1,264,141	1,681,385
Depot Siganlling system	LS	1	-	-	-	-	-	1	250,850	885,100	250,850	885,100	296,141	296,141
ATS system	LS	1	152,000	539,070	152,000	539,070	179,585	1	227,000	557,470	227,000	557,470	255,526	435,111
Onboard Signalling system	LS	1	867,200	-	867,200	-	867,200	1	1,086,000	-	1,086,000	-	1,086,000	1,953,200
Commissioning and O & M Manual	LS	1	79,000	186,000	79,000	186,000	88,518	1	147,000	536,000	147,000	536,000	174,428	262,945
Spare parts for Signalling system	LS	1	130,000	301,000	130,000	301,000	145,402	1	244,000	865,000	244,000	865,000	288,263	433,665
Telecommunication system	LS	1	-	15,598,270	-	15,598,270	798,179	1	-	41,407,904	-	41,407,904	2,118,884	2,917,063
Commissioning and O & M Manual		1	-	960,000	-	960,000	49,124	1		2,566,000	-	2,566,000	131,305	180,429
Spare parts of Telecommunication system		1		1,550,000	-	1,550,000	79,315	1		4,140,000	-	4,140,000	211,848	291,163
Total					1,517,680	21,631,149	2,624,568				2,846,526	58,236,297	5,826,536	8,451,103
							-						-	-
AFC system							-						-	-
AFC system	station	5		500,000	-	2,500,000	127,928	12		500,000	-	6,000,000	307,026	434,954
							-						-	-
Environmental Mitigation and Compensation							-						-	-
Removal works of roadside trees	LS	1		273,150		273,150	13,977	1		309,975		309,975	15,862	29,839
							-						-	-
Total					3,492,400	332,656,343	20,514,758				17,182,151	1,879,153,014	113,340,290	133,855,048

Source: JICA Study Team

Table 6-8 Implementation Cost of Area Development Route of Phase 1

Item	Total			2010			2011			2012			2013			2014			2015		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
A. ELIGIBLE PORTION	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY
I) Procurement / Construction	22,587	2,588	155,040	0	0	0	1,678	272	15,612	8,264	1,104	64,758	8,476	912	55,136	4,169	300	19,534	0	0	0
Mobilization	0	62	3,161	0	0	0	0	39	1,976	0	23	1,185	0	0	0	0	0	0	0	0	0
Relocation of Public Utilities	0	33	1,683	0	0	0	0	21	1,052	0	12	631	0	0	0	0	0	0	0	0	0
Substructure	0	168	8,595	0	0	0	0	19	955	0	112	5,730	0	37	1,910	0	0	0	0	0	0
Superstructure	0	322	16,470	0	0	0	0	32	1,647	0	193	9,882	0	97	4,941	0	0	0	0	0	0
New Road Construction	0	17	856	0	0	0	0	2	110	0	6	331	0	6	331	0	2	83	0	0	0
Staion Building	0	360	18,444	0	0	0	0	29	1,475	0	173	8,853	0	159	8,115	0	0	0	0	0	0
Station with Tunnel section	0	229	11,733	0	0	0	0	16	809	0	95	4,855	0	95	4,855	0	24	1,214	0	0	0
Switch	855	47	3,282	0	0	0	68	4	263	410	23	1,575	376	21	1,444	0	0	0	0	0	0
Depot	1,145	135	8,078	0	0	0	115	14	808	458	54	3,231	573	68	4,039	0	0	0	0	0	0
Rolling stock	5,257	577	34,793	0	0	0	526	58	3,479	1,577	173	10,438	1,577	173	10,438	1,577	173	10,438	0	0	0
Power Supply system	9,054	172	17,845	0	0	0	584	11	1,151	3,505	67	6,908	3,505	67	6,908	1,460	28	2,878	0	0	0
Siganalling and Telecommunication system	4,364	80	8,451	0	0	0	282	5	545	1,689	31	3,271	1,689	31	3,271	704	13	1,363	0	0	0
Automatic Fare Collection system	0	9	435	0	0	0	0	0	0	0	0	0	0	8	399	0	1	36	0	0	0
Environmental Mitigation and Compensation	0	1	30	0	0	0	0	0	3	0	0	18	0	0	9	0	0	0	0	0	0
Base cost for JICA financing	20,675	2,212	133,855	0	0	0	1,574	248	14,274	7,639	963	56,909	7,720	761	46,660	3,741	240	16,012	0	0	0
Price escalation	837	253	13,802	0	0	0	24	11	595	231	89	4,765	353	107	5,850	230	46	2,592	0	0	0
Physical contingency	1,076	123	7,383	0	0	0	80	13	743	394	53	3,084	404	43	2,626	199	14	930	0	0	0
II) Consulting services	4,462	105	9,816	0	0	0	399	6	698	1,867	42	4,015	1,207	34	2,961	918	21	1,973	71	2	169
Base cost	4,086	88	8,614	0	0	0	374	5	647	1,726	37	3,599	1,099	29	2,563	823	16	1,666	63	1	138
Price escalation	163	11	735	0	0	0	6	0	18	52	3	225	50	4	257	51	3	213	5	0	23
Physical contingency	212	5	467	0	0	0	19	0	33	89	2	191	57	2	141	44	1	94	3	0	8
Total (I + II)	27,049	2,693	164,856	0	0	0	2,077	278	16,310	10,131	1,146	68,773	9,683	946	58,097	5,087	321	21,507	71	2	169
B. NON ELIGIBLE PORTION																					
a Procurement / Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Base cost for JICA financing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Price escalation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physical contingency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
b Land Acquisition	0	164	8,415	0	42	2,172	0	122	6,242	0	0	0	0	0	0	0	0	0	0	0	0
Base cost	0	152	7,758	0	40	2,069	0	111	5,689	0	0	0	0	0	0	0	0	0	0	0	0
Price escalation	0	5	256	0	0	0	0	5	256	0	0	0	0	0	0	0	0	0	0	0	0
Physical contingency	0	8	401	0	2	103	0	6	297	0	0	0	0	0	0	0	0	0	0	0	0
c Administration cost	0	102	5,198	0	1	65	0	13	677	0	40	2,063	0	34	1,743	0	13	645	0	0	5
d VAT	0	555	28,398	0	0	0	0	56	2,845	0	232	11,857	0	197	10,072	0	71	3,615	0	0	8
VAT 18% for Procurement /Construction		545	27,907	0	0	0	0	55	2,810	0	228	11,656	0	194	9,924	0	69	3,516	0	0	0
VAT 5% for Consulting Service		10	491	0	0	0	0	1	35	0	4	201	0	3	148	0	2	99	0	0	8
e Import Tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total (a+b+c+d+e)	0	821	42,011	0	44	2,237	0	191	9,764	0	272	13,920	0	231	11,815	0	83	4,260	0	0	14
TOTAL (A+B)	27,049	3,514	206,867	0	44	2,237	2,077	469	26,074	10,131	1,418	82,693	9,683	1,177	69,912	5,087	404	25,767	71	2	183
C. Interest during Construction	9,423	0	9,423	0	0	0	265	0	265	1,371	0	1,371	2,332	0	2,332	2,704	0	2,704	2,750	0	2,750
Interest during Construction(Const.)	9,420	0	9,420	0	0	0	265	0	265	1,371	0	1,371	2,331	0	2,331	2,703	0	2,703	2,749	0	2,749
Interest during Construction (Consul.)	3	0	3	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	1	0	1
D. Commitment Charge	1,046	0	1,046	174	0	174	174	0	174	174	0	174	174	0	174	174	0	174	174	0	174
GRAND TOTAL (A+B+C+D)	37,517	3,514	217,336	174	44	2,412	2,516	469	26,514	11,676	1,418	84,239	12,190	1,177	72,418	7,965	404	28,646	2,995	2	3,107
E. JICA finance portion incl. IDC (A + C + D)	37,517	2,693	175,325	174	0	174	2,516	278	16,750	11,676	1,146	70,318	12,190	946	60,603	7,965	321	24,386	2,995	2	3,093

Source: JICA Study Team

Table 6-9 Annual Distribution of Cost of Area Development Route of Phase 1

Item	Total			2010			2011			2012			2013			2014			2015		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
Mobilization	100%	100%	0%	0%	0%		63%	63%		38%	38%		0%	0%		0%	0%		0%	0%	
Relocation of Public Utilities	100%	100%	0%	0%	0%		63%	63%		38%	38%		0%	0%		0%	0%		0%	0%	
Substructure	100%	100%	0%	0%	0%		11%	11%		67%	67%		22%	22%		0%	0%		0%	0%	
Superstructure	100%	100%	0%	0%	0%		10%	10%		60%	60%		30%	30%		0%	0%		0%	0%	
New Road Construction	100%	100%	0%	0%	0%		13%	13%		39%	39%		39%	39%		10%	10%		0%	0%	
Staion Building	100%	100%	0%	0%	0%		8%	8%		48%	48%		44%	44%		0%	0%		0%	0%	
Station with Tunnel section	100%	100%	0%	0%	0%		7%	7%		41%	41%		41%	41%		10%	10%		0%	0%	
Switch	100%	100%	0%	0%	0%		8%	8%		48%	48%		44%	44%		0%	0%		0%	0%	
Depot	100%	100%	0%	0%	0%		10%	10%		40%	40%		50%	50%		0%	0%		0%	0%	
Rolling stock	100%	100%	0%				10%	10%		30%	30%		30%	30%		30%	30%		0%	0%	
Power Supply system	100%	100%	0%	0%	0%		6%	6%		39%	39%		39%	39%		16%	16%		0%	0%	
Siganalling and Telecommunication system	100%	100%	0%	0%	0%		6%	6%		39%	39%		39%	39%		16%	16%		0%	0%	
Automatic Fare Collection system	100%	100%	0%	0%	0%		0%	0%		0%	0%		92%	92%		8%	8%		0%	0%	
Environmental Mitigation and Compensation	100%	100%	0%	0%	0%		10%	10%		60%	60%		30%	30%		0%	0%		0%	0%	
Land Acquisition					27%			73%			0%			0%			0%			0%	
Consultant	100%	100%	0%	0%	0%	0%	8%	6%	0%	42%	42%	0%	29%	32%	0%	20%	19%	0%	2%	2%	0%

Source: JICA Study Team

Table 6-10 Construction Cost of Phase 2

Item	Unit	Line-2B						Line-2D						Total Phase 2 (2B +2D)
		Quantity	Unit Price		Cost		Total	Quantity	Unit Price		Cost		Total	
			FC	LC	FC	LC			FC	LC	FC	LC		
			1000 JPY	BRL	1000 JPY	BRL	1000 JPY		1000 JPY	BRL	1000 JPY	BRL	1000 JPY	1000 JPY
Mobilization														-
Mobilization	LS	1		35,963,752	-	35,963,752	1,840,301	1		34,810,789	-	34,810,789	1,781,303	3,621,604
Relocation of Public Utilities												-		-
Relocation of Public Utilities	LS	1		20,230,807		20,230,807	1,035,231	1		18,644,149		18,644,149	954,040	1,989,270
Substructure work						-						-		-
Substructure	nos	361		340,000		122,740,000	6,280,729	364		270,000		98,280,000	5,029,086	11,309,814
Superstructure work						-						-		-
PC Girder	nos	666		200,000		133,200,000	6,815,977	636		200,000		127,200,000	6,508,951	13,324,928
Steel Girder	Ton	5,930		12,000		71,160,000	3,641,328	9,665		12,000		115,980,000	5,934,813	9,576,141
Switch Bridge	LS	1				6,900,000	353,080	1				5,962,500	305,107	658,187
Total					-	211,260,000	10,810,385				-	249,142,500	12,748,871	23,559,256
Switch work							-							-
Switch work	LS	1			-	9,680,000	495,335	1			-	26,440,000	1,352,961	1,848,297
Station Building work														-
Type A Station (Standard station)	station	12		24,872,240	-	298,466,880	15,272,849	10		24,872,240	-	248,722,400	12,727,374	28,000,223
Type B Station (Terminal station)	station						-	1		25,326,740	-	25,326,740	1,295,995	1,295,995
Type C Station (Socorro station 2A-11)	station						-						-	-
Type D Station (Faria Lima station 2B-14)	station	1		41,893,350	-	41,893,350	2,143,725						-	2,143,725
Type E Station (Sumare station 2C-5)	station						-						-	-
Type F Station (Jardim Angela station with Tunnel)	station						-						-	-
Type G Station (Underground stations with Tunnel)	station						-						-	-
Total		13				340,360,230	17,416,573	11				274,049,140	14,023,369	31,439,942
Depot Construction		Depot Line 2A (Near JARDIM ANGELA & Additonal tracks)												-
Civil works	LS	1		1,430,000	-	1,430,000	73,175	1		5,070,000	-	5,070,000	259,437	332,612
Track works	LS	1		23,254,000		23,254,000	1,189,930	1		24,470,000		24,470,000	1,252,154	2,442,085
Buildings and workshops	LS						-	1		26,560,000	-	26,560,000	1,359,102	1,359,102
Total						24,684,000	1,263,105					56,100,000	2,870,693	4,133,798
Depot Facilities procurement		Additional Facilities at Phase 2												-
Depot Facilities	LS	1	150,000	6,800,000	150,000	6,800,000	497,963	1	605,000	1,920,000	605,000	1,920,000	703,248	1,201,211
Rolling stock procurement						-								-
Rolling stock (Import)	nos					-	-							-
Rolling stock (Domestic 1st lot)	nos					-	-							-
Rolling stock (Domestic 2nd lot)	nos	262		3,260,000		854,120,000	43,706,175							43,706,175
Spare parts	LS	1			-	42,706,000	2,185,309							2,185,309
Total					-	896,826,000	45,891,483							45,891,483
Electric Power Supply system						-								-
Primary Substation (1000MVA & 30MVA)	LS	1	452,000	4,102,000	452,000	4,102,000	661,903	1	-	345,600	-	345,600	17,685	679,588
Transmission Line (34 kV, 2 Circuit)	LS	1		24,482,212		24,482,212	1,252,779	1	-	24,367,097	-	24,367,097	1,246,889	2,499,668
Power Supply Substation (15 SS)	LS	1	3,168,150	48,463,169	3,168,150	48,463,169	5,648,059	1	2,104,425	32,889,847	2,104,425	32,889,847	3,787,431	9,435,490
Contact Line (1,500V) Main line	LS	1	1,831,116	22,376,629	1,831,116	22,376,629	2,976,151	1	1,887,508	23,065,748	1,887,508	23,065,748	3,067,805	6,043,956
Contact Line (1,500V) Depot	LS	1	782,892	7,558,760	782,892	7,558,760	1,169,681	1	-	-	-	-	-	1,169,681
Distribution Line (13.8kV, 2 Circuit)	LS	1		5,149,478		5,149,478	263,504	1	-	4,097,766	-	4,097,766	209,687	473,191
Power Facilities Station	LS	1		5,834,170		5,834,170	298,540	1.000	-	5,729,770	-	5,729,770	293,198	591,738
Power Facilities Depot	LS						-	1.000		-		-	-	-
Power Facilities OCC	LS						-	1.000		-		-	-	-
Total					6,234,158	117,966,328	12,270,613				3,991,933	90,495,828	8,622,695	20,893,313
Signalling &Telecomm. system														-
Main Line Signalling system	LS	1	895,888	7,344,077	895,888	7,344,077	1,271,692	1	1,114,540	9,389,684	1,114,540	9,389,684	1,595,020	2,866,711
Depot Signalling system	LS	1	-	-	-	-	-	1	148,910	652,870	148,910	652,870	182,318	182,318
ATS system	LS	1	445,000	1,205,540	445,000	1,205,540	506,689	1	445,000	1,187,140	445,000	1,187,140	505,747	1,012,436
Onboard Signalling system	LS	1	1,662,800	-	1,662,800	-	1,662,800	1	1,735,400	-	1,735,400	-	1,735,400	3,398,200
Commissioning and O & M Manual	LS	1	180,000	525,000	180,000	525,000	206,865	1	207,000	698,000	207,000	698,000	242,717	449,582
Spare parts for Signalling system	LS	1	297,000	848,000	297,000	848,000	340,393	1	342,000	1,125,000	342,000	1,125,000	399,567	739,960
Telecommunication system	LS	1		42,103,582	-	42,103,582	2,154,482	1		50,649,175	-	50,649,175	2,591,769	4,746,251
Commissioning and O & M Manual		1		2,610,000	-	2,610,000	133,556	1		3,136,000	-	3,136,000	160,472	294,029
Spare parts of Telecommunication system		1		4,211,000	-	4,211,000	215,481	1		5,059,000	-	5,059,000	258,874	474,355
Total					3,480,688	58,847,199	6,491,958				3,992,850	71,896,869	7,671,885	14,163,843
AFC system														-
AFC system	station	13		500,000	-	6,500,000	332,612	11		500,000	-	5,500,000	281,441	614,052
Environmental Mitigation and Compensation														-
Removal works of roadside trees	LS	1		2,873,089		2,873,089	147,019	1		3,699,912		3,699,912	189,328	336,347
Total					9,864,846	1,854,731,495	104,773,312				8,589,783	930,979,188	56,228,919	161,002,231

Source: JICA Study Team

Table 6-11 Implementation Cost of Phase 2

	Item	Total			2012			2013			2014			2015			2016		
		FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
A. ELIGIBLE PORTION		million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY
Ⅰ)	Procurement / Construction	20,588	3,484	198,848	0	0	0	5,090	996	56,032	8,857	1,552	88,296	6,640	936	54,520	0	0	0
	Mobilization	0	71	3,622	0	0	0	0	71	3,622	0	0	0	0	0	0	0	0	0
	Relocation of Public Utilies	0	39	1,989	0	0	0	0	39	1,989	0	0	0	0	0	0	0	0	0
	Substructure	0	221	11,310	0	0	0	0	77	3,958	0	133	6,786	0	11	565	0	0	0
	Superstructure	0	460	23,559	0	0	0	0	146	7,496	0	251	12,851	0	63	3,213	0	0	0
	Station Building	0	614	31,440	0	0	0	0	172	8,803	0	295	15,091	0	147	7,546	0	0	0
	Switch	0	36	1,848	0	0	0	0	11	554	0	18	924	0	7	370	0	0	0
	Depot	755	90	5,335	0	0	0	211	25	1,494	362	43	2,561	181	21	1,280	0	0	0
	Rolling stock	0	897	45,891	0	0	0	0	203	10,363	0	347	17,764	0	347	17,764	0	0	0
	Power Supply system	10,226	208	20,893	0	0	0	2,557	52	5,223	4,383	89	8,954	3,287	67	6,716	0	0	0
	Signalling and Telecommunication	7,474	131	14,164	0	0	0	1,868	33	3,541	3,203	56	6,070	2,402	42	4,553	0	0	0
	Automatic Fare Collection system	0	12	614	0	0	0	0	0	0	0	4	205	0	8	409	0	0	0
	Environmental Mitigation and Compensation	0	7	336	0	0	0	0	2	107	0	4	183	0	1	46	0	0	0
	Base cost for JICA financing	18,455	2,786	161,002	0	0	0	4,636	831	47,151	7,948	1,240	71,390	5,870	715	42,462	0	0	0
	Price escalation	1,153	532	28,377	0	0	0	212	117	6,213	488	239	12,701	454	176	9,462	0	0	0
	Physical contingency	980	166	9,469	0	0	0	242	47	2,668	422	74	4,205	316	45	2,596	0	0	0
Ⅱ)	Consulting services	4,346	99	9,423	0	0	0	1,221	22	2,364	1,628	41	3,719	1,100	28	2,517	397	8	824
	Base cost	3,892	79	7,910	0	0	0	1,112	19	2,066	1,461	33	3,131	972	21	2,055	346	6	658
	Price escalation	248	16	1,065	0	0	0	51	3	185	90	6	411	75	5	342	32	2	127
	Physical contingency	207	5	449	0	0	0	58	1	113	78	2	177	52	1	120	19	0	39
Total (Ⅰ + Ⅱ)		24,935	3,583	208,271	0	0	0	6,312	1,018	58,396	10,486	1,593	92,014	7,740	963	57,037	397	8	824
B. NON ELIGIBLE PORTION																			
a	Procurement / Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Base cost for JICA financing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Price escalation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Physical contingency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
b	Land Acquisition	0	62	3,179	0	23	1,159	0	39	2,019	0	0	0	0	0	0	0	0	0
	Base cost	0	53	2,696	0	20	1,011	0	33	1,685	0	0	0	0	0	0	0	0	0
	Price escalation	0	6	331	0	2	93	0	5	238	0	0	0	0	0	0	0	0	0
	Physical contingency	0	3	151	0	1	55	0	2	96	0	0	0	0	0	0	0	0	0
c	Administration cost	0	124	6,343	0	1	35	0	35	1,812	0	54	2,760	0	33	1,711	0	0	25
d	VAT	0	709	36,264	0	0	0	0	199	10,204	0	314	16,079	0	194	9,939	0	1	41
	VAT 18% for Procurement /Construction		699	35,793	0	0	0	0	197	10,086	0	311	15,893	0	192	9,814	0	0	0
	VAT 5% for Consulting Service		9	471	0	0	0		2	118	0	4	186	0	2	126	0	1	41
e	Import Tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total (a+b+c+d+e)		0	895	45,786	0	23	1,194	0	274	14,036	0	368	18,840	0	228	11,651	0	1	66
TOTAL (A+B)		24,935	4,478	254,057	0	23	1,194	6,312	1,292	72,432	10,486	1,961	110,854	7,740	1,191	68,687	397	10	890
C. Interest during Construction		10,361	0	10,361	0	0	0	953	0	953	2,470	0	2,470	3,439	0	3,439	3,498	0	3,498
	Interest during Construction(Const.)	10,358	0	10,358	0	0	0	953	0	953	2,470	0	2,470	3,439	0	3,439	3,497	0	3,497
	Interest during Construction (Consul.)	3	0	3	0	0	0	0	0	0	1	0	1	1	0	1	1	0	1
D. Commitment Charge		1,093	0	1,093	219	0	219	219	0	219	219	0	219	219	0	219	219	0	219
GRAND TOTAL (A+B+C+D)		36,388	4,478	265,511	219	23	1,413	7,483	1,292	73,603	13,175	1,961	113,543	11,398	1,191	72,345	4,114	10	4,607
E. JICA finance portion incl. IDC (A + C + D)		36,388	3,583	219,725	219	0	219	7,483	1,018	59,567	13,175	1,593	94,703	11,398	963	60,695	4,114	8	4,541

Source: JICA Study Team

Table 6-12 Annual Distribution of Cost of Phase 2

Item	Total			2012			2013			2014			2015			2016		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
Mobilization	100%	100%	0%	0%	0%		100%	100%		0%	0%		0%	0%		0%	0%	
Relocation of Public Utilies	100%	100%	0%	0%	0%		100%	100%		0%	0%		0%	0%		0%	0%	
Substructure	100%	100%	0%	0%	0%		35%	35%		60%	60%		5%	5%		0%	0%	
Superstructure	100%	100%	0%	0%	0%		32%	32%		55%	55%		14%	14%		0%	0%	
Station Building	100%	100%	0%	0%	0%		28%	28%		48%	48%		24%	24%		0%	0%	
Switch	100%	100%	0%	0%	0%		30%	30%		50%	50%		20%	20%		0%	0%	
Depot	100%	100%	0%	0%	0%		28%	28%		48%	48%		24%	24%		0%	0%	
Rolling stock	100%	100%	0%	0%	0%		23%	23%		39%	39%		39%	39%		0%	0%	
Power Supply system	100%	100%	0%	0%	0%		25%	25%		43%	43%		32%	32%		0%	0%	
Signalling and Telecommunication	100%	100%	0%	0%	0%		25%	25%		43%	43%		32%	32%		0%	0%	
Automatic Fare Collection system	100%	100%	0%	0%	0%		0%	0%		33%	33%		67%	67%		0%	0%	
Environmental Mitigation and Compensation	100%	100%	0%	0%	0%		32%	32%		55%	55%		14%	14%		0%	0%	
Land Acquisition					38%			63%			0%			0%			0%	
Consultant	100%	100%	0%	0%	0%	0%	27%	24%	0%	39%	41%	0%	26%	27%	0%	9%	8%	0%

Source: JICA Study Team

Table 6-13 Construction Cost of Phase 3

Item	Unit	Line-2C					Total Phase 3 (Line-2C)
		Quantity	Unit Price		Cost		
			FC	LC	FC	LC	
			1000 JPY	BRL	1000 JPY	BRL	1000 JPY
Mobilization							
Mobilization	LS	1		21,958,486	-	21,958,486	1,123,638
							-
Relocation of Public Utilities						-	-
Relocation of Public Utilities	LS	1		12,791,351		12,791,351	654,546
							-
Substructure work						-	-
Substructure	nos	237		340,000		80,580,000	4,123,359
							-
Superstructure work						-	-
PC Girder	nos	416		200,000		83,200,000	4,257,427
Steel Girder	Ton	5,535		12,000		66,420,000	3,398,778
Switch Bridge	LS	1				2,400,000	122,810
Total					-	152,020,000	7,779,015
							-
Switch work							-
Total					-	8,140,000	416,532
							-
Station Building work							-
Type A Station (Standard station)	station	6		24,872,240	-	149,233,440	7,636,424
Type B Station (Terminal station)	station	1		25,326,740	-	25,326,740	1,295,995
Type C Station (Socorro station 2A-11)	station						-
Type D Station (Faria Lima station 2B-14)	station						-
Type E Station (Sumare station 2C-5)	station	1		19,218,190	-	19,218,190	983,414
Type F Station (Jardim Angela station with Tunnel)	station						-
Type G Station (Underground stations with Tunnel	station						-
Total		8				193,778,370	9,915,833
							-
Depot Construction							-
Civil works	LS						-
Track works	LS						-
Buildings and workshops	LS						-
Total							-
							-
Depot Facilities procurement							-
Depot Facilities	LS						-
							-
Rolling stock procurement							-
Rolling stock (Import)	nos						-
Rolling stock (Domestic 1st lot)	nos						-
Rolling stock (Domestic 2nd lot)	nos	38		3,260,000		123,880,000	6,339,063
Spare parts	LS	1				6,194,000	316,953
Total					-	130,074,000	6,656,017
							-
Electric Power Supply system							-
Primary Substation (1000MVA & 30MVA)	LS	1	100,000	626,400	100,000	626,400	132,054
Transmission Line (34 kV, 2 Circuit)	LS	1		15,349,774		15,349,774	785,463
Power Supply Substation (15 SS)	LS	1	1,229,025	22,090,932	1,229,025	22,090,932	2,359,440
Contact Line (1,500V) Main line	LS	1	1,186,641	14,501,001	1,186,641	14,501,001	1,928,672
Contact Line (1,500V) Depot	LS	-					-
Distribution Line (13.8kV, 2 Circuit)	LS	1		2,909,083		2,909,083	148,861
Power Facilities Station	LS	1		3,348,340		3,348,340	171,338
Power Facilities Depot	LS						-
Power Facilities OCC	LS						-
Total					2,515,666	58,825,530	5,525,827
							-
Signalling &Telecomm. system							-
Main Line Signalling system	LS	1	446,530	3,973,494	446,530	3,973,494	649,858
Depot Signalling system	LS	1	-	-	-	-	-
ATS system	LS	1	281,000	613,470	281,000	613,470	312,392
Onboard Signalling system	LS	1	71,600	-	71,600	-	71,600
Commissioning and O & M Manual	LS	1	48,000	282,000	48,000	282,000	62,430
Spare parts for Signalling system	LS	1	81,000	455,000	81,000	455,000	104,283
Telecommunication system	LS	1		19,582,905	-	19,582,905	1,002,077
Commissioning and O & M Manual		1		1,223,000	-	1,223,000	62,582
Spare parts of Telecommunication system		1		1,972,000	-	1,972,000	100,909
Total					928,130	28,101,869	2,366,131
							-
AFC system							-
AFC system	station	8		500,000	-	4,000,000	204,684
							-
Environmental Mitigation and Compensation							-
Removal works of roadside trees	LS	1		2,877,331		2,877,331	147,236
							-
Total					3,443,796	693,146,937	38,912,818

Source: JICA Study Team

Table 6-14 Implementation Cost of Phase 3

Item	Total			2014			2015			2016			2017			2018		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
A. ELIGIBLE PORTION	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY	million BRL	million JPY
Ⅰ) Procurement / Construction	3,948	938	51,964	0	0	0	1,289	353	19,332	1,773	436	24,097	885	149	8,535	0	0	0
Mobilization	0	22	1,124	0	0	0	0	22	1,124	0	0	0	0	0	0	0	0	0
Relocation of Public Utilities	0	13	655	0	0	0	0	13	655	0	0	0	0	0	0	0	0	0
Substructure	0	81	4,123	0	0	0	0	40	2,062	0	40	2,062	0	0	0	0	0	0
Superstructure	0	152	7,779	0	0	0	0	65	3,334	0	87	4,445	0	0	0	0	0	0
Station Building	0	194	9,916	0	0	0	0	70	3,570	0	93	4,760	0	31	1,587	0	0	0
Switch	0	8	417	0	0	0	0	4	179	0	5	237	0	0	0	0	0	0
Rolling stock	0	130	6,656	0	0	0	0	26	1,331	0	52	2,662	0	52	2,662	0	0	0
Power Supply system	2,516	59	5,526	0	0	0	830	19	1,824	1,132	26	2,487	553	13	1,216	0	0	0
Signalling and Telecommunication system	928	28	2,366	0	0	0	309	9	789	413	12	1,052	206	6	526	0	0	0
Automatic Fare Collection system	0	4	205	0	0	0	0	0	0	0	2	82	0	2	123	0	0	0
Environmental Mitigation and Compensation	0	3	147	0	0	0	0	1	63	0	2	84	0	0	0	0	0	0
Base cost for JICA financing	3,444	693	38,913	0	0	0	1,140	269	14,929	1,545	319	17,871	760	105	6,113	0	0	0
Price escalation	316	201	10,577	0	0	0	88	66	3,483	144	96	5,079	83	38	2,015	0	0	0
Physical contingency	188	45	2,474	0	0	0	61	17	921	84	21	1,147	42	7	406	0	0	0
Ⅱ) Consulting services	3,456	75	7,305	0	0	0	1,164	21	2,242	1,175	29	2,647	956	22	2,074	161	4	342
Base cost	3,009	55	5,813	0	0	0	1,029	16	1,853	1,023	21	2,100	821	15	1,603	136	2	257
Price escalation	282	17	1,144	0	0	0	80	4	282	96	6	421	90	6	373	17	1	68
Physical contingency	165	4	348	0	0	0	55	1	107	56	1	126	46	1	99	8	0	16
Total (Ⅰ + Ⅱ)	7,403	1,014	59,269	0	0	0	2,453	374	21,574	2,948	465	26,744	1,842	171	10,609	161	4	342
B. NON ELIGIBLE PORTION																		
a Procurement / Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Base cost for JICA financing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Price escalation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physical contingency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
b Land Acquisition	0	2	114	0	0	9	0	2	104	0	0	0	0	0	0	0	0	0
Base cost	0	2	87	0	0	7	0	2	80	0	0	0	0	0	0	0	0	0
Price escalation	0	0	21	0	0	1	0	0	20	0	0	0	0	0	0	0	0	0
Physical contingency	0	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
c Administration cost	0	35	1,781	0	0	0	0	13	650	0	16	802	0	6	318	0	0	10
d VAT	0	191	9,763	0	0	0	0	70	3,592	0	87	4,470	0	32	1,640	0	1	17
VAT 18% for Procurement /Construction	0	183	9,354	0	0	0	0	68	3,480	0	85	4,337	0	30	1,536	0	0	0
VAT 5% for Consulting Service	0	7	365	0	0	0	0	2	112	0	3	132	0	2	104	0	0	17
e Import Tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total (a+b+c+d+e)	0	228	11,658	0	0	9	0	85	4,347	0	103	5,272	0	38	1,958	0	1	27
TOTAL (A+B)	7,403	1,241	70,928	0	0	9	2,453	459	25,921	2,948	568	32,016	1,842	210	12,568	161	5	414
C. Interest during Construction	2,893	0	2,893	0	0	0	329	0	329	744	0	744	902	0	902	918	0	918
Interest during Construction(Const.)	2,891	0	2,891	0	0	0	329	0	329	744	0	744	902	0	902	917	0	917
Interest during Construction (Consul.)	2	0	2	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1
D. Commitment Charge	311	0	311	62	0	62	62	0	62	62	0	62	62	0	62	62	0	62
GRAND TOTAL (A+B+C+D)	10,607	1,241	74,132	62	0	72	2,844	459	26,312	3,754	568	32,822	2,806	210	13,532	1,141	5	1,394
E. JICA finance portion incl. IDC (A + C + D)	10,607	1,014	62,473	62	0	62	2,844	374	21,965	3,754	465	27,550	2,806	171	11,574	1,141	4	1,322

Source: JICA Study Team

Table 6-15 Annual Distribution of Cost of Phase 3

Item	Total			2014			2015			2016			2017			2018		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
Mobilization	100%	100%	0%	0%	0%		100%	100%		0%	0%		0%	0%		0%	0%	
Relocation of Public Utilities	100%	100%	0%	0%	0%		100%	100%		0%	0%		0%	0%		0%	0%	
Substructure	100%	100%	0%	0%	0%		50%	50%		50%	50%		0%	0%		0%	0%	
Superstructure	100%	100%	0%	0%	0%		43%	43%		57%	57%		0%	0%		0%	0%	
Station Building	100%	100%	0%	0%	0%		36%	36%		48%	48%		16%	16%		0%	0%	
Switch	100%	100%	0%	0%	0%		43%	43%		57%	57%		0%	0%		0%	0%	
Rolling stock	100%	100%	0%	0%	0%		20%	20%		40%	40%		40%	40%		0%	0%	
Power Supply system	100%	100%	0%	0%	0%		33%	33%		45%	45%		22%	22%		0%	0%	
Signalling and Telecommunication system	100%	100%	0%	0%	0%		33%	33%		44%	44%		22%	22%		0%	0%	
Automatic Fare Collection system	100%	100%	0%	0%	0%		0%	0%		40%	40%		60%	60%		0%	0%	
Environmental Mitigation and Compensation	100%	100%	0%	0%	0%		43%	43%		57%	57%		0%	0%		0%	0%	
Land Acquisition					8%			92%			0%			0%			0%	
Consultant	100%	100%	0%	0%	0%	0%	33%	30%	0%	36%	38%	0%	27%	28%	0%	4%	4%	0%

Source: JICA Study Team

Table 6-16 Construction Cost of Phase 3-2

item	unit	Quantity	Phase 3-2 Year 2025~				
			Unit Price		Cost		Total
			FC	LC	FC	LC	
			1000 JPY	BRL	1000 JPY	BRL	1000 JPY
Rolling stock procurement							
Rolling stock (Import)	nos						
Rolling stock (Domestic 1st lot)	nos						
Rolling stock (Domestic 2nd lot)	nos	48		3,260,000		156,480,000	8,007,238
Spare parts	LS	1		7,824,000	-	7,824,000	400,362
Total					-	164,304,000	8,407,600
							-
Electric Power Supply system							-
Primary Substation (1000MVA & 30MVA)	LS						-
Transmission Line (34 kV, 2 Circuit)	LS						-
Power Supply Substation (15 SS)	LS	1	1,003,275	7,287,728	1,003,275	7,287,728	1,376,195
Contact Line (1,500V) Main line	LS						-
Contact Line (1,500V) Depot	LS						-
Distribution Line (13.8kV, 2 Circuit)	LS						-
Power Facilities Station	LS						-
Power Facilities Depot	LS						-
Power Facilities OCC	LS						-
Total					1,003,275	7,287,728	1,376,195
Total					1,003,275	171,591,728	9,783,795

Source: JICA Study Team

6.3.4 Cost comparison of Line-2A

The cost comparison between the Original route plan and the Area Development route plan of Line-2A is shown in Table 6-17.

Table 6-17 Cost Comparison of Line-2A

Item		Phase 1 Original route (MB)			Phase 1 Area Development route (AD)			Difference
		FC	LC	Total	FC	LC	Total	FC
		million JPY	million BRL	million JPY	million JPY	million BRL	million JPY	million JPY
A. ELIGIBLE PORTION								(AD)-(MB)
Ⅰ	Procurement / Construction	22,160	2,330	141,411	22,587	2,588	155,040	13,628
	Base cost	20,335	1,996	122,466	20,675	2,212	133,855	11,389
	Price escalation	770	224	12,212	837	253	13,802	1,590
	Physical contingency	1,055	111	6,734	1,076	123	7,383	649
Ⅱ	Consulting services	6,342	50	8,924	6,815	55	9,621	697
	Base cost	5,815	43	8,011	6,239	46	8,612	601
	Price escalation	224	5	488	252	6	551	62
	Physical contingency	302	2	425	325	3	458	33
Total A=(Ⅰ＋Ⅱ)		28,502	2,381	150,336	29,402	2,643	164,661	14,325
a	Land Acquisition	0	96	4,895	0	164	8,415	3,520
	Base cost	0	87	4,477	0	152	7,758	3,281
	Price escalation	0	4	185	0	5	256	71
	Physical contingency	0	5	233	0	8	401	168
b	Administration cost	0	91	4,657	0	101	5,192	535
c	VAT	0	506	25,900	0	555	28,388	2,488
	VAT 18% for Procurement /Construction	0	497	25,454		545	27,907	2,453
	VAT 5% for Consulting Service	0	9	446		9	481	35
d	Import Tax	0	0	0	0	0	0	0
Total B=(a+b+c+d)		0	693	35,452	0	821	41,995	6,543
TOTAL (A+B)		28,502	3,074	185,788	29,402	3,464	206,656	20,868

Source: JICA Study Team

6.3.5 Contents of Construction cost

(1) Mobilization

The mobilization cost for the preparation of the construction works is considered to represent 5% of the total cost of structure, station building and depot construction cost.

(2) Relocation of public utilities

This is the cost of relocating electric and telephone lines, and water, sewage and gas pipes which are likely to interfere with the construction of the monorail system. This cost for is considered to represent 3% of the total cost of structure and station construction cost, and the relocation costs are related to incidental works, simple road restoration work, relocation of traffic signals, simple environmental protection, detour works and so on.

(3) Substructure

The standard shape of all substructures in each section is studied to estimate the unit construction cost, which is multiplied by the required quantity to estimate the total construction cost of substructures. Substructures in the depot are not estimated in this item, but estimated as an item of Depot construction work together with superstructures, because the guideway in the depot is a low elevated structure with a single track, making it a different structure from those of the main line.

(4) Superstructure

The superstructure cost is classified into the following three types.

1) PC girder

PC girders will be installed in standard span section of 22 to about 30 metres. The construction cost is estimated as the required quantity multiplied by the unit price.

2) Steel girder

Steel girders will be installed in long span sections, such as intersections and river crossings. The construction cost is estimated as the required construction weight multiplied by the steel unit price.

3) Pre-stressed concrete (PC) continuous slab

PC continuous slabs will be provided at branches and in passing loop sections. The construction cost is estimated.

(5) New road construction

As for the Area Development route plan of Line-2A, the demolition work of existing houses at the construction site becomes necessary prior to construction beginning. Moreover, after construction completion, a new road becomes necessary along the Monorail route. Consequently, the demolition cost and the construction cost of new road are estimated.

(6) Switches

Switches which are of specialized equipment for the monorail system will be manufactured prototypes in foreign factories and the remainder in domestic factories to make reference to prototypes as described in section 6.2. The cost of switches estimates to separate into foreign and local cost components.

(7) Station building and tunnel works

The construction cost of a station building includes the cost of general station facilities and equipment, such as electric lighting service, water supply and drainage system, mechanical services including lifts, escalators, platform screen doors, and so on. The facilities of the signaling and telecommunication system, such as public address, clock system, radio system etc. are not included in this item, but are included as an item of system cost.

The cost of tunnel section works adjoining Jaridm Angel underground station in Line-2A and two underground stations in the Area Development Route plan are estimated along with respective station costs in Type F Station (Jaldim Angel station with tunnel) and Type G station (Underground station with Tunnel).

For the purpose of cost estimation, stations are classified into standard, terminal and special types. The classification of station is shown in Table 6-18.

Table 6-18 Classification of Station

Type	Station	Outline
A	Standard station	Standard structure type station; A concourse floor and a platform floor are constructed over the road centre and pedestrian bridges are connected to the concourse floor from sidewalks on the both sides of the road.
B	Terminal station	Island platform type station
C	Line-2A- 11 (Socorro)	The station is constructed above a river and the estimated cost includes the cost of the station building and the cost of bridge construction.
D	Line-2B –14 (Faria Lima)	This is the junction station of Line-2B, 2C and 2D with an Island platform type of 4 stories.
E	Line-2C –5 (Sumare)	It is junction station of the SP Metro, with a separated type platform of 2 stories.
F	Underground station Line-2A – 1 (Jardim Angela)	This is an underground station constructed under a bus terminal which adjoins the tunnel section under road and the estimated cost includes the cost of the tunnel section and ventilation facility.
G	Underground stations Line-2A – 2, Line-2A – 4	These are underground stations which adjoin the tunnel section under M'boi Mirim road and the estimated cost includes the cost of adjoining tunnel section and ventilation facility.

Source: JICA Study Team

(8) Depot construction work

For the purpose of cost estimates, the depot construction works and depot facilities are classified into four types.

1) Ground leveling work and incidental works

Ground leveling work is carried out to provide flat ground in whole depot area and incidental works, such as road works, drainage works, retaining wall works, etc. The cost of these works is included in the total construction cost estimate.

2) Guideway and switches

The approach line and guideway in the depot are constructed. The guideway in the depot are constructed as low elevated structures so that their cost is differ in structure from those of the main line. The cost of guideway in the depot is estimated in this item, separately from that of the main line. The costs of switches installed in the depot are included in the item of switches.

3) Building, workshop and other housings

An office building, workshop and other housings which are constructed in the depot are estimated.

4) Depot facilities

The costs of equipment and facilities for the inspection and maintenance of the vehicles and incidental systems are estimated.

(9) Rolling stock

The rolling stock cost is estimated for prototype of 3 trains (18 cars) in foreign currency, and remaining rolling stock which are manufactured domestically in local currency. The cost of local currency is estimated in terms of two types of the primary lot and the second lot for the domestic production respectively.

(10) Power supply system

This item includes the costs of: primary substations, power supply substations, distribution lines and incidental facilities.

(11) Signaling and telecommunication system

The equipment and materials costs of signaling and telecommunication system are classified into foreign and local costs, as described in section 6.2.

(12) Automatic fare collection (AFC) system

AFC equipment to be installed at the ticket control gates of stations is estimated in local cost terms.

(13) Environmental mitigation and compensation

It is estimated for environmental influence measure cost and compensation cost during the construction period.

6.3.6 Consulting service fee

The consultant cost is estimated in consideration of direct cost which is an expense of consulting engineers and incidental indirect costs.

The direct cost is planed the number of each engineer's working months during the project period, which is multiplied by the unit price to estimate the direct cost. Indirect cost contains international airfare, accommodation allowance, office rental, vehicle rental and so on.

The unit prices of the engineer per month are as follows.

	Foreign Currency (JPY)	Local Currency (BRL)
International consultant	2,690,000	0
Domestic consultant	0	26,300
Supporting staff	0	15,000

(1) Main services of consult

1) Preparation stage

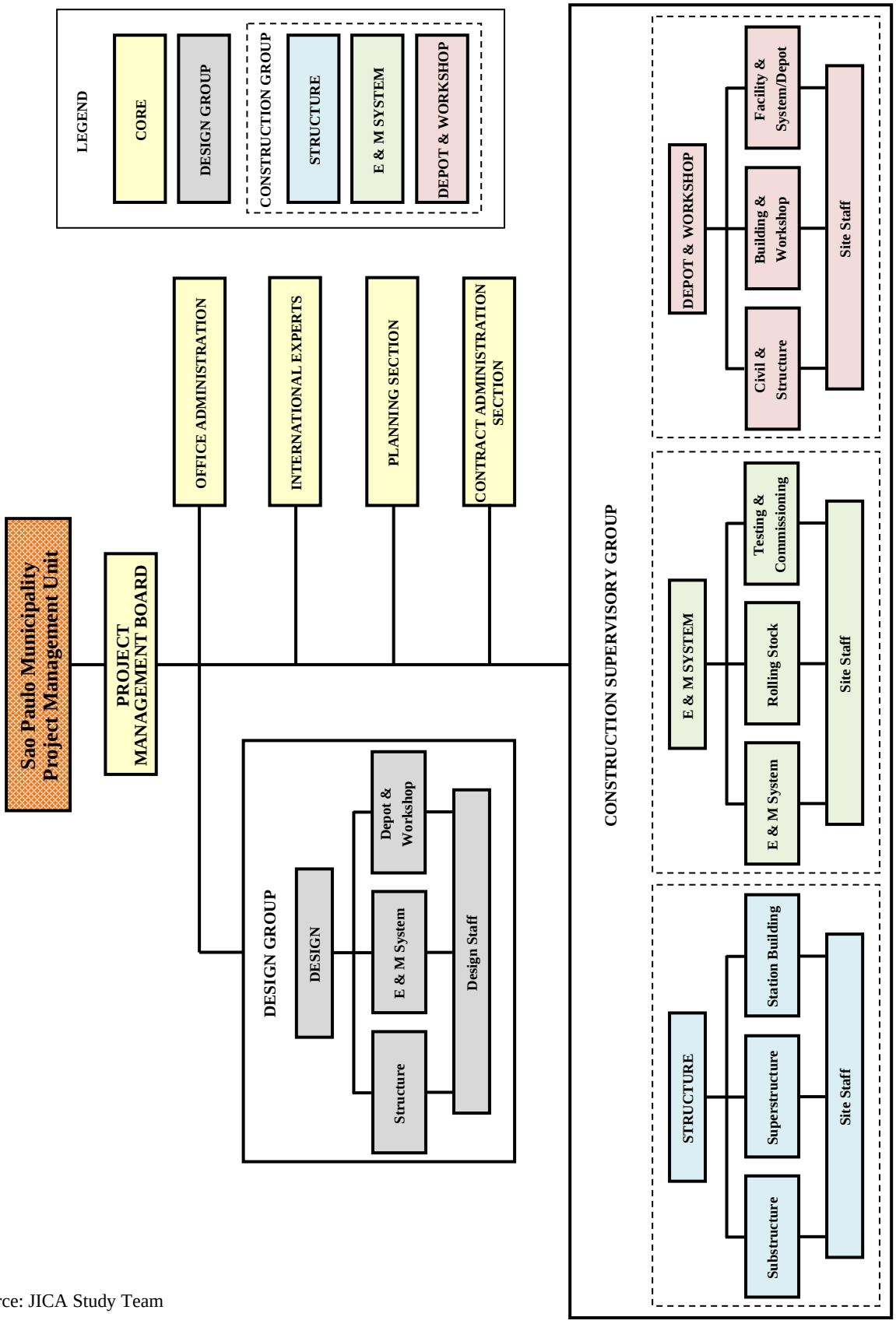
a) Preparation of the basic design
b) Preparation of the construction plan and the outline programme
c) Estimates of construction costs
d) Preparation of tender documents
e) Tender procedure
f) Evaluation of tender documents
g) Recommendation to Employer as to acceptance of the tender

2) Construction stage

a) Review and approval of the detailed design and the specification proposed by the contractor
b) Examination of the construction method and the constructional programme proposed by the contractor
c) Schedule control
d) Quality control
e) Safety control
f) Measurement or Confirmation of the quantities of executed works for the payment
g) Estimation for the variations of costs and programme by changed site conditions or varied requirements of the employer
h) Inspection or confirmation of field tests, function tests, running tests and so on.
i) Preparation of progress reports.

(2) Organization chart and work schedule of consulting service

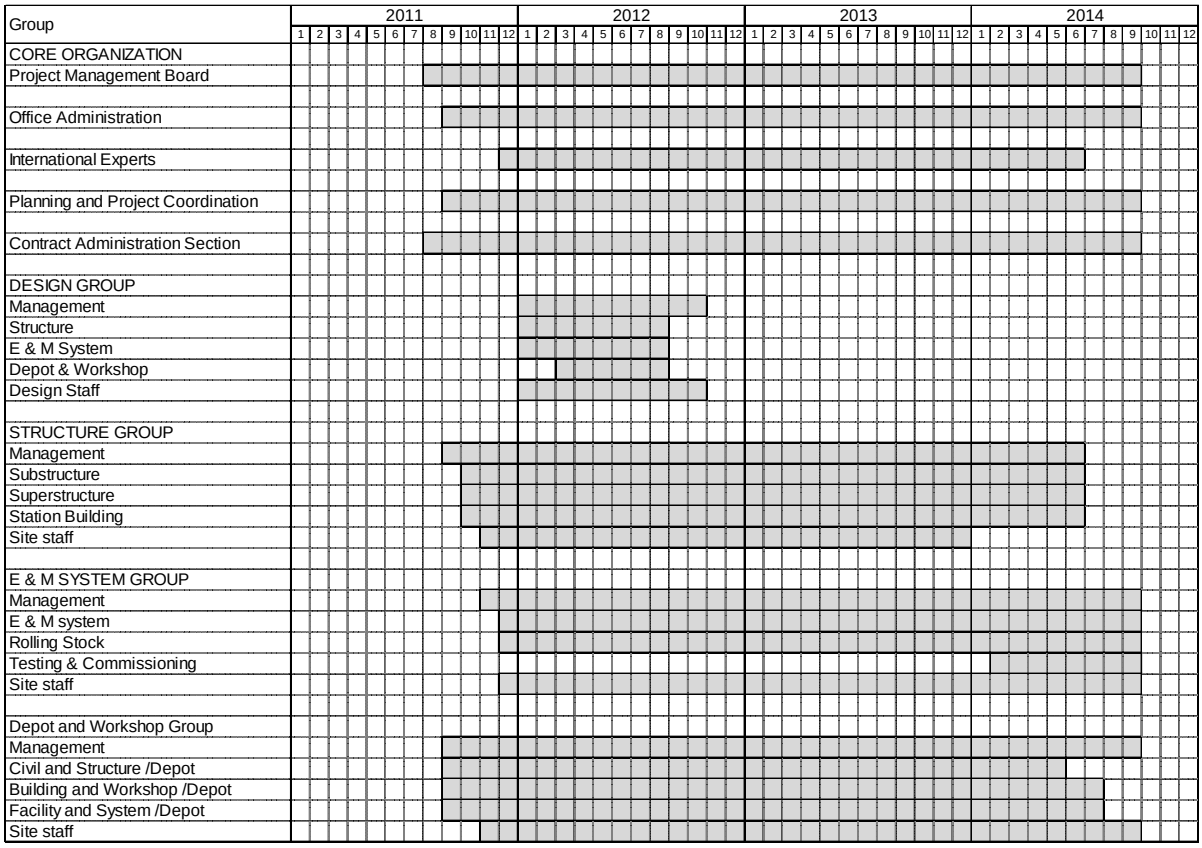
Organization chart of consulting service is shown in Figure 6-8, and work schedules of consulting service for each phase are shown in Table 6-19 to Table 6-22 respectively.



Source: JICA Study Team

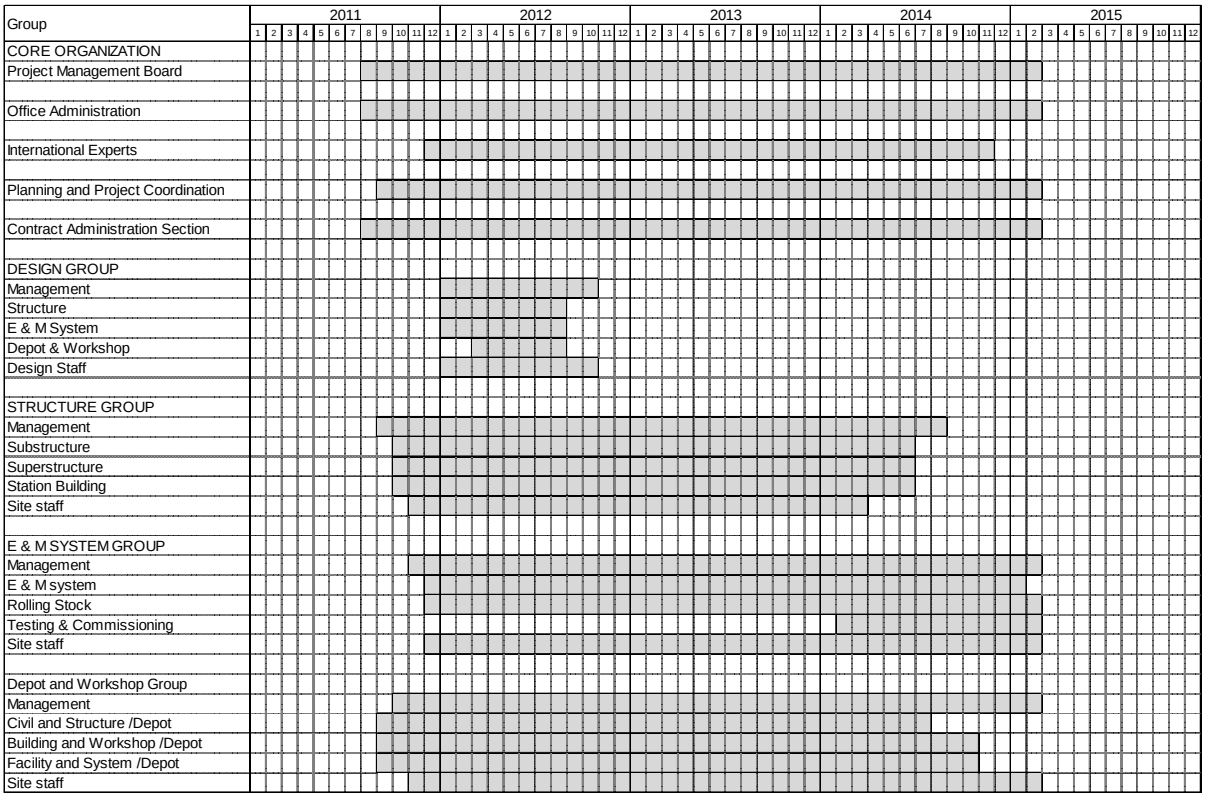
Figure 6-8 Organization Chart of Consulting Service

Table 6-19 Work Schedule of Consulting Services for Original Route Plan of Phase 1



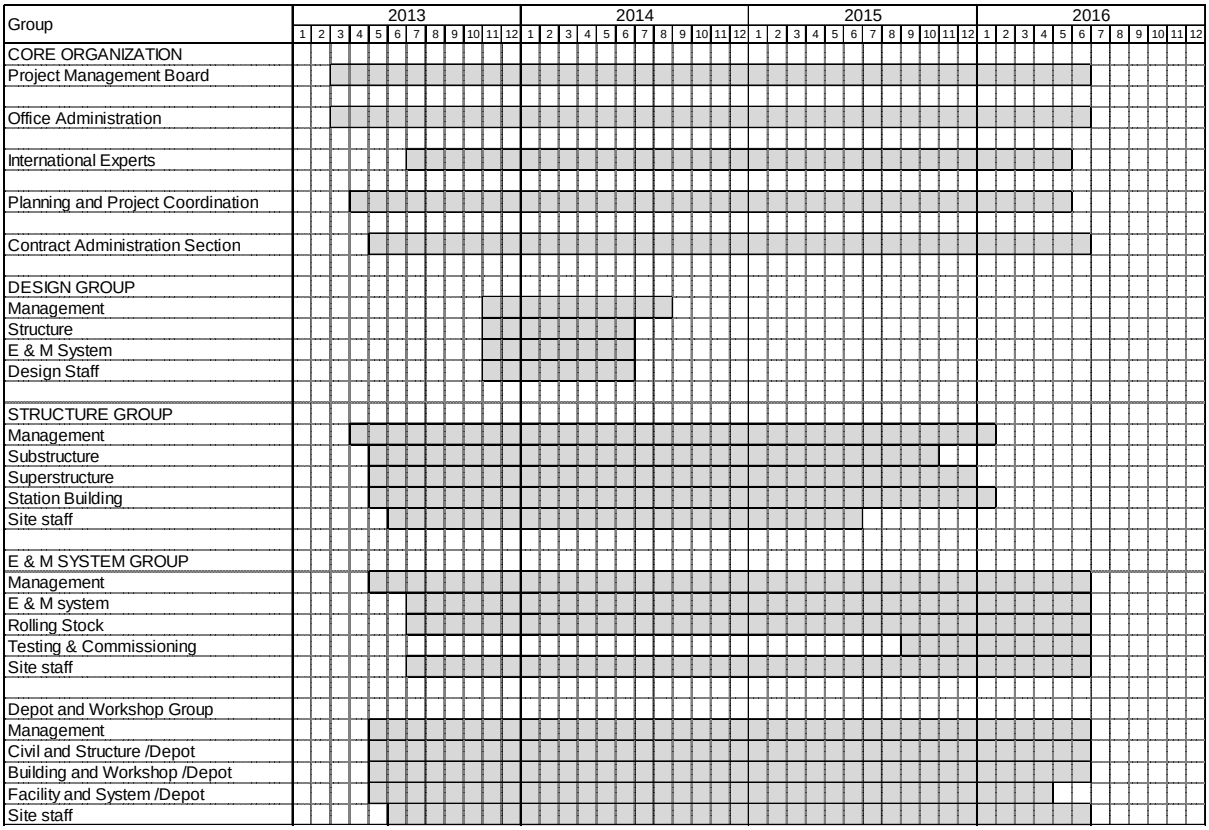
Source: JICA Study Team

Table 6-20 Work Schedule of Consulting Services for Area Development Route Plan of Phase 1



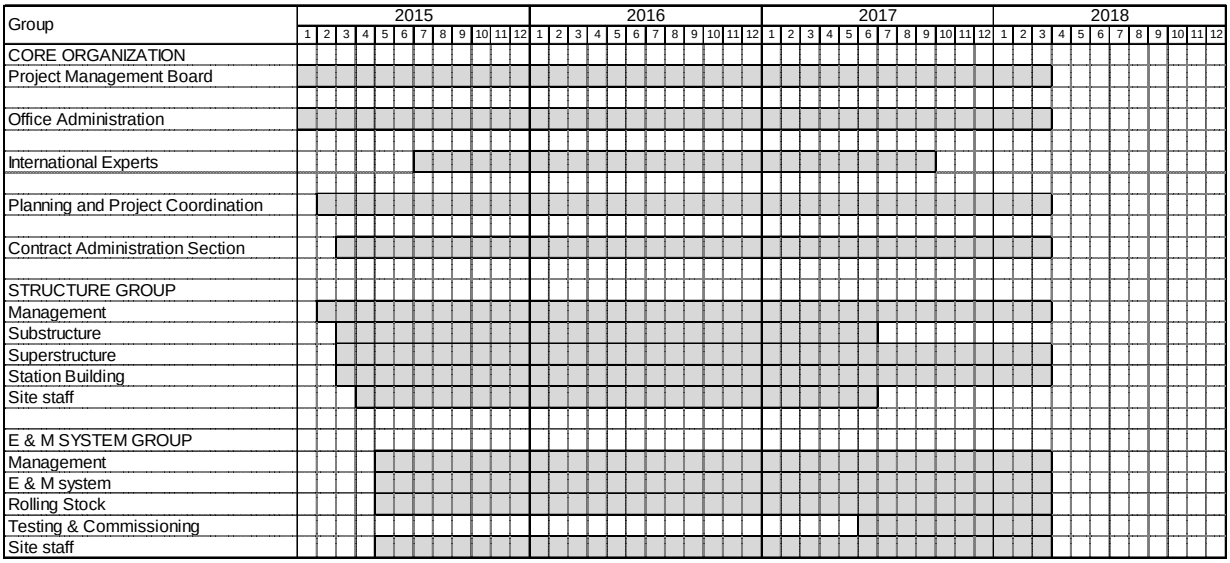
Source: JICA Study Team

Table 6-21 Work Schedule of Consulting Services for Phase 2



Source: JICA Study Team

Table 6-22 Work Schedule of Consulting Services for Phase 3



Source: JICA Study Team

6.4 IMPLEMENTATION SCHEDULE

6.4.1 General

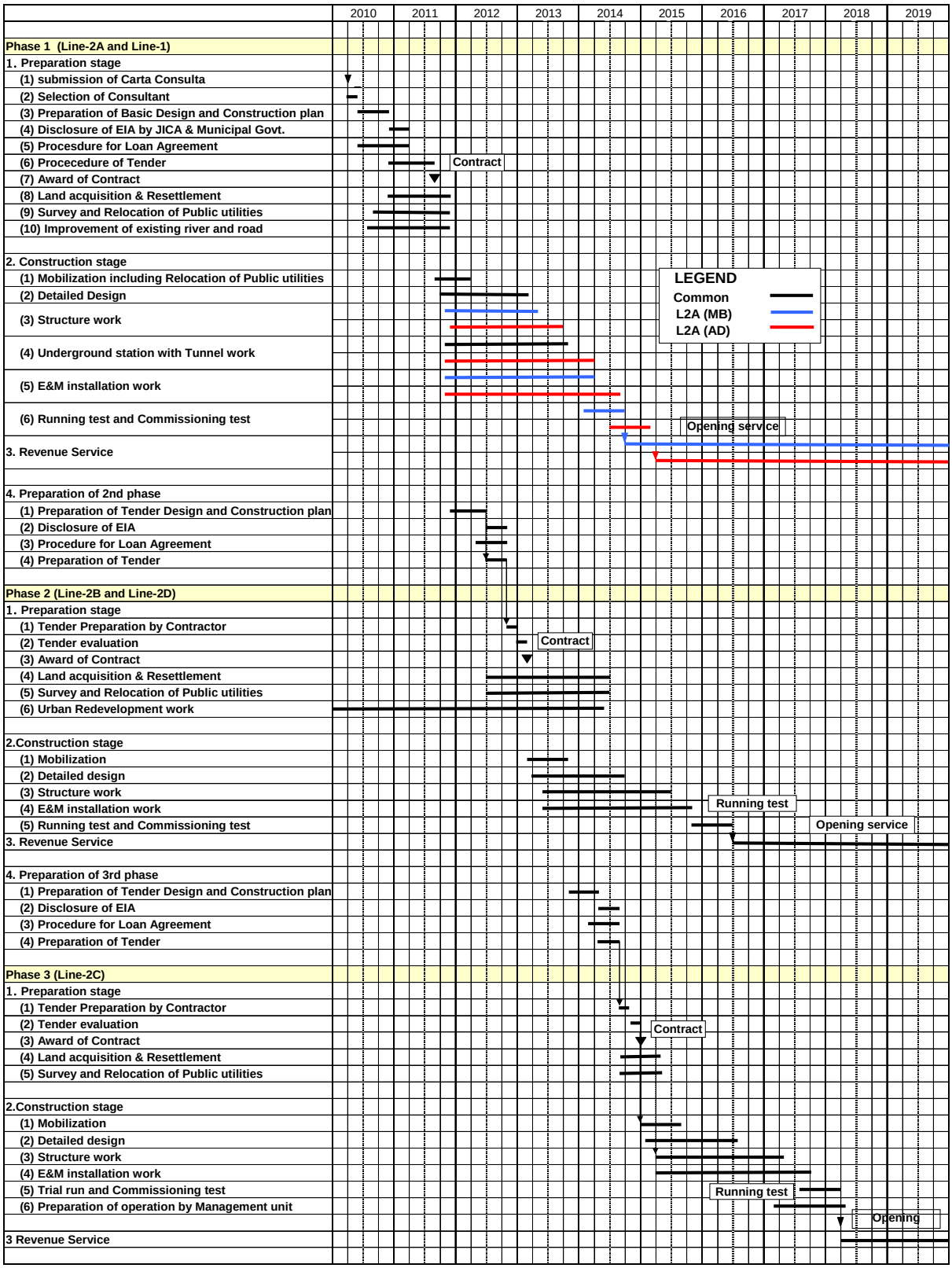
As shown in Table 6-2, this project execute by dividing three phases. Among these, for Line-2A included in Phase 1, there are two alternative plans of the Original Route plan and the Area Development Route plan. In both alternative plans, the commencing time of the construction is the same, but the completion time is different depending on the difference of the construction contents.

In the construction stage, the schedule is planned so that the structure works of the following stage may start when the civil works of the preceding stage mostly complete. In addition, Phase 3-2 in which some power supply system and rolling stock are added with the increase of future demand is shown.

The outline of implementation schedule is shown in Table 6-23. As for two alternatives of Phase 1, common plans are shown with black lines, the Original Route plan is with blue lines, and the Area Development Route plan is with red lines in the table.

The implementation is classified into flowing five categories which are (1) Preparation stage, (2) Construction stage, (3) Revenue service stage, (4) Operation preparation stage, and (5) Preparation stage of succeeding stage.

Table 6-23 Outline of Implementation Schedule

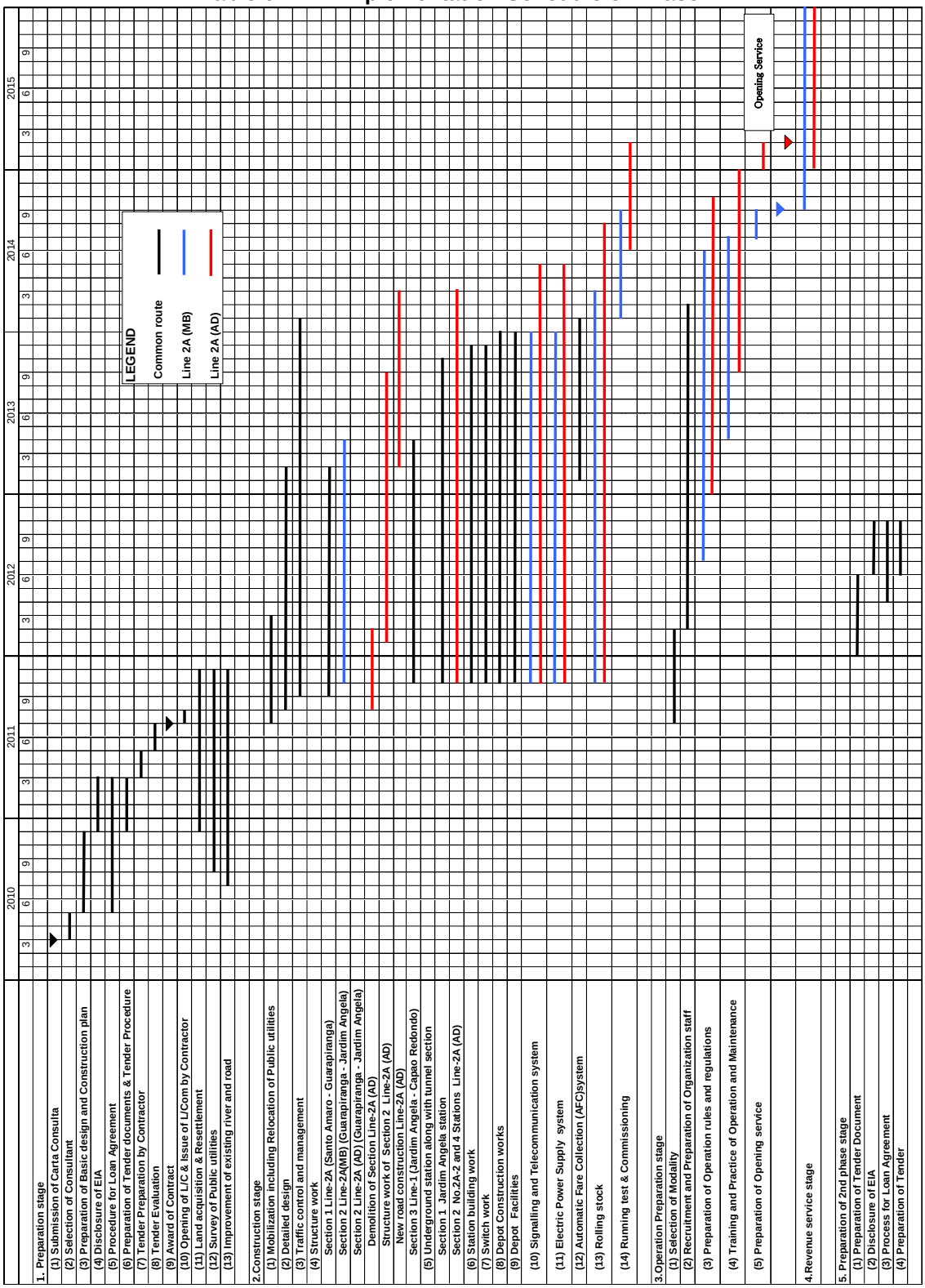


Source: JICA Study Team

6.4.2 Phase 1

The implementation schedule of Phase 1 is shown in Table 6-24. As for two alternatives of Line-2A, common plans are shown with black lines, the Original Route plan is with blue lines, and the Area Development Route plan is with red lines in the table.

Table 6-24 Implementation Schedule of Phase 1



Source: JICA Study Team

(1) Preparation stage

In the preparation stage, the capital items are a public notice of the project, financing, selection of a consultant, tender and contract, which are mainly executed by the municipal government of São Paulo (the government) and the consultant

1) Selection of consultant

The government intends to start earlier preparation of basic design for realization of this project as soon as possible. Therefore, the government intends to select the consultant who conducts the basic design in the government budget.

2) Tender and contract

The contractor will be selected through international tender and made a contract with the government, which is expected in August, 2011.

3) Land acquisition and resettlement of inhabitants

The land acquisition and resettlement of inhabitants which are required for the construction are carried out based on the basic design and an EIA study report.

4) Improvement of existing rivers and roads

There are some sections of existing river and road in the monorail construction site of Line-1 and line-2A respectively, which are improved by the government before the construction. These improvement works shall be completed before the construction begins.

(2) Construction stage

The construction stage is a period for the construction of monorail, test running and handover, which are mainly executed by the contractor. The consultant reviews and approves the detailed design and supervises the construction works.

As for the total construction period, the Original Route plan is assumed 38 months from August, 2011 to September, 2014 and the Area Development Route plan is assumed 43 months from August, 2011 to February, 2015.

1) Structure work

The construction section of Phase 1 is divided into three sections to construct simultaneously to shorten the construction schedule.

Table 6-25 Construction Section of Phase 1

No.	Construction Section	Description
1	Line-2A ,Santo Amaro – Guarapiranga	Advanced section
2	Line-2A Guarapiranga - Jardim Angela (Original Route plan)	Passing along the M'boi Mirim road.
	Line-2A Guarapiranga - Jardim Angela (urben development plan)	Passing into residential area. As incidental works, 6 months of demolition work before the construction and 6 months of new road construction works after the construction.
3	Line-1, Jardim Angela – Capao Redondo	

Source: JICA Study Team

2) Underground stations with tunnel sections

No. 2A–1 station at Jardim Angela is underground station. No. 2A–2 and No. 2A–4 stations in the Area Development Route plan are also underground stations. The Monorail route passes across under the main road, M'boi Mirim, and connects the underground station.

The road crossing construction works are needed to take care to minimize influence of the road traffic. When the work is possibility to affect the road traffic, it shall be night work. Therefore, the work schedule shall be considered the work efficiency which is required sufficient attentions and measures against noise, vibration, etc. occurred by the construction work.

At the No.2A-1 station site, there is no need to demolish the houses and resettlement of inhabitants so that it may be possible to begin the construction early. The construction period is expected 27 months from the contract.

The No.2A-2 station and the No.2A-4 station of the Area Development Route plan need a long period to demolish the houses and resettlement of inhabitants. Furthermore, it is required to construct some access roads around the underground stations after completion of the station. The construction period of those stations is assumed 32months from the contract.

3) Depot construction works

A main depot is constructed along Line-2A in phase 1. It is constructed ground works of whole depot area, guideway works, building works for an operation control center, and for workshop, and respective incidental works. All the Monorail systems such as maintenance facilities, power supply system, and signaling and telecommunication system shall be completed by the time of train delivery.

4) Power supply, signaling and telecommunication systems

The installation works for power supply system, signaling and telecommunication system are carried out one by one from the part where structure work is completed.

As for the completion time of installation works of the Monorail system, the Original Route plan is assumed after 2 months from the completion of No. 2A-1 Jardim Angela station, and the Area Development Route plan are assumed after 2 months from the completion of the underground stations of No. 2A-2 and No.2A-4.

5) Rolling stock

The rolling stock is delivered to the workshop in the depot under the condition which was dismantled for the delivery. The dismantled rolling stock is carried out reassembly, adjustment and inspection works.

Because two alternative plans of Line-2A are different from completion time of system works, the delivery beginning time of train is different. The delivery period of rolling stock is expected for 3 months after the beginning of the delivery of train.

6) Trial run & commissioning test

After the completion of all the structure and system works, all tests which include an individual test, system integrated test, trail run, running tests and commissioning are executed in order to verify the operation normally, safety and accurately.

Those tests start after one month from the delivery of the first train which is carried out

reassembly and adjustment in workshop. The testing period is expected for 8 months.

The São Paulo municipal government has studied to precede the implementation schedule of partial section of Line-2A, from Guarapringa to Santo Amoro, approximate 4 km of length in order to complete by the end of year 2012 at his own budget apart from the implementation schedule of JICA report.

(3) Operation preparation stage

In this stage, it executes the following works.

- Recruit Staff recruiting and arrangement of organization
- Preparation of operation rules and regulations
- Training and practice of operation
- Preparation of opening service

(4) Revenue service stage

Revenue service is executed.

(5) Preparation stage of next construction phase

In order to begin the construction work of Phase 2 without delay, the basic design and tender documents for the construction of Phase 2 is prepared during Phase 1 construction stage.

6.4.3 Phase 2 (Line-2B and Line-2D)

The implementation schedule of Phase 2 is shown in Table 6-26.

Table 6-26 Implementation Schedule of Phase 2 (Line-2B and Line-2D)

Source: JICA Study Team

(1) Preparation stage

The preparation works of the basic design, preparation of tender and financing have already prepared during the Phase 1 construction stage.

In the preparation stage of Phase 2, the capital items are tender and contract, and land acquisition and resettlement.

Moreover, in the 2 km section of northern side of Santo Amaro in Line-2B, the Monorail route passes into the planned road by the master plan of municipality of São Paulo city. In order not to obstruct the monorail construction work, it is necessary to coordinate with the construction project of the plan road.

(2) Construction stage

The construction period is assumed 40 months from March, 2013 to June, 2016.

1) Structure work

The construction section of Phase 2 is divided into three sections to construct simultaneously to shorten the construction schedule. From the part where substructure work is completed, guideway girders will be installed one by one.

Table 6-27 Construction Section of Phase 2

No.	Construction Section	Description
1	Line-2B ,Santo Amaro – Morumbi Mall	Need to coordination to plan road project by the master plan
2	Line-2B Morumbi Mall – Largo da Batata	Need to take sufficient measures to road traffic and environment due to new rising business area.
3	Line-2D Largo de Batata – Ramal Jaguala	

Source: JICA Study Team

2) Depot construction works

At the construction stage of Phase 2, additional stabling lines, inspection lines and maintenance facilities are installed in the main depot which is constructed in Phase 1. Furthermore, the stabling yards are constructed at Ramal Jaguala and Jardim Angela.

3) Rolling stock

The rolling stock is delivered to the workshop of the main depot for reassembly and adjustment works.

4) Trial run and commissioning test

After the completion of all the structure and system works of Phase 2, all kinds of tests, such as integrated test and commissioning are executed at all lines in Phase 2 in order to verify the operation normally, safety and accurately.

(3) Operation preparation stage

The management unit prepares the operation service for extension of Phase 2 as follows.

- Additional staff recruiting and re-arrangement of organization
- Revision of operation rules and regulations due to extension of operation

- Training and practice of operation for additional staff
- Preparation of opening service of Line-2B and Line-2D

(4) Revenue service stage

Revenue service is executed.

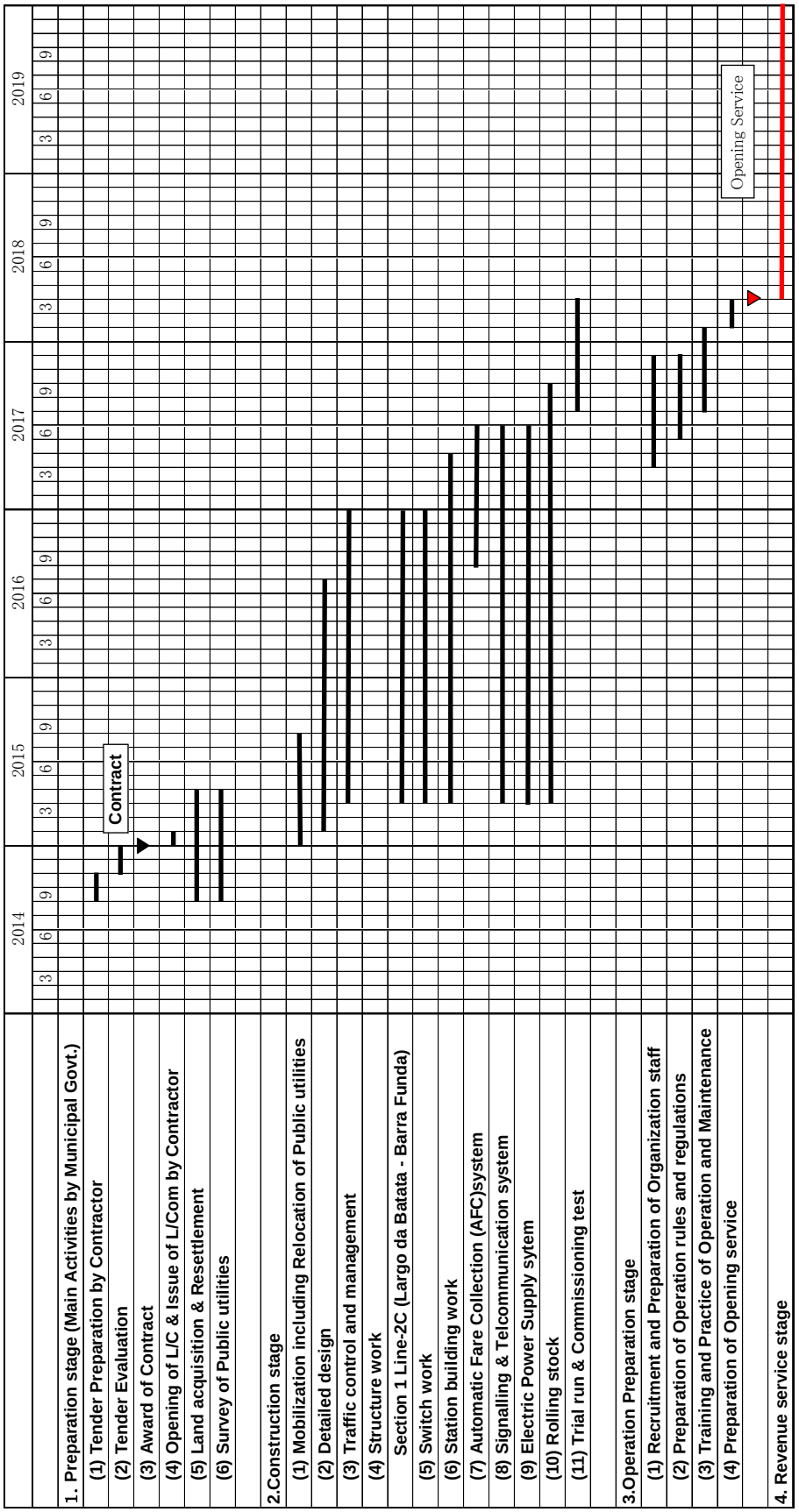
(5) Preparation stage of next construction phase

In order to begin the construction work of Phase 3 without delay, the basic design and tender documents for the construction of Phase 3 are prepared during Phase 2 construction stage.

6.4.4 Phase 3 (Line-2C)

The implementation schedule of Phase 3 is shown in Table 6-28.

Table 6-28 Implementation Schedule of Phase 3 (Line-2C)



Source: JICA Study Team

(1) Preparation stage

The preparation works of the basic design, tender documents and financing are prepared during the Phase 2 construction stage.

In the preparation stage of Phase 3, the capital items are tender and contract, and Land acquisition.

(2) Construction stage

The construction period, is assumed 39 months from January, 2015 to March, 2018. As for the Phase 3, depot construction is not required.

1) Structure work

From the part where substructure work is completed, guideway girders will be installed one by one.

Since Line-2C is constructed in high-class urban area, adequate traffic and environmental planning are needed.

2) Rolling stock

The rolling stock is delivered to the workshop of the main depot for the reassembly and adjustment works.

3) Trial run and commissioning test

After the completion of all the structure and system works of Phase 3, all kinds of tests, such as integrated test and commissioning are executed at all lines in Phase 3 in order to verify the operation normally, safety and accurately.

(3) Operation preparation stage

The management unit prepares the operation service for extension of Phase 3; such as additional staff recruiting, re-arrangement of organization, revision of operation rules and regulations, and training and practice of operation for additional staff.

(4) Revenue service stage

Revenue service is executed.

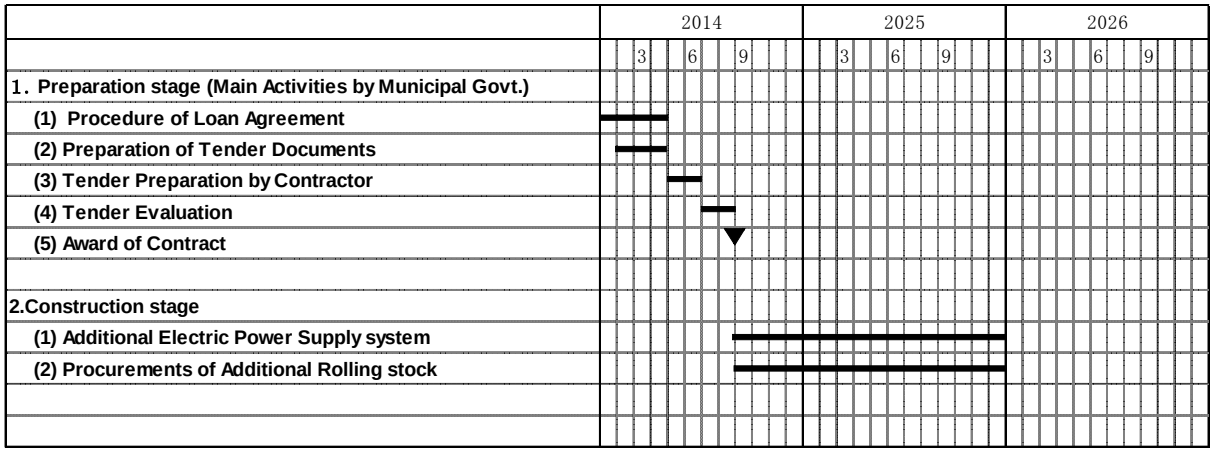
6.4.5 Phase 3-2 (Additional investment)

After the revenue service starts on the whole line of the Monorail system, additional power supply system and rolling stock will be needed in 2025 with the increase of demand. The consulting service is not needed in this Phase.

Loan agreement between the government and JICA, and a contract with each supplier for procurement is executed.

The implementation schedule of Phase 3-2 is shown in Table 6-29.

Table 6-29 Implementation Schedule of Phase 3-2 (Additional Investment)



Source: JICA Study Team

6.5 CONTRACT PACKAGE

As for ordering the monorail construction, it is proposed that civil engineering work and installation of electric facility and machinery (E&M) including rolling stock are ordered in a lump. In this project, the first package of ordering is intended to the civil engineering work and E&M work of phase 1.

As of 2009, the major manufacturers of the rolling stock of Monorail which has suitable transport capacity and performance as the urban transport system are in Japan, Canada and Malaysia. However, the specifications of the vehicle (e.g. size of the train, axle load) are independent by each manufacture and are incompatible.

Now, in the Monorail system, the subsystems shown below shall be integrated mutually and perform each function.

Table 6-30 Subsystems

Facility	Subsystems
Electric facility and machinery	Rolling stock, Signaling, Telecommunication, Operation control, Facility administration, Emergency power supply, Access to electricity and power distribution, Power cable and low voltage power cable, Switch, Platform screen door, Station equipment, Depot equipment and inspection device
Civil	Track, Switch bridge, Substructure and pier, Station building, Depot building, Substation building
Contingent business	Installation work, inventory control of spare parts, training for operation and maintenance, Maintenance

Source: JICA Study Team

Basic information of the Monorail vehicle (e.g. an axle load, vehicle gauge and structure gauge, train length, shape of the track girder, platform height, door arrangement, etc) is provided to civil engineering design as input data. And this information shall be based on the vehicle which will be installed actually. Also, with regard to depot design, the maintenance facilities and the buildings are designed based on maintenance plan.

As described above, in the Monorail, the necessity of the interface between the civil engineering and E&M is relatively high from the design stage. So, it is desirable to order the civil engineering work and E&M work as one package. Also, in the construction stage, when civil engineering work and E&M work require readjustment, this one package ordering makes this situation more flexible.

Examples of the Monorail project in which civil engineering and E&M are packaged in a lump are shown below.

Table 6-31 Example of the Project packaged in a lump

Project	Country	Route Length	Opening Year
Palm Jumeirah Monorail	U.A.E.	5.4km	April 2009
Mumbai Monorail	India	19.6km	2010 (Phase 1 -Plan) 2011 (phase 2 –Plan)
Tiradentes Monorail	Brazil	23.8km	2010 (Phase 1 -Plan) 2011 (Phase 2-Plan) 2012 (Phase 3-Plan)

Source: JICA Study Team

6.6 TECHNICAL ASSISTANCE PLAN

Because monorail is totally new system to be introduced in São Paulo, technical assistance will be essential for the successful implementation of the project. It is not decided at this stage who will be the operator of the new monorail system; SPTrans himself or new PPP organization including SPTrans, or a private concessionaire.

Considering the nature and characteristics of the new system, it is strongly recommended to operate the system by SPTrans or a new PPP organization, not by a private concessionaire. The nature and characteristics of this kind of urban transit system are similar to those of Metro system. It requires wide range of operation and maintenance works, including train operation control, signal and telecommunication, power supply and distribution, track structures, turnouts, various parts of vehicle maintenance, depot and workshop operation, etc.

São Paulo METRO is operating 4 lines, total length of 62.3 km, carrying 2.1 million passengers per day. Number of employee is 7,417 (Dec. 2007), consisting of 3,690 for operation, 2,171 for maintenance, 965 for administration, 405 for expansion and 182 for financial section.

The planned monorail line will be operating 3 lines and total length of 45.6 km, and will carry 1.0 million passengers per day in 2015 and 1.25 million in 2045. Considering the size of the system and passenger handling requirements, the number of employee of the monorail operating entity can be estimated in the order of 2,000 to 3,000. This size seems too big to a private company who has no experience of urban transit system like Metro and Monorail.

Since it has not been decided what kind of entity will operate and maintain the new monorail lines, technical assistance plan for either case, by public operator or private operator, have been studied. In any case, in order to commence the commercial operation soon after completion of the construction and test runs, preparation to form the Monorail Operating Organization shall be started about 3 years prior to the commencement of the commercial operation.

6.6.1 Technical Assistance for Public Operator (incl. PPP)

(1) Monorail Operating Organization

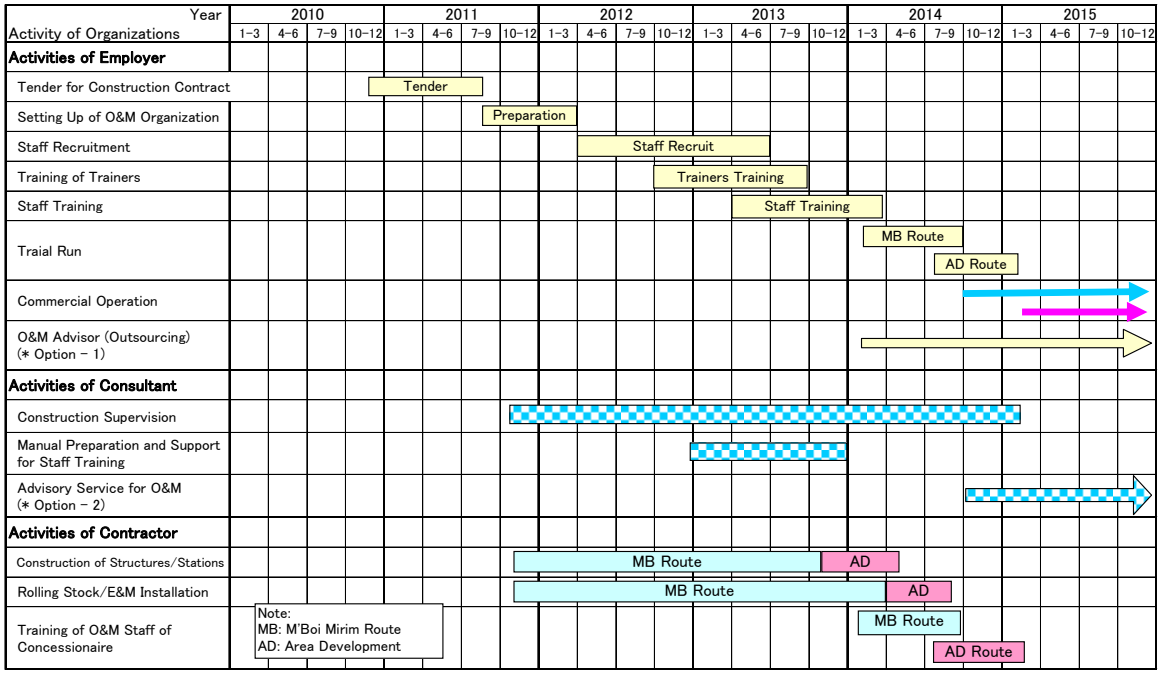
In case when the operation and maintenance of the new monorail system is to be carried out by SPTrans or a newly established public organization (including PPP), the recruit and training of staff will be easier than the case those by a private sector because the new system will require long periods for preparation and training prior to the commercial operation.

As shown in Figure 6-9, it will take approximately 3 years for the formation of the Monorail Operation organization shall be commenced in parallel with the commencement of the construction. Since at least 2,000 to 3,000 staff will be required for the operation and maintenance of 45 km long monorail system, it will take time to recruit and train those personnel as O&M staff.

(2) Technical Assistance during Construction

Technical assistance during construction shall be made by the consultant who provides consulting services for construction supervision. The consultant shall prepare operation manuals together with the contractor and system suppliers. He shall also support to train selected O&M staff who shall be trainers of each system.

Outline schedule of recruit and training of O&M staff and technical assistance is as shown in Figure 6-9.



Source: JICA Study Team

Figure 6-9 Outline Schedule of Staff Recruit/Training and Technical Assistance

(3) Technical Assistance after the Construction

When a new monorail system is to be operated by a newly set up organization who has no experience of monorail, technical assistance will be required for some period.

When the provisional handover process from the contractor and suppliers to the client is completed, the defects liability period starts for one year (usual case) until the final handover of the system. The contractor and supplier are responsible for the defects of the structure and system during this period. However, they are not responsible for the training and technology transfer after the provisional handover process, unless otherwise designated.

As a matter of fact, six months of technology transfer and training period is not enough for the operator to operate the system by himself if he has no operation experience of similar system.

In order to receive continuous technical assistance after the provisional handover, the following measures can be considered;

1) Outsourcing

One of the practical solutions is employing a consulting firm who has operation and maintenance experience of a monorail system. Dubai Monorail is adopting this method. Problem of this method is that the number of consultant or entity who has experience of monorail O&M is very limited.

2) Including in the Consulting Service

Another practical solution is including the technical assistance for O&M in the scope of the consulting service for construction supervision. For example, Ho Chi Minh MRT project is adopting this method.

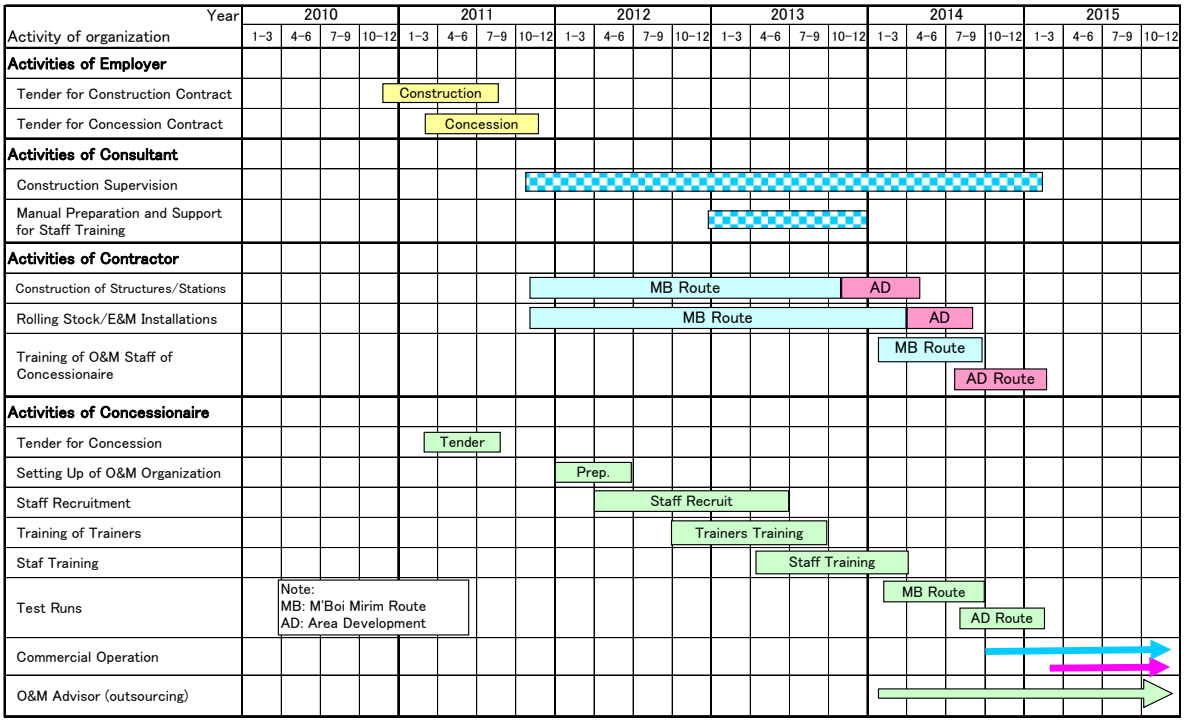
6.6.2 Technical Assistance for Private Operator

(1) Monorail Operating Organization

There is no requirement of technical assistance if the concessionaire has experience of monorail operation and maintenance. If the concessionaire has no experience, technical assistance from outside shall be considered.

One of the ideas that were raised by SPTrans is that the existing bus operation concessionaire operates and maintains the new monorail system. The operation and maintenance of a monorail system is much more complicated than that of public buses, because the nature of monorail is similar to Metro. The difference is that Metro uses steel wheels and steel rail, and monorail uses rubber tires and concrete girders.

Outline schedule of recruit and training of O&M staff and technical assistance of the Concessionaire is as shown in Figure 6-10 below;



Source: JICA Study Team

Figure 6-10 Outline Schedule of Staff Recruit/Training and Technical Assistance

(2) Technical Assistance during Construction

As described in the previous clause, the operation and the maintenance departments will require 2,000 to 3,000 staff. Main problems are the timing of staff recruitment and technology transfer as follows;

1) Timing of Concession Contract and Staff Recruitment

Staff training and technology transfer from the contractor and supplier can be commenced after the completion of construction and installation of each system. The concessionaire staff for O&M shall be ready for receiving training at the moment.

Considering the required number of O&M staff of 2,000 to 3,000, the staff recruitment shall be started at least one year before the commencement of staff training. The

sequence of staff recruitment and training are as outlined in Figure 6-10.

2) Technology Transfer

It is not practical that the contractor and supplier train all of the concessionaire's staff during training period after the completion of system installations. It is widely adopted that the contractor and supplier train selected staff of the operator who will be trainers of other staff to be trained.

Permanent facilities for staff training shall be included in the construction contract. It is recommendable to build inside of the depot and workshop. Those facilities shall be completed by the time of the commencement of staff training by the selected trainers.

The training of the trainers shall be carried out at the origin countries where those systems are manufactured. The cost for this training shall be included in the construction cost.

(3) Technical Assistance after the Construction

Since the responsibility for the staff training by the contractor and supplier is limited to the time of the provisional or final handover of the system, continuous assistance from experienced advisors will be required if the concessionaire has no experience. The required period of the advisory services will be depending on the nature of the systems. It may take one to three years until the concessionaire can operate without assistance of the advisor.

A practical way to receive technical assistance from experienced advisors is employing a consulting firm who has experience of operation and maintenance of monorail systems.

CHAPTER 7 OPERATION AND MAINTENANCE

7.1 IMPLEMENTATION STRUCTURE

7.1.1 Business Operation Method

(1) Current Status in São Paulo City

1) Subway

Line-1,2,3 and 5：Operated by METRO
Line-4(Under Construction)：PPP (Public-private partnership) scheme

Table 7-1 Summary of Operation Plan of Line-4

Items	Contents	
Route	Luz-Vila Sônia 12.8km, 11 stations	
	Phase-1：Construction of 12.8km of line, 6 stations, the structures 3 intermediate stations, systems, depot Phase-2：Finishing of the intermediate stations, construction of 2 new stations, complementary systems In future：Connects Vila Sônia to Taboão da Serra	
Implementation Structure	PPP-method (by Concessionaire)	
	Specification for private sector	1.Investments in rolling stock, signaling, voice and data communication with the train, depot control, central control and supervision 2. Operation for 30 years 3. Connects Vila Sônia to Taboão da Serra (by bus without additional fare)
	Revenue of private sector	100% of the exclusive passenger of Line-4, 50% of the integrated passenger with METRÔ/CPTM(due to Concessionaire)

Source: METRÔ (HP)

2) Bus

Buses are operated by concessionaires under the management of SPTrans. São Paulo city is divided into eight zones and eight bus companies are operating buses under the concessions, (“permission” in case of the trunk line).
Central district is excluded from the division of 8 zones because bus transits from various zones are extended into the central district.

Source：SPTrans

Figure 7-1 Zone of Concession

Table 7-2 Summary of Bus Operation

		Lines	Fleets
Lines	Structural	880	8,860
	Local	450	5,890
	Total	1,330	14,750
Use of Road Length		4,415km (25% of São Paulo Municipal)	
Bus Stops		18,375 points	
Vehicle km		3,015,261 km *1	
Number of Passengers		9,766,473 persons *1	

Source：SPTrans

*1: Average number in a week day as of September, 2009

(2) Potential Methods for Monorail Operation

The following two alternatives are potential methods for the monorail operation;

1) Operated by SPTrans directly

An independent monorail operation entity is to be established inside the organization of SPTrans, a similar organization like METRÔ, and the funding, construction, and management are, consequently, executed thoroughly by themselves. Although present buses are operated by bus companies on the basis of concessions, it is preferable to operate monorail by SPTrans directly because of its unique features which requires professional skills for stable operation.

In this regard, in case of direct management by SP Trans, all of the construction funds have to be procured by city government and it will be subject to the financial capacity of city.

2) PPP (Public-private partnership) scheme

The monorail operation is undertaken jointly by SPTrans and Private entity under a risk sharing scheme for operation. This kind of scheme is able to utilize both the advantage of a public sector and technology and financial capability of privates. However it accompanies the risk sharing issue between both parties. The same kind of scheme is adopted in the operation of METRÔ Line-4 as described before, in which private party supplies rolling stocks and system equipments, and undertakes the train operation and management while public side (METRÔ) constructs the infrastructures except for the above, i.e. track facilities, power line and depot.

In this connection, the urban monorail projects in Japan are undertaken by a similar scheme to PPP, so called “Infrastructure subsidized method”. In this method, public sector provides monorail infrastructures, i.e. columns and track girders, of which cost portion is about 60% of total cost, as the statutory street provision scheme due to reason that monorail shares a part of road function. In this case, private entity, so called “the third sector” in Japan, of which capital is shared by both public and private, provides the rolling stocks, the car depot and the operation equipments in stations, and undertakes train operation and management.

7.2 OPERATION AND MAINTENANCE PLAN

7.2.1 Management Plan

(1) Phased Construction Plan and Phases

The management plan was examined based on the following phased construction plan.

Table 7-3 Phased Construction Plan

Phase / Line	Phase-1	Phase-2	Phase-3	Line length of partial completion (km) *1	Remarks
	Target Year of partial completion				
	2014	2016	2018		
	Planned total operating length (km) *1				
Line	15.6	38.3	45.5		
	14.3	37.0	44.2		
1	●	○	○	4.2	
2A	●	○	○	11.4 10.1	Construction of Depot Facility
2B	－	●	○	11.3	
2C	－	－	●	7.2	
2D	－	●	○	11.4	

Source: JICA Study Team

(Note) ●: Opened in this phase, ○: Section already operated, －: Section not in operation
*1:Case of Line-2A, upper=Area Development Route, Lower=Original Route

(2) Operation Method

Operation of Monorail : ATO（under attendance of crewman）
Attended crewman should have the qualification of manual driving.
Train Operation Control : Centralized control at Operation Control Center in Depot
Signal System : CBTC

Source: JICA Study Team

Figure 7-2 OCC (Chongquing Monorail)

(3) Concept of Fare System

1) Alternatives of fare system

Since Monorail is a new transit system in São Paulo, it is required to define the system in order to set up the fare system. The following models are used for the demand forecast in this study.

a) Monorail is regarded as a kind of bus (transfer monorail-bus is free, transfer to METRÔ/CPTM applies a discount rate)

b) Monorail is regarded as a kind of METRÔ and CPTM trains (transferring monorail-METRÔ/CPTM is free, and transfer to bus applies a discount rate)

c) Monorail is considered as an independent mode (transfer to bus or METRÔ/CPTM applies a discount rate)

Fare system will be the key to decide the fare level. There are two options in the fare systems. One is the flat rate as same as the system currently adopted by SPTrans and METRÔ/CPTM, and the other is the distance-based rate.

In case of abovementioned models a) and b), the fare system will be automatically flat rate system because a transit by monorail will be a part of entire transit route including transit by either the bus or METRÔ/CPTM. In case of model c), the monorail transit is able to select either fare systems.

In case when model c) is selected, i.e. the distance-based fare system is adopted, the revenue of monorail operation will be higher than the revenues obtainable by models a) and b). However, the introduction of different fare system may cause a decrease of ridership and may require extensive renovations of fare collection system. This may create not only negative impacts on the demand, but also brings an increase of initial investment and management cost.

2) Selection of the fare system

The following shall be considered when selecting a fare system to be adopted;

Any of the abovementioned models are physically applicable. When selecting the model, i) the relation between demand and revenue, user's out of pocket cost, operator's feature (SPTrans assumed), and ii) the method of distribution of the income among Monorail operator and METRÔ/CPTM shall be examined.

The distance-based fare system is not recommendable because of the following reasons;

a) Flat fare system is already familiar among the São Paulo citizens through SPTrans and METRÔ/CPTM operations. Therefore, distance-based fare system will create serious confusion for users.

b) If the distance-based fare system is to be introduced, it is necessary to provide totally new fare collection system and equipment because of the difference between the new system and the existing systems already set up in São Paulo. On the other hand, if the flat fare system is adopted, it is possible to utilize the existing fare collection system and equipment and consequently saving the construction cost.

It will be required to join with the existing common card system "Bilhete Unico" adopted in bus and METRÔ. And it will also be required to adopt various discount systems (multi-ride ticket, student discount, silver discount and handicapped person discount) which are adopted in the existing bus and METRÔ/CPTM operations.

3) Introduction of Automatic Fare Collection (AFC) System

Automatic ticket vending machines are not introduced in São Paulo public transportation systems at present. Tickets are sold by sales personnel in both for bus and METRÔ/CPTM. There may be various reasons to keep the existing ticket sale system by personnel. However, the number of sales windows seems to be not enough and long queue in front of sales window is usually observed at stations.

Figure 7-3 Long Queue at the Ticket Windowon Saturday Afternoon（METRÔ Tietê Station）

Source: JICA Study Team

In order to improve abovementioned situation, it is recommendable to introduce automatic ticket vending machines. It will be effective to shorten the time for issuing tickets, saving human costs, and appealing the monorail system as an advanced new transportation system.

In order to introduce automatic ticket vending machines, it is necessary to solve problems as follows.

- Improvement of the recognition accuracy of bills
- Fraud protection

In São Paulo Metropolitan area, “Bilhete Unico” (Common Card) is widely used by commuters although deposit to the card can be made by the personnel at the sales windows. This card is not only providing convenience for passengers but also offering some discount of tickets. If this card can be charged by automatic ticket vending machine the usage rate by passenger will increase. If the charge can be made by credit cards, the usage rate will be much more increased.

7.2.2 Organization and Personnel Plan

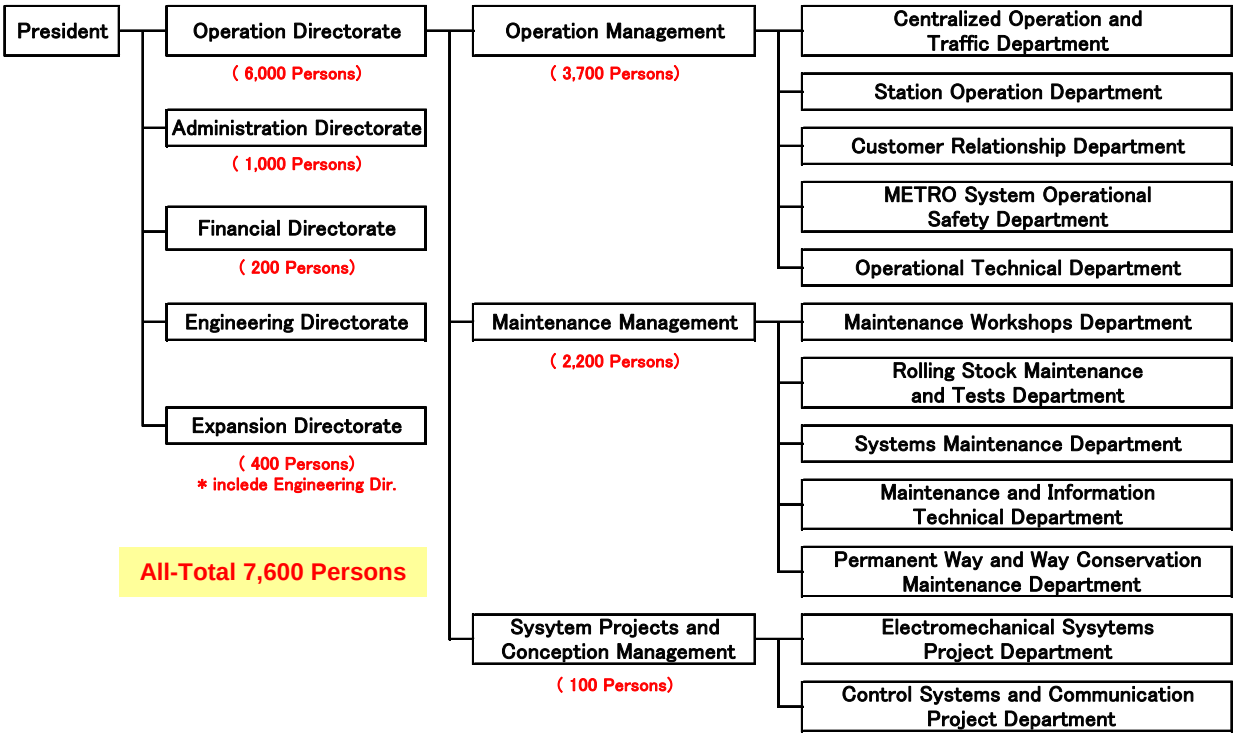
(1) Existing Organizations for Public Transportation in São Paulo

There are four institutions currently engaged in the management of public transit in São Paulo (METRÔ, CPTM, EMTU and SPTrans), and the former two are engaging in railway transit and the latter two are engaging in bus transit. Moreover, beside SPTrans which is a municipal organization, all other institutions are state organizations. Monorail in this study is planned to be managed by SPTrans.

Outline of METRÔ organization is shown in Figure 7-4. Number of staffs for operation is about 3,700, that for maintenance department is about 2,200, that for system department is about 70 and its total number is about 6,000 in METRÔ. In addition, including other staffs such as 1,000 for management department, about 200 for accounting department and about 400 for the route expansion planning department which is in charge of new line construction like route 4, number of staff accounts for 7,400 – 7,600 in total. (There is small difference in total number due to small variation by data.)

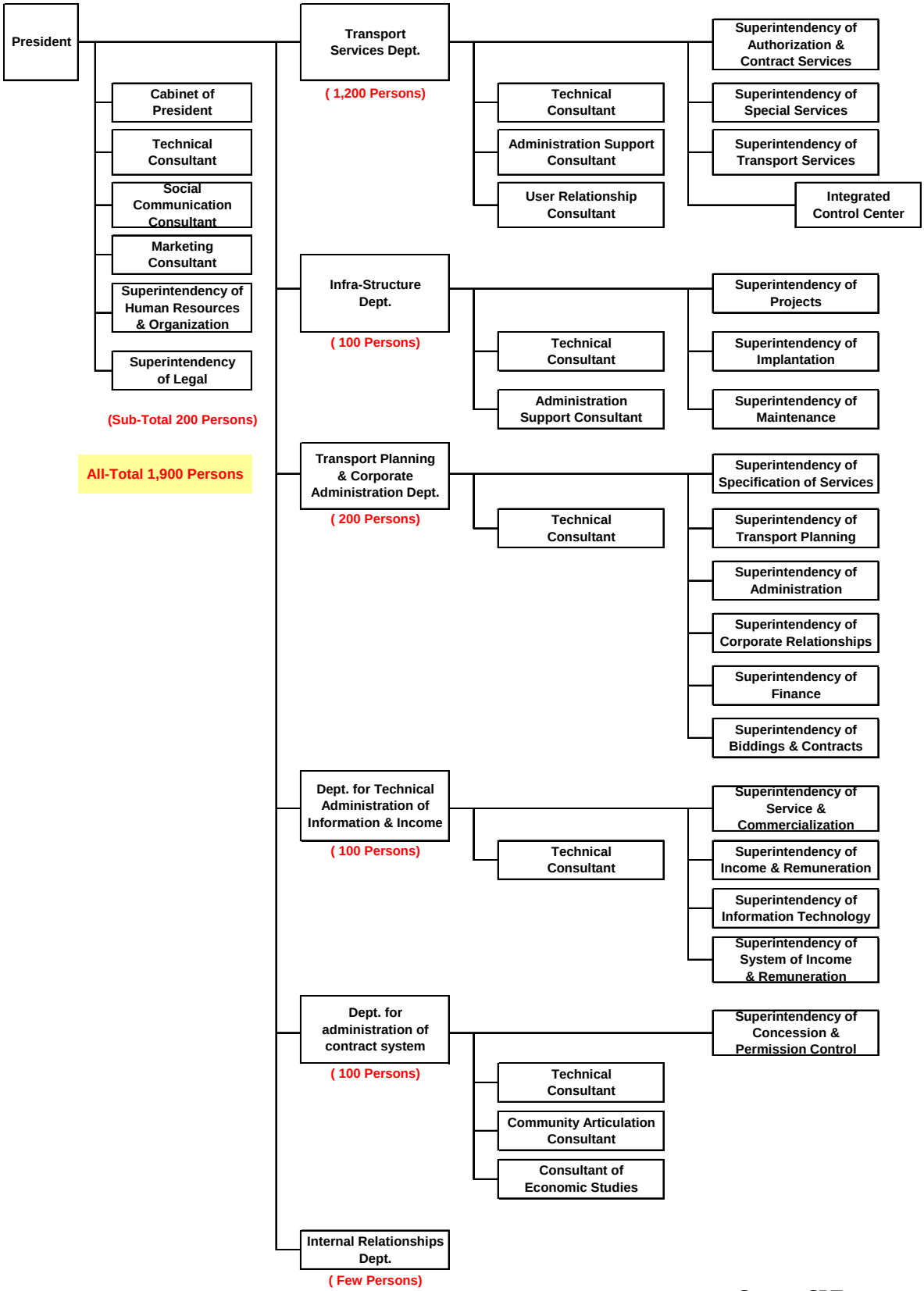
Outline of SPTrans organization is shown in Figure 7-5. SPTrans does not have operation organization because actual bus operations are conducted by concessionaires (private bus operation companies). In this connection, total number of staffs in SPTrans is about 1,900. (it does not include the staffs belonging to other bus operating companies e.g. bus drivers)

Abovementioned organizations are employing huge numbers of security personnel in the stations and bus terminals.



Source: Operation Report São Paulo METRÔ 2007
METRÔ Administration Report 2007

Figure 7-4 Organization Chart of METRÔ (Summary)



Source: SPTrans

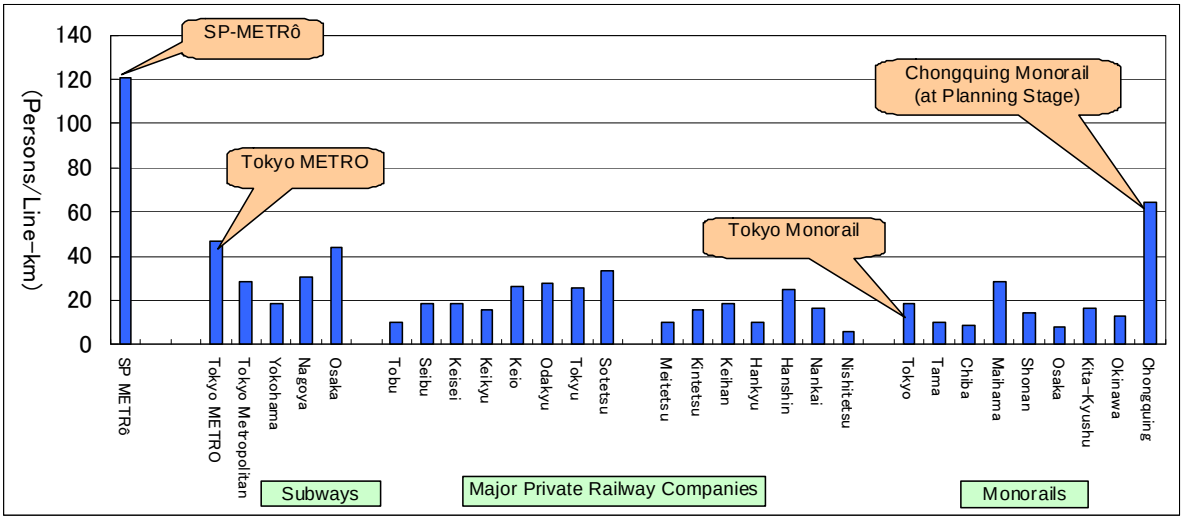
Figure 7-5 Organization Chart of SPTrans

(2) Concept of Proposed Organization Structure and Number of Staffs

The comparison of the number of personnel between SP-METRÔ and Monorail operators in Japan is shown in the graph of Figure 7-6. The number of personnel per Line-km of SP-METRÔ is 121, while the maximum number in Japan is 47 personnel of Tokyo METRO, which is only 39% of SP-METRÔ. In Monorail systems in Japan, 19 personnel of Tokyo Monorail is the largest, but only 16% of SP-METRÔ. Chongqing Monorail is 64 personnel at the stage of plan, which is larger than those of Japanese Monorail system, but still half level of SP-METRÔ.

Reasons that SP-METRÔ has larger number of personnel per Line-km are considered due to;

- Many security guard staff at stations (few in Japan)
- Many ticket selling staff at stations (few in Japan because automatic ticket vending machine is popular)
- In-house working staff for maintenance and inspection (Outsourcing is common in Japan)

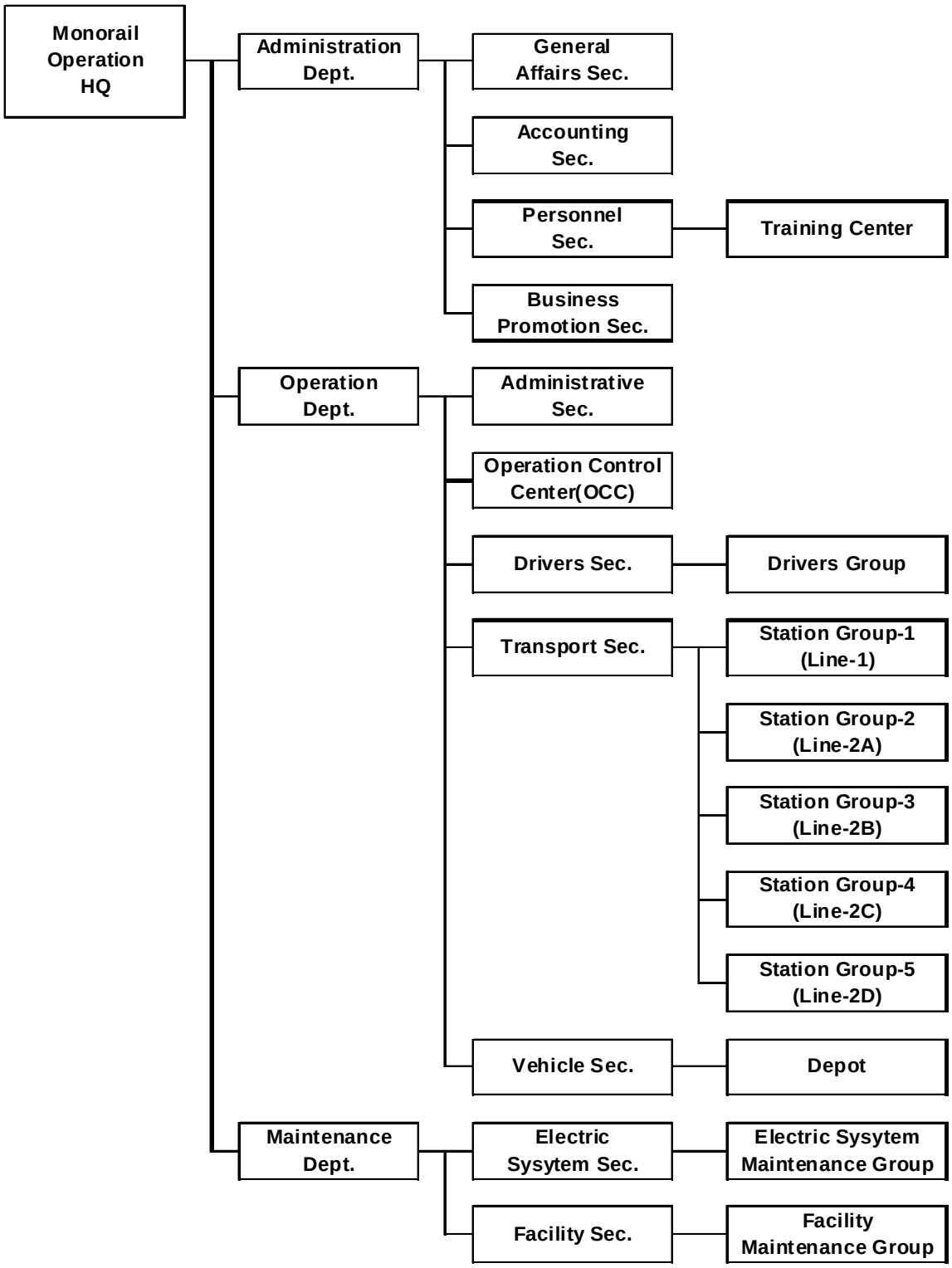


	Persons	Line-km	Ps./km
SP-METRÔ	7,417	61.3	121.0
Tokyo METRO	8,512	183.2	46.5
Tokyo Monorail	336	17.8	18.9
Chongquing Monorail	870	13.5	64.4

Source:
Administration Report 2007 (METRO)
Railway statistics annual report 2007
Tokyo Monorail

Figure 7-6 Comparison of Number of Employees per Operation Length

Having observed SP-METRÔ, it was found that the number of workers per operating length is similar to those in Tokyo Metro or other private railways in Tokyo except those personnel in security section. Therefore, the organization structure for São Paulo Monorail can be similar to those of monorail systems in Japan with some addition of security and ticket selling staffs as observed in SP-METRÔ (Figure 7-7).



Source: JICA Study Team

Figure 7-7 Proposed Organization Chart of Monorail

(3) Concept of Proposed Organization Structure and Number of Staffs

1) Methodology

Although METRÔ/CPTM are operated as the urban transit system in São Paulo, no monorail lines are put into operation yet. Accordingly, the required number of staffs is estimated by multiplying the unit staff number by division, which is calculated based on the actual monorail operation result in Japan, with corresponding volume in each division of the planned roué.

However, as observed in the situation of SP METRÔ, there are considerable number of staffs existing for security and ticket vending in Sao Paulo, and it is unique feature not observed in Japan. Accordingly, for these two divisions, required number of staff is separately calculated based on the result in METRÔ. In addition, required number of staff will be quite large because the route length becomes finally more than 40 km. In order to operate the monorail which has not been operated yet in Brazil, it is important to conduct necessary staff training and thus to establish a specific center for staff training. Since in Japan, there are no training facilities because of small operation size, it is estimated separately.

Followings show the calculation division for staff number estimation and corresponding unit numbers.

Table 7-4 Calculation Division and Unit Numbers for Number of Staff Estimation

Sources	Calculation Division	Unit Number for Quantity
From Actual result in Japan	Track maintenance staff	Per Line-km
	Electric maintenance staff	Per Line-km
	Rolling Stock maintenance staff	Per Number of Rolling Stocks
	Driver	Per Average Train Operation-km a Day (by 1 driver)
	Station Staff	Per Number of Stations
	Other Transport Staff	Per Average Number of Trains Dispatched
	Staff in Headquarter	Ratio to the Number of Field Staffs (Above Division)
From Actual result in METRÔ	Security staff	Per Number of Stations
	Station staff (Ticket Sale)	(Given Otherwise)
	Specific staff in Training center	(Given Otherwise)

Source: JICA Study Team

2) Unit rate and the corresponding volumes in the objective route

From the monorail lines operating in Japan, 5 lines which are classified in straddle monorail and provide urban transport service are selected and their actual data in fiscal 2007 are examined. (Table 7-5) For São Paulo monorail, the unit rate for Tokyo monorail line is adopted because its transport volumes and capacity are similar to São Paulo. However, regarding the driver, unit rate for Osaka monorail line is adopted because Tokyo monorail provides rapid train service and has different operation pattern from that of São Paulo. In addition, regarding the track maintenance staff, the same is adopted because Tokyo monorail opened at considerable long years before.

The principal operational indicators, i.e. operation track length and train running distance, of São Paulo monorail are summarized in Table 7-6.

Table 7-5 Unit Rate Measured for Number of Staff of Monorail Lines in Japan

	Item	Unit	Formula	Tokyo	Tama	Osaka	Kita-Kyushu	Okinawa	Remarks
Number of Personnel	Driver	Persons	A	92	59	59	22	35	
	Station Staff	Persons	B	106	30	69	69	68	
	Other Operational	Persons	C	13	16	17	0	16	
	Track Maintenance	Persons	D	8	5	19	5	0	
	Electric Maintenance	Persons	E	24	15	14	12	8	
	Rolling Stock Maintenance	Persons	F	32	8	15	8	8	
	Sub-Total	Persons	G=A～F	276	133	193	116	135	Without Expansion
	Administrative	Persons	H	60	30	28	25	22	(Okinawa)
	Total	**Persons**	**I=G+H**	**336**	**163**	**221**	**141**	**157**	
Amount for Personnel	Line-km	km	J	17.8	16.0	28.0	8.8	12.9	
	Train-km	km per Day	K	8,686	3,724	6,175	1,825	2,839	
	Car-km	1000km per Year	M	19,076	5,453	9,040	2,673	2,077	
	Number of Train Operations	Train-km/Line-km	N=K/J	488.0	232.8	220.5	207.4	220.1	
	Number of Rolling Stock	Cars	P	120	64	80	40	24	
	Number of Stations	Stations	Q	10	19	18	13	15	
Unit Number of Personnel	Driver	Average Driving-km per Day	R=K/A	94.4	63.1	104.7	83.0	81.1	Selected Osaka
	Station Staff	per Number of Stations	S=B/Q	10.600	1.579	3.833	5.308	4.533	Selected tokyo
	Other Operational	per Number of Train Operations	T=C/N	0.0266	0.0687	0.0771	0.0000	0.0727	Selected tokyo
	Track Maintenance	per Line-km	U=D/J	0.393	0.313	0.679	0.568	0.000	Selected Osaka
	Electric Maintenance	per Line-km	V=E/J	1.348	0.938	0.500	1.364	0.620	Selected tokyo
	Rolling Stock Maintenance	per Number of Rolling Stock	W=F/P	0.267	0.125	0.188	0.200	0.333	Selected tokyo
	Administrative	% for Sub-Total	Y=H/G	22.2%	22.6%	14.5%	21.6%	16.3%	Selected tokyo
	Total	**No. of Personnel/Line-km**	**Z=I/J**	**17.0**	**10.2**	**7.9**	**16.0**	**12.2**	

Source：Railway Statistics Annual Report 2007, Tokyo Monorail

Table 7-6 The Principal Operational Indicators for São Paulo Monorail by Cases

Case		Phase	Period	Line-km	Train-km		Car-km		Number of	Number of
					Weekdays	Year Total	Weekdays	Year Total	Rolling Stock	Stations
				(km)	(km/day)	(1000km/year)	(km/day)	(1000km/year)	(Cars)	(Stations)
Phase1-3	L2A(AD)	1	2014-2015	15.59	8,232	2,799	49,394	16,796	174	17
		2	2016-2017	38.26	19,415	6,653	138,925	47,592	436	41
		3	2018-2024	45.49	20,280	7,038	158,247	54,908	474	49
			2025-2045	45.49	21,198	7,291	165,593	56,935	522	49
	L2A(MB)	1	2014-2015	14.21	7,460	2,539	44,758	15,237	174	15
		2	2016-2017	36.88	18,626	6,388	133,380	45,728	436	39
		3	2018-2024	44.11	19,557	6,792	152,462	52,938	474	47
			2025-2045	44.11	20,442	7,036	159,543	54,892	522	47
Phase1 only	L2A(AD)	1	2014-2019	15.59	8,232	2,799	49,394	16,796	174	17
			2020-2039	15.59	8,794	2,954	52,762	17,726	210	17
			2040-2045	15.59	9,168	3,058	55,007	18,345	228	17
	L2A(MB)	1	2014-2019	14.21	7,460	2,539	44,758	15,237	174	15
			2020-2039	14.21	7,971	2,681	47,827	16,084	210	15
			2040-2045	14.21	8,312	2,775	49,873	16,648	228	15

Source：JICA Study Team

3) Estimation of number of staffs

Estimation result for number of staff is shown in Table 7-7 (Phase1-3) and Table 7-8 （only Phase1）Required number of staffs in inauguration year, 2014, is estimated at 856 in case of “regional development route plan”and at 773 in case of “original route plan”, and average number of staffs per operation track length is estimated at 54 to 55, accounting for 3 times of Tokyo monorail (19). At the last year of operation simulation, 2045, corresponding number reaches at 2,333 in case of “Phase 3, regional development route plan”, the figure per operation track length accounts for 51.

Table 7-7 Required Number of Staffs in Case of Phase1 to Phase3 of São Paulo Monorail

Case：Phase1-3 L2A(Area Development Route)

Item		Occupation	Unit	Formula	2014 Phase-1	2016 Phase-2	2018 Phase-3	2020	2025	2040	2045
Number of Personnel	Based on Japanese Statistics	Track Maintenance	Persons	A=a×m	11	26	31	31	31	31	31
		Electric Maintenance	Persons	B=b×m	22	52	62	62	62	62	62
		Rolling Stock Maintenance	Persons	C=c×n	47	117	127	127	140	140	140
		Driver	Persons	D=n/d	74	175	185	185	191	191	191
		Station Staff	Persons	E=e×q	181	435	520	520	520	520	520
		Other Operational	Persons	F=f×s	14	13	12	12	12	12	12
		Sub-Total	Persons	G=A～F	349	818	937	937	956	956	956
		Administrative	Persons	H=G×g	78	182	209	209	213	213	213
		Sub-Total	**Persons**	**J=G+H**	**427**	**1,000**	**1,146**	**1,146**	**1,169**	**1,169**	**1,169**
		Per Line-km	Persons/km	R2=J/m	27.4	26.1	25.2	25.2	25.7	25.7	25.7
	Based on METRO Statistics	Station Staff (Ticket Seller)	Persons	K=h×r	152	356	423	423	423	423	423
		Security Staff	Persons	M=j×q	247	595	711	711	711	711	711
		Staff of Training Center	Persons	N=k	30	30	30	30	30	30	30
		Sub-Total	**Persons**	**P=K～N**	**429**	**981**	**1,164**	**1,164**	**1,164**	**1,164**	**1,164**
	Total		**Persons**	**Q=J+K**	**856**	**1,981**	**2,310**	**2,310**	**2,333**	**2,333**	**2,333**
	Per Line-km		Persons/km	R=Q/k	54.9	51.8	50.8	50.8	51.3	51.3	51.3
Unit Number of Personnel	Based on Japanese Statistics	Track Maintenance	Persons/Line-km	a	0.679	0.679	0.679	0.679	0.679	0.679	0.679
		Electric Maintenance	Persons/Line-km	b	1.348	1.348	1.348	1.348	1.348	1.348	1.348
		Rolling Stock Maintenance	Persons/Cars	c	0.267	0.267	0.267	0.267	0.267	0.267	0.267
		Driver	Average Operating-km/Day	d	104.7	104.7	104.7	104.7	104.7	104.7	104.7
		Station Staff	Persons/Stations	e	10.600	10.600	10.600	10.600	10.600	10.600	10.600
		Other Operational	Persons/Train Operations	f	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266
		Administrative	% for Sub-Total	g	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%
	Based on METRO Statistics	Station Staff (Ticket Seller)	Persons/Ticket Counters	h	1.92	1.92	1.92	1.92	1.92	1.92	1.92
		Security Staff	Persons/Stations	j	14.50	14.50	14.50	14.50	14.50	14.50	14.50
		Staff of Training Center	Persons (Fixed)	k	30	30	30	30	30	30	30
Amount for Personnel	Planned Line	Line-km	km	m	15.59	38.26	45.49	45.49	45.49	45.49	45.49
		Number of Rolling Stock	Cars	n	174	436	474	474	522	522	522
		Train-km (per Day)	km/day	p	7,670	18,226	19,282	19,282	19,976	19,976	19,976
		Number of Stations	Stations	q	17	41	49	49	49	49	49
		Number of Ticket Counters	Places	r	79	185	220	220	220	220	220
		No. of Train Operations (per Day)	Train Operations/Day	s	492.0	476.4	423.9	423.9	439.1	439.1	439.1

Case：Phase1-3 L2A(Original Route)

Item		Occupation	Unit	Formula	2014 Phase-1	2016 Phase-2	2018 Phase-3	2020	2025	2040	2045
Number of Personnel	Based on Japanese Statistics	Track Maintenance	Persons	A=a×m	10	26	30	30	30	30	30
		Electric Maintenance	Persons	B=b×m	20	50	60	60	60	60	60
		Rolling Stock Maintenance	Persons	C=c×n	47	117	127	127	140	140	140
		Driver	Persons	D=n/d	67	168	178	178	185	185	185
		Station Staff	Persons	E=e×q	159	414	499	499	499	499	499
		Other Operational	Persons	F=f×s	14	13	12	12	12	12	12
		Sub-Total	Persons	G=A～F	317	788	906	906	926	926	926
		Administrative	Persons	H=G×g	71	175	202	202	206	206	206
		Sub-Total	**Persons**	**J=G+H**	**388**	**963**	**1,108**	**1,108**	**1,132**	**1,132**	**1,132**
		Per Line-km	Persons/km	R2=J/m	27.3	26.1	25.1	25.1	25.7	25.7	25.7
	Based on METRO Statistics	Station Staff (Ticket Seller)	Persons	K=h×r	137	340	408	408	408	408	408
		Security Staff	Persons	M=j×q	218	566	682	682	682	682	682
		Staff of Training Center	Persons	N=k	30	30	30	30	30	30	30
		Sub-Total	**Persons**	**P=K～N**	**385**	**936**	**1,120**	**1,120**	**1,120**	**1,120**	**1,120**
	Total		**Persons**	**Q=J+K**	**773**	**1,899**	**2,228**	**2,228**	**2,252**	**2,252**	**2,252**
	Per Line-km		Persons/km	R=Q/k	54.4	51.5	50.5	50.5	51.1	51.1	51.1
Unit Number of Personnel	Based on Japanese Statistics	Track Maintenance	Persons/Line-km	a	0.679	0.679	0.679	0.679	0.679	0.679	0.679
		Electric Maintenance	Persons/Line-km	b	1.348	1.348	1.348	1.348	1.348	1.348	1.348
		Rolling Stock Maintenance	Persons/Cars	c	0.267	0.267	0.267	0.267	0.267	0.267	0.267
		Driver	Average Operating-km/Day	d	104.7	104.7	104.7	104.7	104.7	104.7	104.7
		Station Staff	Persons/Stations	e	10.600	10.600	10.600	10.600	10.600	10.600	10.600
		Other Operational	Persons/Train Operations	f	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266
		Administrative	% for Sub-Total	g	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%
	Based on METRO Statistics	Station Staff (Ticket Seller)	Persons/Ticket Counters	h	1.92	1.92	1.92	1.92	1.92	1.92	1.92
		Security Staff	Persons/Stations	j	14.50	14.50	14.50	14.50	14.50	14.50	14.50
		Staff of Training Center	Persons (Fixed)	k	30	30	30	30	30	30	30
Amount for Personnel	Planned Line	Line-km	km	m	14.21	36.88	44.11	44.11	44.11	44.11	44.11
		Number of Rolling Stock	Cars	n	174	436	474	474	522	522	522
		Train-km (per Day)	km/day	p	6,957	17,501	18,607	18,607	19,276	19,276	19,276
		Number of Stations	Stations	q	15	39	47	47	47	47	47
		Number of Ticket Counters	Places	r	71	177	212	212	212	212	212
		No. of Train Operations (per Day)	Train Operations/Day	s	489.6	474.5	421.8	421.8	437.0	437.0	437.0

Source：JICA Study Team

Table 7-8 Required Number of Staffs in Case of Phase1 Only of São Paulo Monorail

Case：Phase1only L2A(Area Development Route)

Item		Occupation	Unit	Formula	2014 Phase-1	2016	2018	2020	2025	2040	2045
Number of Personnel	Based on Japanese Statistics	Track Maintenance	Persons	A=a×m	11	11	11	11	11	11	11
		Electric Maintenance	Persons	B=b×m	22	22	22	22	22	22	22
		Rolling Stock Maintenance	Persons	C=c×n	47	47	47	57	57	61	61
		Driver	Persons	D=n/d	74	74	74	78	78	81	81
		Station Staff	Persons	E=e×q	181	181	181	181	181	181	181
		Other Operational	Persons	F=f×s	14	14	14	14	14	15	15
		Sub-Total	Persons	G=A～F	349	349	349	363	363	371	371
		Administrative	Persons	H=G×g	78	78	78	81	81	83	83
		Sub-Total	**Persons**	**J=G+H**	**427**	**427**	**427**	**444**	**444**	**454**	**454**
		Per Line-km	Persons/km	R2=J/m	27.4	27.4	27.4	28.5	28.5	29.1	29.1
	Based on METRO Statistics	Station Staff (Ticket Seller)	Persons	K=h×r	152	152	152	152	152	152	152
		Security Staff	Persons	M=j×q	247	247	247	247	247	247	247
		Staff of Training Center	Persons	N=k	30	30	30	30	30	30	30
		Sub-Total	**Persons**	**P=K～N**	**429**	**429**	**429**	**429**	**429**	**429**	**429**
	Total		**Persons**	**Q=J+K**	**856**	**856**	**856**	**873**	**873**	**883**	**883**
	Per Line-km		Persons/km	R=Q/k	54.9	54.9	54.9	56.0	56.0	56.6	56.6
Unit Number of Personnel	Based on Japanese Statistics	Track Maintenance	Persons/Line-km	a	0.679	0.679	0.679	0.679	0.679	0.679	0.679
		Electric Maintenance	Persons/Line-km	b	1.348	1.348	1.348	1.348	1.348	1.348	1.348
		Rolling Stock Maintenance	Persons/Cars	c	0.267	0.267	0.267	0.267	0.267	0.267	0.267
		Driver	Average Operating-km/Day	d	104.7	104.7	104.7	104.7	104.7	104.7	104.7
		Station Staff	Persons/Stations	e	10.600	10.600	10.600	10.600	10.600	10.600	10.600
		Other Operational	Persons/Train Operations	f	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266
		Administrative	% for Sub-Total	g	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%
	Based on METRO Statistics	Station Staff (Ticket Seller)	Persons/Ticket Counters	h	1.92	1.92	1.92	1.92	1.92	1.92	1.92
		Security Staff	Persons/Stations	j	14.50	14.50	14.50	14.50	14.50	14.50	14.50
		Staff of Training Center	Persons (Fixed)	k	30	30	30	30	30	30	30
Amount for Personnel	Planned Line	Line-km	km	m	15.59	15.59	15.59	15.59	15.59	15.59	15.59
		Number of Rolling Stock	Cars	n	174	174	174	210	210	228	228
		Train-km (per Day)	km/day	p	7,670	7,670	7,670	8,094	8,094	8,377	8,377
		Number of Stations	Stations	q	17	17	17	17	17	17	17
		Number of Ticket Counters	Places	r	79	79	79	79	79	79	79
		No. of Train Operations (per Day)	Train Operations/Day	s	492.0	492.0	492.0	519.2	519.2	537.3	537.3

Case：Phase1only L2A(Original Route)

Item		Occupation	Unit	Formula	2014 Phase-1	2016	2018	2020	2025	2040	2045
Number of Personnel	Based on Japanese Statistics	Track Maintenance	Persons	A=a×m	10	10	10	10	10	10	10
		Electric Maintenance	Persons	B=b×m	20	20	20	20	20	20	20
		Rolling Stock Maintenance	Persons	C=c×n	47	47	47	57	57	61	61
		Driver	Persons	D=n/d	67	67	67	71	71	73	73
		Station Staff	Persons	E=e×q	159	159	159	159	159	159	159
		Other Operational	Persons	F=f×s	14	14	14	14	14	15	15
		Sub-Total	Persons	G=A～F	317	317	317	331	331	338	338
		Administrative	Persons	H=G×g	71	71	71	74	74	76	76
		Sub-Total	**Persons**	**J=G+H**	**388**	**388**	**388**	**405**	**405**	**414**	**414**
		Per Line-km	Persons/km	R2=J/m	27.3	27.3	27.3	28.5	28.5	29.1	29.1
	Based on METRO Statistics	Station Staff (Ticket Seller)	Persons	K=h×r	137	137	137	137	137	137	137
		Security Staff	Persons	M=j×q	218	218	218	218	218	218	218
		Staff of Training Center	Persons	N=k	30	30	30	30	30	30	30
		Sub-Total	**Persons**	**P=K～N**	**385**	**385**	**385**	**385**	**385**	**385**	**385**
	Total		**Persons**	**Q=J+K**	**773**	**773**	**773**	**790**	**790**	**799**	**799**
	Per Line-km		Persons/km	R=Q/k	54.4	54.4	54.4	55.6	55.6	56.2	56.2
Unit Number of Personnel	Based on Japanese Statistics	Track Maintenance	Persons/Line-km	a	0.679	0.679	0.679	0.679	0.679	0.679	0.679
		Electric Maintenance	Persons/Line-km	b	1.348	1.348	1.348	1.348	1.348	1.348	1.348
		Rolling Stock Maintenance	Persons/Cars	c	0.267	0.267	0.267	0.267	0.267	0.267	0.267
		Driver	Average Operating-km/Day	d	104.7	104.7	104.7	104.7	104.7	104.7	104.7
		Station Staff	Persons/Stations	e	10.600	10.600	10.600	10.600	10.600	10.600	10.600
		Other Operational	Persons/Train Operations	f	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266
		Administrative	% for Sub-Total	g	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%	22.2%
	Based on METRO Statistics	Station Staff (Ticket Seller)	Persons/Ticket Counters	h	1.92	1.92	1.92	1.92	1.92	1.92	1.92
		Security Staff	Persons/Stations	j	14.50	14.50	14.50	14.50	14.50	14.50	14.50
		Staff of Training Center	Persons (Fixed)	k	30	30	30	30	30	30	30
Amount for Personnel	Planned Line	Line-km	km	m	14.21	14.21	14.21	14.21	14.21	14.21	14.21
		Number of Rolling Stock	Cars	n	174	174	174	210	210	228	228
		Train-km (per Day)	km/day	p	6,957	6,957	6,957	7,344	7,344	7,602	7,602
		Number of Stations	Stations	q	15	15	15	15	15	15	15
		Number of Ticket Counters	Places	r	71	71	71	71	71	71	71
		No. of Train Operations (per Day)	Train Operations/Day	s	489.6	489.6	489.6	516.8	516.8	535.0	535.0

Source：JICA Study Team

7.2.3 Maintenance Plan

(1) Basic Policy

The basic policy for the maintenance of railway in Japan, including monorails, is preventive maintenance method. Based on the past experiences and records, worn parts will be replaced before trouble occur. However, São Paulo METRÔ is adopting different policy in their maintenance work. They will replace parts when it troubled.

Considering the nature of monorail system, difficulty in passenger evacuation between stations, the preventive maintenance policy shall be adopted. For this purpose, the regular maintenance system adopted in monorails in Japan can be referred, such as, daily inspection, monthly inspection, important (critical) parts inspection and general (overall parts) inspection. Those inspections are compulsory by the government regulations in Japan.

(2) Maintenance Work Method Based on Japanese Style

1) Rolling Stock

Table 7-9 shows the requirements of periodical inspections to vehicles in Japan, which are legally stipulated. These inspections contribute to provide preventive measures and attain high safety.

Inspections of tire conditions are important in the operation of monorail, which are quite different characteristics compared to rail system.

In Tokyo Monorail, tires are inspected every 3 weeks.

Table 7-9 Periodical Inspections for Vehicles

Inspection category	Main contents of inspection	Inspection Cycle	Approx. time required ※1
Daily Inspection	☐ Aspect of signal system, braking function ☐ Bogie, Running devices ☐ Cab driving equipments ☐ Door opening functions	**3 days**	Approx. 0.5hours/vehicle
Monthly Inspection	☐ Internal inspection of major parts of equipment without dismounting but with the lid off ☐ General function test after equipment inspection	**3months**	Approx 0.75days/vehicle
Inspection of Important Part	☐ Inspection and maintenance of major equipment dismounted from vehicle body. Some of them are overhauled.	**Earlier of 4 years or 600,000km**	Average 10 days/vehicle
Overhaul	☐ Inspection and maintenance of equipment dismounted from vehicle body and overhauled. ☐ Maintenance for keeping safety operation till next maintenance time by replacing all worn and torn parts.	**8 years**	

Source：JICA Study Team（Based on the Japanese Regulations）
*1: vary depending on availability of facilities and the number of personnel engaged.

Source: JICA Study Team

Figure 7-8 Light Maintenance Daily Inspection (Tama Urban Monorail)

Source: JICA Study Team, Tama Urban Monorail

Figure 7-9 Heavy Maintenance Overhaul (Tama Urban Monorail)

2) Facilities

Same as the estimation for rolling stock, outline of regular inspection for track facilities and electric facilities is shown in Table 7-10, Table 7-11. Regarding the facilities, inspection items and cycles are determined by corresponding regulation, but relatively shorter time than legal inspection cycle is taken by operators.

Due to the peculiar track structure of monorail, track maintenance is provided by special maintenance vehicles.

There are several types of maintenance vehicles such as mobile work-shop, crane car, towing car and clearance car. Since the maintenance works are provided during night hours without traction power, maintenance vehicles are capable to run by their own batteries and/or diesel engines (Figure 7-10).

Maintenance vehicles are ordinary placed in depot and are served for maintenance works with the procedure of “deployment - site works - pullout” during work hours for maintenance (approximately 5 hours) between the latest train and the earliest train of next day.

In case of the monorail project in São Paulo, at the stage of inauguration of entire system, the route length reaches the level of 50km and, therefore, the work time for maintenance is given unsatisfactory. To cope with it, maintenance vehicles are, in addition to main depot, placed in the stabling yard at the end of Line-2D.

Table 7-10 Overview of Inspection/Maintenance for Track facilities, Railway structures and Station equipment

Inspection category	Main contents of inspection	Inspection Cycle
Inspection tour of main line	☐Inspection of main line	**Everyday** (combined with inspection of contact line)
Track	☐Track	**1 year**
Track structure	☐Bridge, Tunnel and other track structures	**2 years**
Elevating Machines	☐Elevating machines such as Elevator and Escalator	**6 months to 1 year**
General building structures	☐Station building, Platform ☐Passenger Screen Door	**Properly dealt**
Station Passenger Facility	☐Operation Check and Cleaning of Automatic Vending Machine and Automated Fare Collection Equipment ☐Replacement of wearing parts and Insulation Test etc.	**Properly dealt**
Others	☐Inspection and commissioning upon construction, renovation and restart from operation halt ☐Signage and record of inspection	**Properly dealt**

Source：JICA Study Team（Based on the Japanese Regulations）

Table 7-11 Overview of Inspection/Maintenance (Inspection & Repair) for Electrical Equipment

Inspection category	Main contents of inspection	Inspection Cycle
Power Equipment	☐Catenary (main line)	**Everyday** (combined with track inspection)
	☐Contact Line, Switchgear, ,automatic circuit-breaker, arrestor, protectionsequence machine of substation ☐Critical portions of electrical equipment other than above ☐Other electrical equipment	**1 year** **1 year** **2 years**
Signaling System	☐Safety Equipment such as Signal equipment, Interlocking equipments, switch & lock movement equipment	**1 year**
Communication System	☐Communication equipment	**1 year**
Various measuring instruments	☐Measuring instruments attached to power equipment, communication equipment and other safety equipment	**1 year**
Disaster Prevention Equipment	☐Fire-alarm box, Sprinkler, Smoke detector, extinguisher etc,	**Six months (visual and functional inspection)** **1 year（overall inspection）**
Other instruments	☐Station monitoring equipment, Signage equipment, lighting equipment etc.	**Properly dealt**
Voluntary Inspection	☐Filter cleaning of Substation, Painting of outside equipment etc.	**Properly dealt**
Others	☐Inspection and commissioning upon construction, renovation and restart from operation halt ☐Signage and record of inspection	**Properly dealt**

Source:JICA Study Team（Based on the Japanese Regulations）

A. Mobile work-shop (battery driven)

B. Crane car (without self-driving unit)

C. Shunting car (Gasoline Engine)

D. Clearance Car (without self-driving unit)

[Tokyo Monorail]

E. Mobile work-shop(Diesel Engine)

[Okinawa Urban Monorail]

F. Mobile work-shop (coupled with crane car)

[Okinawa Urban Monorail]

G. Inside Mobile work-shop(Visual inspection of track)

[Okinawa Urban Monorail]

H. Inspection of track bolts

Source: Tama Urban Monorail (A-D), Tokyo Monorail (Home Page) (E), Weekly Lequio (F), Okinawa Urban Monorail (G, H)

Figure 7-10 Vehicles for Maintenance in Monorail Operation

7.3 ESTIMATION OF O&M COST

7.3.1 Direct Personnel Cost

Direct personnel cost is estimated by multiplying the number of staffs by year, which was estimated in 7.2.2 (3), with average unit cost of personnel cost.

(1) Unit Cost of Personnel Cost

Applied personnel unit cost is estimated by four job categories based on the payroll result of the public transport enterprises in São Paulo. (Table 7-12)

Table 7-12 Unit Personnel Cost by Job Categories

Categories	Explanation	Breakdown	Unit personnel cost *1	
			Local Price (R$/year)	Converted in Japanese price *2 (1000Yen/year)
Category-A	Manager	Assumed at 10% of total number of staffs excluding Janitor and field staffs.	99,581	5,096
Category-B	Technician Driver	Assumed at 90% of total number of staffs excluding Janitor and field staffs.	56,134	2,872
Category-C	Security Staff	Security staffs at stations.	39,688	2,031
Category-D	Station Staff (Ticket Sale)	Station staffs for ticket handlings.	29,621	1,516

Source: Calculated from data of METRÔ and São Paulo city

*1 : Unit cost including social benefit such as social welfare cost.

*2 : Calculated by foreign exchange converter, 51.171 Yen.

(2) Estimation of Direct Personnel Cost

Summary of the direct personnel cost is shown in Table 7-13. The direct personnel cost, which is measured in annual term of 2010 price, is estimated at about 42 million Real for the case of “Area Development Route Plan” , being equivalent to about 2.1 billion Yen, and about 38 million Real for the case of “Original Route Plan” , being equivalent to about 1.9 billion Yen at the inauguration year, 2014.In the final year of simulation, 2045, for the case of “Phase 3, Area Development Route Plan” about 113 million Real, equivalent to 5.8 billion Yen, is estimated as the maximum number.

Table 7-13 Direct Personnel Cost in São Paulo Monorail

Case：Phase1-3 L2A(Area Development Route)

Item	Category		2014 Phase-1	2016 Phase-2	2018 Phase-3	2020	2025	2040	2045
Number of Personnel (Persons)	Category-A	Manager	46	103	118	118	120	120	120
	Category-B	Technician, Driver	411	927	1,058	1,058	1,079	1,079	1,079
	Category-C	Security Staff	247	595	711	711	711	711	711
	Category-D	Station Staff (Ticket Seller)	152	356	423	423	423	423	423
	計		856	1,981	2,310	2,310	2,333	2,333	2,333
Personnel Cost (Brazilian) (1000R$/year)	Category-A	Manager	4,581	10,257	11,751	11,751	11,950	11,950	11,950
	Category-B	Technician, Driver	23,071	52,036	59,390	59,390	60,569	60,569	60,569
	Category-C	Security Staff	9,803	23,614	28,218	28,218	28,218	28,218	28,218
	Category-D	Station Staff (Ticket Seller)	4,502	10,545	12,530	12,530	12,530	12,530	12,530
	計		41,957	96,452	111,888	111,888	113,266	113,266	113,266
Personnel Cost (Japanese) (Million¥/year)	Category-A	Manager	234	525	601	601	611	611	611
	Category-B	Technician, Driver	1,181	2,663	3,039	3,039	3,099	3,099	3,099
	Category-C	Security Staff	502	1,208	1,444	1,444	1,444	1,444	1,444
	Category-D	Station Staff (Ticket Seller)	230	540	641	641	641	641	641
	計		2,147	4,936	5,725	5,725	5,796	5,796	5,796

Case：Phase1-3 L2A(Original Route)

Item	Category		2014 Phase-1	2016 Phase-2	2018 Phase-3	2020	2025	2040	2045
Number of Personnel (Persons)	Category-A	Manager	42	99	114	114	116	116	116
	Category-B	Technician, Driver	376	894	1,024	1,024	1,046	1,046	1,046
	Category-C	Security Staff	218	566	682	682	682	682	682
	Category-D	Station Staff (Ticket Seller)	137	340	408	408	408	408	408
	計		773	1,899	2,228	2,228	2,252	2,252	2,252
Personnel Cost (Brazilian) (1000R$/year)	Category-A	Manager	4,182	9,859	11,352	11,352	11,551	11,551	11,551
	Category-B	Technician, Driver	21,106	50,184	57,481	57,481	58,716	58,716	58,716
	Category-C	Security Staff	8,652	22,463	27,067	27,067	27,067	27,067	27,067
	Category-D	Station Staff (Ticket Seller)	4,058	10,071	12,085	12,085	12,085	12,085	12,085
	計		37,999	92,577	107,986	107,986	109,420	109,420	109,420
Personnel Cost (Japanese) (Million¥/year)	Category-A	Manager	214	504	581	581	591	591	591
	Category-B	Technician, Driver	1,080	2,568	2,941	2,941	3,005	3,005	3,005
	Category-C	Security Staff	443	1,149	1,385	1,385	1,385	1,385	1,385
	Category-D	Station Staff (Ticket Seller)	208	515	618	618	618	618	618
	計		1,944	4,737	5,526	5,526	5,599	5,599	5,599

Case：Phase1only L2A(Area Development Route)

Item	Category		2014 Phase-1	2016	2018	2020	2025	2040	2045
Number of Personnel (Persons)	Category-A	Manager	46	46	46	47	47	48	48
	Category-B	Technician, Driver	411	411	411	427	427	436	436
	Category-C	Security Staff	247	247	247	247	247	247	247
	Category-D	Station Staff (Ticket Seller)	152	152	152	152	152	152	152
	計		856	856	856	873	873	883	883
Personnel Cost (Brazilian) (1000R$/year)	Category-A	Manager	4,581	4,581	4,581	4,680	4,680	4,780	4,780
	Category-B	Technician, Driver	23,071	23,071	23,071	23,969	23,969	24,474	24,474
	Category-C	Security Staff	9,803	9,803	9,803	9,803	9,803	9,803	9,803
	Category-D	Station Staff (Ticket Seller)	4,502	4,502	4,502	4,502	4,502	4,502	4,502
	計		41,957	41,957	41,957	42,955	42,955	43,560	43,560
Personnel Cost (Japanese) (Million¥/year)	Category-A	Manager	234	234	234	239	239	245	245
	Category-B	Technician, Driver	1,181	1,181	1,181	1,227	1,227	1,252	1,252
	Category-C	Security Staff	502	502	502	502	502	502	502
	Category-D	Station Staff (Ticket Seller)	230	230	230	230	230	230	230
	計		2,147	2,147	2,147	2,198	2,198	2,229	2,229

Case：Phase1only L2A(Original Route)

Item	Category		2014 Phase-1	2016	2018	2020	2025	2040	2045
Number of Personnel (Persons)	Category-A	Manager	42	42	42	44	44	44	44
	Category-B	Technician, Driver	376	376	376	391	391	400	400
	Category-C	Security Staff	218	218	218	218	218	218	218
	Category-D	Station Staff (Ticket Seller)	137	137	137	137	137	137	137
	計		773	773	773	790	790	799	799
Personnel Cost (Brazilian) (1000R$/year)	Category-A	Manager	4,182	4,182	4,182	4,382	4,382	4,382	4,382
	Category-B	Technician, Driver	21,106	21,106	21,106	21,948	21,948	22,454	22,454
	Category-C	Security Staff	8,652	8,652	8,652	8,652	8,652	8,652	8,652
	Category-D	Station Staff (Ticket Seller)	4,058	4,058	4,058	4,058	4,058	4,058	4,058
	計		37,999	37,999	37,999	39,040	39,040	39,545	39,545
Personnel Cost (Japanese) (Million¥/year)	Category-A	Manager	214	214	214	224	224	224	224
	Category-B	Technician, Driver	1,080	1,080	1,080	1,123	1,123	1,149	1,149
	Category-C	Security Staff	443	443	443	443	443	443	443
	Category-D	Station Staff (Ticket Seller)	208	208	208	208	208	208	208
	計		1,944	1,944	1,944	1,998	1,998	2,024	2,024

Source:JICA

Note: 1.Each year's price is expressed in base year price (2010), implying converted for economic and financial analysis.

2.Value for 2014 is assumed to a quarter of annual value.
(It was converted at 25% in economic/financial analysis because the line opens in October.)

7.3.2 Other Cost (non-Personnel Cost)

(1) Methodology

Same as the calculation of required staffs, the other cost like track maintenance cost, power cost, etc. except for personnel cost, are calculated, using average unit cost ratio estimated by actual cost result on monorail lines in Japan. However, the specific consideration in São Paulo which was adopted in calculation of number of staffs is not taken into account of for this item.

Following show the relevant cost items and concept of unit cost assumption.

Table 7-14 Cost Items and Unit Cost Estimation for the Cost but Personnel Cost

Item	Calculating Kind of Cost		Unit Cost
Origin from Japanese Statistics	Track Maintenance		Per Line-km
	Electric Maintenance		Per Line-km
	Rolling Stock Maintenance	Power Consumption	Per Number of Rolling Stocks
		Others	Per Number of Rolling Stocks
	Train Operation	Traction Power	Per Car-km
		Others	Per Number of Drivers
	Station	Power Consumption	Per Number of Stations
		Others	Per Number of Stations
	Administration		Per Number of Staffs
	Others		Ratio for the Total Cost Above

Source: JICA Study Team

(2) Unit Cost and Volumes in the Objective Route

Same as the number of staffs, among the monorail lines in Japan, 5 lines, which are straddle type monorail and provide urban transport, are selected and their operation performance data of 2007 are analyzed (Table 7-15). Same as the number of staffs' estimation, unit cost of Tokyo monorail, of which transport volume and capacity is similar to, is adopted. However, regarding the track maintenance cost, that of Osaka monorail is adopted, because Tokyo monorail is pretty old line. Regarding the administration cost, that of Osaka monorail is adopted also because that of Tokyo monorail shows abnormality. In addition the power cost and electric cost in stations are estimated by examining local unit price.

Principal planning indicators of São Paulo monorail, such as operation track length and train running distances are shown together with estimation of required staffs in Table 7-6.

Table 7-15 Unit Cost Actual in Monorail Lines in Japan

Item	Kind of Cost	Unit	Formula	Tokyo	Tama	Osaka	Kita-Kyushu	Okinawa	Remarks
Cost (1000 ¥ /year)	Track Maintenance		A	640,884	65,885	303,950	32,895	55,718	
	Electric Maintenance		B	343,045	295,133	132,231	122,922	126,718	
	Rolling Stock Maintenance		C	650,635	538,211	406,956	185,138	143,484	
	(Power Consumption)		C1	6,680	145,231	0	541	3,633	
	(Others)		C2	643,955	392,980	406,956	184,597	139,851	
	Train Operation		D	554,906	134,435	346,831	89,798	130,406	
	(Traction Power)		D1	541,823	80,447	334,368	89,798	117,268	
	(Others)		D2	13,083	53,988	12,463	0	13,138	
	Station		E	658,575	370,548	753,298	64,576	104,826	
	(Power Consumption)		E1	270,912					
	(Others)		E2	387,663					
	Administration		F	1,358,714	171,665	291,600	189,394	43,728	
	Sub-Total		G=A～F	4,206,759	1,575,877	2,234,866	684,723	604,880	
	Others		H	261,452	102,649	66,394	3,653	10,242	
	Total		**J=G+H**	**4,468,211**	**1,678,526**	**2,301,260**	**688,376**	**615,122**	
Amount for Cost	Line-km	km	a	17.8	16.0	28.0	8.8	12.9	
	Number of Rolling Stock	Cars	b	120	64	80	40	24	
	Car-km (Year Total)	1000km/year	c	19,076	5,453	9,040	2,673	2,077	
	Number of Drivers	Persons	d	92	59	59	22	35	
	Number of Staffs	Persons	e	336	163	221	141	157	
	Number of Stations (Total)	Stations	f	10	19	18	13	15	
	Number of Stations (Underground)	Stations	g	4					
	Number of Stations (Estimate)	Stations	h=f+g/2	12					
Unit Cost	Track Maintenance	K¥/Line-km	j=A/a	36,005	4,118	10,855	3,738	4,319	Selected Osaka
	Electric Maintenance	K¥/Line-km	k=B/a	19,272	18,446	4,723	13,968	9,823	Selected tokyo
	Rolling Stock Maintenance								
	(Power Consumption)	K¥/Rolling Stocks	m1=C1/b	56	2,269	0	14	151	Selected tokyo
	(Others)	K¥/Rolling Stocks	m2=C2/b	5,366	6,140	5,087	4,615	5,827	Selected tokyo
	Train Operation								
	(Traction Power)	¥/Car-km	n1=D1/c	28.4	14.8	37.0	33.6	56.5	Selected Brazilian(33.5)
	(Others)	K¥/Drivers	n2=D2/d	170	915	211	0	375	Selected tokyo
	Station								
	(Power Consumption)	K¥/Stations (Estimate)	p1=E1/h	22,576					Selected Brazilian(26,619)
	(Others)	K¥/Stations (Total)	p2=E2/f	38,766					Selected tokyo
	Administration	K¥/Staffs	q=F/e	4,044	1,053	1,319	1,343	279	Selected Osaka
	Others	% for Sub-Total	r=H/G	6.22%	6.51%	2.97%	0.53%	1.69%	Selected tokyo

Source：Railway Statistics Annual Report 2007, Tokyo Monorail

(3) Estimation of Cost

1) Base cost from actual operation result in Japan

Average cost estimation based on the actual operation result in Japan is shown in Table 7-16 (Phase1 to Phase3) and Table 7-17(Phase1 only).Operation cost in opening year, 2014, which is expressed at annual term as of 2010 price, is estimated at about 4.5 billion Yen for the case of “Area Development Route Plan” and about 4.1 billion Yen for the case of ”Original Route Plan”. In the final simulation year, 2045, it is estimated about 13.2 billion Yen as the maximum for “Phase3, Area Development Route Plan”.

Table 7-16 Cost Based on Actual Operation Result in Japan, in Case of Phase1 to Phase3 for São Paulo Monorail

Case：Phase1-3 L2A(Area Development Route)

Item		Kind of Cost	Unit	Fomula	2014 Phase-1	2016 Phase-2	2018 Phase-3	2020	2025	2040	2045
Cost (Million ¥ /year)	Based on Japanese Statistics	Track Maintenance		A=a×j	169	415	494	494	494	494	494
		Electric Maintenance		B=b×j	300	737	877	877	877	877	877
		Rolling Stock Maintenance		C=C1+C2	943	2,364	2,570	2,570	2,830	2,830	2,830
		（Power Consumption）		C1=c1×k	10	24	27	27	29	29	29
		（Others）		C2=c2×k	934	2,340	2,543	2,543	2,801	2,801	2,801
		Train Operation		D=D1+D2	575	1,623	1,870	1,870	1,939	1,939	1,939
		（Traction Power）		D1=d1×m	562	1,594	1,839	1,839	1,907	1,907	1,907
		（Others）		D2=d2×n	13	30	31	31	32	32	32
		Station		E=E1+E2	1,151	2,721	3,244	3,244	3,244	3,244	3,244
		（Power Consumption）		E1=e1×s	492	1,131	1,344	1,344	1,344	1,344	1,344
		（Others）		E2=e2×q	659	1,589	1,900	1,900	1,900	1,900	1,900
		Administration		F=f×p	1,129	2,613	3,047	3,047	3,077	3,077	3,077
		Sub-Total		G=A～F	4,269	10,474	12,101	12,101	12,461	12,461	12,461
		Others		H=G×h	266	651	753	753	775	775	775
		Total		**J=G+H**	**4,534**	**11,125**	**12,854**	**12,854**	**13,236**	**13,236**	**13,236**
Unit Cost	Based on Japanese Statistics	Track Maintenance	K¥/Line-km	a	10,855	10,855	10,855	10,855	10,855	10,855	10,855
		Electric Maintenance	K¥/Line-km	b	19,272	19,272	19,272	19,272	19,272	19,272	19,272
		Rolling Stock Maintenance									
		（Power Consumption）	K¥/Cars	c1	56	56	56	56	56	56	56
		（Others）	K¥/Cars	c2	5,366	5,366	5,366	5,366	5,366	5,366	5,366
		Train Operation									
		（Traction Power）	¥/Car-km	d1	33.5	33.5	33.5	33.5	33.5	33.5	33.5
		（Others）	K¥/Drivers	d2	170	170	170	170	170	170	170
		Station									
		（Power Consumption）	K¥/Stations（Estimate）	e1	26,619	26,619	26,619	26,619	26,619	26,619	26,619
		（Others）	K¥/Stations（Total）	e2	38,766	38,766	38,766	38,766	38,766	38,766	38,766
		Administration	K¥/Staffs	f	1,319	1,319	1,319	1,319	1,319	1,319	1,319
		Others	% for Sub-Total	h	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%
Amount for Cost	Planned Line	Line-km	km	j	15.59	38.26	45.49	45.49	45.49	45.49	45.49
		Number of Rolling Stock	Cars	k	174	420	474	474	522	522	522
		Car-km（Year Total）	1000km/year	m	13,090	35,900	41,530	43,390	43,390	43,390	43,390
		Number of Drivers	Persons	n	74	170	185	185	191	191	191
		Number of Staffs	Persons	p	856	1,970	2,310	2,310	2,333	2,333	2,333
		Number of Stations（Total）	Stations	q	17	41	49	49	49	49	49
		Number of Stations (Underground)	Stations	r	3	3	3	3	3	3	3
		Number of Stations（Estimate）	Stations	s=q+r×0.5	18.5	42.5	50.5	50.5	50.5	50.5	50.5

Case：Phase1-3 L2A(Original Route)

Item		Kind of Cost	Unit	Fomula	2014 Phase-1	2016 Phase-2	2018 Phase-3	2020	2025	2040	2045
Cost (Million ¥ /year)	Based on Japanese Statistics	Track Maintenance		A=a×j	154	400	479	479	479	479	479
		Electric Maintenance		B=b×j	274	711	850	850	850	850	850
		Rolling Stock Maintenance		C=C1+C2	943	2,364	2,570	2,570	2,830	2,830	2,830
		（Power Consumption）		C1=c1×k	10	24	27	27	29	29	29
		（Others）		C2=c2×k	934	2,340	2,543	2,543	2,801	2,801	2,801
		Train Operation		D=D1+D2	522	1,560	1,803	1,803	1,870	1,870	1,870
		（Traction Power）		D1=d1×m	510	1,531	1,773	1,773	1,838	1,838	1,838
		（Others）		D2=d2×n	11	29	30	30	31	31	31
		Station		E=E1+E2	994	2,563	3,086	3,086	3,086	3,086	3,086
		（Power Consumption）		E1=e1×s	413	1,051	1,264	1,264	1,264	1,264	1,264
		（Others）		E2=e2×q	581	1,512	1,822	1,822	1,822	1,822	1,822
		Administration		F=f×p	1,020	2,505	2,939	2,939	2,970	2,970	2,970
		Sub-Total		G=A～F	3,907	10,103	11,727	11,727	12,086	12,086	12,086
		Others		H=G×h	243	628	729	729	752	752	752
		Total		**J=G+H**	**4,150**	**10,731**	**12,456**	**12,456**	**12,837**	**12,837**	**12,837**
Unit Cost	Based on Japanese Statistics	Track Maintenance	K¥/Line-km	a	10,855	10,855	10,855	10,855	10,855	10,855	10,855
		Electric Maintenance	K¥/Line-km	b	19,272	19,272	19,272	19,272	19,272	19,272	19,272
		Rolling Stock Maintenance									
		（Power Consumption）	K¥/Cars	c1	56	56	56	56	56	56	56
		（Others）	K¥/Cars	c2	5,366	5,366	5,366	5,366	5,366	5,366	5,366
		Train Operation									
		（Traction Power）	¥/Car-km	d1	33.5	33.5	33.5	33.5	33.5	33.5	33.5
		（Others）	K¥/Drivers	d2	170	170	170	170	170	170	170
		Station									
		（Power Consumption）	K¥/Stations（Estimate）	e1	26,619	26,619	26,619	26,619	26,619	26,619	26,619
		（Others）	K¥/Stations（Total）	e2	38,766	38,766	38,766	38,766	38,766	38,766	38,766
		Administration	K¥/Staffs	f	1,319	1,319	1,319	1,319	1,319	1,319	1,319
		Others	% for Sub-Total	h	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%
Amount for Cost	Planned Line	Line-km	km	j	14.21	36.88	44.11	44.11	44.11	44.11	44.11
		Number of Rolling Stock	Cars	k	174	420	474	474	522	522	522
		Car-km（Year Total）	1000km/year	m	11,189	32,771	38,115	39,886	39,886	39,886	39,886
		Number of Drivers	Persons	n	67	164	178	178	185	185	185
		Number of Staffs	Persons	p	773	1,890	2,228	2,228	2,252	2,252	2,252
		Number of Stations（Total）	Stations	q	15	39	47	47	47	47	47
		Number of Stations (Underground)	Stations	r	1	1	1	1	1	1	1
		Number of Stations（Estimate）	Stations	s=q+r×0.5	15.5	39.5	47.5	47.5	47.5	47.5	47.5

Note: 1.Each year's price is expressed in base year price (2010), implying converted for economic and financial analysis.
2.Value for 2014 is assumed to a quarter of annual value.
(It was converted at 25% in economic/financial analysis because the line opens in October.)

Table 7-17 Cost Based on Actual Operation Result in Japan, in Case of Phase1 Only for São Paulo Monorail

Case：Phase1only L2A(Area Development Route)

Item		Kind of Cost	Unit	Fomula	2014 Phase-1	2016	2018	2020	2025	2040	2045
Cost (Million ¥ /year)	Based on Japanese Statistics	Track Maintenance		A=a×j	169	169	169	169	169	169	169
		Electric Maintenance		B=b×j	300	300	300	300	300	300	300
		Rolling Stock Maintenance		C=C1+C2	943	943	943	1,139	1,139	1,236	1,236
		（Power Consumption）		C1=c1×k	10	10	10	12	12	13	13
		（Others）		C2=c2×k	934	934	934	1,127	1,127	1,223	1,223
		Train Operation		D=D1+D2	575	575	575	607	607	628	628
		（Traction Power）		D1=d1×m	562	562	562	594	594	614	614
		（Others）		D2=d2×n	13	13	13	13	13	14	14
		Station		E=E1+E2	1,151	1,151	1,151	1,151	1,151	1,151	1,151
		（Power Consumption）		E1=e1×s	492	492	492	492	492	492	492
		（Others）		E2=e2×q	659	659	659	659	659	659	659
		Administration		F=f×p	1,129	1,129	1,129	1,151	1,151	1,165	1,165
		Sub-Total		G=A～F	4,269	4,269	4,269	4,518	4,518	4,650	4,650
		Others		H=G×h	266	266	266	281	281	289	289
		Total		**J=G+H**	**4,534**	**4,534**	**4,534**	**4,799**	**4,799**	**4,939**	**4,939**
Unit Cost	Based on Japanese Statistics	Track Maintenance	K¥/Line-km	a	10,855	10,855	10,855	10,855	10,855	10,855	10,855
		Electric Maintenance	K¥/Line-km	b	19,272	19,272	19,272	19,272	19,272	19,272	19,272
		Rolling Stock Maintenance									
		（Power Consumption）	K¥/Cars	c1	56	56	56	56	56	56	56
		（Others）	K¥/Cars	c2	5,366	5,366	5,366	5,366	5,366	5,366	5,366
		Train Operation									
		（Traction Power）	¥/Car-km	d1	33.5	33.5	33.5	33.5	33.5	33.5	33.5
		（Others）	K¥/Drivers	d2	170	170	170	170	170	170	170
		Station									
		（Power Consumption）	K¥/Stations（Estimate）	e1	26,619	26,619	26,619	26,619	26,619	26,619	26,619
		（Others）	K¥/Stations（Total）	e2	38,766	38,766	38,766	38,766	38,766	38,766	38,766
		Administration	K¥/Staffs	f	1,319	1,319	1,319	1,319	1,319	1,319	1,319
		Others	% for Sub-Total	h	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%
Amount for Cost	Planned Line	Line-km	km	j	15.59	15.59	15.59	15.59	15.59	15.59	15.59
		Number of Rolling Stock	Cars	k	174	174	174	210	210	228	228
		Car-km（Year Total）	1000km/year	m	13,090	13,090	13,090	13,946	13,946	14,517	14,517
		Number of Drivers	Persons	n	74	74	74	78	78	81	81
		Number of Staffs	Persons	p	856	856	856	873	873	883	883
		Number of Stations（Total）	Stations	q	17	17	17	17	17	17	17
		Number of Stations (Underground)	Stations	r	3	3	3	3	3	3	3
		Number of Stations（Estimate）	Stations	s=q+r×0.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5

Case：Phase1only L2A(Original Route)

Item		Kind of Cost	Unit	Fomula	2014 Phase-1	2016	2018	2020	2025	2040	2045
Cost (Million ¥ /year)	Based on Japanese Statistics	Track Maintenance		A=a×j	154	154	154	154	154	154	154
		Electric Maintenance		B=b×j	274	274	274	274	274	274	274
		Rolling Stock Maintenance		C=C1+C2	943	943	943	1,139	1,139	1,236	1,236
		（Power Consumption）		C1=c1×k	10	10	10	12	12	13	13
		（Others）		C2=c2×k	934	934	934	1,127	1,127	1,223	1,223
		Train Operation		D=D1+D2	522	522	522	551	551	570	570
		（Traction Power）		D1=d1×m	510	510	510	539	539	558	558
		（Others）		D2=d2×n	11	11	11	12	12	12	12
		Station		E=E1+E2	994	994	994	994	994	994	994
		（Power Consumption）		E1=e1×s	413	413	413	413	413	413	413
		（Others）		E2=e2×q	581	581	581	581	581	581	581
		Administration		F=f×p	1,020	1,020	1,020	1,042	1,042	1,054	1,054
		Sub-Total		G=A～F	3,907	3,907	3,907	4,153	4,153	4,282	4,282
		Others		H=G×h	243	243	243	258	258	266	266
		Total		**J=G+H**	**4,150**	**4,150**	**4,150**	**4,412**	**4,412**	**4,549**	**4,549**
Unit Cost	Based on Japanese Statistics	Track Maintenance	K¥/Line-km	a	10,855	10,855	10,855	10,855	10,855	10,855	10,855
		Electric Maintenance	K¥/Line-km	b	19,272	19,272	19,272	19,272	19,272	19,272	19,272
		Rolling Stock Maintenance									
		（Power Consumption）	K¥/Cars	c1	56	56	56	56	56	56	56
		（Others）	K¥/Cars	c2	5,366	5,366	5,366	5,366	5,366	5,366	5,366
		Train Operation									
		（Traction Power）	¥/Car-km	d1	33.5	33.5	33.5	33.5	33.5	33.5	33.5
		（Others）	K¥/Drivers	d2	170	170	170	170	170	170	170
		Station									
		（Power Consumption）	K¥/Stations（Estimate）	e1	26,619	26,619	26,619	26,619	26,619	26,619	26,619
		（Others）	K¥/Stations（Total）	e2	38,766	38,766	38,766	38,766	38,766	38,766	38,766
		Administration	K¥/Staffs	f	1,319	1,319	1,319	1,319	1,319	1,319	1,319
		Others	% for Sub-Total	h	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%	6.22%
Amount for Cost	Planned Line	Line-km	km	j	14.21	14.21	14.21	14.21	14.21	14.21	14.21
		Number of Rolling Stock	Cars	k	174	174	174	210	210	228	228
		Car-km（Year Total）	1000km/year	m	11,189	11,189	11,189	11,957	11,957	12,468	12,468
		Number of Drivers	Persons	n	67	67	67	71	71	73	73
		Number of Staffs	Persons	p	773	773	773	790	790	799	799
		Number of Stations（Total）	Stations	q	15	15	15	15	15	15	15
		Number of Stations (Underground)	Stations	r	1	1	1	1	1	1	1
		Number of Stations（Estimate）	Stations	s=q+r×0.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5

Source:JICA Study Team

Note: 1.Each year's price is expressed in base year price (2010), implying converted for economic and financial analysis.
2.Value for 2014 is assumed to a quarter of annual value.
(It was converted at 25% in economic/financial analysis because the line opens in October.)

2) Cost based on local price

Regarding the cost based on actual result Japan of 1), it is converted to local price basis. In this case, the cost portion of outsourcing included in personnel cost is separated and adjusted, taking into account of the personnel cost difference between São Paulo and Japan. Summarizing the estimation results, it is shown in Table 7-18 (Phase1 to Phase3) and Table 7-19 (Phase1 only). Cost in opening year, 2014, expressed in annual term as of 2010, is estimated at about 80 million Real for "Area Development Route Plan", about 73 million Real for "Original Route Plan". In the final year of simulation, 2045, the cost is estimated at about 233 million Real as the maximum for "Phase3, Area Development Route Plan".

Table 7-18 Base Cost in Local Price in Case of Phase1 to Phase3 of São Paulo Monorail

Case:Phase1-3 L2A(Area Development Route)

Item	Kind of Cost	Formula	2014 Phase-1	2016 Phase-2	2018 Phase-3	2020	2025	2040	2045
Japanese Basis Cost (Million ¥/year)	Track Maintenance	A	169	415	494	494	494	494	494
	Electric Maintenance	B	300	737	877	877	877	877	877
	Rolling Stock Maintenance	C	934	2,340	2,543	2,543	2,801	2,801	2,801
	Station(without Power Consumption)	D	659	1,589	1,900	1,900	1,900	1,900	1,900
	Power Consumption	E	1,065	2,749	3,210	3,210	3,280	3,280	3,280
	Others	F	1,407	3,294	3,831	3,831	3,885	3,885	3,885
	Total	**G=A～F**	**4,534**	**11,125**	**12,854**	**12,854**	**13,236**	**13,236**	**13,236**
Personnel Cost for Outsourcing (Japanese Basis) (Million ¥/year)	Track Maintenance	a=A×50%	85	208	247	247	247	247	247
	Electric Maintenance	b=B×50%	150	369	438	438	438	438	438
	Rolling Stock Maintenance	c=C×40%	373	936	1,017	1,017	1,120	1,120	1,120
	Station	d=D×10%	66	159	190	190	190	190	190
	Total	**g=a～d**	**674**	**1,671**	**1,893**	**1,893**	**1,996**	**1,996**	**1,996**
Exchange Rate (JP¥/R$)		h	51.171	51.171	51.171	51.171	51.171	51.171	51.171
Converting Ratio for Personnel Cost (Jp→Br)		j	33%	33%	33%	33%	33%	33%	33%
Brazilian Basis Cost (1000R$/year)	Personnel Cost for Outsourcing	M=g/h×j	4,348	10,777	12,205	12,205	12,870	12,870	12,870
	Power Consumption	N=E/h	20,806	53,730	62,721	62,721	64,101	64,101	64,101
	Others	P=(G-g-E)/h	54,627	131,025	151,491	151,491	155,561	155,561	155,561
	合計	**Q=M～P**	**79,781**	**195,532**	**226,418**	**226,418**	**232,531**	**232,531**	**232,531**

Case:Phase1-3 L2A(Original Route)

Item	Kind of Cost	Formula	2014 Phase-1	2016 Phase-2	2018 Phase-3	2020	2025	2040	2045
Japanese Basis Cost (Million ¥/year)	Track Maintenance	A	154	400	479	479	479	479	479
	Electric Maintenance	B	274	711	850	850	850	850	850
	Rolling Stock Maintenance	C	934	2,340	2,543	2,543	2,801	2,801	2,801
	Station(without Power Consumption)	D	581	1,512	1,822	1,822	1,822	1,822	1,822
	Power Consumption	E	933	2,607	3,064	3,064	3,132	3,132	3,132
	Others	F	1,274	3,162	3,698	3,698	3,754	3,754	3,754
	Total	**G=A～F**	**4,150**	**10,731**	**12,456**	**12,456**	**12,837**	**12,837**	**12,837**
Personnel Cost for Outsourcing (Japanese Basis) (Million ¥/year)	Track Maintenance	a=A×50%	77	200	239	239	239	239	239
	Electric Maintenance	b=B×50%	137	355	425	425	425	425	425
	Rolling Stock Maintenance	c=C×40%	373	936	1,017	1,017	1,120	1,120	1,120
	Station	d=D×10%	58	151	182	182	182	182	182
	Total	**g=a～d**	**646**	**1,643**	**1,864**	**1,864**	**1,967**	**1,967**	**1,967**
Exchange Rate (JP¥/R$)		h	51.171	51.171	51.171	51.171	51.171	51.171	51.171
Converting Ratio for Personnel Cost (Jp→Br)		j	33%	33%	33%	33%	33%	33%	33%
Brazilian Basis Cost (1000R$/year)	Personnel Cost for Outsourcing	M=g/h×j	4,164	10,593	12,021	12,021	12,686	12,686	12,686
	Power Consumption	N=E/h	18,225	50,950	59,871	59,871	61,203	61,203	61,203
	Others	P=(G-g-E)/h	50,255	126,668	147,129	147,129	151,227	151,227	151,227
	合計	**Q=M～P**	**72,643**	**188,210**	**219,022**	**219,022**	**225,116**	**225,116**	**225,116**

Source:JICA Study Team

Note: 1.Each year's price is expressed in base year price (2010), implying converted for economic and financial analysis.

2.Value for 2014 is assumed to a quarter of annual value.
(It was converted at 25% in economic/financial analysis because the line opens in October.)

Table 7-19 Base Cost in Local Price in Case of Phase1 Only of São Paulo Monorail

Case：Phase1only L2A(Area Development Route)

Item	Kind of Cost	Formula	2014 Phase-1	2016	2018	2020	2025	2040	2045
Japanese Basis Cost	Track Maintenance	A	169	169	169	169	169	169	169
	Electric Maintenance	B	300	300	300	300	300	300	300
	Rolling Stock Maintenance	C	934	934	934	1,127	1,127	1,223	1,223
(Million ¥/year)	Station(without Power Consumption)	D	659	659	659	659	659	659	659
	Power Consumption	E	1,065	1,065	1,065	1,098	1,098	1,120	1,120
	Others	F	1,407	1,407	1,407	1,446	1,446	1,468	1,468
	Total	**G=A～F**	**4,534**	**4,534**	**4,534**	**4,799**	**4,799**	**4,939**	**4,939**
Personnel Cost for Outsourcing (Japanese Basis)	Track Maintenance	a=A×50%	85	85	85	85	85	85	85
	Electric Maintenance	b=B×50%	150	150	150	150	150	150	150
	Rolling Stock Maintenance	c=C×40%	373	373	373	451	451	489	489
	Station	d=D×10%	66	66	66	66	66	66	66
(Million ¥/year)	**Total**	**g=a～d**	**674**	**674**	**674**	**751**	**751**	**790**	**790**
Exchange Rate (JP¥/R$)		h	51.171	51.171	51.171	51.171	51.171	51.171	51.171
Converting Ratio for Personnel Cost (Jp→Br)		j	33%	33%	33%	33%	33%	33%	33%
Brazilian Basis Cost	Personnel Cost for Outsourcing	M=g/h×j	4,348	4,348	4,348	4,846	4,846	5,095	5,095
	Power Consumption	N=E/h	20,806	20,806	20,806	21,453	21,453	21,879	21,879
	Others	P=(G-g-E)/h	54,627	54,627	54,627	57,647	57,647	59,208	59,208
(1000R$/year)	**合計**	**Q=M～P**	**79,781**	**79,781**	**79,781**	**83,947**	**83,947**	**86,182**	**86,182**

Case：Phase1only L2A(Original Route)

Item	Kind of Cost	Formula	2014 Phase-1	2016	2018	2020	2025	2040	2045
Japanese Basis Cost	Track Maintenance	A	154	154	154	154	154	154	154
	Electric Maintenance	B	274	274	274	274	274	274	274
	Rolling Stock Maintenance	C	934	934	934	1,127	1,127	1,223	1,223
(Million ¥/year)	Station(without Power Consumption)	D	581	581	581	581	581	581	581
	Power Consumption	E	933	933	933	963	963	983	983
	Others	F	1,274	1,274	1,274	1,312	1,312	1,333	1,333
	Total	**G=A～F**	**4,150**	**4,150**	**4,150**	**4,412**	**4,412**	**4,549**	**4,549**
Personnel Cost for Outsourcing (Japanese Basis)	Track Maintenance	a=A×50%	77	77	77	77	77	77	77
	Electric Maintenance	b=B×50%	137	137	137	137	137	137	137
	Rolling Stock Maintenance	c=C×40%	373	373	373	451	451	489	489
	Station	d=D×10%	58	58	58	58	58	58	58
(Million ¥/year)	**Total**	**g=a～d**	**646**	**646**	**646**	**723**	**723**	**762**	**762**
Exchange Rate (JP¥/R$)		h	51.171	51.171	51.171	51.171	51.171	51.171	51.171
Converting Ratio for Personnel Cost (Jp→Br)		j	33%	33%	33%	33%	33%	33%	33%
Brazilian Basis Cost	Personnel Cost for Outsourcing	M=g/h×j	4,164	4,164	4,164	4,662	4,662	4,911	4,911
	Power Consumption	N=E/h	18,225	18,225	18,225	18,818	18,818	19,208	19,208
	Others	P=(G-g-E)/h	50,255	50,255	50,255	53,271	53,271	54,799	54,799
(1000R$/year)	**合計**	**Q=M～P**	**72,643**	**72,643**	**72,643**	**76,752**	**76,752**	**78,918**	**78,918**

Source:JICA Study Team

Note: 1.Each year's price is expressed in base year price (2010), implying converted for economic and financial analysis.

2.Value for 2014 is assumed to a quarter of annual value.
(It was converted at 25% in economic/financial analysis because the line opens in October.)

7.3.3 Summary of O&M Cost

Aggregating the result up to here, maintenance cost for objective route in local price/ Japanese price is shown in Table 7-20 and Figure 7-11. Total running cost in opening year, expressed in annual term as of 2010, is estimated at about 122million Real (about 6.7 billion Yen) for the case of "Area Development Route Plan", at about 111 million Real (about 6.1 billion Yen) for the case of "Original Route Plan". In the final year of simulation, 2045, it is estimated at about 346 million Real (about 19.0 billion Yen) for the case of "Phase3, Area Development Route Plan" as the maximum.

Table 7-20 Summary of O&M Cost for São Paulo Monorail Plan

Case：Phase1-3 L2A(Area Development Route)

Item	Kind of Cost	2014 Phase-1	2016 Phase-2	2018 Phase-3	2020	2025	2040	2045
Brazilian Basis Cost	Personnel(Direct+Outsourcing)	46,305	107,229	124,093	124,093	126,136	126,136	126,136
	Power Consumption	20,806	53,730	62,721	62,721	64,101	64,101	64,101
	Others	54,627	131,025	151,491	151,491	155,561	155,561	155,561
(1000R$/year)	**合計**	**121,738**	**291,985**	**338,306**	**338,306**	**345,797**	**345,797**	**345,797**
Japanese Basis Cost	Personnel(Direct+Outsourcing)	2,821	6,607	7,618	7,618	7,792	7,792	7,792
	Power Consumption	1,065	2,749	3,210	3,210	3,280	3,280	3,280
	Others	2,795	6,705	7,752	7,752	7,960	7,960	7,960
(Million ¥/year)	**合計**	**6,681**	**16,061**	**18,579**	**18,579**	**19,032**	**19,032**	**19,032**

Case：Phase1-3 L2A(Original Route)

Item	Kind of Cost	2014 Phase-1	2016 Phase-2	2018 Phase-3	2020	2025	2040	2045
Brazilian Basis Cost	Personnel(Direct+Outsourcing)	42,163	103,170	120,007	120,007	122,106	122,106	122,106
	Power Consumption	18,225	50,950	59,871	59,871	61,203	61,203	61,203
	Others	50,255	126,668	147,129	147,129	151,227	151,227	151,227
(1000R$/year)	**合計**	**110,642**	**280,787**	**327,008**	**327,008**	**334,536**	**334,536**	**334,536**
Japanese Basis Cost	Personnel(Direct+Outsourcing)	2,590	6,380	7,390	7,390	7,566	7,566	7,566
	Power Consumption	933	2,607	3,064	3,064	3,132	3,132	3,132
	Others	2,572	6,482	7,529	7,529	7,738	7,738	7,738
(Million ¥/year)	**合計**	**6,094**	**15,469**	**17,982**	**17,982**	**18,436**	**18,436**	**18,436**

Case：Phase1only L2A(Area Development Route)

Item	Kind of Cost	2014 Phase-1	2016	2018	2020	2025	2040	2045
Brazilian Basis Cost	Personnel(Direct+Outsourcing)	46,305	46,305	46,305	47,801	47,801	48,655	48,655
	Power Consumption	20,806	20,806	20,806	21,453	21,453	21,879	21,879
	Others	54,627	54,627	54,627	57,647	57,647	59,208	59,208
(1000R$/year)	**合計**	**121,738**	**121,738**	**121,738**	**126,902**	**126,902**	**129,741**	**129,741**
Japanese Basis Cost	Personnel(Direct+Outsourcing)	2,821	2,821	2,821	2,950	2,950	3,019	3,019
	Power Consumption	1,065	1,065	1,065	1,098	1,098	1,120	1,120
	Others	2,795	2,795	2,795	2,950	2,950	3,030	3,030
(Million ¥/year)	**合計**	**6,681**	**6,681**	**6,681**	**6,997**	**6,997**	**7,168**	**7,168**

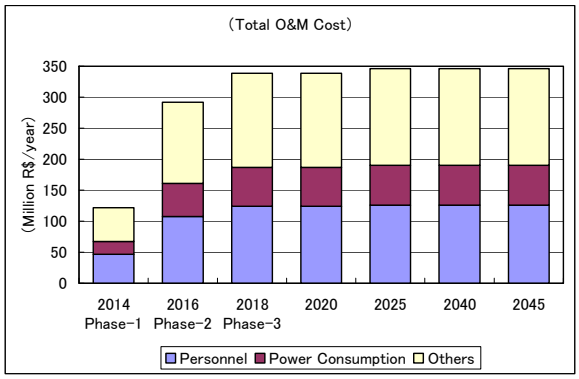
Case：Phase1only L2A(Original Route)

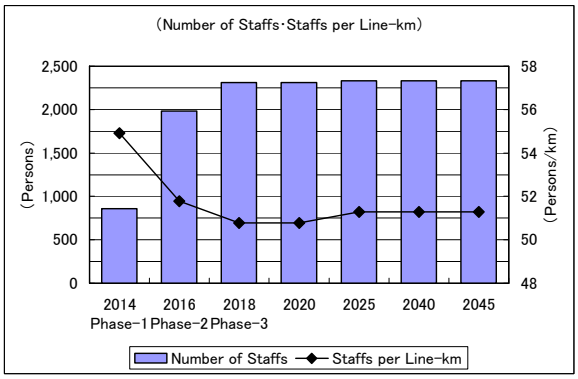
Item	Kind of Cost	2014 Phase-1	2016	2018	2020	2025	2040	2045
Brazilian Basis Cost	Personnel(Direct+Outsourcing)	42,163	42,163	42,163	43,702	43,702	44,457	44,457
	Power Consumption	18,225	18,225	18,225	18,818	18,818	19,208	19,208
	Others	50,255	50,255	50,255	53,271	53,271	54,799	54,799
(1000R$/year)	**合計**	**110,642**	**110,642**	**110,642**	**115,792**	**115,792**	**118,463**	**118,463**
Japanese Basis Cost	Personnel(Direct+Outsourcing)	2,590	2,590	2,590	2,721	2,721	2,785	2,785
	Power Consumption	933	933	933	963	963	983	983
	Others	2,572	2,572	2,572	2,726	2,726	2,804	2,804
(Million ¥/year)	**合計**	**6,094**	**6,094**	**6,094**	**6,410**	**6,410**	**6,572**	**6,572**

Source:JICA Study Team

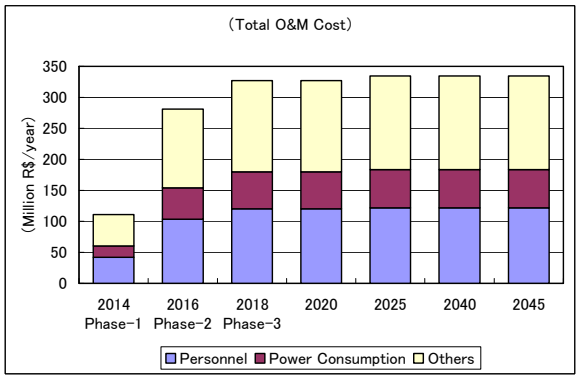
Note: 1.Each year's price is expressed in base year price (2010), implying converted for economic and financial analysis.
2.Value for 2014 is assumed to a quarter of annual value.
(It was converted at 25% in economic/financial analysis because the line opens in October.)

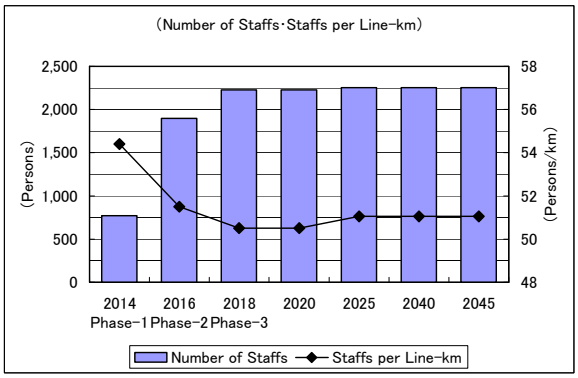
Case：Phase1-3 L2A(Area Development Route)



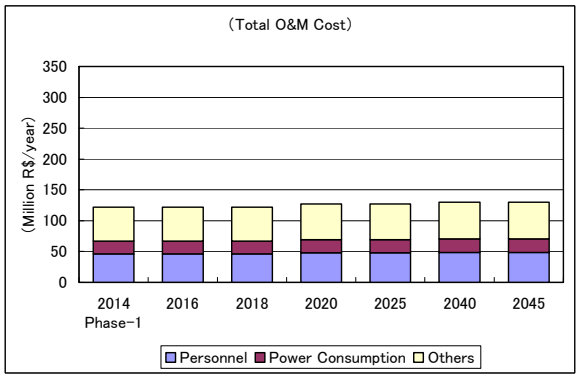


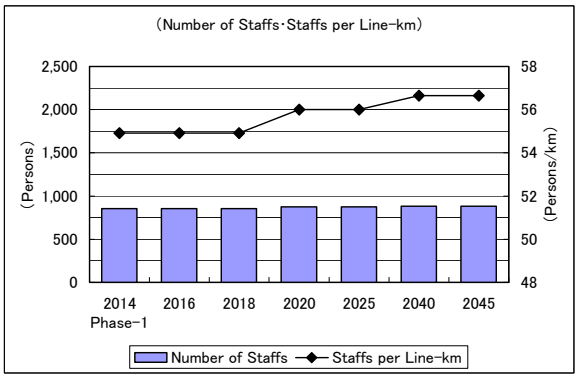
Case：Phase1-3 L2A(Original Route)



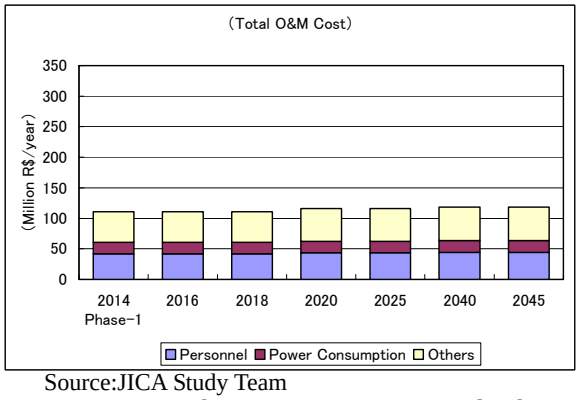


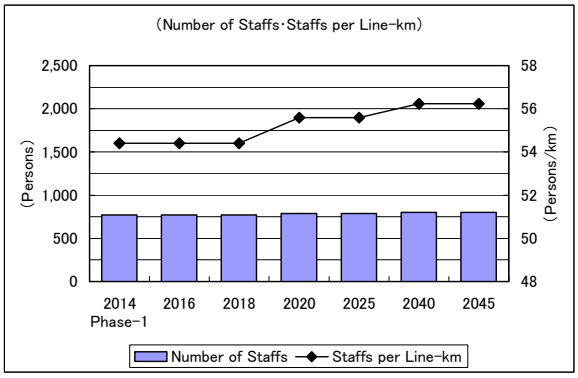
Case：Phase1only L2A(Area Development Route)





Case：Phase1only L2A(Original Route)





Source:JICA Study Team

Note: 1.Each year's price is expressed in base year price (2010).
2.Value for 2014 is assumed to a quarter of annual value.

Figure 7-11 Total O&M Cost and Number of Staffs

CHAPTER 8 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

8.1 LEGAL AND INSTITUTIONAL SYSTEM

8.1.1 Major Environmental Laws

This section presents a compilation of major legal instruments such as laws, decrees, resolutions, and rules that regulate the environmental licensing for the project, also including those related to property acquisition and relocation/resettlement of families and business. Table 8-1 summarizes major legislations on environmental and social considerations related to the project. Outlines of other main relevant laws and regulations are shown in Appendix 1-1.

Table 8-1 List of Major Legislations on Environmental and Social Considerations Related to the Project

1. Major Environmental Laws and Regulations
1) Federal Law No.6938 as of 31/08/1981 It sets forth the National Environmental Policy, its purposes, and formulation and application mechanisms, constitutes the National Environmental System (SISNAMA).
2) Federal Decree No.99274 as of 06/06/1990 It defines the composition of SISNAMA and sets forth the environmental licenses to issue in each stage of the project.
3) Organizational Law of the Municipality of São Paulo It is the basic law of the Municipality of São Paulo with the objective to organize and strengthen democratic institutions and human rights.
4) Municipal Decree No.34.713, as of November 30, 1994 It prescribes the procedure and activities of the Housing and Urban Development Secretariat (SEHAB), the Municipal Transports Secretariat (SMT) and the Municipal Secretariat of Green and Environment (SVMA) in terms of the procedures and approval of the Neighborhood Impact Report (RIVI).
5) Municipal Decree No.36.613, as of December 06, 1996 It amends the Articles 1 and 2 of Decree No.34.713, which provides for, respectively, the definition of enterprises considered as with significant environmental or urban infrastructure impact, and of the cases in which the presentation of the RIVI is not necessary.
6) SVMA Administrative Rule No.38-G/9 It institutes the procedures for the analysis of the environmental licensing requested to the appraisal of the Municipal Secretariat of Green and Environment (SVMA).
7) SVMA Administrative Rule No.39-G/96 It institutes the procedures for the evaluation of the Neighborhood Impact Report (RIVI), within the scope of SVMA/CADES/DECONT.
8) SVMA Administrative Rule No.104-G/96 It defines the procedures for the analysis and follow-up of the Degraded Areas Recuperation Plan (PRAD) and for the issuing of the Operation Environmental License (LAO) for mining enterprises.
2. Environmental Licensing and Environmental Impact Assessment
(1) Federal Laws and Regulations
1) CONAMA Resolution No.001 as of 23/01/1986 It sets forth the definitions, responsibilities, basic criteria and general guidelines for the use and implementation of the Environmental Impact Appraisal as one of the instruments of the National Environmental Policy.
2) CONAMA Resolution No. 237 as of 19/12/1997 It provides for the revision and complementation of procedures and criteria utilized for the environmental licensing set forth by CONAMA Resolution No.001/86.
(2) São Paulo State Laws and Regulations
1) SMA Resolution No. 42 as of 29/12/1994 This resolution sets forth the procedures for the analysis of Environmental Impact Studies (EIS and EIR) within the scope of the Environment Secretariat of São Paulo State.

(3) São Paulo Municipal Laws and Regulations
1) Municipal Law No.11.426/93 It declares SVMA as the local agency for the National Environmental System (SISNAMA), and the Municipal Council of Environment and Sustainable Development (CADES), as consultative and deliberative bodies related to environmental issues in the Municipality of São Paulo.
2) Administrative Rules 038/SVMA.G/95, 039/SVMA.G/96, and 104/SVMA.G/96 It assigns to Department of Environmental Quality Control (DECONT) of SVMA, through the Technical Division of Registration and Licensing (DECONT-2), the coordination roles of environmental impact assessment and environmental licensing processes.
3. Other Relevant Environmental Laws and Regulations
(1) Archaeological Heritage
1) IPHAN Administrative Rule 07/1988 It regulates the requests of permission and authorization and previous communication for the development of field surveys and archaeological excavations in the country with the purpose of protection of scientifically and culturally valuable objects present in the location of such surveys, as provided in Law No.3.924, as of July 26, 1961.
2) IPHAN Administrative Rule 230/2002 It makes the preventive archaeological studies compatible with the environmental licensing phases of projects which potentially affect the archaeological heritage, as well as defines the procedures to adopt in each phases of environmental licensing.
3) SMA Resolution 34/2003 It provides necessary measures for the protection of the archaeological and pre-historic heritage during the environmental licensing of projects and activities potentially causing significant environmental impact, subject to the presentation of EIA/RIMA.
(2) Environmental Compensation
1) Federal Law No.9985/2000 It institutes the National System of Conservation Units (SNUC), defining criteria and rules for the creation, implementation and management of conservation units.
2) CONAMA Resolution No.371/2006 It prescribes guidelines to the environmental agencies for the calculation, collection, application, approval and control of expenditures of resources resulting from environmental compensation, according to Law No.9.985, as of July 18, 2000, and defines other provisions.
(3) Pollution Control
1) State Law No.997/1976 It institutes the System of Prevention and Control of Environmental Pollution in the State of São Paulo, defining the need of licensing for the installation, construction or expansion, as well as for the operation of pollution sources.
2) State Decree No.8468/1976 It endorses the regulation of Law No.997/76 that provides for the prevention and control of environmental pollution in the State of São Paulo. The decree defines the classification of inner waters located in the State territory, the water and air quality standards, as well as the emission standards allowed for both cases, in addition to the restrictions related to the soil pollution.
(4) Permission for Intervention of Water Resources
1) DAEE Administrative Rule No.717/96 It regulates use of surface and underground water resources in the State of São Paulo. This Rule prescribes the minimum conditions to be observed for the implementation of the enterprise; work and service that interferes with surface water and ground water.
(5) Water Source Protection
1) State Law No.898/75 - Water Source Protection and Restoration Law It regulates the land use for the protection of water sources, courses, reservoirs and other water resources of interest in the Metropolitan Region of São Paulo (RMSP).
2) State Law No.1172/76 - Water Source Protection and Restoration Law It defines the limit of protection areas related to water sources, courses and reservoirs mentioned in Article 2 of Law No.898/75, and prescribes rules and restrictions of land use in such areas.
3) State Law No.9866/97 - New Water Source Protection and Restoration Law It prescribes guidelines and rules for the protection and restoration of the environmental quality of

hydrographic basins of regional interest for the water supply of current and future populations of São Paulo State.
4) State Law No.12.233/2006 - Guarapiranga Specific Law It defines the Water Source Protection and Restoration Area of Guarapiranga Hydrographic Basin (APRM-G) and prescribes the environmental and urban guidelines and rules of interest for the preservation, conservation and restoration of the water sources.
5) State Decree No.51686/2007 It regulates the instruments of State Law No.12.233, as of January 16, 2006 – Guarapiranga Specific Law, which defines the Water Source Protection and Restoration Area of the Guarapiranga Hydrographic Basin (APRM-G), and makes other correlate provisions.
(6) Water Quality
1) CONAMA Resolution No.357/2005 It provides for the classification of water bodies and their environmental guidelines, as well as definitions of the effluents discharge conditions and standards.
2) State Decree No.10755/1977 It provides for the classification of receptor water bodies in the State of São Paulo in the classification prescribe in Decree No.8468/1976.
(7) Air Quality
1) CONAMA Resolution No.003/1990 It prescribes the air quality standards that are the objective to attain through the control strategy fixed by the emission standards, and shall guide the elaboration of Regional Plans of Air Pollution Control.
(8) Solid Waste Management
1) ABNT NBR 10004/2004 Brazilian Standard This standard classifies solid wastes as for their potential hazards to the environment and public health, so to appropriately manage them.
2) CONAMA Resolution No.307/2002 It defines guidelines, criteria and procedures for the management of construction wastes, defining the necessary actions to minimize environmental impacts.
3) State Law No.12.300/2006 It institutes the State Solid Waste Policy and defines principles and guidelines, objectives, instruments for the integrated and shared management of solid waste in the State of São Paulo.
(9) Noise
1) CONAMA Resolution No.001/1990 It provides the criteria, standards and guidelines for noise emission, as the result of any industrial, commercial, social or leisure activities.
2) ABNT NBR 10151/2000 Standard It provides for the evaluation of noise in residential areas aiming at the community comfort.
(10) Preservation of Vegetation Coverage
1) Federal Law No.4.771, as of September 15, 1965 (New Forest Code) This law and its subsequent amendments prescribe the mechanisms for preservation and criteria for utilization and exploitation of forests and other forms of vegetation.
2) DEPRN Administrative Rule No.51/2005 It prescribes the simplified and general procedure for the instruction of processes for the authorization of native vegetation suppression, isolated native trees cut, intervention in specially protected areas, and other within the scope of the State Department of Natural Resources Protection (DEPRN).
3) SVMA Administrative Rule No.26/08 It regulates the environmental compensation criteria and procedures for the management through cut, transplantation or any other intervention, of exceptional nature, to allow construction project, land allotment, infrastructure works and public and/or social interest works.
(11) Control of Asbestos
1) Federal Law No. 9055 of 1 June 1995 It describes discipline for the extraction, manufacture, use, marketing and transportation of asbestos/amianthus and products containing asbestos.

2) Federal Decree No. 2350 of 15 October 1997 It regulates the Law No. 9055. The extraction, industrialization, use, marketing and transportation of asbestos/amianthus in the national territory shall be limited to chrysotile variety.
3) Municipal Law No. 13113 of 16 March 2001 The law bans on the use of materials, equipment and elements of construction incorporated of asbestos in the municipality of São Paulo.
4. Land Acquisition
1) Federal Decree No.3365/41 It provides for property expropriation for public interest and known as the General Law of Property Expropriation.
2) Federal Law No.4132/62 It defines the cases of property expropriation for social interest. In other cases, Decree-law No.3365/41 is applicable.
3) Federal Decree No.1075/70 It regulates the provisional right in possession of urban residential properties inhabited by their owners or by promise purchasers that have their titles registered in the Property Registry.
4) Municipal Law No.10257/01 This municipal law regulates the property expropriation for urban policy purposes.

Source: JICA Study Team

Table 8-2 List of Major Institutions on Environmental and Social Considerations Related to the Project

1. Institutions related to Major Environmental Laws and Regulations
(1) Federal Government
1) Brazilian Institute for Environment and Renewable Natural Resources (IBAMA) 2) National Agency for Waters (ANA)
(2) São Paulo State Government
1) Secretariat of Environment (SMA) 2) The Environmental Sanitation Technology Company (CETESB)
(3) São Paulo Municipal Government
1) Secretariat of Green and Environment (SVMA) 2) Secretariat of Housing and Urban Development (SEHAB) 3) Secretariat of Transports (SMT)
2. Institutions related to Other Relevant Environmental Laws and Regulations
(1) Archaeological Heritage
1) Institute of National Historic and Artistic Heritage (IPHAN), Federal Government 2) Secretariat of Environment (SMA), São Paulo State Government
(2) Environmental Compensation
1) Brazilian Institute for Environment and Renewable Natural Resources (IBAMA), Federal Government 2) Secretariat of Environment (SMA), São Paulo State Government 3) Secretariat of Green and Environment (SVMA), São Paulo Municipal Government
(3) Pollution Control
1) Brazilian Institute for Environment and Renewable Natural Resources (IBAMA), Federal Government 2) Secretariat of Environment (SMA), São Paulo State Government 3) Secretariat of Green and Environment (SVMA), São Paulo Municipal Government
(4) Permission for Intervention of Water Resources
1) Secretariat of Environment (SMA), São Paulo State Government 2) Department of Waters and Electric Energy (DAEE), Secretariat of Sanitation and Energy, São Paulo State Government
(5) Water Source Protection
1) Secretariat of Environment (SMA), São Paulo State Government 2) Department of Waters and Electric Energy (DAEE), Secretariat of Sanitation and Energy, São Paulo State Government

(6) Water Quality
1) Secretariat of Environment (SMA), São Paulo State Government 2) Secretariat of Green and Environment (SVMA), São Paulo Municipal Government
(7) Air Quality
1) Secretariat of Environment (SMA), São Paulo State Government 2) Secretariat of Green and Environment (SVMA), São Paulo Municipal Government
(8) Solid Waste Management
1) Secretariat of Environment (SMA), São Paulo State Government 2) Secretariat of Green and Environment (SVMA), São Paulo Municipal Government
(9) Noise
1) Secretariat of Environment (SMA), São Paulo State Government 2) Secretariat of Green and Environment (SVMA), São Paulo Municipal Government
(10) Preservation of Vegetation Coverage
1) Department of Natural Resources Protection (DEPRN), Secretariat of Environment (SMA), São Paulo State Government 2) Secretariat of Green and Environment (SVMA), São Paulo Municipal Government
3. Institutions related to Land Acquisition and Involuntary Resettlement
1) Department of Property Expropriation (DESAP), Secretariat of Legal Affairs (SNJ), São Paulo State Government 2) Secretariat of Housing (SEHAB), São Paulo Municipal Government 3) Land Legalization/Register Office (RESOLO), Secretariat of Housing (SEHAB), São Paulo Municipal Government

Source: JICA Study Team

8.1.2 Major Environmental Laws and their Concerned Institutions in São Paulo

In addition to federal rules, there are state and municipal rules that define the licensing procedures in the respective levels. In the specific case of project entirely located within the territory of São Paulo Municipality, the environmental licensing can be conducted at the Municipal Government level, except for the project that occupy land in the Water Source Protection and Recuperation Area (APRM) of the Metropolitan Region of São Paulo, which environmental licensing is the responsibility of the State Government.

A list with brief explanation about the contents of the main legal instruments that govern the environmental licensing process within the scope of the Municipality of São Paulo is shown as follows.

Table 8-3 List of Major Environmental Laws and their Concerned Institutions

(1) Organic Law of the Municipality of São Paulo In Title V – Municipality Development, Chapter I – Urban Policy, Article 159 prescribes that "the projects of works or equipment implementation, public or private, which, according to the law, have significant repercussion on the environment or on the urban infrastructure, shall be accompanied with Neighborhood Impact Report (RIVI)". The RIVI and Neighborhood Impact Study (EIV) are instruments for urban planning instituted by Federal Law 10.257/2001.
(2) Municipal Decree No.34.713, as of November 30, 1994 This decree prescribes the procedure to make the activities of the Housing and Urban Development Secretariat (SEHAB), the Municipal Transports Secretariat (SMT) and the Municipal Secretariat of Green and Environment (SVMA) compatible in terms of the procedures of analysis and approval of the Neighborhood Impact Report (RIVI), for the implementation of industrial, institutional, service / commerce and housing enterprises works. Article 1 defines the enterprises considered as having a significant impact on the environment or on the urban infrastructure, based on the use and scale of the construction area, and which licensing shall come together with the RIVI. Article 3 defines the RIVI contents, where the following is requested: i) necessary information for the analysis of impacts by the enterprise adjustment to the local and surroundings conditions; ii) necessary

information for the analysis of impacts on traffic conditions of the region; and iii) necessary information for the analysis of impacts on specific environmental conditions of the location and surroundings (noise level, production of suspended particles and smoke, disposal of construction waste, and existence of vegetation coverage on the land).
(3) Municipal Decree No.36.613, as of December 06, 1996 This decree amends the Articles 1 and 2 of Decree No.34.713. Such articles provides for, respectively, the definition of enterprises considered as with significant environmental or urban infrastructure impact, and of the cases in which the presentation of the RIVI is not necessary. The decree addresses industrial, commercial, institutional and residential property enterprises.
(4) SVMA Administrative Rule No.38-G/95 This administrative rule institutes the procedures for the analysis of the environmental licensing to be submitted for the appraisal of the Municipal Secretariat of Green and Environment (SVMA). Article 1 defines that SVMA is responsible for issuing the Previous Environmental License (LAP). Article 2 defines that the Department of Environmental Quality Control (DECONT) is responsible for: i) the coordination and instruction of processes of environmental impact appraisal and ii) issue of licenses regarding the installation and operation of enterprises (LAI and LAO).
(5) SVMA Administrative Rule No.39-G/96 This administrative rule institutes the procedures for the evaluation of the Neighborhood Impact Report (RIVI), within the scope of SVMA/CADES/DECONT.
(6) SVMA Administrative Rule No.104-G/96 This administrative rule defines the procedures for the analysis and follow-up of the Degraded Areas Recuperation Plan (PRAD) and for the issuing of the Operation Environmental License (LAO) for mining enterprises already implemented and/or under the process of expansion, submitted to SVMA appraisal.

Source: JICA Study Team

8.1.3 Environmental Licensing and Environmental Impact Assessment

Municipal Law No.11.426/93 has created SVMA, local agency of the National Environmental System (SISNAMA), and the Municipal Council of Environment and Sustainable Development (CADES), as consultative and deliberative bodies related to environmental issues in the Municipality of São Paulo. Within the scope of its competences and in its jurisdictional area, SVMA is responsible for the elaboration of supplemental and complementary rules, and standards related to the environment, respecting federal and state rules and standards, as well as for the control and inspection of activities capable of causing environmental degradation. Upon instituting the procedures of environmental licensing within the scope of SVMA, the Administrative Rules 038/SVMA.G/95, 039/SVMA.G/96, and 104/SVMA.G/96 assign to Department of Environmental Quality Control (DECONT) of SVMA, through the Technical Division of Registration and Licensing (DECONT-2), the coordination roles of environmental impact assessment and environmental licensing processes.

In conformity with the guidelines prescribed by federal legislation (Federal Law No.6.938/81 and Federal Decree No.99.274/90), the following licenses were defined in the Municipality of São Paulo:

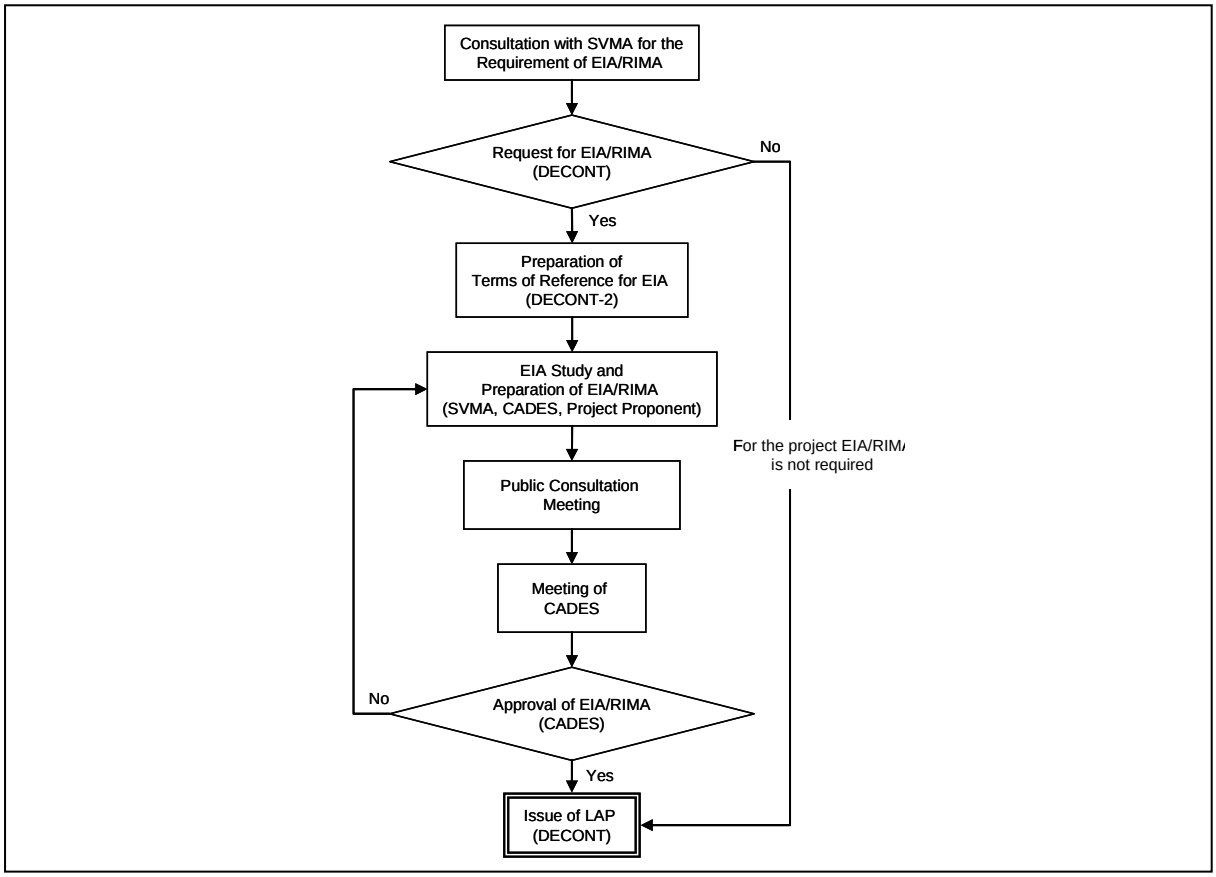
Previous Environmental License (LAP): LAP is granted in the preliminary phase of the activity and planning of the project, containing the basic requirements to fulfill in the phases of location, installation and operation, complying with municipal, state and federal land use plans. The LAP is issued after the approval of environmental impact assessment. The purpose of the LAP is to define conditions so that the entrepreneurs can proceed with the elaboration of their projects, observing the prerequisites defined by the environmental agency. The LAP does not authorize the start of any work or service at the project location.

Environmental License for Installation (LAI): LAI is granted after the analysis and approval of the project and of other studies specifying the environmental control of the

project, according to the type, scale, characteristics, potential environmental impacts and restoration plan of degraded areas. The LAI authorizes the start of the project construction.

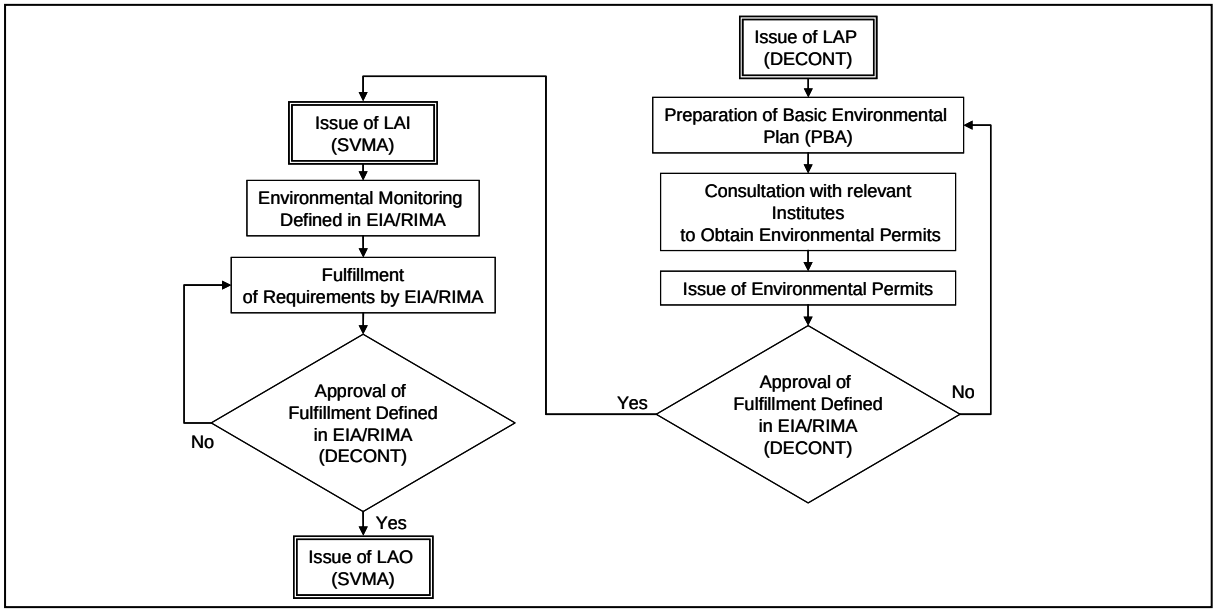
Environmental License for Operation (LAO): LAO authorizes the start of the project operation. LAO is granted after the project construction to verify the environmental control during its operation, and of other requests specified in the previous phases of the environmental licensing.

By consulting with DECONT-2, the entrepreneurs can obtain information about the need to conduct environmental impact assessment and about the environmental licensing required, as well as about technical and administrative procedures to be conducted.



Source: JICA Study Team

Figure 8-1 Procedures of Environmental License in the Municipality of São Paulo up to Issue of LAP



Source: JICA Study Team

Figure 8-2 Procedures of Environmental License in the Municipality of São Paulo between Issues of LAP and LAO

8.1.4 Land Acquisition and Involuntary Resettlement

(1) Relevant Policies, Laws, Regulations, and Guidelines

Laws and regulations applied for land acquisition for public interest are shown in Table 8-1. Besides, there is no specific legislation on the resettlement.

(2) Responsible Agencies of Land Acquisition and Resettlement for Public Project

Department of Property Expropriation (DESAP): DESAP under the Municipal Secretariat of Legal Affairs (SNJ). This department is responsible for representing the municipality in lawsuits regarding property condemnations and the entire service preceding them, such as the elaboration of decree drafts on public and social interest, appraisal of properties, and contracting out and inspection of preparatory services.

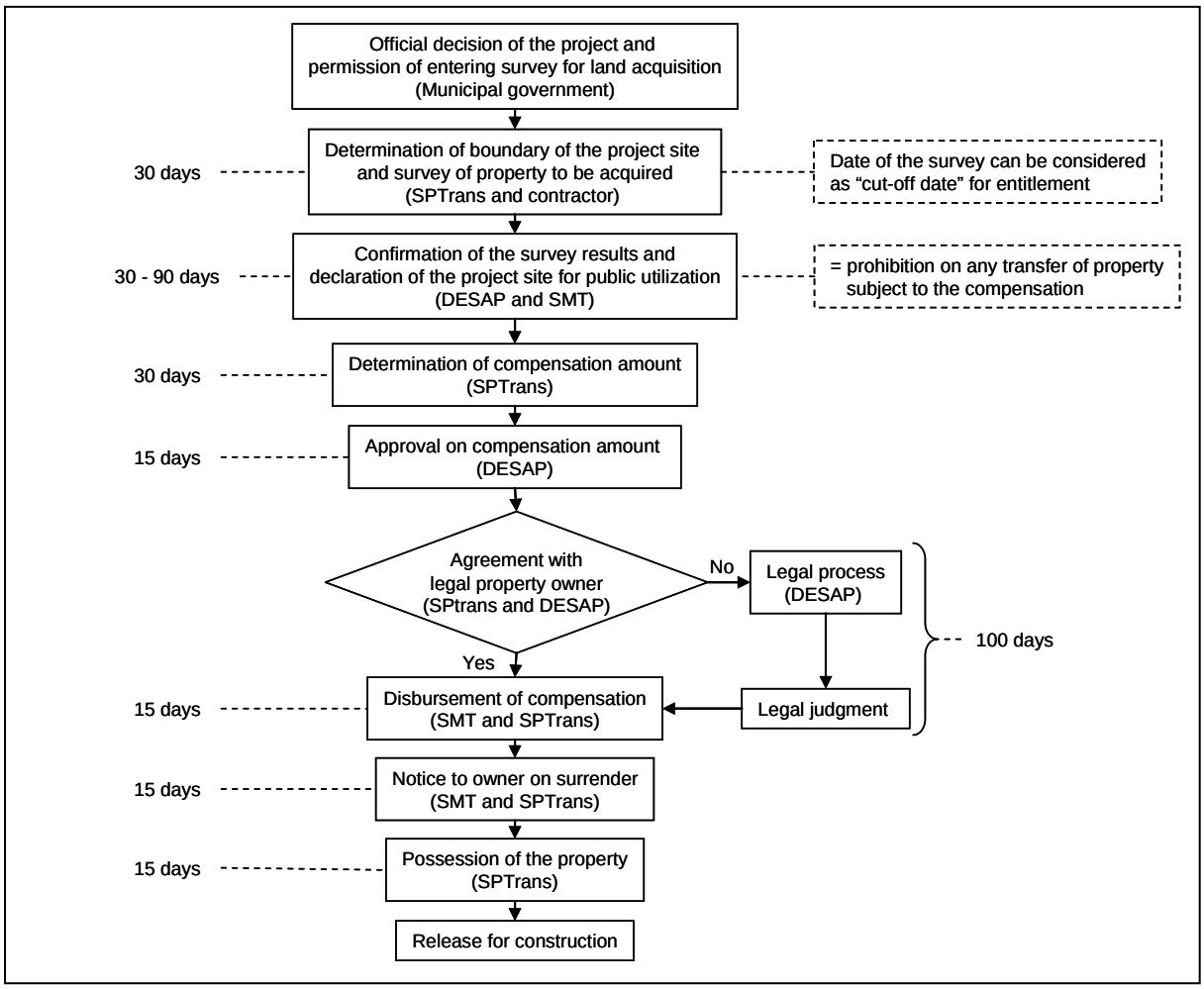
Secretariat of Housing (SEHAB): This secretariat is responsible for land and housing issues in the municipality. The secretariat will be in charge of resettlement in favela[1] cause by the public-purpose project. Under their jurisdiction, a program which relocates the favela is conducted with legalization of the residence of the favela in the resettlement site.

Land Legalization/Register Office (RESOLO): This office under SEHAB is in charge of land register including the legalization of the residence of the favela in the resettlement site.

(3) Land Acquisition Procedure

Legal procedures and actions of the land acquisition for public project are shown in the following figure based on the Decree-Law No.3365/41 and relevant statutes mentioned above.

[1] Areas where low-income non-titleholders occupy public or private lands illegally and build their houses by themselves.



Note: The date shown are not prescribed period, but approximate average date from precious practices. The figure is prepared in the case where the SPTrans is project proponent.
Source: JICA Study Team

Figure 8-3 Procedures of Land Acquisition in São Paulo City

(4) Compensation for Lost Asset and Damage

Based on the relevant statutes, compensation for lost asset and damage are summarized below. On the whole, compensations for lost asset and damage are provided to the project-affected persons at replacement cost in principle.

Compensation for the land: Compensation for the land to be acquired is usually calculated based on investigation of market price of land in the project area. Usually the market price is assessed by experts or companies specializing in property assessment.

In calculation of the compensation amount for the land to be acquired, depreciation of the residual land, which is the rest of land left due to the land acquisition, is taken into account. In the case where area of the residual land is not enough for use for original land use purpose, the entire land for a landowner will be acquired in the most of cases.

Compensation for the house and other kind of structures: The compensation of the house or other kind of structure is usually estimated from the size and standard of construction such as type of material used, and also verified with the construction cost of the same quality of the

property to be replaced. The property valuation conducted by the experts using various methodologies to achieve the precise value of the damages.

In addition to the owner of the land and structure, the following project-affected persons and bodies are compensated and/or supported for their damages.

Lessor of land and/or house: Compensation in the value of land and/or house is provided. However, loss of anticipated income from lease of land and rent of house are not subject to the compensation under the current statutes.

Tenant of land and/or house: The tenant of the land and/or house is not entitled to compensation under the current statutes. Sometimes the entrepreneur offers to support the search for another property to rent in the practice.

Manager of the company, shopkeeper, and vendor whose business will be damaged: There is not a form of compensation for these cases under the law. In some cases, when the company is small and is difficult to reinstall, the entrepreneur offers support to find another property as well as provide some assistances required, to prevent the closing of the shop or activity affected. There is no prescribed compensation for loss of profit. In some cases, affected person or company claim compensation for their damages to court.

Employee whose income will be damaged temporary or permanently: In some cases, the entrepreneurs provide affected persons support for training / retraining in their restoration.

(5) Assistance for Resettlement and Livelihood Recovery

In previous similar cases, several kinds of support are provided for resettlement and livelihood recovery, involving various sectors of municipal agencies to take care of social assistance and promotion such as offering workshops or courses for professional or production of handicrafts.

(6) Resettlement Options

For the title-holders, cash compensation is provided based the current statutes. On the other hand, the non-title holders such as residences in the favela are provided an option to move to the resettlement site with subsidized low-cost house rent and utilities expenditures, which is prepared by the Municipal Secretary of Housing (SEHAB). Apartment type of house is provided in the resettlement site. Such apartment is usually up to 4 floors to secure low-maintenance expenditure for residents since building with over 4 floors has to have an elevator under the building code. The opportunity with moving to the resettlement site provides the non-title holder to become title holder.

(7) Preparation of the Resettlement Action Plan

Though preparation of the resettlement action plan as independent document is not prescribed in the relevant statutes, the resettlement action plan has to be included in the EIA report (EIA/RIMA) as a part of social considerations.

8.2 PROJECT ALTERNATIVES

8.2.1 Negative Environmental Impact of Original Route

This project intends to introduce a medium-capacity transit system on urban roads in São Paulo. Negative impact of a medium capacity transit system is generally small, but some negative impacts were identified for the original routes in the initial environmental evaluation. Major negative impacts are 1) resettlements, 2) impact on street trees and cityscape, and 3) traffic congestion during construction, and 4) noise and vibration during construction. Table 8-4 summarizes the impacts.

Table 8-4 Major Negative Impact on the Original Routes

Route	Major Negative Impact
1	- Resettlement
2A	- Traffic congestion during construction - Resettlement
2B	- Impact on street trees - Resettlement
2C	- Cross in ZEPEC - Impact on street trees
2D	- Low density, low-rise residential area

Source: JICA Study Team

8.2.2 Alternatives to Construction

The purpose of the project to improve urban environment by reducing traffic congestion and air pollution by constructing a medium capacity transit system. However, the construction of a medium capacity transit system will cause negative environmental impact as mentioned above. Instead of introducing a medium capacity transit system, the following countermeasures can be considered:

Road construction,
Traffic management,
Land use policy, and
Improvement of the existing BRT
Construction of underground railway

Traffic management aims to reduce traffic congestion by traffic control such as advanced signaling system, intersection improvement, traffic regulation, parking, demand management, etc. These measures can reduce traffic congestion and should be introduced. São Paulo has already introduced a plate number restriction in the central area. On the other hand, the impact of traffic management on traffic is not as large as that of the project of a medium capacity transit system.

Land use policy aims to reduce the number of long-distance trips by changing land use in the metropolitan region. However, this approach needs a long-term range to achieve the results. In addition, this can not be achieved without public transport system.

Improvement of the existing BRT will expand the transit capacity of BRT and improve traffic flow at intersections. This will contribute to the reduction in traffic congestion along the study routes. However, even if a perfect condition is introduced to the existing BRT, the capacity can not exceed the limit of BRT whose capacity is lower than a medium-capacity transit system in nature.

Introduction of mass transit system like metro is limited to those planned in PITU 2025 with the limited budget.

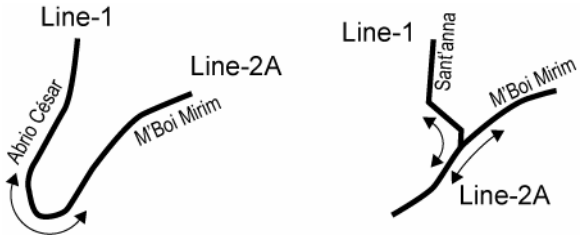
In conclusion, project alternatives other than a medium-capacity transit system would not achieve the purpose.

8.2.3 Analysis of Alternative Routes

To minimize or avoid the negative impacts of original routes, the possibility of alternative routes was examined. Since the medium-capacity transit system generally uses the medium of wide road, the alternative routes for each original route are limited. Therefore, alternative routes could not be found for some cases. Figure 8-5 shows the map of the alternative routes.

(1) Alternative Route of Line-1

The major negative impact of Line-1 is resettlement. The terrain around Line-1 is hilly and roads for the alternative are very limited. There is no road parallel with the original route (Abrio Cesar Road) near the original route. Only Sant'anna Road can be considered as a candidate of the alternative route although the road is located in the opposite side of the original route across a hill. However, this road cannot be the alternative route of Line-1. The medium capacity transit system on Sant'anna Road reduces transit capacity of Line-2A, because Sant'anna branches from M'Boi Mirim Road as Line-1 and Line-2A need to share the same section between Jargim Angela and the branch as shown in Figure 8-4. If Line-1 and Line-2 are connected as shown in the left of the figure, 30 trains per hour per direction will be possible under the condition of two minutes headway. On the other hand, the number of trains will be 15 in the case of the right in the figure if Line-1 and Line-2A need to operate the same number of trains. This will not be able to satisfy the demand of 30,000 PHPDT of Line-2A. Therefore, no alternative route can be proposed for Line-1.



Source: JICA Study Team

Figure 8-4 Relation with Line-1 and Line-2A

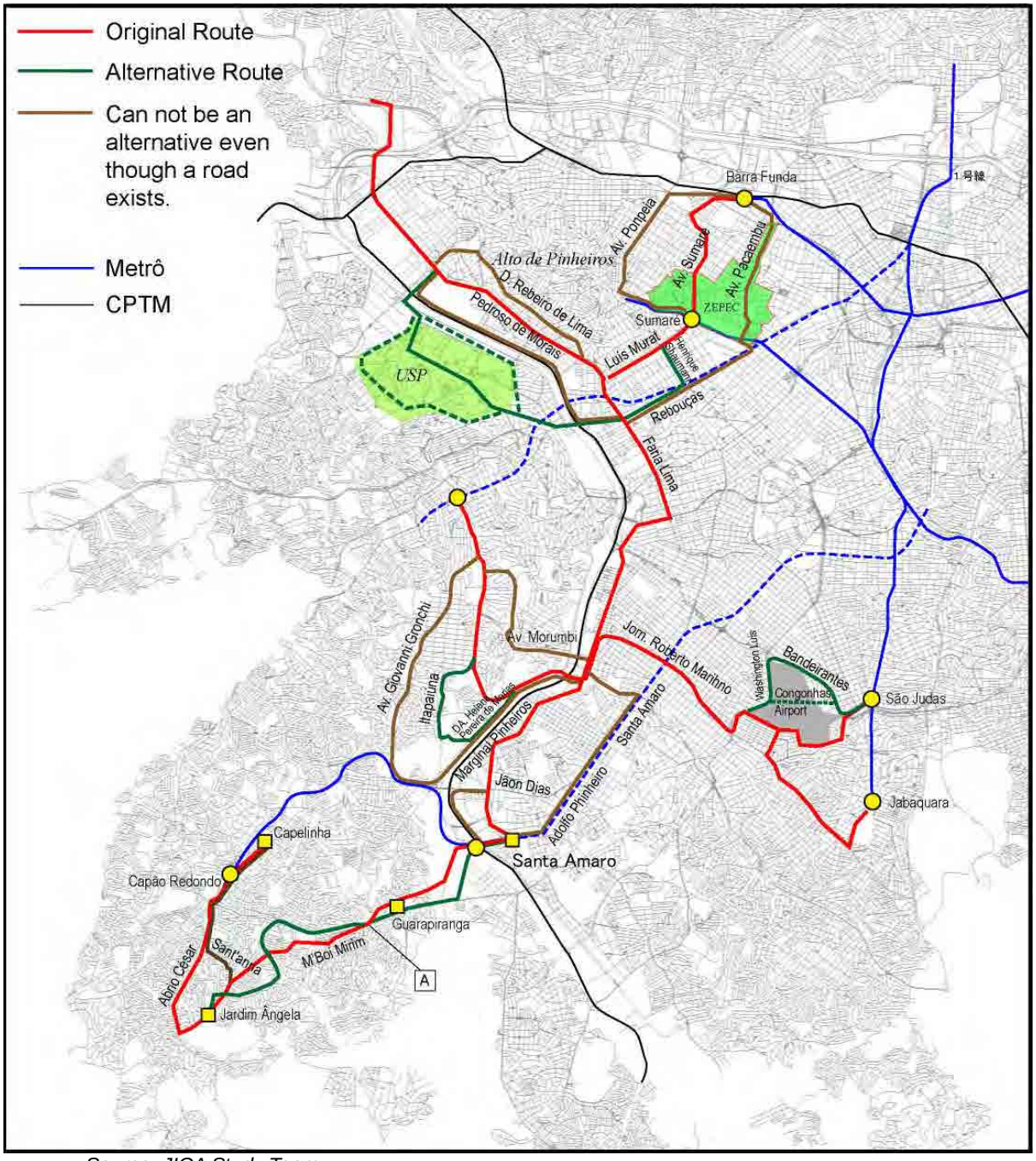
(2) Alternative Route of Line-2A

The major negative impact of Line-2A is traffic congestion during the construction and resettlement along small canal. The original route uses M'Boi Mirim Road between Jardim Angela and the intermediate point[1] from approximately 4km from Jardim Angela, and goes along a small canal from the intermediate point toward Santo Amaro. Traffic congestion during the construciton is the major negative impact on the former section on M'Boi Mirim Road while resettlement is the major one on the latter section.

The possible alternative route to avoid traffic congestion on M'Boi Mirim Road is the route which uses local streets in the community outside M'Boi Mirim Road. Due to the topographical constraint, the route winds both side of M'Boi Mirim Road.

[1] The location is indicated as A in Figure 8-5.

On the other hand, the route on Guarapiranga Ave. is a possible alternative route for the section along the small canal because there is no other local street along the route.



Source: JICA Study Team

Figure 8-5 Alternative Routes

(3) Alternative Route of Line-2B

The major negative impact of Line-2B is resettlement between Sato Amaro and Joao Dias Ave. There are two avenues both side of Line-2B: Adolfo Phinheiro Ave. – Santo Amaro Ave. in the east and Marginal Pinheiros Ave. in the west. The resettlement of the route on Adolfo Phinheiro Ave. is larger than that of the original route. The route of Marginal Pinheiros Ave. takes Joao Dias Ave. to merge with Line-2B. Joao Dias Ave. is the route of Ver. Jose Deniz-Ibirapuera- Santa Cruz BRT. This alternative needs to remove the BRT line on Joao Dias Ave.

Furthermore, these routes duplicate railway lines. Adolfo Phinheiro Ave. – Santo Amaro Ave. is on the extension of Lilac Line while Marginal Pinheiros Ave. is the route of Emerald Line. Therefore, no alternative can be proposed for Line-2B.

(4) Alternative Route of Line-2C

The original route goes through Cultural Preservation Spatial Zone (ZEPEC) and a number of street trees are affected by the project. The roads with enough width to accommodate a medium capacity transit system are Pacaembu Ave. in the east and Ponpeia Ave. in the west.

The negative impact of the route on Pacaembu Ave. is larger than the original route – longer distance in ZEPEC (2.7km and 1.0km) and more street trees affected. The route of Ponpeia Ave. is not possible due to the engineering difficulty at the intersection of Sumare Ave. and Dr. Arnaldo Ave. Therefore, no alternative route is possible for the section between Barra Funda and Sumare.

Another negative impact of Line-2C is resettlement along Luis Murat Road. As an alternative route, the route of Henrique Shaumann Road and Reboueas Ave. is proposed.

(5) Alternative Route of Line-2D

The original route goes through a low density, low rise, and upper class residential zone and a large number of street trees are affected. There is a road of bus route in parallel with the original route but the road can not be an alternative route because it is narrow for a medium capacity transit system and needs land acquisition for approximately 3km length. Although Marginal Pinheiros Ave. runs in parallel with the original road, Emerald Line runs along the avenue. These road and avenue can not be the alternative route.

For Line-2D, an alternative route which goes through the University of São Paulo is proposed. This line crosses Pinheiros River at Eusebio Matoso Bridge and Cidade Universitaria Bridge.

8.2.4 Selected Alternative Routes

Table 8-5 shows the alternative routes identified in the analysis.

Table 8-5 Alternative Routes

Route	Negative Impact	Alternative Route
1	Resettlement	Original route only
2A	Traffic congestion during construction	Local streets
	Resettlement	M'Boi Mirim Road
2B	Resettlement	Original route only
2C	ZEPEC/ Impact on street trees	Original route only
	Resettlement	Reboueas Ave.
2D	Quiet residential area/impact on street trees	USP route

Source: JICA Study Team

8.2.5 Comparison of Alternatives

The original routes and alternative routes were compared in view of resettlement, impact on street trees, impact during construction, and impact on operation stage for Line-2A, Line-2C, Line-2D, Line-3A, and Line-3B.

(1) Comparison of Line-2A (Jardim Angela – Intermediate Point)

The traffic congestion during construction can be avoided in the alternative case. However, the alternative case will have larger negative impacts during construction than the original case. For example, the scale of civil work is much larger due to construction of access roads and tunnels. In addition, the scale of resettlement will be significant in the alternative case. The following is the comparison of between the original route and the alternative route.

Impact Item	Original (M'Boi Mirim Road)	Alternative (Local streets)
Resettlement	Small	Large
Street tree	None	None
Impact during construction	Traffic congestion due to the reduction in the number of lanes	Large impact from Noise and vibration in residential area/ construction in Water Resource Protection Zone/ Large scale of land development
Impact during operation	Reorganization of the existing bus routes	Reduction in travel speed due to longer route and curve
Remark	BRT might be able to operate during construction stage by introduction of reversible lane and other traffic control measurement.	Large scale resettlement will be necessary. Possibility of water contamination will remain due to a large scale development in the Water Resource Protection Zone

(2) Comparison of Line-2A (Intermediate Point – Santo Amaro)

The original route will need a few resettlements along a small canal, while the alternative case will not need any resettlement. However, heavy traffic congestion during construction will occur in case of the alternative route. The municipality of São Paulo has a plan to improve the canal in which resettlement along the canal is inevitable. The following is the comparison of between the original route and the alternative route.

Impact Item	Original (Canal)	Alternative (M'Boi Mirim Road)
Resettlement	Approximately 80 buildings	None
Street tree	None	None
Impact during construction	None	Traffic congestion due to the reduction in the number of lanes
Impact during operation	None	Reorganization of the existing bus routes
Remark	The route is frequent flood area, and an improvement work will be done irrelative to the Project.	Bus traffic is most heavy on M'Boi Mirim Road and the construction of this section should be avoided.

(3) Comparison of Line-2C

The original route connects three metro stations at Barra Funda (Red Line), Sumare (Green Line), and Largo da Batata (Yellow Line). On the other hand, the alternative route has the access to Yellow Line along Reboueas Ave., but the route is duplicated with a BRT line. The only problem of the original route is the large scale of resettlement. However, the cost for the resettlement will be very high because the value of the buildings along the route will be expensive compared to other lines. The following is the comparison of between the original route and the alternative route.

Impact Item	Original (Luis Murat Road)	Alternative (Reboueas Ave.)
Resettlement	Approximately 100 buildings	None
Street tree	None	Small
Impact during construction	Impact of noise and vibration on the communities	Traffic congestion (small)
Impact during operation	None	Duplication with BRT line
Remark	The amount of compensation would be very high.	Impact on street trees could be avoided because of large width of road.

(4) Comparison of Line-2D

The negative impact on street trees in the alternative route is as same as the original route because the number of street trees in the University of São Paulo are as much as that of the original route. The negative impact during construction is almost the same although the original route will cause noise and vibration to residential area while the alternative route will cause the problem to the university. There are some variations of the alternative route, which might reduce the negative impact on street trees. In the alternative case, it is necessary to evaluate the impact of the electro magnetic wave on laboratories in the university. The following is the comparison of between the original route and the alternative route.

Impact Item	Original (Quiet residential area)	Alternative (University of São Paulo)
Resettlement	None	None
Street tree	Approximately 120 trees	Approximately 100 trees
Impact during construction	Impact of noise and vibration on the residential area	Impact of noise and vibration on the university
Impact during operation	Noise in the residential area/ small demand in the residential area	None
Remark	Traffic demand in the residential area will be small and through traffic will be the major traffic.	This alternative needs cooperation of the university.

8.3 ENVIRONMENTAL SCOPING FOR PROPOSED PROJECTS

Environmental scoping for the proposed lines, which clarify conceivable environmental and social impacts caused by the proposed projects to be subject to the environmental impact assessment study, are presented in the following scoping matrix and checklist. Details on the scoping will be examined for its finalization among SPTrans and relevant agencies such as SVMA as well as through the public consultation meeting to be conducted in Environmental Impact Assessment process.

It is noted that evaluation in the matrix is made by considering degree of conceivable impact in the case where any adequate mitigation measure is not conducted and also common to the all of the proposed route. The evaluation was utilized for preparation of specifications of detailed study as environmental assessment study (EIA study) as explained in the subsequent section.

8.3.1 Environmental Scoping Matrix for the Proposed Project

The environmental scoping matrixes for the proposed project are shown in the Table 8-6. Main conceivable impacts are shown below:.

- Involuntary resettlement due to land acquisition for construction of facilities for operation of trains,
- Impact on existing social infrastructures and services due to land land acquisition for construction of facilities, and traffic restriction during construction,
- Impact on illegal occupants in the area called Favela who are not entitled for property compensation,
- Impact on removal of existing roadside trees due to construction of railway track,
- Impact on landscape due to construction of facilities and removal of existing roadside trees,
- Impact by residue soil due to earth works and construction waste,
- Impact by noise and vibration during construction and operation of trains,
- Impact on local economy such as employment and livelihood due to involuntary resettlement and traffic restriction during construction,
- Impact on land use due to developing around railways by operation of trains,
- Impact on vehicle traffic due to traffic restriction during construction,
- Hazardous (risk) of infectious diseases such as HIV/AIDS in case of considerable number of workers working together,
- Invention of privacy of building/house closing to elevated railway,
- Possibility of accident during construction work and operation of trains,
- Impact on topography and geographical features due to construction work along river/channel,
- Soil erosion due to alteration of ground by cut, filling and drilling works and tunnel,
- Impact by groundwater usage due to tunnel construction and operation of depot/office,
- Decrease of absorption capacity of greenhouse effect gas due to removal of roadside trees,
- Air pollution by construction equipment and vehicles,
- Water pollution due to wastewater discharge during construction and from dept/office,
- Offensive odor due to excavation and dredging of mud in rivers/channels,
- Flushing of excavated soil into rivers/channels,
- Interfering of radio wave by facilities such as station structure, and
- Obstruction of sunshine along elevated track.

The impacts listed above are preliminary examined, and mitigation measures are proposed in the section 8.5.

Table 8-6 Environmental Scoping Matrix for the Proposed Projects

	No.	Likely Impacts	Overall Rating	Project-related Activities									
				Planning / Design Phase		Construction Phase					Operation Phase		
				Land acquisition	Change of land use plan, control of various activities by regulations for the construction	Deforestation / tree cutting	Alteration to ground by cut land, filling, drilling, tunnel, etc.	Operation of construction equipment and vehicles	Construction of track, station, depot, viaduct/bridges and other related facilities	Traffic restriction in construction area	Operation of trains	Appearance / occupancy of track and related facilities	Operation and maintenance of depot
Social Environment*	1	Involuntary resettlement	A-	A-/-	-	-	-	-	-	-	-	-	-
	2	Local economy such as employment and livelihood, etc.	B-/B+	B-	B-	-	-	-	-	B-	B+	-	-
	3	(Surrounding) Land use	B-	B-	B-	-	-	-	-	-	B-	-	-
	4	Transportation	B-/A+	-	-	-	B-	B-	B-	B-	A+	-	-
	5	Existing social infrastructures and services	A-/A+	B-	A-	-	-	A-	-	A-	A+	-	-
	6	Regional severance	-	-	-	-	-	-	-	-	-	-	-
	7	Socially vulnerable groups such as the poor, indigenous and ethnic people	A-/B+	A-	C-	-	-	-	-	C-	B+	-	-
	8	Historical and cultural heritage	C-	C-	C-		C-	-	-	-	-	-	-
	9	Religious matters	C-	C-	-	-	-	C-	-	C-	-	-	-
	10	Water usage or water rights and rights of common	-	-	-	-	-	-	-	-	-	-	-
	11	Sanitation	C-	-	-	-	-	-	-	-	C-	-	-
	12	Hazardous (risk) of infectious diseases such as HIV/AIDS	B-	-	-	-	-	-	B-	-	-	-	-
	13	Invasion of privacy	B-	-	-	-	-	-	-	-	B-	-	-
	14	Accident	B-/B+	-	-	-	B-	B-	B-	-	B+	-	-
Natural Environment	15	Topography and geographical features	B-	-	-	-	B-	-	-	-	-	-	-
	16	Soil erosion	B-	-	-	-	B-	-	-	-	-	-	-
	17	Groundwater	B-	-	-	-	-	-	-	-	-	-	B-
	18	Hydrological situation	C-	-	-	-	C-	-	-	-	-	-	-
	19	Coastal zone	-	-	-	-	-	-	-	-	-	-	-
	20	Flora, fauna and biodiversity	A-	-	-	A-	B-	-	A-	-	-	-	-
	21	Meteorology	-	-	-	-	-	-	-	-	-	-	-
	22	Landscape	A-	-	-	A-	B-	-	-	-	-	B-	-
	23	Global warming	B-/B+	-	-	B-	-	-	-	-	B+	-	-
Pollution	24	Air pollution	B-/B+	-	-	-	-	B-	B-	-	B+	-	-
	25	Water pollution	B-	-	-	-	B-	-	B-	-	-	-	B-
	26	Soil contamination	C-	-	-	-	C-	-	C-	-	-	-	-
	27	Waste	A-	-	-	A-	B-	-	B-	-	-	-	-
	28	Noise and vibration	A-	-	-	B-	B-	B-	B-	-	A-	-	B-
	29	Ground subsidence	-	-	-	-	-	-	-	-	-	-	-
	30	Offensive odor	B-	-	-	-	B-	-	B-	-	-	-	-
	31	Bottom sediment	B-	-	-	-	B-	-	B-	-	-	-	-
	32	Electromagnetic effect	B-	-	-	-	-	-	-	-	-	B-	-
	33	Obstruction of sunshine	B-	-	-	-	-	-	-	-	-	B-	-
	34	Disaster	-	-	-	-	-	-	-	-	-	-	-

Note: * Regarding the impacts on "Gender" and "Children's Right", might be related to all criteria of Social Environment.

<Rating>

A-: Serious impact is expected, if any measure is not implemented to the impact.

B-: Some impact is expected, if any measure is not implemented to the impact.

C-: Extent of impact is unknown (Examination is needed. Impact may become clear as study progresses.)

-: No impact is expected. Therefore, EIA is not required.

A+: Remarkable effect is expected due to the project implementation itself and environmental improvement caused by the project.

B+: Some effect is expected due to the project implementation itself and environmental improvement caused by the project.

Overall rating: Highest rate will be the overall rating among the rating of relevant project-related activities for negative and positive ratings, respectively. (e.g. Even only one "A-" is included in an environmental item, overall rating of the environmental item becomes "A-".)

Reference: Japan Transport Cooperation Association (JTCA) and Japan Railway Technical Service (JARTS) (1996) "Manual for Environmental Considerations in International Cooperation for Transportation Technology (Railway Project) (provisional translation)", Tokyo, Japan.

8.3.2 Checklist of Environmental Scoping

The checklists of environmental scoping are shown below.

Table 8-7 Checklist of Environmental Scoping for the Proposed Projects (1/4 page)

No.	Likely Impacts	Rating		Project phase	Explanation on Potential Impacts (Project-related activity is shown in the parenthesis.)
		Overall	by project phase		
Social Environment*					
1	Involuntary Resettlement	A-	A- / -	P	<*Land acquisition*> Although land acquisition for the Project is not concentrated in the specific area, large-scale involuntary resettlement in total would occur in the proposed project site with lack of width of ROW for railway track and lack of open space for station and depot construction in the Lines 1, 2A and 2B. On the other, no or few resettlement would occur in the Lines 2C, and 2D.
2	Local economy such as employment and livelihood, etc.	B- B+	B-	P	<*Land acquisition*> Involuntary resettlement due to the land acquisition would affect local economy in some extent.
			B-	P	<*Change of land use plan, control of various activities by regulations for the construction*> Some limitations to activities during construction would affect local economy in some extent.
			B-	C	<*Traffic restriction in construction area*> Since the project site is mainly located in the center of and along the existing road, construction activities would affect local economy in some extent due to disturbance of smooth operation of commercial vehicles and public bus service due to traffic restriction during construction.
			B+	O	<*Operation of trains*> After the operation of monorail, local economy particularly commercial sector along the railway would have positive impact due to increased number of passengers and improved transportation of commodities.
3	(Surrounding) Land use	B-	B-	P	<*Land acquisition*> <*Change of land use plan, control of various activities by regulations for the construction*> Inadequate land use would occur due to acceleration of unplanned development along the proposed route and around new stations.
			B-	O	<*Operation of trains*> - ditto -
4	Transportation	B- A+	B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> <*Operation of construction equipment and vehicles*> <*Traffic restriction in construction area*> Since the project site is mainly located in the center of and along the existing road, construction activities would cause disturbance of smooth operation of commercial vehicles and public bus service due to traffic restriction during construction.
			A+	O	<*Operation of trains*> Improvement of traffic flow and accessibility would be expected due to reduction of vehicle traffic, especially along the proposed route, by operating railway transport such as monorail.
5	Existing social infrastructures and services	A- A+	B-	P	<*Land acquisition*> Land acquisition for the project, involving relocation of public and/or community facilities, would affect local communities in some extent.
			A-	P	<*Change of land use plan, control of various activities by regulations for the construction*> Since the project site is mainly located in the center of and along the existing road, construction activities would affect existing social infrastructures and services in some extent due to disturbance of smooth operation of commercial vehicles and public bus service due to traffic restriction during construction.
			A-	C	<*Operation of construction equipment and vehicles*> <*Traffic restriction in construction area*> - ditto -
			A+	O	<*Operation of trains*> Smooth operation of the public bus system and commercial vehicles would be expected due to reduction of vehicle traffic, especially along the proposed route, with operation of the proposed railway system such as monorail.
6	Regional severance	-	-	-	Since the proposed transport system is constructed with elevated bridge structure in almost the entire route, regional severance due to existence of the structure would not be caused.

Table 8-8 Checklist of Environmental Scoping for the Proposed Projects (2/4 page)

No.	Likely Impacts	Rating		Project phase	Explanation on Potential Impacts (Project-related activity is shown in the parenthesis.)
		Overall	by project phase		
Social Environment*					
7	Socially vulnerable groups such as the poor, indigenous and ethnic people	A- B+	A-	P	<*Land acquisition*> Households living in the Favela as illegal occupants, who are mostly low-income, to be relocated would remarkably be affected for their livelihood since they are not entitled for the property compensation as legal title-holders.
			C-	P	<*Change of land use plan, control of various activities by regulations for the construction*> Social impact to the socially vulnerable groups, mainly low-income household residing in the Favela, is not known and should be examined.
			C-	C	<*Traffic restriction in construction area*> - ditto -
			B+	O	<*Operation of trains*> Improvement of transport situation would be expected, especially for low-income people who commute to central area of São Paulo City with long-time traveling by transferring several public buses at present. In addition, new employment opportunity would be expected due to improvement of the transportation mode.
8	Historical and cultural heritage	C-	C-	P	<*Land acquisition*> <*Change of land use plan, control of various activities by regulations for the construction*> Existing of such historical and cultural assets in and around the project site is not known and should be studied.
			C-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> - ditto -
9	Religious matters	C-	C-	P	<*Land acquisition*> Any impact related to religious aspect in and around the project site is not known and should be studied.
			C-	C	<*Operation of construction equipment and vehicles*> <*Traffic restriction in construction area*> - ditto -
10	Water usage or water rights and rights of common	-	-	-	Though rivers/channels where proposed route pass along and cross in some sections are used as drainage, there is no water usage in such rivers and channels at present.
11	Sanitation	C-	C-	O	<*Operation of trains*> Such information should be obtained and examined if any impact.
12	Hazardous (risk) of infectious diseases such as HIV/AIDS	B-	B-	C	<*Construction of track, station, depot, viaduct/bridges and other related facilities*> Risk of infectious diseases by labors would be expected during construction.
13	Invasion of privacy	B-	B-	O	<*Operation of trains*> In the case where elevated railway structure is close to the building/house, privacy of residents in such building/house would be invaded by passenger of the train.
14	Accident	B- B+	B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> <*Operation of construction equipment and vehicles*> <*Construction of track, station, depot, viaduct/bridges and other related facilities*> Accident in construction works and operation of construction vehicle/equipment would occur.
			B+	O	<*Operation of trains*> With change of transport mode from vehicle to railway system such as monorail, reduction of traffic accidents would be expected due to reduction of vehicle traffic.
15	Topography and geographical features	B-	B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> In the most of sections, elevated bridge structure of the railway track will mainly be constructed in the center or along the existing road. However, earthworks would affect topographic condition in some sections along the river/channel.
16	Soil erosion	B-	B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> Construction works along the river/channel in some sections would cause soil erosion in some sections.

Table 8-9 Checklist of Environmental Scoping for the Proposed Projects (3/4 page)

No.	Likely Impacts	Rating		Project phase	Explanation on Potential Impacts (Project-related activity is shown in the parenthesis.)
		Overall	by project phase		
Natural Environment					
17	Groundwater	B-	B-	O	<*Operation of trains*> Lowering groundwater level due to excessive use of the groundwater in the depot would affect groundwater use around the area.
18	Hydrological situation	C-	C-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> Construction works along the river/channel in some sections would affect hydrological situation in such channel/river.
19	Coastal zone	-	-	-	The project area is not located in and around the coastal area and is not related to the coastal area.
20	Flora, fauna and biodiversity	A-	A-	C	<*Deforestation / tree cutting*> <*Construction of track, station, depot, viaduct/bridges and other related facilities*> Existing roadside trees and plants would be removed tentatively or permanently since elevated bridge structure of the railway track will mainly be constructed in the center or along the existing road.
			B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> Existing trees and plants would be cut due to construction works such as earth works.
21	Meteorology	-	-	-	The project does not have any factor which may affect and/or be related to the meteorology.
22	Landscape	A-	A-	C	<*Deforestation / tree cutting*> Removal of existing roadside trees and plants due to construction of the railway track would change the landscape along the existing roads.
			B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> Construction works such as earthworks would affect the landscape in the project site.
			B-	O	<*Appearance / occupancy of track and related facilities*> Existing of elevated bridge structure of the railway track would affect the landscape from prior one in and around the project site.
23	Global warming	B- B+	B-	C	<*Deforestation / tree cutting*> Cutting of existing roadside trees and plants due to construction of the railway track would reduce absorption capacity of greenhouse gas such as CO_2 on the street along the project site.
			B+	O	<*Operation of trains*> With change of transport mode from vehicle to railway system such as monorail, reduction of emission of greenhouse gas such as CO_2 will be expected as per unit transport distance per person.
Pollution					
24	Air pollution	B- B+	B-	C	<*Operation of construction equipment and vehicles*> <*Construction of track, station, depot, viaduct/bridges and other related facilities*> Emission of exhaust gas from construction equipment and vehicles and dust pollution due to operation of the construction equipment and vehicles would cause air pollution in and around the construction sites during the construction.
			B+	O	<*Operation of trains*> Reduction of hazardous substances emitted from vehicles would be expected due to reduction of traffic congestion and traffic volume by changing transportation mode from vehicle to the proposed railway system such as monorail.
25	Water pollution	B-	B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> <*Construction of track, station, depot, viaduct/bridges and other related facilities*> Muddy water from construction site and oil spill from construction equipment and vehicles would cause water pollution in the channel/river in and around the construction site.
			B-	O	<*Operation and maintenance of depot*> Oil-content waste water and domestic waste water from depot would affect water body nearby in the case of direct discharge without pre-treatment or without connection to the sewerage system in the depot.
26	Soil contamination	C-	C-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> <*Construction of track, station, depot, viaduct/bridges and other related facilities*> In the case where the land to be acquired contains contaminated soil in the existing or old industrial facility, residue soil excavated from the land would cause soil and/or water pollution in and around the disposal site.

Table 8-10 Checklist of Environmental Scoping for the Proposed Projects (4/4 page)

No.	Likely Impacts	Rating: Overall	Rating: by project phase	Project phase	Explanation on Potential Impacts (Project-related activity is shown in the parenthesis.)
Pollution					
27	Waste	A-	A-	C	<*Deforestation / tree cutting*> In the case where most of the existing roadside trees will not be transplanted, but be cut, large volume of tree-waste would occur and it cause environmental impact in the disposal site.
			B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> Residue soil due to earth works would cause environmental impact in the disposal site.
			B-	C	<*Construction of track, station, depot, viaduct/bridges and other related facilities*> Construction waste including residue soil would cause environmental impact in the disposal site.
28	Noise and vibration	A-	B-	C	<*Deforestation / tree cutting*> Cutting and replanting work of the roadside trees used by using tools and heavy equipment would cause noise during the construction.
			B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> <*Operation of construction equipment and vehicles*> <*Construction of track, station, depot, viaduct/bridges and other related facilities*> - Noise and vibration caused by such construction works and construction vehicle/equipment would annoy the residents and school/hospital nearby. - Vibration caused by such construction works would cause damage to the existing house and other kinds of building structures such as cracks in the wall.
			A-	O	<*Operation of trains*> Operation of the trains would cause noise along the railway track during operation time.
			B-	O	<*Operation and maintenance of depot*> Maintenance works in deport would cause noise pollution to around the depot site.
29	Ground subsidence	-	-	-	The project does not have any factor which may cause the ground subsidence in terms of project location and construction method.
30	Offensive odor	B-	B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> <*Construction of track, station, depot, viaduct/bridges and other related facilities*> - In some sections where pass along rivers and channels, offensive odor would occur around the construction site due to excavation and dredging of mud in the rivers/channels during the construction. - In the case where contaminated soil is found in the construction site such as site of old factory, offensive odor would occur in removal and transport of such contaminated soil.
31	Bottom sediment	B-	B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> <*Construction of track, station, depot, viaduct/bridges and other related facilities*> During the works in the construction phase, excavated soil would cause sedimentation, flushed into water course in case of rain.
32	Electromagnetic effect	B-	B-	O	<*Appearance / occupancy of track and related facilities*> Station structure of the railway would interfere with the radio wave such as radio and television nearby.
33	Obstruction of sunshine	B-	B-	O	<*Appearance / occupancy of track and related facilities*> Due to bridge structure for elevated track, some railway tracks close to the building would cause obstruction of sunshine to the building, especially residential house.
34	Disaster	-	-	-	Construction is not planned in the disaster-prone area such as landslide-prone area.

Note: * Regarding the impacts on "Gender" and "Children's Right", might be related to all criteria of Social Environment.

<Rating>

A-: Serious impact is expected, if any measure is not implemented to the impact.
B-: Some impact is expected, if any measure is not implemented to the impact.
C-: Extent of impact is unknown (Examination is needed. Impact may become clear as study progresses.)
-: No impact is expected. Therefore, EIA is not required.
A+: Remarkable effect is expected due to the project implementation itself and environmental improvement caused by the project.
B+: Some effect is expected due to the project implementation itself and environmental improvement caused by the project.
Overall rating: Highest rate will be the overall rating among the rating of relevant project-related activities for negative and positive ratings, respectively. (e.g. Even only one "A-" is included in an environmental item, overall rating of the environmental item becomes "A-".)

<Project phase> P: Planning and design phase, C: Construction phase, O: Operation phase

Reference: Japan Transport Cooperation Association (JTCA) and Japan Railway Technical Service (JARTS) (1996) "Manual for Environmental Considerations in International Cooperation for Transportation Technology (Railway Project) (provisional translation)", Tokyo, Japan.

8.4 SUGGESTED TERMS OF REFERENCE FOR EIA STUDY

8.4.1 Discussion Process on Draft ToR of EIA Study

JICA Study Team discussed with SPTrans on the scoping matrix and checklist based on preliminary scoping of environmental and social impacts and a draft ToR of EIA study. Contents and measures of public consultation meetings were recommended for implementing public consultation based on the JICA Environment and Social Consideration Guideline.

As a result of discussion with SPTrans on feasibility of the draft ToR, it was found that the draft ToR is feasible because its requirements are not quite different from ones on EIA under Brazilian legislation.

Regarding public consultation, generally, a public consultation meeting is held when a draft EIA report is prepared under Brazilian legislation, but JICA Study Team proposed to hold two meetings at not only draft EIA report preparation phase but also draft scoping phase to reflect stakeholders' recommendation for finalizing EIA ToR. Detail of the proposal on public consultation is shown in the section 8.8.

8.4.2 Timeframe of EIA Study

As shown in the section 8.1.3, Brazilian environmental licensing process can be divided into: 1) Previous Environmental License (LAP), 2) Environmental License for Installation (LAI), and 3) Environmental License for Operation (LAO). EIA is generally implemented before basic design phase, because EIA is required to obtain LAP. In this Project, affected area will be confirmed in basic design phase, so EIA will be implemented in basic design phase based on approval by relevant administrations of São Paulo municipality.

8.4.3 Main Tasks of EIA Study

Suggested terms of reference for the EIA study (Draft ToR) was prepared by considering the results of environmental scoping as shown in Appendix 1-2 Suggested table of contents for the RIMA (EIA report) as attached in the ToR was prepared based on relevant status on the EIA and previous RIMAs for similar project. After the draft ToR will be examined between SPTrans and JICA study team, the ToR will be finalized by reviewing and discussing with relevant agencies such as SVMA as well as through public consultation meeting to be conducted as per JICA environmental guidelines. Outline of the ToR is explained as follows.

(1) Environmental Baseline Study

1) Collection and review of existing secondary data
2) Field surveys
   a) Air quality measurement
   b) Noise and vibration level measurement
   c) Water quality measurement
   d) Soil contamination survey
   e) Inventory Survey on Street Trees and Plants

(2) Study on Land Acquisition and Resettlement Action Plan

1) Collection and review of existing secondary data
2) Field surveys
   a) Perception survey
   b) Household inventory survey for resettlement
3) Preparation of Land Acquisition and Resettlement Action Plan

(3) EIA/RIMA Preparation

1) Impact identification and assessment
2) Examination of environmental mitigation measures and social consideration measures including proposal on compensation approach
3) Preparation of environmental management and monitoring plan (EMMP)
4) Preparation of Environmental Impact Report (RIMA)

8.4.4 Study Area

- Project-affected area in and around the proposed Lines 1, 2A to 2D. Width of the project site and extent of the project-affected area are differ by type of project sites and facilities such as elevated bridge structure of the railway track, station, and deport. The project site consists mainly of railway track, stations, and depot. 62 stations and 3 depots are supposed to be constructed in whole routes.

8.4.5 Study items

- Social Environment: (1) Involuntary Resettlement including social impact due to land acquisition without resettlement, (2) local economy, (3) Social infrastructure and service, (4) Socially vulnerable groups, (5) Historical and cultural heritage, (6) Religious matters, (7) Water use and water use right, (8) Sanitation, (9) Infectious disease, (10) Invasion of privacy
- Natural environment: (1) Topography and geology, (2) Soil erosion, (3) Groundwater, (4) Hydrological situation, (5) Flora, fauna and biodiversity, (6) Landscape, (7) Global warming
- Pollution: (1) Air pollution, (2) Water pollution, (3) Waste, (4) Noise and vibration, (5) Interference to radio wave and precision instrument, (6) Obstruction of sunshine

8.4.6 Study contents

- Collection of Data and Information: Data and information on present environmental and social situations shall be collected through field surveys and secondary data collection.

Table 8-11 Outline of Field Surveys

Survey Name	Survey Items	Survey Area and Period/Frequency
Air Quality Measurement	TSP, PM10, NO_2, SO_2, CO, O_3, Wind speed, Wind direction	6 sites including 3 sites for residential/industrial are and 3 sites for road area (42 sites in total), one site in proposed station site and depot site, respectively (62 stations and 3 depots in total) One hour average for 24 hours in weekday
Noise and Vibration Level Measurement	Noise (Laeq, L90, L10 (dB(A)), Vibration (L10 (dB)	6 sites including 3 sites for residential/industrial are and 3 sites for road area (42 sites in total), one site in proposed station site and depot site, respectively (62 stations and 3 depots in total) Continuous 10 minutes value for 24 hours in weekday
Water Quality Measurement	pH, water temperature, DO, turbidity, SS, BOD, flow rate, velocity and groundwater level	1 site each at downstream and upstream of the river/channel in the case where the target route passes and/or is located along any river/channel. One time for both daytime and nighttime in weekday
Soil Contamination Study	volatile organic compounds, heavy metals, pesticides and PCB	1 site or more sites (if necessary) in each possible plot with contaminated soil.
Inventory Survey on Street Trees and Plants	All trees and plants in the project site to be removed	Along the project site Once during the study
Socio-economic survey	Socio-economic characteristics on project-affected households related to the land acquisition and resettlement, intention and opinion on the project-related issue	Over 20% of total project-affected households per proposed line. Once during the study
Inventory Survey for Resettlement	Situation of property for the project-affected persons to be compensated	All project-affected households and parties such as shop Once during the study

Source: JICA Study Team

8.4.7 Examination of environmental and social impact

- Based on results of existing data, field reconnaissance, and field surveys for the environmental and social impact items to be studied, conceivable impacts shall be examined as quantitatively as possible to consider required measures to avoid or minimize the impacts in planning, construction, and operation phases of the project.

8.4.8 Preparation of Land Acquisition and Resettlement Action Plan

- Land Acquisition and Resettlement Action Plan shall be prepared including the following items.
  1) Avoidance and minimization of the resettlement
  2) Approximate identification of magnitude of the impact
     a) Land area to be acquired by area and by type
     b) Number of structures to be relocated
  3) Socio-economic features of the Project-Affected Persons (PAPs)
     a) Socio-economic data based on secondary data
     b) Results of socio-economic survey
  4) Compensation and assistance under current legislations
  5) Entitlement matrix
  6) Securing resettlement sites
  7) Resettlement assistance
  8) Assistances for livelihood recovery
  9) Public involvement in the process of the resettlement
  10) Grievance redress system
  11) Monitoring plan
  12) Responsibilities of relevant organizations
  13) Cost estimate and financial arrangement

8.4.9 Preparation of mitigation measures, and environmental management and monitoring plans

- Based on result of examination on environmental and social impacts, measures to avoid or minimize the impacts shall be proposed, especially for the environmental and social items which would be affected significantly. Based on the proposed measures, an Environmental Management Plan shall be prepared to implement such measures adequately, considering detailed implementation method, period, cost, and organizations. In addition, an Environmental Monitoring Plan shall be prepared to check effect of the measures and unexpected impact after the operation of the project. The Environmental Monitoring Plan includes monitoring items, period and frequency, and location, and necessary cost and implementation organization for the monitoring activities.
- Noise and vibration, air quality and water quality are set as main targets of environmental monitoring. For these environmental monitoring, the following standards are referred (see appendix 1-1 for detail of the standards).

Table 8-12 Main Standards for Environmental Monitoring

Monitoring	Standard
Noise and vibration monitoring	1) Standard ABNT NBR 10151/2000 It defines standards of noise and vibration to keep preferable living environment in residential area.
Air quality monitoring	2) CONAMA Resolution No.003/1990 It prescribes air quality standards to achieve regional air pollution control plan with applying emission standards.
Water quality monitoring	1) State Decree No.8468/1976 It endorses the regulation of Law No.997/76 that provides for the prevention and control of environmental pollution in the State of São Paulo. The decree defines the classification of inner waters located in the State territory, the water and air quality standards, as well as the emission standards allowed for both cases, in addition to the restrictions related to the soil pollution. 2) State Decree No.10755/1977 It provides for the classification of receptor water bodies in the State of São Paulo in the classification prescribe in Decree No.8468/1976.

8.5 PRELIMINARY EXAMINATION ON MITIGATION MEASURES FOR MAJOR ENVIRONMENTAL AND SOCIAL IMPACTS

This section summarizes proposed mitigation measures for the potential negative impact of the Project on the surrounding environment. Impact items with rating of negative as A- are covered here based on the Scoping Matrix in the 8.3 of this chapter. Mitigation measure for each impact item was identified based on the present situation of the project site and measures applied in previous similar projects. More detailed information and concrete measures to minimize the impact for each item will be proposed in EIA to be conducted in further stage of the Project.

8.5.1 Impact on Social Environment: Rate A-

(1) Mitigation Measures for the Impact of "Involuntary Resettlement"

1. Impact Item	Involuntary resettlement			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	A-	**A-**	-	-
3. Impact Descriptions	General Description - Land acquisition for the construction of railway, station, train depot, workshop and other facilities associated for the operation of monorail may cause involuntary resettlement. Route Situation - Large-scale involuntary resettlement would occur in Lines 1, 2A and 2B, since major part of the proposed route of Lines 1, 2A and 2B cross the site with lack of width of ROW for railway track and lack of open space for station and depot construction. - No or few resettlement would occur in the Lines 2C and 2D. Major part of the proposed route of Lines 2C and 2D goes along the existing streets which have sufficient space for overhead structure. - There would be no involuntary resettlement for the construction of train depot and workshop, since public lands are planed to be used for those facilities.			
4. Specific Impacts	Displaced people may be suffered from the following: - Lost of present livelihood - Difficulty in adopting new livelihood in relocation site - Creating social conflict with existing inhabitants - Declining of living standard in relocation site			
5. Important Conditions for the Assessment	- How much people are satisfied with present livelihood (In case it is supported by special environmental condition, resettlement would be more difficult for those people.) - How much people possess assets in present location (As financial status is higher, relocation would be more difficult.) - Social class/status (Lower class may have difficulty accustoming new neighborhood.) - Whether relocation site can be found in nearby area (As it is far, more support will be required.)			
6. Mitigation Measures Applied for the Project	Mitigation Measures Identified - Dialogue with residents, promoting public understanding through information disclosure - Search for relocation site by consultation with local people - Support for resettlement, and compensation for resettlement expenses - Support for adopting new livelihood such as support for new employment - Other support require for the smooth adaptation to the new livelihood Status as of March 2010 - For Lines 1 and 2A, above items were discussed to be confirmed with SP Environmental Secretary (SVMA) and SP Habitat Secretary (SEHAB). - For Lines 1 and 2A, preliminary survey for identification of relocation site, socio-demographic characteristics, and proposed resettling site were carried out by SPTrans in consultation with SEHAB. - Expected resettlement cost for all proposed routes were tentatively calculated. - Concrete measure will be proposed in "environmental program for resettlement" which will be elaborated in EIA report to minimize the impact.			

(2) Mitigation Measures for the Impact of "Existing Social Infrastructures and Services"

1. Impact Item	Existing social infrastructures and services			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	A-	**A-**	**A-**	**-**
3. Impact Descriptions	General Description - Land acquisition involving relocation of public and/or community facilities, would affect local communities in some extent. - Since the project site is mainly along the existing road, construction activities would affect local economy in some extent due to disturbance of smooth operation of commercial vehicles and public bus service due to traffic restriction during construction. - Traffic restriction in construction area may disturb social and business activities. Route Situation - Lines 2A and 2B are currently facing heavy traffic, which may be worse by various disturbance caused by construction. - Lines 2A is a major route of municipal bus service with mostly narrow 2+2 road. During construction the operation of bus service may be disturbed. - Lines 1 and 2C are 2+2 roads, and may have traffic congestion if the construction work gives lane-use restriction.			
4. Specific Impacts	- Traffic restriction such as one way traffic - Deterioration and increment of traffic due to of construction vehicles - Disturbance of smooth transport from both sides of lines due to railway infrastructure - Temporary public service stop of electricity, water and gas due to the interruption due to construction			
5. Important Conditions for the Assessment	- The circulation of the commodities around railway - Traffic of public transport such as bus - Industrial scale and configuration of the area - Value-added productivity in each industry (less if it is difficult to survive)			
6. Mitigation Measures Applied for the Project	Mitigation Measure Identified - Minimize interference in public services - Planned traffic restrictions in appropriate timing to minimize the impact - Dialogue with residents, promoting public understanding through information disclosure - Monitor traffic to reflect the results in traffic restrictions appropriately - Compensation to the industry if there is a significant loss Status as of March 2010 - "Plan for traffic regulations" will be proposed in "environmental program for construction site" which will be elaborated in EIA to minimize the impact.			

(3) Mitigation Measures for the Impact of "Socially Vulnerable Groups Such As the Poor, Indigenous and Ethnic People"

1. Impact Item	Socially vulnerable groups such as the poor, indigenous and ethnic people			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	A-	**A-**	**C-**	**-**
3. Impact Descriptions	General Description - Households living in the area called Favela as illegal occupants are mostly low-income and socially vulnerable. Since they are not entitled for the property compensation as illegal title-holders, the relocation of the area would give difficulties in their living. - Detailed study on the social impact to the socially vulnerable groups, mainly low-income household residing in the Favela, need to be carried out in EIA. Route Situation - Lines 1 and 2A are planned to cross the area of low-income residents that contains many Favela areas. These two lines need special attention to minimize the impact on socially vulnerable groups.			
4. Specific Impacts	- Loss of livelihood due to relocation, especially the poor and disadvantaged members of society - Deterioration of the sentiments of residents by deportation			
5. Important Conditions for the Assessment	- Number and type of socially disadvantaged group - Required area for relocation, their land type and scale - Presence of peculiar communities such as drug traffickers - Presence of SP Municipal Ordinance, regulation and program to relief disadvantaged group			

6. Mitigation Measures applied for the Project	Mitigation Measure Identified - Dialogue with residents, promoting public understanding through information disclosure - Selection of relocation destination with respect to the wishes of the residents - Relocation assistance and compensation for relocation expenses - Assistance for resettled people to promote smooth adaptation in relocation destination - Support in order to set up livelihood in relocation destination - Support for new employment and vocational training Status as of March 2010 - For Lines 1 and 2A, location and scale of Favela, and potential relocation destination were investigated by SPTrans and SEHAB. - More concrete measures to minimize the impact will be proposed in "environmental program for resettlement" which will be elaborated in EIA report.

8.5.2 Impact on Natural Environment: Rate A-

(1) Mitigation Measures for the Impact of "Flora, Fauna and Biodiversity"

<table>
<tr><td>1. Impact Item</td><td colspan="4">Flora, fauna and biodiversity</td></tr>
<tr><td rowspan="2">2. Impact Rating</td><td>Overall Rating</td><td>Planning / Design Phase</td><td>Construction Phase</td><td>Operation Phase</td></tr>
<tr><td>A-</td><td>-</td><td>A-</td><td>-</td></tr>
<tr><td>3. Impact Descriptions</td><td colspan="4">General Description
- Existing roadside trees and plants would be removed tentatively or permanently since elevated bridge structure of the railway track will mainly be constructed in the center or along the existing road.
Route Situation
Estimated Number of Trees to be Affected by the Project
<table>
<tr><th>Route</th><th>Affected Trees(total)</th><th>Transplanted Trees</th><th>Suppressed trees</th></tr>
<tr><td>Line-1</td><td>94</td><td>85</td><td>9</td></tr>
<tr><td>Line-2A(MB)</td><td>77</td><td>69</td><td>8</td></tr>
<tr><td>Line-2A(AD)</td><td>108</td><td>97</td><td>11</td></tr>
<tr><td>Line-2B</td><td>1,140</td><td>1,026</td><td>114</td></tr>
<tr><td>Line-2C</td><td>1,001</td><td>901</td><td>100</td></tr>
<tr><td>Line-2D</td><td>1,173</td><td>1,056</td><td>117</td></tr>
</table>
- Large number (more than 1,000) of trees in Lines 2B, 2C and 2D would be affected by the Project.
- Approx. 80% of trees to be removed for Line-2B are native species which require special handling in transplantation.</td></tr>
<tr><td>4. Specific Impacts</td><td colspan="4">- Cutting of plant species along street (mainly woody species)
- Reduction of green and tree shade
- Spoiling of the landscape by cutting trees
- Deterioration of feeling of local residents by cutting tree</td></tr>
<tr><td>5. Important Conditions for the Assessment</td><td colspan="4">Cutting / transplantation tree :
- Age, size
- Quantity
- Invasive species or native species
- Species protected / endangered species
- Health (phytosanitary) condition of plants
- Presence of pest/fungi attack</td></tr>
<tr><td>6. Mitigation Measures applied for the Project</td><td colspan="4">Mitigation Measure Identified
- Consultation with relevant agencies for specific ToR to reduce the environmental impact by cutting trees
- Cutting/transplantation in accordance with the guidelines of SVMA (Protected species / endangered species are treated separately by SVMA compliant.)
- Dialogue with residents, promoting public understanding through information disclosure
Status as of March 2010
- Pre-specification of target trees for cutting/transplantation has done for all lines.
- Based on the results of pre-specification, compensation cost has been estimated for all lines.
- More concrete measures to minimize the impact will be proposed in "environmental program for cutting of trees" which will be elaborated in EIA.</td></tr>
</table>

(2) Mitigation Measures for the Impact of "Landscape"

1. Impact Item	Landscape			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	A-	**-**	**A-**	**B-**
3. Impact Descriptions	General Description - Removal of existing roadside trees and plants due to construction of the railway track would change the landscape along the existing roads. - Construction works such as earthworks would affect the landscape in the project site. - Existing of elevated bridge structure of the railway track would affect the landscape. Route Situation - Line-2A has two bridge constructions that need to maintain harmony with the landscape. - Line-2D has three bridge constructions, that need to maintain harmony with the landscape. - Line-2A is near the historical center of Santo Amaro District, should be considered interference with the local landscape - The Faria Lima Avenue in Line-2B, an emerging commercial district of restaurants and shops, need to maintain harmony with the landscape. - Lines 2B and 2C that pass through the area called "Jardim Paulistano", a part of the historic landscape preservation regulations, need to maintain harmony with existing buildings. - In Sumare Avenue in Line-2C, a flyway construction is planned where subway and road (two lanes each way) cross together with the monorail railway. The flyover construction could affect the landscape. - Line-2D pass through the land in Butantan Institute, where there are buildings of historical value, which is protected and also many trees, so there is need to harmonize the project with the local landscape. - In case, Line-2D passes through the campus of the São Paulo University, there is a need to harmonize the project with the local landscape.			
4. Specific Impacts	- Changes in the landscape by the emergence of the railway - Changes in the landscape by alteration of land by land cut and embankment - Deterioration of the landscape by cutting trees			
5. Important Conditions for the Assessment	- Presence of a unique landscape such as Historic District - Availability of horizontal and vertical space for the construction of railway and stations - Geological conditions - Number and size of the trees for importance as landscape elements - Presence of SP Municipal Ordinance for the protection of the landscape, the presence of relevant legislation or program.			
6. Mitigation Measures applied for the Project	Mitigation Measure Identified - Compliance with SP Municipal Ordinance for historic landscape preservation - Appropriate design of railway, station and bridge in harmony with the landscape - Consultation with a Landscape Specialist for harmonizing with the landscape - Re-plantation of removed tree in the site - Carry out additional tree planting, if necessary - Dialogue with residents, promoting public understanding through information disclosure Status as of March 2010 - JICA Study Team proposed the environmentally-friendly design of flyover in Sumare Avenue of Line-2C without changing the current structural layout.			

8.5.3 Impact of Pollution: Rate A-

(1) Mitigation Measures for the Impact of "Waste"

1. Impact Item	Waste			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	A-	**-**	**A-**	**-**
3. Impact Descriptions	General Description - Cutting and/or transplanting trees generate large volume of biomass waste. - Inappropriate treatment of waste may cause environmental impact in the disposal site. - Residue soil due to earth works, cut land, filling, drilling, tunnel, etc., would cause environmental impact in the disposal site. - Construction waste including residue soil generated during construction of track, station, depot, viaduct/bridges and other related facilities would cause environmental impact in the disposal site. Route Situation - Large number of trees in Lines 2B, 2C and 2D would be removed that would generate biomass waste. - Line-2A(AD) has construction of three tunnels that would generate large volume of residue soil. - Line-2A(AD) needs demolition of large number of buildings that would generate considerable volume of construction waste.			
4. Specific Impacts	- Generation of biomass waste by cutting trees during construction - Generation of construction waste by demolition of existing buildings - Generation of construction residue by land cut and embankment - Impact to the surrounding environment by improper disposal of waste			
5. Important Conditions for the Assessment	- Monorail route plan for less demolition of buildings - Space design for railway for minimized land cut and embankment - Methodology for land cutting and embankment - Methodology of tunnel construction			
6. Mitigation Measures applied for the Project	Mitigation Measure Identified - Minimize construction waste - Set the route for less impact on the environment - Dialogue with residents, promoting public understanding through information disclosure Status as of March 2010 - More concrete measures to minimize the impact will be proposed in "environmental program for construction site", which will be elaborated in EIA.			

(2) Mitigation Measures for the Impact of "Noise and Vibration"

1. Impact Item	Noise and vibration			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	A-	**-**	**B-**	**A-**
3. Impact Descriptions	General Description - During the construction, noise and vibration are expected mainly by 1) cutting and replanting work of the roadside trees, 2) ground alternation by cut land, filling, 3) operation of construction equipment and vehicles and 4) construction of track, station, depot, viaduct/bridges and other related facilities. - During the operation, 1) rains make noise along the railway track, 2) Maintenance works in deport and workshop would make noise to around the site. Route Situation - Lines 2A and 2B would have larger number of operation trains since the expected passengers are larger. - The depot/office is proposed to construct in Line-2A. - Large number (more than 1,000) of trees in Lines 2B, 2C and 2D would be removed.			
4. Specific Impacts	- Noise and vibration would give physical and mental stress to the residents. - Noise and vibration would disturb comfortable sleep of residents in night time. - Noise and vibration would disturb daily service of school and hospital nearby. - Vibration created by construction heavy equipment would cause damage to the existing house and other kinds of building structures such as cracks in the wall.			

5. Important Conditions for the Assessment	During Construction - Type of construction vehicle - Type of construction machinery - Presence of sensitive institutions in neighborhood (hospitals, schools, etc.) During Operation - Type of monorail vehicles - Type of railway track - Type of switch machine - Operating conditions (operation diagram, travel speed, etc.) - Presence of sensitive institutions in neighborhood (hospitals, schools, etc.)
6. Mitigation Measures applied for the Project	Mitigation Measure Identified - Use of construction vehicles and machinery which produce lower noise and vibration - During construction, fence will be used for noise absorption - Installation of noise wall/barriers for particularly sound-sensitive places - Guidance for depot workers to reduce noise during their works - Restriction in monorail travel speed, interval and operation time especially in residential areas if necessary - Sound-proof equipment attached to the vehicle (i.e., the wheel cover) if necessary - Use of switch which produce minimum noise and vibration - Dialogue with residents, promoting of public understanding through information disclosure - Reinforcement of building around to withstand the noise and vibration Status as of March 2010 - As for noise and vibration, more concrete measures to minimize the impact will be proposed in "environmental program for monitoring noise and vibration" which will be elaborated in EIA report.

8.5.4 Impact on Social Environment: Rate B-

(1) Mitigation Measures for the Impact of "Local Economy Such As Employment and Livelihood"

1. Impact Item	Local economy such as employment and livelihood			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-	**B-**	**B -**	**-**
3. Impact Descriptions	General Description - Involuntary resettlement due to the land acquisition would affect local economy in some extent. - Since the project site is mainly located in the center of and along the existing road, construction activities would affect local economy in some extent due to disturbance of smooth operation of commercial vehicles and public bus service due to traffic restriction during construction. Route Situation - Large-scale involuntary resettlement would occur in Lines 1 and 2A, since major part of the proposed route cross the site with lack of width of ROW. The area is considered as low-income resident that contains many Favela areas. These two lines need special attention to minimize the impact on local economy. - Lines 2A and 2B are currently facing heavy traffic which may be worse due to the disturbance made by construction works. Line 2A is a major route of municipal bus service with mostly very narrow 2+2 road. During construction, the operation of bus service may be disturbed.			
4. Specific Impacts	- Changes in population distribution and demographic characteristics due to land use change - Changes in commercial activities - Change in employment opportunities - Rise in land price in the vicinity of railway - Worsening of the gap between rich and poor			
5. Important Conditions for the Assessment	- Scale and characteristics of the industry and commercial activities - Opportunities for local employment - Value-added productivity in each industrial/commercial activities (if less, it is difficult to survive.)			

6. Mitigation Measures Applied for the Project	Mitigation Measure Identified - Dialogue with residents, promoting public understanding through information disclosure - Compensation for the land owner and economic sector if necessary - Provide alternative land for economic activities if necessary - Provide alternative means of crossing the railway in case industrial/commercial activity need geographic continuity

(2) Mitigation Measures for the Impact of "Land Use"

1. Impact Item	(Surrounding) Land use			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-	**B-**	**-**	**B-**
3. Impact Descriptions	General Description - Inadequate land use would occur due to acceleration of unplanned development along the proposed route and around new stations. - In the operation of trains, land use may be changed because of commercial development along railways. Route Situation - After the start of operation, Lines 1 and 2A will gain significantly better access to the city centre. Consequently, the land price would increase considerably in coming several years. - The depot/office, which is planed to be constructed in Line 2A, would have 1,000 - 3,000 workers. The area would attract a lot of street venders, and would have commercial development.			
4. Specific Impacts	- Rise in land price particularly close to the stations - Changes in land use from residential use to commercial use after the commencement of monorail operation - Unplanned development in the vicinity of railway			
5. Important Conditions for the Assessment	- Land use planning in the vicinity of railway - Legal restrictions on land use - Legal restriction for selling land (DUP: Municipal Decree for Public Utilization)			
6. Mitigation Measures Applied for the Project	Mitigation Measure Identified - Planning on land use by SP municipal authorities concerned - Enforcement of laws and regulations concerning land use by SP municipal authorities concerned - Enforcement of laws and regulations concerning selling land (DUP: Municipal Decree for Public Utilization) by SP municipal authorities concerned			

(3) Mitigation Measures for the Impact of "Transportation"

1. Impact Item	Transportation			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-	**-**	**B-**	**-**
3. Impact Descriptions	General Description - Regional transportation and communication will be disturbed due to railway construction. - Since the project site is mainly located in the center of and along the existing road, construction activities would cause disturbance of smooth operation of commercial vehicles and public bus service due to traffic restriction during construction. Route Situation - Lines 2A and 2B are currently facing heavy traffic, which may be worse by various disturbance made by construction works. - Line 2A is a major route of municipal bus service with mostly very narrow 2+2 road. During construction the operation of bus service may be disturbed. - Lines 1 and 2C are 2+2 roads, and may have traffic jams if the construction work gives lane-use restriction.			
4. Specific Impacts	- Inhibition in conventional traffic - Inhibition of regional transport/circulation of goods and products - Inhibition of regional communication - Modal shift of local residents, local industrial and commercial sectors			
5. Important Conditions for the Assessment	- If the construction of monorail-related facilities consequence geographically isolated areas - If there are traditional events and customs in the area - If there are especially strong community ties (if the community is sensitive for the			

	geographic division)
6. Mitigation Measures Applied for the Project	Mitigation Measure Identified - Compensation in case of significant problems - Provision of necessary measures to prevent geographical division such as alternative transportation - Dialogue with residents, promoting public understanding through information disclosure

(4) Mitigation Measures for the Impact of "Hazardous (risk) of infectious Diseases such as HIV/AIDS "

1. Impact Item	Hazardous (risk) of infectious Diseases such as HIV/AIDS			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-	**-**	**B-**	**-**
3. Impact Descriptions	General Description - Risk of infectious diseases by labors would be predictable during construction. Route Situation - Entire route may have some risk of infectious diseases in case considerable number of workers works together.			
4. Specific Impacts	- Infectious diseases such as influenza may outbreak and spread to other workers in case workers stay together in dormitories. - Infectious disease outbroken in workers may spread to nearby areas.			
5. Important Conditions for the Assessment	- Number of workers - Health conditions of workers - Sanitary condition of work environment - Sanitary condition of nationhood areas			
6. Mitigation Measures Applied for the Project	Mitigation Measures Identified - Implement education program to raise awareness for infectious diseases to workers and people of nearby communities. - Mainteina good sanitation condition of work environment. - Implement regular health check for workers.			

(5) Mitigation Measures for the Impact of "Invasion of Privacy"

1. Impact Item	Invasion of privacy			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-	**-**	**-**	**B-**
3. Impact Descriptions	General Description - In the case where elevated railway structure is close to the building/house, privacy of residents in such building/house would be invaded by passenger of the train. Route Situation - Entire route may have some invasion of privacy, especially around stations. - Proposed route of Lines 1, 2A and 2B (Santo Amaro District) cross dense residential areas. - Line 2B (Faria Lima Avenue and Luis Carlos Berrini Avenue) cross the newly developed modern commercial area with high story office buildings.			
4. Specific Impacts	- View from the station and viaduct adjacent to the railway - View from the railway passing the front yard of the adjacent houses - Inappropriate disposal of paper/ slip which contain personal information - Unlawful leakage of personal information			
5. Important Conditions for the Assessment	- Present land use near railway and station (There is a different sense of privacy in commercial area and residential area.) - Orientation of the house and garden - Whether windows face railway or not			
6. Mitigation Measures Applied for the Project	Mitigation Measures Identified - Take necessary measure to prevent the invasion of privacy in infrastructure design - Installation of a blind in stations to block eyes if necessary			

(6) Mitigation Measures for the Impact of "Accident"

1. Impact Item	Accident			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-		**B-**	
3. Impact Descriptions	General Description - Accident in construction works and operation of construction vehicle/equipment would occur. Route Situation - Entire route may have some risk of accidents especially around stations. - Lines 1, 2A and 2B (Santa Amaro District) cross dense residential areas that need special effort to prevent accidents with local residents.			
4. Specific Impacts	- Accident by vehicle and machinery at construction site - Accidents between construction vehicles and local residents in the vicinity of the construction site - Landslides caused by inappropriate land cut and embankment			
5. Important Conditions for the Assessment	- Safety standards set by the SP municipal government - Presence of steep slope - Presence of soft ground			
6. Mitigation Measures Applied for the Project	Mitigation Measure Identified - Compliance with safety standards of the SP municipal government - Setting more strict safety standards at construction site for the Project - Maintain guideline/manual for emergency situation - Strict application of safety standards to workers in construction site - Proper maintenance of vehicles to prevent accident - Proper loading of materials to prevent accidental fall on the road - Installment of the additional drainage if necessary - Take necessary measures for slope protection Status as of March 2010 - More concrete measures to minimize the impact will be proposed in "environmental program for construction site and risk management", which will be elaborated in EIA.			

8.5.5 Impact on Natural Environment: Rate B-

(1) Mitigation Measures for the Impact of "Topography and Geographical Features"

1. Impact Item	Topography and geographical features			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-	**-**	**B-**	**-**
3. Impact Descriptions	General Description - Elevated bridge structure of the railway track will mainly be constructed in the center or along the existing road. However, earthworks would affect topographic condition in some sections along the river/channel. Route Situation - Line 2C (Sumare Avenue) has a large-scale "flyover" with subway and 3+3 road crossing together in one point. The addition of monorail flyover to the existing flyover would result alternation of topographic feature. - Line 2A-ud has construction of three tunnels that would alter topographic feature.			
4. Specific Impacts	- Alternation of terrain by land cut, embankment and tunnel construction - Alteration of land use by railway, station and tunnel installment - Occurrence of soil subsidence and lift due to imbalance by cutting a large volume of soil			
5. Important Conditions for the Assessment	- Route planning (if it require modification of land) - Design in three-dimensional extent of railway and station (if the design require modification of land) - Route design restriction due to maximum travel speed (if the speed is faster, design restriction become more severe) - Geological conditions			
6. Mitigation Measures Applied for the Project	Mitigation Measure Identified - Take necessary alternation in route plan - Take necessary alternation in space design of railway and stations - Apply necessary restriction of travel speed limit (slow down if necessary) - Take necessary measures to prevent landslide at tunnel construction			

(2) Mitigation Measures for the Impact of "Soil Erosion"

1. Impact Item	Soil erosion			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-	**-**	**B-**	**-**
3. Impact Descriptions	General Description - Alteration of ground by cut land, filling, drilling, tunnel, etc may induce soil erosion. - Construction works along the river/channel in some sections would cause soil erosion. Route Situation - Line 2A-ud has a major earth work of three tunnel constructions. "Cut & fill" construction method will make cut surface which is fragile to wind and rain erosion.			
4. Specific Impacts	- Silting up the channel of the nearby river and altering its natural flow - Turbidity in the river, which might affect aquatic fauna and flora			
5. Important Conditions for the Assessment	- Terrain and geological condition of the construction site (if susceptible to erosion) - Scale of cutting land and embankment - Flow of water into the rivers in the vicinity			
6. Mitigation Measures Applied for the Project	Mitigation Measure Identified - During construction, potential slope erosion should be mitigated by installing slope erosion controls such as benching and planting. - During construction, it should be mitigated by the implementation of sedimentation controls such as silt barriers and sedimentation ponds. - All cut slopes, and other erosion-prone working areas should be stabilized. - Open cut areas should be promptly seeded. Status as of March 2010 - More concrete measures to minimize the impact will be proposed in "environmental program for construction site", which will be elaborated in EIA.			

(3) Mitigation Measures for the Impact of "Groundwater"

1. Impact Item	Groundwater			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-	**-**	**-**	**B-**
3. Impact Descriptions	General Description - Increase water demand in the vicinity especially around the depot/office - Cut of ground water stream due to tunnel construction Route Situation - The depot/office, planed to be constructed in Line 2A, would have 1,000-3,000 workers. Also, the area would have commercial development. Water demand would significantly increase.			
4. Specific Impacts	- Reduction of groundwater recharge function - Decline in groundwater levels - Depletion of shallow water wells - Land subsidence in the alluvial and clayey soil layer			
5. Important Conditions for the Assessment	- Groundwater protection policy of SP municipal government - Historical aspect on declining groundwater level - Development of alternative water sources by SP municipal government			
6. Mitigation Measures Applied for the Project	Mitigation Measure Identified - Exchange information with SP municipal authorities concerned to conserve water use - Promote reuse of water for washing trains - Conduct survey on water use in vicinity if necessary - Dialogue with residents, promoting public understandings through information disclosure Status as of March 2010 - More concrete measures to minimize the impact will be proposed in "environmental program during operation", which will be elaborated in EIA.			

(4) Mitigation Measures for the Impact of "Global Warming"

1. Impact Item	Global warming			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-	**-**	**B-**	**-**

3. Impact Descriptions	General Description - Cutting of existing roadside trees and plants due to construction of the railway track would reduce absorption capacity of greenhouse effect gas such as CO_2. Route Situation - Large number (more than 1,000) of trees in Lines 2B, 2C and 2D would be affected by the Project.
4. Specific Impacts	- Reduction in the amount of carbon fixed by plants
5. Important Conditions for the Assessment	- Age, size, quantity of roadside trees - Total biomass
6. Mitigation Measures Applied for the Project	Mitigation Measure Identified - Specification of TOR to minimize the impact by tree cutting - Consultation with relevant agencies to reduce the environmental impact of logging - Promoting transplantation and planting trees in accordance with the SVMA guidelines - Dialogue with residents, promoting public understanding of the logging information disclosure on tree cutting

8.5.6 Impact of Pollution: Rate B-

(1) Mitigation Measures for the Impact of "Air Pollution"

1. Impact Item	Air pollution			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-	**-**	**B-**	**-**
3. Impact Descriptions	General Description - Emission of exhaust gas from construction equipment and vehicles and dust pollution due to operation of the construction equipment and vehicles would cause air pollution in and around the construction sites during the construction. Route Situation - Site office/parking, which will be identified by the contractor, will have intensive use of heavy equipment which needs special effort t to mitigate air pollution.			
4. Specific Impacts	- Emission from vehicles - Generation of dust in construction site			
5. Important Conditions for the Assessment	- Facilities that require clean air in the vicinity (hospital, school, etc.) - SP municipal emission standard			
6. Mitigation Measures Applied for the Project	Mitigation Measure Identified - Management of vehicle exhaust for sensitive vicinity such as hospital and school - Dust control such as water sprinkler in construction site - Choose appropriate work time for construction - Dialogue with residents, promoting public understanding through information disclosure Status as of March 2010 - More concrete measures to minimize the impact will be proposed in "environmental program for air pollution control ", which will be elaborated in EIA.			

(2) Mitigation Measures for the Impact of "Water Pollution"

1. Impact Item	Water pollution			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-		**B-**	**B-**
3. Impact Descriptions	General Description - Muddy water from construction site and oil spill from construction equipment and vehicles would cause water pollution in the channel/river in and around the construction site. - Oil-content waste water from depot/office would affect water body nearby in the case of direct discharge without pre-treatment or without connection to the sewerage system in the depot/office. Route Situation - Proposed depot/office along Line 2A is nearby river. - Part of Line 2B is planned to disturb existing major sewage pipe under ground. The construction would interrupt the sewage pipe and generate sewage run off.			

4. Specific Impacts	- Water pollution by land cut, embankment and bowling - Generation of domestic wastewater in depot/office - Generation of polluted water by washing vehicles in depot/office
5. Important Conditions for the Assessment	- The number of construction vehicles - Scale of cutting land and embankment - Number of operation train and the frequency of cleaning of them - Scale of the depot/office, number of workers working in - Groundwater level - SP municipal regulation for waste water effluent
6. Mitigation Measures Applied for the Project	Mitigation Measure Identified - Compliance with effluent standards of the SP municipal government - Setting strict standards to prevent oil pollution in land and ground water - Setting strict standards to prevent water pollution by garbage disposal - Processing in sediment tank for polluted water to remove solid substances - Establishing a manual/guideline for applying wastewater treatment - Establishment of treatment facilities for the monorail vehicle wash water treatment Status as of March 2010 - More concrete measures to minimize the impact will be proposed in "environmental program for construction site", which will be elaborated in EIA report.

(3) Mitigation Measures for the Impact of "Offensive Odor"

1. Impact Item	Offensive odor			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-	**-**	**B-**	**-**
3. Impact Descriptions	General Description - In some sections where pass along rivers and channels, offensive odor would occur around the construction site due to excavation and dredging of mud in the rivers/channels during the construction. - In the case where contaminated soil is found in the construction site such as site of old factory, offensive odor would occur in removal and transport of such contaminated soil. Route Situation - Part of Line 1 and 2A goes along existing water way. The construction of elevated structure would dredge stagnant water and would create offensive odor.			
4. Specific Impacts	- Offensive odor caused by the inflow of waste water into river - Spoil of the comforts of living for local residents			
5. Important Conditions for the Assessment	- Population densities as greater more heavily affected - If the water stagnant (stagnant water tend to generate more offensive odor) - Water quality of rivers			
6. Mitigation Measures Applied for the Project	Mitigation Measure Identified - Appropriate dredging practice to minimize odor - Appropriate waste water drainage to minimize odor - Maintain proper waste treatment facility to minimize odor - Dialogue with residents, promoting public understanding through information disclosure Status as of March 2010 - More concrete measures to minimize the impact will be proposed in "environmental program for construction site", which will be elaborated in EIA.			

(4) Mitigation Measures for the Impact of "Bottom Sediment"

1. Impact Item	Bottom sediment			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-	**-**	**B-**	**-**
3. Impact Descriptions	General Description - During construction, excavated soil would cause sedimentation, flushed into water course in case of rain. Route Situation - Line 2A has two bridges, and Line 2D has three bridges. Bridge construction would generate bottom sediment in nearby rivers - Line 2B will be located near the small river running parallel to it on the west side. - Line 2A-ud has a major earth work of three tunnel constructions. "Cut & fill" construction method will make cut surface which is fragile to wind and rain erosion.			

4. Specific Impacts	- Bottom sediment caused by gravel water during construction - Water pollution by land cut and embankment - Generation of domestic waste water from depot/office - Generation of polluted water by washing vehicles in depot/office
5. Important Conditions for the Assessment	- Method of railway construction - Scale of land cut and embankment - Scale of depot/office, number of employees - Quantity of water flow in nearby rivers
6. Mitigation Measures Applied for the Project	Mitigation Measure Identified - Compliance with the effluent standards of SP municipal government - During construction, potential slope erosion will be mitigated by designing slope erosion controls such as benching and planting. - During construction, it will be mitigated by the implementation of sedimentation controls such as silt barriers and sedimentation ponds. - All cut slopes, and other erosion-prone working areas will be stabilized. - Open cut areas will be promptly seeded. - Establishing a manual/guideline for waste water effluent and treatment Status as of March 2010 - More concrete measures to minimize the impact will be proposed in "environmental program for construction site", which will be elaborated in EIA.

(5) Mitigation Measures for the Impact of "Electromagnetic Effect"

1. Impact Item	Electromagnetic effect			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-	**-**	**-**	**B-**
3. Impact Descriptions	General Description - Station structure of the railway would interfere with the radio wave such as radio and television nearby. Route Situation - Entire route may have some impact of electromagnetic effect during operation.			
4. Specific Impacts	- Low quality in radio wave reception for TVs and radios - Breakdown of the communication cable			
5. Important Conditions for the Assessment	- The location of elevated structures - The size of the elevated structure			
6. Mitigation Measures Applied for the Project	Mitigation Measure Identified - Provide necessary support such as installment of new antenna to solve the problem, if it arises - Compensation if significant effect - Dialogue with residents, promoting public understanding through information disclosure			

(6) Mitigation Measures for the Impact of "Obstruction of Sunshine"

1. Impact Item	Obstruction of sunshine			
2. Impact Rating	Overall Rating	Planning / Design Phase	Construction Phase	Operation Phase
	B-	**-**	**-**	**B-**
3. Impact Descriptions	General Description - Due to bridge structure for elevated track, some railway tracks close to the building would cause obstruction of sunshine to the building, especially residential house. Route Situation - Entire route may have some obstruction of sunshine especially around station. - Line 1, 2A and 2B (Santo Amaro District) cross residential areas. - Line 2B (Faria Lima Avenue and Luis Carlos Berrini Avenue) cross the newly developed modern commercial area with high story office buildings.			
4. Specific Impacts	- Deterioration of residential living environment - Impact on growing of plants by obstruction of sunshine - Deterioration of the sentiments of residents by obstruction of sunshine			
5. Important Conditions for the Assessment	- The location of elevated structures - The size of the elevated structure			

6. Mitigation Measures Applied for the Project	Mitigation Measure Identified - Appropriate elevated design of the station to minimize the impact - Provide necessary support to solve the problem if it arises - Compensation if significant effect - Dialogue with residents, promoting public understanding through information disclosure

8.6 MITIGATION MEASURES FOR SPECIFIC TOPICS

As a result of preliminary examination of environmental and social impacts, land acquisition and resettlement, and removal of roadside trees were identified as significant iimpacts to be examined its impacts. Considering current situation of the project site and experiences of mitigation measures in past projects, conceivable measures are proposed. Outlines of the measures are shown below.

8.6.1 Land Acquisition and Resettlement

(1) Current Progress of Land Acquisition and Resettlement by SPTrans

1) Preparation of Resettlement Sites

As shown in Figure 8-6, SPTrans consulting with DESAP has so far identified 19 potential resettlement sites for PAPs of the Project, who are low-income & non-titleholders and currently reside in illegal places such as Favela and Loteamentos. The potential resettlement sites were identified from idle lands where are located nearby the proposed Line-2A of the Project. Criteria by SPTrans for selection of the resettlement site are shown below.

1) Resettlement near current residence
2) Considerations of movability to station area
3) Improvement of living environment
4) Considerations of accessibility to public transport

Source: SPTrans, 2009

Figure 8-6 Potential Resettlement Sites along the Line-2A

Total area for the 19 potential resettlement sites are 491,200 m^2, including proposed monorail depot site in Santo Amaro with area of 107,000 m^2. Out of the 19 sites, 7 sites, where field survey has been conducted, have 195,800 m^2 land area in total. Assuming 60

m^2/household is required for the resettlement site as per Law No.14.933/09, the 7 sites have capacity for about 3,200 households for resettlement.

So far, Decree of Public Interest (DUP)[1] has been issued for the part of land area for the monorail station near the Jardim Angela bus terminal and candidate monorail depot site in Santo Amaro, but not for the potential resettlement sites. Other areas need issuance of Decree of Public Interest (DUP) that will be done in the process to obtain LAI in EIA.

SPTrans has been identified project-affected sites under socially sensitive categories with higher priority, which are shown in the following table. In general resettlement process takes for longer time in these areas due to its social characteristics and legal procedures, comparing with other areas.

Table 8-13 Categories of Socially Sensitive Residential Area / Felicity

Category	Definitions	Legal Status of Residents	
		Legal	Illegal
Favela	Area where low-income non-titleholders occupy public or private land illegally and build their houses by themselves. In general, development condition of urban infrastructure in the area is very poor.	-	O
Loteamentos	Land rezoned for residential area. Some illegal occupants are seen in the vacant land.	O	O
Cortieos	Old house and collective residence left for long time and occupied by illegal occupants. Most of the residences were developed in 1950 - 1970 under public housing scheme and maintenance for the residence has not been provided well and left.	-	O
Núcleos Urbanizados	Area where has been originally Favela. SEHAB has provided urban infrastructure as well as legalization of the residents at the same time under municipal program of São Paulo.	O	-
Conjuntos Habitacionais	Area for collective residence for resettlement or public residence.	O	-

Source: JICA Study Team by using secondary information and inquiry to expert

(2) Preliminary Cost Estimate for Land Acquisition and Resettlement

1) Methodology

For cost estimate for land acquisition and resettlement required for the implementing the proposed project in São Paulo City, the following procedures were adopted.

a) Quantification of Land Acquisition and Resettlement

Land area to be acquired and the number of existing buildings along each proposed route of the project were estimated based on the analysis of aerial photographs and of land use map. With regard to the slums, registry data of families of those slums by SEHAB was adopted for estimate of the number of families to be affected by the project. More detailed survey and the corresponding budget will be examined during the preparation of the Land Acquisition and Resettlement Plan in EIA study.

b) Prices of Land and Buildings

For cost estimate of land and building, current housing prices were reviewed through

[1] DUP is a legal procedure to declare possible land expropriation for public purpose.

some real estate companies in the region. Collected data were analyzed and established unit prices for land and houses as shown in the table below.

Table 8-14 Average Price of Land and Building

Reference Region	Land Price (Unit: R$/ m^2)	Building Price (Unit: R$/ m^2)
Jardim Angela/ Capao Redondo	350	770
Santo Amaro	760	1,415

Source: JICA Study Team

c) Cost of Housing for Resettlement

For cost estimate of housing for resettlement of families, mainly for low-income families, reference cost by SEHAB was adopted as unit cost based on other resettlement cases conducted by the Secretariat.

Table 8-15 Unit Cost of Housing for Resettlement

Type of Building	Area (m^2)	Cost (R$)
Apartment	50	65,000

Source: JICA Study Team

2) Cost Estimate of Land and Building Acquisition

The following table shows the estimated amount of land and buildings to be acquired, and their costs. For the Line-2C, only land acquisition is required, but not acquisition of building. For the Line-2D, no acquisition of both land and building is required.

Table 8-16 Cost of Land and Building Acquisition

	Quantity (land - m^2)	Unit Price (R$)	Total (R$)
< Line-1 >			
Land	25,480	350	8,918,000
Building	42	77,000	3,234,000
		Total	12,152,000
< Line-2A(MB) >			
Land	91,040	350	31,864,000
Building	39	77,000	3,003,000
		Total	34,867,000
< Line-2A(AD) >			
Land	157,150	350	55,002,500
Building	182	77,000	14,014,000
		Total	69,016,500
< Line-2B >			
Land	59,655	760	45,337,800
Building	52	141,500	7,358,000
		Total	52,695,800
< Line-2C >			
Land	2,240	760	1,702,400
		Total	1,702,400
		Ground Total	170,433,700

Note: In the estimating of cost of the buildings was considered that these had on average a constructed area of 100 m2
Source: JICA Study Team

3) Cost Estimate of Resettlement Site Preparation

The following table shows estimated number of low-income families to be resettled and their housing costs. For the Lines 2B, 2C and 2D, resettlement of low-income families is not expected.

Table 8-17 Cost Estimate of Resettlement Site Preparation

	Number of family	Unit Price (R$)	Total (R$)
Line-1	307	65,000	19,955,000
Line-2A(MB)	205	65,000	13,325,000
Line-2A(AD)	465	65,000	30,225,000
		Total	63,505,000

Source: JICA Study Team

8.6.2 Environmental Mitigation and Compensation for Trees/Vegetation Removal

To mitigate/compensate unavoidable negative environmental impact made by trees/vegetation removal during construction, the Project is required to undertake compensatory measures by means of the maintenance, expansion and improvement of the vegetation coverage in other places as it is instructed by the laws and regulations concerned. The following instruments prescribe definitions and procedures to be considered for obtaining authorizations for trees/vegetation removal by the Project.

(1) Major Laws and Regulations for the Preservation of Tree/Vegetation Coverage

To complement federal laws and rules , states and municipalities have also set forth their legislations in the scope of respective territories in order to adjust them to local peculiarities and interests. In this section, we focus on laws and regulation that are directly applicable to the Project from three levels – federal, state, and municipality.

1) Federal Law No.4.771/1965 (New Forest Code)

The law and its subsequent amendments prescribe the mechanisms for preservation, utilization and exploitation of forests and other forms of vegetation. It defines the Permanent Preservation Areas (APP), Legal Reserve (RL) and other interventions considered as public and social interest.

Article 2 defines as being of permanent preservation of those forests and other forms of vegetation located:

a) along rivers or any water course, from its highest level at the margin strip which minimum width is:

- 30 m for water courses with less than 10 m of width
- 50 m for water courses with 10 m to 50 m of width
- 100 m for water courses with 50 m to 200 m of width
- 200 m for water courses with 200 m to 600 m of width
- 500 m for water courses with width over 600 m

b) around ponds, lakes or natural or artificial water reservoirs;

c) at water sources within a minimum radius of 50 m;

d) at the top of hills, mountains and mountain ranges;

e) at hillsides or part of them, with gradient over 45 degree, equivalent to 100% at the highest gradient line;

f) at "restingas" (sand or rock strips starting at the coast), which stabilize sand dunes or mangroves;

g) at the borders of tablelands or plateaus, from the relief rupture line, in a strip never narrower than 100 m in horizontal projections;

h) in elevations over 1,800 m, whatever be the vegetation.

Article 4 defines that the felling of trees in APPs can only be authorized in case of public or social interest, duly characterized and motivated in its own administrative procedure, when there is no technical nor location alternative to the proposed project.

According to Article 16, forests and other forms of native vegetation, except those located in APPs, as well as those not subject to the limited utilization regime nor object of specific legislation, are susceptible of suppression, provided that the following minimum percentage is kept as RL:

- 80% of the rural property located in forest area within Legal Amazon;
- 35% of rural property located within Cerrado (savannah) area;
- 20% of rural property located in area of forest or of other forms of native vegetation in other regions of the country;

2) DEPRN Ordinance No.51/2005

It prescribes the simplified general procedure for the authorization of native vegetation suppression, isolated native trees cut, intervention in especially protected areas, and others within the scope of the Department of Natural Resources Protection (DEPRN), SMA of São Paulo State Government. The Ordinance defines when the simplified procedure is applicable, in other cases being adopted the general procedure. The list of necessary documents for each of the situations is presented in this Ordinance.

3) SVMA Ordinance No.26/08

Within the scope of the SVMA of São Paulo Municipal Government, this Ordinance regulates the environmental compensation criteria and procedures for the management through cut, transplantation or other intervention to be followed by the project for construction, land allotment, infrastructure and public and/or social interest works. Among other specifications, this Ordinance presents the list of necessary documents to request the authorization for cut and/or transplant of trees, the criteria to determine the compensation to be done, as well as guidelines for the execution of the necessary tree registration.

(2) Government Institutions Responsible for the Authorization for the Project

As discussed previously, the laws and regulations for environmental mitigation/compensation are set forth in federal, state and municipal level. The authorization procedures for the Project are principally controlled by the Technical Division of Environmental Protection and Evaluation (DPAA), SVMA of São Paulo Municipal Government, as instituted by Municipal Decree No.47.949/2006. DPAA/SVMA is responsible for the analysis, follow-up and

conclusive technical report of administrative processes that result in cut, transplantation or in any other intervention of trees, in public or private land of São Paulo municipal territories.

(3) Compensatory Measures for Trees/Vegetation Removal

The compensatory measure shall be executed by 1) planting of tree species or 2) supplying of seedlings to the municipal seedling department. Exceptionally, the compensatory measure can be converted into 3) works and services.

1) Planting of Tree Species

Principally, the environmental compensation needs to ensure tree density which is equal or higher than the original tree density. The basis for calculating the compensation measure is the removal of native tree with Diameter at Breast Height (DAP) equal to or more than 5 cm as provided in SVMA Ordinance 26/2008. In cases of removal of species included in the Official List for Threatened for Extinction of IBAMA Ordinance 37-N/92 and SMA Ordinance 48 21/09/2004, special application will be required. The number of seedlings for compensation depends on the average DAPs of trees to be cut or transplanted. The average DAP corresponds to the arithmetic mean of 10% of the largest DAPs. The conversion rates for transplanting and cutting are different as indicated below.

a) For the removal of trees by transplanting, following conversion rate will be applied for compensation.

Table 8-18 Conversion Rate for Transplanting

Class - DAP (cm)	Compensation Ratio
05-10	2:1
11-30	3:1
31-60	6:1
61-90	10:1
91-120	14:1
121-150	18:1
Greater than 150	20:1

Source: SVMA Ordinance 26/08

b) For the removal of trees by cutting, following conversion rate will be applied for compensation. The compensation due for the exotic trees will be reduced in 50%.

Table 8-19 Conversion Rate for Cutting

Class - DAP (cm)	Compensation Ratio
05-10	3:1
11-30	6:1
31-60	9:1
61-90	15:1
91-120	21:1
121-150	30:1
Greater than 150	45:1
Eucalyptus and pine	1:1
Dead tree	1:1

Source: SVMA Ordinance 26/08

The planting needs to be made with seedlings with minimum DAP of 5 cm. In case of utilization of seedlings with greater DAP, there is a reduction factor in the number of seedlings. The planting of trees will have to obey the norms provided by the Urban Tree Planting Technician Guideline, of Inter-Secretarial Ordinance 5/SMMA-SIS/02, Ordinance 17/DEPAVE –G/01 and SVMA Ordinance 26/08.

The tree species used for planting must be native, preferably chosen from Native Species Indicative List made by the DEPAVE/DPAA. In principle, the planting need to use the seedlings of the same species. If the species does not be adjusted to the place, consultation with SVMA is required to determine another species to be planted.

The compensatory planting can be done within the property or in public areas (parks, streets, squares, etc). Therefore; there is no need for acquisition of areas for compensation by the project proponent

2) Supplying of Seedlings

If compensatory planting is not possible, the applicant must supply to the local seedling department the doubled number of trees that can not be planted. For supplying seedling to the municipal seedling department, the seedling will have to be at least DAP of 3 cm and minimum height of 2.5 m. Also, the tree species used for supplying to the municipal seedling departments must be native, preferably chosen from Native Species Indicative List made by the DEPAVE/SVMA.

3) Conversion to Works and Services

Works and services converted for environmental compensation shall be related to the elimination, reduction or restoration of the environmental damage and with the increment of green areas in the municipal territory with reference to the Municipal Decree Nº 47.145/2006. The SVMA Ordinance mentions the following cases for the conversion to works and services. The type of compensation shall be made by the request of DEPAVE/SVMA which consults sub-prefectures of influenced areas.

a) executive projects, work and services required for deployment of squares, parks and linear parks;

b) design and implementation of tree planting in public areas;

c) recovery of degraded areas;

d) acquisition for implementation of green area;

e) other measures of interest for protection, expansion, management and recovery of green areas.

Exceptionally, the DEPAVE/SVMA may require the purchase of area for deployment of green area. However; most measures which were taken by the previous similar projects were recovery of squares and/or parks or establishment of bike lanes and other facilities.

(4) Preparation of Environmental Compensation Plan

Project proponent has to prepare an Environmental Compensation Plan with implementation schedule, which is subject to DEPAVE/DPAA for approval. The removal of tree/vegetation by cut or transplantation can be allowed only by examining the Environmental Compensation Plan by DPAA/SVMA. Generally, the compensatory planting must be made during the implementation of the Project, because one of the conditions for obtaining the License of

Operation (LAO) is the fulfillment of all requirements of Installation License(LAI) and the compensatory planting is one of requirements.

(5) Monitoring and Inspection of Environmental Compensation

For monitoring green area management obliged by concerned laws and regulations, DPAA require the Project to prepare Technical Report. All tree management will have to be proven by Technical Photographic Report and Notation of Technical Responsibility (ART). The Technical Photographic Report will have to indicate the number of each tree unit and demonstrate: 1) the open hollow, 2) the size of the chunk, 3) the used equipment to raise and to carry the tree and 4) the tree in the definitive place. The ART have to indicate: 1) the tree register (Plant of Current Situation) and 2) the botanical survey (current situation survey).

(6) Calculation of the Monetary Value of the Compensatory Measure

In principle, the cost of work and services defined for environmental compensation should be equivalent to the value of the product obtained by multiplying the number of seedlings by cost composed of each seedling, which is monthly published by Environmental Compensation Board (CCA). The work and services will be appropriate as a ¨unit price¨ from the prices of the official table of unit costs charged by municipal government or from market research. The calculation of the monetary value of the compensatory measure will be done by following formula:

$VCF = CF \times V$

VCF = monetary value of compensatory measure
CF = number of seedlings of final compensation
V = monetary value of one unit planting

$V = Vm + Vp$

Vm = monetary value of a seedling calculated by SVMA (Ordinance 123/SVMA-G/2002)
Vp = monetary value of the protector

(7) Roadside Trees in the Proposed Route

Species that were widely used are *Caesalpinia Peloto Phoroides* and *tipuana*. Other species that appear quite often are: pata de vaca, pau-ferro, ipê amarelo, figueira / falsa seringueira.

(8) Preliminary Identification and Cost Estimate of the Roadside Trees to be Removed

1) Methodology

For preliminary cost estimate for the services to cut and transplantation of the roadside for implementation of the monorail project in the city of São Paulo and the implementation of compensatory planting, the following procedures are adopted.

a) Quantification of Affected Vegetation

Estimation of the number of roadside trees to be removed along the routes of the project is conducted based on the analysis of aerial photographs and rapid field checking on their size and species types such as native and exotic. Detailed survey and the corresponding cost estimate will be made during the development of the EIA/RIMA for the project.

b) Estimation of Number of Trees to be Transplanted and Failed

In order to estimate the costs of required services for failing and transplantation, it is assumed, in accordance with the previous similar projects, that about 90% of the trees will be transplanted and the remaining 10% should be failed due to current health situation such as diseases, termite infestation, and fungal attack, or due to difficulties that prevent their transplant.

Precise determination of which trees should be transplanted or failed will be made during the development of the EIA/RIMA, when the survey and inventory of the trees affected by the project is conducted.

c) Estimation of Compensatory Planting

To estimate the number of seedlings to be planted as compensatory planting, the criteria prescribed in the SVMA Ordinance 26/08 will be adopted, which regulates the procedures of environmental compensation for the failing and transplanting woody vegetation in São Paulo. This law prescribes that the number of seedlings for compensation shall be calculated on the size of the trees determined from the average value of the DAPs (diameter at 1.30 m of breast height) of 10% larger DAPs of trees to be transplanted and failed. The compensation factors are shown in the following tables.

Table 8-20 Compensation Factors in Case of Transplantation

DAP_{m10} (cm)	Compensation Factors
5-10	2:1
11-30	3:1
31-60	6:1
61-90	**10:1**
91-120	14:1
121-150	18:1
>150	20:1

Note: DAPm10 – Average of DAPs for 10% largest DAPs for trees will be to transplantation.
Source: SVMA Ordinance 26/08

Table 8-21 Compensation Factors in Case of Failing

DAP_{m10} (cm)	Compensation Factors
5-10	3:1
11-30	6:1
31-60	9:1
61-90	15:1
91-120	**21:1**
121-150	30:1
>150	45:1
Eucalyptus / pinus	1:1
Dead Tree	1:1

Note: DAPm10 – Average of DAPs for 10% largest DAPs for trees will be to transplantation
Source: SVMA Ordinance 26/08

For the purposes of the cost estimate, it is assumed that the DAP_{m10} of trees to be transplanted is in the range of 61-90 cm and DAP_{m10} of trees to be removed is in the range of 91-120 cm. Therefore, the compensation will be 10 seedlings for each transplanted tree to be transplanted and 21 seedlings for each tree to be failed.

d) Costs of Transplant, Failing, and Planting Seedlings

For the cost estimate of transplanting trees, failing trees and planting of seedlings, unit prices prepared by SIURB (Municipal Department of Infrastructure and Works) is used[1].

Table 8-22 Unit Price of Service and Supply of Work

Description	Unit	Unit Price (R$)
(1) Supply and planting of a tree seedling	unit	97.64
(2) Tutor and tying	unit	6.62
(3) Protector tree	unit	35.29
(4) Total price for planting tree (Total of (1) - (3))	unit	139.55
(5) Transplantation tree DAP<30 cm	unit	502.05
(6) Transplantation tree DAP>30 cm	unit	3,661.33
(7) Cut trees with DAP<30 cm	unit	50.20
(8) Cut trees with DAP>30 cm	unit	366.10
(9) Handy man	hour	8.87
(10) Agronomist or Forest Engineer	hour	95.34
(11) Water truck	hour	88.69
(12) Light vehicle	hour	23.48

Source: SIURB, July 2009

e) Maintenance Works and Replacement of Dead Seedlings

For the sound development of planted seedlings, it is necessary to conduct frequent maintenance, involving the watering in very dry periods, the replacement of trees that had died or suffered from vandalism.

It is assumed that the replacement of trees was considered for a loss of about 20% of planted seedlings.

To carry out the maintenance works, provision of the following human and material resources was considered:

- 1 Agronomist or forestry engineer;
- 2 handy man;
- 1 water truck with driver;
- 1 light vehicle for the transportation of materials and people.

For the purposes of cost estimate, it is considered that minimum 6 month-period is required to perform the maintenance work.

2) Estimate of Quantity of the Services

a) Number of trees to be transplanted and failed

The following tables show the estimated total number of trees that will be affected in each routes of the Project.

[1] The reference works for the city's public and are available the link below
http://portal.prefeitura.sp.gov.br/secretarias/infraestruturaurbana/tabela_de_precos/0023

Table 8-23 Estimated Number of Trees Affected in each Proposed Route

Route	Native species		Exotic Species		Total		Grand Total
	DAP <30 cm	DAP >30 cm	DAP <30 cm	DAP >30 cm	DAP <30 cm	DAP >30 cm	
Line-1	50	10	19	15	69	25	94
Line-2A(MB)	41	6	16	14	57	20	77
Line-2A(AD)	50	8	30	20	80	28	108
Line-2B	766	91	218	65	984	156	1,140
Line-2C	472	98	269	162	741	260	1,001
Line-2D	638	73	116	346	754	419	1,173

Source: JICA Study Team

Table 8-24 Estimate Number of Trees in each Proposed Route for Transplant, Cutting and Compensation

Route	Affected Trees	Transplanted Trees	Suppressed trees	Compensation
Line-1	94	85	9	1,039
Line-2A(MB)	77	69	8	858
Line-2A(AD)	108	97	11	1,201
Line-2B	1,140	1,026	114	12,654
Line-2C	1,001	901	100	11,110
Line-2D	1,173	1,056	117	13,017
Total (in case of Line-2A(MB))	3,485	3,137	348	38,678
Total (in case of Line-2A(AD))	3,516	3,165	351	39,021

Source: JICA Study Team

b) Estimated Costs of the Transplants, Cut and Compensatory Plantations

The following table summarizes the cost calculations for transplantation and failing of trees affected in each routes of the Monorail Project and the costs of compensatory planting required.

Table 8-25 Preliminary Cost Estimates for Removal of Roadside Trees

Route	Transplantation DAP<30 cm		Transplantation DAP>30 cm		Cut DA P<30 cm		Cut DAP >30 cm		Compensation		Conservation		Total Cost (R$)
	No of Trees	Unit Price	No of Trees	Unit Price	No of Trees	Unit Price	No of Trees	Unit Price	No of Trees	Unit Price	No of Trees	Unit Price	
Line-1	62	502.05	23	3,661.33	6	50.2	3	366.1	1,039	139.55	1,133	10.08	273,150.28
Line-2A(MB)	51	502.05	18	3,661.33	6	50.2	2	366.1	858	139.55	935	10.08	221,700.59
Line-2A(AD)	72	502.05	25	3,661.33	8	50.2	3	366.1	1,201	139.55	1,309	10.08	309,975.02
Line-2B	886	502.05	140	3,661.33	98	50.2	16	366.1	12,654	139.55	13,794	10.08	2,873,088.92
Line-2C	667	502.05	234	3,661.33	74	50.2	26	366.1	11,110	139.55	12,111	10.08	2,877,331.35
Line-2D	679	502.05	377	3,661.33	75	50.2	42	366.1	13,017	139.55	14,190	10.08	3,699,912.11
Total (in case of Line-2A(MB))	2,345	-	792	-	259	-	89	-	38,678	-	42,163	-	9,945,183.25
Total (in case of Line-2A(AD))	2,366	-	799	-	261	-	90	-	39,021	-	42,537	-	10,033,458

Source: JICA Study Team

8.7 ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN (EMMP)

It is very important to formulate an environmental management plan to adopt appropriate measures such as the proposed preliminary mitigation measures mentioned in the section 8.4.7. An environmental monitoring plan should be also prepared to confirm effects of implemented mitigation measures and unpredicted impacts arisen after implementing the Project. In this section, the required contents of Environmental Management and Monitoring Plan (EMMP), which were prepared based on Brazilian legislation system and experiences of the past projects, and proposed to SPTrans, are described.

8.7.1 Objectives of EMMP

The Environmental Management & Monitoring Plan (EMMP) include all activities related to the environmental management, supervision and monitoring of construction phase as well as operation phase with regard to the environmental guidelines and standards specified by concerned laws and regulations. The definition and the content of the Environmental Management & Monitoring Plan (EMMP) will be decided within the scope of the EIA through discussions with authority concerned. This chapter presents basic recommendations on activities to be included in EMMP with reference to the previous similar cases and concerned laws and regulations.

The overall objectives of the Environmental Management & Monitoring Plan (EMMP) for the Project are as follows:

- To ensure compliance with all environmental laws and regulations by taking necessary steps and procedures required;

- To control and monitor the environmental activities proposed in the Environmental Impact Assessment Report(EIA/RIMA) that are detailed in the Basic Environmental Plan (PBA), and to ensure that its implementation meets the goals and the deadlines; and

- To coordinate and supervise all concerned activities involved in the environmental management of the Project, anticipating the actions in relation to prevent, reduce and mitigate the environmental impacts.

8.7.2 Major Modules and Components

The Environmental Management & Monitoring Plan (EMMP) is required to have at least three modules covering activities for environmental licensing, environmental management, environmental control and environmental monitoring. These modules are not independent but interrelated; therefore appropriate coordination is important to ensure efficient and effective results. Suggested module names and their main components are as follows:

Module Name	Main Components
1. Environmental Licensing	1. Preliminary Environmental License (LAP) 2. Installment Environmental License (LAI) 3. Operation Environmental License (LAO)
2. Environmental Management and Control	1. Training and Awareness Raising of Workers 2. Control of Occupational Health and Work Safety 3. Transplantation and Cutting of Trees and Transportation of Timber and Plant Debris 4. Erosion and Sedimentation Control 5. Recovery of Degraded Areas by Construction 6. Control Traffics and Heavy Machinery during Construction 7. Control of Dust Formation 8. Control of Noise Emission 9. Risk Management and Support to Environmental Emergencies during Construction
3. Environmental Monitoring	1. Noise and Vibration 2. Air quality 3. Water quality

8.7.3 Responsible Parties for Execution

(1) Hiring of Consultants

SPTrans as the project proponent will have overall responsibility through the environmental division. However, for the technical support on the environmental management and monitoring of the construction as well as operation, SPTrans is planning to employ consulting firms.

Preparation Phase

For the preparation phase of environmental management and monitoring, in many cases, two employments are necessary; 1) to prepare the EIA/RIMA, which is required to obtain the Preliminary Environmental License (LAP), and 2) to implement studies and to prepare documents necessary for obtain the Installation Environmental License (LAI), usually consolidated in a document called the Basic Environmental Plan (PBA).

Construction and Operation Phases

For the construction and operation phases, employment of structured team with technical expertise to oversee and manage the implementation of proposed environmental activities in EIA and also to supervise the construction to verify the adoption of environmental measures and procedures by the construction contractors is nessesary. The adoption of environmental measures and procedures by the construction contractors is closely related to the procedure for obtaining the Operation Environmental License (LAO).

(2) Role of SPTrans

SPTrans will manage consulting works. Based on the reporting by the hired consultant on environmental management and monitoring, SPTrans will instruct measures for improvement of operation of the Project as necessary. SPTrans will also submit reports on environmental management and monitoring to related administrations such as SVMA, and get required environmental permissions. Dissemination of environmental management activities and environment monitoring results is another important task.

(3) Example of Consultant Team

An example of a consultant team for EMMP is shown below.

Module	Task	Expert
1. Acquisition of environmental license	Involuntary resettlement	Social experts
	Environmental monitoring	Chemical engineer Environmental engineer
	Remote sensing and GIS	Geographical engineer
	Traffic plan	Civil engineer
	Risk management and emergency response	Chemical engineer Mechanical engineer
2. Environmental management and control	Environmental management in construction sites	Civil work engineer Environmental engineer
	Removal and transplanting of roadside trees	Forestry expert Agricultural engineer
	Noise and vibration, and dust monitoring	Environmental engineer
	Air quality monitoring	Chemical engineer
	Water quality monitoring	Chemical engineer
	Securing of sanitation, health, safety of construction sites	Sanitation and safety engineer
3. Environmental monitoring	Noise and vibration montioring	Environmental engineer (noise and vibration)
	Air quality monitoring	Chemical engineer (air quality analysis)
	Water quality monitoring	Chemical engineer (water quality analysis)

8.7.4 Module 1: Environmental Licensing

(1) Objectives of the Module

This module contains the supporting activities for obtaining all necessary environmental permits and licenses by preparing all required technical documents with regard to the procedures and conditions set by concerned laws and regulations. The specific objectives are as follows:

- To create enabling environment in construction as well as in operation for implementing activities which are related to environmental permits and licenses; and

- To bring and coordinate all technical documents together to meet the requirements of Preliminary Environmental License (LAP), Installment Environmental License (LAI) and Operation Environmental License (LAO) with regard to the procedures and conditions set by the DECONT/SVMA and CADES.

(2) Main Components

Under above objectives, the main components are as follows:

1) Preparation of environmental management tools such as:

- general schedule for contracting and implementation of environmental activities,

- Terms of Reference for contracting companies and / or consultants for the implementation of specific environmental activities,

- A database with information on the studies, the progress and results of environmental activities; and

- monthly environmental management reports;

2) Preparation of necessary documents to obtain permission for interventions in watercourses, as provided in the Ordinance 717/96 of DAEE, in case crossings and channeling.

3) Preparation of the Deviation of Traffic following the guidelines by the state Traffic Engineering Company (CET).

4) Elaboration of the Emergency Action Plan (PAE) and Risk Management Plan (PGR) for the construction phase of the Project. The plans should be prepared in accordance with the guidelines of CETESB.

5) Preparation of technical document for obtaining the Operation Environmental License (LAO), which includes photographic records completed and the demonstration of compliance with all requirements and recommendations contained in Installment Environmental License (LAI).

8.7.5 Module 2: Environmental Management and Control

(1) Objectives of the Module

Most of the environmental impacts of the Project are associated with the construction phase, so it is necessary to adopt construction procedures and measures aimed to prevent or

effectively reduce the environmental impacts on surrounding environment. Specific objectives are as follows:

- To monitor and supervise daily activities of the construction to verify the effective adoption of measures and procedures aimed at prevention, control and remediation of environmental impacts;
- To establish environmental guidelines and procedures for the implementation of environmental activities to ensure appropriate environmental conditions in the directly affected areas of the Project; and
- To guide the construction contractors to adopt measures and care required to effectively prevent and control the potential environmental impacts identified.

(2) Main Components

1) Environmental Training and Environmental Awareness Raising of Workers

All workers of the construction should receive training and environmental education on the measures, care and procedures to be followed during construction in order to avoid and mitigate possible negative impact. The training and environmental education should provide information regarding the following subjects:

- The relevant aspects of environmental legislation;
- Fire prevention;
- Procedures for emergency situations (accidents, fire, etc.);
- Care of the fauna and flora;
- Care of the historical and archeological heritages;
- Collecting, packing, storage and disposal of solid waste;
- Information on venomous animals and plants;
- Use of safety equipment;
- Prevention and control of erosion; and
- Prevention of pollution and contamination of water.

2) Control of Occupational Health and Work Safety

The construction contractor must meet all requirements of legislations relating to work safety and occupational health. For structuring necessary programs, the Regulatory Norms (NRs) of the Ministry of Labor and Employment should be adhered[5]. Specific programs and services required are as follows:

- the Program for Medical Control of Occupational Health (PCMSO)
- the Environmental Risk Prevention Program (PPRA)
- the Specialized Services in Safety Engineering and Work Medicine (SESMT)

[5] Detailed information is available at “http://www.mte.gov.br/legislacao/normas_regulamentadoras/default.asp”.

- the Internal Commission for the Prevention of Accidents (CIPA)

PCMSO and PPRA should be prepared in accordance with the Regulatory Norms NR-7 and NR-9, respectively. SESMT should be organized and retained in accordance with the Regulatory Norm NR-4 and will be designed to promote health and protect the integrity of the worker in the workplace. The SESMT should be composed of technicians, nurses, engineers and occupational physician, in sufficient number according to the degree of risk and number of employees. The construction contractor should structured the CIPA in according to Regulatory Norm NR-5, which will aim to prevent accidents and illnesses resulting from work.

In case that risk of infection diseases such as HIV/AIDS should be examined, required measures to improve health management and sanitation condition should be included in the programs and services mentioned above. Measures for preventing infection should be implemented for construction workers, such as spread of necessary knowledge by trainings and awareness raising. As necessary, these activities would be implemented for local residents around construction sites.

3) Transplantation and Cutting of Trees, and Transportation of Timber and Plant Debris

For transplantation and cutting trees, the Project proponent needs to follow the guidelines and the conditions set by SVMA. The main guidelines are described in Capter :

4) Erosion and Sedimentation Control

Most of monorail construction will be along existing roads and the construction will not require large amount of soil movements. Therefore, special attentions should be made for the construction of stations and depots, which may involve significant movement of soil.

The procedures for environmental control of the earthworks and the drainage include prevention, mitigation and corrective measures to control erosion and sedimentation, shall be applied not only in front of the main construction, but also in areas of soil lending, depositing of surplus materials and temporary storage. Among others, should be provided the following guidelines:

- Minimize the areas with exposed soil.
- Protect the exposed soil and / or installation of measures to retain sediment;
- Implement temporary drainage devices to allow water to drain away without erosion and carrying of soil materials;
- Correction or stabilization in the shortest possible time all the soils encountered in the excavation area;
- Constant cleaning and maintenance of the installed sediment restraint;
- Deploy appropriate devices for the protection of waterways in places where services will be held near the channels and / or watercourses.

5) Recovery of Degraded and Altered Areas

At the end of the construction, all areas used during construction should be thoroughly cleaned and restored, if necessary, vegetated. Major measurements to be taken by the Project are:

- To make a clean sweep of all the affected areas, including the removal of construction debris, rubble, and other contaminated materials. All materials from the cleaning and demolition to release the area of the construction should be referred for final disposal sites suitable and licensed.

- The roads used for the construction should be returned to normal, at least in terms of use consistent with its position before the start of the construction. According to the situation, services may be necessary to recover the pavement, sidewalks and drainage system.

- Removal of signs used in construction, resettlement and restoration of normal signaling of pathways.

6) Control of Traffics and Heavy Machinery during Construction

The plan for control traffics and heavy machinery should include the temporary diversion and / or narrowing of lanes and their respective signaling so as to ensure the execution of the construction without jeopardizing the safety of the road.

In addition to the control of ordinal traffics around construction sites, it should be developed a traffic plan, which includes the paths for transporting heavy machineries, construction materials, soils and so on, and time and movement restrictions.

7) Control of Dust Formation

To avoid dust formation, which causes discomfort to road users and residents near the construction sites, the construction constructor should provide a constant watering as well as regular washing of the affected roads.

8) Control of Noise Emission

To minimize noise emission, the vehicles and equipment to be used in the construction sites should have regular maintenance to eliminate mechanical problems for noises. The maintenance should have emphasis on the machines that produce excessive noise such as compressors, chainsaws and hammers. The operation of the work sites should be guided for minimum noise generation, requiring of the workers to respect operation hours, so as not to give stress to the nearby residents.

8.7.6 Module 3: Environmental Monitoring

(1) Objectives of the Module

The monitoring is important to understand changes on the environmental quality resulting from the construction and operation of the Project. The monitoring is primarily done by daily inspections of works including qualitative assessment of environmental damages such as the generation of noise, dust formation, emission of black smoke, pollution of water courses by any effluent the construction site, etc. In addition, the monitoring program includes periodic monitoring of noise, vibration, air quality and water quality. The specific objectives for both construction and operation phases area as follows:

Construction Stage:

- To know the changes in the parameters monitored whether reaching higher levels than the standards established by the concerned legislations, and

- To propose adjustments to the construction procedures and / or the adoption of additional measures to avoid and mitigate identified impacts.

Operation Stage:

- To check that the monorail operation generates only little noise and vibration as those were expected; and

- To verify the reduction of air pollution level and noise level in relation to the previous traffic mode.

(2) Main Components

1) Noise and Vibration Monitoring

Monitoring Targets

Construction Stage: The noise monitoring is intended to verify that the Project does not generate noise, which exceeds the standards set out in Brazilian law, specifically NBR 10151. In the case of vibration, there is not yet established any legislation, so it is recommended to adopt the criteria used by CETESB, which consider the vibration limits according to the type of occupation and the period.

Operation Stage: Monorail train is powered by electric motor with rubbers tire which produce little noise and vibration without emission. The monitoring during operation is intended to confirm the low level of noise and vibration generated by the monorail as those were expected. Also, the monitoring is important to make necessary decision for adjusting operation in case substantial level of noises and vibration are identified.

Monitoring Points

In the preparation of EIA/RIMA, monitoring points will be chosen for both construction and operation phases. In principle, the monitoring points should be chosen from the points where noise and vibration produced by the Project may result in greater impact (i.e., residential areas, and critical receptors, such as hospitals, schools).

Construction Stage: For EIA of the Project, it is recommended to have three to six points on each route depending on the length of the lines situation based on existing monitoring plans in similar projects. Additionally, all stations and depots should be monitored. The amount of points according to the routes being studied is as shown in the table below.

Table 8-26 Table Suggested Monitoring Points for Noise and Vibration

Route	Street points critical receptors	Stations and depots	Total of monitoring points
Line-1	3	6	9
Line-2A	4	11	15
Line-2B	6	14	20
Line-2C	3	9	12
Line-2D	6	13	19
Total	22	53	75

Source: JICA Study Team

The measurement should be performed in front of works, especially in residential areas and/or near of critical receptors.

Operation Stage: In the initial stage of the operation, the number of monitoring points

and their locations shall be equal to that considered in the EIA preferably. However, with technical justification, these points may be reduced, and these locations may be changed.

Monitoring Parameters

For the statistical analysis of noise data obtained, following three indexes are applied:

- LAeq (equivalent continuous) - the benchmark for the legal case in question;
- L90 (background noise - noise level exceeded 90% of the time);
- L10 (maximum noise level - noise that is exceeded in 10% of the time).

For the statistical analysis of vibration data obtained, the following index is applied:

- L10 (maximum vibration level – vibration level that is exceeded in 10% of the time).

The noise measurements should be performed in accordance with the determinations of the Regulatory norm NBR 10151. The instrument for measurement of noise level to be used should be calibrated and submit Certificate of Calibration performed by laboratory belonging to the RBC - Brazilian Network of Calibration / INMETRO. Besides the noise level, measurements on the vibrations induced by the use of construction machinery and monorail train are important. Sampling duration should be not less than 10 minutes.

Monitoring Frequency and Schedule

Construction stage: One measurement should be made in EIA study. The results serve as references for the verification of changes in noise levels and vibrations caused by the Project. During construction, at least one measurement should be completed in each construction sites. Additional measurement should be carried out whenever need arises during construction work causing significant level of noise such as piling. The measurements should be carried out during the opening hours of work. At each monitoring point, sound/vibration level measurements should be done with a period of a minimum of 10 minutes, since it has the value of Leq stabilized.

Operation stage: Before starting operation, one measurement should be done for obtaining references. A series of inspections should be made every six months for the first year (two times). Each measurement should be done three times a day, in the early morning, mid afternoon and at night.

2) Air Quality Monitoring

Monitoring Targets

The air quality depends on the sources of pollution in the area and weather conditions present at every moment. So to have precise understandings of air quality of the region, it is important to make continuous measurements for a long time so that variations in the concentrations of pollutants associated with changes in climatic conditions can be properly identified. It should have verification of air quality standards based on the Brazilian legislation, the CONAMA Resolution No. 003/90.

Monitoring Points

In principle, the measuring points should cover residential areas and sensitive locations such as hospitals, nursing homes, schools, etc. Monitoring points will be decided in the

preparation of EIA/RIMA.

CETESB is the contractor responsible for monitoring air quality throughout the state of São Paulo, which has a network spanning the major cities of the state. In the metropolitan area of São Paulo, CETESB maintains an automatic monitoring network with 21 stations, and 13 stations are located in São Paulo city. Some of these stations are located near the Project area, such as: Santo Amaro (lines 2A / 2B), Pinheiros (lines 2B / 2C / 2D), IPEN / USP (line 2D).

The results of the CETESB monitoring will be very useful for monitoring temporal variations of air quality in mid-long term basis. In contrast, following monitoring points are proposed to establish parameters for a specific analysis of changes associated with the Project.

Construction stage: For the EIA, it is recommended to have on the stations and depot based on existing monitoring plans in similar projects. The amount of points according to the routes being studied is as shown in the table below.

Table 8-27 Suggested Monitoring Points for Air quality

Route	Stations and depots	Total of monitoring points
Line-1	6	6
Line-2A	11	11
Line-2B	14	14
Line-2C	9	9
Line-2D	13	13
Total	53	53

Source: JICA Study Team

During the construction, the measurement of the air quality should be performed in front of works in construction sites, where they are located in residential areas and/or critical receptors.

Operation stage: In the stage of operation, monitoring will be designed to evaluate possible reduction in the concentration of parameters due to the reduction of traffic volume and the consequences. Initially the number of monitoring points will be equal to that considered in the EIA and, preferably, in the same locations. However, with technical justification on monitoring methodology, these points may be altered.

Monitoring Parameters

The parameters to be investigated are the following:

TSP(Total Suspended Particulates (size range <100 microns)), PM_{10}(Inhalable Particulate (size range <10 microns)), SO_2(Sulfur Dioxide), NO_2(Nitrogen Dioxide), CO(Monoxide), O_3(Ozone), Wind Speed and Wind Direction

Monitoring Frequency and Schedule

Construction stage: During the construction period, at least one measurement should be done with duration as established by CONAMA Resolution Nº 03/90.

Operation stage: Before starting operation, one measurement should be done for obtaining references. During the operation, measurement should be done every 6 months

in the first year (two times).

3) Water Quality Monitoring

Monitoring Targets

Construction stage: During construction, Monitoring of water quality should have emphasis on controlling sediment. All sewage should be connected to the public sewage network operated by SABESP (São Paulo state's Basic Sanitation Company) or adequately addressed when there isn't network available nearby.

Operation stage: During the operation, the waste water from stations and the depot, where there will be facilities for maintenance and washing trains, should be monitored primarily. It is confirmed that in all sites intended for stations and depot are available for sewage network of SABESP to be connected to the public sewage treatment facilities.

To suit the parameters required by the law (Articles 19A and 19B of the São Paulo State Decree 8468/76), it is recommended to have a pre-treatment facility for the effluent water from maintenance workshops and washing facility of trains before they go into the public sewage network.

Monitoring Points

CETESB is responsible for monitoring water quality throughout the state. The routes have several crossings of watercourses, and Guarapiranga channel, Pinheiros river, and Tiete river. Among watercourses in São Paulo city, only the Pinheiros river and the Tiete river have monitoring point of CETESB, and the results of the monitoring can be used for understanding mid-long temporal variations of water quality and potential impact during construction and operation.

In addition to these permanent monitoring points, special measurement should be done by different ways in construction and operation phases.

Construction stage: All crossings of major watercourses (approx width is more than 2 m) should be monitored. In each monitoring point, one sampling in upstream and another sampling in downstream should be taken.

Operation stage: Monitoring should be implemented on the effluent of the pre-treatment plant in the depot.

Monitoring Parameters

Construction stage: The parameters to be monitored in major watercourses during the period of the construction are as follows. These are indicated in Article 19A of the São Paulo State Decree Nº 8468/76.

pH, water temperature, and dissolved oxygen (DO), turbidity, suspended solids (SS), biochemical oxygen demand (BOD), flow rate, velocity, and groundwater level

Operation stage: In the case of pre-treated effluent for release in the sewage network, the parameters are those provided in Article 19A of the São Paulo State Decree Nº 8468/76 or as may be required by SABESP. The parameters provided in this article are as follows:

pH, settleable material (Imhoff cone), oils and greases, substances are soluble in hexane, solvents and flammable substances, substances that cause obstruction of pipes, toxic's

substances disturbing biological processes sewage treatment, arsenic , cadmium, lead, copper, chromium, mercury, silver, selenium, total chromium, zinc, tin, nickel, cyanide, phenol, soluble iron, fluoride, sulfide, sulfate and groundwater level (in case of massive groundwater usage during operation stage).

Monitoring Frequency and Schedule

Construction stage: In the construction phase, it should be held at least one series of inspections in each point. Turbidity should be monitored whenever need arises during construction work with excavation.

Operation stage: In the case of pre-treated effluent in the depot, the frequency will be monthly or as may be required by SABESP and/or CETESB.

8.8 PUBLIC CONSULTATIONS

Public consultation and participation in planning and implementing the project is recommended to follow JICA guidelines. The guidelines require consultation with affected groups and local NGOs as part of the EIA report preparation process. Information dissemination is a necessary precondition for consultation and participation.

8.8.1 Types of Public Consultation

Consultation can solicit views of stakeholders on proposed mitigation measures to engage them in a dialogue. While information dissemination is one way communication, consultation is characterized by two-way communication, from project proponents to stakeholders, and from stakeholders to project proponents. Although decision-making authority is retained by the project proponent, interaction with people allows affected populations to influence the decision making process. Public consultation should be considered in scoping; project design; mitigation, monitoring and management plans; and the analysis of alternatives.

Consultation with affected populations during two stages of the EIA process is generally recommended: (1) during EIA scoping, and (2) once a draft EIA has been prepared. Consultation for EIA should be linked to consultation on social issues as well.

(1) Consultation during EIA Scoping

Consultation during EIA scoping is useful to identify key issues and to develop EIA Terms of Reference (ToRs). JICA Guidelines for Environmental and Social Considerations recommends that other government departments, local NGOs and affected groups participate in the discussions that lead to preparation of ToRs for the EIA. In addition to the consultation during EIA scoping, consultation during EIA report preparation can help avoid misconceptions to enhance stakeholder's acceptability. Also, the consultations provide the EIA consultants with important information for the mitigation plan.

(2) Consultation for Draft EIA Report

Consultation on the draft EIA report is one of the most important elements of the EIA process, and it is mandated by JICA Guidelines for Environmental and Social Considerations. Affected populations to be consulted should be given sufficient time to review and prepare comments on the draft EIA report before actual consultation takes place. Since affected populations are non-specialist, a combination of seminars, written materials, and visual presentation are useful to help them understand the situation. The findings from these consultations can give feedbacks in further project preparation and implementation.

8.8.2 Important Features for Effective Public Consultation

For effective consultation with publics, following aspects should be considered:

1. At the start of the consultation process, making clear agreement on what, when, who, where and how of the consultation process, encourages respect and trust among the participants.

2. Wide dissemination of information before consultation begins is very important to give sufficient time to review understand and prepare comments on the EIA process or on draft EIA report.

3. To make individuals and groups feel free to talk frankly, the setting for the consultation should create appropriate surroundings to gain respect, familiarity and trust. For example, using interviewers familiar with the local situation, holding meetings in community halls rather than bringing people to places they may be unfamiliar with, or holding separate meetings for those that are poorer than the rest of the groups, can help withdraw real feeling on the Project.

8.8.3 Suggested Outline for the Public Consultation Meeting for EIA

As discussed previously, in accordance with JICA Guidelines for Environmental and Social Considerations, public consultation meeting is recommended in order to secure transparency in decision making process, and to ensure involvement of stakeholders in planning, execution and monitoring of the Project. Brazilian laws and legislations concerned also require public consultation meeting in the process of EIA.

Suggested outline for the public consultation meeting for EIA is described below. It is recommended to hold a meeting after draft scoping to reflect stakeholders' recommendations on ToR of EIA, in addition to a meeting to discuss draft EIA report. The concerned route /area for each meeting and the total number of meetings to be held for the EIA of the Project will be decided in the process of EIA by consultation with SPTrans, SVMA and CADES.

Table 8-28 Suggested Outline for the Public Consultation Meeting for EIA

	First Meeting (EIA)	Second Meeting (EIA)
Objectives	To consult stakeholders on draft Scoping Table	To consult stakeholders on draft EIA report (EIA/RIMA)
Scheduled Timing	After the preparation of draft Scoping Table	After the preparation of draft EIA report (EIA/RIMA)
Agendas for the Meeting	Presentation on the project outlines Explanation and consultation on draft Scoping Table and draft ToR for EIA Study Explanation and consultation on foreseeable environmental/social impacts	Presentation and consultation on the results of EIA study Presentation and consultation on the Environmental Management and Monitoring Plan Presentation and consultation on the Environmental Compensation Programs
Prospected No. of Participants	Approximately 100 people	Approximately 200 people
Stakeholders*	Project Executing Bodies (e.g., SPTrans, SMT) Municipal Government Bodies (e.g., SMDU, SEHAB, SEMPLA) Environmental Licensing Bodies (e.g., SVMA, IBAMA, IPHAN) Affected People (Including illegal occupants) NGOs, representatives of communities, etc.	Project Executing Bodies (e.g., SPTrans、SMT) Municipal Government Bodies (e.g., SMDU, SEHAB, SEMPLA) State Government Bodies (e.g., SEMA, STM) Environmental Licensing Bodies (e.g., SVMA, IBAMA, IPHAN) Affected People (Including illegal occupants) NGOs, representatives of communities, etc.
Concerned Route /Area and Place of the Meeting	To be discussed with SPTrans	
Public Notification	Invitation to individuals, public notification on newspaper etc.	

Note: SEHAB-Municipal Secretary of Habitations, SEMPLA-Municipal Secretary of Planning, SNJ-Municipal Secretary of Legal Affaires, SVMA-Municipal Secretary of Green and Environment, IBAMA-Brazilian Institute for Environmental and Renewable Natural Resources, IPHAN-National Institute for Historical and Artistic Heritages, SEMA-State Secretary of Environment, STM-State Secretary of Transport for Metropolitan Region

Source: JICA Study Team

8.8.4 Suggested Outline for the Public Consultation Meeting for RAP

Brazilian laws and regulations concerned expropriation of land or resettlement of people do not require to prepare Resettlement Action Plan (RAP) separately from EIA, and hence, public consultation meeting for expropriation of land or resettlement of people is not compulsory. Under the legislation system, issues to be included in RAP are required to be discussed in EIA process. However, considering some of EIA stakeholders do not relate with land acquisition and involuntary resettlement, and RAP should be discussed sufficiently, it is recommended to hold public consultation meetings focusing on RAP separately from the meetings for EIA during draft RAP preparation phase. Suggested outline for the public consultation meeting for RAP is described below.

Table 8-29 Suggested Outline for the Public Consultation Meeting for Resettlement Action Plan

	First Meeting (RAP)	Second Meeting (RAP)
Objectives	To consult stakeholder on the draft RAP	To consult stakeholders on the revised RAP which reflects the results of the first consultation meeting
Scheduled Timing	After the preparation of draft RAP	After the preparation of revised RAP
Agendas for the Meeting	Presentations on the project outlines Explanation and consultation on foreseeable environmental/social impacts and measures to be employed for their compensation Explanation and consultation on draft RAP	Explanation and consultation on the changes from previous version of RAP Discussions for further modifications and additions on RAP
Prospected No. of Participants	Approximately 100 people	
Stakeholders*	Project Executing Bodies（i.g., SPTrans, SMT） Municipal Government Bodies (i.g., SEHAB, SEMPLA, SNJ, SVMA) Affected people for expropriation of land or involuntary resettlement（including illegal occupants） NGOs, representatives of communities, etc.	
Concerned Route /Area and Place of the Meeting	To be discussed with SPTrans	
Public Notification	Invitation to individuals, public notification on newspaper etc.	

Note: SEHAB-Municipal Secretary of Habitations, SEMPLA-Municipal Secretary of Planning, SNJ-Municipal Secretary of Legal Affaires, SVMA-Municipal Secretary of Green and Environment
Source: JICA Study Team

Appendix 1-1

Legal and Institutional System on Environmental and Social Considerations at Federal and State Levels

1. NATIONAL ENVIRONMENTAL POLICY

The Law No.6938 as of 31/08/1981 sets forth the National Environmental Policy, its purposes, and formulation and application mechanisms, constitutes the National Environmental System (SISNAMA) and institutes the Environmental Defense Register.

It defines that the National Environmental Policy has the objective of preserving, improving and recuperating the environmental quality that is favorable to life, aiming at ensuring conditions in the Country for the socioeconomic development, for the national security interests and for the protection of human life dignity. For that, it sets forth the principles to fulfill. It sets forth that the licensing and the revision of effectively or potentially polluting activities are one of the instruments of the National Environmental Policy.

The construction, installation, expansion and operation of facilities or activities that use environmental resources, considered as effectively and potentially polluting, as well as capable of causing, under any form, environmental degradation, will depend on a previous licensing from the competent state agency, member of the National Environmental System (SISNAMA), and of the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), in supplementary character, without harming other demandable licenses. Section 4 of this Article sets forth that IBAMA is responsible for the licensing provided for in this article, in case of activities and works with significant environmental impact, at national or regional level.

IBAMA is responsible for proposing to the National Environmental Council (CONAMA) rules and standards for the implementation, follow-up and inspection of the licensing provided for in the previous article, apart from those established by CONAMA. The inspection and control of the application of environmental quality criteria, rules and standards shall be performed by IBAMA, in addition to the performance of competent state and municipal agencies.

The actions of licensing, registration, authorization, concession and permission related to fauna, flora and environmental control are the exclusive responsibility of agencies member of the National Environmental System.

Decree No.99274 as of 06/06/1990 that regulates Law 6938, among others, defines the composition of SISNAMA and sets forth the environmental licenses to issue in each stage of an enterprise.

It sets forth that the National Environmental System (SISNAMA), formed by agencies and entities of the Union, of the States, of the Federal District, of the Municipalities and by the foundations instituted by the Public Power, responsible for the environmental quality protection and improvement, has the following structure:

I. Upper Body: the Government Council;

II. Consultative and Deliberative Body: the National Environmental Council (CONAMA);

III. Central Body: the Environment Secretariat of the Republic Presidency;

IV. Executing Bodies: The Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) and the Chico Mendes Institute of Biodiversity Conservation (Chico Mendes Institute);

V. Sectional Bodies: The agencies or entities of the direct and indirect Federal Public Administration, foundations instituted by the Public Power which activities are associated to the protection of environmental quality or to those activities that regulate the use of environmental resources, as well as state agencies and entities responsible for the execution of programs and projects, and for the control and inspection of activities capable of causing environmental degradation; and

VI. Local Bodies: the municipal agencies or entities responsible for the control and inspection of activities mentioned in the aforementioned item, within their respective jurisdictions.

It sets forth that CONAMA is composed of the following:

I. General Meeting;

II. Special Appeal Chamber;

III. Committee of Environmental Policies Integration;

IV. Technical Chambers;

V. Work Groups; and

VI. Advisory Groups.

CONAMA's General Meeting, which has the responsibility of deliberating about the approval of projects and the concession of environmental licenses, among others, is formed by the State Minister of Environment (chairman), by the Executive Secretary of the Ministry of Environment (executive secretary) and by representatives from IBAMA, the National Agency of Waters (ANA), from the Ministries, from the Secretariats of the Republic Presidency, from the Military Commands, from State Governments and Federal District, from Municipal Governments and from entities representing workers, civil society, environmental entities, scientific institutions, entrepreneurial sectors, health and sanitation professionals, among others.

CONAMA is responsible to the following:

I. set forth, through IBAMA's proposal, rules and criteria for the licensing of effectively or potentially polluting activities, to be granted by the Union, States, Federal District and Municipalities, and supervised by the aforementioned Institute;

II. to determine, whenever considered necessary, the elaboration of studies on alternatives and on possible environmental consequences of public or private projects, requesting from federal, state and municipal agencies, as well as from private entities, the information indispensable for the appraisal of environmental impact studies, and respective reports, in case of works or activities that cause significant environmental degradation, especially in areas considered as national heritage;

The Public Power, in performing its control competence, shall issue the following licenses:

I. Previous License (LP), in the preliminary phase of the activity planning, containing the basic requirements to fulfill in the phases of location, installation and operation, complying with municipal, state and federal land use plans;

II. Installation License (LI), authorizing the start of the implementation, according to specifications included in the approved Detailed Design; and

III. Operation License (LO), authorizing, after necessary verifications, the start of the licensed activity and the operation of its pollution control equipment, according to the provisions of the Previous and Installation Licenses.

Except for the competence of licensing nuclear enterprises, in all other federal competence cases, IBAMA will be responsible for the issuing of the respective licenses, after appraising the technical examination conducted by state and municipal pollution control agencies.

2. ENVIRONMENTAL LICENSING

Regarding federal rules, we shall mention CONAMA resolutions 001/86 and 237/97. The first one set forth the requirement and guidelines for the elaboration and presentation of the Environmental Impact Study (EIS), and the respective Environmental Impact Report (EIR), for the purpose of obtaining environmental licenses, and the second one revised and complemented the first one.

In the State of São Paulo, the rule that sets forth the procedures for the environmental licensing is the State Secretariat of Environment (SMA) Resolution 42 as of 29/12/1994, and in the Municipality of São Paulo, it is the SVMA Administrative Rule 038/G/95.

2.1 Federal Rules

CONAMA Resolution No.001 as of 23/01/1986

This resolution sets forth the definitions, responsibilities, basic criteria and general guidelines for the use and implementation of the Environmental Impact Appraisal as one of the instruments of the National Environmental Policy. Article 1 defines what environmental impact is and Article 2 presents a list of enterprises that should get the license through the presentation of the EIS and respective EIR, among which "Railways" is mentioned. It sets forth that the environmental impact study shall obey the following general guidelines:

I. Include all technological and project location alternatives, comparing them with the hypothesis of the project non-execution;

II. Systematically identify and evaluate the environmental impacts generated in the phases of implementation and operation of the activity;

III. Define the limits of the geographic area directly or indirectly affected by the impacts, called project influence area, in all cases considering the hydrographic basin in which it is located;

IV. Take into consideration governmental plans and programs, proposed and under implementation in the project influence area, and their compatibility.

It sets forth that the environmental impact study shall develop, at least, the following technical activities:

I. Environmental diagnosis of the project influence area, with the complete description and analysis of environmental resources and their interactions, such as existent, in order to characterize the environmental situation of the area, before the project implementation, considering:

   a) the physical environment - underground, water, air and climate, highlighting mineral resources, topography, soil types and aptitudes, water bodies, hydrological regimen, sea currents, atmospheric currents;

   b) biological environment and natural ecosystems – fauna and flora, highlighting the species that indicate environmental quality, with scientific and economic value, rare and threatened with extinction, and the permanent preservation areas;

   c) the socioeconomic environment – land use and occupation, water uses and socio-economy, highlighting archaeological, historic and cultural sites and monuments of the community, the dependence relations between the local society and the environmental resources, and the potential future utilization of such resources.

II. Analysis of the project environmental impacts and its alternatives, through the identification, forecast of magnitude and interpretation of the importance of possible relevant impacts, discriminating: positive and negative (beneficial and adverse), direct and indirect, immediate and medium and long terms, temporary and permanent impacts; their degree of reversibility; their cumulative and synergetic properties; the distribution of social onus and benefits.

III. Definition of mitigating measures for negative impacts, among which control equipment and waste treatment systems, evaluating the efficiency of each of them.

IV. Elaboration of the positive and negative impacts follow-up and monitoring program, indicating the factors and parameters to take into consideration.

Sole Paragraph – Upon determining the execution of the environmental impact study, the competent state agency; or IBAMA or, when applicable, the Municipality, shall provide additional instructions when necessary, considering the project peculiarities and the environmental characteristics of the area.

Article 9 sets forth the minimum contents of the EIR and informs that such document shall reflect the conclusions of the EIS.

The competent state agency or IBAMA or, when applicable the Municipality, whenever considered necessary, shall promote the conduction of a public hearing for information about the project and of its environmental impacts, as well as for the discussion of the EIR.

CONAMA Resolution No. 237 as of 19/12/1997

This resolution provides for the revision and complementation of procedures and criteria utilized for the environmental licensing set forth by CONAMA Resolution No.001/86. It regulates some aspects that had not yet been defined, although were provided for in the National Environmental Policy. It sets forth, in a clear and detailed manner, the licensing process procedures.

Annex I of this resolution presents an expanded and more detailed list of enterprises and activities that are subject to the environmental licensing process, listing highways, railways and metropolitan ways, among others.

It also sets forth that the environmental agency has the responsibility for defining the criteria to make the license obligatory, the detailing and complementation of Annex I, taking into consideration the specificities, environmental hazards, scale and other characteristics of the enterprise or activity.

It defines that IBAMA is responsible for the licensing of enterprises and activities with significant environmental impact at national or regional level, and presents the details of such cases. Among others, it mentions enterprises located or developed in two or more States.

IBAMA shall grant the license provided for in this article after considering the technical examination conducted by environmental agencies of States and Municipalities in which the activity or enterprise is located, as well as, when applicable, the opinion report of other competent agencies of the Union, State, Federal District and Municipality involved in the licensing procedure.

IBAMA, except for its supplementary competence, can delegate to States the licensing of activity with significant environmental impact at the regional level, whenever possible standardizing the requirements.

It is the State or Federal District environmental agency responsibility to conduct the environmental licensing of enterprises and activities located or developed in more than one municipality or in conservation units under the State or Federal District domain. It is also applicable in cases when direct environmental impacts surpass territorial boundaries of one or more municipalities, and also when the responsibility is delegated by the Union to States or to the Federal District, through legal instrument or agreement.

State or the Federal District environmental agency shall grant the license provided for in this article after considering the technical examination conducted by environmental agencies of Municipalities in which the activity or enterprise is located, as well as, when applicable, the opinion report of other competent agencies of the Union, State, Federal District and Municipality involved in the licensing procedure.

The municipal environmental agency, upon hearing the competent Union, States and Federal District agencies when applicable, is responsible for the environmental licensing of enterprises and activities of local environmental impact and of those delegated to it by the State through legal instrument or agreement.

Enterprises and activities shall get the license in a single competence level, as set forth in previous articles.

The Public Power, in performing its control competence, shall issue the following licenses:

> Previous License (LP): The LP granted in the preliminary phase of the enterprise or activity planning, approving its location and conception, certifying the environmental feasibility and defining basic requirements and conditions to fulfill in the next implementation phases. The LP validity term shall be at least the term defined by the schedule of elaboration of plans, programs and projects related to the enterprise or activity, limited to 5 (five) years;
>
> Installation License (LI): The LI authorizes the installation of the enterprise or activity according to specifications in approved plans, programs and projects, including environmental control measures and other conditions, of which they constitute determining factors. The LI validity term shall be at least the term defined by the schedule of the enterprise or activity installation, limited to 6 (six) years;
>
> Operation License (LO): The LO authorizes the operation of the activity or enterprise, after verifying the effective accomplishment of the previous licenses provisions, with the environmental control measures and conditions determined for the operation. The LO validity term shall consider the environmental control plans, and shall be at least 4 (four) years and at most 10 (ten) years.

The environmental licensing procedure shall obey the following stages:

I. Definition by the competent environmental agency, with the participation of the entrepreneur, of documents, environmental projects and studies necessary for the start of the licensing process corresponding to the license to be requested;

II. Request of the environmental license by the entrepreneur, accompanied with documents, and pertinent environmental projects and studies, giving the due publicity;

III. Analysis by the competent environmental agency, member of SISNAMA, of presented documents, projects and environmental studies, and conduction of technical inspections, when necessary;

IV. Request of explanations and complementation by the competent environment agency, member of SISNAMA, a single time, as the result of the analysis of presented documents, projects and environmental studies, when applicable, with possibility of reiterating such request if the explanations and complementation are considered not satisfactory;

V. Public hearing, when applicable, according to the pertinent regulation;

VI. Request of explanations and complementation by the competent environmental agency, as the result of public hearings, when applicable, with possibility of reiterating such request if the explanations and complementation are considered not satisfactory;

VII. Issuing of conclusive technical report and, when applicable, of a legal report;

VIII. Approval or rejection of the license request, providing due publicity.

In the environmental licensing procedure, it is obligatory to include the Municipal Prefecture certificate stating that the enterprise or activity location and type comply with the applicable land use legislation and, when applicable, the authorization for the suppression of vegetation and the grant for the use of water, issued by competent agencies.

The federation entities, to perform their licensing competences, shall have their respective Environmental Councils, with deliberative nature and social participation, having in their staff or at their disposal legally qualified professionals.

2.2 State Rules

SMA Resolution No. 42 as of 29/12/1994

This resolution sets forth the procedures for the analysis of Environmental Impact Studies (EIS and EIR) within the scope of the Environment Secretariat of Sao Paulo State. According to this Resolution, in general cases, the whole licensing process (LP, LI and LO) occurs within DAIA scope, through the presentation of the PER or EIS/EIR. However, in the cases of activities or enterprises that are pollution sources, only the Previous License is obtained at DAIA, the other licenses (LI and LO) are obtained at CETESB.

Similarly, the LP of housing developments, condominiums, housing projects, with area equal or larger than 100 ha, is obtained at DAIA and the licensing continues within the scope of GRAPROHAB and CETESB.

A brief description of the agencies that take part in the environmental licensing process at the State level is presented as follows. Their participation occurs through the preparation of reports about the enterprises submitted to licensing and the issuing of specific licenses, those usually required to obtain the Installation License.

1) CETESB

The Environmental Sanitation Technology Company (CETESB), a company connected to the São Paulo State Environment Secretariat, has the responsibility of performing the control, inspection and monitoring of the State environmental quality. Therefore, it permanently performs the following activities:

- licensing and inspection of fixed sources;
- inspection of movable sources;
- monitoring of air quality, inner superficial water, groundwater and swimmability of beaches, including of the inner ones.

2) CONSEMA

Consultative and deliberative body regarding environmental issues in the State of São Paulo, integrated to the structure of the Environment Secretariat. Among other attributions, it has the responsibility for the appraisal of the EIS/EIR and for the approval of the environmental licensing of enterprises.

3) DAIA

The Department of Environmental Impact Appraisal (DAIA) is the agency of São Paulo State Environment Secretariat, connected to the Biodiversity and Natural Resources Coordination – CBRN, responsible for the processes of analysis of Environmental Impact Appraisal Studies

and of the Environmental Licensing of enterprises potentially or effectively causing significant environmental impact.

4) DEPRN

The State Department of Natural Resources Protection (DEPRN) is agency of the São Paulo State Environment Secretariat, connected to the Biodiversity and Natural Resources Coordination – CBRN, responsible for the evaluation of works, activities and enterprises that, for their implementation, need to suppress native vegetation, native tree individuals, or to carry out interventions in permanent preservation areas, issuing specific authorizations based on the forest legislation in force.

5) DUSM

Department of Metropolitan Land Use (DUSM) is the agency of the São Paulo State Environment Secretariat, connected to the Biodiversity and Natural Resources Coordination – CBRN, responsible for the licensing and inspection of enterprises and activities located in the Spring Protection Areas: housing developments and divisions, residences, commercial facilities, deforestations and earth works, street opening, industrial and mining activities, cemeteries, schools, clubs and sanitation works. DUSM, upon request, can issue the Report on Metropolitan Feasibility and License.

6) GRAPROHAB

Group of Analysis and Approval of Housing Projects in the State of São Paulo (GRAPROHAB) was restructured through the State Decree no. 52.053, as of August 13 of 2007, and has the objective to centralize and speed up State administrative approval procedures, for the implementation of land allotment enterprises for residential purposes, housing projects and condominiums, either public or private.

7) DAEE

Department of Waters and Electric Energy (DAEE), connected to the Secretary of Sanitation and Energy, is the managing agency of São Paulo State water resources.

DAEE, through the Water Resources Management Center, has the responsibility to inspect, plan, register, file and grant the use of or intervention in superficial and underground water resources.

Part I – Initial Procedures

1. In the cases provided for in art. 2 of CONAMA Resolution 1/86, the interested party shall request the environmental license, instructed with the Preliminary Environmental Report (PER), according to guidance script defined by SMA.
   1.1. In cases when the enterprise is also a pollution source, subject to CETESB license by force of the provision of the Regulation approved by Decree no. 8.468/76, the request shall also be delivered to CETESB that will forward it to SMA, with the preliminary considerations considered pertinent.
   1.2. In the other cases, the request shall only be directly delivered to SMA.
2. Upon the license request publication, any interested party can manifest in written through a request delivered to SMA, no longer than 30 days after the publication date.
3. MA, through DAIA, will analyze the PER and the written manifestations received, with possibility to:
   a) reject the license request by reason of legal or technical impediments;
   b) request the presentation of the EIS/EIR or dismiss it.
   3.1. In any of the cases, the decision will be duly explained and published, with the divulgation of the received petitions.
   3.2. In case the presentation of EIS and EIR is requested, the conduction of a Public Hearing can be requested, according to the legislation in force, no longer than 45 days after the decision publication date.
4. Then, the interested party shall submit to SMA the Work Plan for the elaboration of the EIS and EIR, which shall explain the methodology and the contents of the studies necessary to the appraisal of all

relevant environmental impacts of the Project, also considering the written manifestations referred to in item 2, as well as those made during the Public Hearing, if this is held.

4.1. The Work Plan shall be presented no longer than 180 days after the publication of the decision requesting the presentation of the EIS and EIR.

4.2. The Work Plan shall be presented no longer than 180 days after the publication of the decision requesting the presentation of the EIS and EIR.

5. Based on the analysis of the Work Plan, of the PER and of other information included in the process, DAIA will define the Term of Reference (TR), fixing the period for the elaboration of the EIS and EIR, publishing its decision.

5.1. DAIA will hear CONSEMA, before defining the TR, whenever this evokes the analysis of such Term by reason of the magnitude and complexity of the environmental impacts of the enterprise.

Part II – Revision of the EIS and EIR

6. The interested party shall present the EIS and EIR to SMA, within the period as defined in item 5.

6.1. Upon receiving EIS and EIR, DAIA will announce in the local press the start of the 45 days period for the request of Public Hearing, according to provisions of CONAMA Resolution no. 9/87, and of CONSEMA Deliberation no. 50/92.

6.2. The Public Hearing can also be held in the Capital of the State, if the impacts affect two or more municipalities, and if it is requested according to CONAMA Resolution no. 9/87.

7. EIS and EIR revision shall consider the written contributions of interested parties, send as defined in item 2 of this Resolution or presented during the Public Hearing, as well as the complementation that might be requested.

8. Upon the conclusion of the revision, DAIA will issue a report on the technical quality of the EIS and EIR, informing whether they show the environmental feasibility of the enterprise or not, and suggesting conditions of the different stages of the licensing.

Part III – Enterprise Analysis

9. Upon publication of the DAIA report abstract, CONSEMA Executive Secretariat will send the EIR and DAIA report to one of CONSEMA Technical Chambers that will analyze the enterprise, hearing the interested party, SMA technicians involved with the issue and other interested social groups.

10. Upon finishing the analysis, the Technical Chamber will issue its report, proposing the approval or rejection of the enterprise, sending it to the General Meeting of CONSEMA, through its Executive Secretariat.

11. CONSEMA, in its full composition, will analyze the Technical Chamber report, approving it, the way it was presented or modifying it, with possibility of rejecting it, having the right to making the final deliberation.

Part IV - Licensing

12. Upon approval of the enterprise by CONSEMA, SMA will issue the Previous License (LP), fixing its validity term.

13. DAIA will issue a Technical Report certifying the accomplishment of requests formulated upon the enterprise approval, sending a copy to CONSEMA Executive Secretariat.

13.1. SMA, considering the technical report, will issue the Installation License, fixing its validity term.

14. CONSEMA Executive Secretariat will inform the General Meeting about having received the technical report from DAIA, in the first meeting subsequent to receiving it, providing a copy to the counselors who ask it.

15. The same procedure set forth in items 13 and 14 will be adopted for the grant of the Operation or Activity License.

15.1. The Operation or Activity License will have included its validity term.

16. In cases when the licensing is the responsibility of CETESB, this shall perform all determinations provided for in items 13 and 15, including the determination of validity terms of licenses.

The following diagram summarizes the procedure of the environmental licenses in the state of São Paulo.

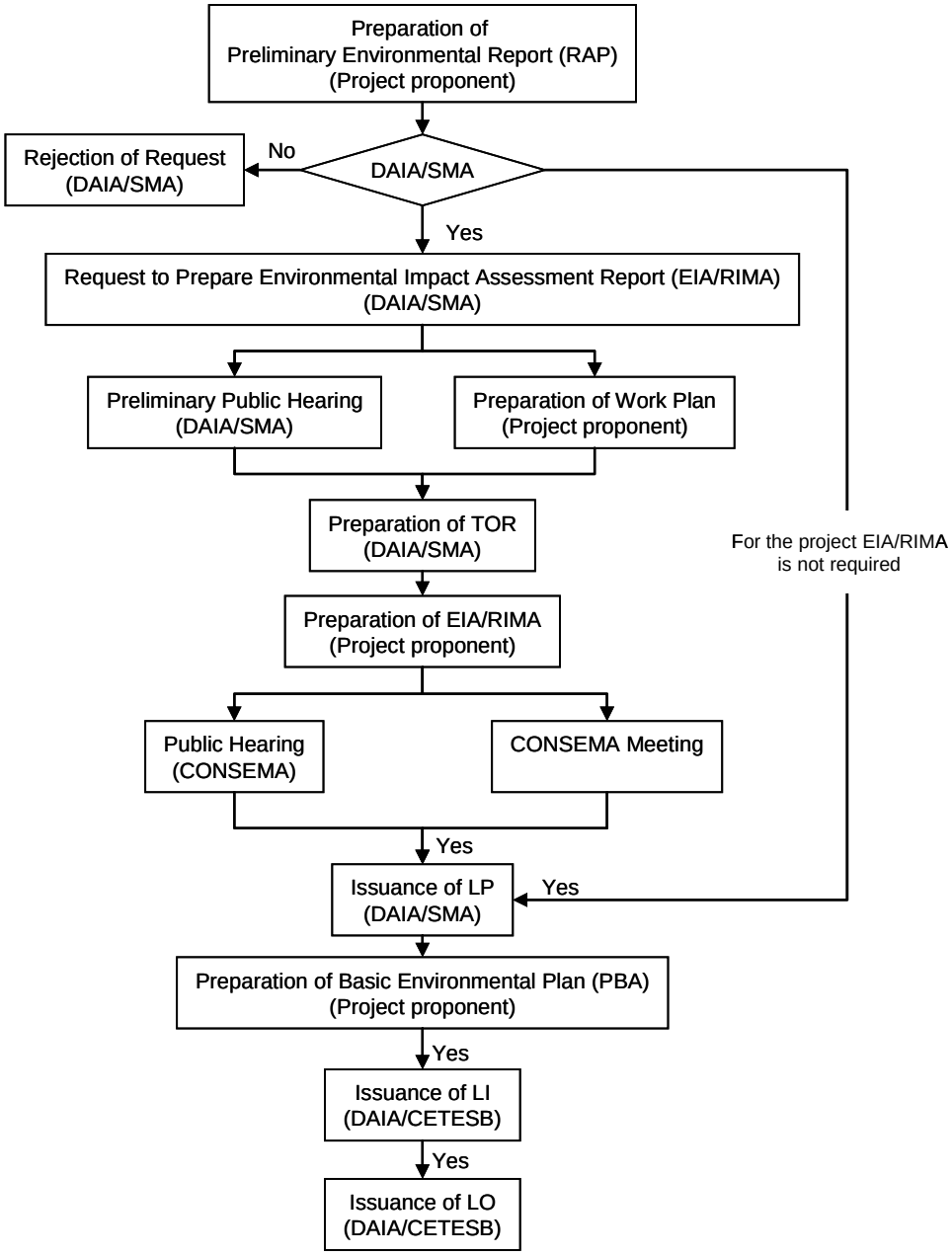


Figure Procedures of Environmental License in the State of São Paulo

Appendix 1-2

(Draft) Terms of Reference

The Environmental Impact Assessment Study for The Urban Transport Development Project in São Paulo

1. GENERAL SPECIFICATIONS

1.1 General

This terms of reference was prepared to implement the Environmental Impact Assessment Study (hereinafter referred to as the "EIA Study") for the Urban Transport Development Project in São Paulo (hereinafter referred to as the "Project"). The EIA Study shall be executed and completed by the subcontracted local consultant (hereinafter referred to as the "Consultant") under supervision of SPTrans in accordance with the specifications presented hereunder.

The EIA Study consists of the following main tasks.

(1) Environmental Baseline Study
   1) Collection and review of existing secondary data
   2) Field surveys
      a) Air quality measurement
      b) Noise and vibration level measurement
      c) Water quality measurement
      d) Soil contamination survey
      e) Inventory survey on roadside trees
      f) Measurement survey on electromagnetic field intensity

(2) Preparation of Land Acquisition and Resettlement Action Plan
   1) Collection and review of existing secondary data
   2) Field surveys
      a) Socio-economic survey
      b) Household inventory survey for resettlement
   3) Preparation of Land Acquisition and Resettlement Action Plan (LARAP)
   4) Public consultation meetings on LARAP

(3) EIA/RIMA Preparation
   1) Impact identification and assessment
   2) Examination of environmental mitigation measures and social consideration measures
   3) Preparation of environmental management and monitoring plan (EMMP)
   4) Preparation of Environmental Impact Assessment Report (EIA/RIMA)
   5) Public consultation meetings on EIA

1.2 Objectives

The main objectives of the EIA Study by each task are shown below.

(1) Environmental Baseline Study

- to collect environmental baseline information in order to identify and assess potential impacts on social/natural environment and pollution caused by the Project.

(2) Preparation of Land Acquisition and Resettlement Action Plan

- to identify settlements potentially affected by the Project including project-affected persons (PAPs) to be resettled, collect data on them, and propose necessary assistance for the PAPs to be covered in implementation of the Project.

(3) EIA/RIMA Preparation

- to identify and assess potential impacts on social/natural environment and pollution caused by the Project, and to prepare environmental management & monitoring plan (EMMP) for the necessary actions to the potential environmental impacts as well as to proposed mitigation measures.

Necessary legal procedures on the Environmental Impact Assessment (EIA) for the Project will be conducted by SPTrans as project proponent agency under the Environmental Impact Assessment (EIA) system in Brazil. Therefore, the EIA Study shall cover all requirements of EIA system in Brazil and the Ex-JBIC Guidelines for Environmental and Social Considerations (2002)[1].

1.3 Study Area

The study area for the EIA Study shall cover areas affected by the Project where differs by item of environmental and social considerations. The target railway transport route, consisting of the Lines 1, 2A, 2B, 2C, and 2D are shown in **Figure 1**. Study results shall be examined and presented for the each route. The project site consists mainly of railway track, stations, and depot. Main features of the proposed routes are shown in **Table 1**. 53 stations and 2 depots are supposed to be constructed in whole routes.

Under the EIA Study, firstly, alternative alignments shall be examined for selection of optimum alignments. Secondly, the optimal alignments and optimal project packages shall be examined in detail.

[1] JBIC Guidelines for Confirmation of Environmental and Social Considerations, April 2002.

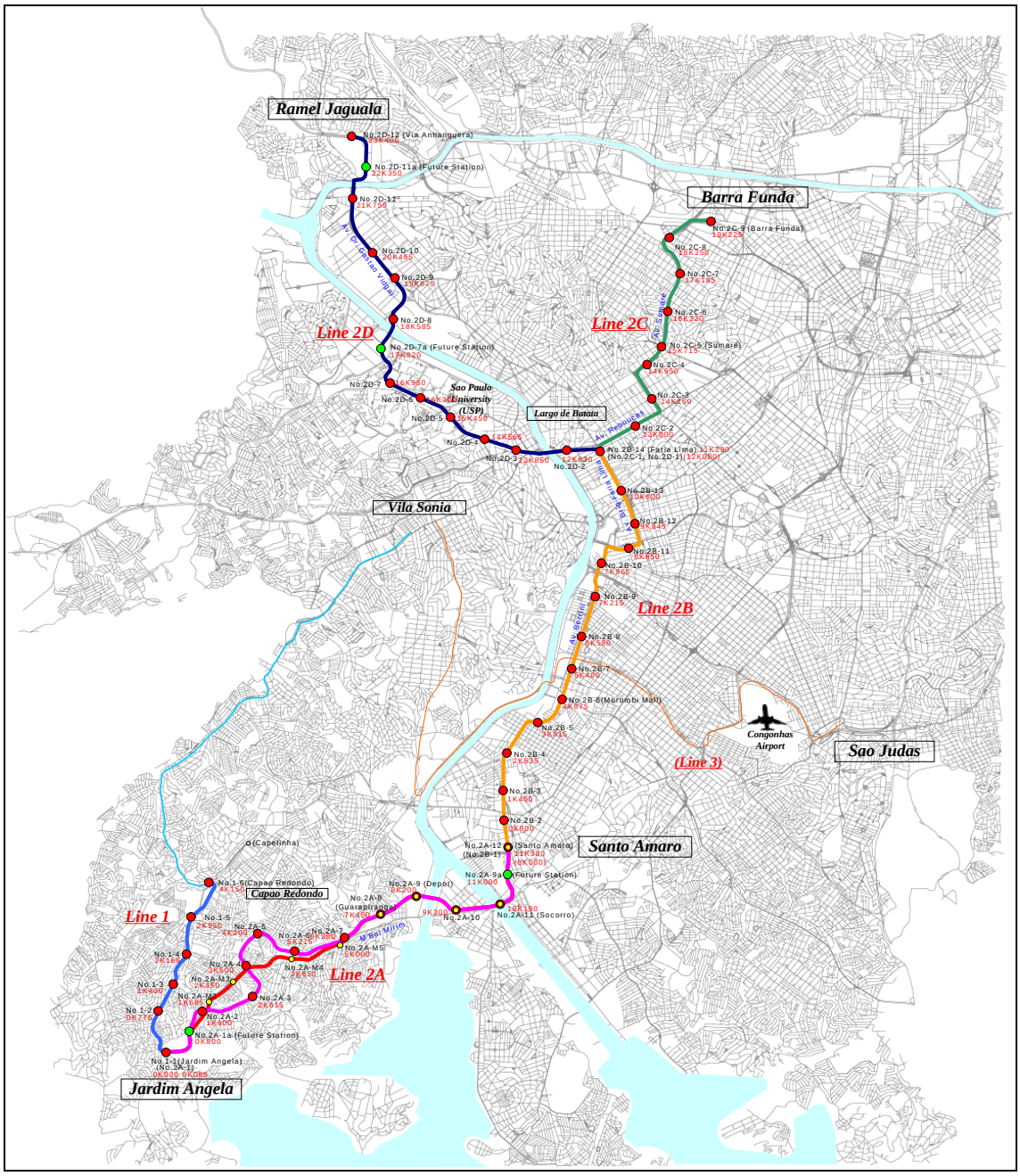


Figure 1 Study Area

Table 1 Main Specifications of the Project

Route No.	Section	Length (km)	Number of Station	Proposed Transport Mode
Line 1	Jardim Angela - Capelinha	4.150	6	Straddle-type monorail or AGT
Line 2A-mb	Jardim Angela - Santo Amaro	10.000	10	Straddle-type monorail
Line 2A-ud	Jardim Angela - Santo Amaro	11.380	12	
Line 2B	Santo Amaro - Av. Rebouças	11.290	14	
Line 2C	Av. Rebouças - Barra Funda	7.225	9	
Line 2D	Av. Rebouças - Jaguare	11.400	12	
		Total	51	In case of Line 2A-mb
			53	In case of Line 2A-ud

Note: AGT - Automated Guideway Transit

2. TECHNICAL SPECIFICATIONS

The following technical specifications were prepared by SPTrans. Before commencement of the EIA Study, a meeting on the technical specifications shall be held among parties concerned such as DECONT, CADES, SPTrans, and the Consultant, in order to fulfill requirements of the Environmental Impact Assessment (EIA) system in Brazil and then to accelerate the EIA process for the project implementation.

The EIA Study requires information of the Project such as feasibility study conducted by JICA and SPTrans. Therefore, the Consultant shall communicate frequently and closely with SPTrans to obtain latest information on the Project.

2.1 Environmental Items to be Studied

Main environmental items to be studied on both preconstruction & construction stage and operational & maintenance stage of the Project are tentatively supposed as shown in **Table 2** and **Table 3**, which are environmental scoping matrix and checklist, respectively.

2.2 Collection of Data and Information

(1) Environmental Baseline Study

The Environmental Baseline Study shall be carried out through collection of information and data in the study area. The information and data collected shall be verified and supplemented through the field reconnaissance. The results of the examinations shall not only be described in the text, but also summarized in the maps and drawings with adequate scale, tables and graphs. In addition, the environmental standards and regulations, legal system relating to the implementation of EIA shall be collected and summarized. Information to be collected for the Environmental Baseline Study are shown in **Table 4**. Additional information shall be collected and examined, considering the Sample Table of Contents for EIA Report as shown in **Attachment 1**.

(2) Social Study

The Social Study shall be carried out through collection of information and data in the study area. The information and data collected shall be verified and supplemented through the field reconnaissance. The results of the examinations shall not only be described in the text, but also summarized in the maps and drawings with adequate scale, tables and graphs. In addition, standards and regulations, legal system relating to the resettlement and other social considerations shall be collected and summarized. Information to be collected for the Social Study are shown in **Table 5**. Additional information shall be collected and examined, considering the Sample Table of Contents for EIA Report as shown in **Attachment 1**.

Table 2 Environmental Scoping Matrix for the Proposed Projects

	No.	Likely Impacts	Overall Rating	Project-related Activities										
				Planning / Design Phase		Construction Phase						Operation Phase		
				Land acquisition	Change of land use plan, control of various activities by regulations for the construction	Reclamation of wetland	Deforestation / tree cutting	Alteration to ground by cut land, filling, drilling, tunnel, etc.	Operation of construction equipment and vehicles	Construction of track, station, depot, viaduct/bridges and other related facilities	Traffic restriction in construction area	Operation of trains	Appearance / occupancy of track and related facilities	Operation and maintenance of depot
Social Environment*	1	Involuntary resettlement	A-	A-/ -	-	-	-	-	-	-	-	-	-	-
	2	Local economy such as employment and livelihood, etc.	B-/B+	B-	B-	-	-	-	-	-	B-	-	-	-
	3	(Surrounding) Land use	B-	B-	B-	-	-	-	-	-	-	B-	-	-
	4	Transportation	B-/A+	-	-	-	-	B-	B-	B-	B-	A+	-	-
	5	Existing social infrastructures and services	A-/A+	B-	A-	-	-	-	A-	-	A-	A+	-	-
	6	Regional severance	-	-	-	-	-	-	-	-	-	-	-	-
	7	Socially vulnerable groups such as the poor, indigenous and ethnic people	A-/B+	A-	C-	-	-	-	-	-	C-	B+	-	-
	8	Historical and cultural heritage	C-	C-	C-	-		C-	-	-	-	-	-	-
	9	Religious matters	C-	C-	-	-	-	-	C-	-	C-	-	-	-
	10	Water usage or water rights and rights of common	-	-	-	-	-	-	-	-	-	-	-	-
	11	Sanitation	C-	-	-	-	-	-	-	-	-	C-	-	-
	12	Hazardous (risk) infectious diseases such as HIV/AIDS	C-	-	-	-	-	-	-	C-	-	-	-	-
	13	Invasion of privacy	B-	-	-	-	-	-	-	-	-	B-	-	-
	14	Accident	B-/B+	-	-	-	-	B-	B-	B-	-	B+	-	-
Natural Environment	15	Topography and geographical features	B-	-	-	-	-	B-	-	-	-	-	-	-
	16	Soil erosion	B-	-	-	-	-	B-	-	-	-	-	-	-
	17	Groundwater	B-	-	-	-	-	-	-	-	-	-	-	B-
	18	Hydrological situation	C-	-	-	-	-	C-	-	-	-	-	-	-
	19	Coastal zone	-	-	-	-	-	-	-	-	-	-	-	-
	20	Flora, fauna and biodiversity	A-	-	-	-	A-	B-	-	A-	-	-	-	-
	21	Meteorology	-	-	-	-	-	-	-	-	-	-	-	-
	22	Landscape	A-	-	-	-	A-	B-	-	-	-	-	B-	-
	23	Global warming	B-/B+	-	-	-	B-	-	-	-	-	B+	-	-
Pollution	24	Air pollution	B-/B+	-	-	-	-	-	B-	B-	-	B+	-	-
	25	Water pollution	B-	-	-	-	-	B-	-	B-	-	-	-	B-
	26	Soil contamination	C-	-	-	-	-	C-	-	C-	-	-	-	-
	27	Waste	A-	-	-	-	A-	B-	-	B-	-	-	-	-
	28	Noise and vibration	A-	-	-	-	B-	B-	B-	B-	-	A-	-	B-
	29	Ground subsidence	-	-	-	-	-	-	-	-	-	-	-	-
	30	Offensive odor	B-	-	-	-	-	B-	-	B-	-	-	-	-
	31	Bottom sediment	B-	-	-	-	-	B-	-	B-	-	-	-	-
	32	Electromagnetic effect	B-	-	-	-	-	-	-	-	-	-	B-	-
	33	Obstruction of sunshine	B-	-	-	-	-	-	-	-	-	-	B-	-
	34	Disaster	-	-	-	-	-	-	-	-	-	-	-	-

Note: * Regarding the impacts on “Gender” and “Children’s Right”, might be related to all criteria of Social Environment.

<Rating>

A-: Serious impact is expected, if any measure is not implemented to the impact.

B-: Some impact is expected, if any measure is not implemented to the impact.

C-: Extent of impact is unknown (Examination is needed. Impact may become clear as study progresses.)

-: No impact is expected. Therefore, EIA is not required.

A+: Remarkable effect is expected due to the project implementation itself and environmental improvement caused by the project.

B+: Some effect is expected due to the project implementation itself and environmental improvement caused by the project.

Overall rating: Highest rate will be the overall rating among the rating of relevant project-related activities for negative and positive ratings, respectively. (e.g. Even only one “A-” is included in an environmental item, overall rating of the environmental item becomes “A-”.)

Reference: Japan Transport Cooperation Association (JTCA) and Japan Railway Technical Service (JARTS) (1996) “Manual for Environmental Considerations in International Cooperation for Transportation Technology (Railway Project) (provisional translation)”, Tokyo, Japan.

Table 3 Checklist of Environmental Scoping for the Proposed Projects (1/4 page)

No.	Likely Impacts	Rating		Project phase	Explanation on Potential Impacts (Project-related activity is shown in the parenthesis.)
		Overall	by project phase		
Social Environment*					
1	Involuntary Resettlement	A-	A- / -	P	*<Land acquisition>* Although land acquisition for the Project is not concentrated in the specific area, large-scale involuntary resettlement in total would occur in the proposed project site with lack of width of ROW for railway track and lack of open space for station and depot construction in the Lines 1, 2A and 2B. On the other, no or few resettlement would occur in the Lines 2C, and 2D.
2	Local economy such as employment and livelihood, etc.	B- B+	B-	P	*<Land acquisition>* Involuntary resettlement due to the land acquisition would affect local economy in some extent.
			B-	P	*<Change of land use plan, control of various activities by regulations for the construction>* Some limitations to activities during construction would affect local economy in some extent.
			B-	C	*<Traffic restriction in construction area>* Since the project site is mainly located in the center of and along the existing road, construction activities would affect local economy in some extent due to disturbance of smooth operation of commercial vehicles and public bus service due to traffic restriction during construction.
3	(Surrounding) Land use	B-	B-	P	*<Land acquisition>* *<Change of land use plan, control of various activities by regulations for the construction>* Inadequate land use would occur due to acceleration of unplanned development along the proposed route and around new stations.
			B-	O	*<Operation of trains>* - ditto -
4	Transportation	B- A+	B-	C	*<Alteration to ground by cut land, filling, drilling, tunnel, etc.>* *<Operation of construction equipment and vehicles>* *<Traffic restriction in construction area>* Since the project site is mainly located in the center of and along the existing road, construction activities would cause disturbance of smooth operation of commercial vehicles and public bus service due to traffic restriction during construction.
			A+	O	*<Operation of trains>* Improvement of traffic flow and accessibility would be expected due to reduction of vehicle traffic, especially along the proposed route, by operating railway transport such as monorail.
5	Existing social infrastructures and services	A- A+	B-	P	*<Land acquisition>* Land acquisition for the project, involving relocation of public and/or community facilities, would affect local communities in some extent.
			A-	P	*<Change of land use plan, control of various activities by regulations for the construction>* Since the project site is mainly located in the center of and along the existing road, construction activities would affect local economy in some extent due to disturbance of smooth operation of commercial vehicles and public bus service due to traffic restriction during construction.
			A-	C	*<Operation of construction equipment and vehicles>* *<Traffic restriction in construction area>* - ditto -
			A+	O	*<Operation of trains>* Smooth operation of the public bus system and commercial vehicles would be expected due to reduction of vehicle traffic, especially along the proposed route, with operation of the proposed railway system such as monorail.
6	Regional severance	-	-	-	Since the proposed transport system is constructed with elevated bridge structure in almost the entire route, regional severance due to existence of the structure would not be caused.

Table 3 Checklist of Environmental Scoping for the Proposed Projects (2/4 page)

No.	Likely Impacts	Rating		Project phase	Explanation on Potential Impacts (Project-related activity is shown in the parenthesis.)
		Overall	by project phase		
Social Environment*					
7	Socially vulnerable groups such as the poor, indigenous and ethnic people	A- B+	A-	P	<*Land acquisition*> Households living in the Favela as illegal occupants, who are mostly low-income, to be relocated would remarkably be affected for their livelihood since they are not entitled for the property compensation as legal title-holders.
			C-	P	<*Change of land use plan, control of various activities by regulations for the construction*> Social impact to the socially vulnerable groups, mainly low-income household residing in the Favela, is not known and should be examined.
			C-	C	<*Traffic restriction in construction area*> - ditto -
			B+	O	<*Operation of trains*> Improvement of transport situation would be expected, especially for low-income people who commute to central area of São Paulo City with long-time traveling by transferring several public buses at present. In addition, new employment opportunity would be expected due to improvement of the transportation mode.
8	Historical and cultural heritage	C-	C-	P	<*Land acquisition*> <*Change of land use plan, control of various activities by regulations for the construction*> Existing of such historical and cultural assets in and around the project site is not known and should be studied.
			C-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> - ditto -
9	Religious matters	C-	C-	P	<*Land acquisition*> Any impact related to religious aspect in and around the project site is not known and should be studied.
			C-	C	<*Operation of construction equipment and vehicles*> <*Traffic restriction in construction area*> - ditto -
10	Water usage or water rights and rights of common	-	-	-	Though rivers/channels where proposed route pass along and cross in some sections are used as drainage, there is no water usage in such rivers and channels at present.
11	Sanitation	C-	C-	O	<*Operation of trains*> <*Increasing influx of settlers / workers*> Such information should be obtained and examined if any impact.
12	Hazardous (risk) infectious diseases such as HIV/AIDS	B-	B-	C	<*Construction of track, station, depot, viaduct/bridges and other related facilities*> Risk of infectious diseases by labors would be expected during construction.
13	Invasion of privacy	B-	B-	O	<*Operation of trains*> In the case where elevated railway structure is close to the building/house, privacy of residents in such building/house would be invaded by passenger of the train.
14	Accident	B- B+	B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> <*Operation of construction equipment and vehicles*> <*Construction of track, station, depot, viaduct/bridges and other related facilities*> Accident in construction works and operation of construction vehicle/equipment would occur.
			B+	O	<*Operation of trains*> With change of transport mode from vehicle to railway system such as monorail, reduction of traffic accidents would be expected due to reduction of vehicle traffic.
15	Topography and geographical features	B-	B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> In the most of sections, elevated bridge structure of the railway track will mainly be constructed in the center or along the existing road. However, earthworks would affect topographic condition in some sections along the river/channel.
16	Soil erosion	B-	B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> Construction works along the river/channel in some sections would cause soil erosion in some sections.

Table 3 Checklist of Environmental Scoping for the Proposed Projects (3/4 page)

No.	Likely Impacts	Rating		Project phase	Explanation on Potential Impacts (Project-related activity is shown in the parenthesis.)
		Overall	by project phase		
Natural Environment					
17	Groundwater	B-	B-	O	<*Operation of trains*> Lowering groundwater level due to excessive use of the groundwater in the depot would affect groundwater use around the area.
18	Hydrological situation	C-	C-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> Construction works along the river/channel in some sections would affect hydrological situation in such channel/river.
19	Coastal zone	-	-	-	The project area is not located in and around the coastal area and is not related to the coastal area.
20	Flora, fauna and biodiversity	A-	A-	C	<*Deforestation / tree cutting*> <*Construction of track, station, depot, viaduct/bridges and other related facilities*> Existing roadside trees and plants would be removed tentatively or permanently since elevated bridge structure of the railway track will mainly be constructed in the center or along the existing road.
			B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> Existing trees and plants would be cut due to construction works such as earth works.
21	Meteorology	-	-	-	The project does not have any factor which may affect and/or be related to the meteorology.
22	Landscape	A-	A-	C	<*Deforestation / tree cutting*> Removal of existing roadside trees and plants due to construction of the railway track would change the landscape along the existing roads.
			B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> Construction works such as earthworks would affect the landscape in the project site.
			B-	O	<*Appearance / occupancy of track and related facilities*> Existing of elevated bridge structure of the railway track would affect the landscape from prior one in and around the project site.
23	Global warming	B- B+	B-	C	<*Deforestation / tree cutting*> Cutting of existing roadside trees and plants due to construction of the railway track would reduce absorption capacity of greenhouse gas such as CO_2 on the street along the project site.
			B+	O	<*Operation of trains*> With change of transport mode from vehicle to railway system such as monorail, reduction of emission of greenhouse gas such as CO_2 will be expected as per unit transport distance per person.
Pollution					
24	Air pollution	B- B+	B-	C	<*Operation of construction equipment and vehicles*> <*Construction of track, station, depot, viaduct/bridges and other related facilities*> Emission of exhaust gas from construction equipment and vehicles and dust pollution due to operation of the construction equipment and vehicles would cause air pollution in and around the construction sites during the construction.
			B+	O	<*Operation of trains*> Reduction of hazardous substances emitted from vehicles would be expected due to reduction of traffic congestion and traffic volume by changing transportation mode from vehicle to the proposed railway system such as monorail.
25	Water pollution	B-	B-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> <*Construction of track, station, depot, viaduct/bridges and other related facilities*> Muddy water from construction site and oil spill from construction equipment and vehicles would cause water pollution in the channel/river in and around the construction site.
			B-	O	<*Operation and maintenance of depot*> Oil-content waste water and domestic waste water from depot would affect water body nearby in the case of direct discharge without pre-treatment or without connection to the sewerage system in the depot.
26	Soil contamination	C-	C-	C	<*Alteration to ground by cut land, filling, drilling, tunnel, etc.*> <*Construction of track, station, depot, viaduct/bridges and other related facilities*> In the case where the land to be acquired contains contaminated soil in the existing or old industrial facility, residue soil excavated from the land would cause soil and/or water pollution in and around the disposal site.

Table 3 Checklist of Environmental Scoping for the Proposed Projects (4/4 page)

No.	Likely Impacts	Rating		Project phase	Explanation on Potential Impacts (Project-related activity is shown in the parenthesis.)
		Overall	by project phase		
Pollution					
27	Waste	A-	A-	C	*<Deforestation / tree cutting>* In the case where most of the existing roadside trees will not be transplanted, but be cut, large volume of tree-waste would occur and it cause environmental impact in the disposal site.
			B-	C	*<Alteration to ground by cut land, filling, drilling, tunnel, etc.>* Residue soil due to earth works would cause environmental impact in the disposal site.
			B-	C	*<Construction of track, station, depot, viaduct/bridges and other related facilities>* Construction waste including residue soil would cause environmental impact in the disposal site.
28	Noise and vibration	A-	B-	C	*<Deforestation / tree cutting>* Cutting and replanting work of the roadside trees used by using tools and heavy equipment would cause noise during the construction.
			B-	C	*<Alteration to ground by cut land, filling, drilling, tunnel, etc.>* *<Operation of construction equipment and vehicles>* *<Construction of track, station, depot, viaduct/bridges and other related facilities>* - Noise and vibration caused by such construction works and construction vehicle/equipment would annoy the residents and school/hospital nearby. - Vibration caused by such construction works would cause damage to the existing house and other kinds of building structures such as cracks in the wall.
			A-	O	*<Operation of trains>* Operation of the trains would cause noise along the railway track during operation time.
			B-	O	*<Operation and maintenance of depot>* Maintenance works in deport would cause noise pollution to around the depot site.
29	Ground subsidence	-	-	-	The project does not have any factor which may cause the ground subsidence in terms of project location and construction method.
30	Offensive odor	B-	B-	C	*<Alteration to ground by cut land, filling, drilling, tunnel, etc.>* *<Construction of track, station, depot, viaduct/bridges and other related facilities>* - In some sections where pass along rivers and channels, offensive odor would occur around the construction site due to excavation and dredging of mad in the rivers/channels during the construction. - In the case where contaminated soil is found in the construction site such as site of old factory, offensive odor would occur in removal and transport of such contaminated soil.
31	Bottom sediment	B-	B-	C	*<Alteration to ground by cut land, filling, drilling, tunnel, etc.>* *<Construction of track, station, depot, viaduct/bridges and other related facilities>* During the works in the construction phase, excavated soil would cause sedimentation, flushed into water course in case of rain.
32	Electromagnetic effect	B-	B-	O	*<Appearance / occupancy of track and related facilities>* Station structure of the railway would interfere with the radio wave such as radio and television nearby.
33	Obstruction of sunshine	B-	B-	O	*<Appearance / occupancy of track and related facilities>* Due to bridge structure for elevated track, some railway tracks close to the building would cause obstruction of sunshine to the building, especially residential house.
34	Disaster	-	-	-	Construction is not planned in the disaster-prone area such as landslide-prone area.

Note: * Regarding the impacts on "Gender" and "Children's Right", might be related to all criteria of Social Environment.

<Rating>

A-: Serious impact is expected, if any measure is not implemented to the impact.

B-: Some impact is expected, if any measure is not implemented to the impact.

C-: Extent of impact is unknown (Examination is needed. Impact may become clear as study progresses.)

-: No impact is expected. Therefore, EIA is not required.

A+: Remarkable effect is expected due to the project implementation itself and environmental improvement caused by the project.

B+: Some effect is expected due to the project implementation itself and environmental improvement caused by the project.

Overall rating: Highest rate will be the overall rating among the rating of relevant project-related activities for negative and positive ratings, respectively. (e.g. Even only one "A-" is included in an environmental item, overall rating of the environmental item becomes "A-".)

<Project phase> P: Planning and design phase, C: Construction phase, O: Operation phase

Reference: Japan Transport Cooperation Association (JTCA) and Japan Railway Technical Service (JARTS) (1996) "Manual for Environmental Considerations in International Cooperation for Transportation Technology (Railway Project) (provisional translation)", Tokyo, Japan.

Table 4 Example of Baseline Information to be Collected for Environmental Baseline Study

Environmental Items	Scope and Coverage	Data source & Methodology	Maps, Diagram, Tables Required
A. Physical Environment			
1. Topography	• Land form, terrain pattern	• Slope and elevation analysis	• Topographic map
2. Geology	• Geological condition	• Secondary data	• Geological map
3. Soils	• Soil cover and condition • Soil erosion and deposition	• Secondary data	• Soil map • Existing and projected soil erosion and deposition map
4. Hydrology and Geo-hydrology	• Surface water characteristics, watershed areas, river systems • Groundwater characteristics, water table, depth	• Characterization of surface water and groundwater	• Regional and local hydrological map • Regional and local geo-hydrological map
5. Meteorology and Climatology	• Frequency distribution and surface wind, wind direction • Any atmospheric disturbances • Rainfall and temperature • Climatologically normal and extremes	• Secondary data	• Wind rose diagrams • Climographs
6. Water Quality	• Surface water quality (in comparison with national standards) such as pH, DO, TSS, BOD, and Flow rate	• Water quality survey for surface water	• Sampling stations map • Table showing analysis of sampling report results
7. Air Quality	• Ambient air quality (in comparison with national standards) such as TSP, SPM, NO_2, SO_2, CO, and O_3	• Ambient air quality survey	• Sampling stations map • Table showing analysis of sampling report results
8. Noise and Vibration Levels	• Ambient noise and vibration levels in project site, along the boundaries or project site, and at locations near human settlement	• Noise and vibration measurement survey	• Sampling stations map • Table showing analysis of sampling report results
B. Biological Environment			
1. Roadside Tree and Plant	• Inventory of roadside tree and plant	• Inventory survey for street tree and plant	• Inventory of roadside tree and plant to be affected
C. Land Use			
1. Land Use	• Land use-existing, planned and development trends in the project site	• Identification of land uses in the project site	• Land use/zoning map • Certification of zoning viability
D. Others			
1. Archaeological /Historical Assets	• Natural, historical, cultural, archaeological properties	• Field reconnaissance/inventory	• Map showing archaeological / historical preservation areas
2. Aesthetics and Amenities	• Aesthetic quality • Visual quality (land, bodies of water, vegetation, buildings, streets)	• Field reconnaissance/inventory	• Map showing such information
3. Construction Materials	• Type, source, amounts of materials used	• Field reconnaissance/inventory	• Map showing sources of materials
4. Recreational area	• Park, hiking course, river side, glass land	• Field reconnaissance/inventory	• Map showing such information
5. Waste	• Waste collection, treatment and disposal system	• Field reconnaissance/inventory	• Map showing such information

Table 5 Example of Baseline Information to be Collected for Social Study

Environmental Items	Scope and Coverage	Data source & Methodology	Maps, Diagram, Tables Required
1. Demography	• Population size and distribution • Growth rate • Population density • Dependency ratio • Population by gender and age • Population by region • Educational attainment • Literacy rate • No. of households directly affected by the Project • Population of distinct vulnerable sectors (i.e. indigenous community) • Household population by employment status • Main source of income • Dislocation of people, communities/ displacement of commercial activities • Informal settlers	• Secondary data • Socio-economic survey	• Population distribution map • Public perception survey report • Map showing the primary and secondary impact areas • Map showing relocation sites
2. Health	• Leading causes of morbidity and mortality in children and adults • Morbidity and mortality rates • 5 year trend in morbidity and mortality • Data on hospitals, clinics and public health facilities/staff • Notifiable diseases in the area including endemic diseases	• Secondary data	• Table showing morbidity and mortality
3. Housing, Public Utilities and Commercial Structures	• Housing characteristics and utilities • Public utilities (power, water and telecommunication lines, sewerage and drainage systems, waste treatment facilities, irrigation system) • Displacement of commercial and related structure	• Secondary data • Survey/inventory of housing and public utilities	• Map showing distribution of hosing and public utilities/ settlement clusters •
4. Livelihood	• Average income • Employment	• Secondary data • Socio-economic survey	• Map showing such information
5. Local Economy	• Agriculture • Characteristics of commercial area • Characteristics of industrial area	• Secondary data • Field reconnaissance	• Map showing such information

2.3 Field Survey

The following field survey shall be conducted to obtain latest and proper site information. The coordination of survey location should be recorded at measurement.

(1) Environmental Baseline Study

1) Air Quality Measurement

a) Survey location: 6 sites including 3 sites for residential/industrial are and 3 sites for road area shall be selected for each route (6 sites X 5 routes = 30 sites in total). In addition, one site shall be selected for proposed station and depot sites (53 stations and 2 depots in total. Location of the station and deport sites shall be confirmed to SPTrans.). The detailed survey locations including numbers shall be proposed by the Consultant and determined with SPTrans.

b) Survey duration: Continuous survey for 24 hours in a weekday. 1 hour average data shall be estimated based on the measurement.

c) Survey items: TSP, SPM, NO_2, SO_2, CO, O_3, Wind speed, Wind direction

2) Noise and Vibration Level Measurement

a) Survey location: 6 sites including 3 sites for residential/industrial area and 3 sites for road area shall be selected for each route (6 sites X 5 routes = 30 sites in total). In addition, one site shall be selected for proposed station and depot sites (53 stations and 2 depots in total. Location of the station and deport sites shall be confirmed to SPTrans.). The detailed survey locations including numbers shall be proposed by the Consultant and determined with SPTrans.

b) Survey duration: 24 hours for one location in a weekday. 10 minutes continuous measurement per hour.

c) Survey items: Average noise level (Leq (dB)A) and vibration level (L10 (dB)) per 10 minutes for 3 sites for residential/industrial area and for 3 sites for road area with traffic volume per 10 minutes. The vehicle types should be same as traffic survey conducted by SPTrans or other relevant authority.

3) Water Quality Measurement

a) Survey location: 1 site each at downstream and upstream of the river/channel shall be selected in the case where the target route passes and/or is located along any river/channel. The detailed survey locations including numbers shall be proposed by the Consultant and determined with SPTrans.

b) Survey duration: One sampling in daytime and nighttime, respectively, for each site in a weekday.

c) Survey items: pH, water temperature, Dissolved Oxygen (DO), Turbidity, Suspended Solids (SS), Biological Oxygen Demand (BOD), and flow rate.

4) Soil Contamination Study

a) Survey location: 1 site or more sites (if necessary) in each possible plot with contaminated soil. Selection of the survey location should be complied with relevant legislations in Brazil.
b) Survey items: volatile organic compounds, heavy metals, pesticides and PCB, which are prescribed in relevant legislations in Brazil.

5) Inventory Survey on Roadside Trees

Inventories of roadside trees to be potentially affected by the Project shall be prepared through the field survey. Items of the inventory shall be location, species including classification of native or exotic, size such as height and girth, age, conditions, etc. Likely-affected conditions of the roadside trees in and around the project site shall also be identified. Based on the inventory, the Consultant shall search possible site for transplantation, considering required species and quantities of trees to be transplanted.

6) Measurement Survey on Electromagnetic Field Intensity

a) Survey location: specific location where may be shaded by station structure of the Project in relation with location of the TV antenna tower and may affect TV broadcast.
b) Survey items: intensity of electromagnetic field.

(2) Field Study on Land Acquisition and Resettlement Action Plan

The field surveys for Land Acquisition and Resettlement Action Plan consist of the following surveys:

1) Socio-economic Survey
2) Household Inventory Survey for Resettlement

1) Socio-economic Survey

Socio-economic Survey shall be conducted to collect socio-economic conditions of the project-affected persons (PAPs), who are directly affected by land acquisition and resettlement due to the Project, and to inquiry perception and acceptability of the proposed project by the PAPs. Based on the survey results, conceivable social impacts to the PAPs by the proposed projects are examined as well as peoples intention and demand related to the proposed project.

a) Survey location: Community along the proposed routes
b) Survey sample size: Over 20% of the total population of the project-affected households.
c) Survey items: Survey form with the items to be surveyed shall be proposed by the Consultant and finalized with SPTrans.

2) Household Inventory Survey for Resettlement

The objectives of the Household Inventory Survey for Resettlement are to identify the land to be acquired and house/structure/movable properties to be relocated by the proposed measures, and to identify residential households to be resettled and to collect their socio-economic data, opinion on improvement of their living environment, and intention and demand related to the resettlement.

a) Extent to be surveyed

For the Household Inventory Survey for Resettlement, the survey for land to be acquired and project-affected households/property owners and users to be resettled/relocated by the Project shall be conducted within required right-of-way (ROW).

All of the structures to be potentially relocated (approximately 1,000 structures including both completely and partially relocated house and industrial/commercial structures) shall be surveyed by inquiry survey method. Any properties located in the ROW to be acquired shall be inventoried such as public/private facilities, factories, and trees. In the place where there is no settlement such as open land and abandoned cultivated area, land title shall be confirmed and recorded in the inventory with map.

b) Methodologies

At the beginning of the survey, exact locations to be surveyed shall be confirmed jointly by both SPTrans and Consultant. In the survey, an inventory of acquired land and house/structures to be relocated, and any socially significant properties such as religious facility and historical monument in and around the Project sites shall be prepared with the topographical maps with detailed scale as possible, which both hardcopies and digital data are available from SPTrans. Favelas or illegal occupants' communities, project-affected settlements and structures to be relocated shall be highlighted on the map.

At the same time of the confirmation of the lands to be acquired and properties to be relocated at the site, direct inquiry survey to affected households and property owners to be resettled shall be conducted to obtain the latest information.

c) Survey Items

Survey form with the items to be surveyed shall be proposed by the Consultant and finalized with SPTrans. Collected data and information shall be sorted and analyzed from the viewpoint of social environmental considerations.

In principle, the Social Surveys shall be conducted based on the specifications mentioned in this TOR. However, the Consultant shall propose additional and/or revised survey items and methodologies to SPTrans from local expert's viewpoints and discuss with SPTrans on a survey plan to be prepared in the Inception Report prior to commencement of the Survey.

2.4 Preparation of Land Acquisition and Resettlement Action Plan

In the case where resettlement is required with the land acquisition, a land acquisition and resettlement action plan (LARAP) shall be prepared for the Project by studying the following items with necessary field survey to collect relevant data as well as relevant national legislations. Through preparation of the LARAP, the Socio-economic Survey and Household Inventory Survey for Resettlement shall be conducted to obtain information on assets for proper compensation and socio-economic conditions for necessary assistance as well as to identify any vulnerable groups (for example, squatters, landless, those without formal titles, female-headed households, disabled persons, indigenous peoples) who might require special assistance before and after the relocation. The LARAP shall include the following:

a) Details of the benchmark situation, including maps showing settlements, land use patterns, trees, vegetation and other geo-profiles of the project-affected area.
b) Analysis of the survey data and an assessment of both permanent and temporary impacts in terms of loss of resources and livelihoods.
c) Project compensation policy - entitlement matrix and criteria for the resettlement eligibility of affected households, including special provisions for any vulnerable groups/those without legal title to lost assets.
d) Provisions for relocation/resettlement options and income restoration programs. If resettlement sites are required, include provisions for public utilities at the resettlement sites.
e) Institutional and organizational framework for implementation of LARAP, including linkages with project implementing agencies, local administration, community/NGO and other related organization.
f) An estimated budget for LARAP implementation, separately identifying major compensation costs, implementation and administrative costs, consulting services for monitoring and evaluation activities.
g) A time-frame and implementation schedule for land acquisition and resettlement in conjunction with construction schedule for project components.
h) A monitoring and evaluation plan identifying the responsibilities, time-frame, and some key indicators. Specify the time-frame for monitoring and reporting.

Accompanying with the resettlement, improvement of living environment for the PAPs to be resettled shall be well examined with combination of any assistance by the Project and municipal government based on the peoples' demand. The following items should be discussed and presented in LARAP.

Table 5 Main Items of the LARAP

1) Measures taken for avoidance and minimization of the resettlement
2) Approximate identification of magnitude of the impact
a) Land area to be acquired by area and by type
b) Number of structures to be relocated
3) Socio-economic features of the Project-Affected Persons (PAPs)
a) Socio-economic data based on secondary data
b) Results of socio-economic survey
4) Compensation and assistance under current legislations
5) Entitlement matrix
6) Securing resettlement sites
7) Resettlement assistance
8) Assistances for livelihood recovery
9) Public involvement in the process of the resettlement
10) Grievance redress system
11) Monitoring plan
12) Responsibilities of relevant organizations
13) Cost estimate and financial arrangement

2.5 Impact Identification and Assessment

Based on the result of analysis of the secondary data and field surveys, the magnitude and extent of environmental impacts accompanied by the project implementation shall be estimated and evaluated as quantitatively as possible to meet requirements under the EIA system in Brazil, including nature, magnitude, extent and location, timing, duration, reversibility, and likelihood. The Consultant shall propose and discuss with SPTrans on adequate methods for prediction of impacts such as mathematical model analysis and estimate from similar case studies. Environmental scoping for the target projects are shown in **Table 2** and **Table 3**. This scoping shall be reviewed prior to the implementation of the EIA Study.

2.6 Preparation of Mitigation Measures

Feasible and cost effective mitigation measures for the Project shall be proposed. The mitigation measure is to prevent or reduce the negative impacts predictable in the result of impact assessment. Aspects of mitigation measure which should be considered including target level of impact mitigation, method, expected effect, timing, duration, institutional arrangement, and cost. In addition, residual impacts which can not be prevented or reduced by the mitigation measures shall be identified. In the case, the cost of compensation to affected parties for impacts that cannot be mitigated shall be estimated.

2.7 Preparation of Environmental Management and Monitoring Plan

An environmental management and monitoring plan (EMMP) for optimal project packages shall be prepared. Required information for the EMMP is shown in **Table 6**. In addition, summary matrices of the EMMP shall be prepared as shown in **Tables 7** and **Table 8**.

Table 6 Sample Items of Environmental Management & Monitoring Plan

1. Environmental Management Program
   - Impacts, mitigation program
2. Construction/Contractor Environmental Program
   - Environmental safeguards/management measures implemented by the contractors
3. Social Development Program
   - A social development plan including livelihood programs (based on people's needs) for displaced or resettled people
4. Contingency/Emergency Response Plan
   - Procedure on the method of coping with emergencies or accidents
5. Rehabilitation Plan
   - Maintenance program(routine and periodic)
6. Monitoring program
   - Environmental monitoring program matrix containing the following information
   - 6.1 Frequency of sampling and sampling points
   - 6.2 Sampling parameter: water quality of the surrounding bodies of water (e.g. TSS, oil and grease, noise etc.)
   - 6.3 Sampling methodology and the corresponding cost
   - 6.4 Work and financial plan for the current year
7. Institutional Plan
   - The Institutional, organizational and financial capability of the proponent to manage and sustain the projects as well as to implement the programs in the EMMP

Table 7 Summary Matrix of the Environmental Management Program

Project activities	Impact Description	Mitigation/Enhancement Measure	Cost of mitigation/Enhancement	Institutional Responsibility	Schedule
I. Construction Stage A. Social Environment B. Natural Environment C. Pollution					
II. Operational Stage A. Social Environment B. Natural Environment C. Pollution					

Table 8 Summary Matrix of the Environmental Monitoring Program

Project activities	Parameters	Location	Frequency	Responsibility	Estimated Cost
I. Construction Stage	A. Social Environment B. Natural Environment C. Pollution				
II. Operational Stage	A. Social Environment B. Natural Environment C. Pollution				

2.8 Public Hearing / Consultation Meeting

In accordance with JBIC Guidelines for Confirmation of Environmental and Social Considerations, series of public consultation meetings shall be held on EIA and LARAP in order to secure transparency and involvement of stakeholders in planning process of the Project. Brazilian laws and legislations concerned also require public consultation meeting in the process of EIA. Frameworks of the public consultation meetings for EIA and LARAP are shown in **Table 9** and **Table 10**, respectively. The concerned route /area for each meeting and the total number of meetings to be held shall be discussed with SPTrans, SVMA, CADES, local authority and other relevant bodies in planning of the meetings.

Table 9 Draft Frameworks for the Public Consultation Meeting for EIA

	First Meeting	Second Meeting
Objectives	- To disseminate project outline - To consult with stakeholders on draft environmental scoping and draft TOR for EIA Study	- To disseminate progress of the project planning - To consult with stakeholders on draft EIA report (EIA/RIMA)
Scheduled Timing	- After preparation of draft environmental scoping and draft TOR for EIA Study	- After preparation of draft EIA report (EIA/RIMA)
Agendas for the Meeting	- Presentation on the project outlines - Explanation and consultation on draft environmental scoping and draft TOR for EIA Study - Explanation and consultation on conceivable environmental/social impacts	- Presentation on progress of the project planning - Presentation and consultation on the results of EIA study - Presentation and consultation on the Environmental Monitoring Plan - Presentation and consultation on the Environmental Compensation Programs
Number and Location of Venues	To be considered.	To be considered.
Number of Participants	To be considered.	To be considered.
Participants	- Project Executing Bodies (e.g., SPTrans) - Municipal Government Bodies (e.g., SMDU, SEHAB, SEMPLA) - Environmental Licensing Bodies (e.g., SVMA, IBAMA, IPHAN) - Affected People (Including illegal occupants) - NGOs, representatives of communities, etc.	- Project Executing Bodies (e.g., SPTrans) - Municipal Government Bodies (e.g., SMDU, SEHAB, SEMPLA) - State Government Bodies (e.g., SEMA, STM) - Environmental Licensing Bodies (e.g., SVMA, IBAMA, IPHAN) - Affected People (Including illegal occupants) - NGOs, representatives of communities, etc.
Concerned Route /Area and Place of the Meeting	To be discussed with SPTrans	
Public Notification	Invitation to individuals, public notification on newspaper etc.	

Note: SEHAB-Municipal Secretary of Habitations, SEMPLA-Municipal Secretary of Planning, SNJ-Municipal Secretary of Legal Affaires, SVMA-Municipal Secretary of Green and Environment, IBAMA-Brazilian Institute for Environmental and Renewable Natural Resources, IPHAN-National Institute for Historical and Artistic Heritages, SEMA-State Secretary of Environment, STM-State Secretary of Transport for Metropolitan Region

Table 10 Draft Frameworks for the Public Consultation Meeting for LARAP

	First Meeting	Second Meeting
Objectives	- To disseminate information on the contents of draft LARAP to the Project-Affected Persons (PAPs) - To consult PAPs on the draft LARAP	- To consult PAPs on the revised LARAP which reflects the results of the first consultation meeting
Scheduled Timing	- After the preparation of draft LARAP	- After the preparation of revised LARAP
Agendas for the Meeting	- Presentations on the project outlines - Explanation and consultation on foreseeable environmental/social impacts and measures to be employed for their compensation - Explanation and consultation on draft LARAP	- Explanation and consultation on the changes from previous version of LARAP - Discussions for further modifications and additions on LARAP
Number and Location of Venues	To be considered.	To be considered.
Number of Participants	To be considered.	To be considered.
Participants	- Project Executing Bodies (e.g., SPTrans) - Municipal Government Bodies (e.g., SEHAB, SEMPLA, SNJ, SVMA) - Affected people for expropriation of land or involuntary resettlement (including illegal occupants) - NGOs, representatives of communities, etc.	
Concerned Route /Area and Place of the Meeting	To be discussed with SPTrans	
Public Notification	Invitation to individuals, public notification on newspaper etc.	

Note: SEHAB-Municipal Secretary of Habitations, SEMPLA-Municipal Secretary of Planning, SNJ-Municipal Secretary of Legal Affaires, SVMA-Municipal Secretary of Green and Environment

2.9 Preparation of Environmental Impact Assessment Report (EIA/RIMA)

The Environmental Impact Assessment Report (EIA/RIMA) shall be prepared for the Projects by compiling results of the EIA Study. The style or Table of Contents (TOC) of the EIA/RIMA shall be referred to relevant EIA regulations or guidelines in the Brazil. A sample TOC is presented in **Attachment 1**.

3. Organization of Survey Team

The EIA Study shall be conducted under the responsibility of the Consultant under supervision of SPTrans. Due to various items to be studied under the EIA system, a local survey team under Consultant company shall be formed with sufficient number of local experts from various fields to complete the EIA Study. In addition, adequate number of the supporting staffs shall be also mobilized to conduct the EIA Study.

Especially, the following experts should be included in the Team.

- Team Leader / Environmental impact assessment
- Air quality
- Noise and vibration
- Water quality
- Fauna and flora
- Geology and topography
- Socio-economics
- Resettlement

4. STUDY SCHEDULE

The EIA Study is supposed to be completed within six (6) months including the field surveys. After submission of final EIA report, the Consultant is expected to support SPTrans for approval procedures of the EIA/RIMA and acquisition of LAP. Whole schedule of the Work will be discussed with SPTrans in the commencement of the Work. In addition, meetings shall be held occasionally upon the requests of the SPTrans.

5. SUBMISSION OF THE OUTPUT

The following outputs of the Work shall be submitted to the SPTrans according to the schedule designated the above. Information and data sources refereed for the Work shall be clearly described in the reports.

(1) Inception Report

Inception report describing the approach, methodology, team mobilization plan, and schedule to be applied to the EIA Study shall be submitted to the SPTrans within one (1) week after signing of the contract.

(2) Draft Final Report

Draft final report shall be submitted to the SPTrans within 2 weeks after completion of all of the works mentioned in sub-sections 2.2 - 2.8. The report shall consist of the contents required by approved TOR.

(3) Final Report

The final report shall be submitted to the SPTrans within 2 weeks after corrections, additions, and subtractions based on the comments issued in the meeting and discussions with SPTrans for the draft final report.

Sample table of contents for draft Final Report/Final Report are attached in **Attachment 1**.

(4) Number of Submissions

1) Five (5) sets of the Inception Report in both Portuguese and English, respectively.
2) Five (5) sets of Draft Final Report in both Portuguese and English, respectively.
3) Five (5) sets of Final Report in both Portuguese and English, respectively, with one (1) set of CD-ROM including the full contents of Final Report applying a mutually agreed software.

End.

Attachment 1

Sample Table of Contents for draft Final Report/Final Report

4. ALTERNATIVES STUDY
   4.1. Route Alternatives
   4.2. Modal and Technology Alternatives
   4.3. Selected Alternative

5. PROJECT CHARACTERIZATION
   5.1. Project Location
   5.2. Characterization of Demand
   5.3. Description of Project
      5.3.1. Technical Characteristics of Project
         5.3.1.1. Plan and profile of outline
      5.3.2. Description of Stations
         5.3.2.1. Features of the stations
         5.3.2.2. Stations location and their characteristics
         5.3.2.3. Stations dimensions and capacity
      5.3.3. Constructive Characteristics
         5.3.3.1. Constructive method
      5.3.4. Operating Characteristics
         5.3.4.1. General characteristics of the line
         5.3.4.2. Rolling stock characteristics
         5.3.4.3. Trains maneuvers
      5.3.5. Characteristics of Systems
         5.3.5.1. Monitoring and control system
         5.3.5.2. Signaling and control system
         5.3.5.3. Protection and automatic operation system
         5.3.5.4. Power system
         5.3.5.5. Telecommunications system
         5.3.5.6. Access and passengers control system
         5.3.5.7. Maintenance support system
         5.3.5.8. Auxiliaries system
         5.3.5.9. Security control center
         5.3.5.10. Rolling stocks
   5.5. Schedule, Investment and Labor
      5.5.1. Schedule for Enterprise Implementation
      5.5.2. Investment Estimated
      5.5.3. Labor

6. ENVIRONMENTAL CONDITION
   6.1. Definition of Project Influence Areas
      6.1.1. Indirect Influence Area – IIA
      6.1.2. Direct Influence Area – DIA (Around the Project Site)
      6.1.3. Directly Affected Area – DAA (In the Project Site)
   6.2. Characterization and Analysis of Physical Environment
      6.2.1. Weather
      6.2.2. Air Quality
         6.2.2.1. Characterization of air quality in RMSP
         6.2.2.2. Quality parameters
         6.2.2.3. Air quality in DIA
      6.2.3. Regional Geology – IIA
      6.2.4. Geomorphology – IIA
      6.2.5. Pedology – IIA
      6.2.6. Ground Water – IIA
      6.2.8. Geotechnical Aspects – IIA
      6.2.9. Geology, Geomorphology and Pedology of the DIA and DAA
      6.2.10. Geotechnical Aspects of the DIA and DAA
      6.2.11. Water Resources
         6.2.11.1. Hydrography in the IIA and DIA
         6.2.11.2. Hydrology in the IIA and DIA
         6.2.11.3. Water quality
      6.2.12. Noise and Vibration

6.2.12.1. Standards of reference
6.2.12.2. Methodology of analysis
6.2.12.3. Measurements of noise and vibration
6.3. Characterization and Analysis of Urban Environment
6.3.1. Regional Economic Development
6.3.1.1. Location of jobs in the RMSP
6.3.1.2. Characterization of employment in the Direct Influence Area
6.3.2. Socioeconomic and Demographic Profile
6.3.2.1. Population and demographic dynamics
6.3.2.2. Family income
6.3.2.3. Education
6.3.2.4. Health
6.3.2.5. Human development index
6.3.3. Urban Structure
6.3.3.1. Expansion and densification of the occupation
6.3.3.2. Urban dynamics in IIA
6.3.4. Soil Use, Occupancy, and Zoning
6.3.4.1. Soil use and occupancy in AID
6.3.4.2. Zoning and urban areas of the IDA
6.3.5. Archaeological and Cultural Heritage
6.3.6. Real Estate Market
6.3.6.1. A dynamic real estate in RMSP: recent trends 1987 - 2006
6.3.6.2. Dynamics around the real estate development
6.3.6.3. Released real estate for private use
6.3.6.4. Released real estate for commercial use
6.3.6.5. Real estate prices
6.3.6.6. Standard price of land
6.3.6.7. Considerations on the dynamics of real estate
6.3.7. Regional Accessibility Standards
6.3.8. Road System and Traffic
6.3.8.1. Structure of the road system of RMSP
6.3.8.2. Characterization of the traffic management
6.3.8.3. Soil use and urban movement
6.3.8.4. Surveillance
6.3.8.5. Security
6.3.8.6. Main road system and their hierarchies in the Direct and Indirect Areas
6.3.8.7. Major problems and shortcomings of the road system
6.3.9. Mass Transport
6.3.9.1. Collective transport in RMSP
6.3.9.2. Integrated system
6.3.9.3. Collective transport in the area of influence
6.3.10. Social Organizations
6.3.11. Areas to be Expropriated
6.3.11.1. Definition of the areas listed for expropriation
6.3.11.2. Characterization of the areas listed for expropriation
6.4. Characterization and Analysis of Biota
6.4.1. Vegetation in the Indirect Influence Area - IIA
6.4.1.1. Regional characterization
6.4.1.2. Units of conservation and protected areas
6.4.1.3. Plant cover in IIA
6.4.2. Characterization of Fauna in IIA
6.4.3. Characterization of Vegetation in IDA
6.4.3.1. Municipal parks
6.4.3.2. Plant cover in AID
6.4.4. Characterization of Fauna in IDA
6.4.5. Characterization of Vegetation in ADA
6.4.5.1. Plant cover
6.4.5.2. Environmental compensation
6.4.6. Characterization of the Fauna in ADA
6.4.6.1. Fauna observed

8.1.2.10. Relocation of public services (electricity, telephone, water etc.)
8.1.2.11. Transport of materials and equipment and traffic diversions
8.1.2.12. Disposal of surplus material
8.1.2.13. Recuperation of contaminated land (past environmental pollution)
8.1.2.14. Archaeological asset
8.1.2.15. Degradation of the urban landscape
8.1.2.16. Works related to the termination of construction
8.1.3. Program for Archaeological Investigation and Restoration
8.2. Land Acquisition and Resettlement Action Plan
8.2.1. Avoidance and minimization of the Resettlement
8.2.2. Approximate Identification of Magnitude of the Impact
8.2.2.1 Land area to be acquired by area and by type
8.2.2.2 Number of structures to be relocated
8.2.3 Socio-economic Features of the Project-Affected Persons (PAPs)
8.2.3.1 Socio-economic data based on secondary data
8.2.3.2 Results of socio-economic survey
8.2.4. Compensation and Assistance under Current Legislations
8.2.5. Entitlement Matrix
8.2.6. Securing Resettlement Sites
8.2.7. Resettlement Assistance
8.2.8. Assistances for Livelihood Recovery
8.2.9. Public Involvement in the Process of the Resettlement
8.2.10. Monitoring Plan
8.2.11. Responsibilities of Relevant Organizations
8.2.12. Cost Estimate and Financial Arrangement
8.3. Plan of Social Communication
8.3.1. Key Actions in Various Stages of Development
8.3.2. Sub-Program Monitoring on Relocation of Population and Economic Activities
8.3.3. Subprogram of Communication and Social Monitoring for Emergencies
8.4. Environmental Monitoring Plan
8.4.1. Monitoring Program for Water Quality
8.4.2. Monitoring Program for Subsidence
8.4.3. Monitoring Program for Air Quality
8.4.4. Monitoring Program for Noise Level
8.4.5. Monitoring Program for Vibration Level
8.4.6. Environmental Compensation Program

9. Conclusions and Recommendations

10. Bibliography

11. Technical Team

12. Attachments

CHAPTER 9 PROJECT EFFECT

9.1 OPERATION AND EFFECT INDICATORS

9.1.1 Operation Indicator

Operation indicators are the reference numbers to monitor whether or not (or how much degree) the transport system that is developed in the project is operated as expected in the project plan. On the other hand, Effect indicators are used to monitor whether or not (or how much degree) the project achieves its purpose. These indicators will be checked after the transport system starts the operation. Operation indicators should be measurable. The tables below show the operation indicators proposed by JICA Study Team. Indicators of transport volume will be used to check whether the system provides sufficient capacity as expected, while those of train operation evaluate efficient usage of the system.

Table 9-1 Operation Indicators (Phase-1)

Indicator Group	Indicator	Line	Target	
			2014	2016
Transport volume	No. of passengers per weekday	ALL	393,000	407,000
	Revenue per weekday (R$)	ALL	675,400	695,000
	PHPDT of weekday	1A	13,600	14,100
		2A	22,800	23,200
Train operation	No. of trains per weekday	1A		220
		2A		280
	Car-km per weekday	1A		10,950
		2A		33,800
	Peak hour headway	1A		4 min
		2A		2 min 20s
	Rolling stock operating rate*1	ALL		80-90%*2

Source: JICA Study Team

Table 9-2 Operation Indicators (Phase-2)

Indicator Group	Indicator	Line	Target	
			2016	2018
Transport volume	No. of passengers per weekday	ALL	754,400	773,800
	Revenue per weekday	ALL	1,294,500	1,327,900
	PHPDT of weekday	1A	11,500	12,200
		2A	29,800	30,300
		2B	26,700	26,900
		2D	13,700	14,400
Train operation	No. of trains per weekday	1A		202
		2A		274
		2B		274
		2D		202
	Car-km per weekday	1A		12,800
		2A		40,200
		2B		45,100
		2C		32,700
	Peak hour headway	1A, 2D		5 min
		2A, 2B		2 min 30s
	Rolling stock operating rate*1	ALL		80-90%*2

Source: JICA Study Team

Table 9-3 Operation Indicators (Phase-3)

Indicator Group	Indicator	Line	Target	
			2018	2020
Transport volume	No. of passengers per weekday	ALL	1,170,000	1,104,300
	Revenue per weekday	ALL	1,836,200	1,895,000
	PHPDT of weekday	1A	16,000	16,900
		2A	28,000	28,500
		2B	23,800	24,000
		2C	4,700	4,800
		2D	14,400	15,200
Train operation	No. of trains per weekday	1A		202
		2A		400
		2B		400
		2C		138
		2D		202
	Car-km per weekday	1A		13,400
		2A		42,100
		2B		50,800
		2C		11,900
		2D		34,000
	Peak hour headway	1A, 2D		4 min 15s
		2A, 2B		2 min 30s
		2C		6 min
	Rolling stock operating rate*1	ALL		80-90%*2

*1: Cumulative operating days per year per train / (365 – average inspection days)
*2: The target of 80-90% is suggested in the JICA post evaluation guideline
Source: JICA Study Team

9.1.2 Effect Indicator

Effect indicators should be measurable numbers which will be the result of the project. Transport volume of the system is one of the most important effect indicators. Decongestion of road traffic and environmental improvement are the major purpose of the project. However, the effect of these items is affected by not only this project but also other transport projects such as the metro expansion. The travel time and speed between Jardim Angela and Santo Amaro were selected as the effect indicators because it can be said that the change in traffic on M'Boi Mirim Road will be the result of this project. In São Paulo, an image survey for transportation services is carried out sometimes. The image rate can be one of the reference numbers of the project effect.

Table 9-4 Effect Indicators

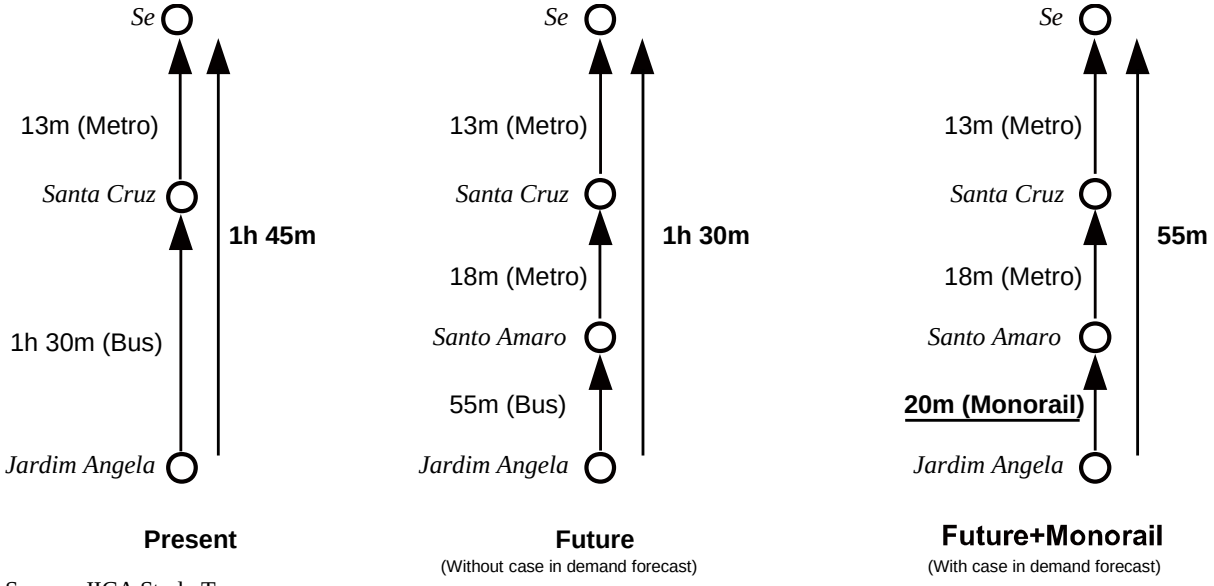
Indicator Group	Indicator	Target
Transport volume	PHPDT	23,000
	Passenger-km	2,600,000
Road traffic	Travel time from Jardim Angela to Snato Amaro by monorail including ticket purchase and waiting time	30 minutes
	Bus speed on M'Boi Mirm in peak hours	15km/h
Service	Image rate in the research of transportation image services	95% (excellent + good)

*1: The present off-peak speed
*2: Higher target than 94% of metro in 2000 research
Source: JICA Study Team

9.2 PROJECT IMPACT

9.2.1 Travel Time Reduction

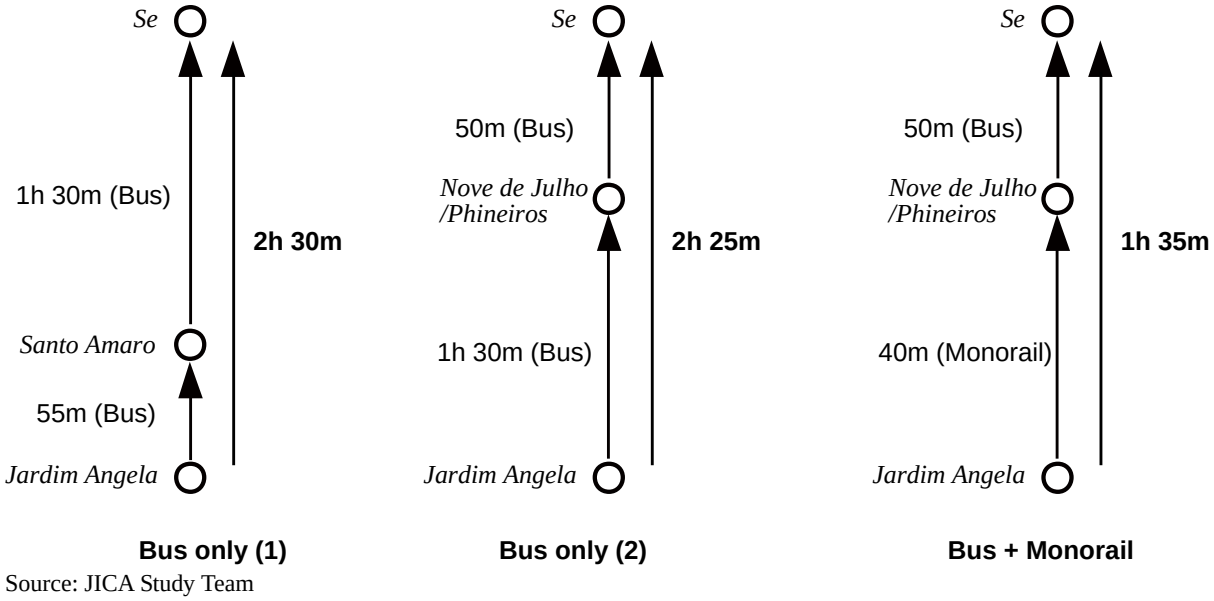
The project will reduce the travel time. Currently, the travel time from Jardim Angela Terminal to the center of the city (Metro Se Station) in the morning peak hour is approximately 1 hour and 45 minutes by bus and metro at a fare of R$ 3.85. The metro expansion (Line-5) will reduce the travel time by 15 minutes in the future. In addition to the metro project, the monorail will reduce the travel time by 35 minutes.



Source: JICA Study Team

Figure 9-1 Travel Time from Jardim Angela to Se in Peak Hours (Bus - Metro)

If metro is excluded for the travel mode to avoid extra charge, the travel time from Jardin Angela to the center of the city is long at approximately 2 hours 30 minutes in peak hours. If the fare system of monorail belongs to SPTrans network, the monorail project will reduce the travel time by 50 minutes at a fare of R$ 2.3.



Source: JICA Study Team

Figure 9-2 Travel Time from Jardim Angela to Se in Peak Hours (Bus network only)

The travel time reduction is also expected for Line-2D corridor. Currently, it takes 50 minutes from CPTM Imperatriz Leopordina Station to Faria Lima/Reboucas intersection by bus in the morning peak hours. Although Line-2D is detour of this route, it will take only 15 minutes by monorail.

The travel time reduction of the transport network in São Paulo was calculated in terms of passenger-hours in the peak hour from with - without analysis in Chapter 3. The difference of travel time between bus and monorail in off-peak is smaller than that of peak time because bus speed increases in off-peak hours. To convert the reduction in passenger-hours in peak hour to a daily one, the number of passengers of the project lines was calculated for every hour from the simple traffic assignment by using hourly OD. Travel speed by bus was assumed as 12km/h in peak hours and 18 km/h in off-peak hours while the speed of monorail was assumed as 30km/h. From the hourly passenger volume and the assumptions about speed, the conversion factor of peak-hour passenger-hours to daily passenger-hours was calculated as 8.6. Table below shows the calculated reduction in passenger-hours.

Table 9-5 Reduction in Passenger-Hours by Project

(passenger-hours in peak hour, '000 passenger-hours in day)

		2015	2025	2045
Peak hour	Private-car users	4,290	9,218	26,580
	Monorail users	16,323	10,149	27,727
	Bus users	16,730	10,959	26,675
Day	Private-car users	36.9	72.3	228.6
	Monorail users	140.4	87.3	238.5
	Bus users	143.9	94.2	229.4

Source: JICA Study Team

9.2.2 Traffic Reduction

The project can reduce the large number of bus fleet along the corridors. The capacity of 30,000 PHPDT by the monorail system is as large as 1.5 times the present peak traffic of BRT along M'Boi Mirim Road where the traffic is already saturated. In without case, a long detour will be necessary to carry the future demand because of the limited capacity of the shortest route. Therefore, the project can reduce the travel distance.

To evaluate the reduction in the number of buses and the travel distance, the reduction in vehicle kilometers was calculated by the same method of the travel time reduction. To convert peak-hour vehicle-kilometer reduction to the daily one, a conversion factor of 9.1 (peak hour rate is 11%) was used.

Table 9-6 Reduction in Vehicle-Kilometers by Project

		2015	2025	2045
Peak hour	Private-mode	7,530	28,718	32,305
	Public-mode*	7,154	27,282	30,690
Day	Private-mode	68,455	261,076	293,684
	Public-mode*	65,032	248,023	278,999

* calculated from 30 passengers per bus (= 2PCU)
Source: JICA Study Team

9.3 ENVIRONMENTAL BENEFITS

9.3.1 Expected Environmental Benefits

As mentioned in the Chapter 8, while some environmental and social impacts would be arisen environmental benefits such as reduction of carbon dioxide (CO_2) and air pollutants emission with decrease of vehicle traffic amount by implementation of the Project. In this section, these environmental benefits are estimated quantitatively.

9.3.2 Characteristics of Brazilian Vehicle Traffic

One of the characteristics of Brazilian vehicle traffic is to use ethanol made from sugar cane, main agricultural products in Brazil, as vehicle fuel. When environmental benefits of the Project is examined, the followings should be remarked.

(1) Utilization of Ethanol as Vehicle Fuel

Ethanol is one of biomass fuels, and is considered to contribute to mitigation of climate change. In 1970s, Brazil had adopted a national policy to use ethanol made from sugar cane as fuel to address rising of import price of oil and depreciation of selling price of sugar cane which was a main agricultural product. The policy has been kept to date, even though it has been affected by some external factors, such as fluctuation of oil price. Currently, anhydride ethanol mixed with gasoline, named "gasoline C", is widely used in Brazil. Additionally, as mentioned below, number of flexible-fuel vehicles, that could use both gasoline and ethanol, is increasing, and such tendency is considered to continue and expand in Brazil.

(2) Wide Utilization of Flexible-fuel Vehicles

In Brazil, flexible-fuel vehicles are used widely, especially in passenger car category. Flexible-fuel vehicles can use both alcohol fuels and gasoline. Brazilian flexible-fuel vehicles can use gasoline C and 100 % of ethanol (E100) as a mixing fuel. This type of vehicles had been produced from 1979, and the number of its production and registration is increasing year by year.

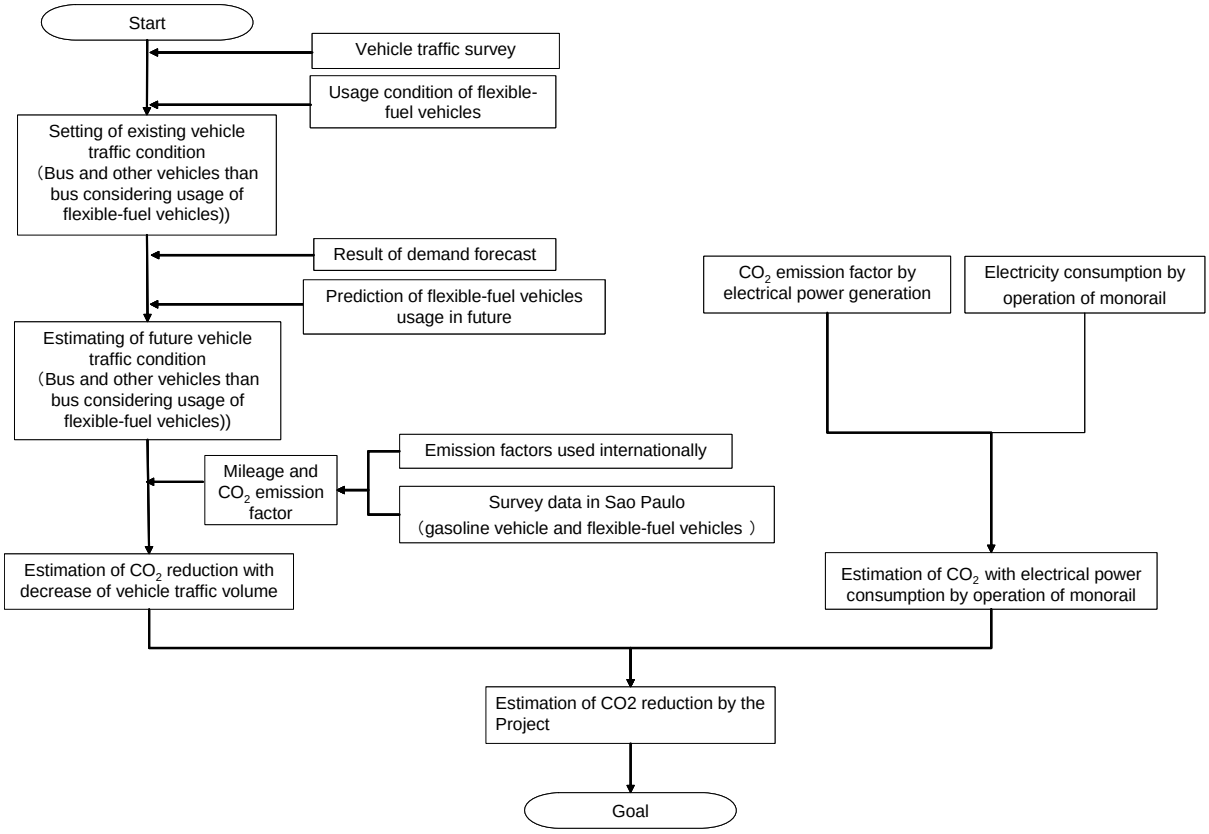
Currently, the number of newly registered flexible-fuel vehicles is larger than that of gasoline vehicles. In 2008, approximately 2,300,000 of flexible-fuel vehicles were registered in Brazil, of which rate to total number was about 82%[1]. In São Paulo metropolitan, same tendency has been observed. According to statistical data by Company of Environmental Technology and Sanitation (CETESB), flexible-fuel vehicles occupied approximately 14% of total number of vehicles in São Paulo[2]. It is considered that the rate of flexible-fuel vehicles will increase continuously, and a report predicts for flexible-fuel vehicles to occupy approximately 60% of total number of vehicles in Brazil in 2015[3].

[1] Brazilian Automotive Industry Yearbook (2009), ANFAVEA
[2] Report on Air Quality Survey in São Paulo in 2008 (2009), CETESB, São Paulo
[3] http://ethanolbrasil.blogspot.com/2010/01/frota-nacional-de-veiculos-flex-fuel.html, IETHA

9.3.3 Estimation of Carbon Dioxide Emission Reduction by the Project

(1) Measures for Estimation of Carbon Dioxide Reduction by the Project

Reduction amount of carbon dioxide (CO_2) emission was estimated with considering both a positive effect, reduction of CO_2 emission with decrease of vehicle traffic volume, and an offset effect, discharge of CO_2 by electrical power consumption for operation of monorail. A target year of the estimation was set as 2015 when all proposed lines are operated. Outline of the measure for estimation of CO_2 reduction by the Project is shown in Figure 9-3.



Source: prepared by JICA Study Team

Figure 9-3 Outline of Measure for Estimation of CO_2 Reduction by the Project

Based on decrease of vehicle traffic volume calculated by the result of demand forecast (decrease of total vehicle driving distance in São Paulo), and predicted electrical power consumption for operating monorail, amount of CO_2 reduction by the Project was estimated by the following equation.

$$RA_{co2} = (\sum (Vi \times Mi \times EFi) / 1{,}000) - (E \times EFe / 1{,}000)$$

RA_{CO2}: Amount of CO_2 reduction by the Project (ton-CO_2/day)
Vi: Reduction of vehicle driving distance by the Project (km/day)
Mi: Mileage of vehicles (L/km)
EFi: CO_2 emission factor per unit fuel consumption (kg-CO_2/L)
E: Electrical power consumption by operating monorail (kWh/day)
EFe: CO_2 emission factor per unit power generation (kg-CO_2/kWh)

Mileages and emission factors by each type of vehicle were set with existing literatures by CETASB and other institutes. CO_2 emission factors set are shown in Table 9-7.

Table 9-7 CO_2 Emission Factors per Unit Fuel Consumption

Type of vehicle	Estimated actual vehicle distribution by type	GHG emissions	
		Actual rate	Weighted average rate
		(Kg CO_{2eq}/litre	(Kg CO_{2eq}/litre
Car - gasoline fuelled		2.163	
Car- ethanol fuelled		1.381	
Car - gasoline only	0.45	2.163	0.973
Car - flexi fuel (50% gas,50% ethanol)	0.55	1.772	0.975
Average car			1.948
Rigid Bus - diesel fuelled	0.77	2.793	2.152
Articulated Bus - diesel fuelled	0.23	2.793	0.641
Average bus			2.793

Sources:
(1) Companhia de Tecnolgia de Saneamento Ambiental, *Qualidade do Ar No Estado de Sao Paulo,* 2008
(2) Victoria Transport Policy Institute, *Climate Change Emission Valuation for Transportation Economic Analysis, 02 Jan.2009*
(3) SPTrans Presentation March 2009 (Tipos de veículo especificados)
(4) JICA Study Team Questionnaire on Bus Costs 18 June 2009

CO_2 emission factor per unit power generation was set as 0.41 kg-CO_2/kWh, considering reference value adopted in a CDM project for co-generation plant operation in Brazil and rate of hydropower generation in São Paulo state.

The weighted average rate of fuel consumption per vehicle-km was estimated as shown in Table 9-8.

Table 9-8 Estimation of Fuel Consumption per vehicle-km (car and bus)

Type of vehicle	Estimated actual vehicle distribution by type	Fuel consumption	
		Actual rate	Weighted average rate
		(Litres/'000 km)	(Litres/'000 km)
Car - gasoline fuelled		103	
Car- ethanol fuelled		85	
Car - gasoline only	0.45	103	46.2011
Car - flexi fuel (50% gas,50% ethanol)	0.55	94	51.7384
Average car			97.9394
Rigid Bus	0.77	416	320.6729
Articulated Bus	0.23	753	172.8707
Average bus			493.5436

Sources:
(1) Companhia de Tecnolgia de Saneamento Ambiental, *Qualidade do Ar No Estado de Sao Paulo,* 2008
(2) Victoria Transport Policy Institute, *Climate Change Emission Valuation for Transportation Economic Analysis, 02 Jan.2009*
(3) SPTrans Presentation March 2009 (Tipos de veículo especificados)
(4) JICA Study Team Questionnaire on Bus Costs 18 June 2009

(2) Estimation Result

Table 9-9 shows the result of the estimation. The reduction in CO_2 emission by the Project was estimated as approximately 18,400 ton per year (50 ton per day) in 2015, 57,300 ton per year (157 ton per day) in 2025, and 72,000 ton (197 ton per day) in 2045. The estimated value will be changed in accordance with transport policy in São Paulo[4].

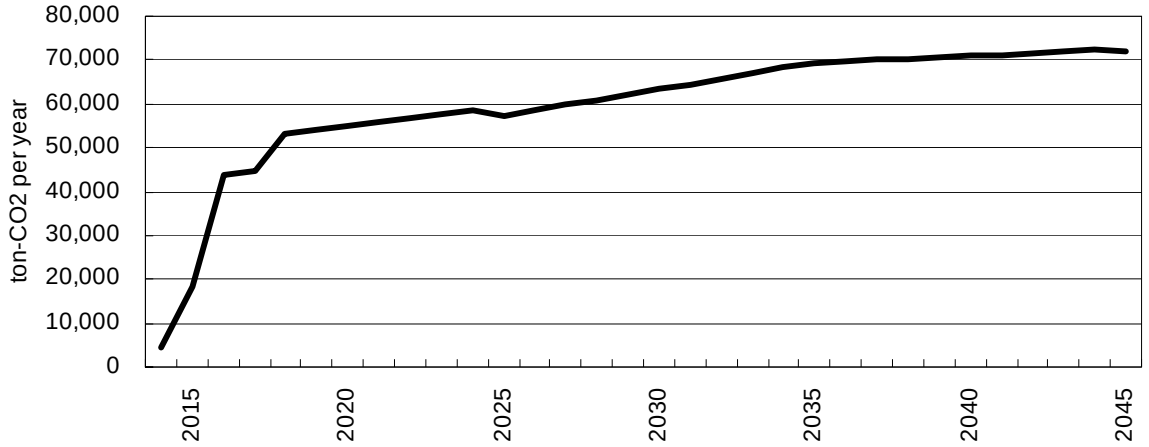
Table 9-9 Estimation of the reduction in CO_2 emission (the case of entire routes)

Year	Reduction in Veh-km (000)		Reduction in CO_2-tons /day		Reduction in CO_2-tons /year	Monorail Car-km (000) per year	Increase in CO_2-tons /year by monorail	Reduction in CO_2-tons /year Total
	Bus (a)	Car (b)	Bus (c)=(a)*K1	Car (d)=(b)*K2	Bus&Car (e)=((c)+(d))*340	(f)	(g)=(f)*0.8984	(e)-(g)
2015	65.0	68.5	89.6	13.1	32,035	15,237	13,658	18,377
2025	248.0	261.1	341.8	49.8	122,176	72,404	64,903	57,272
2035	272.7	287.0	375.7	54.8	134,310	72,404	64,903	69,407
2045	279.0	293.7	384.5	56.0	137,435	72,992	65,430	72,005

K1 = 1.378 CO_2-kg/bus-km
K2= 0.8964 CO_2-kg/car-km

Source: JICA Study Team

Figure 9-4 shows the chart of the reduction in CO_2 emission by year.



Source: JICA Study Team

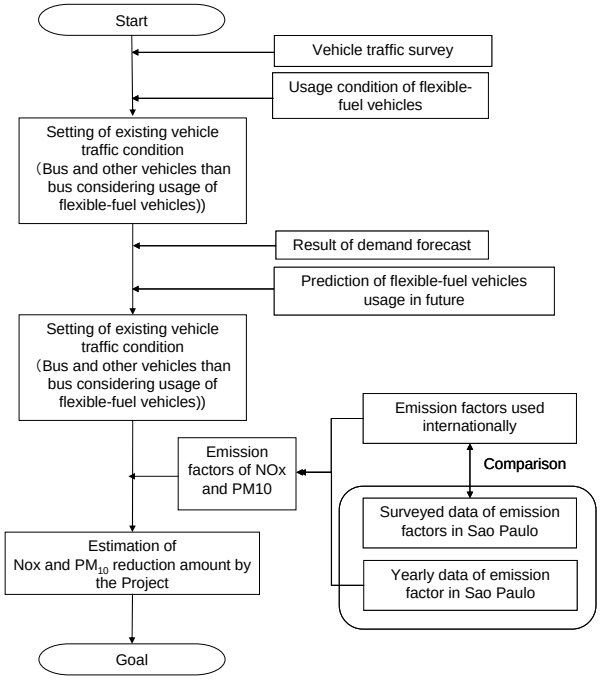
Figure 9-4 Estimation of CO_2 Emission Reduction by the Project

9.3.4 Estimation of Air Pollutants Emission Reduction by the Project

(1) Measures for Estimation of Air Pollutants Reduction by the Project

To examine effect of reduction of air pollutants emission by the Project, nitrogen oxide (NOx) and particulate matter (PM_{10}) reduction amount by the Project was estimated. Outline of the measure for estimation of air pollutants reduction amount is shown in Figure 9-5.

[4] World Bank has been started "Sustainable Transportation and Air Quality (STAQ) Project" from 2010, and plans to implement activities to contribute to improvement of air quality and reduction of greenhouse gasses emission.



Source: prepared by JICA Study Team

Figure 9-5 Outline of Measure for Estimation of Air Pollutants Reduction by the Project

Reduction amounts of NOx and PM_{10} emission were estimated by the following equation with predicted decrease of vehicle driving distance based on demand forecast, same as reduction of CO_2 emission.

$$RA_{NOx,\,PM10} = \sum (Vi \times EFi) / 1{,}000$$

$RA_{NOx,\,PM10}$: Amounts of NOx, PM_{10} reduction (kg-NOx/day, kg-PM_{10}/day)
Vi: Reduction of vehicle driving distance by the Project (km/day)
EFi: NOx and PM_{10} emission factor pers unit driving distances (kg-NOx/km, kg-PM_{10}/km)

Emission factors were set based on literatures by CETASB for gasoline vehicle using gasoline C, and flexible-fuel vehicle, and other institutes as shown in Table 9-10.

Table 9-10 NOx and PM10 emission per vehicle-km (gram)

Type of vehicle	Type of pollutant	
	NO_x	PM_{10}
Car	1.600[4]	0.110[2]
Taxi	1.680[4]	0.116[2]
Shared Taxi	4.330[3]	1.408[2]
Minibus	4.330[3]	1.408[4]
Public Bus	4.763[3]	2.872[3]
2-Axle truck	19.327[3]	4.329[4]
3-Axle	20.206[3]	4.525[4]
> 3-Axle	21.084[3]	4.722[4]

Notes:
1. Sulphur content of gasoline is considered to be 50 wt.ppm and of diesel 150 wt.ppm.
2. Expert estimation based on emission factors for Iran, Malaysia, USEPA and spot data from South Africa.
3. Based on Chassis Dynamometer test, conducted in Malaysia.
4. Expert estimation based on emission factors of Malaysia.

These unit emission rates were converted into the weighted average rates of passenger car-km and bus-km as shown in Table 9-11.

Table 9-11 Estimation of Average Unit Emission Rates of Car and Bus in São Paulo

Type of vehicle	Estimated actual vehicle distribution by type	NO_x emissions		PM_{10} emissions	
		Actual rate	Weighted average rate	Actual rate	Weighted average rate
		grams per km	grams per km	grams per km	grams per km
Car - gasoline fuelled		0.860		0.110	
Car- ethanol fuelled		1.007		0.110	
Car - gasoline only	0.45	0.860	0.387	0.110	0.050
Car - flexi fuel (50% gas,50% ethanol)	0.55	0.933	0.513	0.110	0.061
Average car			0.900		0.110
Rigid Bus - diesel fuelled	0.77	4.763	3.669	2.872	2.212
Articulated Bus - diesel fuelled	0.23	21.084	4.842	4.722	1.084
Average bus			8.511		3.297

Sources:

(1) Companhia de Tecnolgia de Saneamento Ambiental, *Qualidade do Ar No Estado de Sao Paulo,* 2008
(2) Victoria Transport Policy Institute, *Climate Change Emission Valuation for Transportation Economic Analysis, 02 Jan.2009*
(3) SPTrans Presentation March 2009 (Tipos de veículo especificados)
(4) JICA Study Team Questionnaire on Bus Costs 18 June 2009

(2) Estimation Result

As shown in Table 9-12, the reduction in NOx and PM_{10} was estimated as approximately 192 ton per year (562kg-NOx per day) and 69.2 ton (190 kg-PM_{10} per day) in 2015 when only Line-1A and Line-2A are operated. After the start of the operation of the entire routes, the reduction will be approximately 732 ton per year (2 ton-NOx per day) and 264 ton (724 kg-PM_{10} per day) in 2045, for example. These estimated values would be changed in accordance with transport policy in São Paulo, same as estimation result of CO_2 reduction by the Project.

Table 9-12 Air Pollutants Reduction Amount (2015)

Year	Reduction in Veh-km (000)		Reduction in NO_X-tons /day		Reduction in NO_X-tons /yr	Reduction in PM_{10}-kg /day		Reduction in PM_{10}-kg /yr
	Bus (a)	Car (b)	Bus (c)=(a)*K1	Car (d)=(b)*K2	(e)= ((c)+(d))*340	Bus (f)=(a)*K3	Car (g)=(b)*K4	(h)= ((e)+(h))*340
2015	65.0	68.5	0.6	0.1	191.9	214.4	7.5	69.2
2025	248.0	261.1	2.1	0.2	731.9	817.7	28.7	264.1
2035	272.7	287.0	2.3	0.3	804.6	898.9	31.6	290.3
2045	279.0	293.7	2.4	0.3	823.3	919.9	32.3	297.1

Source: JICA Study Team

CHAPTER 10 ECONOMIC AND FINANCIAL APPRAISAL

10.1 INTRODUCTION

Two cases of economic and financial appraisal, one for Phase-1 (Line-A1 and Line-A2 only) and the other for the entire route opening case, have been carried out.

10.2 PRECONDITIONS

10.2.1 Appraisal period

The evaluation period assumed for the appraisal of Phase-1 and the entire route starts in 2010, when the process of acquiring land and paying compensation to project affected persons commence, and ends in 2045, which is the last year of the demand forecast. The construction period (2011-2014 in the case of Phase-1, 2013-2016 in the case of Phase-2 and 2015-2018 in the case of Phase-3) forms part of the evaluation period, as does the operating period.

10.2.2 Expected lifetime

Expected lifetime for economic and financial appraisals were assumed as shown below,

Tunnel	100 years
Other civil structures (elevated structures, elevated stations, depot)	50 years
E & M	50 years
Rolling stock	50 years

These expected lifetimes will be used in order to calculate residual values in the last year of the project appraisal period for economic and financial appraisal, and also be used to calculate depreciation cost for financial appraisals.

10.2.3 Annualization factor

The transport demand forecast provides a projection of daily demand. These daily demand forecasts were in particular used as the basis for estimating the project's economic benefits and income from fare revenue. In order to convert these estimates from a daily to an annual basis, it was necessary to derive a factor for use in converting daily to annual demand. On the basis of advice received from SPTrans a factor of 312 was used, in order to allow for the relatively large number of public holidays and other low traffic days in São Paulo.

10.3 ECONOMIC APPRAISAL

10.3.1 Methodology

In this project, economic appraisals will be made in a standard way, by comparing economic benefits with economic cost over the appraisal period.

The economic benefits are measured by comparing the economic cost streams associated with the *With* and *Without* project cases. The presumption is that the project will bring about a reduction in the volume of traffic circulation (measured in terms of vehicle-km) on urban road network. The reduction in the volume of road traffic circulation will lead directly to a saving in vehicle operating costs (VOC's) and a reduction of air pollution and indirectly, through a reduction in traffic congestion and an increase in the average road traffic speed, to a saving in the value of travel time (VOT).

The reduction in vehicle-km and passenger-hours by the project is summarized in Chapter 9.

The economic costs are calculated from the project cost estimated in Chapter 6, by removing transfer cost such as tax and factors which may distort market prices, such as subsidies. VAT (18%) can be removed from the project cost because it is estimated separately.

Since there remain other factors to be excluded such as fuel taxes, the economic costs are estimated assuming a conversion factor of 0.95 to exclude these remained factors.

10.3.2 Estimation of economic benefits

Although an urban public transport project can generate several types of economic benefit, it was considered that only three types of benefit were capable of practical measurement. These are: savings of vehicle operating costs, savings in the value of travel time, and a reduction in air pollution costs.

(1) Savings of vehicle operating costs (VOC's)

VOCs by vehicle type were estimated from several sources as shown in Table 10-1.

It was necessary to distinguish between gasoline only vehicles and the newer flex vehicles (ie. vehicles which can operate flexibly on gasoline or ethanol fuel) in calculating fuel consumption cost. In late 2008, Flex vehicles were estimated to represent only 16.4 per cent of the total number of registered cars in the São Paulo metropolitan area. Within the next decade, this percentage is expected to increase to more than 50%. Thus for the purposes of this study, the ratio of gasoline and flex vehicle was assumed to be 45%:55%.

Table 10-1 Estimates of VOCs in Sao Paulo city

Item	Gasoline only vehicle	Flex vehicle
Assumed average km per year	25,000	25,000
Assumed new vehicle price (R$)[1]	30,000	45,000
Economic price (new price less VAT @ 18%)	24,600	36,900
Assumed vehicle life (years)	9	9
Annual depreciation	2,733	4,100
Depreciation per 1000 Km, R$	**109**	**164**
Fuel consumption (litres/1000 km) [2]	103	94
Weighted av.price per litre[3]	2.50	2.15
Economic price (retail price less tax @ 41%)[4]	2.09	1.74
Economic cost of fuel per 1000 km (R$)	**214.48**	**163.59**
Lubricants (ass. 5% of fuel cost). R$/1000 km	**10.72**	**8.18**
Maintenance labour and spare parts per 1000km (R$) (assumed at 40% of fuel cost)	**85.79**	**65.43**
Insurance per 1000km (R$) (assumed at 4% of vehicle depreciation)	**43.73**	**65.60**
Total , R$ per 1000 km	**464.06**	**466.80**
Weighted average cost per 1000 km (assuming 55% flex and 45% gasoline powered)	**465.57**	

Notes: (1) Review of new car prices quoted in Jornal Do Carro, 27 February 2010
(2) Fuel consumption rates for gas and flex vehicles from Companhia de Tecnolgia de Saneamento Ambiental, Qualidade do Ar No Estado de Sao Paulo, 2008
(3) Local survey of pump prices 01 March 2010: Gas Comum R$ 2.499 per litre and Alcohol Comum R$ 1.799 per litre. Assumed 50:50 gas/ethanol for flex vehicles
(4) Fuel tax rates from Petrobras website: http://www2.petrobras.com.br

Unit VOC's for buses were estimated from planning data provided by SPTrans in respect of 11 bus types operated within the São Paulo metropolitan area.

The financial costs obtained from the source were converted to economic costs by removing tax as shown in Table 10-2.

Table 10-2 VOC estimates of standard buses in Sao Paulo city

Financial Cost *Unit: R$ per vehicle-km*

Bus type	Minibus	Light Bus	Heavy Bus	Single Articulated Bus	Double Articulated Bus
Monthly distance	6,237	6,237	6,237	6,237	6,237
Variable costs					
Diesel Fuel	0.6750	0.9478	1.2157	1.2617	1.4663
Lubricants	0.0221	0.0214	0.0214	0.0628	0.0759
New Tyres	0.0389	0.0937	0.1482	0.1853	0.2557
Parts & Accessories	0.2190	0.2867	0.3553	0.1913	0.2761
Maint.of ticket machines	0.0063	0.0063	0.0063	0.0063	0.0063
Maintenance.of GPS	0.0048	0.0048	0.0048	0.0048	0.0048
Sub-total	0.9661	1.3606	1.7517	1.7121	2.0851
Fixed costs					
Vehicle depreciation	0.4662	0.6102	0.9535	1.1972	2.0864
Depreciation of ticket machines	0.0043	0.0043	0.0043	0.0043	0.0043
GPS depreciation	0.0133	0.0133	0.0133	0.0133	0.0133
Depreciation of installations	0.0128	0.0128	0.0148	0.0192	0.0192
Salaries and Wages(Op.staff)	1.4587	2.1579	2.1579	2.2328	2.2328
Sub-total	1.9554	2.7986	3.1438	3.4669	4.3561
Administrative costs					
Administrative overhead	0.2830	0.2830	0.2830	0.2830	0.2830
Vehicle insurance	0.0211	0.0268	0.9320	0.0269	0.0269
Sub-total	0.3041	0.3098	1.2150	0.3099	0.3099
GRAND TOTAL	3.2256	4.4690	6.1104	5.4889	6.7510

Economic Cost *Unit: R$ per vehicle-km*

Bus type	SPF	Minibus	Light Bus	Heavy Bus	Single Articulated Bus	Double Articulated Bus
Monthly distance		6,237	6,237	6,237		
Variable costs						
Diesel Fuel	0.76	0.5130	0.7203	0.9239	0.9589	1.1144
Lubricants	0.76	0.0168	0.0163	0.0163	0.0477	0.0577
New Tyres	0.82	0.0319	0.0768	0.1215	0.1519	0.2097
Parts & Accessories	0.82	0.1796	0.2351	0.2913	0.1568	0.2264
Maint.of ticket machines	0.82	0.0051	0.0051	0.0051	0.0051	0.0051
Maintenance.of GPS	0.82	0.0039	0.0039	0.0039	0.0039	0.0039
Total - variable costs		0.7504	1.0576	1.3621	1.3245	1.6172
Fixed costs						
Vehicle depreciation	0.82	0.3823	0.5004	0.7819	0.9817	1.7109
Depreciation of ticket machines	0.82	0.0035	0.0035	0.0035	0.0035	0.0035
GPS depreciation	0.82	0.0109	0.0109	0.0109	0.0109	0.0109
Depreciation of installations	0.82	0.0105	0.0105	0.0121	0.0158	0.0158
Salaries and Wages(Op.staff)	0.67	0.9773	1.4458	1.4458	1.4960	1.4960
Sub-total		1.3846	1.9712	2.2542	2.5079	3.2371
Administrative costs						
Administrative overhead	0.67	0.1896	0.1896	0.1896	0.1896	0.1896
Vehicle insurance	0.82	0.0173	0.0220	0.7642	0.0221	0.0221
Sub-total		0.2069	0.2116	0.9538	0.2117	0.2117
GRAND TOTAL		2.3419	3.2403	4.5702	4.0441	5.0660

Source: Economic studies department, SPTrans, March 2010

Weighted average unit economic costs for rigid and articulated buses were estimated by weighting the costs of each bus type by its proportion of the total fleet (77:23) in each of these categories. The resulting unit economic costs are given shown in Table 10-3.

Table 10-3 Summary of VOC estimation of automobiles and buses

Type of vehicle	Estimated actual vehicle distribution by type	PCU factor applicable to vehicle type	Fuel Type	PCU distribution by vehicle type	Coefficient	VOC	
						Average per category	Weighted average cost
						R$ per 1000 km	R$ per 1000 PCU-Km
Car - gasoline powered	0.4295	1.0	Gasoline	0.4295	0.4087	464	189.6
Car - flexi fuel powered	0.5249	1.0	50% gas;50% eth	0.5249	0.4995	467	233.2
Regular Bus	0.0352	2.0	Diesel	0.0703	0.0669	3,170	212.1
Articulated Bus	0.0105	2.5	Diesel	0.0262	0.0249	4,189	104.4
All sampled vehicle types	1.0000			1.0509	1.0000		***739.3***

VOC's cars only	465.6
VOC's buses only	3,404.2
Proportion of rigid buses	0.7704
Proportion of articulated buses	0.2296

Source: JICA study team

(2) Travel time savings

Travel time savings typically represent a major economic benefit of mass transit projects. In this study, travel time savings have been estimated both for mass transit and remaining road users, the former receiving a direct benefit as a result of much faster mass transit trip times and the latter receiving an indirect benefit resulting from the faster average road speeds made possible by the transfer of traffic from the roads to the mass transit system.

The valuation of travel time (VOT) savings is conventionally based on household income data, with different rates applying to different categories of commuters. This reflects the likelihood that bus passengers will value time differently from private car occupants, while mass transit passengers will value their time differently from the other two groups of commuters.

The stream of benefits resulting from the reduction of travel time will be estimated by applying travel time values to the difference between the person hours estimated for the urban transport network in the *"With"* and *"Without"* project cases.

In this study, estimates of urban travel time values have been based on the results of the latest OD survey in 2007. As shown in Table 10-4, the 2007 base year estimates of the unit value of time for private and public transport users were projected up to 2045 at the real rates of increase in GDP based on the IMF forecast.

Table 10-4 Time value estimation in Sao Paulo City

Year	Value of time				Annual growth rates				Source of growth estimate
	Non-travellers $R/hour	Public transport users $R/hour	Private transport users $R/hour	General $R/hour	Non-traveller	Public transport users	Private transport users	General	
1997	0.71	1.87	3.93	1.58					
2002	0.89	2.30	5.15	2.00	4.6%	4.2%	5.6%	4.8%	
2007	1.58	3.25	6.60	2.80	12.2%	7.2%	5.1%	7.0%	
2014		4.20	8.54	3.62		**3.74%**	**3.74%**	**3.74%**	IMF World Economic Outlook Oct 2009
2025		6.47	13.14	5.57		4.0%	4.0%	4.0%	Consultant's forecast of Real GDP growth
2035		9.76	19.83	8.41		4.2%	4.2%	4.2%	Consultant's forecast of Real GDP growth
2045		15.16	30.79	13.06		4.5%	4.5%	4.5%	Consultant's forecast of Real GDP growth

Sources: (1) Sao Paulo Metro, *Pesquisa Origem e Destino 2007* (completed October 2008)
(2) IMF World Economic Outlook Database, October 2009
(3) Consultant's estimates

(3) Air pollution mitigation

The saving to the economy from reduced atmospheric emissions from road vehicles similarly represents a potentially significant economic benefit of mass transit system development, especially so in a city of the size and traffic density of São Paulo. This benefit is of two types:

- savings from reduced vehicle emissions of greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), which add to global warming; and
- savings from reduced vehicle emissions of noxious gases and particulate matter, such as sulphur dioxide (SO_2), PM_{10}, nitrogen oxides (NO_x), carbon monoxide (CO) and Volatile Organic Hydrocarbons (VOC), which are harmful to health.

These reductions were estimated in Chapter 9. Is this chapter, the reductions were converted into monetary values.

1) Valuation of reduction in greenhouse gas emissions

While fairly robust indicators are available (as shown) for the measurement of the physical volume of emissions, both of greenhouse and noxious gases, by motor vehicles, the valuation of emissions presents a particular problem. This is especially so where a carbon trading market does not operate, or where there are no monetary measurements of the local damage caused by vehicular emissions of noxious gases in the country under study.

For these reasons, the valuation of road vehicle emissions in metropolitan São Paulo is based on the European Union Emissions Trading Scheme in the case of Greenhouse Gas emissions and on data from a study by the Victoria Transport Policy Institute in Canada in the case of emissions of noxious gases and particulate matter.

The valuation of greenhouse gas emissions in line with the price of European carbon emission permits (or EUAs) is considered valid for two reasons. First, they represent the willingness to pay for the right to emit greenhouse gases and are thus an appropriate market measure of value. Second, since the effects of the greenhouse gas emissions are widespread, there will be a tendency for global carbon prices to converge towards the prices established in the European Carbon Trading Scheme, which is the largest and longest established of the world's carbon markets.

For the purposes of valuing the reduction in GHG's which is attributable to the monorail project, the February 2010 benchmark price of EUA's, as at 29 October 2009, was used. This price was €12.91, equivalent to R$ 31.31, per tonne (Source: Carbon Positive (http://www.carbonpositive.net), Carbon Trading Prices 29/10/09).

2) Nitrogen oxide and floating particle substance

The valuation of noxious gas and particulate emissions is more problematical, since the effects of noxious gas emissions are specifically related to the number of receptors (exposed persons), the extent to which their health is impaired, and the extent to which their health impairment will be reflected in increased medical costs. In the absence of adequate local valuations of these costs, this feasibility study makes use of the unit values of noxious gas and particulate emissions as estimated by the VTPI[1]. These were US$ 11,209 (equivalent to R$ 19,616) per tonne for NOx and US$ 7,391 (equivalent to R$ 12,934) per tonne for PM10.

[1] VTIP, Air Pollution Costs spreadsheet 25 November 2006

3) Benefit of urban development

The economic benefit of the urban development route which does not use M'Boi Mirim includes: 1) accessibility to stations will be improved, 2) Favela will be redeveloped, and 3) traffic congestion of M'Boi Mirim during construction will be smaller. Since travel time becomes longer due to the longer distance, the impact of 1) is not clear and difficult to measure from the demand forecast due to its accuracy. Although the valuation of the impact of 2) is difficult in normal economic analysis, the economic benefit should be considered. In case of the economic benefit of 3), it will be probably canceled by the cost of tunnel construction.

10.3.3 Calculation of Economic Internal Rate of Return (EIRR)

Table 10-5 shows the result of the calculation of the economic internal rate of return (EIRR). The entire route case results in the EIRR of 19.0% while the Phase-1 only case (original route) results in 17.0%. In case of Phase-I only (urban development case), the EIRR was estimated as 17.7% because the economic costs of the case is higher than the original case if the benefit described in 10.3.2 is not considered.

Table 10-5 Cash-flow sheet for economic analysis

Year	All network					Phase-1 Original				
	Capital Expenditure	O&M	VOC Savings	VOT Savings	Net Benefit	Capital Expenditure	O&M	VOC Savings	VOT Savings	Net Benefit
2010	7.5				-7.5	7.5				-7.5
2011	366.3				-366.3	366.3				-366.3
2012	1,197.3				-1,197.3	1,177.0				-1,177.0
2013	1,937.7				-1,937.7	917.7				-917.7
2014	1,726.9	21.1	21.3	116.0	-1,610.6	233.5	21.0	21.3	116.0	-117.2
2015	1,228.6	84.5	86.1	494.1	-732.9		84.1	86.1	494.1	496.1
2016	399.0	213.8	226.5	890.0	503.7		84.1	87.0	524.8	527.7
2017	153.4	213.8	229.3	939.9	802.0		84.1	87.8	556.2	559.9
2018	4.9	319.2	232.1	990.7	898.7		84.1	88.7	588.3	592.8
2019		319.2	313.6	1,283.9	1,278.3	117.1	84.1	89.5	621.0	509.3
2020		319.2	316.1	1,351.2	1,348.1		88.0	90.4	654.4	656.8
2021		319.2	318.5	1,419.8	1,419.2		88.0	91.2	688.5	691.7
2022		319.2	321.0	1,489.7	1,491.5		88.0	92.1	723.3	727.3
2023		319.2	323.5	1,560.8	1,565.1		88.0	92.9	758.7	763.7
2024	49.1	319.2	325.9	1,633.3	1,590.9		88.0	93.8	794.9	800.6
2025		326.1	328.4	1,707.0	1,709.2		88.0	94.6	831.7	838.3
2026		326.1	331.7	1,804.6	1,810.1		88.0	95.6	876.9	884.5
2027		326.1	334.9	1,903.2	1,912.0		88.0	96.5	922.4	930.9
2028		326.1	338.2	2,002.9	2,015.0		88.0	97.5	968.2	977.6
2029		326.1	341.4	2,103.7	2,119.0		88.0	98.4	1,014.2	1,024.6
2030		326.1	344.7	2,205.4	2,224.0		88.0	99.4	1,060.6	1,071.9
2031		326.1	348.0	2,308.3	2,330.1		88.0	100.3	1,107.2	1,119.5
2032		326.1	351.2	2,412.1	2,437.2		88.0	101.3	1,154.1	1,167.3
2033		326.1	354.5	2,517.0	2,545.4		88.0	102.2	1,201.2	1,215.4
2034		326.1	357.8	2,623.0	2,654.6		88.0	103.2	1,248.7	1,263.8
2035		326.1	361.0	2,729.9	2,764.8		88.0	104.1	1,296.4	1,312.5
2036		326.1	361.9	2,891.5	2,927.2		88.0	104.7	1,371.3	1,388.0
2037		326.1	362.7	3,054.1	3,090.6		88.0	105.3	1,446.4	1,463.8
2038		326.1	363.5	3,217.8	3,255.2	58.5	88.0	105.9	1,522.0	1,481.3
2039	6.5	326.1	364.4	3,382.7	3,414.4		88.0	106.5	1,597.8	1,616.3
2040		328.0	365.2	3,548.6	3,585.9		90.0	107.1	1,674.0	1,691.1
2041		328.0	366.1	3,715.7	3,753.8		90.0	107.7	1,750.5	1,768.2
2042	665.3	328.0	366.9	3,883.9	3,257.5	665.3	90.0	108.4	1,827.3	1,180.4
2043	665.3	328.0	367.7	4,053.1	3,427.6	665.3	90.0	109.0	1,904.5	1,258.2
2044		328.0	368.6	4,223.5	4,264.1		90.0	109.6	1,982.0	2,001.6
2045	-2,224.8	328.0	369.4	4,395.0	6,661.2	-1,517.4	90.0	110.2	2,059.9	3,597.4
EIRR					17.0%					19.0%

Source: JICA study team

The Net Present Value (NPV) and the Benefit Cost Ratio (B/C) are calculated as shown in Table 10-6.

Table 10-6 Results of NPV and B/C (economic analysis)

	Entire route case	Phase-1
NPV (R$ million)	2,785	1,676
B/C	1.52	1.71

Source: JICA study team

10.3.4 Sensitivity analysis

The sensitivity analysis was carried out for the following three cases: 1) increase in the capital expenditure by 20%, 2) increase in the O&M cost by 20%, and 3) decrease in the benefit by 20%.

Figure 10-1 shows the result of the entire route case. The reduction in the benefit shows the largest impact on the EIRR, while that of the increase in O&M is small. In all cases, the EIRR is larger than 12%, which is general benchmark of a project appraisal. If the three cases are combined, the EIRR drops to 11.9%, which implies that there exist a small risk in the project.

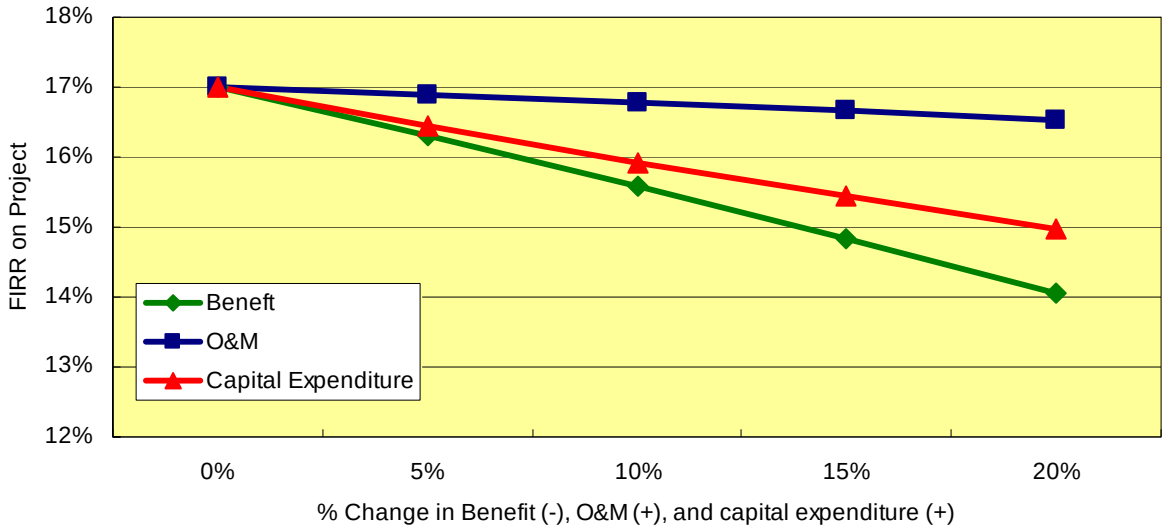


Figure 10-1 Sensitivity analysis of EIRR (entire route case)

The result of Phase-1 case (original route) shows the same trend that benefit has the greatest impact, and EIRR is 18.8% in the case that benefit decreases 20%. However, even if three conditions are satisfied, EIRR is 13.7%, which is higher than 12%. From this result, it can be said that stable benefits are expected.

The environmental benefit is not so large compared to other benefits (R$ 22.4 million in 2045), and the benefit was not included in the EIRR calculation since the value is within the range of sensitivity analysis above.

10.4 FINANCIAL APPRAISAL

10.4.1 Cases of financial appraisal

The financial analysis was carried out for the case of entire routes and phase-1 only (original route) like economic analysis.

10.4.2 Estimation of FIRR on Project

Financial Internal Rate of Return (FIRR) was calculated without consideration of financial sources (i.e. in case of 100% self-financing) to evaluate the profitability of the project.

(1) Initial investment and O&M cost

The capital and O&M costs forming the cash outflows of the project are summarized in Chapter 6 and 7, respectively. The outflows of capital costs were assumed to apply as from 2011 (the first year of cost disbursement), while the outflows of O&M costs were assumed to apply as from 2014 (the first year of operation)..

Since the asset lives of E&M and rolling stock are assumed as 30 years, the renewal investment corresponding to Phase-1 and Phase-2 will take place in the end of the project evaluation period. The evaluation period finishes immediately after the renewal investment for Phase-2, and the investment is calculated as residual value in the inflow. Therefore, the renewal investment is considered only for that of Phase-1.

(2) Project revenue forecast

The project revenue was estimated from the result of demand forecast in Chapter 3. It is assumed that revenues from fares and from non-fare income will be generated as from 2014 (the first year of the operation). According the demand forecast, 85% of passengers will transfer between monorail and other public transport modes under the integrated fare system. Therefore, the revenue per passenger in case of the integrated fare system is estimated as R$1.56, which is lower than single ticket fare (R$ 2.7).

Table 10-7 Estimation of fare income per passenger

vehicle	Standard fee	Allotment ratiofor Monorail	Income of Monorail	Composition ratio	Weighed fare income
	(A)	(B)	(C)=(A)*(B)	(D)	(C)*(D)
Monorail only	R$2.7	100%	R$2.7	15%	R$0.41
Monorail to/from bus	R$2.7	50%	R$1.35	41%	R$0.55
Monorail to/from metro	R$4.0	50%	R$2.0	16%	R$0.32
Monorail to/from bus and metro	R$4.0	25%	R$1.0	28%	R$0.28
Fare income per person					R$1.56

Source: JICA study team (composition ratio from EMME/2)

It was assumed that the monorail system would retain 50 per cent of the revenue collected from the sale of transfer tickets.

In recent years, bus fares have been increasing significantly faster than the rate of inflation (for example by more than 17 per cent during the three years between the end of 2006 and the beginning of 2010). However, the municipal government may expect to face increased pressure to restrain the growth of public transport fares in future, in order to maintain the affordability of fares for poor people. Thus, it has been assumed that monorail fares will

increase by only 4 per cent per year over the forecast period (barely keeping pace with inflation).

It was assumed that the monorail system would generate significant revenue from non-fare sources (such as property leases and advertising), as indeed the metro system currently does. It is understood that the São Paul Metro generates about 15 per cent of its revenue from non-fare sources. The assumption for the monorail is that non-fare revenue would initially constitute about 10 per cent of total revenue, rising to 15 per cent by 2026.

On the basis of these assumptions, monorail revenue (assuming constant fares) was projected for the Phase-1 only and entire route cases, as shown in Table 10-8.

Table 10-8 Projected profits (Unified fare system)

	Phase-1 Only				Entire Routes			
	2015	2025	2035	2045	2015	2025	2035	2045
Fare	194.9	227.7	239.3	246.7	194.9	591.0	594.0	597.0
No-Fare	19.5	22.8	35.9	37.0	19.5	88.7	89.1	89.5
Total	214.3	250.4	275.2	283.7	214.3	679.7	683.1	686.5

Source: JICA study team

The revenue in case that the monorail does not join the integrated fare system is estimated as shown in Table 10-9. In this case, the average fare revenue per passenger becomes approximately 1.2 times that of the integrated fare system. However, public transport development with this kind of independent fare system would be difficult due to the inconsistency with the transport policy in São Paulo.

Table 10-9 Projected profits (Independent fare system)

	Phase-1 Only				Entire Routes			
	2015	2025	2035	2045	2015	2025	2035	2045
Fare	218.2	255.0	268.0	276.3	218.2	662.0	665.3	668.6
No-Fare	19.5	22.8	35.9	37.0	19.5	88.7	89.1	89.5
Total	237.7	277.7	303.9	313.3	237.7	750.6	754.4	758.1

Source: JICA study team

(3) FIRR

The FIRR was calculated from the cash flow of the capital expenditure, O&M, and revenue as shown in Table 10-10. In case of the entire routes, FIRR is very low at negative value of 0.7%. It is positive in case of the Phase-1 only (original route) case but is as low as 1.4%. In case of the Phase-1 only (urban development route), it is calculated as 0.7%.

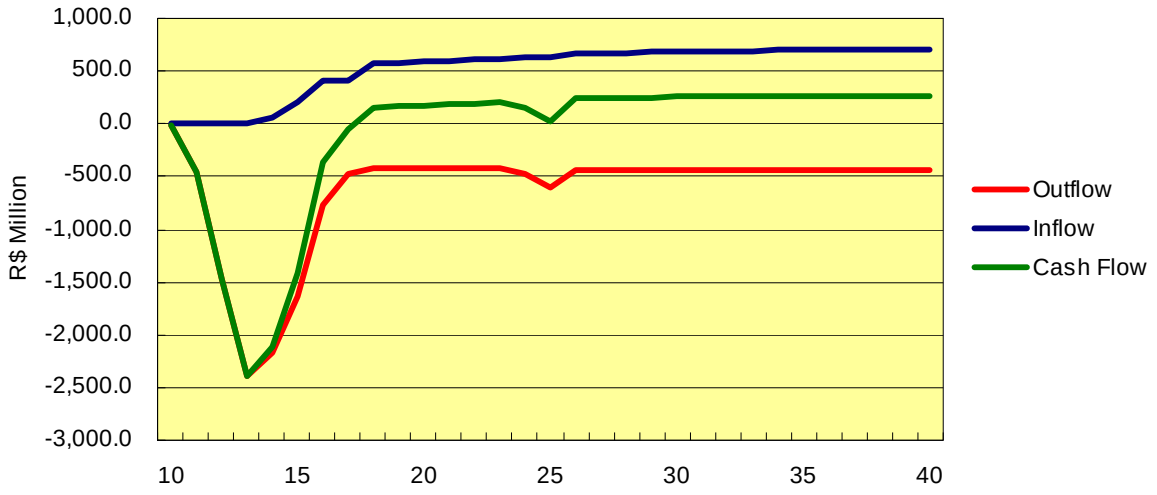
On the other hand, if the fare system of the monorail is independent from the integrated fare system, FIRR of each case increases to 1.8%, 3.7%, and 2.9%, respectively.

Price escalation is not included in the cash flow estimation for the calculation of FIRR.

Table 10-10 Cash-flow for calculation of FIRR on Project

Year	All network				Phase-1 only (Original)				Phase-1 only (Urban Development)			
	Capital Expenditure	O&M	Revenue	Net Income	Capital Expenditure	O&M	Revenue	Net Income	Capital Expenditure	O&M	Revenue	Net Income
2010	9.3			-9.3	9.3			-9.3	10.1			-10.1
2011	453.4			-453.4	453.4			-453.4	490.5			-490.5
2012	1,478.1			-1,478.1	1,452.9			-1,452.9	1,572.0			-1,572.0
2013	2,395.1			-2,395.1	1,133.3			-1,133.3	1,226.3			-1,226.3
2014	2,133.9	27.8	52.7	-2,109.0	286.9	27.7	52.7	-261.9	310.4	30.4	52.7	-288.2
2015	1,516.2	111.2	214.3	-1,413.0		110.6	214.3	103.7		121.7	214.3	92.6
2016	490.2	281.3	403.9	-367.6		110.6	218.0	107.3		121.7	218.0	96.2
2017	186.5	281.3	409.1	-58.7		110.6	221.6	110.9		121.7	221.6	99.8
2018	5.5	420.0	572.9	147.5		110.6	225.2	114.5		121.7	225.2	103.4
2019		420.0	582.1	162.1		110.6	228.8	118.1		121.7	228.8	107.0
2020		420.0	591.3	171.3		115.8	232.4	116.6		126.9	232.4	105.5
2021		420.0	600.4	180.4		115.8	236.0	120.2		126.9	236.0	109.1
2022		420.0	609.6	189.6		115.8	239.6	123.8		126.9	239.6	112.7
2023		420.0	618.8	198.8		115.8	243.2	127.4		126.9	243.2	116.3
2024	61.0	420.0	628.0	147.0		115.8	246.8	131.0		126.9	246.8	119.9
2025	183.0	429.1	637.2	25.0		115.8	250.4	134.6		126.9	250.4	123.5
2026		429.1	669.5	240.4		115.8	263.1	147.4		126.9	263.1	136.2
2027		429.1	672.9	243.8		115.8	264.5	148.7		126.9	264.5	137.6
2028		429.1	676.3	247.2		115.8	265.8	150.0		126.9	265.8	138.9
2029		429.1	679.7	250.6		115.8	267.2	151.4		126.9	267.2	140.2
2030		429.1	683.1	254.0		115.8	268.5	152.7		126.9	268.5	141.6
2031		429.1	686.5	257.4		115.8	269.8	154.0		126.9	269.8	142.9
2032		429.1	689.9	260.8		115.8	271.2	155.4		126.9	271.2	144.3
2033		429.1	693.3	264.1		115.8	272.5	156.7		126.9	272.5	145.6
2034		429.1	696.7	267.5		115.8	273.8	158.0		126.9	273.8	146.9
2035		429.1	700.1	270.9		115.8	275.2	159.4		126.9	275.2	148.3
2036		429.1	699.8	270.7		115.8	275.8	160.0		126.9	275.8	148.9
2037		429.1	699.6	270.5		115.8	276.4	160.6		126.9	276.4	149.5
2038		429.1	699.4	270.2	72.7	115.8	277.1	88.6	78.7	126.9	277.1	71.5
2039	8.1	429.1	699.1	261.9		115.8	277.7	161.9		126.9	277.7	150.8
2040		431.5	698.9	267.3		118.5	278.3	159.9		129.7	278.3	148.6
2041		431.5	698.6	267.1		118.5	279.0	160.5		129.7	279.0	149.2
2042	826.4	431.5	698.4	-559.5	826.4	118.5	279.6	-665.2	894.1	129.7	279.6	-744.2
2043	826.4	431.5	698.1	-559.8	826.4	118.5	280.3	-664.6	894.1	129.7	280.3	-743.6
2044		431.5	697.9	266.4		118.5	280.9	162.4		129.7	280.9	151.2
2045	-2,341.9	431.5	697.7	2,608.0	-1,597.2	118.5	283.7	1,762.5	-1,728.2	129.7	283.7	1,882.1
FIRR on Project				-0.7%				1.4%				0.5%

Source: JICA study team)



Source: JICA study team

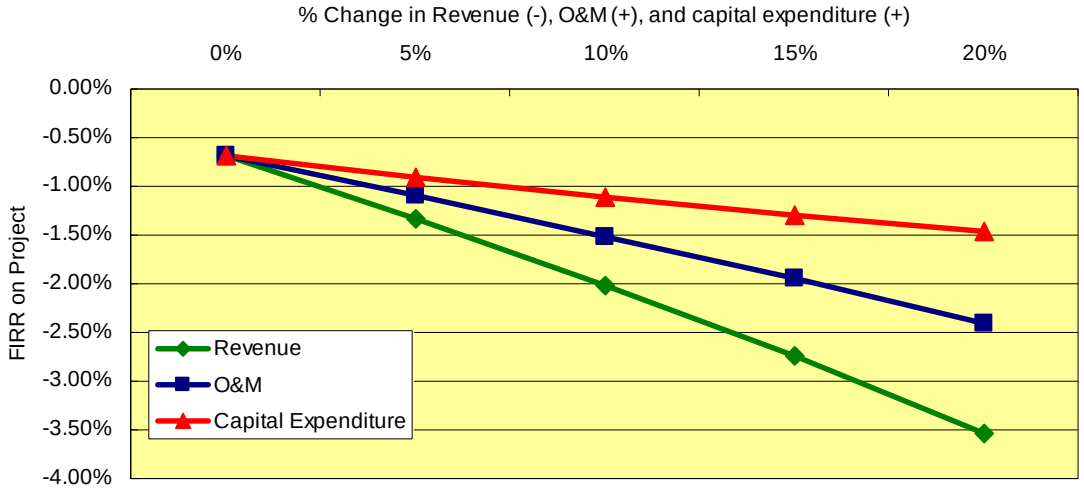
Figure 10-2 Financial cash flow (entire route case)

(4) Sensitivity analysis

As with economic appraisals, following sensitivity analyses were made.

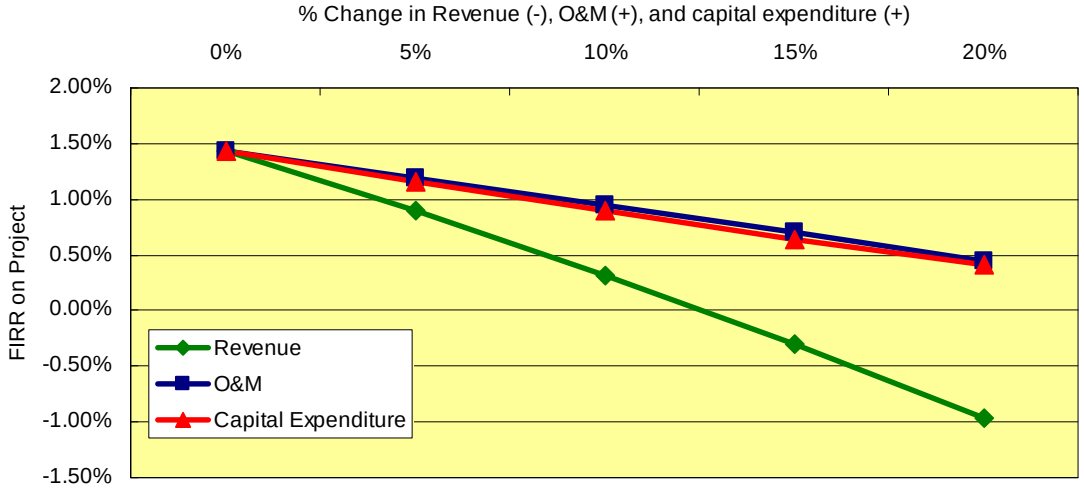
- Increase in capital expenditure by 20%
- Increase in O&M cost by 20%
- Decrease in revenue by 20%

The results are shown in Figure 10-4. The sensitivity to the change in fare revenue is the largest, followed by the change in O&M cost, while the sensitivity to the change in the capital expenditure is the lowest. If all cases are combined, the FIRR is calculated as a negative value of 6.1%, which implies that the financial viability of this project is very low. In case of the Phase-1 only (original route), the sensitivity to the revenue is the largest but that of O&M cost and capital expenditure are the same level. If all cases are combined, the FIRR of the Phase-1 only (original route) is calculated as a negative value of 3.0%.



Source: JICA study team

Figure 10-3 Sensitivity analysis (entire route) of FIRR calculation



Source: JICA study team

Figure 10-4 Sensitivity analyses (Phase-1, original rote) of FIRR calculation

10.4.3 Financing Plan

(1) Preconditions on financing plan

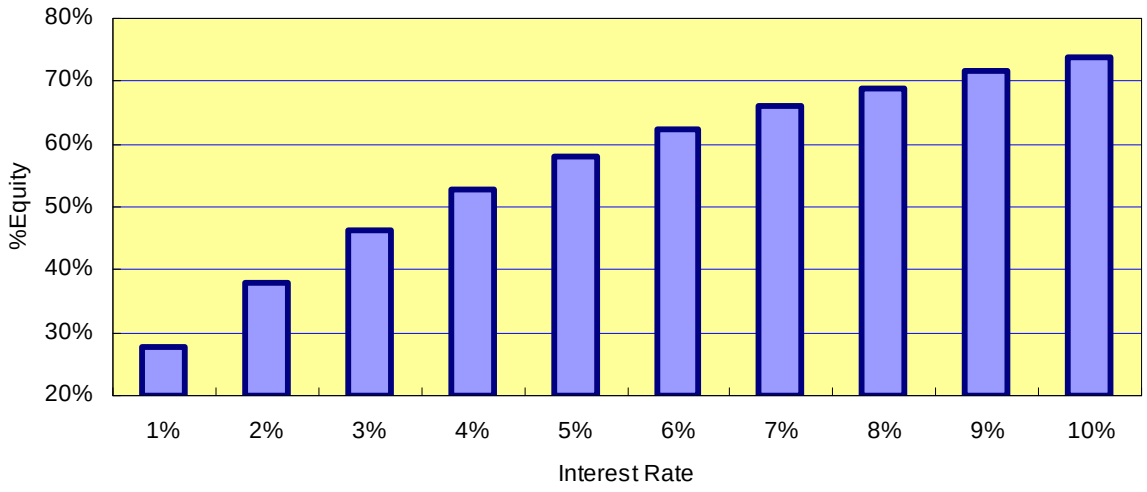
As indicated from the result of the FIRR calculation, the profitability of this project is very low. Therefore, borrowing with loose conditions of interest rate, repayment period and grace period like soft-loan and self-financing with small burden on the dividend are the issues in the funding. Cash flow statements and profit loss statements were prepared and such a financial plan that will not run short of cash was formulated. The preconditions of the analysis are:

Borrowing condition	Repayment period 25 years; Grace period 7 years (the same condition of JICA's untied loan to middle-class developed country)
Price escalation	Applicable（O&M: 4.35%, rolling stock: 4.2%, construction works : 4.0%, revenues:4.0%）
Corporate tax	25%
dividend	Not applicable
Depreciation	Straight-line method

The table in the next page shows the financial statements calculated under the condition of the interest rate of 4.8% and the proportion of equity and loan is 60% and 40%. If the proportion of the equity decreases from this level, the project will run short of cash in 2024.

(2) Analysis of equity

If the project is fully funded by its own money, it will not fall into cash shortage, while it will short of cash in two years after the opening of the entire routes in case that the project is fully funded by loan. Figure 10-5 shows the necessary proportion of the project's own money by interest rate. Even if the interest rate is as low as 2%, the project needs own money which is approximately 40% of the total project cost. It is assumed that this project is implemented by Sao Paulo City. Therefore, Sao Paulo will be the largest stakeholder of this project.



Source: JICA study team

Figure 10-5 Percentage of required private fund by amount of borrowing rates

Figure 10-6 Financial Cash Flow

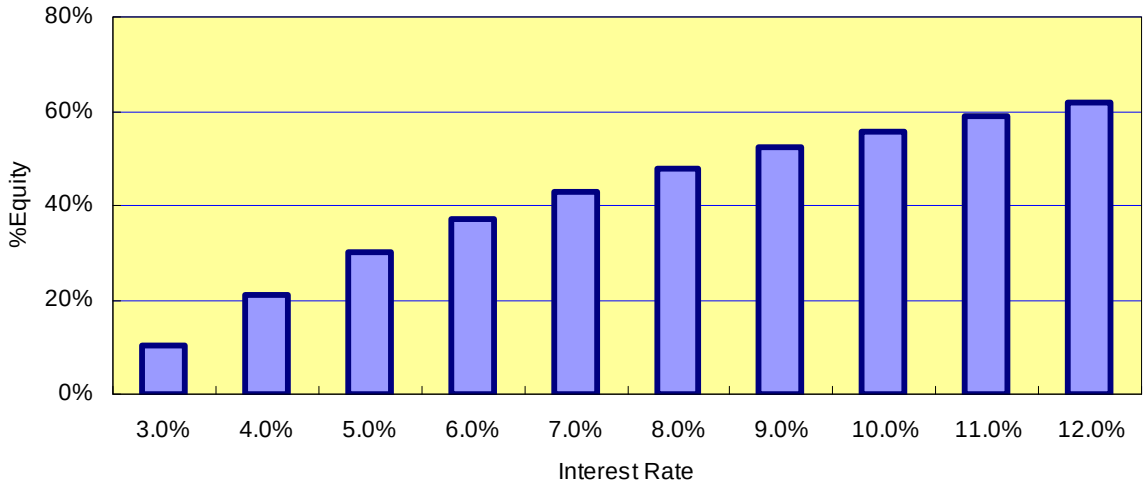
C/F		R$ Million																	
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Revenue						61.6	260.8	511.1	538.4	784.0	828.5	875.2	924.3	976.0	1,030.3	1,087.4	1,147.5	1,254.0	1,310.8
O&M						33.0	137.6	363.2	379.0	590.4	616.1	642.9	670.9	700.1	730.5	762.3	812.8	848.2	885.1
Operation Income						28.7	123.2	147.8	159.3	193.6	212.4	232.3	253.5	275.9	299.8	325.1	334.7	405.8	425.7
Balance brought							28.7	151.9	299.7	459.1	652.7	648.1	628.6	572.3	486.5	388.7	308.6	235.4	224.7
Interest	4.80%	0.0	-0.2	-9.1	-39.8	-91.7	-141.1	-178.8	-194.0	-202.3	-206.3	-205.8	-203.6	-198.5	-190.6	-180.7	-173.8	-162.6	-151.1
TAX		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-15.1	-21.4
Net Cash from Operation		0.0	-0.2	-9.1	-39.8	-63.1	10.8	120.9	265.1	450.4	658.7	674.6	678.5	649.8	595.7	533.2	469.5	463.5	477.9
Equity	60%	5.6	280.0	957.4	1,624.0	1,541.1	1,178.9	475.3	259.4	125.4									
Borrowing	40%	3.7	186.7	638.2	1,082.6	1,027.4	786.0	316.9	172.9	83.6						80.6			
Repayment		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-10.6	-46.0	-106.2	-163.3	-206.9	-224.5	-234.1	-238.8	-238.8
Net Cash from Financing		9.3	466.7	1,595.6	2,706.6	2,568.5	1,964.9	792.1	432.3	208.7	-10.6	-46.0	-106.2	-163.3	-206.9	-143.9	-234.1	-238.8	-238.8
Net Cash from Investment		-9.3	-466.5	-1,586.4	-2,666.9	-2,476.8	-1,823.9	-613.4	-238.4	-6.5	0.0	0.0	0.0	0.0	0.0	-80.6	0.0	0.0	0.0
Cumulative Cash Flow		0.0	0.0	0.0	0.0	28.7	151.9	299.7	459.1	652.7	648.1	628.6	572.3	486.5	388.7	308.6	235.4	224.7	239.1

P/L		R$ Million																	
		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Operation Income						28.7	123.2	147.8	159.3	193.6	212.4	232.3	253.5	275.9	299.8	325.1	334.7	405.8	425.7
Interest			-0.2	-9.1	-39.8	-91.7	-141.1	-178.8	-194.0	-202.3	-206.3	-205.8	-203.6	-198.5	-190.6	-180.7	-173.8	-162.6	-151.1
Depreciation						-60.6	-60.6	-147.8	-147.8	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6
Net Profit before TAX		0.0	-0.2	-9.1	-39.8	-123.7	-78.4	-178.7	-182.4	-176.3	-161.6	-141.1	-117.7	-90.2	-58.5	-23.2	-6.8	75.6	107.0
TAX	20%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.1	21.4
Net Profit after TAX		0.0	-0.2	-9.1	-39.8	-123.7	-78.4	-178.7	-182.4	-176.3	-161.6	-141.1	-117.7	-90.2	-58.5	-23.2	-6.8	60.5	85.6

C/F		R$ Million																	
		2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Revenue		1,370.1	1,432.0	1,496.8	1,564.4	1,635.0	1,708.8	1,785.8	1,866.3	1,940.3	2,017.2	2,097.2	2,180.3	2,266.7	2,356.6	2,450.0	2,547.1	2,648.0	2,753.0
O&M		923.6	963.7	1,005.7	1,049.4	1,095.1	1,142.7	1,192.4	1,244.3	1,298.4	1,354.9	1,413.8	1,475.3	1,548.1	1,615.4	1,685.7	1,759.0	1,835.5	1,915.4
Operation Income		446.5	468.3	491.1	515.0	539.9	566.1	593.4	622.1	641.9	662.3	683.4	705.0	718.6	741.1	764.3	788.1	812.5	837.6
Balance brought		239.1	279.4	346.2	440.5	563.0	710.2	887.6	1,096.2	1,337.1	1,603.5	1,905.8	2,269.4	2,718.0	3,238.8	3,824.4	4,447.4	5,099.8	5,778.9
Interest	4.80%	-139.6	-128.2	-116.7	-105.3	-93.8	-82.1	-70.4	-58.8	-47.1	-35.4	-24.3	-14.8	-9.5	-5.7	-4.0	-3.1	0.0	0.0
TAX		-27.8	-34.5	-41.4	-48.4	-55.7	-63.3	-71.1	-79.1	-85.4	-91.9	-98.3	-104.5	-108.3	-113.6	-118.5	-123.5	-129.0	-134.0
Net Cash from Operation		518.2	585.0	679.2	801.8	953.4	1,130.9	1,339.5	1,580.4	1,846.5	2,138.5	2,466.6	2,855.1	3,318.8	3,860.7	4,466.1	5,109.0	5,783.4	6,482.5
Equity	60%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Borrowing	40%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.8	0.0	0.0	0.0	0.0	0.0	0.0
Repayment		-238.8	-238.8	-238.8	-238.8	-243.3	-243.3	-243.3	-243.3	-243.1	-232.7	-197.2	-137.1	-80.0	-36.3	-18.7	-9.1	-4.5	-4.5
Net Cash from Financing		-238.8	-238.8	-238.8	-238.8	-243.3	-243.3	-243.3	-243.3	-243.1	-232.7	-197.2	-109.3	-80.0	-36.3	-18.7	-9.1	-4.5	-4.5
Net Cash from Investment		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-27.8	0.0	0.0	0.0	0.0	0.0	0.0
Cumulative Cash Flow		279.4	346.2	440.5	563.0	710.2	887.6	1,096.2	1,337.1	1,603.5	1,905.8	2,269.4	2,718.0	3,238.8	3,824.4	4,447.4	5,099.8	5,778.9	6,478.0

P/L		R$ Million																	
		2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Operation Income		446.5	468.3	491.1	515.0	539.9	566.1	593.4	622.1	641.9	662.3	683.4	705.0	718.6	741.1	764.3	788.1	812.5	837.6
Interest		-139.6	-128.2	-116.7	-105.3	-93.8	-82.1	-70.4	-58.8	-47.1	-35.4	-24.3	-14.8	-9.5	-5.7	-4.0	-3.1	0.0	0.0
Depreciation		-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6	-167.6
Net Profit before TAX		139.2	172.5	206.8	242.1	278.5	316.3	355.4	395.7	427.2	459.3	491.5	522.6	541.5	567.8	592.7	617.4	644.9	670.0
TAX	20%	27.8	34.5	41.4	48.4	55.7	63.3	71.1	79.1	85.4	91.9	98.3	104.5	108.3	113.6	118.5	123.5	129.0	134.0
Net Profit after TAX		111.4	138.0	165.4	193.7	222.8	253.1	284.3	316.5	341.7	367.4	393.2	418.1	433.2	454.3	474.2	493.9	515.9	536.0

On the other hand, it is possible to increase the average fare revenue per passenger up to 1.7 times the above projection by making the fare system independent or reducing discount rate of transfer. This enables more flexible financial plan such as 7% of the interest rate and 40% of own money as shown in Figure 10-7.



Source: JICA study team

Figure 10-7 Percentage of required private fund by borrowing rate

(3) Studies for loans

1) Soft loans

Given Brazil's status as an Upper-Middle Income country, it is unlikely that the monorail project would qualify for a soft loan from the IBRD or other multi-lateral lending agency. On the other hand, Japanese Yen loan will be possible if the project satisfies some conditions of the loan. The conditions of Japanese Yen Loan are available from the JICA website.[1] Different terms and conditions are applied to different countries depending on the level of their Gross National Income per capita.

In case of the monorail project in Sao Paulo, the possible loans would be a general untied loan having the condition of an interest rate of 1.7 per cent per annum, a grace period of 7 years and a loan repayment period of 25 years. In the case of loans of this type, there is no requirement for the project to utilize Japanese technology.

2) Sources of finance available in Brazil

This project needs good loan conditions with low interest, long repayment, and long grace period such as soft loan. Although loan from private banks in Brazil is difficult to be expected, BNDES (the Brazilian Development Bank)[2] is a possible source of the project. A list of terms and conditions available from the website of this bank suggests that it may offer loans for urban transport projects aimed at improvement of the urban transportation system. The cost of borrowing from this source would be relatively expensive (a base long term interest rate of 6.0% would be supplemented by the BNDES spread rate of 0.9% and a credit risk fee of 1%, giving an overall rate of 7.9%). It is also

[1] Terms and conditions pertaining to ODA loans can be found at:
http://www.jica.go.jp/english/operations/schemes/oda_loans/standard/
[2] The full name of this bank in Portugese is Banco Nacional do Desenvolvimento Economico e Social.

unclear whether these conditions would apply to loans above R$ 10 million and no details are given with respect to the loan maturity.

(4) Composition of funds

In case that the loans were provided both from BNDES and Japanese Yen Loan in the equal amount, the interest rate will be 4.8% which is the average of them. If this interest rate is applied, the project's own money should be not less than 60% of the total project cost and the composition of financial sources in this case is shown in Table 10-11.

Table 10-11 Composition of funds (entire route case)

Total amount of project (including interest rate)	Private funds	Yen loan	BNDES
10,745	6,447	2,149	2,149
Composition ratio	60%	20%	20%

Source: JICA study team

On the other hand, the same analysis has been made for Phase-1 (original route). The composition of funds in this case is shown in Table 10-12.

Table 10-12 Composition of funds (Phase-1, original route)

Total amount of project (including interest rate)	Private funds	Yen loan	BNDES
3,797	1,519	1,139	1,139
Composition ratio	40%	30%	30%

Source: JICA study team

(5) Subsidy

If it is difficult to prepare the project's own money and is necessary to use loan, subsidy can be considered for the interest payment or principal repayment, although short-term borrowing is another option.

In order to improve the financial viability, it can be proposed to reduce personnel cost by introducing ticketing machine instead of ticket sales by station staff. In addition, O&M cost can be reduced if security guards at stations are provided by Sao Paulo City instead of the operator. In case that the operator needs not share the part of security guards at stations, O&M cost can be reduced by 14%.

10.5 COOPERATION STRATEGY FOR TRANSPORTATION SECTOR BY INTER-AMERICAN DEVELOPMENT BANK (IDB) AND WORLD BANK (WB)

10.5.1 Background

IDB and World Bank are the most active donor organization in Brazil and their main objective is to support Brazil to achieve strong sustainable growth and to become a global player as G-20 member.

Although it has had history of economic boom and bust and its development has been hampered by high inflation and foreign debt, reforms in the 1990s and ongoing sound macroeconomic and social policies have resulted in an extended period of stability, growth and social gains. The country was one of the last to go into recession in 2008 and among the first to resume growth in 2009. IDB as well as World Bank maintained their program previously agreed with the Brazilian Government.

Actually, due to the recession in 2008, IDB had a problem of capital shortage since last year, meanwhile, the Board of Governors of the IDB agreed, on March 22, 2010, to take the necessary steps to increase the Bank's ordinary capital by US$ 70 billion, the largest expansion of resources in the Bank's history.

The following shows the strategy, policy and approach of their each support specially to Transportation Sector in Brazil. It is meaningful to understand their strategy at this moment to seek possibility of their co-finance with Japanese Government or other Brazilian own found to implement the Project.

10.5.2 IDB support

Brazil is the most important borrower for IDB, achieving US$ 108,536.4 million and sharing about 27% of the total cost of projects from 1961 and 2009.[1] Also IDB's distribution of Non-Reimbursable Technical Cooperation for Brazil was US$ 26,232 thousands in 2009 ranking the third country of recipient and US$ 212,088 thousands from 1961 to 2009[2].

IDB established *"Bank Strategy with Brazil (2004-2007)"* and after that they make Annual Plan, which is prepared through discussion between IDB's program mission and Brazilian public authorities in accordance with the Multiyear Plan (PPA: Plano Plurianual) 2008-2011 submitted to the Brazilian Congress, the following areas of activities have been identified as priorities [3]:

- Mass Consumption – increasing of family income, productivity, and employment, economic growth through consumption and investment, improvement of conditions of credit line, poverty alleviation through Government transfer
- Improvement of Infrastructure, Education and Social Agenda – Priority Goals are defined in 19 sectors, including transportation

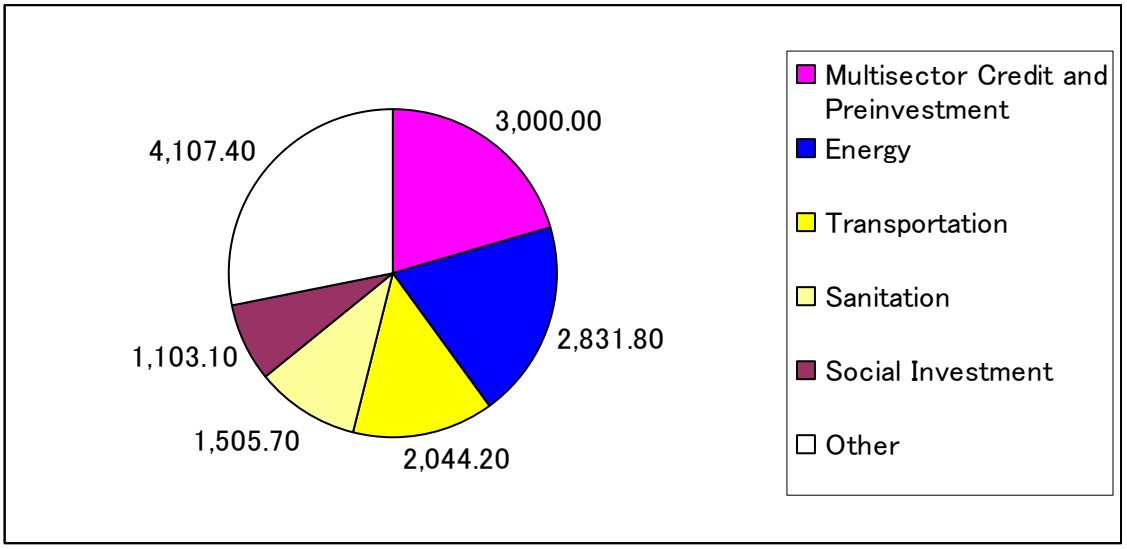
10.5.3 IDB Support for Transport Sector

IDB consider the positive effect of transportation improvement in order to improve productivity and infrastructure, which is important for the area of competitiveness and modernization, and also regional integration, which is an important approach for regional differences.

[1] *IDB Annual Report 2009*, Washington, p.45
[2] ditto p. 49
[3] According to IDB Brazil Office, new Country Strategy to Brazil will be prepared on June, 2010.

Portfolio of IDB in Brazil during last five (5) years is composed as follow. Total amount of Transportation Sector achieves US$ 2,044.2 million in last five years and shares 14% in total.

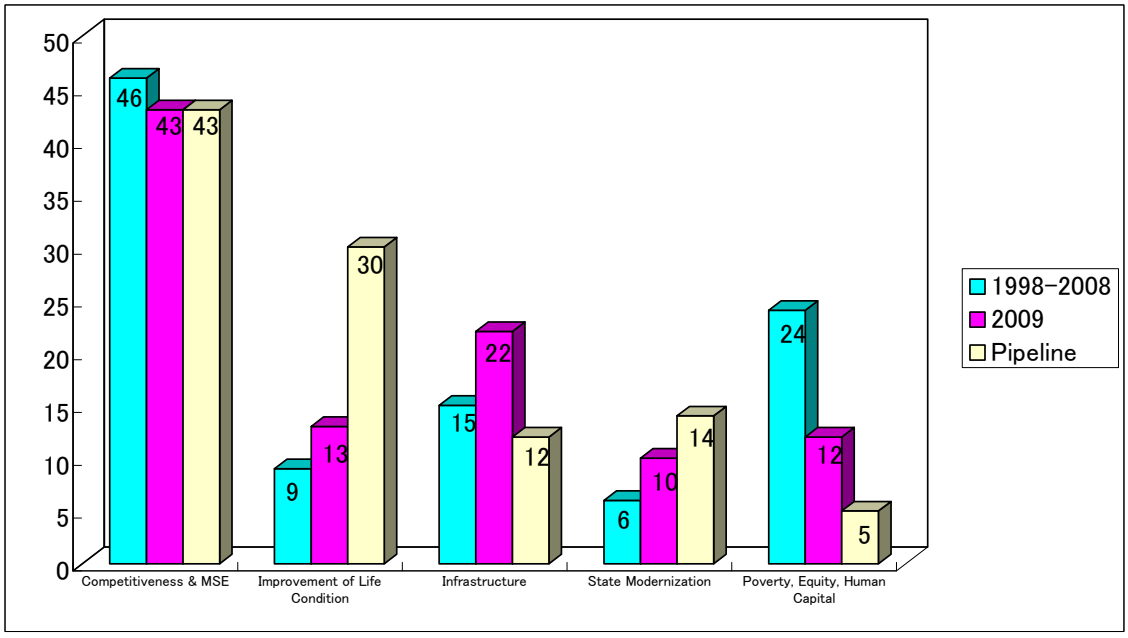
(Unit: Millions of US$) Total: US$ 14,592.2 million



Source: IDB HP

Figure 10-8 Portfolio of IDB in Brazil during Last Five Years

Specially regarding the operation in 2009, infrastructure including transportation shared 22% of the operation and there are 26 projects (as of April 2010) in Transport Sector are in execution.



Source: Result of IDB Operation in Brazil in 2009 and Perspective for 2010 (Executive Summary)

Figure 10-9 Financial Distribution by Sectors (%)

IDB approved a $481 million loan to help Brazil's State of São Paulo expand and upgrade its Metro Line 5 (Purple Line) on March 10, 2010. IDB's support for expantion of São Paulo Metro continues to execute together with Line 4, which was already disbursed. Meanwhile, other transportation projects in the pipeline are limited in only road projects.

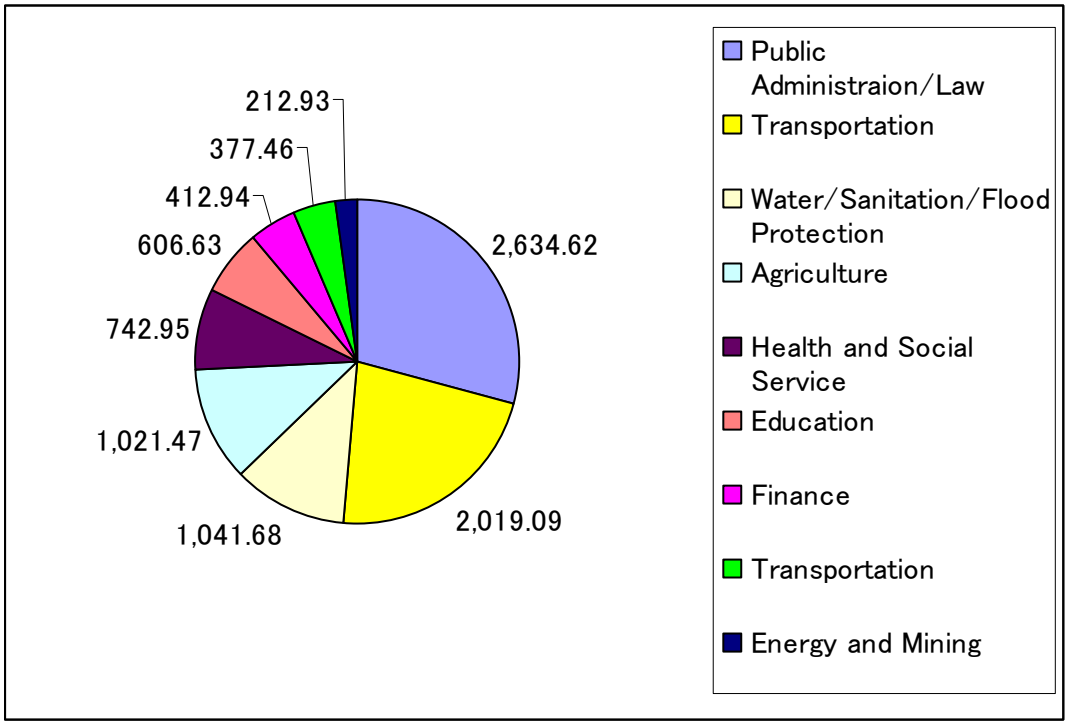
10.5.4 World Bank Support for Brazil

"Country Partnership Strategy (2008-2011)" for Brazil was approved in fiscal 2008 for Brazil.

- Fiscal and Public Sector Reform: Overcome constrains to growth, short and long term action
- Private Sector Development: Create environment for investment and growth
- Infra-structure for Development and Poverty Reduction: Institutional framework, investment
- Human Development: Strengthening human capital and labor force
- Rural and Agriculture Development: Reduce disparity between agribusiness and family farms
- The Amazon: Economic Development and Environmental Sustainability

Lending amount of World Bank in Brazil during last five (5) years is composed as follow. Total amount of Transportation Sector achieves US$ 2,019.09 million in last five years and shares 22% in total.

(Unit: Millions of US$) Total: US$ 9,069.77 million



Source: World Bank HP

Figure 10-10 Lending Amount of World Bank in Brazil during Last Five (5) Years

Even though the sustainable environmental management comes to be the important sector as WB's strategy, approving USD 1.3 billion loan during fiscal 2009 due to climate change that has strong impact in the world, there are still 23 active projects in Transport sector in Brazil. Transport sector is therefore expected to continue to represent a large share of Bank investment lending. The policy and approach of WB to this sector is crossing several aspects..

WB's approach to improvement of Transport services is linked to alleviation of life cost. WB analyze, for example, poor quality public transport in urban areas (a) affects economic efficiency; and (b) places a much higher burden on the poor who typically have to travel long distances, at high costs, to commute to work.

For more than a decade the Bank has also supported an urban transport strategy, including financing a large program of metro projects aimed at reducing transport costs for the poorest, and reducing environmental externalities of urban transport congestion. Urban transport investments have helped decrease the average commuting time for many low-income workers, but implementation has been tied up in political stalemate that affected funding in several metropolitan regions.

Also regarding their support for improvement of long distance transportation services, they are considering Logistics costs in Brazil, that are twice as high as in the United States and are lagging well behind the average in OECD countries. This affects industries' capacity to compete efficiently within Brazil and abroad.

The recent and outstanding Bank's movement in Transport Sector is as follow. Approved of Transport Project in São Paulo and Rio de Janeiro in July, 2009.

- São Paulo State Feeder Road Project: Rehabilitation of 12,000 km of municipal roads (US$ 166.65 million)
- Rio de Janeiro Mass Transit 2 Project: Purchasing at least 30 trains of four cars and accessories (US$ 211.7 million)

There are 20 projects in pipeline (as of April 2010) and four (6) projects are in Transport Sector including São Paulo Metro Line 4 and Line 5.

- São Paulo Metro Line 4 (Phase 2): US$ 130 million
- São Paulo Metro Line 5: US$ 650.4 million
- São Paulo Trains and Signaling Additional Financing (CPTM, METRO): US$ 112.91 million
- São Paulo State Feeder Roads Additional Financing: US$ 326.78 million
- Mato Grosso do Sul State Road Transport Project: US$ 300 million
- Minas Gerais Partnership II SWAP AF: US$ 461 million

10.5.5 Implementation Challenges

"Country Partnership Strategy" also includes Implementation Challenges in order to improve the Project Cycle, such as cutting time between project identification and approval and to address a major disbursement. World Bank and IDB have formed a working group with the Ministries of Finance and Planning, with the aim being to develop procedures whereby the processing time can be reduced by at least half, from 30 months to 15 months1.

10.5.6 Co-Finance

IDB as well as World Bank do take into account what others execute in the country. According to *Country Partnership Strategy,* there is an informal structure between IDB and World Bank.

There are:

Areas where the two banks can work together effectively, for example "Bolsa Familia Program" and Areas where demand is so large to engage independently such as public sector management and infrastructure.

In Transport Sector, "São Paulo Line 4" and "São Paulo Line 5"

[1] Country Partnership Strategy Brazil 2008-2011, Washington, 2008, p.34

Table 10-13 Co-Finance between IDB and WB for Transport Sector in Brazil

	Financing IDB (US$ million)	Financing by WB (US$ million)
São Paulo Line 4	412,081（Approved）	304,000 (Approved) 130,000 (Pipeline）
São Paulo Line 5	480,960（Approved）	650,000 (Pipeline)

(Source: IDB/World Bank HP)

Contribution from the both Banks is for the same project, but “financial condition” as well as “scope of work” is different and separated for each Bank.

CHAPTER 11 CONCLUSION AND RECOMMENDATIONS

As the result of this survey, it was concluded that a large size monorail is the most suitable urban transit system for the planned routes in São Paulo city. The details of conclusion and recommendations are as follows.

11.1 CONCLUSIONS

(1) Demand Forecast

As the result of demand forecast, 32,100 PHPDT (number of Peak Hour Peak Direction traffic) is estimated on 2045.

(2) Route Selection

- Line-1: Original alignment is selected as the optimum route. However, considering future extension towards Villa Sonia, Capao Redondo – Capelinfa section is removed.

- Line-2: There are 2 alignments in 2A section; “Area Development Route” planned by SPTrans and “M’Boi Mirim (trunk road) Route” recommended by the study team. 2B and 2C sections are following the original alignments. Due to the anticipated environmental problem at the Southern half of 2D section, the study team recommended to divert the alignment to West side, crossing Pinheiros river and go inside or outside of USP. (Universidade de São Paulo). Since USP is an independent administrative area, the alignment can be decided after the confirmation of USP.

- Line-3: Because Line-3 will be handled by METRO, study for Line-3 was removed from the scope of work.

(3) System Selection

Large size straddle type Monorail system was selected because of the following reasons.

- Large size monorail system covers the estimated ridership along the planned corridors
- Applicable to the maximum gradient and the minimum radius of the planned alignments
- Low construction cost per transport capacity
- Less impacts to the environment (noise, air and vibration)
- Less impact to the landscape by slim structure

(4) Economic and Financial Analyses

Economic and financial appraisals were completed for the following monorail project cases:

- The Phase 1 route defined by the alignment originally proposed for Line-2A;
- The Phase 1 route subsequently identified as the “area development” alternative, involving a deviation from the original alignment; and
- The entire route incorporating sections for all three project phases.

The result of the economic analysis shows that the Economic Internal Rate of Return (EIRR) is calculated as 17–19% and the EIRRs are stable in the sensitivity analysis, which implies that this project is economically feasible.

On the other hand, the Financial Internal Rate of Return (FIRR) on Project resulted in very low value. Therefore, the project is difficult to be implemented as a private business and the financial support by public is inevitable. Even if the project uses soft loans with relatively advantageous conditions, approximately 60% of the project cost should be funded by its own money (in case that no subsidy is expected during operation period). In the case of Phase-1 only, the necessary own money is approximately 40%.

(5) Environmental Impacts

It was confirmed that the environmental licensing concerning Environmental Impact Assessment (EIA/RIMA) will be conducted by the Municipal Government mainly under municipal laws and regulations. An Initial Environmental Examination (IEE) was carried out, and it was concluded that items "resettlement", "land acquisition" and "tree/vegetation removal" require special considerations. Mitigation measures for land acquisition and resettlement were preliminary examined, and it was anticipated that R$233 million approx. will be required for mitigation and compensation. For the removal of tree/vegetation, R$10 million approx. will be required for mitigation and compensation.

(6) Management of the Operation and Maintenance (O&M) Function

Monorail is a totally new urban transport system to be introduced in Brasil. However, the operation and maintenance of the monorail system is similar to those of a metro system. Therefore, in order to secure the safety and stable operation, it is recommended that the operation shall be done by SPTrans or a public organization including SPTrans, not by a private concessionaire.

The operation and maintenance (O&M) organization for São Paulo Monorail was planned based on the data of existing O&M organizations in monorail operators in Japan, adding some security and ticketing staff. As the result, the required number of staff for Phase 1 is 800 approx., and 2,300 approx. in final. This means that the number of staff per operating km will be 50. (Refer to the same of São Paulo Metro: 120, Tokyo Metro: 50 and Tokyo Monorail: 20)

(7) Required Action to be taken

- Follow up the process of issuing Carta Consulta (official document detailing the project outline, to be issued by the municipal government to the federal government).

- Monitoring of progress of Projeto Basico (basic design) which will be carried out by SPTrans, especially the route selection at the Section 2A and the extension of Line-1.

11.2 RECOMMENDATIONS

(1) Route Selection

Although Line-1B (Capao Redondo – Vila Sonia) section was not added to the study scope, SPTrans has decided to extend Line-1 up to Villa Sonia, the terminal station of the Metro Line No. 4. By this extension, the existing Metro Line 5 and Line 4 (under construction) can be connected, and thus the passenger convenience will be improved. The demand forecast indicated that the number of passengers will be increased when Line-1 is extended to Villa Sonia. Therefore, further study of this extension is recommended.

Area development route, which go through illegal housing area with two tunnel sections, was selected by SPTrans at Line-2A. JICA study team recommended M'Boi Mirim route, which go along the M'Boi Mirim road because of the approximate cost saving of US$200 million (construction 136 million and land acquisition etc. 64 million) compare with the area

development route. Those two alternative routes shall be studied in detail when SPTrans carry out Projeto Basico.

(2) Train Operation

Following the train operation manner Sap Paulo Metro, SPTrans is planning to operate monorails in same way; i.e. short headway operation. Having observed Metro operation at peak time, many trains stop between stations waiting for clearance of block signal. The same situation can be seen on roads; fully loaded buses are making line and running at very low speed less than 10 km/h.

The abovementioned train operation requires unnecessary number of rolling stock, it is recommended to set the optimum headway which can keep the schedule speed at peak hour. The number of train sets can be minimized by this consideration.

(3) Environmental Consideration

It is recommended to implement EIA based on the ToR suggested in this report, and appropriate mitigation measures should be taken on the environmental and social impacts predicted by EIA. Especially, suitable mitigation measures should be taken on the impacts of land acquisition and involuntary resettlement, and trees/vegetation removal, based on the EIA with referring the measures and preliminary cost estimation in the section 8.6.

Regarding public consultation, it is recommended to hold a meeting after draft scoping to reflect stakeholders' recommendations on ToR of EIA, in addition to a meeting to discuss draft EIA report. Considering some of EIA stakeholders do not relate with land acquisition and involuntary resettlement, and Resettlement Action Plan (RAP) should be discussed carefully, it is recommended to hold public consultation meetings focusing on RAP separately from the meetings for EIA to mitigate the impacts on land acquisition and involuntary resettlement.