Chapter 20 Road Extension and Widening Projects

20.1 Introduction

Colombo has many roads that have insufficient capacity to deal with current traffic demand. There are also missing links that if constructed would help to alleviate traffic congestion by creating a more efficient road network. The objective of this chapter will prepare designs for the Pre-FS projects that will either increase capacity via road widening or will produce a more rational network by constructing missing road links. In undertaking this, social impacts were taken into account and a balance had to be found between reducing congestion and mitigating social impacts. Therefore, the designs for some of these projects were lowered to minimize adverse impacts. Finally, where design work has been completed or is in progress by a local organization, the results of this work were confirmed and utilized for the design work of this study. Cost estimates were also prepared.

20.2 Outline of Projects

Table 20.1 outlines the project to construct two missing links (the Marine Drive extension) and Table 20.2 outlines the locations of the five road widening projects. Figure 20.1 provides a map of the projects. RDA or the Western Province Road Development Authority (WPRDA) has completed or is in process of completing detailed design for some of these roads. Additional information regarding the timelines and tasks can be found in Appendix 20.

Table 20.1 Marine Drive Extension

No	Road ID	Road Name		Road Class	Length (km)	Existing Width (m)	Proposed Width (m)	Detail Design
1	R7	Marine Drive	North	A	2.0	-	18.3	Completed[1)]
			South	A	1.7	-	18.3	DNE[2)]

1) Detailed design has been completed by RDA.
2) DNE: Does not exist
Source: This Study

Table 20.2 Road Widening Projects

No	Road ID	Road Name	Road Class	Length (km)	Existing Width (m)	Proposed Width (m)	Detail Design
2	R14	B152	B	5.2	6.0	15.2	Completed
		B425	B	5.9			DNE
		Eppamulla-Pamunugama Road	B	2.8			DNE
3	R20	Nugegoda-Katiya Junction-Pepiliyana Road	B	2.1	6.0	15.2	Completed[1)] (1.3km)
4	R21	Thalawathugoda-Pannipitiya Road	B	3.2	9.0	21.8	Completed
5	RWP2	Thalawathugoda-Koskadwila Road	C	4.2	5.0	11.9	DNE[2)]
6	RWP4	Pannipitiya-Tumbowil Road	D	7.2	5.0	10.9	DNE[2)]

1) Detailed design work for only 1.3 km of R20 is completed, and remaining 0.8 km is not existed.
2) No designs for RWP2 and RWP4, which come under the jurisdiction of the WPRDA, are available.
Source: This Study

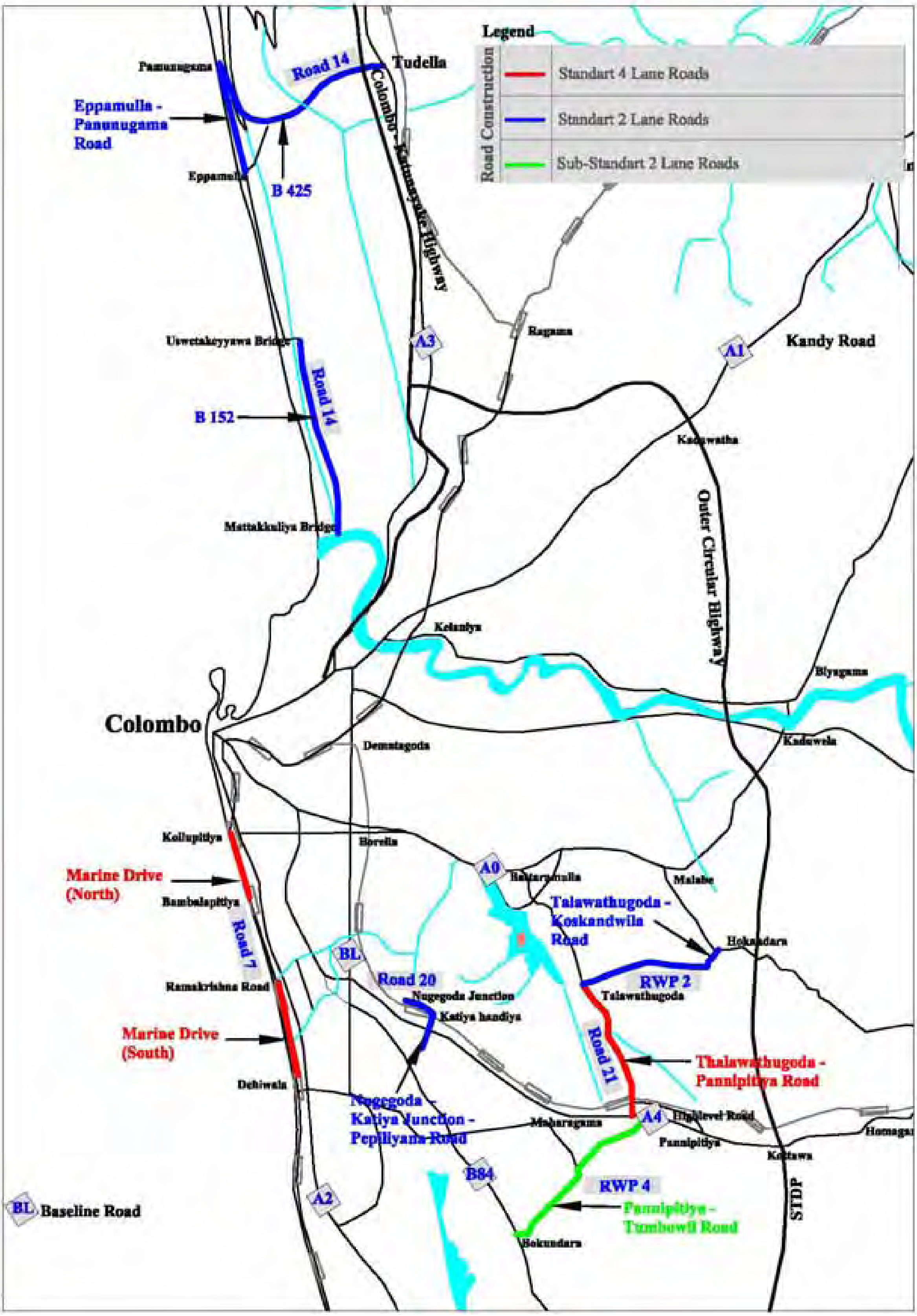


Figure 20.1 Locations of Road Extension/Widening Pre-FS Projects

20.3 Project Design

The following basic concepts are applied in the design work of the study:

- Completed or on-going design work by local organizations is inspected and revised as necessary for the designs of this Study;
- For sections without any design work, the existing road alignment is basically followed with regards to future improvements; and
- The design vertical profile is considered to be at the same level as the existing road.

(1) R7: Marine Drive Extension

Design Overview

Marine Drive functions as a bypass for Galle Road and runs along the railway near the coast. The existing part of this road extends from Bambalapitiya Station Road to Ramakirishna Road and should be extended north to Kollupitiya and south to Dehiwala in order to attract a greater number of long-distance trips to increase its effectiveness as a bypass (Figure 20.2). RDA has completed the detailed design work for the north section and has made arrangements to acquire the necessary land for the right-of-way. Note that the cross section contained in the detailed design work for the north part has been examined and it is recommended that it be utilized for the south section as well, which would unify the specifications for this road. The alignment of south part is set along the railway so as to minimize land acquisition and social impacts.

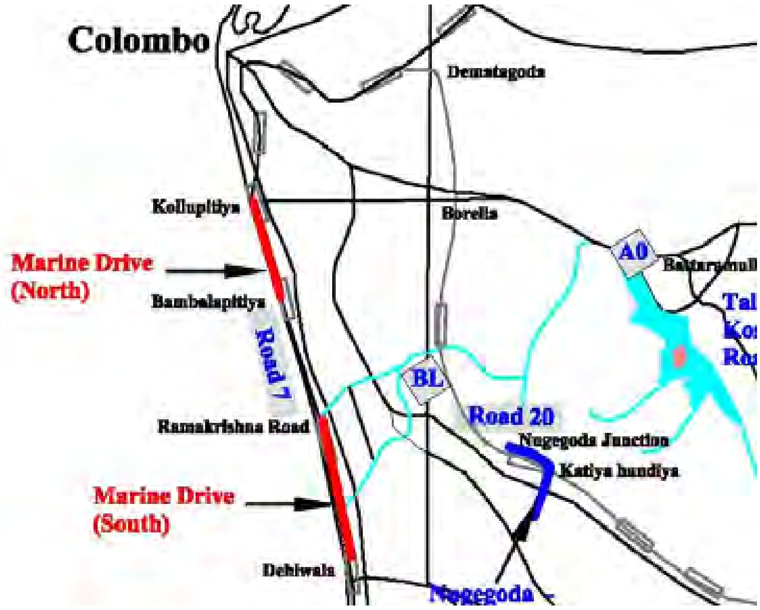


Figure 20.2 Layout of Marine Drive Extension

Cross Section

The proposed right-of-way will have a four-lane carriageway with a center median and footpath on either side of the road. Drainage will be located under the foot path. The typical cross section for Marine Drive is shown in Figure 20.3 and will be used throughout the entire length of the extension. Further details on the design aspects of Marine Drive are shown in Appendix 30.

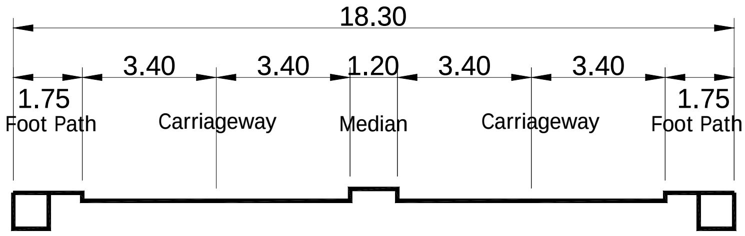


Figure 20.3 Proposed Typical Cross Section for Marine Drive

(2) R14: B152/B425/Eppamulla - Pamunugama Road

Design Overview

Project Road 14 (R14) consists of the three sections of B152, B425, and Eppamulla-Pamunugama Road (Figure 20.4). RDA has completed the detailed design for B152 and according to this detailed design, the road will have high embankments with retaining walls and gabion installed throughout in order to protect residents from canal flooding. The cross section of B152 has been examined and it is recommended that it be utilized for the other two roads as well, except that embankments will not be necessary. Note that road widening will be carried out on either side of the existing road (Figure 20.7).

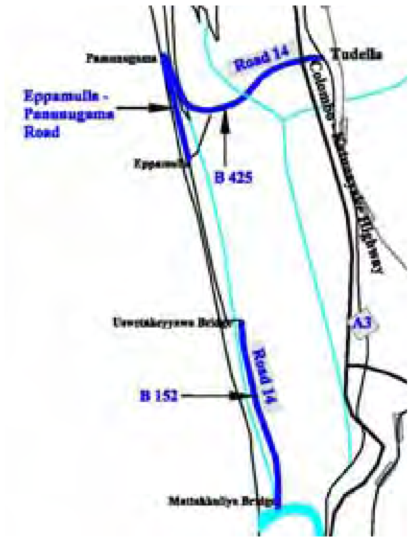


Figure 20.4 Layout of R14

Cross Section

The proposed right-of-way will have a two-lane carriageway with shoulders and foot paths on either side, which is in accordance with RDA's detailed design. Drainage will be located at the edge of the road. The proposed cross section is as shown in Figure 20.6 and more detailed drawings can be found in Appendix 30.

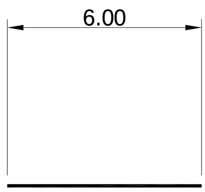


Figure 20.5 Existing Typical Cross Section (R14)

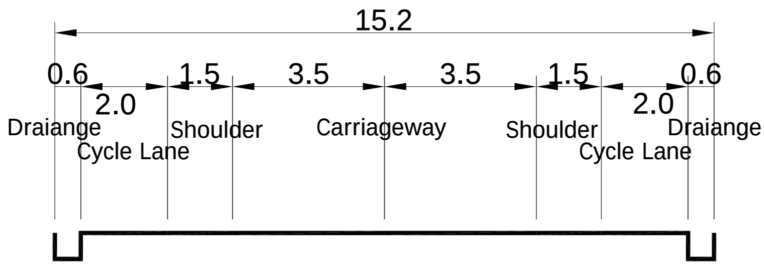


Figure 20.6 Proposed Typical Cross Section (R14)

(3) R20: Nugegoda - Katiya Junction – Pepiliyana Road

Design Overview

The detailed design for the widening of the Katiya Junction-Pepliyana Road section is already complete. Widening from Nugegoda to Katiya Junction should be designed to avoid any negative impacts on the adjacent railway line. After examining the requirements of the Nugegoda-Katiya Junction section and the completed detailed design of the cross section for the road from Katiya Junction to Pepliyana, it is recommended that the cross section be utilized throughout the proposed scheme. According to RDA, drainage should be located under the cycle lane in the areas where residents will not allow land acquisition for road widening. This project also covers a small bridge (Ratmalana Bridge) improvement at the south end of this section. The basic layout of R20 is shown in Figure 20.7.

Figure 20.7 Layout of R20

Cross Section

The proposed right-of-way will have a two-lane carriageway with a shoulder and foot path on either side in accordance with RDA's detailed design. Drainage will be located at the edge of the road. The proposed typical cross section is as shown in Figure 20.9 and more detailed drawings can be found in Appendix 30.

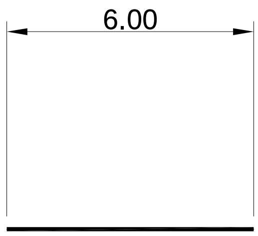


Figure 20.8 Existing Typical Cross Section (R20)

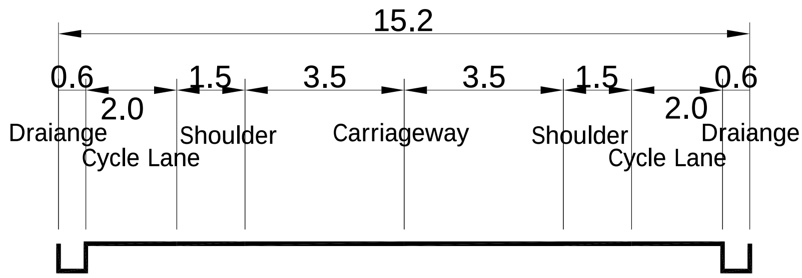


Figure 20.9 Proposed Typical Cross Section (R20)

Ratmalana Bridge

The length of bridge crossing the Ratmalana River is only 18.0 meters. Therefore, the simple bridge of the PCT girder is considered. A lane width of 3.3 meters and shoulder width of 1.5 meters per direction are considered to be suitable considering the existing traffic condition.

Table 20.3 Bridge Type

Road Bridge	Length (m)	Span	Superstructure	Substructure/Foundation
1. Ratmalana	18.0	1 Span	PC T Girder	RC Abutment/Bored Pile

Source: This Study

(4) R21: Thalawathugoda - Pannipitiya Road

Design Overview

The detailed design for R21 has already been completed by RDA and should be utilized for the design of this study. The proposed section extends from Thalawathugoda to Pannipitiya, where there is an unused flyover that crosses the railway (Figure 20.10).

Figure 20.10 Layout of R21

Cross Section

The proposed right-of-way consists of a four-lane carriageway with a median and shoulder on either side in accordance with RDA's detailed design. Drainage will be located at the edge of the road. The proposed typical cross section is as shown in Figure 20.12 and more detailed drawings can be found in Appendix 30.

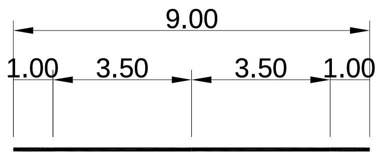


Figure 20.11 Existing Typical Cross Section (R21)

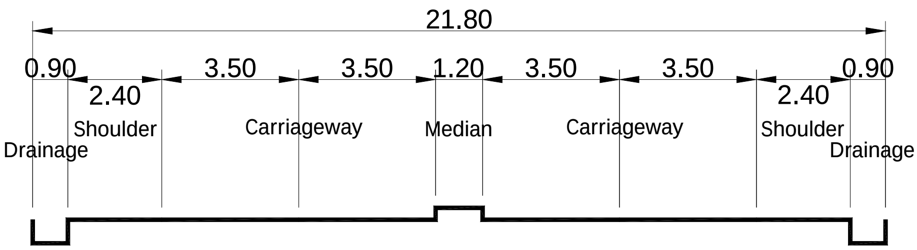


Figure 20.12 Proposed Typical Cross Section (R21)

(5) RWP2: Thalawathugoda - Koskadwila Road

Design Overview

This road is administered by the WPRDA and the design was prepared in discussions with this organization. In order to minimize impacts, the road should be widened, but also remain as a sub-standard two-lane structure. Widening will be basically carried out from both sides of the center line of the existing road. Note that some re-alignment is necessary in order to make the road straighter, but it is recommended that further consideration be given to this issue in the detailed design stage (Figure 20.13).

Figure 20.13 Layout of RWP2

Cross Section

The proposed right-of-way consists of a two-lane carriageway with a shoulder on either side. Drainage will be located at the edge of road. The proposed cross section is as shown in Figure 20.15 and more detailed drawings can be found in Appendix 30.

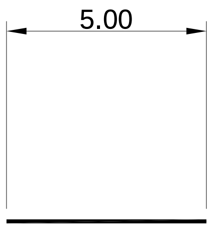


Figure 20.14 Existing Typical Cross Section (RWP2)

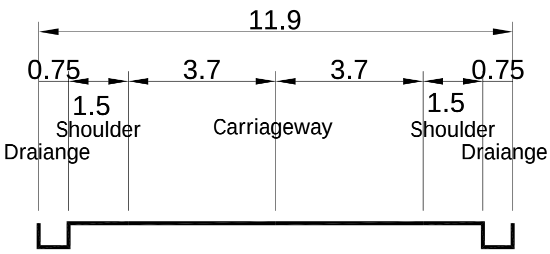


Figure 20.15 Proposed Typical Cross Section (RWP2)

(6) RWP4: Pannipitiya - Tumbowil Road

This road is also administered by the WPRDA. The existing road alignment has some steep curves at several points. However, it was decided in discussions with WPRDA that the design adhere to the existing alignment in order to minimize social impacts. It is recommended that in the future the alignment of this road be revised and made straighter as its function in the road network becomes more important (Figure 20.16).

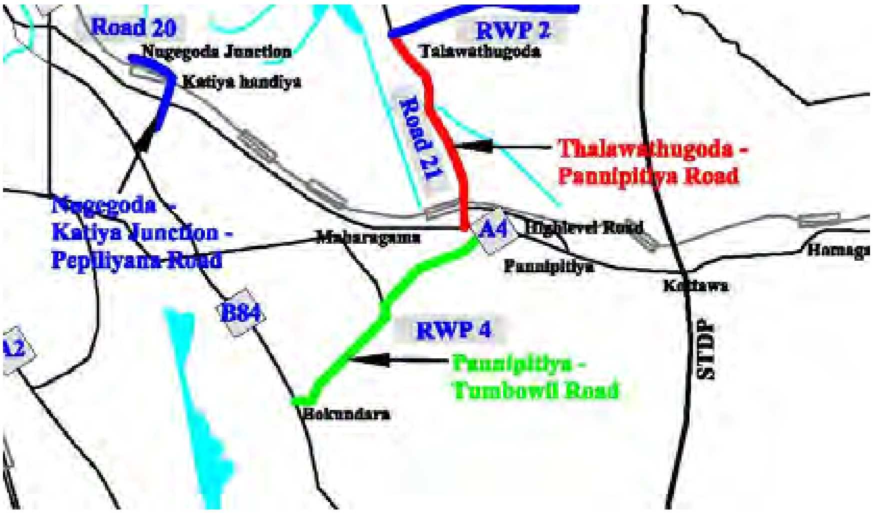


Figure 20.16 Layout of RWP4

Cross Section

The proposed right-of-way will consist of a two-lane carriageway with a shoulder on either side. Drainage will be located at the edge of road. The proposed cross section is as shown in Figure 20.18 and more detailed drawings can be found in Appendix 30.

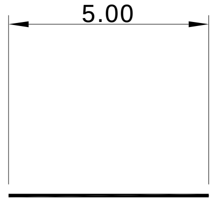


Figure 20.17 Existing Cross Section (RWP4)

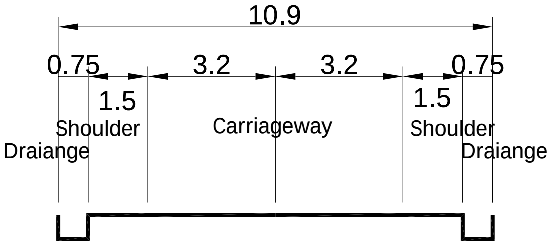


Figure 20.18 Proposed Cross Section (RWP4)

20.4 Cost Estimate

Costs are estimated where possible by applying an existing bill of quantity (BoQ) previously prepared by RDA or WPRDA. Costs were examined and updated to reflect 2006 market prices. For sections of road without any design work and BoQ, project costs were estimated by applying unit prices from other projects and using design calculations prepared by this study.

The overall project costs for the pre-FS road extension and widening schemes are as shown in Table 20.3, with a more detailed breakdown for each scheme given in Table 20.4.

Table 20.4 Overall Cost Estimates for Road Extension/Widening Pre-FS Project

Projects	**Location**	**Amount (MRs.)**
Construction Cost		
R7 - Marine Drive		197
R15		912
R20	Nugegoda-Katiya Junction-Pepiliyana Road (including Ratmalana Bridge)	154
R21	Thalawathugoda-Pannipitiya Road	192
RWP2	Thalawathugoda-Koskadwila Road	98
RWP4	Pannipitiya-Tumbowil Road	161
Total Construction Costs		**1,648**
Engineering Services		115
Land Acquisition		4,573
Compensation		3,090
Total Project Cost		**9,426**

VAT (15%) is not included in the above-mentioned calculations
Source: JICA Study Team

Table 20.5 Bill of Quantity for Road Extension/Widening Pre-FS Projects

Bill of Quantity	R7(Marine Drive)		R15			R20 with Ratmalana Bridge	R20 Widening Only	R21	RWP2	RWP4	Total
	North	South	B152	B425	Eppamulla						
Work Item											
Construction Costs											
Preliminaries & General	9,459,928	8,277,437	23,373,995	19,058,262	9,361,953	7,021,465	7,021,465	15,441,064	5,733,757	9,355,077	114,104,405
Site Clearing	966,545	845,727	1,050,800	665,204	326,767	245,075	245,075	538,950	670,190	1,089,430	6,643,763
Earth Works	3,411,937	2,985,445	11,038,840	6,391,442	3,139,656	2,354,742	2,354,742	5,178,366	3,254,499	6,767,666	46,877,335
Construction of Subbase, Base, and Shoulder	16,730,539	14,639,222	74,335,767	48,790,352	23,967,190	17,975,393	17,975,393	39,530,096	44,726,676	74,955,108	373,625,736
Surfacings	21,621,114	18,918,475	63,838,110	21,122,357	10,375,895	7,781,921	7,781,921	17,113,400			
Structures	5,569,850	4,873,619	162,882,569	35,783,418	17,577,820	48,791,284	13,183,365	28,991,838			317,653,762
Drainage Construction	10,650,168	9,318,897	33,643,860	21,456,155	10,539,866	7,904,899	7,904,899	17,383,844	18,893,360	28,266,945	165,962,893
Incidental Construction	7,436,359	6,506,814	33,055,526	18,775,104	9,222,858	6,917,144	6,917,144	15,211,648			104,042,597
Dayworks	3,792,322	3,318,282	20,160,973	7,579,362	3,723,196	2,792,397	2,792,397	6,140,823	938,524	1,531,276	52,769,552
Total Construction Costs	**79,638,764**	**69,683,919**	**423,380,441**	**179,621,657**	**88,235,200**	**101,784,319**	**66,176,400**	**145,530,030**	**74,217,006**	**121,965,502**	**1,350,233,237**
Overhead 20% of Construction Costs	15,927,753	13,936,784	84,676,088	35,924,331	17,647,040	20,356,864	13,235,280	29,106,006	14,843,401	24,393,100	270,046,647
Contingencies 10% of Construction + Overhead	9,556,652	8,362,070	50,805,653	21,554,599	10,588,224	12,214,118	7,941,168	17,463,604	8,906,041	14,635,860	162,027,988
Subtotal (Construction, Overhead, Contingencies)	**105,123,169**	**91,982,772**	**558,862,182**	**237,100,587**	**116,470,464**	**134,355,301**	**87,352,848**	**192,099,640**	**97,966,448**	**160,994,462**	**1,782,307,873**
Vat 15% of Subtotal	15,768,475	13,797,416	83,829,327	35,565,088	17,470,570	20,153,295	13,102,927	28,814,946	14,694,967	24,149,169	267,346,181
Total	**120,891,644**	**105,780,188**	**642,691,510**	**272,665,675**	**133,941,033**	**154,508,596**	**100,455,775**	**220,914,586**	**112,661,415**	**185,143,632**	**2,049,654,054**
Unit Price(Rs./m2)	2,872	2,872	7,353	2,737	2,737	4,209	2,737	2,737	1,960	1,996	

Table 20.6 Bill of Quantity for Ratmalana Bridge (Component of R20)

		Unit	Ratmalana Bridge		
			Qty	Unit Price (Rs)	Amount (Rs)
Structure	Steel Girder Weight	tf	0.0	246,000	0
	Slab Concrete	cu-m	0.0	18,000	0
	Slab Reinforcement	tf	0.0	120,000	0
	PC Girder Concrete	cu-m	93.6	30,000	2,808,000
	PC Cable	tf	2.7	170,000	451,860
	PC Girder Reinforcemer	tf	10.7	120,000	1,281,600
	Girder Concrete	cu-m	20.6	25,000	514,350
	Girder Reinforcement	cu-m	2.1	15,000	30,861
	Railimg	m	36.0	5,000	180,000
	Pavement	sq-m	180.0	1,000	180,000
	Saport for Steel Girder	No.	0.0	50,000	0
	Saport for PC Girder	No.	12.0	15,000	180,000
	RC Pier Concrete	cu-m	431.5	18,000	7,767,360
	RC Pier Reinforcement	tf	51.8	120,000	6,213,888
	Steel Pier Weight	tf	0.0	310,000	0
	Bored Pile	m	320.0	50,000	16,000,000
	Steel Pile	m	0.0	30,000	0
	Flyover Total				**35,607,919**

Source: This Study

20.5 Drawings

The scale for the design plans for the pre-FS road extension and widening projects are as listed in Table 20.5, with the plans contained in Appendix 30.

Table 20.7 Scale of Pre-FS Design Drawings

Pre-FS Project	Design Scale
Marine Drive (North)	Scale=1:8,000
Marine Drive (South)	Scale=1:8,000
B152	Scale=1:8,000
B425 (1), (2)	Scale=1:8,000
Eppamulla – Pamunugama Road	Scale=1:8,000
R20	Scale=1:8,000
Ratmalana Bridge (R20)	Scale=1:400
R21	Scale=1:8,000
RWP2	Scale=1:8,000
RWP4 (1), (2)	Scale=1:8,000

Chapter 21 Grade Separation Projects

21.1 Introduction

This chapter analyzes the various intersections' capacity to identify which should be subject to grade separation projects. For those needing such a structure, the road and structural designs are provided, along with cost estimates and the bill of quantity.

21.2 Intersection Capacity Analysis

(1) Introduction

Intersection capacity analysis has been undertaken to analyze the traffic conditions of the intersections where flyovers are proposed. The locations is listed in Table 21.1 and shown in Figure 21.1. Of these locations, a capacity analysis at the proposed Kelani Railway Crossing flyover was undertaken as the junction is road and railway crossing, not an intersection of 2+ roads.

Table 21.1 Proposed Flyover Locations

Number	Project Name	Intersection to be Bridged	Type
1	Orugodawatte Flyover (Baseline Road)	Orugodawatta	Signalized, 4-legs
2	Borella-Kanata Flyover (Baseline Road)	Borella	Signalized, 5 legs
		Horton Place	Signalized, 4 legs
		Bauddhaloka	Signalized, 5 legs
3	Dehiwala Flyover	Dehiwala	Signalized, 4 legs
4	Kohuwala Flyover	Kohuwala	Unsignalized, 4 legs
5	Armour Street Flyover	Armour Street	Signalized, 4 legs
6	Kelaniya Railway Flyover	Kelani Railway Crossing	Railway crossing
7	Rajagiriya Flyover	Rajagiriya	Unsignalized, 5 legs
		Rajagiriya Police St.	Unsignalized, T-shaped

The analysis was undertaken to estimate the level of congestion during peak hours in the present traffic conditions and the extent of congestion alleviation if a flyover were to be built.

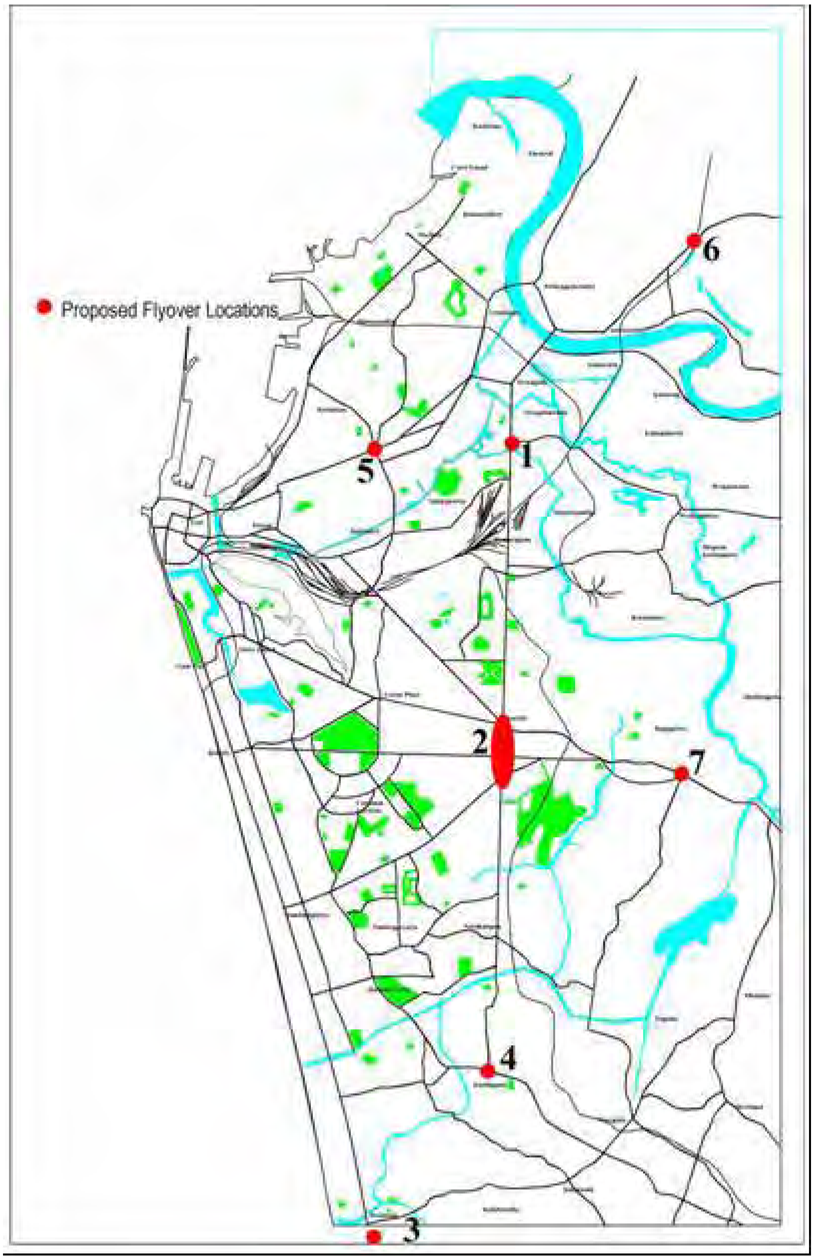


Figure 21.1 Proposed Flyover Locations

(2) Analysis

Process

Turning movement counts expressed in passenger car units (PCU) and intersection geometry information are required are input in the analysis. An intersection turning movement count survey was conducted at some of the proposed intersections.[1] Where available, the traffic count data obtained from a recent survey was also utilized. Based on the data, two peak hours were

[1] Between 4-19 July 2006

determined – one morning and one afternoon/evening.[2] The results are summarized in a diagram as shown in Figure 21.2.

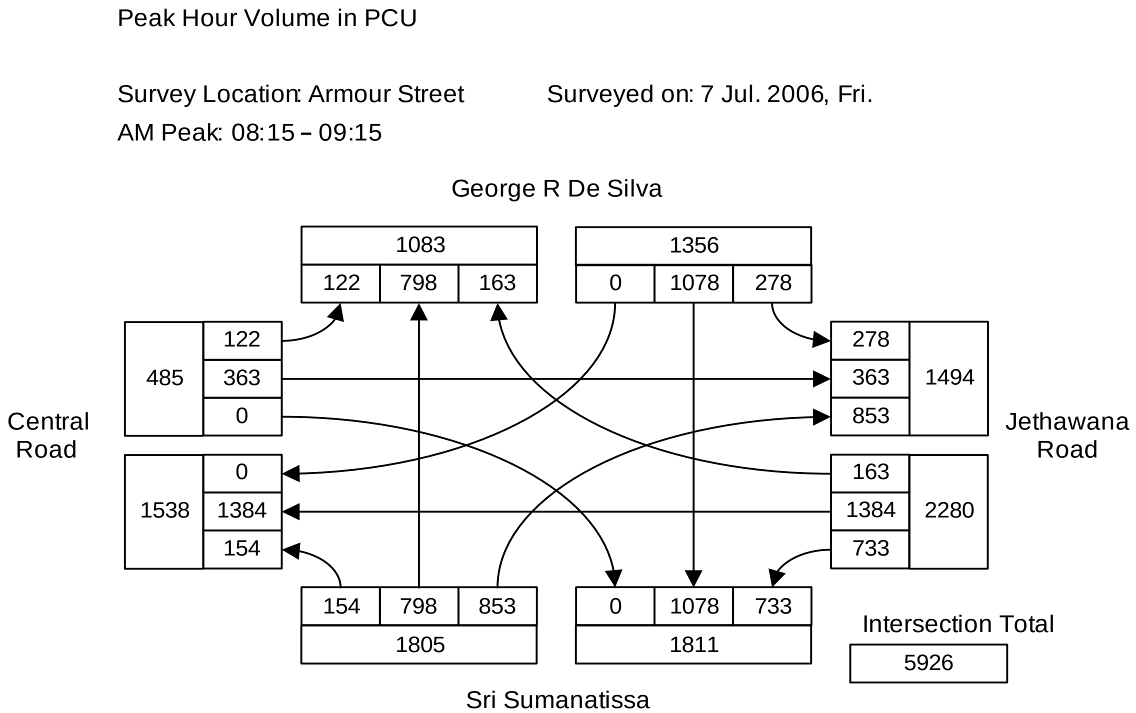


Figure 21.2 Intersection Turning Movement Count Diagram Example

As the objective of the analysis is to estimate the traffic conditions before and after an improvement, no detailed survey was conducted to determine the effective capacity of the intersection. Instead, standard or default values were used.

A spreadsheet template which calculates the volume/capacity ratio of each movement and determines the intersection's volume/capacity ratio was used for the analysis. The volume-capacity (V/C) ratio indicates the degree of conflicting traffic and is used to estimate the congestion levels of an intersection and determine if signalization or grade separation is needed. In the case of a four-way standard intersection, the V/C ratio is obtained by calculating the maximum of the volume divided by the saturated flow rate for both the N-S direction and the E-W direction, which is then summed to calculate the intersection's overall V/C ratio. A higher V/C ratio means that an intersection is more congested.[3] Normally, a traffic signal is warranted if the V/C ratio is greater than 0.6, although for a signal to operate relatively uncongested, the V/C ratio should be less than 0.75. Severe congestion occurs if the V/C ratio exceeds 0.85. Thresholds for intersection V/C Ratio is summarized in Table 21.2.

[2] The 60 minute period with the highest intersection traffic volume in PCU

[3] Because the assumed saturation flow rate is achievable only under ideal conditions and because inter-green loss time and specific signal timing are not considered in the calculation, it is extremely important to understand that the computed V/C ratio is not equivalent to actual volume/capacity ratio or even close to it.

Table 21.2 Definition of V/C Ratios for Intersections

V/C Ratio	Capacity Definition
<0.75	Below Capacity
0.75 to 0.85	Capacity
> 0.85	Over Capacity

(3) Analysis of Present Conditions

The results of the current traffic conditions' capacity analysis are summarized in Table 21.3.

Table 21.3 V/C Ratio under Existing Traffic Condition

Number	Project Name	Intersection	Peak Hour Traffic (PCU)		V/C	
			AM	PM	AM	PM
1	Orugodawatte Flyover (Baseline Road)	Orugodawatta	7,819	8,216	**1.08**	**1.06**
2	Borella-Kanata Flyover (Baseline Road)	Borella				
		Senanayake	6,354	6,319	0.72	0.83
		Bauddhaloka				
3	Dehiwala Flyover	Dehiwala	4,471	4,836	*0.48*	*0.53*
4	Kohuwala Flyover	Kohuwala	4,769	4,201	**0.89**	0.81
5	Armour Street Flyover	Armour Street	5,926	6,472	**0.92**	**0.91**
7	Rajagiriya Flyover	Rajagiriya	5,930		0.8	
		Rajagiriya Police St.	5,143	5,246	0.78	**0.86**

Note: Analysis was not made at Kelani Railway Crossing as it is not an intersection. No reliable data is available for Baseline-Borella Intersection, Baseline Bauddhaloka Intersection, and the PM peak at Rajagiriya Intersection.

The V/C ratio exceeds 0.85 at the following intersections: Orugodawatta, Kohuwala, Armour Street, and Rajagiriya Police Station. Therefore, these intersections require significant capacity improvements. The V/C ratio at Dehiwala Intersection was estimated at 0.48 and 0.53 for the morning and afternoon peaks, respectively. This shows that demand is manageable for an at-grade intersection. Therefore, a flyover is not recommended for Dehiwala Intersection.[4]

(4) V/C Analysis with Flyovers

A similar capacity analysis was conducted for flyovers and the results are summarized in Table 21.4. The study team analyzed and selected the direction and turning movements to be elevated so as to best reduce the intersection's V/C ratio. It is then that the estimated congestion levels of an at-grade intersection will be reduced in order to utilize traffic signals at all flyover locations. With regard to Kohuwala Intersection, which uses an unsignalized roundabout, the Study Team believes that a signal may not be needed after the flyover is built and the existing roundabout can be retained. Details of grade separation methodologies are explained in following sections.

[4] However, it is true that congestion occurs presently due to inadequate intersection geometry, poor pavement condition, lack of pavement marking, inadequate signal timing, conflict between vehicles and crossing pedestrians, or loading and unloading of bus passengers. The subject is discussed in the section of intersection geometric improvement.

Table 21.4 V/C Ratio With and Without Flyovers

Intersection (Case for elevation)		Peak Hour Traffic (PCU)	V/C for at-grade intersection	
			Existing	With flyover[5]
1. Orugodawatta (North ⇔ South-4 lanes)	AM	7,819	**1.08**	0.53
	PM	8,216	**1.06**	0.53
2. Senanayake (North ⇔ South-4 lanes)	AM	6,354	0.72	0.54
	PM	6,319	0.83	0.64
4. Kohuwala (North ⇔ South-2 lanes)	AM	4,769	**0.89**	0.43
	PM	4,201	0.81	0.40
5. Armour Street (South ⇨ East-2 lanes)	AM	5,926	**0.92**	0.62
	PM	6,472	**0.91**	0.52
7. Rajagiriya (East ⇔ West-4 lanes)	AM	5,930	**0.89**	0.66
	PM	-	-	-

Note: Analysis was not made at Kelani Railway Crossing (#6) as it is not an intersection
Source: This Study

21.3 Road Design

(1) Location of Flyover Projects

The locations of the proposed six flyover projects for this Study are as shown in Figure 21.3 and many are located on or near Baseline Road, one of the major roads in the CMR.

[5] The estimated value may become smaller than actual case. This analysis ignores effect of induced traffic.

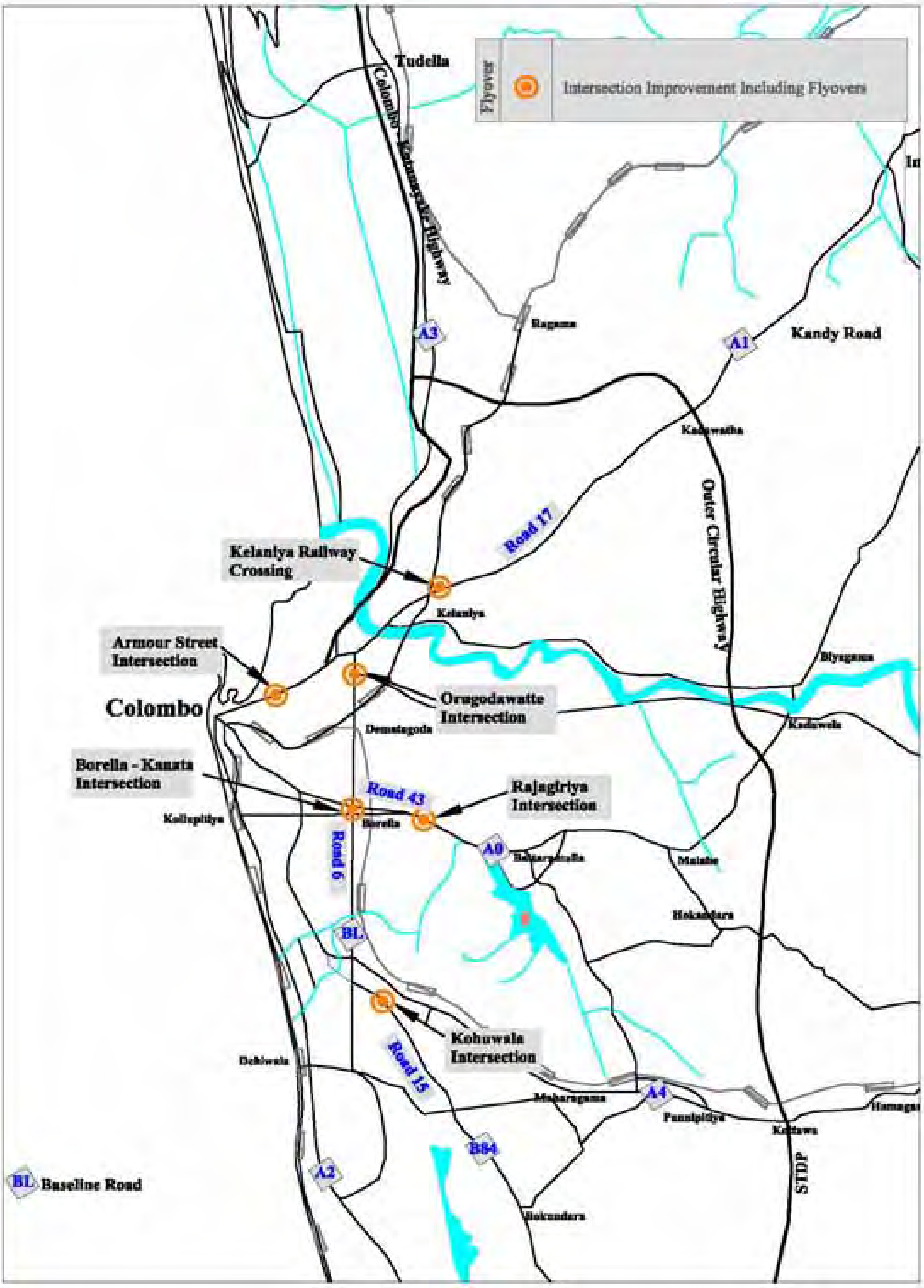


Figure 21.3 Location Map for Flyover Projects

(2) Outline of Flyover Projects

Five of the six flyovers selected for pre-FS analysis are located at intersections, with the other at a railway crossing. Except for Kohuwala, all flyovers are located on a Class A road. Note that flyover design was carried out based on intersection capacity analysis, taking into account directional movements, number of lanes, and access roads. Previously, detailed design work has only been undertaken by RDA for the Kelaniya Flyover. A summary of the flyover projects is as shown in Table 21.5. Additional information regarding the timelines and tasks can be found in Appendix 20.

Table 21.5 Outline of Flyover Projects

No.	Road ID	Name of Flyover	Road Class	Design Speed (km/h)	Number of lanes on Flyover	Detail Design
1	R6 (BL)	Orugodawatte	A (R0)	60	4 Lanes	No
2		Borella-Kanatta	A (R0)	60	4 Lanes	No
4	R15 (B84)	Kohuwala	B (R2)	60	2 Lanes	No
5	R17 (A1)	Armour Street	A (R1)	40*	2 Lanes (Right Turn)	No
6		Kelaniya Railway	A (R1)	60	4 Lanes	Completed*
7	R43 (A0)	Rajagiriya	A (R1)	60	4 Lanes	No

*The design speed for the Armour Street Flyover is 40km/h due to the turning alignment.
*There is an existing detailed design for the Kelaniya Railway Flyover and was carried out by RDA.

(3) Geometric Design Criteria

RDA's *Geometric Design Standards of Roads* is applied to establish geometric design criteria for major roads in Sri Lanka. For this study, design criteria have been set based on these standards and on discussions with RDA. Below, the design criteria for each flyover project are described.

Design Speed

Design speeds are set according to road type and class. As a flyover is considered part of the surrounding road, the adopted values in this study are based on this logic, as shown in Table 21.6.

Table 21.6 Design Speed

Type of Road	Road Class	Design Volume (PCU/day)	RDA Design Speed Values (km/h)	Adopted Design Speed Values (km/h)
R0	A	72,000-108,000	70	60
R1	A	40,000-72,000	70	60
R2	A, B	25,000-40,000	70	60
R3	A, B	18,000-25,000	60	60
R4	C, D	300-18,000	50	50

Horizontal Minimum Curve Radius

Based on the above design speeds, the minimum horizontal curve radii are set as shown in Table 21.7.

Table 21.7 Minimum Horizontal Curve Radius

Design Speed (km/h)	Superelevation (m)								
	2.5%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%
40	60	60	55	55	55	50	50	45	45
50	105	100	95	90	90	85	80	80	75
60	155	150	145	135	130	125	120	115	110

Minimum Grade

Minimum grades are decided in accordance with road class and the type of terrain as shown in Table 21.8. In the designs for this study, the minimum grade was determined in discussion with RDA with the goal of minimizing the elevated portions of flyovers.

Table 21.8 Minimum Grade

Road Class	Flat	Rolling	Adopted Values
A	4%	6%	6%
B	5%	7%	6%

Minimum Vertical Curve Length

The minimum vertical curve length applied is shown in Table 21.9 and is based on RDA's standards.

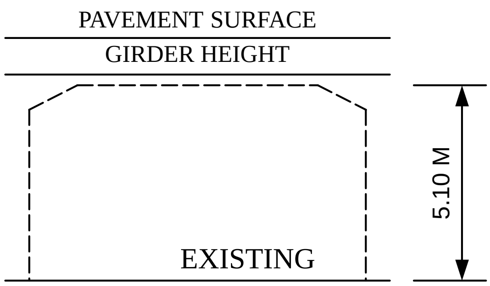
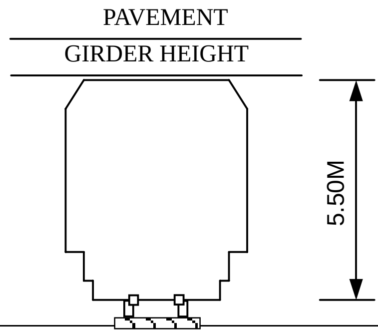
Table 21.9 Minimum Vertical Curve Length

Design Speed (km/h)	Minimum Vertical Curve Length	
	Crest	Sag
40	4.7	7.3
50	9.8	12
60	17	17

Vertical Clearance

The vertical clearances applied in this study for crossings above a road and railway are as shown in Table 21.10 and are based on RDA's standards.

Table 21.10 Vertical Clearance

<table>
<tr><th>Type of Crossing</th><th>Crossing Over Roads</th><th>Crossing Over Railways</th></tr>
<tr><td>Image</td><td>
</td><td>
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</table>

(4) Flyover Design

The following basic concepts are applied to the flyover design work of the study:

- The existing formation width of the study roads is not consistent. Therefore, the road formation widths applied to the flyovers in the study are based on maps prepared from on-site surveys executed by the JICA Study Team;
- The cross section and horizontal/vertical alignment is set to minimize land acquisition; and
- The existing ground level is considered to be flat in this study, excluding Kohuwala Intersection.

Orugodawatte Flyover (No.1) (Figure 21.4)

Design Overview: Orugodawatte Intersection is located on the northern section of Baseline Road and intersects with an important radial road that leads to/from the center of Colombo. The design overview for the flyover is as follows:

- The flyover will be a four-lane carriageway and will be located on Baseline Road crossing over Orugodawatte Intersection;
- The alignment of the flyover will be set so as to avoid a sacred Bo tree located near the intersection. That is, the width of the flyover shall be adjusted to ensure that the tree is not cut down;
- Land acquisition around the intersection, as well as impacts on a bridge south of the intersection, will be minimized. Note that access roads to provide an approach to the at-grade crossing road shall also be constructed;
- In order to construct the above-mentioned access road under the flyover, the vertical alignment is designed taking into consideration the structure beam and slab as well as the necessary clearance; and
- Land acquisition is necessary on either side of the intersection in order to provide access for both sides of the road that will parallel the flyover and its ramps.

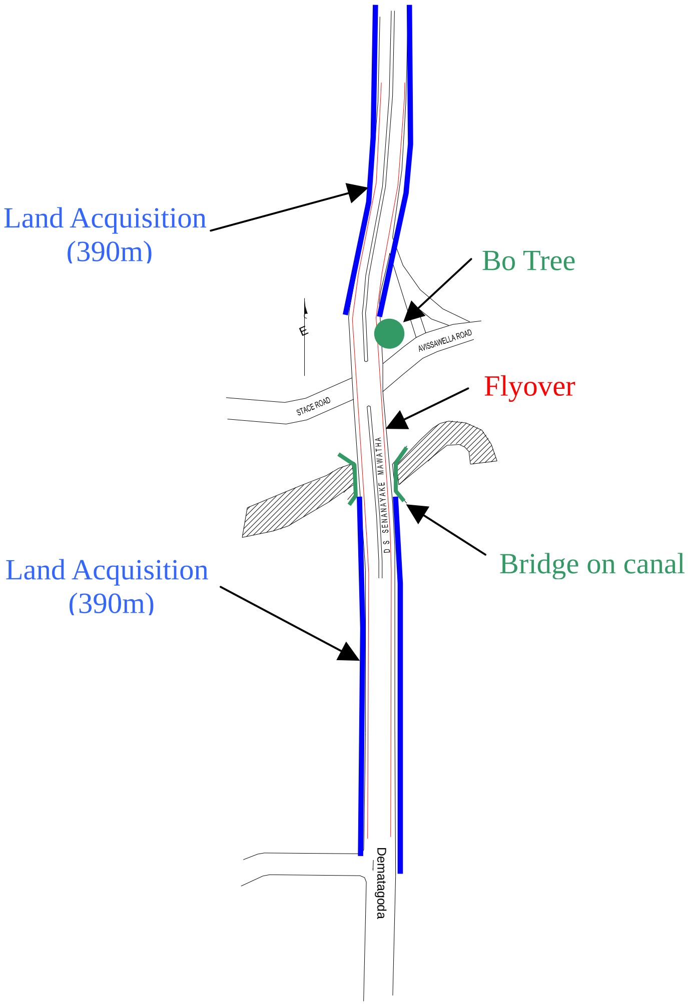


Figure 21.4 Layout of the Orugodawatte Flyover

Cross Section: The width of the existing Baseline Road is 28.2 meters and consists of a six-lane carriageway with a center median and footpaths on either side (Figure 21.5). The proposed widths of the ramps and flyover sections are 31.1 meters and 28.2 meters, respectively (Figure 21.6, and Figure 21.7). Land acquisition for access roads will be unnecessary when the roads are directly underneath the flyover. Excluding that section, the right-of-way will have to be expanded by 0.95 meters on either side of the ramps and a part of the flyover for a total distance of 780 meters.

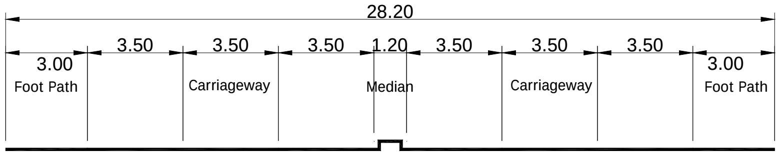


Figure 21.5 Existing Cross Section

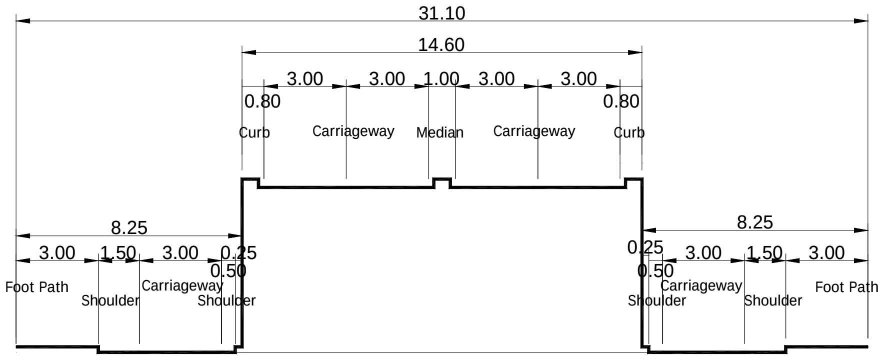


Figure 21.6 Proposed Ramp Cross Section

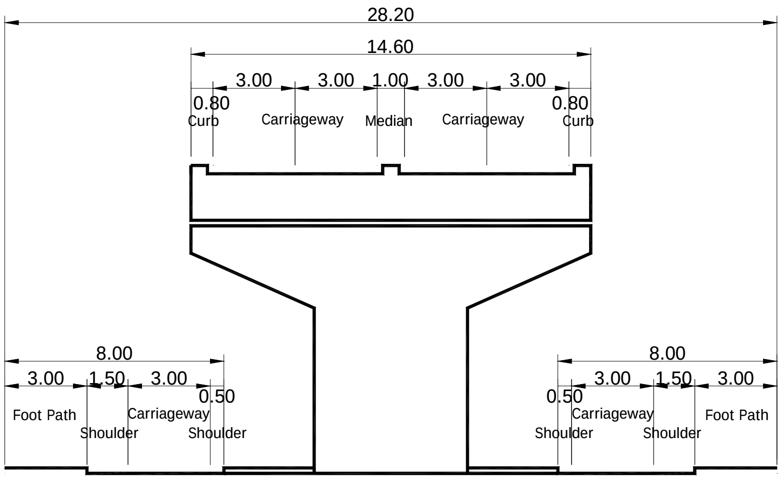


Figure 21.7 Proposed Flyover Cross Section

Borella – Kanatta Flyover (No.2) (Figure 21.8)

Design Overview: This proposed section is also located on Baseline Road, south of Orugodawatte Intersection. The flyover is designed to cross over three highly congested intersections: Borella, D.S.Senanayake, and Kanatta. The design overview is as follows:

- The flyover will consist of a four-lane carriageway, with two two-lane access roads to be constructed on either side in order to access the at-grade crossing;
- The alignment of the flyover is designed as close to the existing Baseline Road as possible in order to minimize land acquisition;
- To prevent impacts on the cemetery adjacent to Kanatta Intersection, the flyover is extended to the south;
- To minimize land acquisition around the intersections, access roads are designed to come under the flyover when approaching the at-grade crossing roads;
- In locating the access roads under the flyover, vertical alignment is designed taking into consideration the structural beam and slab as well as the necessary clearance;
- Although the ground is considered flat for this design, it is necessary to consider the actual ground level around Borella Intersection; and
- Land acquisition is necessary on either side of the ramp and parts of the flyover where the access roads run parallel to these structures.

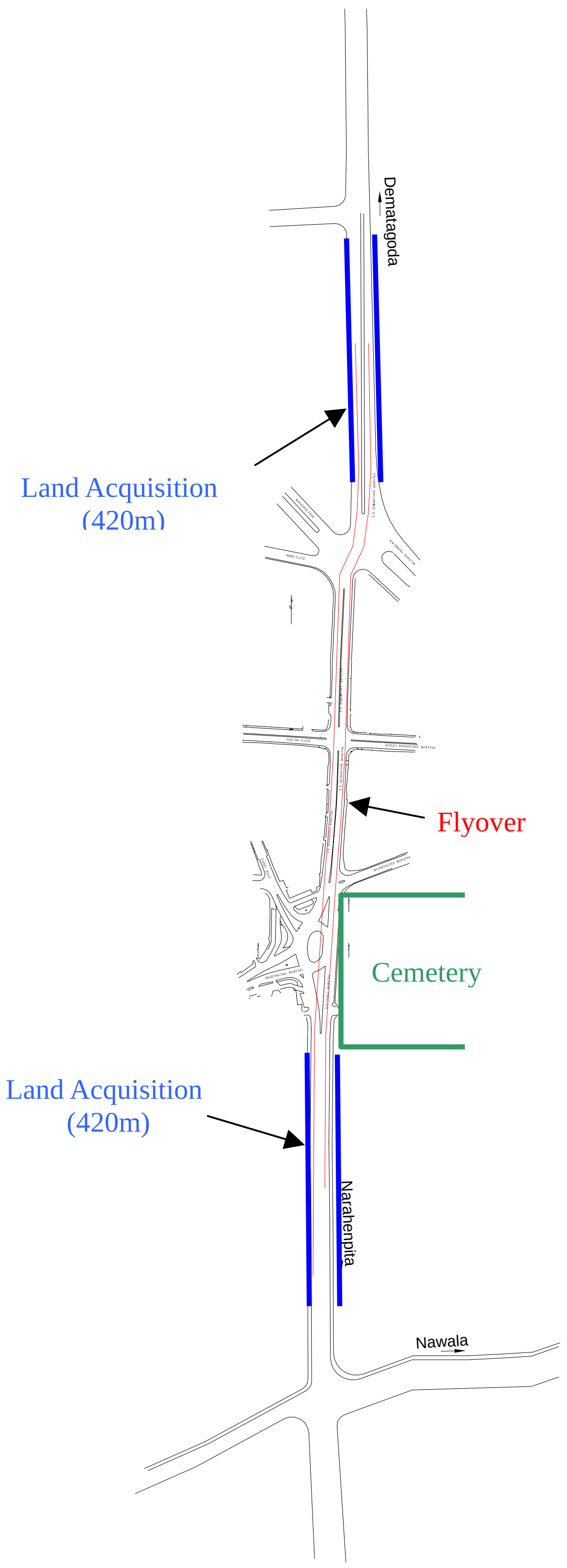


Figure 21.8 Layout of the Borella-Kanatta Flyover

Cross Section: The width of the existing road around the proposed section is 27.2 meters and consists of a six-lane carriageway with a center median and footpaths on either side (Figure 21.9). The proposed widths of the ramps and flyover section are 34.1 meters and 27.2 meters, respectively (Figure 21.10, and Figure 21.11). Land acquisition is unnecessary where access roads come completely under the flyover. Excluding those sections, it will be necessary to expand the right-of-way by 3.45 meters on either side of the ramps and at a part of the flyover for a total distance of 840 meters.

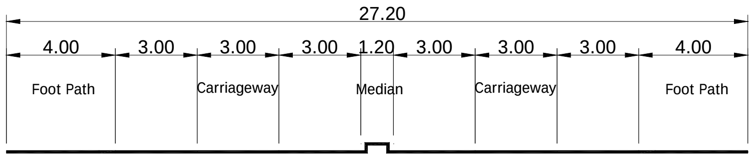


Figure 21.9 Existing Cross Section

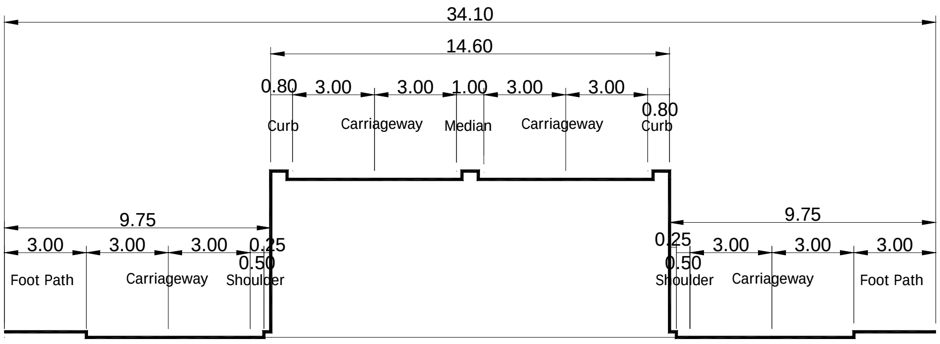


Figure 21.10 Proposed Ramp Cross Section

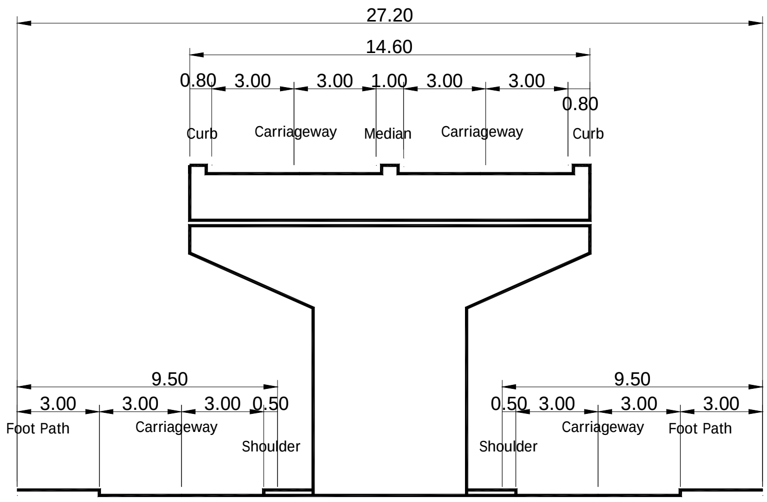


Figure 21.11 Proposed Flyover Cross Section

Kohuwala Flyover (No.4) (Figure 21.12)

Design Overview: The Kohuwala Flyover is the only pre-FS flyover located on a Class B road. The design overview for this project is as follows:

- The flyover will consist of a two-lane carriageway with two one-lane access roads on either side and will be located on Colombo-Horana Road;
- The flyover's alignment is designed along the existing road to minimize land acquisition;
- The flyover's vertical grade adheres to the existing grades at both ends of the flyover; and
- Land acquisition is necessary on either side of the flyover and ramps.

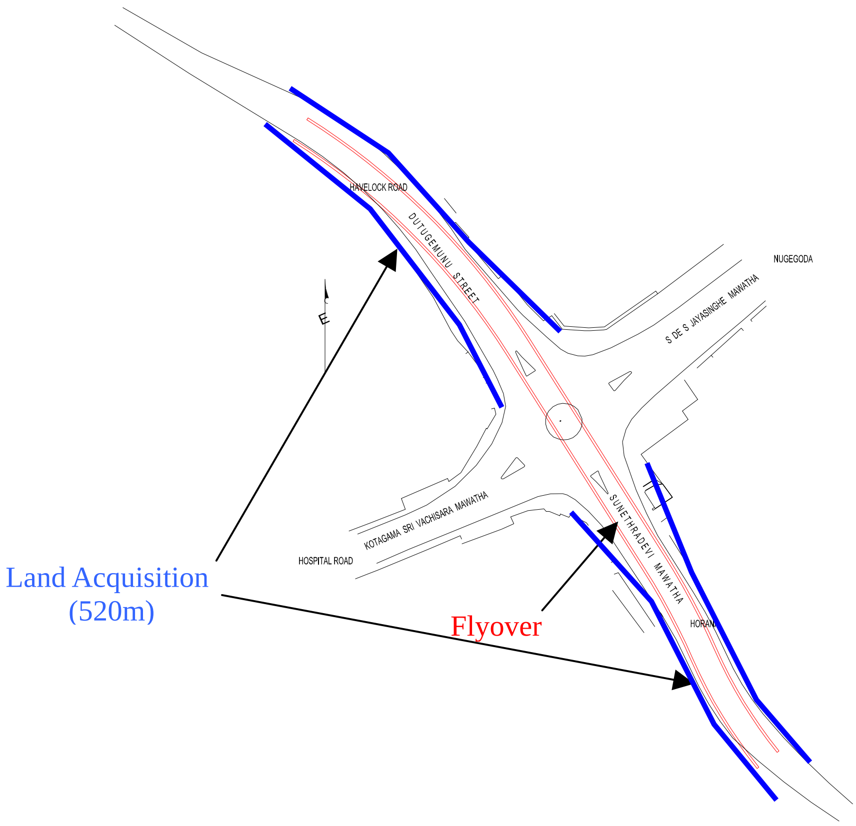


Figure 21.12 Layout of Kohuwala Flyover

Cross Section: The width of the existing road around the proposed section is 15.0 meters and consists of a four-lane carriageway with a shoulder on either side (Figure 21.13). The flyover will have a two-lane carriageway and a shoulder and curb on either side in case a car needs to stop. The proposed ramp and flyover widths are 26.5 meters. Land acquisition of 5.75 meters in width on either side of the flyover and ramps will be necessary for a total distance of 520 meters (Figure 21.14).

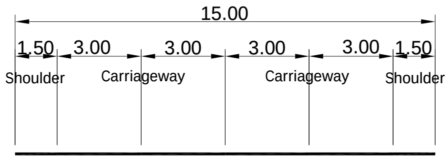


Figure 21.13 Existing Cross Section

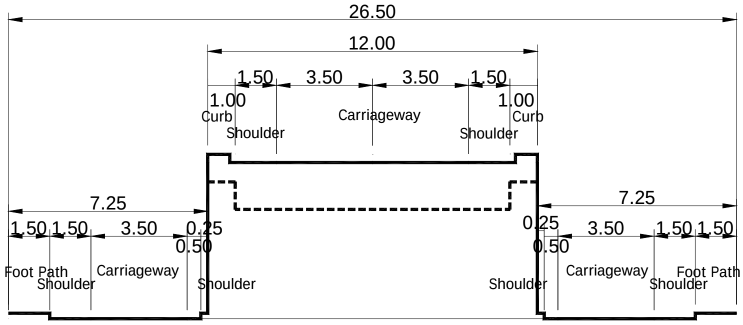


Figure 21.14 Proposed Cross Section for Flyover and Ramps

Armour Street Flyover (No.5) (Figure 21.15)

Design Overview: This flyover will be located on A1 Road, which is the most important route to connect Colombo and Kandy. The design overview for the flyover is as follows:

- According to traffic flow analysis, the main traffic flows are from south to east and as a result it is recommended that the flyover turn right from Sri Sumanatissa Road onto Central Road heading east;
- The flyover will consist of a two-lane carriageway as shown in Figure 21.15;
- The flyover's alignment will pass over an existing traffic island and a flyover pier will be built there;
- Passage from the intersecting road south of the intersection will become impossible as the ramp of the flyover will be located there; and
- Land acquisition is unnecessary for the section of the flyover on Sri Sumanatissa Road, but will be necessary for the south side of Central Road to ensure a sufficient right-of-way.

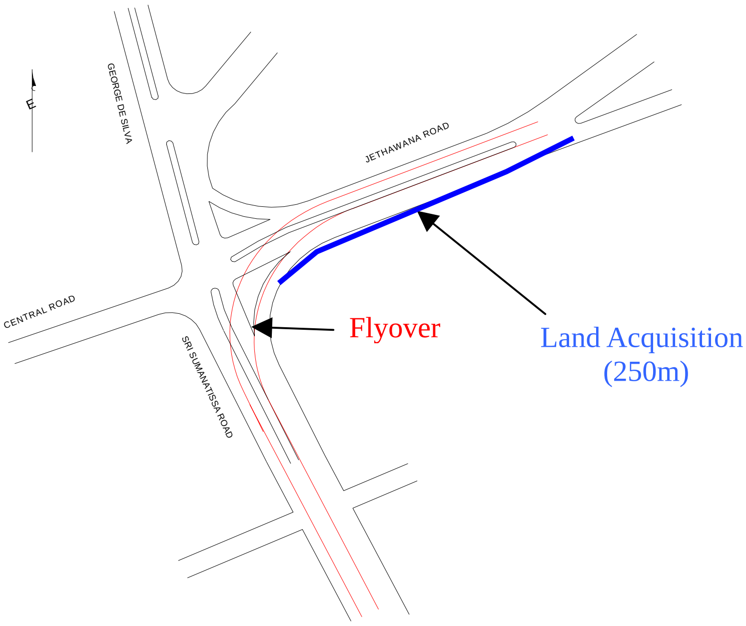


Figure 21.15 Layout of Armour Street Flyover

Cross Section: The width of the existing road around the proposed section is 30.5 meters and consists of a six-lane carriageway with a center median and a footpath on either side (Figure 21.16). The flyover, which will have a two-lane carriageway, will be 30.5 meters wide on the southern portion and 32.0 meters wide on the eastern portion. The width of the footpaths on the proposed section will be 2.50 meters as compared to 3.25 meters for the existing road (Figure 21.17, and Figure 21.18). Land acquisition of 1.5 meters on the south side of Central Road will be necessary for both the flyover and ramp sections.

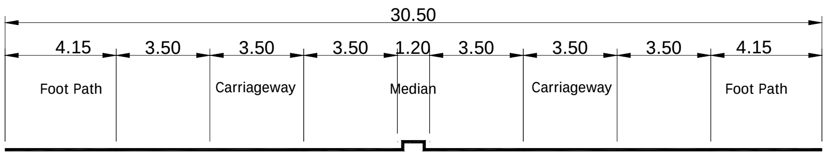


Figure 21.16 Existing Cross Section

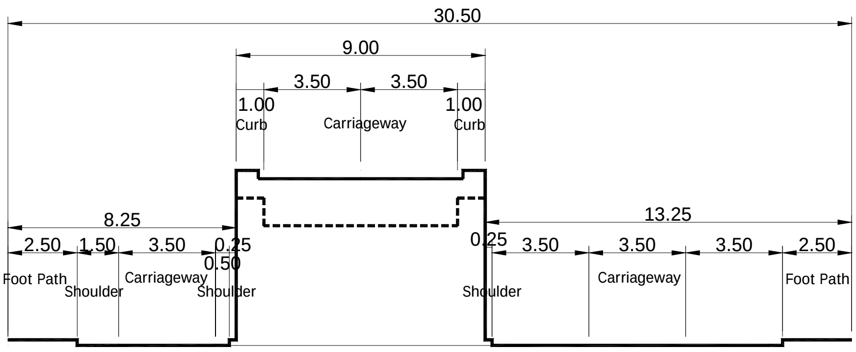


Figure 21.17 Proposed Flyover Cross Section (Southern Part)

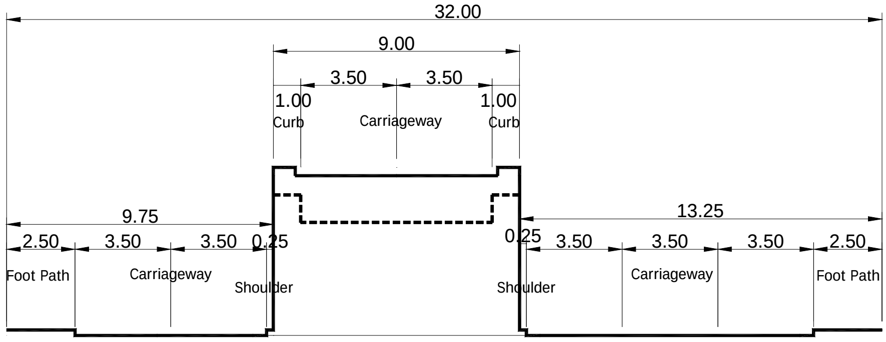


Figure 21.18 Proposed Flyover Cross Section (Eastern Part)

Kelaniya Railway Flyover (No.6) (Figure 21.19)

Design Overview: This flyover will be located on A1 Road and will cross the existing railway. The road and railway do not cross at a 90 degree angle. The design overview is as follows:

- The flyover will consist of a two-lane carriageway with two one-lane access roads;
- Due to the skewed crossing, the flyover will be designed as two separate structures for the two opposing traffic flows;
- The vertical alignment has taken into consideration the area where the number of railway tracks is increased; and
- Land acquisition is necessary for both sides of the flyover.

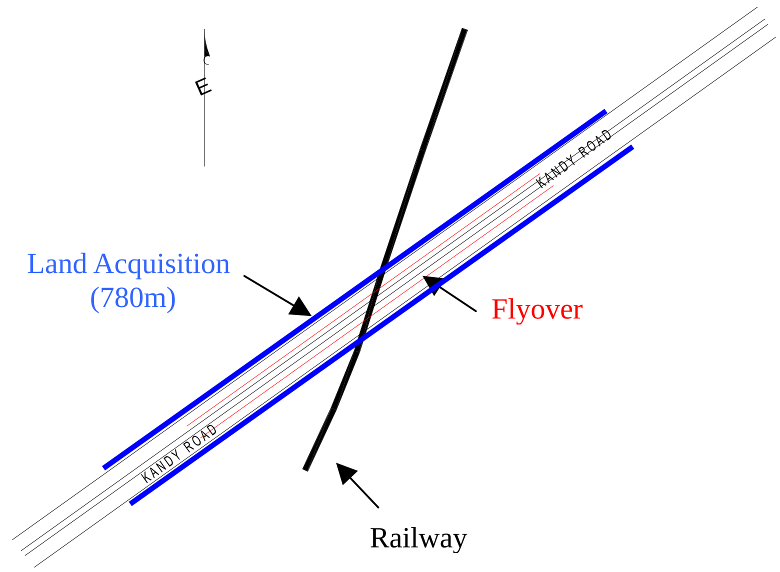


Figure 21.19 Layout of Kelaniya Railway Flyover

Cross Section: The width of the existing road at the proposed section is 25.0 meters and consists of a four-lane carriageway with a median and a footpath on either side (Figure 21.20). The cross section in RDA's detailed design should be adopted and land acquisition will be necessary and includes 2.95 meters in width on either side for the flyover and ramp sections (Figure 21.21).

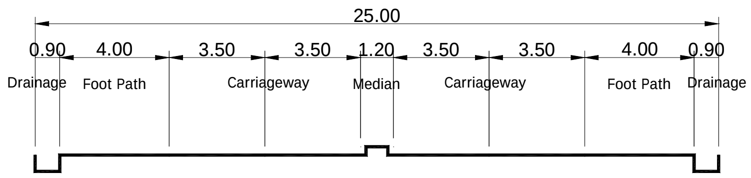


Figure 21.20 Existing Cross Section

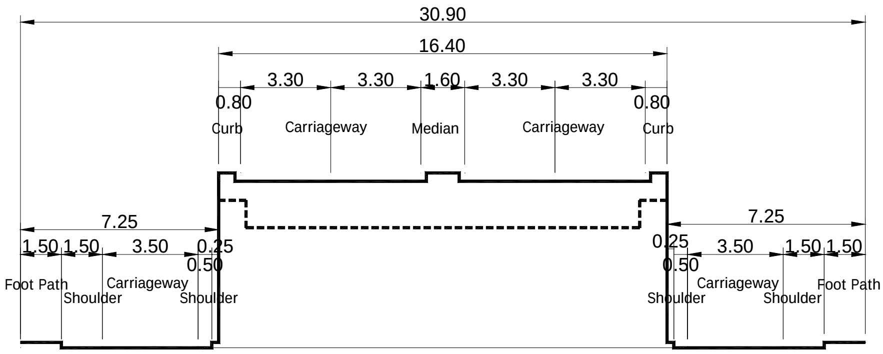


Figure 21.21 Proposed Cross Section (Ramp Wall/Flyover)

Rajagiriya (No.7) (Figure 21.22)

Design Overview: Rajagiriya Intersection is located on a small curve on A0 Road, which is one of Colombo's most important arterial roads as it leads to the country's Parliament. The design overview is as follows:

- The flyover, which will consist of a four-lane carriageway, will be located on A0 Road and cross over Rajagiriya Intersection;
- The alignment of the flyover is set to run along the existing road as much as possible in order to avoid a sacred Bo tree and Welikada Plaza to the north of the intersection;
- It is recommended that traffic operations of the two intersecting roads from the south be changed to ensure smoother traffic flows: one would be converted to a one-way street from a two-way street and the other to a two-way street from a one-way street;
- A 5% grade will be applied for the vertical alignment of the flyover, as the curves of the vertical alignment would overlap if a 6% gradient is used; and
- Land acquisition is necessary for both sides of the entire flyover structure.

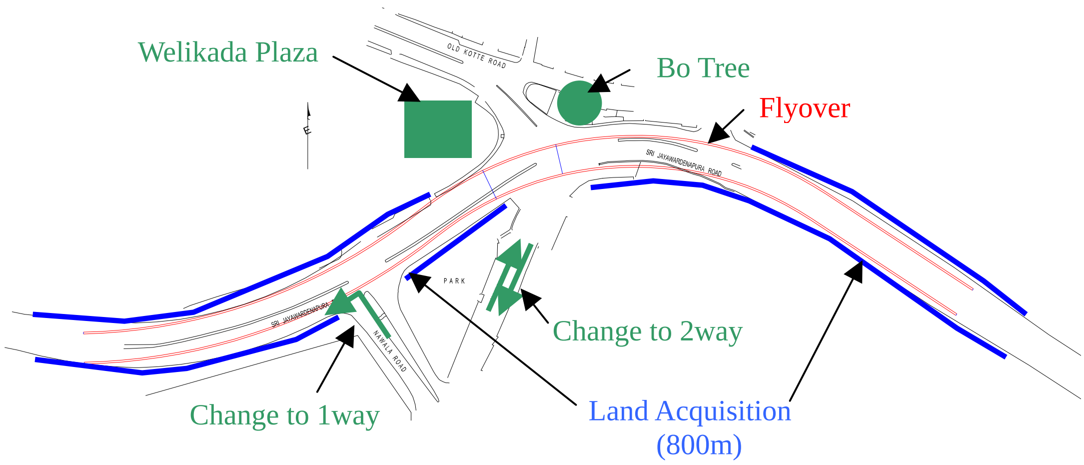


Figure 21.22 Layout of Rajagiriya Flyover

Cross Section: The width of the existing road around the proposed section is 28.2 meters and consists of a six-lane carriageway with a center median and a footpath on either side (Figure 21.23). Land acquisition of 3.25 meters in width on either side is required for the flyover and ramp sections (Figure 21.24).

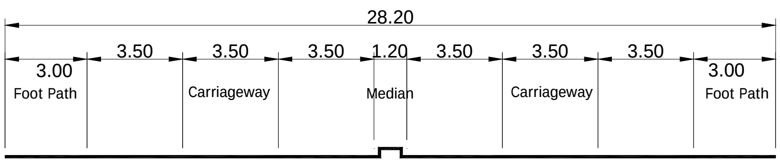


Figure 21.23 Existing Cross Section

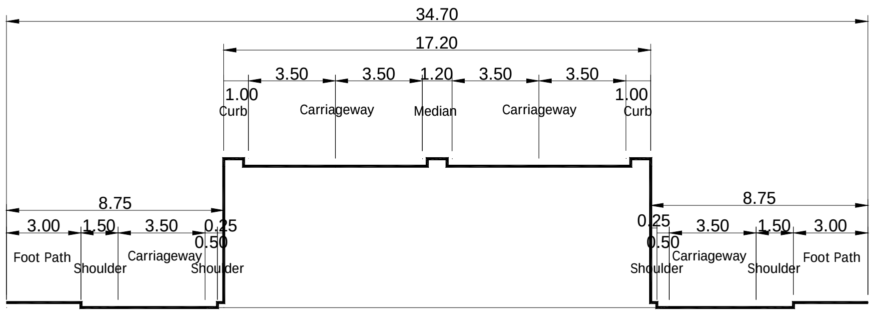


Figure 21.24 Proposed Cross Section for Flyover and Ramps

(5) Drawings

The drawings for the plans and profiles of the flyovers are contained in Appendix 31. The scale of these drawings is shown in Table 21.11.

Table 21.11 Scale of Pre-FS Design Drawings

Number	Pre-FS Project	Design Scale
1	Orugodawatte	Scale=1:4,000
2	Bollera – Kanatta	Scale=1:4,000
4	Kohuwala	Scale=1:4,000
5	Armour Street	Scale=1:4,000
6	Kelaniya Railway	Scale=1:4,000
7	Rajagiriya	Scale=1:4,000

21.4 Structural Design

(1) Design Standards

The Sri Lanka Standard Bridge Design Manual (BDM) and BS5400 were utilized for bridge design.

(2) Load

Dead Load

The dead load densities for bridge design were chosen in accordance with the BS5400 Standard as shown in Table 21.12.

Table 21.12 Densities

Material	Density (kN/cu-m)
Steel	77.0
Reinforcement Concrete	24.0
Normal Concrete	22.0
Asphalt Concrete	22.0
Compacted Sand	19.0
Loose Sand	15.0
Water	10.0

Source: BS 5400

Live Load

The live load of HA and HB loading on BS5400 that was specified in the BDM, Article 2.2.3 will be used for the design. The BDM specifies the following loads given in Part 2 of BS5400, which will be used for bridge design in the local network:

- All bridges should be designed to resist the effects of HA loading specified in the relevant code; and
- Bridges should be able to resist the effects of 30 units of HB loading for A and B class roads.

Seismic Forces

Bridges in Sri Lanka do not need to be designed to withstand earthquakes as Sri Lanka is a seismic-affected area.

(3) Materials

Concrete

Concrete strengths and typical applications by class are given in Table 21.13.

Table 21.13 Concrete Strength (28 Day Period)

Class	Strength (N/mm^2)	Typical Application
40	40	PC girder
30	30	RC Girder, Deck slab, Diaphragm, Pile
25	25	Abutment, Pier

Source: Bridge Design Manual

Steel Plate

- All steel plates should be high yield deformed plates and the minimum yield strength should be 355 N/mm^2 (50EE) confirming BS 4360; and
- The modulus of elasticity of reinforcing steel should be Es = 200,000 N/mm^2.

Steel Bar

- All reinforcing steel bars should be high yield deformed bars and the minimum yield strength should be 460 N/mm^2 confirming with BS 4449, 4461, and 4483; and
- The modulus of elasticity of reinforcing steel should be Es = 200,000 N/mm^2.

Pre-stressed Steel

Pre-stressed steel should meet the requirements of the American Association of State Highway and Transportation Officials (AASHTO) M 203M (ASTM A-416M) - uncoated, seven-wire, stress-relieved strands for pre-stressed concrete, grade 270 having minimum tensile strength of 1,860 N/mm^2. Low-relaxation strands are used for the pre-stressed strands. Tensile and yield strengths for the pre-stressed strands are specified as in Table 21.14.

Table 21.14 Properties of Pre-stressed Strands

Material	Grade	Diameter (mm)	Tensile Strength -fpu- (N/mm^2)	Yield Strength -fpy- (N/mm^2)
Strand	1,860N/mm^2 (Grade 270)	9.53 to 15.24	1,860	85% of fpu for low-relaxation strand

Source: ASTM A-416

(4) Intersection Conditions

Table 21.15 lists the general intersection descriptions.

Table 21.15 Intersection Positions

Intersection	Main Road	Sub Road	Flyover
1. Orugodawatte	Baseline Road	Stace Rd-Avissawella Rd	Baseline Rd
2. Borella - Kanata	Baseline Road	Ward Place, Gnanarth Pradeepaya Road-Dr N M Perera Mawatha	Baseline Road
		Horton Place-Dudley Senanayake Mawatha	
		Baudhaloka Mawatha, Kinsey Rd	
4. Kohuwala	Horana Road	Kotagama Sri Vachissara Mawatha -S De S Jayasingha Mawatha	Horana Road
5. Armour Street	George R De Silva Mawatha - Sri Sumanatissa Mawwatha	Maha Vidyalaya Mawatha -Jethawana Road	Sri Sumanatissa - Jethawana Road
6. Kelaniya Railway	Kandy Road	Railway Main Line	Kandy Rd
7. Rajagiriya	Sri Jayawardenepura Road, Kotte Road	Nawala Road	Sri Jayawardenepura

Source: JICA Study Team

(5) Soil Profiling

The material properties of subsoil identified were summarized in Table 21.16.

Table 21.16 Summary of Soil Property

Layer	1. Orugodawatte	2. Borella-Kanata	4. Kohuwala	5. Armour Street	6. Kelaniya Railway	7. Rajagiriya
Surface	Sand	Clayey Sand	Sandy Clay		Gravel	Sandy Clay
Depth (m)	00.00-10.10	00.00-04.00	00.00-05.10		00.00-02.70	00.00-05.50
Medium	Clay	Sandy Clay	Sandy Clay		Silty Clay	Clayey Sand
Depth (m)	10.10-20.00	04.00-19.30	05.10-10.50		02.70-21.40	05.50-17.60
Basis	Rock	Rock	Rock	Rock	Rock	Rock
Depth (m)	20.00 -	19.30 -	10.50 -	20.00 -	21.40 -	17.60 -

Source: JICA Study Team

(6) Typical Cross Sections

The typical cross section of a bridge is shown in Figure 21.25, and Figure 21.26. The total widths are 14.6-17.2 meters for four-lane roads and 9.0-12.0 meters for two-lane roads.

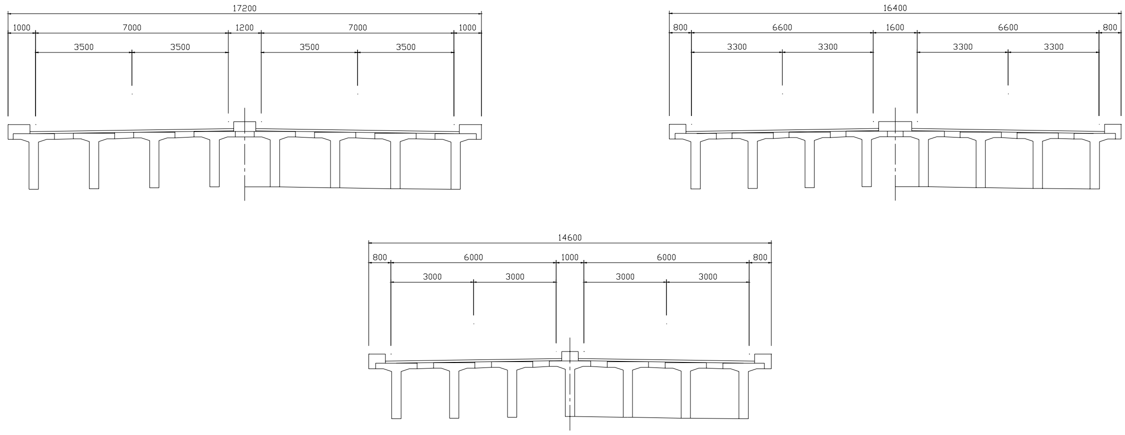
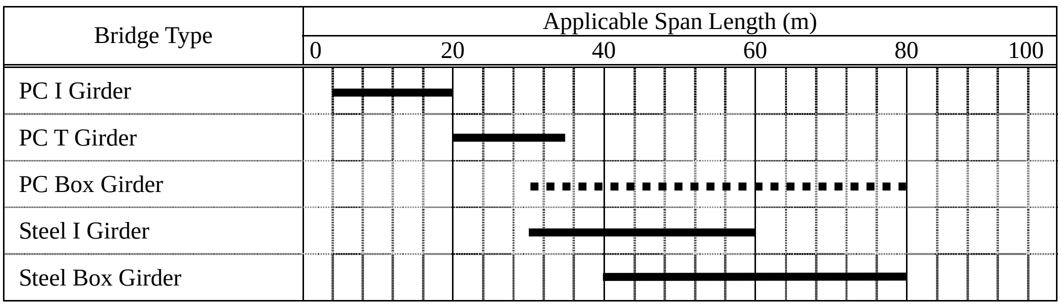


Figure 21.25 Typical Cross Section for a Four-Lane Road

Figure 21.26 Typical Cross Section for a Two-Lane Road

(7) Applicable Span Length by Bridge Type

The span arrangement and layout alignment were considered to decide the applicable superstructure types. From Sri Lanka and other international experiences, the conceivable superstructure types are: (i) PC I girder; (ii) PC T girder; (iii) steel I girder; and (iv) steel box girder. Additionally, a PC box girder could be applicable, but ensuring safety during construction is difficult, so it will not be considered. A span length depends on the type of bridge. Figure 21.27 shows the applicable span lengths for various bridge types.

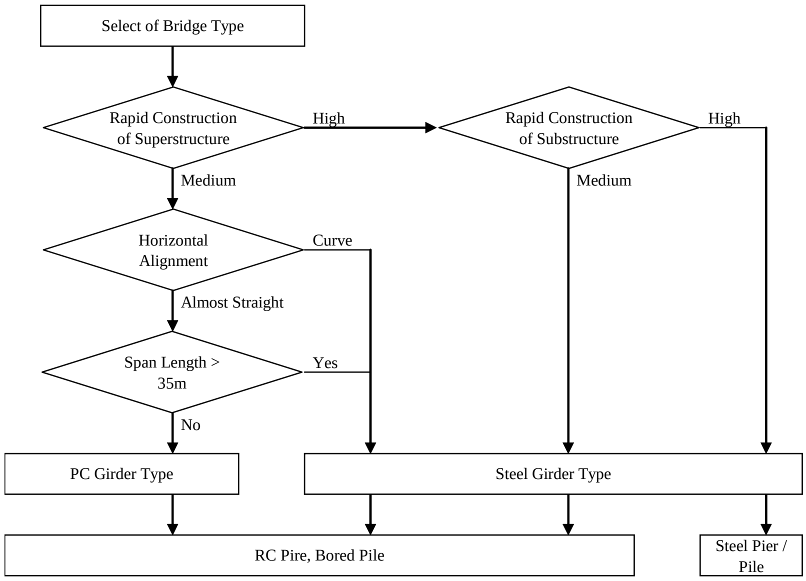


Source: Japan Pre-stressed Concrete Contractors Association / Japan Association of Steel Bridge Construction

Figure 21.27 Applicable Span Lengths for Various Bridge Types

(8) Summary of Bridge Type Selection

The bridge type is selected by the procedures outlined in Figure 21.28. The structural type was selected for alternatives considering horizontal alignments and the necessary construction period.



Source: JICA Study Team

Figure 21.28 Select of Bridge Type

(9) Summary of Sites

The conditions of sites are summarized in Table 21.17.

Table 21.17 Condition of Site

Flyover	No. of Lanes	Width (m/lane)	Rapid Cons. Superstructure	Rapid Cons. Substructure	Horizontal Alignment	Max. Span Length (m)
1. Orugodawatte	4	3.00	Medium	—	Straight	70.00
2. Borella-Kanata	4	3.00	High	High	Straight	80.00
4. Kohuwala	2	3.50	Medium	—	Straight	35.00
5. Armour Street	2	3.50	Medium	—	Curve	55.00
6. Kelaniya Railway	4	3.30	High	Medium	Straight	40.00
7. Rajagiriya	4	3.50	High	High	Curve	40.00

Source: JICA Study Team

Orugodawatte Flyover (No.1)

The proposed structure would help control traffic at Orugodawatte Intersection, which is a very important intersection in Colombo because it crosses Colombo-Avissawella Road at grade level on Baseline Road. Baseline Road is the priority road and uninterrupted traffic flow is desirable. RDA is constructing a flyover over the railway line about 500 m from this intersection along Colombo-Avissawella road. There is a sacred Bo tree in the area and removing this tree would have negative social impacts, although this could be minimized by pruning the tree where necessary.

Borella - Kanata Flyover (No.2)

A flyover is proposed from Borella-Kanata Intersection to Borella Intersection crossing three main junctions. The crossroads are Rajagiriya-Bambalapitiya Road, D.S.Senanayaka Road and Old Borella-Rajagiriya Road. The Borella-Kanata Intersection borders a cemetery and therefore, it is not likely that land acquisition of cemetery property will possible. The proposed flyover will be four-lanes wide with dual carriageways of a 6.0 meter width and a 0.6 m wide center median. Thus, the overall width of the flyover structure will be 14.6 meters with a 1.0 meter raised pavement on both sides to accommodate curb and safety guardrails. Taking into account the construction constrains such as time, traffic management, ground disturbance, type of equipment used, and aesthetic considerations, an 80.0 meter-long steel girder superstructure is suggested. The proposed road section is about 800 meter long, so traffic delays due to construction is highly likely, therefore it is necessary to ensure rapid construction, which is possible by using steel. Furthermore, the inner-excavation construction method is proposed to install the steel piles because there is lower noise - about 70 decibels instead of 100 decibels using the ram down method.

Kohuwala Flyover (No.4)

This flyover is proposed at the intersection between Colombo-Horana Road and Nugegoda-Kalubowila Road. Presently, there is a circular roundabout at this intersection. Both roads are equally busy and are located close to Nugegoda. During peak hours, more vehicles travel between Colombo-Horana.

Armour Street Flyover (No.5)

The proposed structure will help to control traffic at Armour Street, which is the main road connecting Colombo and Kandy. This intersection is at a busy commercial area and has a large volume of traffic. The study recommends improving this intersection due to the high volume of commercial traffic. Currently, right-hand turn traffic from the priority road enters a minor road through a ramp traveling in the opposite direction. A plane curve with a small radius is arranged in the road plan. Therefore, the steel curved box girder which has high torque rigidity is recommended.

Kelaniya Railway Flyover (No.6)

The proposed location of the flyover is on Colombo Kandy Road (A1) at Kelaniya. This road is the main road connecting Colombo and Kandy and one of the busiest railway lines crosses here. The crossing does not occur at a 90 degree angle, but is skewed at 50 degrees. Therefore, structures that are isolated in each direction will shift the arrangement of substructure.

Rajagiriya Flyover (No.7)

This junction is the main road that connects Colombo with Parliament. Therefore, high-level officials travel regularly in this area, especially on Colombo-Battaramulla Road. Considering the traffic patterns and priority of traffic, Battaramulla-Colombo Road is recommended to have an elevated road structure.

The result of flowcharts and applicable span lengths are summarized in Table 21.18.

Table 21.18 Bridge Type

Flyover	Length (m)	Span	Superstructure	Substructure/Foundation
1. Orugodawatte	435.0	10 Span	Steel Box and PC T Girder	RC Pier/Bored Pile
2. Borella - Kanata	1,430.0	30 Span	Steel Box and I Girder	Steel Pier/Steel Pile
4. Kohuwala	175.0	5 Span	PC T Girder	RC Pier/Bored Pile
5. Armour Street	280.0	8 Span	Steel Box and PC T Girder	Steel and RC Pier/Bored Pile
6. Kelaniya Railway	330.0	9 Span	Steel I and PC T Girder	RC Pier/Bored Pile
7. Rajagiriya	200.0	5 Span	Steel Box Girder	Steel Pier/Steel Pile

Source: This Study

(10) General Structural View

The general structural views of the proposed Pre-FS flyovers are shown in Appendix 31.

(11) Summary of Construction Period

The estimated construction time is shown in Table 21.19.

Table 21.19 Construction Period for Grade Separation Projects

No.	Flyover	Unit	Foundation	Substructure	Superstructure	Total
1	Orugodawatte	month	4.5	15.0	10.0	24.0
2	Borella-Kanata	month	6.0	18.0	20.0	38.0
4	Kohuwala	month	4.0	6.0	7.0	15.0
5	Armour Street	month	5.0	8.0	6.0	16.0
6	Kelaniya Railway	month	6.0	14.0	16.0	30.0
7	Rajagiriya	month	6.0	8.0	6.0	18.0

Source: JICA Study Team

(12) Future Topics to be Examined

At the time of detail design, the topics below should be examined as potential cost reducing strategies.

Employ a Rigid Connection of Superstructure and Substructure

In order to reduce the costs, the connection of the superstructure and substructure could be reduced to a rigid connection, as opposed to the above normal connection. This would reduce the formation height of the whole road due to the use of a part notch in the steel girder and a different method to assure the unification of the steel girder and pier head.

Use Rational Orthotropic Plate Girder and PC composite Girder

Because Baseline Road would be affected by some of the proposed projects and it already has high congestion, it is recommended that the detailed design look at opportunities to reduce the time needed for construction on those projects. If a rational orthotropic plate girder and pc composite girder were utilized, this may help reduce the construction time needed, thereby reducing negative impacts on Baseline Road.

Use of Weather Resistant Steel

Using weather resistant steel may help to reduce the maintenance costs.

21.5 Cost Estimates

(1) Bill of Quantity

The bill of quantity for pre-FS projects' design is shown in Table 21.20.

(2) Estimates of Project Costs

The Pre-FS project costs for the grade separated projects are shown in Table 21.21.

Table 21.20 Bill of Quantity (1/2)

		Unit	Orugodawatte Flyover			Borella - Kanata Flyover			Kohuwala		
			Qty	Unit Price (Rs)	Amount (Rs)	Qty	Unit Price (Rs)	Amount (Rs)	Qty	Unit Price (Rs)	Amount (Rs)
Road	Preliminaries & General	ls	1.0	5,662,252	5,662,252	1.0	5,779,455	5,779,455	1.0	3,042,216	3,042,216
	Earth Works	cu-m	9,592.0	791	7,585,550	12,187.0	817	9,961,050	6,553.0	519	3,398,600
	Pavement	tf	3,799.0	8,076	30,679,851	3,873.0	7,233	28,014,392	1,146.0	12,231	14,016,849
	Median Strip	m	2,775.0	1,551	4,305,000	2,630.0	1,540	4,049,000	1,340.0	1,300	1,742,000
	Retaining Wall	sq-m	698.0	7,000	4,886,000	479.0	7,000	3,353,000	705.0	7,000	4,935,000
	Drainage	m	1,550.0	6,352	9,846,000	1,730.0	6,356	10,996,000	1,010.0	6,360	6,424,000
	Incidental	ls	1.0	4,557,750	4,557,750	1.0	4,116,750	4,116,750	1.0	2,576,250	2,576,250
	Facilities	ls	1.0	4,032,000	4,032,000	1.0	8,400,000	8,400,000	0.0		0
	Dayworks	ls	1.0	1,415,563	1,415,563	1.0	1,444,864	1,444,864	1.0	760,554	760,554
	Road Total				**72,969,966**			**76,114,511**			**36,895,469**
Flyover	Steel Girder Weight	tf	1,007.3	295,000	297,166,775	5,343.9	271,000	1,448,202,320	0.0	246,000	0
	Slab Concrete	cu-m	788.4	18,000	14,191,200	5,010.7	18,000	90,192,960	0.0	18,000	0
	Slab Reinforcement	tf	94.6	120,000	11,352,960	601.3	120,000	72,154,368	0.0	120,000	0
	PC Girder Concrete	cu-m	1,449.0	30,000	43,470,000	0.0	30,000	0	1,035.0	30,000	31,050,000
	PC Cable	tf	69.4	170,000	11,795,280	0.0	170,000	0	49.6	170,000	8,425,200
	PC Girder Reinforcement	tf	152.8	120,000	18,340,560	0.0	120,000	0	109.2	120,000	13,100,400
	Girder Concrete	cu-m	253.8	25,000	6,345,150	0.0	25,000	0	181.3	25,000	4,532,250
	Girder Reinforcement	cu-m	25.4	15,000	380,709	0.0	15,000	0	18.1	15,000	271,935
	Railimg	m	870.0	5,000	4,350,000	2,860.0	5,000	14,300,000	350.0	5,000	1,750,000
	Pavement	sq-m	5,568.0	1,000	5,568,000	18,304.0	1,000	18,304,000	1,820.0	1,000	1,820,000
	Saport for Steel Girder	No.	20.0	50,000	1,000,000	181.0	50,000	9,050,000	0.0	50,000	0
	Saport for PC Girder	No.	56.0	15,000	840,000	0.0	15,000	0	36.0	15,000	540,000
	RC Pier Concrete	cu-m	3,132.8	18,000	56,390,760	4,568.3	18,000	82,229,040	1,296.3	18,000	23,333,400
	RC Pier Reinforcement	tf	375.9	120,000	45,112,608	548.2	120,000	65,783,232	155.6	120,000	18,666,720
	Steel Pier Weight	tf	0.0	310,000	0	3,420.0	310,000	1,060,200,000	0.0	310,000	0
	Bored Pile	m	2,268.0	50,000	113,400,000	0.0	50,000	0	660.0	50,000	33,000,000
	Steel Pile	m	0.0	30,000	0	7,560.0	30,000	226,800,000	0.0	30,000	0
	Flyover Total				**629,704,002**			**3,087,215,920**			**136,489,905**
1. Direct Cost Total					702,673,968			3,163,330,431			173,385,374
2. Overheads & Profit Contractor 20% of 1					140,534,794			632,666,086			34,677,075
3. Price Escalation 10% of (1+2)					84,320,876			379,599,652			20,806,245
4. Contingencies 10% of (1+2+3)					92,752,964			417,559,617			22,886,869
Total					**1,020,282,602**			**4,593,155,786**			**251,755,563**

Table 21.20 Bill of Quantity (2/2)

		Unit	Armour Street Flyover			Kelaniya Railway Flyover			Rajagiriya Flyover		
			Qty	Unit Price (Rs)	Amount (Rs)	Qty	Unit Price (Rs)	Amount (Rs)	Qty	Unit Price (Rs)	Amount (Rs)
Road	Preliminaries & General	ls	1.0	3,583,354	3,583,354	1.0	4,377,934	4,377,934	1.0	5,564,851	5,564,851
	Earth Works	cu-m	6,372.0	673	4,285,850	9,812.0	559	5,485,800	14,092.0	615	8,673,500
	Pavement	tf	2,157.0	7,073	15,256,326	2,365.0	10,742	25,405,379	3,471.0	9,171	31,831,632
	Median Strip	m	1,830.0	1,477	2,703,000	2,370.0	1,608	3,812,000	2,480.0	1,643	4,074,000
	Retaining Wall	sq-m	625.0	7,000	4,375,000	488.0	7,000	3,416,000	830.0	7,000	5,810,000
	Drainage	m	1,270.0	6,353	8,068,000	1,440.0	6,350	9,144,000	1,340.0	6,355	8,516,000
	Incidental	ls	1.0	5,728,750	5,728,750	1.0	4,045,000	4,045,000	1.0	4,845,500	4,845,500
	Facilities	ls	0.0		0	0.0		0	0.0		0
	Dayworks	ls	1.0	895,839	895,839	1.0	1,094,484	1,094,484	1.0	1,391,213	1,391,213
	Road Total				**44,896,119**			**56,780,597**			**70,706,696**
Flyover	Steel Girder Weight	tf	319.7	295,000	94,305,600	352.8	246,000	86,788,800	842.4	295,000	248,508,000
	Slab Concrete	cu-m	345.6	18,000	6,220,800	472.3	18,000	8,501,760	825.6	18,000	14,860,800
	Slab Reinforcement	tf	41.5	120,000	4,976,640	56.7	120,000	6,801,408	99.1	120,000	11,888,640
	PC Girder Concrete	cu-m	552.0	30,000	16,560,000	1,656.0	30,000	49,680,000	0.0	30,000	0
	PC Cable	tf	22.7	170,000	3,862,400	79.3	170,000	13,480,320	0.0	170,000	0
	PC Girder Reinforcement	tf	59.8	120,000	7,178,400	174.7	120,000	20,960,640	0.0	120,000	0
	Girder Concrete	cu-m	99.7	25,000	2,493,000	290.1	25,000	7,251,600	0.0	25,000	0
	Girder Reinforcement	cu-m	10.0	15,000	149,580	29.0	15,000	435,096	0.0	15,000	0
	Railimg	m	560.0	5,000	2,800,000	660.0	5,000	3,300,000	400.0	5,000	2,000,000
	Pavement	sq-m	2,072.0	1,000	2,072,000	4,620.0	1,000	4,620,000	2,960.0	1,000	2,960,000
	Saport for Steel Girder	No.	20.0	50,000	1,000,000	24.0	50,000	1,200,000	0.0	50,000	0
	Saport for PC Girder	No.	30.0	15,000	450,000	64.0	15,000	960,000	36.0	15,000	540,000
	RC Pier Concrete	cu-m	1,130.5	18,000	20,349,000	2,856.2	18,000	51,411,240	1,258.0	18,000	22,644,720
	RC Pier Reinforcement	tf	135.7	120,000	16,279,200	342.7	120,000	41,128,992	151.0	120,000	18,115,776
	Steel Pier Weight	tf	195.5	310,000	60,605,000	0.0	310,000	0	492.0	310,000	152,520,000
	Bored Pile	m	1,080.0	50,000	54,000,000	2,520.0	50,000	126,000,000	0.0	50,000	0
	Steel Pile	m	0.0	30,000	0	0.0	30,000	0	1,536.0	30,000	46,080,000
	Flyover Total				**293,301,620**			**422,519,856**			**520,117,936**
1. Direct Cost Total					338,197,739			479,300,453			590,824,632
2. Overheads & Profit Contractor 20% of 1					67,639,548			95,860,091			118,164,926
3. Price Escalation 10% of (1+2)					40,583,729			57,516,054			70,898,956
4. Contingencies 10% of (1+2+3)					44,642,102			63,267,660			77,988,851
	Total				**491,063,117**			**695,944,258**			**857,877,366**

Table 21.21 Pre-FS Project Costs

(Thousand Rs.)

	Orugodawatte	Borella - Kanata	Kohuwala	Armour Street	Kelaniya Railway	Rajagiriya	Ratmalana	Total
A. Direct Cost								
(1) Road Construction	72,970	76,115	36,895	44,896	56,781	70,707	0	358,363
(2) Flyover Construction	629,704	3,087,216	136,490	293,302	422,520	520,118	35,608	5,124,957
Total Direct Cost	702,674	3,163,330	173,385	338,198	479,300	590,825	35,608	5,483,321
B-1. Overhead & Profit	140,535	632,666	34,677	67,640	95,860	118,165	7,122	1,096,664
B-2. Price Escalation	84,321	379,600	20,806	40,584	57,516	70,899	4,273	657,998
B-3. Contingency	92,753	417,560	22,887	44,642	63,268	77,989	4,700	723,798
Total Construction Cost	1,020,283	4,593,156	251,756	491,063	695,944	857,877	51,703	7,961,781
C-1. Detailed Design	23,807	107,174	5,874	11,458	16,239	20,017	1,206	185,775
C-2. Construction Supervision	47,613	214,347	11,749	22,916	32,477	40,034	2,413	371,550
D. Land Acquisition	141,000	401,000	415,000	832,000	336,000	415,000	0	2,540,000
E. Compensation	107,000	680,000	246,000	455,000	238,000	166,000	0	1,892,000
Total Project Cost	1,339,702	5,995,677	930,378	1,812,438	1,318,660	1,498,929	55,322	12,951,106
F. Annual Maintenance Cost	2,959	22,159	205	1,470	1,339	3,449	53	31,635

1Yen=0.9Rs. , VAT (15%) it is not included in the above-mentioned amount

Source: This Study

Chapter 22 ATC System Project and Corridor Improvement Project

22.1 Introduction

This chapter presents the results of two pre-feasibility (pre-FS) studies – an area traffic control (ATC) system and a corridor improvement project. The preliminary design of the ATC system was carried out for the Colombo Municipal Council (CMC) area and its immediate vicinity based on the system design policy defined below. System configuration was subsequently determined and the functional requirements were defined. A preliminary design of the closed circuit television system was also created. As part of the ATC project, geometric improvements of intersections are to be undertaken and two sample designs were made. Operation and maintenance recommendations are also made as they are two key factors to a sustainable ATC system. The preliminary design of corridor traffic improvements were undertaken on two corridors – A2 (Galle Road) and A0 (Sri Jayawardenepura). Based on the design, initial cost estimates were made.

22.2 ATC System Design Concept

(1) System Design Policy

The objectives of area traffic control (ATC) system are to realize smooth and safe traffic and prevent congestion where possible. To attain these goals, an ATC system maximizes intersection capacity and creates balanced and predictable traffic conditions. In designing an ATC system for Colombo, the following design policies were adopted.

Simple and Cost Effective System

Although the basic functions of an ATC system are same, there are many possible designs and configurations. Adaptive signal control, the most advanced type of signal control, requires more vehicle detectors than responsive signal control, which results in higher system construction costs. Such systems also incur higher operating costs and require highly skilled engineers, which could be a burden for the operating agency. Considering the marginal gains of such an advanced system and its higher costs, a simplified and lower cost ATC system is more suitable to Colombo.

Consideration of Local Conditions

In Colombo, pavement conditions are generally poor and the curb or road edge is not clearly demarcated. The mix of vehicles is unique due to the large number of three-wheelers and the ATC system design must take this into consideration. For example, a loop type vehicle detector is not suitable to Colombo as the loop is easily damaged and the sensing area cannot be easily changed.

User Friendly and Fault Tolerant System

Not all of the operators assigned to the ATC system’s operation will be traffic engineers or signal control experts. Ease of use is essential for effective operation of the system. A Windows-based graphical user interface must be adopted to improve human-machine interface. Various levels of software and database access control must be provided together with a backup system to prevent accidentally altering important data and signal operations.

Use of Local Products

Most of the ATC system equipment is not locally available and must be imported, except for signal lanterns as there are local manufacturers whose products are already in use. To promote local industry, local products will be used as long as their quality and reliability are acceptable.

Replacement of Existing Signal Equipment

There are 86 signals operating in the proposed coverage ATC area. Some of them are old and have been operating for more than 15 years, while others are relatively new. As the ATC system requires local controllers equipped with several modes of operation and the capability to communicate with the central controller, all existing local controllers will be replaced with new controllers.

Existing signal poles vary in design, dimension, and condition. Most of them, in particular the mast-arm poles, have inadequate design. Signal lanterns are inadequate as well. Most of the signals are dim and unclear, except for those recently installed. In principle, all poles and signal lanterns will be replaced with new ones, although some can be retained, which will be determined during detailed design.

(2) System Configuration

Basic configuration of the ATC system is shown in Figure 22.1. It is worth noting that the presented hardware configuration is reference only and different configurations are possible. The proposed ATC system consists of the equipment listed below, which includes closed circuit television (CCTV) system equipment.

Control Center

- System server;
- Signal control server (duplex configuration);
- Operator consoles;
- Projector and controller;
- Projection screen;
- Communication control unit;
- Modem;
- Main distribution frame (MDF);
- Video and camera control panel;
- Video switch, camera controller and time lapse video recorder; and
- Modem and decoder for CCTV system.

Field Equipment

- Local controller;
- Vehicle detector;
- Modem (housed in local controller cabinet);
- Video camera;
- Pan-tilt head;
- Video camera controller; and
- AD converter, encoder and Modem for CCTV system.

Control Center Facilities

- Uninterruptible power supply system (engine, generator, constant voltage and constant frequency device (CVCF), and battery);
- Air-conditioning equipment; and
- Fire detection and extinguishing system.

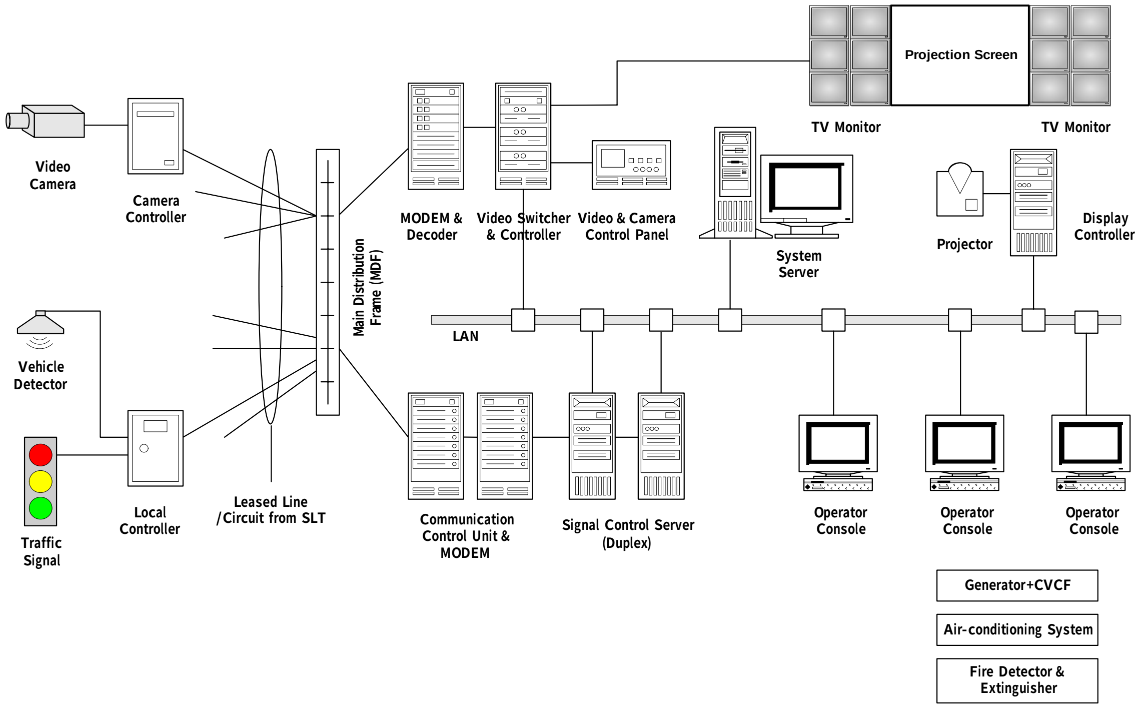


Figure 22.1 ATC System Configuration

22.3 Geometric Improvements of Intersection

(1) Review of Existing Intersection Layouts

In order for a signal to fully exhibit its functionality and secure the safety of both vehicles and pedestrians, intersection geometry must be adequately designed. Therefore, intersection geometry must be reviewed for all the ATC system intersections regardless of whether there is an existing signal or not. The review work should begin by preparing the intersection base drawing via a topographic survey. The review will be made based on traffic efficiency and safety. The following factors will be considered:

- Angle and direction of approaches;
- Number and width of lanes;
- Location, width, and length of median;
- Location, shape, and size of corner island;
- Location of pedestrian crossings;
- Pavement marking layouts (if any); and
- Signal locations (if signalized).

(2) Examples of Geometric Improvements of Intersections

A geometric review of two intersections was made at two intersections – Dehiwala intersection in Dehiwala District and Lotus Road/York Street intersection in Fort, Colombo. A brief description of the results is presented below.

Dehiwala Intersection

Dehiwala intersection is located at Galle Road and Hill Street/Station Road It is a signalized intersection and operates with time-of-day control. Previously, it was a roundabout, but was converted into an intersection and signalized.

Congestion is observed during peak hours and a flyover was proposed for the location. An intersection capacity analysis that used surveyed turning movement counts and standard lane assignment and capacity showed that the volume/capacity ratio (V/C) of the intersection is below the level a traffic signal can manage. Review of the intersection's geometry revealed the following design defects:

- Two roads do not intersect each other at right angles;
- Approach centerlines do not meet at a single point at the center of the intersection;
- Location of median is inadequate along all approaches;
- Location, shape, and size of corner islands are inadequate;
- Pedestrian crossings are provided at inadequate locations; and
- No pavement markings are provided, so vehicle paths are not clear.

A new geometric intersection design was developed to correct these defects. Existing intersection geometry and proposed geometry are shown in Figure 22.2 and Figure 22.3, respectively. More detailed designs can be seen in Appendix 36.

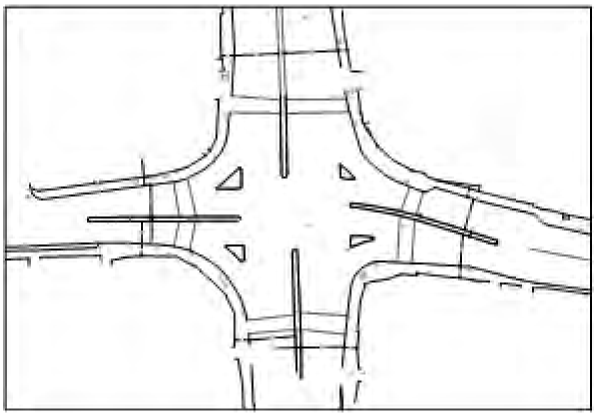


Figure 22.2 Existing Intersection Layout

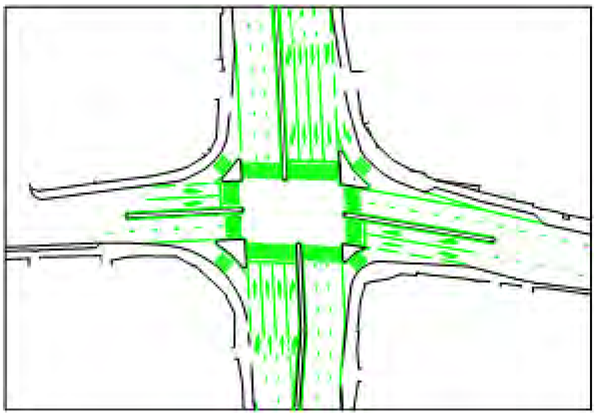


Figure 22.3 Proposed Layout

Lotus Road – York Street Intersection

The intersection is an unsignalized intersection located in Fort. The direction of travel on the northern approach of Lotus Road is one-way towards the intersection, while York Street is one-way from the intersection. The other two approaches are bi-directional streets and all are four-lane roads. Traffic volume is already at a level that warrants a traffic signal, but because there is no signal, congestion occurs frequently. Vehicles interlock in the intersection because the intersection is wide and no travel paths are defined.

A capacity analysis of the intersection indicated that traffic demand can be managed by a traffic signal and no grade separation is necessary. The present intersection layout and proposed improvements are shown in Figure 22.4 and Figure 22.5, respectively. Corner islands will be constructed at four corners and the intersection of two two-lane one-way roads will be reconstructed. More detailed designs can be seen in Appendix 36.

Figure 22.4 Existing Intersection Layout

Figure 22.5 Proposed Layout

22.4 Signal Control System

(1) Coverage Area and System Capacity

As described previously, the analysis of the road network and traffic movements will not be confined to the Colombo Municipality Council (CMC) area. There are several bottlenecks just outside of CMC in addition to those within it. These bottlenecks are caused by traffic commuting from the suburbs to Colombo. Thus, these bottlenecks must be treated within the same coverage area of the proposed ATC system and therefore, the coverage area of the ATC system must extend beyond the CMC boundary.

As of August 2006, there were 86 signals in Colombo and its immediate vicinity and all will be connected to ATC system. In addition, the Study Team identified an additional 18 locations where a signal is warranted for a total of 114 locations. Based on these figure, the proposed system capacity should initially be able to handle 128 signals expandable to 256 signals without major configuration changes.[1] The proposed signal locations are shown in Figure 22.6 and location list is provided in Appendix.

[1] 128 is the closest binary power (i.e. 2^7)

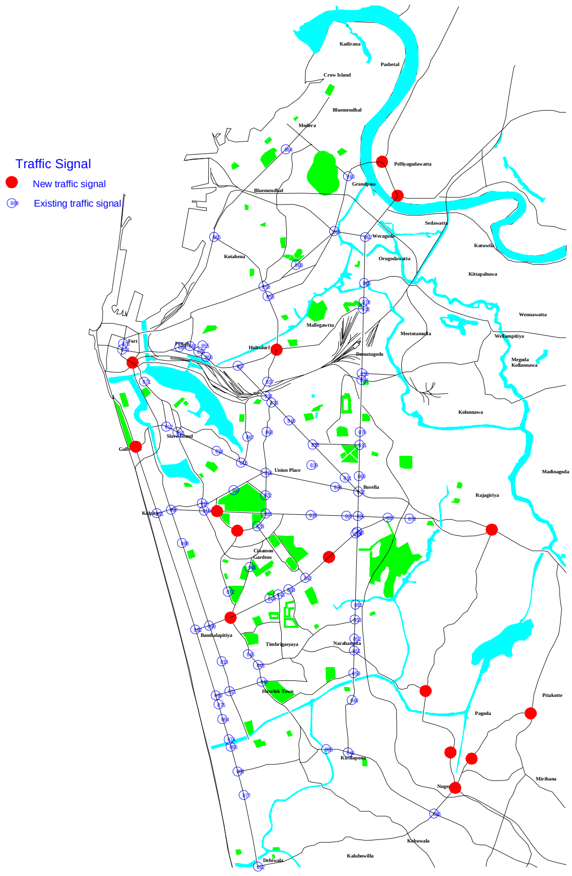


Figure 22.6 Proposed ATC Signal Locations

(2) System Functions

Functionally, an ATC system consists of the below components:

- Signal monitoring and control;
- Local controllers;
- Vehicle detectors;
- Data gathering and processing detectors;
- Data transmission;
- Human-machine interface;
- Supporting system facilities;
- Operation and maintenance; and
- Traffic surveillance through a closed caption television (CCTV) system.

A description of some of these functions is shown in Figure 22.7. The CCTV system, traffic control center, and operation and maintenance are presented in separate sections.

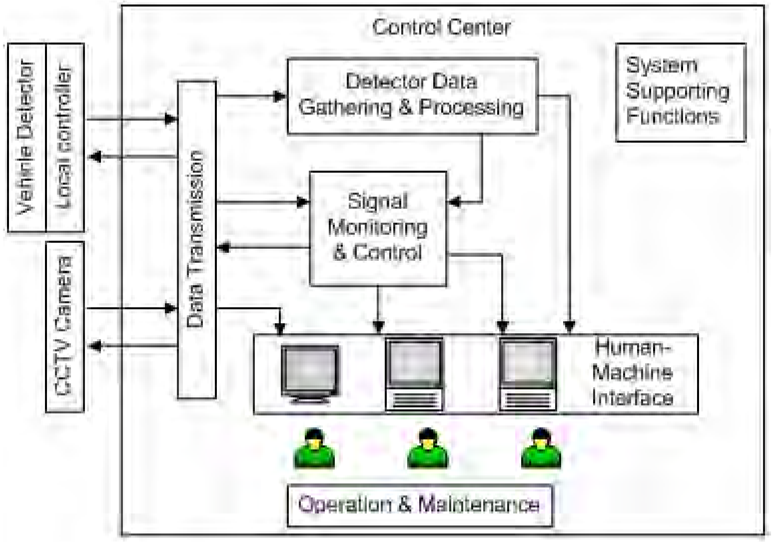


Figure 22.7 Functional Components of ATC System

(3) Signal Monitoring and Control

The proposed ATC system will have the following signal control modes:

- On-line traffic responsive control;
- On-line time-of-day control;
- Isolated last timing pattern control;
- Isolated time-of-day, day-of-the-week control;
- Isolated manual control; and
- Flashing.

Traffic responsive control is recommended because of its simplicity. Understanding the control logic and preparing and adjusting control parameters is much easier than undertaking traffic adaptive control. The number of vehicle detectors required is also less than adaptive control resulting in less construction and operation and maintenance costs.

Other control modes are for contingency purposes. On-line time-of-day control is used when detector data is not available. The mode is also effective to cope with recursive traffic demand changes such as a sudden rise in traffic volumes during the morning peak.

Isolated last timing pattern control memorizes the signal timing sent from the central computer and applies it even if communication is interrupted for a specific period. It is intended to prevent a local controller from changing the timing parameters frequently between on-line and off-line control that can be caused by interruptions in the communication system. If the communication line is interrupted for some time, the local controller will revert to the isolated time-of-day control mode and maintain the coordination.

The local controller must be monitored continuously by sending the controller's status to the central computer every second. If any abnormality is detected, including a disconnection of the communication system, an alarm should be issued and the event logged. One of the system operation monitoring screens will be a map showing the status of each local controller.

(4) Local Controller

Any local controller installed under the ATC system project must have the following control modes:

- Central computer control;
- Local coordinated control;
- Local isolated control;
- Manual control;
- Flashing; and
- Lamp off.

Normally, the local controller operates in the central computer control mode. If the central computer system fails or the data communication link between the control center and the local controller is interrupted, the local controller operates in local coordinated mode. Likewise, when a higher level control mode is not possible, the next control mode listed is used. The transition from one control mode to another control mode must be smooth so as not to confuse drivers and reduce intersection safety. The local controller will also have the following minimum capabilities:

- Execute up to 4 different phasing sequences under central computer control and local coordinated control;
- Execute local coordinated control using one of the locally stored timing plans on a time-of-day basis and maintain offset synchronization. The number of timing plans must be 16 or greater. It will be possible to store ten time-of-day schedules for different days and each daily schedule shall have 24 timings;
- The local controller will have a calendar and seven time-of-day schedules will be assigned for each day of the week. The remaining three time-of-day schedules will be used for holidays or special events;
- It will be possible to change the locally stored time-of-day timing plans from the controller keyboard or attached computer;
- It will also be possible to change the locally isolated timing plan, timing constants, and various control flags from the controller keyboard or attached computer;
- The local controller will have self-diagnostic and monitoring capabilities which will detect error conditions such as green conflicts and timing errors (i.e. display length shorter than minimum or longer than maximum) and transmit the error type to the central computer instantaneously;
- The central computer will find the local controller immediately when the Auto/Manual switch is set to Auto and will start central computer control from a new cycle;
- Allow flashing and lamp off of all signal lanterns from control panel switches;
- Contain an accurate and battery backed internal clock and calendar. It will be possible to set the date and time from the controller keyboard or attached computer; and
- Receive recall and extension detector signals from a maximum of eight detectors for recall and extension control.

(5) Vehicle Detector

Use of Vehicle Detector Data

The vehicle detector in the ATC system is used for timing parameter selection and the recall/extension function. In computer control, the signal timing plan that is most effective for the prevailing traffic conditions is selected based on the traffic condition data gathered by vehicle detector. Extension control adjusts the green time duration cycle by cycle in real time, while the recall function determines whether a phase should to be displayed or skipped in a signal cycle. These functions can be provided either by the central computer system or local controller.

Detector Locations

Detectors are placed at different locations depending on their usage. A vehicle detector used to select the timing plan is placed mid-block where a queue does not normally exist so that it can measure traffic volumes and occupancy data. On the other hand, a recall detector is placed near the stop line and an extension detector is placed 20-30 meters from the stop line. A typical detector layout is shown in Figure 22.8.

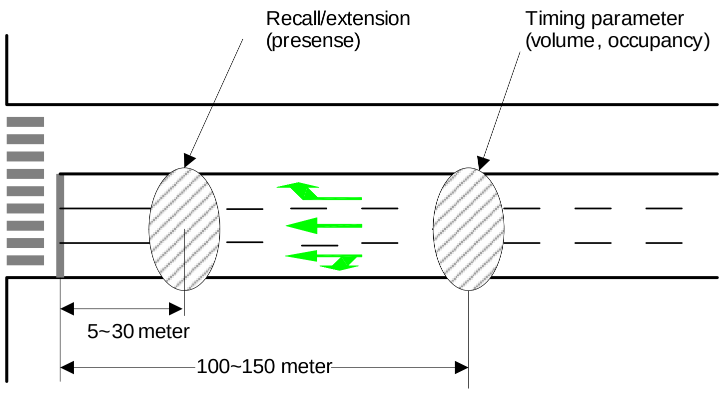


Figure 22.8 Detector Location on Approach

Sub-area and Detectors

In responsive signal control, timing parameter settings are selected for each sub-area, which is assumed to have similar traffic conditions. Traffic conditions of the sub-area can be measured by detectors placed at representative locations in the sub-area. The detector should be placed about 100-150 meters from the stop line. The detector is installed in an up and down direction of the major road in the sub-area and also in two directions along the minor road. For signal control purposes, detectors will be placed on a representative traffic lane. But if traffic count data is required, detectors should be placed on all lanes. The concept of a detector layout for a sub-area is shown in Figure 22.9.

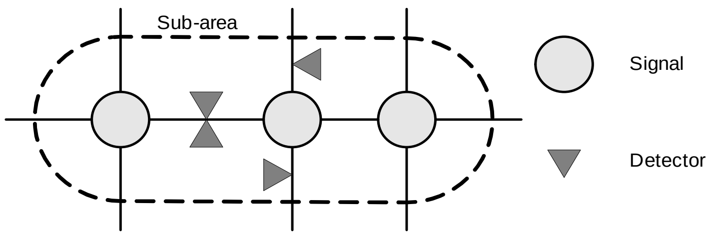


Figure 22.9 Detector Location in Sub-Area

Detector Types

Vehicle detectors send two-state signals that indicate if a vehicle exists within its sensing zone. In this sense, any type of vehicle detector is acceptable for the ATC system as long as its output is correct and accurate. From a practical point of view however, some types of vehicle detectors are preferable. Given the poor pavement conditions and drivers' lack of lane discipline, inductive loop detectors are not suitable for Colombo's ATC system because the loop will be easily damaged and adjusting the sensing area is not possible.

Number of Detectors

An initial design of detector locations has been carried out to determine an estimation of recall/extension and sub-area detectors. The total was estimated to be 240 and locations will be reviewed during detailed design. Final locations will be determined during the system's construction based on signal control logic requirements and site conditions.

(6) Detector Data Gathering and Processing

Detection signals or signals indicating the presence of vehicles must be sent to the control center from all vehicle detectors. If local recall/extension is adopted, however, data may not be sent. The signal transmission interval must be 50 milliseconds or shorter to calculate the occupancy ratio. Received detection signals must first be verified for any errors and then detection pulses must be reconstructed to count the volume. Traffic volumes and occupancy ratios must be calculated for all detectors for every five minutes. Other forms of processing depend on the system to be provided. If a detection signal from a particular detector is judged to be false, it must not be used for signal control or other applications. Repeated failures of data verification should raise an alarm that maintenance or monitoring is necessary.

(7) Data Transmission

Data transmission between the central computer and each local controller requires a separate dedicated circuit for each controller. Detection signal outputs from vehicle detectors will be merged with upstream data from the local controller. It must be possible to send detector signals from eight or more vehicle detectors over a circuit. Data transmissions will be made through telephone grade circuits to be leased from Sri Lanka Telecom (SLT); they have indicated that there will be no problem with cable availability within the coverage area of the system. Data transmission for signal control will have a transmission rate of 9,600 bauds or less. The details of the transmission system will be left to the system supplier, but they must comply with the applicable International Telecommunication Union (ITU) standards.

22.5 Closed Circuit Television System

(1) System Functions

A CCTV system provides the ATC system operator and road administrator with live images of traffic, which is a vital tool to understand actual traffic conditions. Although traffic data such as the traffic volumes and occupancy ratios available at the control center are good indicators of traffic conditions, actual images convey significant information that is indispensable for proper traffic management. Thus, CCTV has become a standard feature of ATC systems.

Basically, one camera operates in each key location. It is mounted on a pan-tilt head attached to high pole so that it has a wide range of coverage. The camera is controlled by the video and camera control panel at the control center.

At the control center, monitoring televisions will be placed in the control room. Ideally, a one-to-one camera and television monitor connection system is preferable as all images can be seen at one time. However, because there will be at least 19 cameras, this configuration is not practical. Therefore, 12 monitors will be placed in the control room and video images shown on the monitor will be selected via the video and camera control panel.

A video recording function will be installed as well, with video images recorded with a time lapse video recorder. These record the image at a reduced frame rate to obtain a longer recording time. The location name and time stamp will be added to the image at the time of recording.

(2) Camera Locations

Discussions with Traffic Management Working Group (TMWG) members outlined the following 19 locations shown in Table 22.1. Figure 22.10 maps the camera locations, although the locations will be finalized during detailed design.

Table 22.1 Proposed CCTV Camera Locations

Code	Location	Code	Location
01	Fort	11	Willawatta
02	Slave Island	12	Grandpass
03	Kolpitiya	13	Negombo Road
04	Central-Main	14	Orugodawatta
05	Pettah	15	Dematagoda
06	Koskas	16	Borella
07	Maligawatta	17	Model Farm
08	Maradana	18	Narahenpita
09	Lipton Circus	19	Kirillapone
10	Bamabalapitiya		

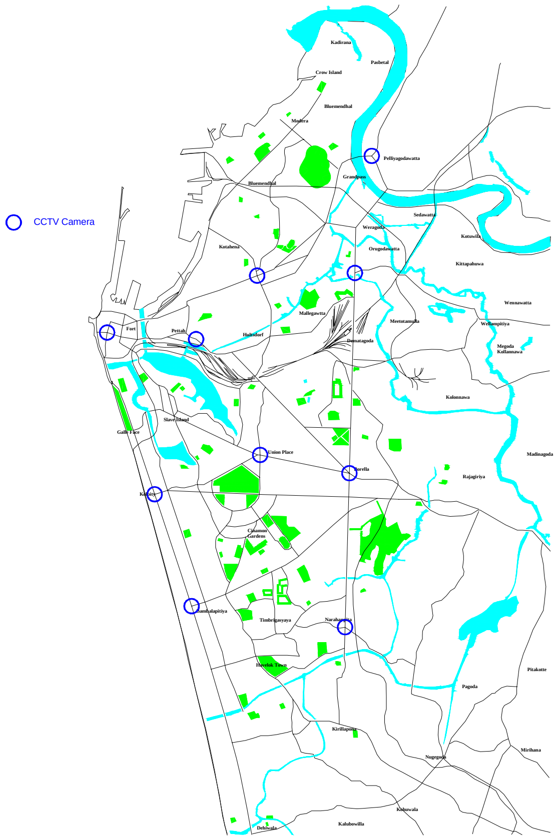


Figure 22.10 Proposed CCTV Camera Locations

(3) Video Signal Transmission System

Video signals require wide frequency bands. Conventional analog video signals occupy 6 MHz, including voice channels. If optical cables are available between the camera locations and control center, video signals can also be sent over the same cable. However, this will not be possible in the proposed system. Cables or circuits must be leased from Sri Lanka Telecom.

Recent developments in digital signal technology have made it possible to convert analog video signals into digital signal streams and compress them without sacrificing picture quality. The moving picture experts group (MPEG) is commonly provides this technology. If MPEG-1 is used, VHS class quality video can be sent over a 1.5 M-bits digital circuit. The method and details of video transmission for the proposed ATC system will be determined after consultation with Sri Lanka Telecom during detailed design.

Telephone grade circuits are required for each camera controller for remote camera control.

(4) Remote Monitoring

Video images can be delivered to other locations if required. This will be made by branching the video circuits at the telecom station. Additional video signal transmission lines are required between the telecom station and the remote monitoring station, which results in additional operating costs.

Even if video images are supplied to other locations, the camera control function will be retained at the control center since the prime objective of the system is to monitor traffic conditions at the control center.

22.6 Traffic Control Center

(1) Role of the Control Center

The basic roles of the control center are to:

- Accommodate computer systems and associated equipment in an environment suitable for these devices (computer room);
- Provide human-machine interfacing to allow traffic and system condition monitoring and system operation (control room); and
- Accommodate supporting facilities (emergency power, air-conditioning systems, etc.) that provide suitable working environments for both operators and equipment.

(2) Composition of the Control Center

The Traffic Control Center will be composed of the following rooms:

- Computer room;
- Control room;
- Emergency power room;
- Operator's room; and
- Maintenance and storage room.

Requirements for each room are described below and a sample layout for each room is shown in Figures 22.11- 22.13.

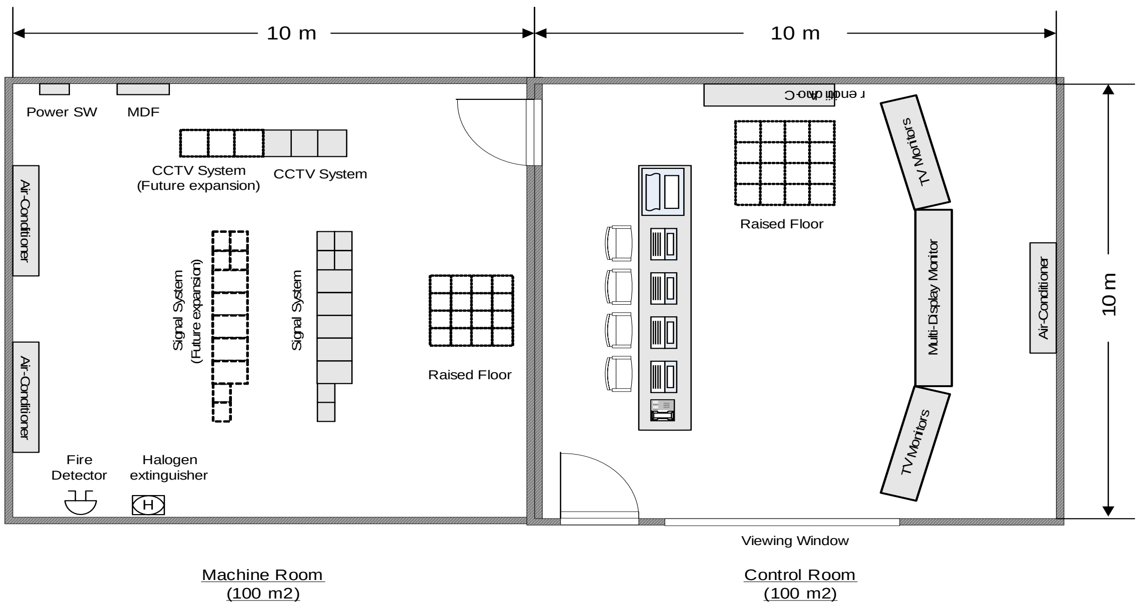


Figure 22.11 Control Center Layout (1) (Reference)

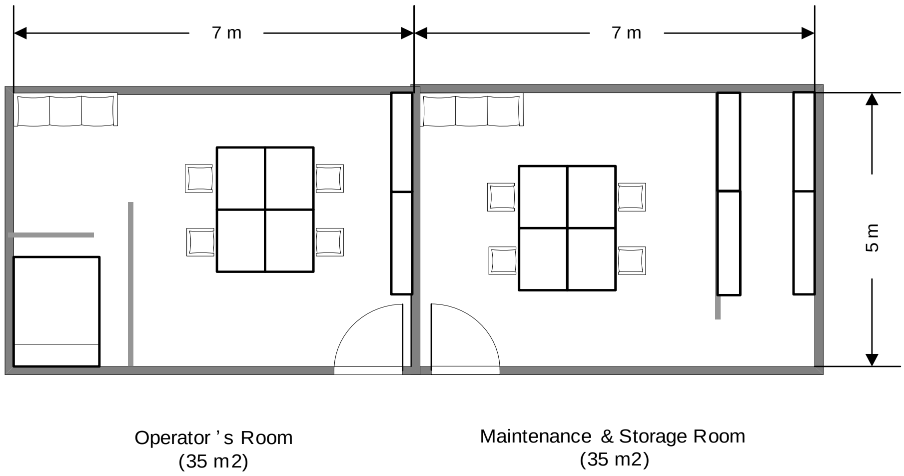


Figure 22.12 Control Center Layout (2) (Reference)

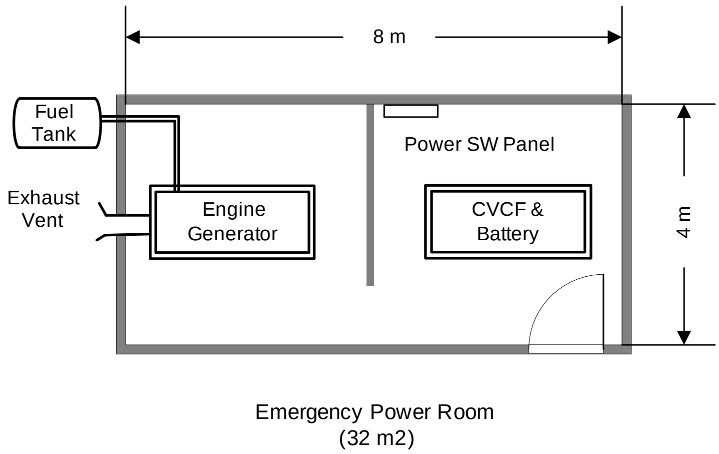


Figure 22.13 Control Center Layout (3) (Reference)

Computer room

The computer room accommodates the following equipment and facilities:

- Central computer system consisting of a number of servers and peripherals;
- Communications equipment consisting of the communication control unit and modems;
- Air-conditioning system;
- Main Distributing Flame (MDF) to terminate SLT leased lines;
- Power distribution panel to receive and distribute power; and
- Other associated facilities including grounding wires, emergency lighting, etc.

The area of the computer room must be more than 100 m^2 as indicated in the reference drawing due to the equipment and facilities that will be installed. This also takes into account possible future system expansion. The computer room must have a raised floor so that all necessary cables can be installed under the flooring. This feature will also all temperature and humidity controls to be supplied directly to the equipment.

Control Room

The control room accommodates the following equipment and facilities:

- Control console equipped with a number of workstations, printers, and telephones and operators' desks/chairs;
- Multi-display wall map; and
- CCTV system monitors and video and camera control panel.

The area of the computer room must be more than 100 m^2 as indicated in the reference drawing due to the equipment and facilities that will be installed. This also takes into account possible future system expansion. The size of the multi-display wall map is flexible based on the block construction of unit display panel. The size of unit display panel can be either 50 inches (1.00 m wide by 0.750 m high) or 70 inch (1.40 m wide by 1.05 m high). The maximum size of the multi-display wall map should be designed after considering the height of the control room.

A total of 12 CCTV monitors will be installed on both sides of the multi-display wall map. As the number of monitors is less than the number of cameras, camera selection capabilities will be provided at the video and camera control panel. The multi-display system and control console must be separated by at least five meters to ensure easy monitoring of the display. The control room should be designed to hold this space accordingly and the lighting system must be adjustable. A viewing window is recommended to show the ATC system to visitors.

Emergency Power Room

The emergency power room accommodates the following equipment and facilities:

- CVCF to supply regulated power to the computer system;
- An engine generator to supply emergency power for the whole ATC system including air conditioning equipment when commercial power fails;
- A set of batteries to supply power to CVCF until the generator supplies power;
- Automatic transfer switches between the commercial power line and the engine generator, and associated facilities including grounding wires and a power distributing switch panel; and
- Fuel tank outside of the emergency power room.

The engine generator and batteries must be installed on the ground floor due to their weight, vibration, and noise. Antacid treatment must be provided around the battery rack. The area of the emergency power room must be at least 32 m^2 as indicated in the reference drawing, considering the equipment and facilities to be installed.

Operator's Room

The ATC system will be continuously operated 24 hours a day, 7 days a week. The operators will work a two shift schedule, each lasting eight hours on average. A room for the operators should be provided for general office work and rest and this should be separate from the control room. This room should have suitable office furniture and the suggested area is 35 m^2 as indicated in the reference drawing.

Maintenance and Storage Room

A maintenance and storage room must be provided in the control center for minor maintenance work, office work, and spare parts storage. The suggested area of the maintenance and storage room is 35 m^2 as indicated in the reference drawing.

22.7 Types of Impacts & ATC System Costs

(1) Types of Impacts

The ATC system results in several types of improvements that have positive impacts and they are as summarized in Figure 22.14, with a brief description on each impact given after that.

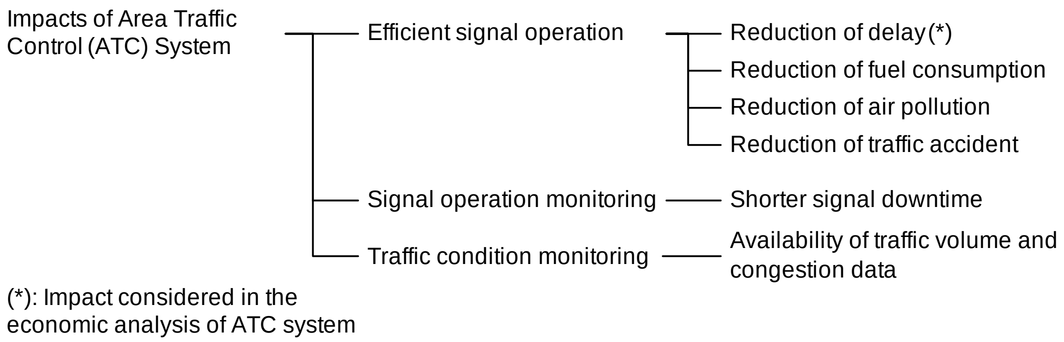


Figure 22.14 Impacts of ATC System

Efficient Signal Operation

There are three cases of efficient signal operation found in an ATC system as shown in Figure 22.15. If an unsignalized intersection is signalized, intersection delays can be reduced. This is due to the fact that traffic volumes are already high and there are no gaps in the traffic stream to allow for conflicting movements. Therefore, a signal is needed to provide those movements with right-of-way.

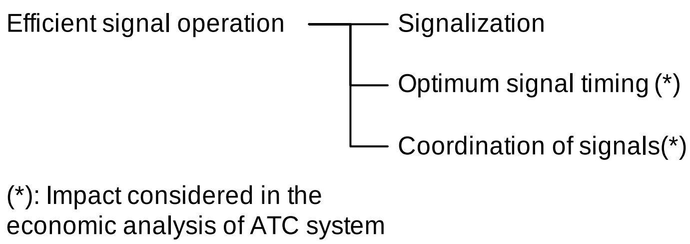


Figure 22.15 Efficient Signal Operation

In an ATC system, traffic conditions are monitored by vehicle detectors and different signal timings are applied to each signal in response to the prevailing traffic conditions. Thus, signal operation is more efficient than fixed time or time-of-day control. In a road network like Colombo's, where signal installation is dense and the distance between two signals is relatively short, signal coordination is important and greatly affects overall performance of the road network. The ATC system always coordinates signals by adjusting the offset between two signals to minimize delays based on traffic data. The concept of the impacts of signal coordination is shown in Figure 22.16.

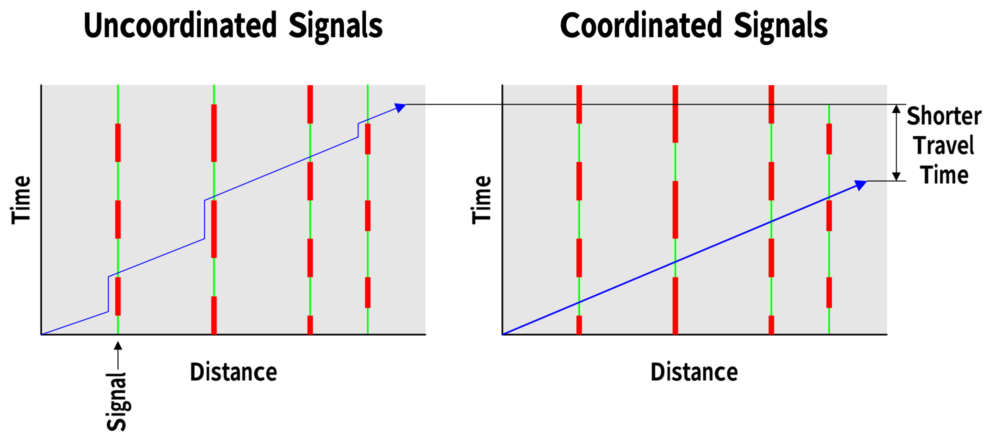


Figure 22.16 Effects of Signal Coordination

Impacts of Efficient Signal Operation

Reduction of Intersection Delays

As explained above, efficient signal operation reduces intersection delays. The expected amount reduced is discussed in the next section.

Reduction in Fuel Consumption

Reducing delays results in higher travel speeds and shorter travel times, ensuing in lesser fuel consumption.

Reduction of Air Pollution

Motor vehicles emit pollutants such as NO_x, SPM, SO_x, CO, and O_x and the level of pollutants is proportional to the amount of fuel consumed. Therefore, if fuel consumption is reduced the amount of pollutants is also reduced. The ATC system contributes to a reduction in fuel consumption by (i) increasing travel speeds and (ii) reducing the number of stops. Increasing travel speeds mean shorter travel times and less fuel consumption, and higher travel speeds results in fewer pollutants being emitted (except for NO_x). A reduction in the number of stops due to optimized signal timings and coordinated signals also results in less fuel consumption as vehicles consume more fuel due to acceleration.

Reduction in Traffic Accidents

A reduction in traffic accidents is expected because:

- Vehicular and pedestrian movements at intersections are clearly controlled by signals and conflicting movements are eliminated where possible;
- The number of stops at intersections is reduced; and
- Traffic engineering improvements implemented during signal installation including lane markings, traffic signs, and corner islands reduce potential hazards and enhance safety.

Signal Operation Monitoring

Shorter Signal Downtime

If a signal becomes inoperable, traffic flow will be disturbed and road users will incur time and monetary losses. The problem can be caused by either damage incurred by the local controller in a traffic accident or by the local controller's malfunction. The ATC system continuously monitors signal operations and any abnormalities are immediately detected. Thus, corrective action can be taken without delay, reducing losses caused by inoperative signals.

Traffic Condition Monitoring

Availability of Traffic Volumes and Congestion Data

Vehicle detectors placed at strategic locations in the road network continuously measure traffic volumes and calculate occupancy rates, which is used for signal operation. In parallel, data is recorded and kept for future use. The recorded data is a valuable resource to improve the system, plan the road network, traffic, and transport.

(2) ATC System Costs

ATC system construction costs, technical assistance costs, and annual operation and maintenance costs are estimated and summarized in Table 22.2 and Table 22.3.

Table 22.2 Estimation of System Construction and Engineering Service Costs

Description	Amount (US$ 000)
ATC System and Geometric Improvement Project	
Geometric Improvements	3,742
ATC System	13,545
Subtotal	17,287
Engineering Services	
Detailed design	1,741
Construction Supervision	1,192
Subtotal Engineering Service	2,934
Total Project Cost	20,221

Table 22.3 Annual Operation and Maintenance Costs

Type of Cost	Rs. 000
Annual operation cost	44,220
Annual maintenance cost	13,535
Total Annual Cost	**57,755**

Source: This Study

22.8 Operation and Maintenance of ATC System

The performance and effectiveness of the ATC system depends on how it is operated, maintained, and administered. Traffic conditions vary daily with fluctuations in traffic demand and the effects of increased vehicle growth/ownership. Additionally, vehicles and pedestrians often behave irrationally and the variations in weather affect the demand and patterns of travel. Accidents also disturb traffic flows. Therefore, the system's operator plays an important role in handling these circumstances and ensuring the effective operation of the system.

Like any other system, ATC equipment can break down and in the case of a defective local controller an intersection may become unsafe. In addition, as signal facilities are placed on the street, damage caused by traffic accident is unavoidable. To prevent or minimize such incidents from happening, maintenance work must be managed and carried out efficiently and effectively.

ATC operation covers not only running the computers, communications equipment, and local controllers, but also carrying out traffic engineering and management activities. ATC system operation can be divided into on-line and off-line operations. On-line operation focuses on real-time activities and deals with changing traffic and system conditions such as monitoring traffic conditions and implementing countermeasures if there is an incident. It is undertaken by an operator stationed at the Control Center. Off-line operations cover all the back office work such as collecting traffic data, reviewing system performance, and modifying and upgrading the system. The overall structure of the ATC system operation is illustrated below in Figure 22.17.

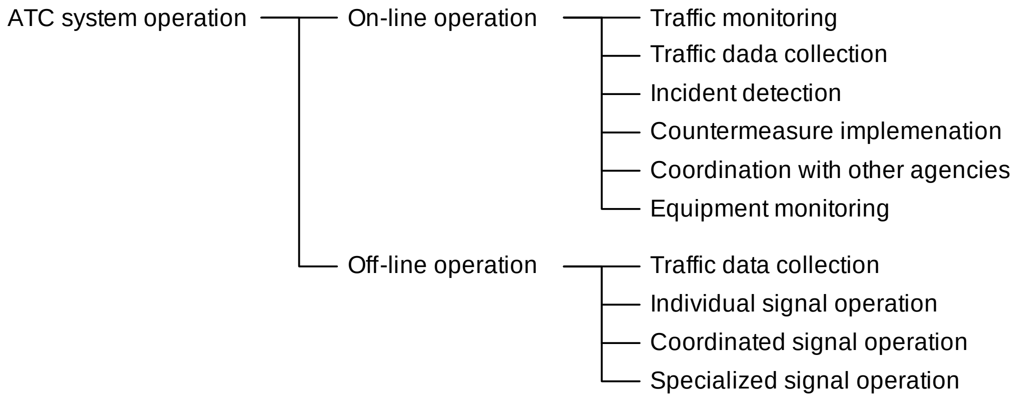


Figure 22.17 Structure of ATC System Operation

(1) On-line Operation

On-line operation refers to activities that respond to the changing road, traffic, and equipment conditions and consists of several activities as shown in Figure 22.18.

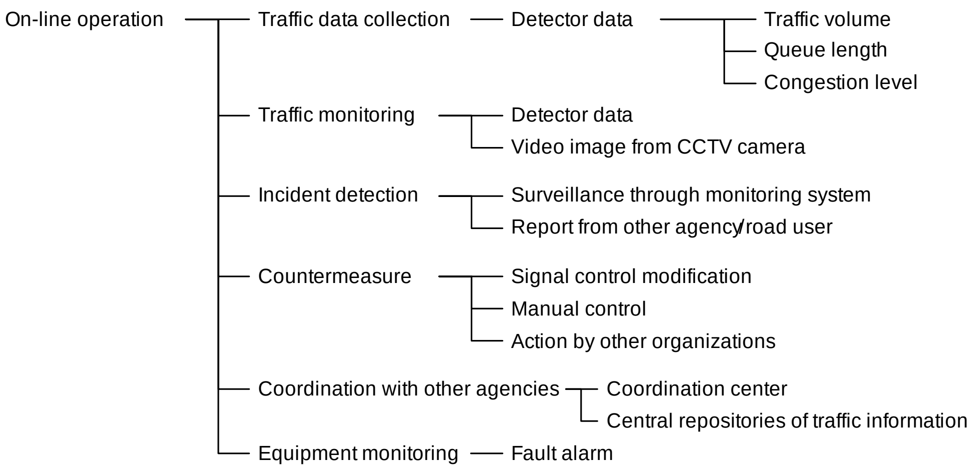


Figure 22.18 On-line ATC System Operation

(2) Off-line Operation

Off-line operations include back office work as noted above. The corresponding diagram is shown in Figure 22.19.

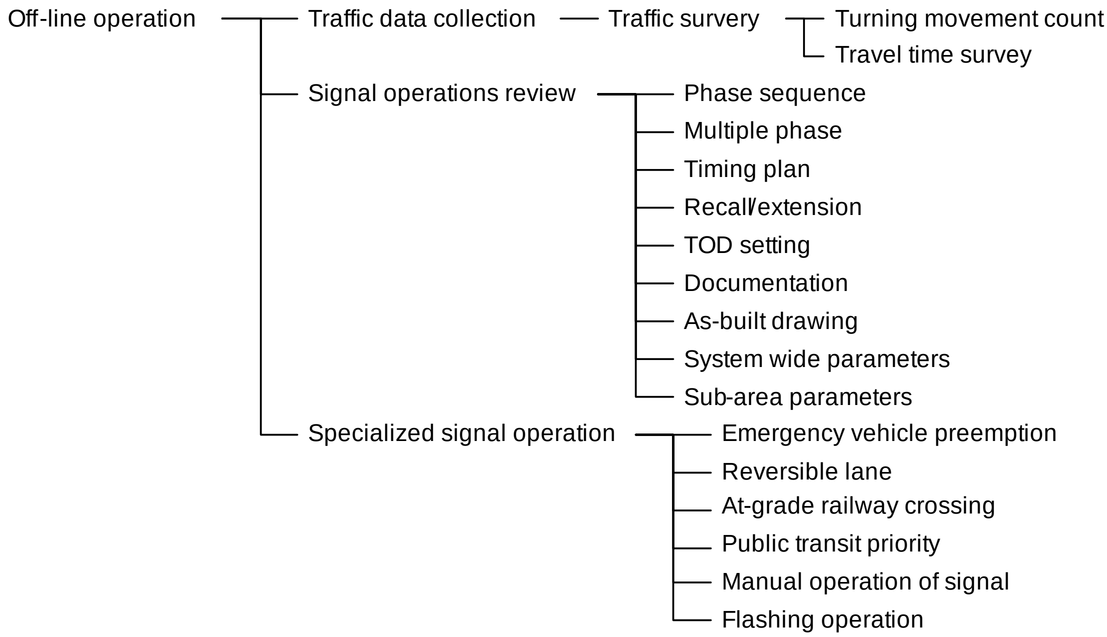


Figure 22.19 Off-line ATC System Operation

(3) Categories of Maintenance Work

System maintenance work is divided into four categories as shown in Figure 22.20.

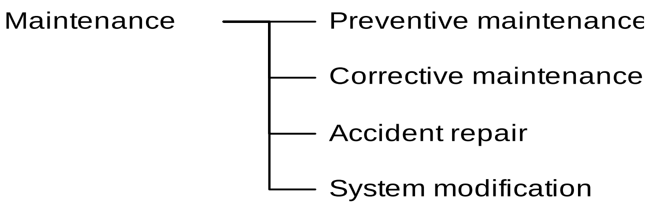


Figure 22.20 Categories of Maintenance

Preventive Maintenance

Preventive maintenance is work performed at regular intervals before defects develop. This includes inspecting, spot checking, cleaning, routinely replacing, adjusting, tuning, and calibrating the equipment to maintain full operating conditions. Preventive maintenance also includes repairing minor defects. If, during preventive maintenance, a defect requires further attention or spare part(s), it will be rectified by another category of maintenance.

Corrective Maintenance

Corrective maintenance refers to repairing malfunctions that result from equipment failure, normal wear and tear, and deterioration under normal operating conditions.

Accident Repairs

Accident repairs include repairing damage to the equipment due to unexpected events, traffic accidents, vandalism, or construction activities of third parties.

System Modifications

Modification work includes minor modifications to the system, control center equipment, field equipment, software, or database. Relocation, removal, or addition of intersection facilities and the subsequent modification of the parameters in the database or local controllers are examples of system modification.

22.9 Implementation Program of ATC System Project

(1) Detailed Design and Construction

Detailed design of the ATC system must be undertaken before construction can begin. Design of intersections to be improved geometrically, as well as, traffic signal design must be carried out for all intersections planned for the ATC system. In addition, vehicle detectors must be deployed at suitable locations.

For the Control Center, functional requirements and minimum hardware and software requirements must be defined. The results of the design work will be used to identify technical specifications and drawings. As the system is expected to be procured through tendering, the requisite tender documents must be prepared. Finally, the responsible organization must be studied and operation and maintenance procedures must be defined.

The detailed design work will be grouped into four task groups:

- Intersection surveys and signal design standards;
- Detailed design of ATC system;
- Preparing tender documents; and
- Implementation plan, operation, and maintenance.

Draft Terms of Reference for the detailed design of the ATC system is included in Appendix 29.

The proposed ATC system project is expected to be completed in 32 months as shown in Appendix 20 (TM-2). Detailed design will take ten months to complete and will be followed by tendering. System construction is expected to take 18 months.

(2) Executing Agency

The Executing Agency will be accountable to the Ministry of Finance for the loan needed to design and construct the ATC System. Responsibilities entail monitoring, supervising, and quality control. After significant discussions among a number of stakeholders, it was decided that the Western Provincial Council (WPC) will be the Executing Agency of the ATC System because: (i) international funding cannot be given to the Ministry of Defense, which includes the Police; (ii) it has the closest supervisory role of CMC, the other main stakeholders of the project; (iii) it has some capacity to absorb miscellaneous expenditures; and (iv) WPC has the ability to coordinate the numerous local authorities involved. Similar project setups have occurred previously in Sri Lanka and it is expected that this project will utilize lessons learned. WPC has also indicated that they will work closely with the Police, given their large role in this project.

(3) Implementation Organization

After consideration and discussions with stakeholders, it was decided that a Project Management Unit (PMU) should be established at the Executing Agency to manage the project, engage the contractors and suppliers, and test and commission the system. The PMU will also be responsible for coordinating operational and maintenance activities of the ATC System, including engaging RDA, CMC and Traffic Police, as well as coordinating the other local authorities covered by the system. The PMU staff will be seconded from the Traffic Police, RDA and CMC and potentially other relevant organizations where possible. The proposed organizational setup of PMU is shown in Figure 22.21 together with the name of organization which will fill the positionsindicated.

During this time, the Project Director will also be tasked with preparing the groundwork to handover the project to the final operating authority, preliminarily called the ATC System Division. This will involve hiring the relevant individuals as well as outlining processes and procedures for operation and maintenance. It is believed, based on Figure 22.21, the staff from the Project Director and below will transition into the ATC System Director and below positions, as shown in Figure 22.22.

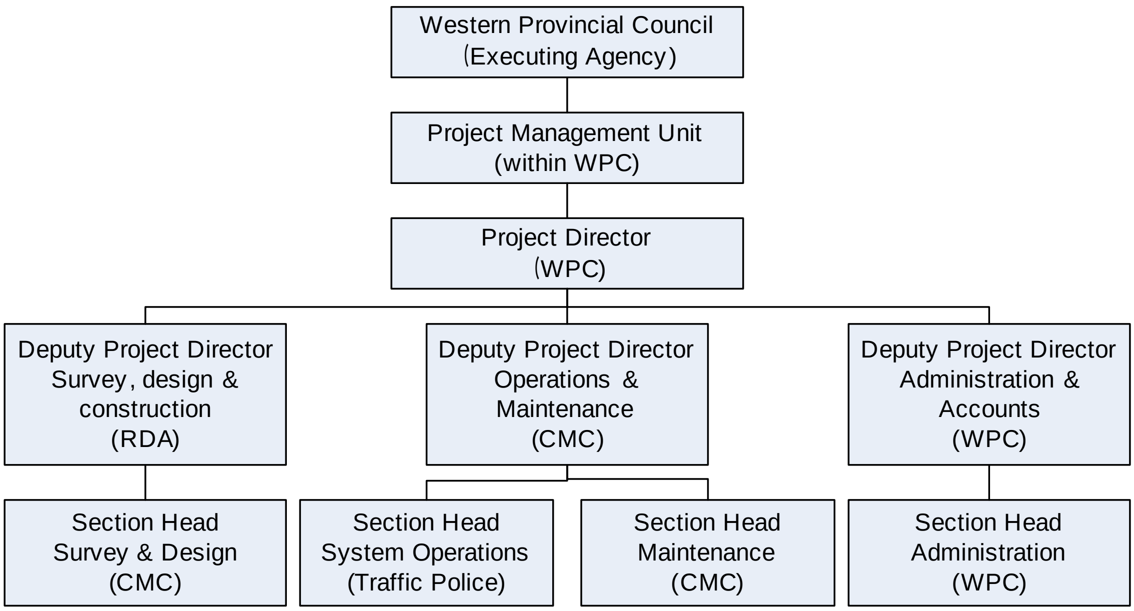


Figure 22.21 Project Management Unit Organizational Chart[2]

(4) Operations and Maintenance Organization

The ATC System Division will be responsible for operations and maintenance and be staffed by a combination of the RDA, CMC and Traffic Police. After discussions with the latter two organizations, it was decided that the CMC would be responsible for operations and maintenance and the Traffic Police for monitoring traffic conditions and enforcement. RDA will play a supplemental role as only a limited number of ATC signals will be located on roads

[2] Responsible agencies shown in this organization chart are all indicative. Further adjustment should be made at Detail Design stage.

managed by RDA. The division will be headed by an ATC System Director and consist of four sections under three Deputy Directors as shown in the figure below.

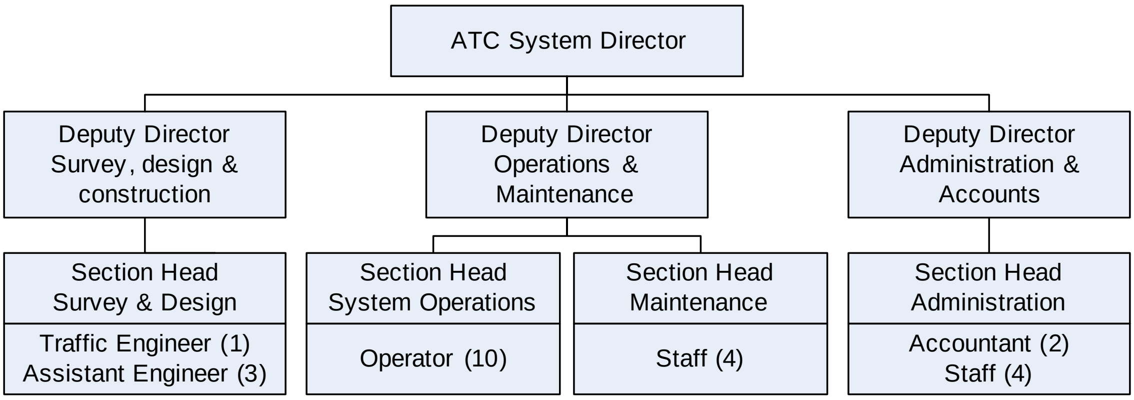


Figure 22.22 ATC System Division Organizational Chart

Actual organizational arrangement and staffing will have to be discussed and agreed upon among the relevant agencies, in particular by WPC, RDA, CMC, and Traffic Police.

Descriptions of the sections are as follows.

Survey and Design Section

- Planning and supervising traffic counts and topographic surveys;
- Compiling survey results into the traffic database in a suitable format;
- Preparing base intersection drawings;
- Analyzing data using analytical tools;
- Undertaking signal warrant analysis;
- Undertaking geometric improvement design of intersections;
- Undertaking signal operation design for new signals;
- Reviewing signal operations for existing signals; and
- Planning system expansion, modifications, and upgrading.

System Operation Section

- Monitoring traffic conditions;
- Monitoring equipment;
- Receiving fault reports;
- Notifying faults to maintenance contractors;
- Communicating with event organizers;
- Communicating with traffic enforcers; and
- Logging operation activities.

Maintenance Section

- Receiving fault and defect reports and notifying maintenance contractors;
- Preparing and issuing job orders to maintenance contractors;
- Managing spare parts inventories;

- Supervising and reviewing maintenance contractor operations; and
- Collecting and analyzing the reliability data of system components.

Administration Section

- Budgeting and accounting;
- Personnel management;
- Managing supplier and maintenance contractor contracts;
- Public relations;
- Coordinating with other agencies; and
- Staff training.

In addition to accounting and personal management, which are common to any organization, ATC system management includes the following activities:

- Resource management;
- Coordination with other organizations;
- Public relations; and
- Human resources development.

To effectively operate the ATC system, a workforce and sufficient budget are key elements of resource management. The ATC system must be staffed with a sufficient number of qualified personnel. It will be necessary to review the number and qualifications of technical and non-technical staff assigned to various tasks. If any inadequacies are found, the current staff must be supported by more staff or personnel with the necessary qualification.

Working Hours

Operators will work in two shifts with the first shift lasting from 6 am-2 pm and the second shift lasting from 2 pm-8 pm, Monday through Friday. When there is a special event, operating hours should be adjusted according to the event hours. Staff in other sections will work during regular business hours from 8 am-5 pm, Monday to Friday.

(5) Maintenance Contractor

The maintenance section of the Traffic Control Center will be responsible for maintenance management, while actual maintenance work will be undertaken by a contractor. A maintenance contract will be made between ATC System Division and the maintenance contractor. Responsibilities and tasks of the two parties are illustrated in Figure 22.23.

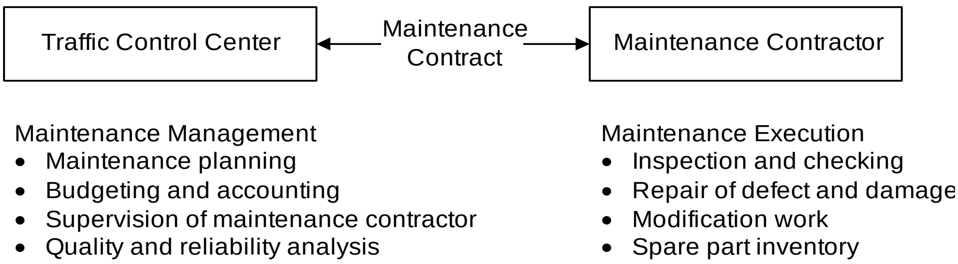


Figure 22.23 Maintenance Organization

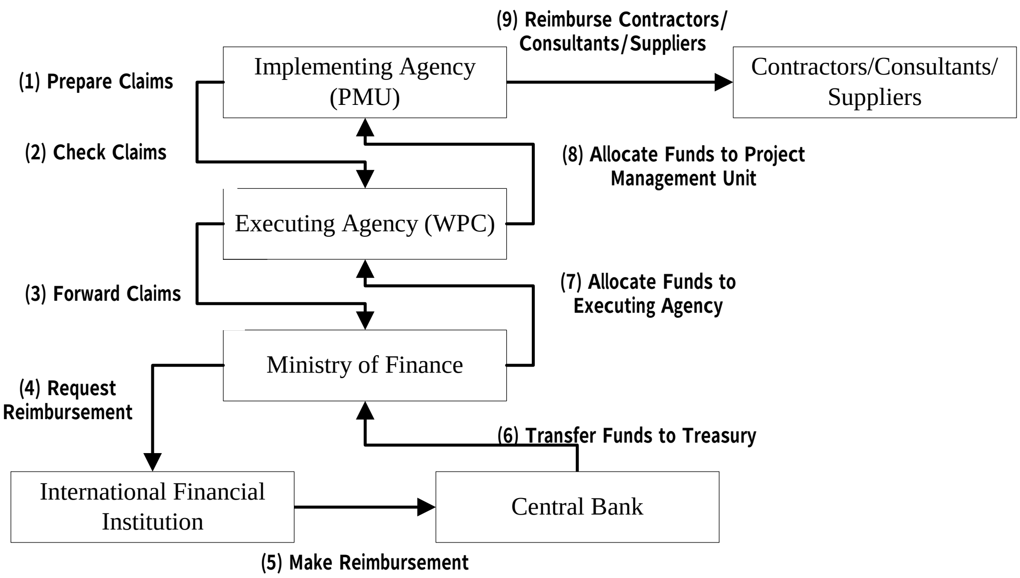
(6) Financial Arrangements

Design and Construction

System design, costing, document preparation, construction, testing and commissioning will be undertaken by the project's consultants and contractors under international funding arrangements. If the funds are provided to the WPC, the Finance Commission must concur in accordance with Article 154R of the national Constitution. The Government of Sri Lanka must provide counterpart funds equal to 15% of the international loan.

Project Management Unit

The PMU can be funded by the MoF via the WPC, although arrangements would need to be further outlined. A portion of the counterpart funds could be utilized for the PMU. The funds should be given directly to WPC for the PMU, not split between CMC and the Police to then be allocated. The financial administrative functions, in accordance with financial regulations 136-139, should be further discussed with the main stakeholders to ensure that there is no breakdown of budgeting and expenditure management. The flow of funds is as shown in Figure 22.24, beginning with (1) on the left side. Note that due to CMC and WPC involvement, provincial laws and regulations must be reviewed.



Note that the PMU is comprised of staff from the CMC and the Traffic Police

Figure 22.24 Fund Flow for ATC System Implementation

Operations and Maintenance

Operations and maintenance costs must be separately funded within Sri Lanka, either from national, provincial, or local funds. The Police have indicated that they are unable to financially support the system and through discussions, costs are likely to be allocated through the national budget. Like the PMU, funds should be provided directly to the ATC System Division (via the overhead authority) and should not be divided between CMC and the Police.

The operating and maintenance costs include personnel costs and general office expenses, as well as a sufficient budget to cover the following:

- Planning, design, and review activities of the ATC system such as traffic surveys and data analysis;
- Utilities (leased communication circuit and electricity); and
- Maintenance.

Also, in addition to the maintenance contract, a contingency fund must be secured to cover expenses brought about due to accidents and other unexpected maintenance work, which the control center is directly responsible for.

22.10 Corridor Improvement Project

(1) Introduction

Pre-FS level analysis was undertaken for the improvement of two corridors – A2 (Galle Road) and A0 (Sri Jayawardenepura Mawatha) – and preliminary designs were carried out applying results from site surveys executed by the Study. Note that project costs were estimated using a materials list.

(2) Pre-Feasibility Study Corridors

Four corridors, A1 (Kandy Road), A2 (Galle Road), A3 (Negombo Road), and A0 (Sri Jayawardenepura), were initially considered for improvements. Of these four, A2 (Galle Road) and A0 (Sri Jayawardenepura) were ultimately selected as pre-FS projects (Table 22.4, and Figure 22.25). These roads were selected because improvement work is already underway on A1 and A3, while A2 and A0 have no ongoing upgrading work and do require work such based on the site surveys of the Study. The selected corridors are summarized below and shown in Appendix 36.

Table 22.4 Pre-FS Corridors and Sections Improvement Projects

Road	Section	Length	Description
A2 Galle Road	Dehiwala to Ratmalana	3.6 km	Mostly four-lane undivided road with sidewalk. Center median exists near key intersections.
A0 Sri Jayawardenepura	Baseline Road -Battaramulla	5.2 km	Mostly four-lane undivided road with no sidewalk. Center median and sidewalk are provided near key intersections.

Figure 22.25 Corridor Improvement Locations

(3) Improvement Measures

As shown below, a number of measures were considered. They consist of work near intersections on the corridor and at both intersections and mid-block sections. Improvement measures include:

- Providing a right turn lane;
- Improving corner radius;
- Constructing, modifying, or removing the corner island;
- Improving the pavement;
- Constructing or improving the sidewalk;
- Constructing, removing, extending, or reducing the center median;
- Adding or modifying pavement markings;
- Adding or modifying traffic signage;
- Adding rumble strips;
- Adding edge reflectors;
- Adding a pedestrian crossing, with or without signals or flashers;
- Adding a pedestrian barrier; and
- Adding street lights.

(4) Preliminary Design

Preliminary designs for the improvement of the two corridors, which are based on site survey findings, are schematically presented in Appendix 36 for Galle Road and Sri Jayawardenepura, respectively, and include intersection geometric improvement works at Rajagiriya Intersection.

(5) Types of Impacts

Corridor improvements have quantitative and qualitative impacts as shown in Figure 22.26. Quantitative impacts are clear. If roads and road facilities are improved, vehicles can travel at a higher speed resulting in a shorter travel time. If delays are reduced, so is fuel consumption, thereby reducing air pollution. Corridor improvements also reduce potential accidents that occur because of inadequate lane layouts, potholes, hidden roadside obstacles, jaywalking, and inadequate lane markings. They are reduced by either correcting the problems or constructing warning signs or pedestrian barriers. If the pavement is smooth, lane and road edge are clearly marked, rumble strips or edge reflectors are added, and necessary warning and guidance signage is provided, there is less stress for drivers.

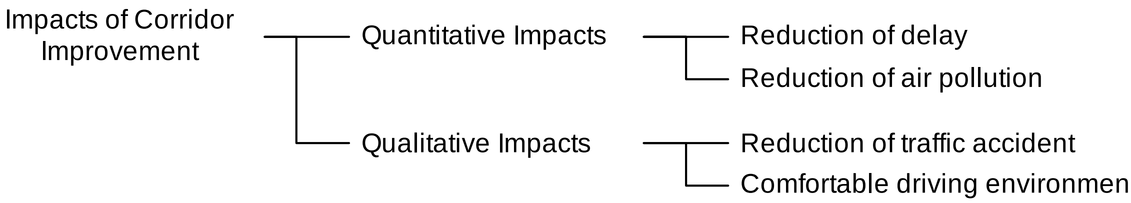


Figure 22.26 Corridor Improvement Impacts

Calculation of impact expressed in monetary term is presented in Section 19.7.

(6) Cost Estimates

Costs of implementing these improvements were estimated using RDA's prevailing costs for the corresponding items. Estimated costs are shown in Table 22.5 and Table 22.6 for A2 and A0, respectively.

Table 22.5 Estimated Cost of Corridor Improvement-A2

Description	Direct Construction Cost (Rs)
Sidewalk improvements	14,446,000
Roadside curb	923,450
Center island improvements	11,968,314
Pedestrian crossings	234,000
Reflective studs on the roadway	912,000
Pelican crossing	1,400,000
Roadside fencing	11,972,000
Street lighting	3,625,000
Asphalt overlay	19,860,120
Road markings	5,437,500
Installation of traffic signage	1,268,750
Engineering services	5,763,770
Contingency	6,224,872
Total Cost	**84,035,776**

Source: JICA Study Team

Table 22.6 Estimated Cost of Corridor Improvement-A0

Description	Direct Construction Cost (Rs)
Sidewalk improvements	32,700,000
Roadside curb	8,568,693
Pedestrian crossings	312,000
Reflective studs on the roadway	1,392,000
Pelican crossing	1,400,000
Roadside fencing	15,411,900
Street lighting	8,950,000
Signalizing Kotte Intersection	2,500,000
Asphalt overlay	32,714,400
Road markings	7,882,500
Installation of traffic signage	1,750,000
Engineering services	9,086,519
Contingency	9,813,440
Total Cost	**132,481,452**

Source: JICA Study Team

Economic evaluation of the project is presented in Chapter 23.

Chapter 23 Economic Analysis

23.1 Objective

The objective of this chapter is to calculate the economic viability of the pre-FS projects by calculating the economic internal rate of return (EIRR) and net present value (NPV). The scenarios to be economically evaluated are as shown in Table 18.7 of Chapter 18.

23.2 Project Cost-Benefit & Lifecycle

Project Cost-Benefit

The costs and benefits that are considered for the projects of this Study and which are evaluated from 2007 to the beginning of 2030 are as listed in Table 23.1. Except for the exclusion of reductions in traffic accidents, the items taken up are typical for a transport study. Accident reduction was not considered as it was difficult to establish a clear link with the proposed improvement projects.

Table 23.1 List of Project Costs and Benefits

Project Costs	Construction costs
	Resettlement and compensation costs
	Engineering services costs
	Operations and Maintenance costs
Project Benefits	Vehicle Operating Cost (VOC) savings
	Travel time savings

Project Lifecycle

As for the timing and lifecycle of project costs and benefits, the ATC system and corridor improvement projects are different than that of the other projects, which are assumed to be completed by the end of 2012 and to have a lifespan of 30 years. That is, the ATC system and corridor improvement projects will be open to traffic in 2010 and 2011, respectively, and are assumed to have a lifespan of 20 years. It is assumed that the construction of all pre-FS projects will be completed by the end of 2012 and that they will be open to traffic from 2013. Therefore, the time period for economic benefit evaluation is 17 years. Note that it is typical to consider a period between 15 and 20 years.[1] The exception to this is the ATC system, which is constructed in 2009 and 2010 and starts operation in 2011 with a ten-year span extending to 2020.

23.3 Cost and Benefit Valuation

In this Study, the domestic price numeraire is applied in order to carry out economic evaluation using domestic market prices as the common denominator, with costs and benefits updated to constant 2006 economic prices in Sri Lankan rupees (Rs.). It is therefore necessary to breakdown Study inputs and outputs into tradable and non-tradable items. In the case of tradable items, an exchange rate from the Central Bank of Sri Lanka (equivalent to the average for January to August 2006) of Rs.1 to 1.124 Japanese yen and US$1 to Rs.102.87 is applied, together with a shadow exchange rate factor (SERF) of 1.042 to take into account foreign exchange effects.[2] For components of a project that are to be purchased in Sri Lanka (i.e.

[1] *Overseas Road Note 5: A guide to project appraisal*, Transport and Road Research Laboratory, UK, 1988.
[2] Based on *Economics and Research Dept. Technical Note 11*, ADB, February 2004.

domestic resources) no conversion factor is necessary, since it is assumed that the market is competitive for these resources and also because they do not have an impact on exports/imports. Note that all taxes and duties are excluded from economic costs. As for project benefits, since they consist of location-specific intangibles such as time saving, they are considered non-tradable goods and are also evaluated without applying a conversion factor. Benefits in this report have been evaluated in domestic prices based on surveys carried out in the project area.

(1) Cost Valuation

The assumptions and shadow prices used for converting the financial costs of a project to economic costs for evaluation are as described in Table 23.2. Note that financial costs for all costs items are based on values taken from the relevant chapters of this report that deal with the different projects and their components (i.e., Chapter 20, 21, 22, and Appendix 27).

Table 23.2 Study Economic Cost Evaluation Assumptions

Type of Cost	Assumption	Shadow Price
Construction Cost (excludes labor)	20% Tradable Equipment and Material	Yes. Tradable items multiplied by 1.042
	80% Non-Tradable Equipment and Material	No
Labor Cost for Construction	50% Skilled labor	No (competitive market no shadow price required)
	50% Semi-skilled/unskilled labor	Yes (SWFR = 0.7)[3]
Land Acquisition and Compensation	Equivalent to opportunity cost.	No (market prices applied as is)
O&M Cost (excludes labor)	All equipment and materials purchased locally at competitive prices	No
O&M Labor Cost	70% Skilled Labor	No (competitive market no shadow price required)
	30% Semi-skilled/unskilled labor	Yes (SWFR = 0.7)
Engineering Services	80% Tradable	Yes. Multiplied by 1.042
	20% Non-Tradable	No (already in domestic prices)

Source: This Study

(2) Benefit Valuation

The benefits of projects, which will flow from 2013 to after their completion, are quantified by comparing the impacts that the construction and non-construction of the pre-FS projects would have on congestion on an area-wide and local basis (i.e., Western Province). With the results of this comparison, it is possible to measure savings in VOC and travel time. A description of each of these measurements is as given below.

VOC Savings Benefits

VOC savings is calculated by deriving the annual reduction in vehicle distance traveled (or vehicle km) by vehicle type for with and without the different pre-FS projects and then multiplied by average VOC per km. The economic price of VOC per km by vehicle type is

[3] Shadow wage rate factor (SWFR) revised after reviewing various documents including: (1) Sri Lanka Power Sector Development Program Report, ADB, RRP-SRI 30207, October 2002. (2) Report on Sri Lanka Secondary Towns and Rural Community-Based Water Supply and Sanitation Project, ADB, RRP-SRI 31501, December 2002.

estimated by updating values applied in a JICA 2005 report for the OCH, using the Greater Colombo Consumer Price Index (see Table 23.3).[4] The calculation of VOC is based on the opportunity cost of purchasing a vehicle and the cost of owing and using it. Note, however, that the value for passenger car was revised downwards after examining the relationship between VOC for vehicles from another road project study in Sri Lanka.[5]

Table 23.3 Vehicle Operating Costs

Unit: Rs/km

Type of Vehicle	Average VOC per km (2006 Economic Prices)
1.Passenger Car	21.0
2. Three Wheeler	7.8
3. Motorbike	4.8
4. Bus	33.4
5. Truck	38.4

Based on the results of the application of the JICA STRADA model described in Chapter 19, daily vehicle km for each vehicle type are derived and expanded to annual vehicle km.[6] With this information and that in Table 23.3, it is possible to calculate annual VOC savings for the pre-FS scenarios described in Table 18.7. The results are shown in Table 23.4. Note, however, that calculations for the ATC system, corridor improvement, and individual flyovers were not done as they are not expected to produce any significant VOC savings, as improvements to discreet small sections of road are insufficient to change traffic patterns. In addition, as described in Chapter 19, since the Marine Drive extension itself has no impact on reducing VOC calculations for this scenario are also not carried out.

Table 23.4 VOC Savings for 2013-30

2006 Constant Economic Prices

Year	Annual Reduction in Veh-km With Project (millions)	Annual VOC Savings With Project (Rs. millions)
Scenario: Road Widening Program I		
2013	13.80	287.36
2025	16.41	335.03
2030	51.02	1,124.63
Scenario: Road Widening Program II		
2013	13.72	282.20
2025	16.41	335.03
2030	50.62	1,109.26
Scenario: B152 and B425 Road Widening		
2013	5.18	98.25
2025	19.70	419.16
2030	-19.18	-223.51
Scenario: Koskadwila-Thalawatugoda-Pannipitiya-Tumbowila Road Widening		
2013	10.86	218.27
2025	17.99	326.25

[4] *The Detailed Design Study on the Outer Circular Highway to the City of Colombo*, Final Report, Basic Design Volume, JICA, July 2005.
[5] *Recovery, Rehabilitation and Development Project for Tsunami Affected Roads on the East Coast in the Democratic Socialist Republic if Sri Lanka*, JICA, May 2006.
[6] Expansion factor of 330 is applied based on the following text: *Assessing Public Investment in the Transport Sector*, Department of National Planning, Ministry of Finance and Planning, Sri Lanka, Sept. 2001.

Year	Annual Reduction in Veh-km With Project (millions)	Annual VOC Savings With Project (Rs. millions)
2030	9.12	283.86
All Project Implementation Program I		
2013	28.93	530.50
2025	26.26	422.86
2030	-81.24	-1,580.65
All Project Implementation Program II		
2013	20.35	417.28
2025	-27.18	-627.81
2030	-50.99	-993.92

Source: This Study

Based on the preceding tables, the following conclusions can be made about VOC savings in regard to the pre-FS project scenarios.

- The difference in VOC savings for Road Widening Program I and Program II is minimal, meaning that the widening of the Nugegoda-Pedpiliyana Road, which will be costly because of its location, can be foregone without there being any adverse impacts in VOC terms. Note that as time passes that the savings in VOC for either of these scenarios also increases significantly, surpassing Rs.1.1 billion in the year 2030, and that the project is therefore effective through time.
- Road widening of B152 and B425 results in VOC savings up until 2025 but then turns to minus (i.e., VOC increases) in 2030. Overall, however, the savings in VOC for the lifecycle of the project is positive. The reason for VOC savings becoming negative is that drivers will travel extra distances to save time, which can result in VOC becoming negative. This line of thinking is applicable to all scenarios that experience a negative VOC and indicates that the road network is highly congested.
- The road widening of the Koskadwila-Thalawatugoda-Pannipitiya-Tumbowila Road produces reductions in VOC for the entire valuation period; although, there is a decrease in the level of savings after 2025.
- The execution of All Project Implementation Program I, including all the proposed flyovers and corridor improvements, results in VOC savings up till 2025 and then turns to minus in 2030. Overall, however, there is a savings in VOC for the valuation period.
- The execution of All Project Implementation Program II, which excludes the Marine Drive extension and the widening of the Nugegoda-Pepiliyana Road, produces a reduction in VOC for 2013 only and thereafter savings in VOC is negative, indicating that it would be better to implement the preceding item rather than this one.
- Based on the above, it can be said that of all the scenarios considered here result in savings in VOC over the valuation period except for All Project Implementation Program II.

Time Saving Benefits

Time saving is calculated by utilizing a value of time (VOT) per vehicle type and multiplied by the time saving that would be achieved with pre-FS project construction, which is estimated with the traffic demand model in Chapter 19. Vehicle-type VOT is derived by updating values contained in the 2005 JICA report on the OCH by applying the Greater Colombo Consumer Price Index. Note that the VOT is based on the value of working time and does not consider the value of non-working time, which is assumed to be zero[7]. The reason for excluding non-working time is due to the lack of job opportunities and the large number of migrant workers. Note that individual VOT is converted into vehicle VOT by multiplying by vehicle occupancy rates and the percentage of work trips (see Table 23.5), which are based on traffic survey data.[8] The value of time of trucks, bus drivers, and 3-wheelers is not considered since it is included in the vehicle operating costs.

Table 23.5 Value of Time by Vehicle Type

2006 Constant Economic Prices

Type of Vehicle	Value of Working Time of Passengers (Rs)	Ratio of Work Trips	Vehicle Occupancy[1)]	Vehicle VOT (Rs/hr)
1. Passenger Car	234.8	.30	2.69[2)]	189
2. Motorbike	234.8	.50	1.30	153
3. 3-Wheeler	68.0	.17	1.16	13
4. Bus	68.0	.06[2)]	40.00	163

1) Except for motorbikes and passenger cars, drivers are not included as their value of time costs are considered as a part of vehicle operating costs.
2) Value from CUTS II Working Paper 21, June 1999.

All the scenarios considered for economic analysis (see Table 18.7) produced time savings and the details are as shown in Table 23.6.

Table 23.6 Time Savings for 2013-30

2006 Constant Economic Prices

Year	Annual Reduction in V-hr With Project (millions)	Annual Time Savings With Project (Rs. millions)
Scenario: ATC System Construction		
2011	4.816	722.0
2015	4.816	722.0
2020	4.816	722.0
Scenario: Orugodawatta Flyover Construction		
2013	0.614	106.59
2025	2.723	875.79
2030	5.066	1,132.19
Scenario: Borella-Kanata Flyover Construction		
2013	2.897	498.99
2025	7.109	1,435.99
2030	10.332	1,748.32
Scenario: Kohuwala Flyover Construction		
2013	1.355	239.49
2025	3.390	609.14
2030	4.238	763.16
Scenario: Armour Street Flyover Construction		
2013	2.605	463.24
2025	5.672	1,020.54
2030	6.950	1,252.75
Scenario: Kelaniya Flyover Construction		

[7] According to the UK's Transport and Road Research Laboratory's *Overseas Road Note 5: A guide to project appraisal*, non-working time is usually valued from zero to 45% of working time, and should normally be valued at the lower end of this range.
[8] Vehicle occupancy rates were derived from a JICA traffic survey carried out in early 1999 for the feasibility study on the Outer Circular Highway (OCH).

Year	Annual Reduction in V-hr With Project (millions)	Annual Time Savings With Project (Rs. millions)
2013	1.308	229.6
2025	2.316	400.5
2030	2.652	457.5
Scenario: Rajagiriya Flyover Construction		
2013	0.308	53.58
2025	1.024	230.52
2030	1.687	289.51
Scenario: A2 Corridor Improvement		
2010	0.079	12.08
2020	0.107	17.80
2027	0.128	21.23
Scenario: A0 Corridor Improvement		
2010	0.111	19.22
2020	0.150	26.42
2027	0.179	30.74
Scenario: Road Widening Program I		
2013	0.932	149.59
2025	2.362	380.44
2030	6.864	1,165.34
Scenario: Road Widening Program II		
2013	0.937	149.58
2025	2.301	370.01
2030	6.704	1,137.35
Scenario: B152 and B425 Road Widening		
2013	0.253	34.37
2025	1.190	183.88
2030	3.075	525.67
Scenario: Koskadwila-Thalawatugoda-Pannipitiya-Tumbowila Road Widening		
2013	0.707	115.41
2025	0.745	105.65
2030	5.14	868.17
Scenario: Marine Drive Extension		
2013	1.384	222.64
2025	0.808	105.10
2030	0.054	1.95
Scenario: All Project Implementation Program I		
2013	6.987	1065.6
2025	3.396	646.6
2030	2.867	528.5
Scenario: All Project Implementation Program II		
2013	6.428	978.0
2025	2.914	535.0
2030	3.370	572.2

Source: This Study

Based on the preceding tables, the following conclusions can be made about VOT savings with regards to the pre-FS project scenarios.

- The ATC system produces on average one of the largest savings in terms of vehicle-hours annually (i.e., more than 4.8 million hours) and is therefore a very effective congestion reduction measure.
- Comparatively speaking, four of the six flyovers produce significant time savings benefits, ranging from Rs.763 million to Rs.1.748 billion in 2030. The other two, Kelaniya and Rajagiriya, have relatively small time savings in 2030 that are equivalent to Rs.457 million and Rs.289 million, respectively.
- Of all the scenarios, the corridor improvement scenarios, which are small in scale, result in the smallest savings of time, varying from a mere Rs. 12.1 million to Rs. 19.2 million in 2010 for the A2 and A0 corridors, respectively, to Rs. 21.2 million to Rs. 30.7 million in 2030. On the other hand, the cost for these works is also not large.
- The difference in VOT savings for Road Widening Program I and Program II, as in the case of VOC savings for these two scenarios, is minimal. This means that the widening of the Nugegoda-Pedpiliyana Road can be foregone without there being any adverse impacts in VOT terms as well. Note that as time passes that the savings in VOT for either of these scenarios also increases significantly, surpassing Rs.1.1 billion in the year 2030, and that the project is therefore effective through time.
- Road widening of B152 and B425 results in VOT savings throughout the valuation period and is significant, being about Rs.525 million in the year 2030.
- The road widening of the Koskadwila-Thalawatugoda-Pannipitiya-Tumbowila Road also produces significant time savings benefits over the entirety of the valuation period and reaches approximately Rs.868 million in 2030.
- The construction of the Marine Drive extension produces time savings benefits in 2013 of Rs.222 million. However, this then declines to about Rs.105 million in 2025 and to Rs.1.9 million in 2030. Of all the scenarios, this is the only one that experiences such a drastic drop in time saving. The explanation for this is that this particular area is highly congested and that even with the Marine Drive extension the impact on reducing congestion declines over time as this piece of infrastructure also becomes congested itself. This line of thinking would be applicable to other areas of the network experiencing the same phenomenon.
- The implementation of the All Project Implementation Program I scenario, which includes all of the flyovers and corridor improvements, results in VOT savings throughout the entirety of the valuation period, reaching Rs. 1.065 billion in 2013 and then falling to Rs. 528 million in 2030. This is due to the end of the lifecycles of the ATC system and corridor improvements.
- The implementation of the All Project Implementation Program II scenario, which is the same as Program I, but excludes Marine Drive and widening of Nugegoda-Pedpiliyana Road, produces overall significantly smaller time savings benefits (about Rs.3 billion less) for the valuation period. Therefore, Program I is more recommendable than Program II.
- Based on the preceding, it can be said that all of the scenarios produce time savings over the valuation period. Note that purely from a time savings viewpoint, it is seems prudent to improve all of the roads instead of just a selection and therefore to execute Scenario All Project Implementation Program I instead of II. On the other hand, Marine Drive, which consists of new construction produces insufficient time savings benefits and are actually the smallest of any of the scenarios except for the small-scale corridor improvement works. Also, the widening of the Nugegoda-Pedpiliyana Road has minimal positive impacts. From a cost-effectiveness viewpoint, these two points should be considered.

23.4 Economic Evaluation

(1) Calculation of EIRR & NPV

Applying the results of the above analysis for economic costs and benefits, the EIRR and NPV for the pre-FS scenarios are as calculated in Table 23.7 (see Appendix 37 for details). Note that the discount rate of 12% is applied in calculating the NPV.

Table 23.7 EIRR and NPV by Scenario

Constant 2006 economic prices, domestic price numeraire, Rs millions

Scenario	EIRR (%)	NPV (Rs. Millions)
1. ATC	41.30	1,904.2
2. Orudogawatta Flyover	19.38	631.3
3. Borella-Kanata Flyover	12.74	212.8
4. Kohuwala Flyover	21.75	846.6
5. Armour Street Flyover	20.61	1,364.5
6. Kelaniya Flyover	16.31	336.9
7. Rajagiriya Flyover	6.35	-401.6
8. A2 Corridor Improvement	14.27	9.9
9. A0 Corridor Improvement	13.70	11.5
10. Road Widening Program II	9.90	-549.8
11. B152 and B425 Widening	7.94	-608.1
12. Koskadwila-Thalawatugoda-Pannipitiya-Tumbowila Road Widening	17.50	940.4
13. Marine Drive	0.75	-1,648.5
14. All Project Implementation I	0.39	-10,636.7

Based on the preceding table, the following conclusions can be made about the economic viability of the pre-FS project scenarios.

- Although the ATC system has only a design life of 10 years, it would produce an EIRR of 41.30% and is therefore highly viable. Given this, it should be put into place as quickly as possible.
- Five of the six proposed flyovers have an EIRR greater than 12% and are therefore acceptable for implementation. The flyover that did not exceed 12% is Rajagiriya and, since its EIRR is 6.35%, it should be dropped as a high priority project. On the other hand, traffic management measures to relieve congestion should be considered.
- Both of the corridor improvement projects for upgrading parts of A2 and A0 produced an acceptable EIRR of more than 13% and can therefore be implemented.
- As indicated in the analysis in 23.3, there was virtually no difference in VOC or time savings between Road Widening Program I and II. As a result, economic analysis is only carried out for the latter because of its lower cost. Despite this, the EIRR for Road Widening Program II is only 9.90% and therefore it is economically unfeasible.9
- Widening of B152 and B425 produces an EIRR of 7.94% and is substantially below the threshold of 12%, meaning that this project should also be dropped as a high priority project and not considered.
- Widening Koskadwila-Thalawatugoda-Pannipitiya-Tumbowila Road would strengthen infrastructure for both north-south and east-west flows and is highly feasible with an

[9] Note that the EIRR calculated for the Nugegoda-Pepiliyana Road Widening project is negative because of the large land acquisition and compensation costs and therefore is not feasible and should not be packaged with the other road widening projects.

EIRR of 17.50%. This scheme is also attractive as it would improve a national road as well as provincial roads, which are important for local traffic and as feeder and collector roads.

- Because of the high cost of land acquisition and compensation, which accounts for more than 90% of the total project cost, the Marine Drive extension is not economically viable and should be dropped from further consideration.
- The All Project Implementation Program I, which assumes all the scenarios would be implemented (including ATC, flyovers, and corridor improvement), has a low EIRR. The reason for this is that although more than Rs.24 billion in benefits would be produced, the economic cost for realizing this is too high, costing about Rs.21 billion. Again, the main reason for this seems to be the high cost of land acquisition and compensation, which accounts for about 60% of all costs (excluding operation and maintenance expenditures). This indicates that careful consideration has to be given to the high costs of implementation inherent in built-up areas such as Colombo and the tradeoff between costs and benefits closely examined before proceeding with a project.

Implementing all of the projects that are feasible could prove financially burdensome for the Sri Lanka Government; especially, if the two pipeline projects OCH and Baseline extension are also considered for implementation (see Chapter 25 for details). Therefore, it is recommended that projects be prioritized applying the NPV. Unlike the EIRR, the NPV gives an absolute number regarding the benefits that a project would produce. That is, once a project is deemed feasible via the EIRR, it can be prioritized by determining the size of its NPV in relation to the NPV of other projects. Based on this concept the order of implementing the pre-FS projects could be as shown in Table 23.8.

Table 23.8 Order for Implementing Scenarios by NPV

Scenario	NPV
ATC	1,904.20
Armour Street Flyover	1,364.50
Koskadwila-Thalawatugoda-Pannipitiya-Tumbowila Road Widening	940.4
Kohuwala Flyover	846.6
Orudogawatta Flyover	955.2
Kelaniya Flyover	336.9
Borella-Kanata Flyover	212.8
A0 Corridor Improvement	11.5
A2 Corridor Improvement	9.9
Rajagiriya Flyover	-401.6
Road Widening Program II	-549.8
B152 and B425 Widening	-608.1
Marine Drive	-1,648.5
All Project Implementation I	-10,636.7

The last five scenarios shaded in grey indicate projects that are unfeasible. Below, a sensitivity analysis is carried out for all of the projects listed in Table 23.8, with check on what will happen to feasible projects should benefits decrease and costs increase by 10% and 20%, respectively, as well as to see if those projects that are unfeasible have the potential of becoming feasible by checking the impacts of benefits increasing and costs decreasing by 10% and 20%.

(2) Sensitivity Analysis

ATC System

The results of the sensitivity analysis for the ATC system are as shown in Table 23.9. As the table indicates, even with a 20% decrease in benefits or a 20% increase in costs, the EIRR of the project still substantially exceeds 12% and is therefore economically highly viable. In fact, benefits would have to decrease by about 60% and costs increase by 2.4 times for the project to become unviable, which are orders of magnitude that are extremely unlikely.

Table 23.9 Sensitivity Analysis for ATC System

Scenario	EIRR (%)	NPV (Mil. of Rs)	Switching Value
Base	41.30	1,904	
Sensitivity Tests			
Benefits			
-10%	37.05	1,259	Base X 0.4146
-20%	32.58	999	
Costs			
+10%	37.44	1,411	Base X 2.4126
+20%	34.10	1,303	

Source: This Study

Flyovers

The results for the sensitivity analysis for flyovers are contained in Tables 23.10 to 23.15. Except for the Borella-Kanata Flyover and the Rajagiriya Flyover, the results indicate that even a 20% decrease in benefits or a 20% increase in costs would not produce an EIRR of less than 12%, meaning that these are economically robust projects and attractive investments.

As for the Borella-Kanata Flyover, the switching values indicate that a decrease in benefits of about 6% or a rise in costs of approximately 3% would result in the project becoming unviable and that costs especially should be monitored when the project is implemented to ensure that viability is not adversely impacted. Finally, the Rajagiriya Flyover, because of its low EIRR, would not even be feasible with a 20% increase in benefits or decrease in costs, respectively. In fact, as the switching values indicate, benefits would have to increase by 1.863 times or costs decrease by 46% before an EIRR of 12% would be achieved, which is unrealistic.

Armour Street Flyover

Table 23.10 Sensitivity Analysis for Armour Street Flyover

Scenario	EIRR (%)	NPV (Mil. of Rs)	Switching Value
Base	20.61	1,364	
Sensitivity Tests			
Benefits			
-10%	19.28	1,106	Base X 0.4715
-20%	17.85	848	
Costs			
+10%	19.41	18.34	Base X 2.121
+20%	1,243	1,121	

Source: This Study

Kohuwala Flyover

Table 23.11 Sensitivity Analysis for Kohuwala Flyover

Scenario	EIRR (%)	NPV (Mil. of Rs)	Switching Value
Base	21.75	847	
Sensitivity Tests			
Benefits			
-10%	20.42	700	Base X 0.4236
-20%	18.98	553	
Costs			
+10%	20.54	784	Base X 2.362
+20%	19.47	722	

Source: This Study

Orudogawatta Flyover

Table 23.12 Sensitivity Analysis for Orugodawatta Flyover

Scenario	EIRR (%)	NPV (Mil. of Rs)	Switching Value
Base	19.38	631	
Sensitivity Tests			
Benefits			
-10%	18.19	563	Base X 0.5210
-20%	17.15	494	
Costs			
+10%	18.07	500	Base X 1.9200
+20%	16.67	368	

Source: This Study

Kelaniya Flyover

Table 23.13 Sensitivity Analysis for Kelaniya Flyover

Scenario	EIRR (%)	NPV (Mil. of Rs)	Switching Value
Base	16.31	337	
Sensitivity Tests			
Benefits			
-10%	15.00	226	Base X 0.6960
-20%	13.59	115	
Costs			
+10%	15.12	260	Base X 1.4370
+20%	14.07	183	

Source: This Study

Borella-Kanata Flyover

Table 23.14 Sensitivity Analysis for Borella-Kanata Flyover

Scenario	EIRR (%)	NPV (Mil. of Rs)	Switching Value
Base	12.74		
Sensitivity Tests			
Benefits			
-10%	11.57	-120	Base X 0.9362
-20%	10.32	-453	
Costs			
+10%	11.68	-99	Base X 1.0682
+20%	10.74	-411	

Source: This Study

Rajagiriya Flyover

Table 23.15 Sensitivity Analysis for Rajagiriya Flyover

Scenario	EIRR (%)	NPV (Mil. of Rs)	Switching Value
Base	6.35	401.6	
Sensitivity Tests			
Benefits			
+10%	7.14	-355.0	Base X1.8630
+20%	7.88	-308.5	
Costs			
-10%	7.22	-314.9	Base X 0.5367
-20%	8.24	-228.2	

Source: This Study

(3) Road Widening

Sensitivity analysis results for road widening are contained in Tables 23.16 to 23.18. Table 23.16 shows that the widening of the Kosakadwila-Thalawatugoda-Pannipitiiya-Tumbowila Road is economically robust and a good investment, as the EIRR exceeds 12% despite increases in costs and decreases in benefits by 20%. On the other hand, the EIRR for Road Widening Program II in Table 23.17, which consists of the schemes shown in 23.16 and 23.18, only becomes viable if there is a 20% decrease in costs, which seems unlikely. The reason for this is that the widening of B152 and B425 is economically unviable and only becomes so if there is an increase in benefits by about 1.54 times or a decrease in costs by about 35%, orders of magnitude that seem unlikely.

Kosakadwila-Thalawatugoda-Pannipitiiya-Tumbowila Road Widening

Table 23.16 Sensitivity Analysis for Kosakadwila-Thalawatugoda-Pannipitiiya-Tumbowila Road Widening

Scenario	EIRR (%)	NPV (Mil. of Rs)	Switching Value
Base	17.50	940	
Sensitivity Tests			
Benefits			
-10%	16.31	706	Base X 0.5985
-20%	15.02	472	
Costs			
+10%	16.42	800	Base X 1.6710
+20%	15.46	660	

Source: This Study

Road Widening Program II

Table 23.17 Sensitivity Analysis for Road Widening Program II

Scenario	EIRR (%)	NPV (Mil. of Rs)	Switching Value
Base	9.90	-550	
Sensitivity Tests			
Benefits			
+10%	10.80	-326	Base X 1.2454
+20%	11.64	-101	
Costs			
-10%	10.89	-271	Base X 0.8030
-20%	12.04	8	

Source: This Study

<u>B152 and B425 Road Widening</u>

Table 23.18 Sensitivity Analysis for B152 and B425 Road Widening

Scenario	EIRR (%)	NPV (Mil. of SLR)	Switching Value
Base	7.94	-608	
Sensitivity Tests			
Benefits			
+10%	8.80	-496	Base X 1.5404
+20%	9.60	-383	
Costs			
-10%	8.89	-435	Base X 0.6490
-20%	9.98	-261	

Source: This Study

(4) Corridor Improvement

As Tables 23.19 and 23.20 indicate, the improvement schemes for corridors A2 and A0, which consist of traffic management measures for the most part, are economically viable. However, they are not robust, meaning that relatively slight increases in costs or decreases in benefits make them uneconomically unviable. In the case of A2, a decrease in benefits of 5% or an increase in costs by 1.06 times results in NPV becoming zero. As for A0, which is even less robust, an increase in costs or a decrease in benefits by a mere 1% will produce an NPV of zero and should therefore be carefully planned prior to execution.

<u>A2 Corridor Improvement</u>

Table 23.19 Sensitivity Analysis for A2 Corridor Improvement

Scenario	EIRR (%)	NPV (Mil. of Rs)	Switching Value
Base	14.27	9.9	
Sensitivity Tests			
Benefits			
-10%	11.48	-2	Base X 0.9500
-20%	10.15	-8	
Costs			
+10%	11.60	-7	Base X 1.0600
+20%	10.61	-8	

Source: This Study

<u>A0 Corridor Improvement</u>

Table 23.20 Sensitivity Analysis for A0 Corridor Improvement

Scenario	EIRR (%)	NPV (Mil. of Rs)	Switching Value
Base	13.70	11.5	
Sensitivity Tests			
Benefits			
-10%	10.92	-7	Base X 0.9900
-20%	9.61	-16	
Costs			
+10%	11.03	-7	Base X 1.0100
+20%	10.06	-15	

Source: This Study

(5) Other Improvements

The results for the remaining improvements, or the Marine Drive extension and the case when all pre-FS projects are implemented, are indicated in Tables 23.21 and 23.22, respectively. As these tables indicate, the base EIRRs are substantially lower than 12% and even with a 20% increase in benefits or decrease in costs they are not economically viable. In fact, benefits would have to increase by about 2.8 times and 3.1 times for the Marine Drive extension and All Project Implementation I, respectively, before they would become viable, while costs would have to decrease by approximately 65% and 68%.

Marine Drive Extension

Table 23.21 Sensitivity Analysis for Marine Drive Extension

Scenario	EIRR (%)	NPV (Mil. of Rs)	Switching Value
Base	0.75	-1,649	
Sensitivity Tests			
Benefits			
+10%	1.67	-1558	Base X 2.825
+20%	2.52	-1468	
Costs			
-10%	1.76	-1393	Base X 0.3538
-20%	2.93	-1138	

Source: This Study

All Project Implementation I

Table 23.22 Sensitivity Analysis for All Project Implementation I

Scenario	EIRR (%)	NPV (Mil. of Rs)	Switching Value
Base	0.39	-10,637	
Sensitivity Tests			
Benefits			
+10%	0.55	-10,928	Base X 3.1264
+20%	1.26	-10,389	
Costs			
-10%	0.63	-9,782	Base X 0.3198
-20%	1.61	-8096	

Source: This Study

Chapter 24 Natural and Social Environmental Analysis

24.1 Introduction

(1) Pre-Feasibility Projects Requiring Natural and Social Environmental Analysis

Pre-feasibility (Pre-FS) projects are categorized as follows:

- Extending or widening roads;
- Constructing flyovers; and
- Increasing intersection capacity.

Increasing intersection capacity consists of introducing an Area Traffic Control (ATC) system and improving geometric design. However, because neither of these projects consists of large scale construction or land acquisition, they are not subject to an environmental or social analysis. Therefore, only the following Pre-FS projects are subjected to a natural and social environmental analysis. As shown in Figure 24.1, the projects are as follows:

- Marine Drive Extension;
- B152/B425 Widening;
- Nugegoda-Kattiya Junction-Pepiliyana Road Widening;
- Thalawatugoda-Pannipitiya Road Widening;
- Thalawatugoda-Koskadwila Road Widening;
- Pannipitiya-Tumbowil Road Widening;
- Orugodawatte Flyover (Baseline Road);
- Borella-Kanata Flyover;
- Kohuwala Flyover;
- Armour Street Flyover;
- Kelaniya Railway Flyover; and
- Rajagiriya Flyover.

(2) Methodology

The current condition of each project site will be outlined and the negative environmental impacts caused by each stage of the project will be discussed. Environmental mitigation measures will be proposed if any negative impacts are anticipated. Finally, the magnitude of each project’s environmental impacts will be evaluated. The evaluation parameters consist of the following: (i) impacts on land acquisition/resettlement; (ii) natural environment impacts; and (iii) social environment impacts.

Land acquisition and resettlement is a major constraint of road development projects. Under Sri Lanka’s National Environmental Act (NEA) with regards to road projects, an environmental impact assessment (EIA) is required if more than 100 families must be relocated. Therefore, the impacts of a project requiring the relocation of more than 100 families are considered *highly significant*; impacts of a project requiring the relocation of somewhat less than 100 families are considered *moderately significant*; and project impacts requiring the relocation of far below 100 families are considered *insignificant*.

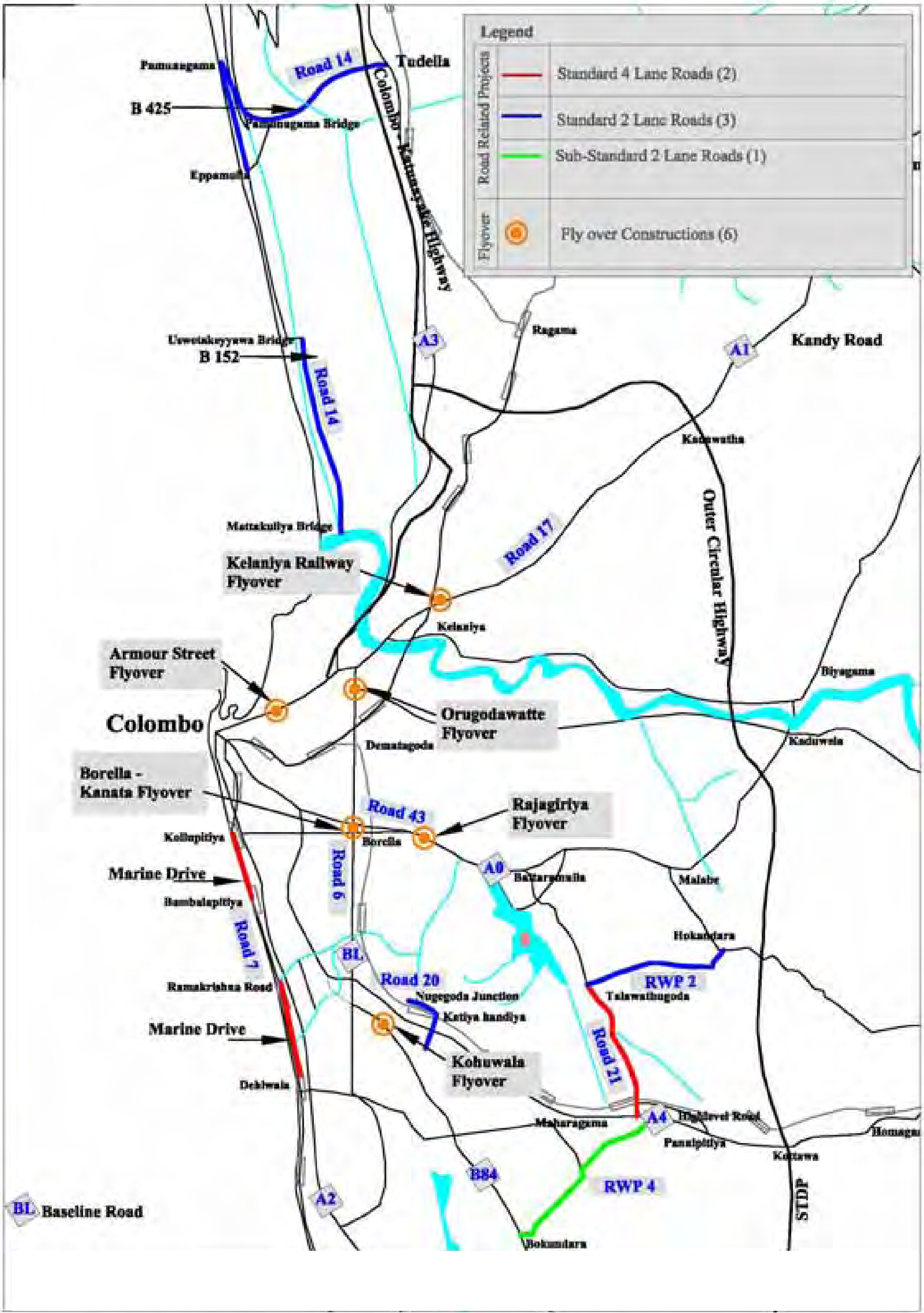
With regard to the natural and social environment, a project having serious negative impacts is considered *highly significant*; a project having minor negative impacts is considered *moderately significant*; and a project having minimal negative impacts is considered *insignificant*.

Based on the above, overall project feasibility will be evaluated as (i) *highly feasible* meaning that the project should cause no serious or irreversible negative environmental or social impacts; (ii) *feasible* meaning that the project may have some negative environmental or social impacts, but they can be alleviated through mitigation measures; and (iii) *not recommended*, meaning the project may cause irreversible negative environmental or social impacts or where effective and realistic mitigation measures do not exist.

(3) Land Acquisition and Involuntary Resettlement

All Pre-FS projects require land acquisition and/or involuntary resettlement. Land acquisition plans for some Pre-FS road construction projects have already been prepared by the RDA. The JICA Study Team with the support of RDA's Land Acquisition Division conducted inventory surveys for the affected properties of those projects that did not have available information about potential land acquisition/involuntary resettlement impacts.

Based on the survey results, the cost of land acquisition and compensation for resettlement related to the Pre-FS projects were calculated using unit costs provided by RDA's Land Acquisition Division. The costs are summarized in Appendix 27.



Source: This Study

Figure 24.1 Location of Pre-FS Projects Subject to Natural and Social Environmental Analysis

24.2 Project Specific Natural and Social Environmental Analysis

(1) Marine Drive Extension

Present Condition of Project Site

The project corridor stretches across Colombo District and covers Kollupitiya, Bambalapitiya, Wellawatta, and Dehiwala, all of which are highly developed urban areas. The ethnic composition of the communities differs throughout the corridor such as a high Sinhalese majority in Dehiwala with a high Tamil majority in Wellawatta, Bambalapitiya, and Kollupitiya. Throughout the corridor, land values are very high, particularly in Kollupitiya, Wellawatta and Bambalapitiya and the permanent residents are mostly high-income.

The western side holds the railway right-of-way. Only the eastern side of the corridor is developed and is primarily residential, although there are some commercial and retail establishments as well. Within the residential development there are some multi-story luxury high rises built recently with more under construction. Additionally, a Hindu temple was constructed in Wellawatta.

Since Marine Drive was originally constructed, it has been a popular bypass to Galle Road during peak hours by private vehicles. Public transport, except three-wheelers, does not use the corridor. With the narrow connections to Galle Road from Marine Drive, this corridor is not used to its full potential, but with the proposed extensions, this may change.

All basic infrastructure facilities are provided along the corridor with majority of the community receiving piped water, electricity, and telecommunication facilities.

Beyond the rail right-of-way is the ocean, but beyond that there are no natural water bodies in close proximity to the corridor. The corridor crosses Wellawatte Canal which drains the collected wastewater from CMC to the ocean. The new proposed extension from Ramakrishna Road to the Dehiwala Station Road will also cross Dehiwala Canal, a smaller drainage canal. Vegetation exists near the ocean and contains coastal species such as Pandanus and coconut.

The only natural resources of special significance are marine resources. A fishing community illegally occupies the beachfront in areas between Dehiwala Station and Ramakrishna Road. One of the main environmental problems in Dehiwala is lack of solid waste management.

Anticipated Negative Impacts and Mitigation Measures

<u>Pre-Construction Stage</u>

Land Acquisition: RDA has already started land acquisition procedures for the northern section (Bambalapitiya to Kolluiptiya) and the plan for the southern section (Ramakrishna Road to Dehiwala) is under preparation. The inventory surveys have been conducted by the Study Team in order to identify the latest conditions of affected properties. The results are shown in Appendix 27. There are 138 affected structures consisting of about 80% of residential building. The number of affected properties along the northern section (38) is smaller than that of southern section (100) because demolition along the northern section is underway. The table above shows that the amount of land acquisition will be rather significant. In addition the property values in the area are also rather high. This is particularly true for properties between Bambalapitiya and Kollupitiya where land values are extremely high. The households appear to be well established and they will be much reluctant to be resettled, hence during the pre-construction stage there will be many social issues to handle while surveying and negotiating with land owners.

Construction Stage

Social Conflicts: During the construction stage the main concern is the demolitions that result from land acquisitions. Even if negotiations are underway and compensation has been paid, social problems are likely when there is partial demolition and residents still occupy the undamaged portion. At this phase serious conflicts can arise between the workers and the residents. This situation will be aggravated if the workers are not sensitive to the issues involved.

Degradation of Water Quality by Workers' Housing: Camps to house temporary workers are likely to have wastewater and solid waste disposal problems.

Degradation of Air Quality and Increased Noise and Vibration: Demolition of existing structures will discharge dust into the air and create health problems for local residents. Since this project is being undertaken in a residential area, this is a cause of concern particularly since demolition activities occur during the day and breezes from the sea will assist in circulating the dust in the area. Movements of heavy vehicles will also result in air pollution and further disbursement of dust.

Noise and vibration generated from workers' camps and construction activities are other issues of concern since there are a number of households exposed. Toxic emissions from asphalt plants and particulate matter from concrete mixing plants will be a problem of concern.

Road Blockage: Since road construction is located near the ocean there should not be much disturbance to existing traffic flow. Additionally, traffic flow has been minimal in this area except for local residents.

Solid Waste: Solid waste from construction activities and demolition will be an issue, although the municipality already has a solid waste disposal problem in operation.

Damage to Drainage System: Construction activities and debris may block or damage the existing drainage system to the ocean, thus blocking drains leading to overflows and potential flooding. The drainage patterns in the area and canal flows will also change as a bridge will be built over the Dehiwala Canal (the existing bridge is rail only).

Ecology: The area is highly developed with minimal natural habitats or vegetation. Hence there should be no negative impacts on natural vegetation, biodiversity, or rare or endangered species.

Operational Stage

Accident Risk: The road will be new to the area and residents may take some time to get used to it. The road will also be used to access the beach. Accidents are inevitable unless precautions are taken.

Air Quality/Noise: Road usage is expected to be heavy during business hours, which will increase the noise levels in the area, as well as negatively impact air quality.

(2) B152/B425 Widening

Present Condition of Project Site

The project corridor lies mainly in Gampaha District and stretches from Mattakkuliya Bridge to Tudella Junction. It crosses towns between Wattala and Ja Ela, which are well developed areas except for some sections between Pamunugama and Tudella that are marshy. Sinhalese are the majority along this corridor and many are Roman Catholics. Most residents are classified as middle-income, although between Pamunugama and Tudella it is mixed. There are also a few high-income households in the area. All basic infrastructure is provided to the households with majority of the community receiving piped water, electricity, and telecommunication facilities. This road section ends at Tudella Junction where there is no traffic control.

B152 begins at Mattakkuliya Bridge at the edge of Colombo District and traverses the villages of Wattala until Uswettakeiyawa Bridge. Most of the developments along B152 are residential. There is negligible vegetation in this area, although houses have gardens with coconut and king coconut trees. The Kelaniya River meets the ocean at Mattakkuliya Bridge and Hamilton Canal runs parallel to the alignment. The coastal area was affected by the tsunami in December 2004, which was an anomaly as the area is not generally affected by natural hazards, including floods. The population is literate and employment is mainly in the fishing industry and general business. Many fishermen have stalls along the road. Marine and mineral resources (sand) are the primary natural resources in the area.

B425 Road lies between Eppamulla and Tudella Junction crossing Pamunugama Bridge. The area has mixed land use with 70% residential, 20% commercial, and 10% agricultural (coconut plantations and scrub). Employment is mainly in the fishing industry and general business. Vegetation is negligible and small marshes run parallel to the road.

Anticipated Negative Impacts and Mitigation Measures

<u>Pre-Construction Stage</u>

Land Acquisition: The land acquisition plan for B152 has already been prepared by the RDA. According to the plan, the type and number of buildings which will be partially and fully damaged due to construction along B152 are shown in Appendix 27. There are 99 affected structures consisting of about 20% of residential buildings. The results show that the amount of land acquisition will be rather significant but most of them will be only partially damaged because there are no structures on one side of B152 as it runs parallel to a canal. Even if the other side is fairly densely populated, the properties are rather large with each household having more than twenty perches each with large gardens in front. Between Tudella Junction and Pamunugama Bridge, the road traverses open space, as well as large properties of about thirty perches each. Because of the low number of structures affected, there should be low resistance to land acquisition during the pre-construction phase.

An inventory survey was conducted on the affected properties along B-425 including the road between Eppamulla and Pamunugama Bridge. About 270 properties consisting of about 50% of residential building will be affected as shown in Appendix 27. The amount of land acquisition is rather significant.

<u>Construction Stage</u>

Road Blockage: Construction related activities will require road blocks and traffic diversions which will cause delays and inconvenience road users.

Utility Relocation: Existing utility infrastructure such as telephone and power lines, as well as some water supply lines, will need to be relocated. This will cause short-term but significant inconvenience to the community.

Social Conflicts: Construction workers sometimes behave irresponsibly and create conflicts with local community. Along the stretch between Mattakkuliya Bridge and Uswetakeiyawa Bridge there are a number of fish vendors and it is likely that if their business activities are disturbed, conflicts will arise.

Degradation of Water Quality: Temporary worker camps will have wastewater and solid waste disposal issues.

Solid Waste: Nearby canals will be affected by soil and debris runoff from excavation and dredging as well as asphalt and concrete mixing plants.

Degradation of Air Quality and Increased Noise and Vibration: Air quality will be negatively affected due to emissions of dust and particulates during site clearing activities, excavation and dredging, use of construction vehicles, and operation of asphalt and concrete mixing plants. Noise and vibrations will be generated from workers' camps and construction activities.

Ecology: The stretch from Mattakkuliya Bridge to Uswatakeiyawa Bridge is well developed and the ecological aspects are home gardens with coconut trees. Therefore, there will be minimal impact on natural habitats or vegetation and bio-diversity.

<u>Operational Stage</u>

Accident Risk: The road network in the area is already in place and developed. Widening and rehabilitating the road will not result in a dramatic increase in traffic and should improve the safety aspects. Therefore, accidents should not increase.

Air Quality/Noise: Additional air pollution from vehicles on the improved road will not be high. Road widening will reduce traffic congestion thus reducing vehicle emissions. As there are no schools, religious facilities, or hospitals, the negative impacts during operation will be minimal.

(3) Nugegoda-Kattiya Junction-Pepiliyana Road Widening

Present Condition of Project Site

The project corridor traverses Rajagiriya, Koswatte, Nawala, Nugegoda, Kattiya Handiya, and Gamsabha Handiya in Sri Jayewardenepura Kotte DS Division; Pepiliyana and Bellantota in Kesbawa DS Division, and Attidiya and Ratmalana in Ratmalana DS Division-all in Colombo District. All are highly urban developed areas and the road goes through high density residential areas. The existing road is extremely narrow and the houses adjacent to the road do not have much front garden space. Near Bailey Bridge are marshes and a large playground.

The land values are generally high, particularly in Kotte DS Division. The majority of population is Sinhalese and Buddhist. The literacy rates are high and most are middle- and high-income. Other than the stretch between Nawala Junction and Nugegoda Junction, which is highly commercialized, the road traverses mainly residential areas. Vegetation is mainly in home gardens with coconut, king coconut, jackfruit, and bread fruit trees. The area is heavily prone to flooding.

The road alignment is as follows:

- Nugegoda Supermarket Junction is in Nugegoda GN Division which is located in Sri Jayawardenepura Kotte DS Division. It is highly commercialized with no traffic control and high congestion. There is a fuel station 100 meters towards Nawala Road.
- From Nugegoda Supermarket to Nugegoda Gamsabha Junction is heavily populated with high density. There is a temple and a court complex in this section. Nugegoda Gamsabha Junction is heavily congested, although there is signalized traffic control at this junction. 80% of the development is commercial with the remainder being residential.
- From Nugegoda Gamsabha Junction to Bailey Bridge at Dehiwala Road, 80% of the development is residential.

Anticipated Negative Impacts and Mitigation Measures

<u>Pre-Construction Stage</u>

Land Acquisition: A large Buddhist Temple and the Nugegoda Court Complex are situated along this road, although they will be minimally affected, losing about 2.5 meters in front. Some residences will get their properties damaged. From Nugegoda Gamsabha Junction to Bailey Bridge at Dehiwala Road, some residences will be affected. These belong to mainly middle-income households. The Study Team conducted an inventory survey on the affected properties and the result shows 163 properties consisting of about 48% of residential building will be affected as shown in Appendix 27. The results show that the negative impacts caused by the land acquisition will be highly significant.

<u>Construction Stage</u>

Utility Relocation: Existing utility infrastructure such as telephone and power lines, as well as some water supply lines, will need to be relocated. This will cause short-term but significant inconvenience to the community.

Road Blockage: Construction related activities will require road blocks and traffic diversions which will cause delays and inconvenience road users.

Social Conflicts: Construction workers may have conflicts with local residents.

Degradation of Water Quality: Temporary worker camps will have wastewater and solid waste disposal issues. Construction, excavation, and dredging can also create runoff which will pollute surface water in the canals. This is especially relevant during the rainy season as canals tend to overflow and flood the surrounding area.

Degradation of Air Quality and Increased Noise and Vibration: Site clearing activities will affect air quality due to dust and particulate emissions during excavation, dredging, and vehicle movements. Noise and vibration generated from construction activities will also affect the area. Toxic emissions from asphalt plants and particulate matter from concrete mixing plants will also pose an environmental and health hazard.

Ecology: Minimal vegetation exists in the area except close to Bailey Bridge. A number of coconut trees grown in home gardens will need to be removed.

<u>Operational Stage</u>

Accident Risks: Currently, this road is heavily used during peak times as an alternate to Nugegoda-Kohuwela Road. Improving the road will lead to additional traffic which may increase the risk of accidents. However, widening the road will improve safety and therefore, no overall increases in accidents are expected.

Air Quality/Noise: There will be additional air pollution from vehicles on the improved road, but widening should reduce congestion, thus reducing vehicle emissions. The traffic noise will disturb the temple's and courthouse's activities, although this should not be much greater than what is currently experienced.

(4) Thalawatugoda-Pannipitiya Road Widening

Present Condition of Project Site

The project corridor lies in the Colombo District and traverses Maharagama DS Division. The population is mainly Sinhalese and Buddhists. They are mainly middle-and high-income. Thalawathugoda Junction is rather commercialized and about 80% of the facilities are commercial with the remainder as residential. At present there is no traffic control at the junction. Between Thalawathugoda Junction and High Level Road there are more residential areas. Piped water is available, although some residences use well-water. Vegetation is mainly in home gardens including coconut, king coconut, jackfruit, and bread fruit trees. The area is flood prone, although there are no natural hazards in these areas.

Anticipated Negative Impacts and Mitigation Measures

<u>Pre-Construction Stage</u>

Land Acquisition: RDA prepared a land acquisition plan and the type and number of partially and fully damaged houses along both sections of the proposed road are given in Appendix 27. The results show that 169 properties consisting of about 60% of residential building will be affected. The negative impacts caused by the land acquisition will be highly significant.

<u>Construction Stage</u>

Road Blockage: Construction related activities will require road blocks and traffic diversions which will cause delays and inconvenience road users.

Utility Relocation: Existing utility infrastructure such as telephone and power lines, as well as some water supply lines, will need to be relocated. This will cause short-term but significant inconvenience to the community.

Degradation of Water Quality: Temporary worker camps will have wastewater and solid waste disposal issues. Construction, excavation, and dredging can also create runoff which will pollute surface water in the canals.

Degradation of Air Quality and Increased Noise and Vibration: Site clearing activities will affect air quality due to dust and particulate emissions during excavation, dredging, and vehicle movements. Noise and vibration generated from construction activities will also affect the area.

Toxic emissions from asphalt plants and particulate matter from concrete mixing plants will also pose an environmental and health hazard.

Ecology: This area has more vegetation than most areas in Colombo District, but it is from home gardens.

<u>Operational Stage</u>

Accident Risk: Improving the road will lead to additional traffic which may increase the risk of accidents. However, widening the road will improve safety overall and, therefore, no increases in accidents are expected.

Air Quality/Noise: There will be additional air pollution from vehicles on the improved road, but widening should reduce congestion, thus reducing vehicle emissions. There are no sensitive facilities along this road.

(5) Thalawatugoda-Koskadwila Road Widening

Present Condition of Project Site

The road stretches from Thalawathugoda in Maharagama DS Division to Hokandara in Kaduwela DS Division and it traverses semi-urban areas. The land values in this area are not very high and the facilities are mainly residential. The population is mainly Sinhalese and Buddhists and 80% are medium-income, with the rest being high-income. The area has piped water, electricity, and telecommunications, although some residencies use well-water. About 20% of the residences have home gardens including vegetation such as coconut, king coconut, jackfruit, and bread fruit. Paddy fields are also present. Some of the area is flood prone, but there are no other natural hazards in this area.

Anticipated Negative Impacts and Mitigation Measures

<u>Pre-Construction Stage</u>

Land Acquisition: An approximate estimate of required land acquisition according to the Western Province RDA is given in Appendix 27. The results show that 151 properties will be affected but the negative impacts caused by the land acquisition will be not significant because most of them will be necessary to remove only their walls.

<u>Construction Stage</u>

Utility Relocation: Existing utility infrastructure such as telephone and power lines, as well as some water supply lines, will need to be relocated. This will cause short-term but significant inconvenience to the community.

Road Blockage: Construction related activities will require road blocks and traffic diversions which will cause delays and inconvenience road users. Since the existing road is narrow, it may be difficult to manage traffic flows during construction.

Social Conflicts: If construction workers are from other areas they may have conflicts with local communities.

Degradation of Water Quality: Waste from workers may be disposed of haphazardly, which can reduce water quality. Construction, excavation, and dredging can also create runoff which will pollute surface water in the canals.

Solid Waste: Construction waste disposal may be problematic since solid waste management in the area is already overburdened.

Degradation of Air Quality and Increased Noise and Vibration: Site clearing activities will affect air quality due to dust and particulate emissions during excavation, dredging, and vehicle movements. Noise and vibration generated from construction activities will also affect the area. Toxic emissions from asphalt plants and particulate matter from concrete mixing plants will also pose an environmental and health hazard.

Ecology: Vegetation is minimal except in the home gardens, some of which will need to be removed and replanted.

Operational Stage

Accident Risk: Improving the road will lead to additional traffic which may increase the risk of accidents. However, widening the road will improve safety and therefore, no overall increases in accidents are expected.

Air Quality/Noise: There will be additional air pollution from vehicles on the improved road, but widening should reduce congestion, thus reducing vehicle emissions. There are no sensitive facilities along this road.

(6) Pannipitiya-Tumbowil Road Widening

Present Condition of Project Site

The road stretches from Pannipitiya in Maharagama DS Division to Bokundara in Kesbewa DS Division traversing semi-urban areas. There is no traffic control at Pannipitiya Junction. The land values in this area are relatively low and about 70% of the developments are residential, 20% are commercial, and 10% are agricultural, including home gardens. The population is primarily Sinhalese and Buddhists and they are mainly middle-income. Most of the area has piped water, electricity, and telecommunications, although some use well-water. There are many residences have home gardens including vegetation such as coconut, king coconut, jackfruit, and bread fruit. Paddy fields are also present. Some of the area is flood prone, but there are no other natural hazards in this area.

Anticipated Negative Impacts and Mitigation Measures

Pre-Construction Stage

Land Acquisition: Western Province RDA approximated the required acquisitions as indicated in Appendix 27. The results show that 307 properties will be affected but the negative impacts caused by the land acquisition will be not significant because most of them will be necessary to remove only their walls.

Construction Stage

Utility Relocation: Existing utility infrastructure such as telephone and power lines, as well as some water supply lines, will need to be relocated. This will cause short-term but significant inconvenience to the community.

Road Blockage: Construction related activities will require road blocks and traffic diversions which will cause delays and inconvenience road users. This is significant due to the narrowness of the existing road.

Social Conflicts: Construction workers might have conflicts with local communities.

Degradation of Water Quality: Waste from workers may be disposed of haphazardly, which can reduce water quality. Construction, excavation, and dredging can also create runoff which will pollute surface water in the canals. This is especially relevant during the rainy season as the canals flood easily.

Solid Waste: Construction waste disposal may be problematic since solid waste management in the area is already overburdened.

Degradation of Air Quality and Increased Noise and Vibration: Site clearing activities will affect air quality due to dust and particulate emissions during excavation, dredging, and vehicle movements. Noise and vibration generated from construction activities will also affect the area, especially near the temples and school. Toxic emissions from asphalt plants and particulate matter from concrete mixing plants will also pose an environmental and health hazard.

Ecology: Vegetation is minimal except in the home gardens, some of which will need to be removed and replanted.

Operational Stage

Accident Risk: Improving the road will lead to additional traffic which may increase the risk of accidents. This should be a concern around the schools. However, widening/rehabilitating the road will improve safety and therefore, no overall increases in accidents are expected.

Air Quality/Noise: There will be additional air pollution from vehicles on the improved road, but widening should reduce congestion, thus reducing vehicle emissions. There are no sensitive facilities along this road.

(7) Orugodawatte Flyover (Baseline Road)

Present Condition of Project Site

Orugodawatte Junction is a very important as it crosses Colombo-Avissawella Road at grade level on Baseline Road. It is a main thoroughfare in Colombo District and passes through Kollonnawa, Borella North, Borella South, Thimbirigasyaya, and Kirulapone DS divisions which are all highly developed urban areas. The population is mainly Sinhalese and Buddhist. Kelanitissa Power Station is the most important facility closest to the intersection, but it is not near the area affected by the project. Other buildings of significance in the vicinity include a fuel station 100 meters from the Power Station and a school 150 meters from the power station. There is a Bo tree near the junction, which is a sacred tree in Buddhism.

Anticipated Negative Impacts and Mitigation Measures

Pre-Construction Stage

Land Acquisition: Construction of the flyover will require approximately an area six meters wide and 350 meters long on each side of the alignment for service roads. The Study Team conducted an inventory survey on the affected properties as shown in Appendix 27. The results show that the negative impacts caused by the land acquisition will be not significant because there are only 32 affected structures consisting of about 90% of commercial building.

Construction Stage

Road Blockage: Construction related activities will require road blocks and traffic diversions which will cause delays and inconvenience road users. This is of great concern since Baseline Road is heavily traveled.

Social Conflicts: Construction workers might have conflicts with local communities, although as there are few residential facilities in the area, this is not a large concern.

Degradation of Water Quality: Waste from workers and temporary camps (if necessary) may be disposed of haphazardly, which can reduce water quality. Construction, excavation, and dredging can also create runoff which will pollute surface water in the canals. This is especially relevant during the rainy season as the canals flood easily.

Degradation of Air Quality and Increased Noise and Vibration: Site clearing activities will affect air quality due to dust and particulate emissions during excavation, dredging, and vehicle movements. Noise and vibration generated from construction activities will also affect the area. Toxic emissions from asphalt plants and particulate matter from concrete mixing plants will also pose an environmental and health hazard.

Ecology: The area is a highly developed area with minimal natural habitats or vegetation, except for the Bo tree near the junction. The flyover alignment will encroach on the canopy of the tree.

Operational Stage

Accident Risk: The road network is already well developed and the flyover will not dramatically increase the traffic. Residents in the area are used to heavy traffic. The flyover is expected to reduce traffic loads on the main road and therefore there should not be any increase in the risks of accidents.

Air Quality/Noise: Air pollution is not a major concern since there are not many high-rise buildings or sensitive facilities such as schools or hospitals. Therefore, the operational phase impacts will be minimal.

(8) Borella-Kanatta Flyover

Present Condition of Project Site

The relevant crossroads are Rajagiriya-Bambalapitiya Road, D.S. Senanayaka Road, and Old Boralla-Rajagiriya Road. Many buildings exist at the junctions and most buildings are commercial.

- Borella Wesley College Junction is an extremely congested junction with *Kannangara Maha Vidyalaya*, a school, and *Lady Ridgeway Hospital for Children*, which is the biggest children's hospital in the country and draws a large number of patients and visitors daily. The school is a complex consisting of a primary, junior high, and high school.
- D.S Senanayke Mawatha Junction is also very congested junction, although has signalized traffic control. There is a fuel station adjacent to the junction.
- Cemetery Junction (Baudhaloka Mawatha Junction) also is extremely congested and has signalized traffic control. Prior to the junction, there is a roundabout with three large Acacia trees about 25 meters high. The roundabout is a landmark and has aesthetic and sentimental value to nearby residents. The Boralla-Kanatha Junction borders the Borella Cemetery which is the main cemetery in Colombo. This means that land acquisition near the cemetery may not be possible.

Anticipated Negative Impacts and Mitigation Measures

<u>Pre-Construction Stage</u>

Land Acquisition: Construction of the flyover will require approximately an area six meters wide and 350 meters long on each side of the alignment for service roads. The Study Team conducted an affected property inventory and the result was 188 properties consisting of about 90% of commercial building will be affected, as shown in Appendix 27. The negative impact caused by the project will be highly significant because of not only the large number of the affected properties but also the difficulty of providing same business opportunities at resettled areas.

<u>Construction Stage</u>

Road Blockage: Construction related activities will require road blocks and traffic diversions which will cause delays and inconvenience road users. This is of great concern since this is a central location with key developments like the cemetery, two schools, and the hospital.

Social Conflicts: As there are few residential developments, conflicts between workers and the local residents should not be much of an issue.

Degradation of Water Quality: Waste from workers and temporary camps (if necessary) may be disposed of haphazardly, which can reduce water quality. Construction, excavation, and dredging can also create runoff which will pollute storm water in the canals. Even though there are no bodies of surfaces water near the project site, polluted drainage in the canals will ultimately affect surface water. Runoff from asphalt and concrete mixing plants will also be detrimental.

Degradation of Air Quality and Increased Noise and Vibration: Site clearing activities will affect air quality due to dust and particulate emissions during excavation, dredging, and vehicle movements, especially those carrying uncovered raw materials. Noise and vibration generated from construction activities and workers camps will also affect the area, especially the sensitive areas near the school, hospital, and cemetery. Toxic emissions from asphalt plants and particulate matter from concrete mixing plants will also pose an environmental and health hazard.

Ecology: The area is a highly developed area with minimal natural habitats or vegetation. However, the three large Acacia trees in the roundabout near the cemetery junction have been there for many years and serve as a significant landmark. Construction of the flyover will require pruning the tree branches.

Operational Stage

Accident Risk: The road network in the area is already in place and well developed. The flyover is not expected to attract new traffic to the area, but in any case residents and other road users are used to heavy traffic. The flyover is expected to reduce the traffic load on the main road and therefore, there should not be any increase in the risk of accidents.

Air Quality/Noise: There are two schools and a hospital which would be very disturbed by the noise from the flyover. Vehicle emissions and particulate matter released from the vehicles using the flyover will also cause significant health concern since the schools and most of the buildings adjacent to the road are high risers.

(9) Kohuwala Flyover

Present Condition of Project Site

The intersection is located along Colombo-Horana Road, which traverses Thimbirigasyaya, Pamankada, Kirulapone, Kohuwala, Pepiliyana, Raththanapitiya, Boralasgamuwa, Piliyandala, Kesbawa, Kahathduwa, and Polgasowita. Those areas between Polgasowita and Horana are in Kalutara District while the others are in Colombo District. The population is mainly Sinhalese and Buddhist. In Thimbirigasyaya, Pamankada, Kirulapone, Kohuwala and Pepiliyana the land values are quite high, which correspond to the high-income population in the area. Literacy rates are also high in these areas.

Land use along the corridor is mixed with both commercial and residential developments along both sides of the road. From Colombo to Papiliyana there is negligible vegetation. From Papiliyana to Horana the only vegetation is found in home gardens with trees such as jackfruit, bread fruit, coconut, and mango. From Raththanpitiya on there are also paddy fields.

Kohuwala Junction is highly urbanized and commercialized with no significant vegetation. The intersection has heavy traffic with a roundabout and no signalized traffic control. 100% of the facilities are commercial facilities. Approaching from Colombo, prior to the intersection there is the Kohuwala Police station. After the intersection is a fuel station and near the intersection is the Kohuwala Cemetery.

Anticipated Negative Impacts and Mitigation Measures

Pre-Construction Stage

Land Acquisition: Construction of the flyover will require approximately an area six meters wide and 350 meters long on each side of the alignment for service roads. The Study Team conducted inventory survey on the affected properties and the result showed that 75 properties consisting of about 70% of commercial building will be affected as shown in Appendix 27. The negative impacts of land acquisition will be considered moderately significant considering the amount of the affected properties.

Construction Stage

Utility Relocation: Existing utility infrastructure such as telephone and power lines, as well as some water supply lines, will need to be relocated. This will cause short-term but significant inconvenience to the community.

Road Blockage: Construction related activities will require road blocks and traffic diversions which will cause delays and inconvenience road users. This is of great concern during peak periods as traffic is already quite heavy. Construction activities will also obstruct access to the police station and cemetery.

Social Conflicts: Construction workers may be a nuisance to the local community, but as the area is highly commercialized, problems should be minimal.

Degradation of Water Quality: Waste from workers and temporary camps (if necessary) may be disposed of haphazardly, which can reduce water quality. Construction, excavation, and dredging can also create runoff which will pollute storm water in the canals, which will ultimately affect surface water. Runoff from asphalt and concrete mixing plants will also be detrimental.

Degradation of Air Quality and Increased Noise and Vibration: Site clearing activities will affect air quality due to dust and particulate emissions during excavation, dredging, and vehicle movements, especially those carrying uncovered raw materials. Noise and vibration generated from construction activities and workers camps will also affect the area. Toxic emissions from asphalt plants and particulate matter from concrete mixing plants will also pose an environmental and health hazard.

Solid Waste: Construction waste will create disposal concerns since the solid waste collection service in the area is limited.

Ecology: The area is a highly developed area with minimal natural habitats or vegetation and therefore, there will be no impact on natural vegetation, bio-diversity, or rare and endangered species.

Operational Stage

Accident Risk: One of the intended outcomes of the flyover is to reduce congestion on the road, which will likely attract drivers to this road from alternatives. However, it is not expected that this increase will be substantial. Additionally, local residents and workers are used to heavy traffic, so a significant increase in accidents is not expected. Therefore, operational phase impacts are projected to be minimal.

(10) Armour Street Flyover

Present Condition of Project Site

Armour Street Junction is in Colombo DS Division of Colombo District. The majority of residents are Sinhalese and Buddhist. The area is highly commercialized with few residences. The area has minimal vegetation due to its highly developed nature and there are no bodies of water in the vicinity of the junction. The area has no known natural resources and is not prone to natural disasters. The junction has signalized traffic control as heavy traffic is common. Panchikawatte is famous for its used auto parts stores and part of the congestion is attributed to the stores' clientele. The junction is mainly commercial in nature, although when considering the residents, 80% are high-income and the remainder is middle-income. Piped water, electricity, and telecommunication facilities are available in the area, although not for all the households.

Anticipated Negative Impacts and Mitigation Measures

Pre-Construction Stage

Land Acquisition: Construction of the flyover will require approximately an area six meters wide and 350 meters long on each side of the alignment for service roads. The Study Team conducted an inventory survey on the affected properties and results show 126 properties consisting of about 97% of commercial building will be affected as shown in Appendix 27. The negative impact caused by the project will be highly significant because of not only the large number of the affected properties but also the difficulty of providing same business opportunities at resettled areas.

Construction Stage

Road Blockage: As Panchikawatte Junction is already heavily congested, further blocking the roads for construction activities will cause greater road congestion.

Degradation of Water Quality: Waste from workers and temporary camps (if necessary) may be disposed of haphazardly, which can reduce water quality. Construction, excavation, and dredging can also create runoff which will pollute storm water in the canals, which will ultimately affect surface water. Runoff from asphalt and concrete mixing plants will also be detrimental.

Social Conflicts: Temporary on-site workers will only be a minor nuisance factor since it is already full of commuters from various parts of the country.

Degradation of Air Quality and Increased Noise and Vibration: During the construction phase, emissions from dust and particulate matter can be a significant issue to workers, residents and commuters. Mainly those shop owners and employees who work during the day will be affected. Asphalt and concrete mixing plants also emit toxic gases leading to health hazards.

Ecology: The area is a highly developed area with minimal natural habitation or vegetation and therefore, there will be no impact on ecological aspects of the environment.

Operational Stage

Accident Risk: This flyover is not expected to cause much increase in traffic, so the risk of increased accidents is minimal.

Air Quality/Noise: Vehicle emissions from the vehicles on the flyover may affect residents of high rises, but there are very few such buildings in the area so the overall risk is low.

(11) Kelaniya Railway Flyover

Present Condition of Project Site

Kelaniya Railway Crossing Junction is located in Kelaniya GN division of Kelaniya DS Division in Gampaha District. The GN Division population is mainly Sinhalese and Buddhist. This are has no significant vegetation. The junction is close to the Kelaniya River, which is used for sand mining, but there are no other significant natural resources. While some of the immediate areas are flood prone, there are no other natural hazards recorded from this area. Piped water, electricity and telecommunications facilities are available in the area, although not for all the households. The junction has no traffic control. About 80% of the development is commercial, although beyond the junction there is a Buddhist Temple and school for priests. There are squatters living along the railway right-of-way.

Anticipated Negative Impacts and Mitigation Measures

Pre-Construction Stage

Land Acquisition: Construction of the flyover will require approximately an area six meters wide and 350 meters long on each side of the alignment for service roads. The Study Team conducted inventory survey on the affected properties and the results show 77 properties consisting of about 75% of commercial building affected as shown in Appendix 27. The negative impacts of land acquisition will be considered moderately significant considering the amount of the affected properties.

Construction Phase

Utility Relocation: Existing utility infrastructure such as telephone and power lines, as well as some water supply lines, will need to be relocated. This will cause short-term but significant inconvenience to the community.

Road Blockage: Construction activities will impede traffic flow on this road as well as rail traffic, since the railway crosses the road at grade.

Safety: Worker safety is an issue due to the proximity of the railway.

Degradation of Water Quality: Waste from workers and temporary camps (if necessary) may be disposed of haphazardly, which can reduce water quality. Construction, excavation, and dredging can also create runoff which will pollute storm water in the canals, which will ultimately affect surface water. Runoff from asphalt and concrete mixing plants will also be detrimental.

Social Conflicts: Temporary on-site workers may cause problems for the local community. Activities at the Buddhist Institute may be impeded due to overall noise.

Solid Waste: Managing disposal of construction debris may be problematic as solid waste management by the local authority is overburdened.

Degradation of Air Quality and Increased Noise and Vibration: Site clearing activities will affect air quality due to dust and particulate emissions during excavation, dredging, and vehicle movements, especially those carrying uncovered raw materials. Noise and vibration generated from construction activities and workers camps will also affect the area, especially the Buddhist Institute. Toxic emissions from asphalt plants and particulate matter from concrete mixing plants will also pose an environmental and health hazard.

Ecology: Remaining natural habitats and vegetation is rather limited and therefore, there will be minimal impact on the ecological aspects of the environment.

Operational Stage

Accident Risk: Presently, pedestrians, private bus drivers, and three-wheelers use the road unsafely and pedestrian facilities are minimal. Therefore, safety measures should be undertaken or the accidents risk will increase.

Air Quality/Noise: Vehicle emissions from the vehicles on the flyover will affect users of some commercial multi-story buildings in the area. The Buddhist Institute will also be affected to a certain degree by these emissions since it is located adjacent to the flyover. Noise generated from the vehicles using the flyover will have a significant impact on the Buddhist Institute, as a quiet environment is needed.

(12) Rajagiriya Flyover

Present Condition of Project Site

Rajagiriya GN Division is in Sri Jayawardenepura Kotte DS Division. The land values in this area are very high and the population is mainly Sinhalese and Buddhists. The literacy rate in the area is high, with incomes in the middle to high range. Piped water, electricity, and telecommunications infrastructure is available. There is no vegetation of any kind at the intersection, except for some greenery in the children’s park adjacent to the intersection. Rajagiriya Intersection is highly commercialized and has heavy traffic flows. Beyond the children’s park, the Kotte Municipal Council is housed. There is a home for the elderly along the road, which has a Bo tree on the property.

Anticipated Negative Impacts and Mitigation Measures

Pre-Construction Stage

Land Acquisition: Construction of the flyover will require approximately an area six meters wide and 350 meters long on each side of the alignment for service roads. The Study Team conducted an inventory survey on the affected properties and the results show 46 properties consisting of about 60% of commercial building will be affected as shown in Appendix 27. The negative impacts of land acquisition will be considered moderately significant considering the amount of the affected properties.

Construction Stage

Utility Relocation: Existing utility infrastructure such as telephone and power lines, as well as some water supply lines, will need to be relocated. This will cause short-term but significant inconvenience to the community.

Road Blockage: Rajagiriya Junction is an extremely congested intersection due to heavy traffic flows along Parliament Road. Therefore, during construction there will be severe road blocks.

Degradation of Water Quality: Waste from workers and temporary camps (if necessary) may be disposed of haphazardly, which can reduce water quality. Construction, excavation, and dredging can also create runoff which will pollute storm water in the canals, which will ultimately affect surface water. Runoff from asphalt and concrete mixing plants will also be detrimental.

Social Conflict: Temporary on-site workers may be a nuisance to the local community and shopkeepers.

Solid Waste: Managing the disposal of construction debris can be problematic.

Degradation of Air Quality and Increased Noise and Vibration: Site clearing activities will affect air quality due to dust and particulate emissions during excavation, dredging, and vehicle movements, especially those carrying uncovered raw materials. Noise and vibration generated from construction activities and workers camps will also affect the area. Toxic emissions from asphalt plants and particulate matter from concrete mixing plants will also pose an environmental and health hazard.

Ecology: The area is a highly developed area with minimal natural habitation or vegetation and therefore, there will be no impact on the ecological aspects of the environment. The alignment of the flyover might encroach on the elderly facility and therefore attention should be paid to minimize impacts on the facility and the Bo tree.

<u>Operational Stage</u>

Accident Risk: It is envisaged that there will be an increase in traffic due to the improvements and unless proper measures are taken, it is possible that the increased traffic will result in an increase in accidents.

Air Quality/Noise: Emissions from vehicles using the interchange will affect residents of some of the multi-story buildings in the vicinity.

24.3 Summary and Recommendations

(1) Evaluation of Overall Project Feasibility

The information on the negative environmental impacts caused by the each project could be summarized as shown in **Table 24.2** based on the project components and the outline of current condition of each project site. The negative environmental impact parameters consist of the following: (i) impacts on land acquisition/resettlement; (ii) natural environment impacts; and (iii) social environment impacts.

The magnitude of each project’s environmental impacts was evaluated based on information obtained during the study. Land acquisition and resettlement is a major constraint of road development projects. Under Sri Lanka’s National Environmental Act (NEA) with regards to road projects, an environmental impact assessment (EIA) is required if more than 100 families must be relocated. Therefore, the impacts of a project requiring the relocation of more than 100 families are considered *highly significant*; impacts of a project requiring somewhat less than 100 families are considered *moderately significant*; and project impacts requiring the relocation of far below 100 families are considered *insignificant*.

With regard to the natural and social environment, a project having serious negative impacts is considered *highly significant*; a project having minor negative impacts is considered *moderately significant*; and a project having minimal negative impacts is considered *insignificant*.

Based on the above, overall project feasibility was evaluated as (i) *highly feasible* meaning that the project should cause no serious or irreversible negative environmental or social impacts; (ii) *feasible* meaning that the project may have some negative environmental or social impacts, but they can be alleviated through mitigation measures; and (iii) *not recommended*, meaning the project may cause irreversible negative environmental or social impacts or where effective and realistic mitigation measures do not exist.

The results of the overall evaluation are as shown in Table 24.2. There are six highly feasible projects and six feasible projects.

Table 24.1 Summary of Negative Impacts caused by the Projects

No.	Project	Land Acquisition and Resettlement	Environmental Impacts	Social Impacts
1	Marine Drive Extension	138 affected structures	Minimal on natural habitats or vegetation	Since the households appear to be well established and they will be much reluctant to be resettled, during the pre-construction stage there will be many social issues to handle while surveying and negotiating with land owners.
2	B152/ B425 Widening	99 affected structures	Minimal on natural habitats or vegetation	Minimal except those resulting from land acquisition
3	Nugegoda/Katiya Junction-Pepiliyana Road Widening	163 affected structures	Minimal on natural habitats or vegetation	Minimal except those resulting from land acquisition
4	Thalawatugoda-Pannipitiya Road Widening	169 affected structures	Minimal on natural habitats or vegetation	Minimal except those resulting from land acquisition
5	Thalawatugoda-Koskadwila Road Widening	151 affected structures but necessary to remove only their walls.	Minimal on natural habitats or vegetation	Minimal except those resulting from land acquisition
6	Pannipitiya-Tumbowil Road Widening	307 affected structures but necessary to remove only their walls.	Minimal on natural habitats or vegetation	Minimal except those resulting from land acquisition
7	Orugodawatta Flyover	only 32 affected structures	Minimal on natural habitats or vegetation	Minimal except those resulting from land acquisition
8	Borella-Kanata Flyover	188 affected structures	Minimal on natural habitats or vegetation	Difficulty in providing the same business opportunities at resettled areas
9	Kohuwala Flyover	75 affected structures	Minimal on natural habitats or vegetation	Difficulty in providing the same business opportunities at resettled areas
10	Armour Street Flyover	126 affected structures	Minimal on natural habitats or vegetation	Difficulty in providing the same business opportunities at resettled areas
11	Kelaniya Railway Flyover	77 affected structures	Minimal on natural habitats or vegetation	Difficulty in providing the same business opportunities at resettled areas
12	Rajagiriya Flyover	46 affected structures	Minimal on natural habitats or vegetation	Difficulty in providing the same business opportunities at resettled areas

Table 24.2 Results of Feasibility Evaluation for All Projects

No.	Project	Land Acquisition and Resettlement	Natural Impact	Social Impacts	Feasibility
1	Marine Drive Extension	✓✓✓	✓	✓✓	Feasible
2	B152/ B425 Widening	✓✓✓	✓	✓	Feasible
3	Nugegoda/Katiya Junction-Pepiliyana Road Widening	✓✓✓	✓	✓	Feasible
4	Thalawatugoda-Pannipitiya Road Widening	✓✓✓	✓	✓	Feasible
5	Thalawatugoda-Koskadwila Road Widening	✓	✓	✓	Highly Feasible
6	Pannipitiya-Tumbowil Road Widening	✓	✓	✓	Highly Feasible
7	Orugodawatta Flyover	✓	✓	✓	Highly Feasible
8	Borella-Kanata Flyover	✓✓✓	✓	✓✓	Feasible
9	Kohuwala Flyover	✓✓	✓	✓	Highly Feasible
10	Armour Street Flyover	✓✓✓	✓	✓	Feasible
11	Kelaniya Railway Flyover	✓✓	✓	✓	Highly Feasible
12	Rajagiriya Flyover	✓✓	✓	✓	Highly Feasible

Impact magnitude: ✓✓✓: Highly Significant ✓✓:Moderately Significant ✓ : Not Significant
Source: This Study

(2) Recommendations

Projects evaluated as *highly feasible* in terms of not only environmental aspects but also technical, financial/economical, and other relevant aspects should have a feasibility study and basic design undertaken with the ultimate goal of implementation. If this is undertaken, the following social and environmental actions must be conducted:

Environmental Compliance with National Environmental Act (NEA)

The National Environmental Act (NEA) No.47 (1980) is the basic national charter to protect and manage the Sri Lankan environment. Regulation No.5 emphasizes that project proponents should submit preliminary information (PI) to the Central Environmental Agency (CEA). RDA is therefore advised to start the EIA process for the projects evaluated as *highly feasible* as early in the project cycle as possible.

The NEA has identified two levels of EIA reports depending on the severity and significance of the anticipated impacts. The first level, an Initial Environmental Examination (IEE), is an investigation that assesses the possible impacts of a proposed project for their significance and identifies mitigation measures and recommendations. The second level, an EIA, is a more comprehensive assessment where alternatives to the proposed project are identified and the alternative with the least environmental impacts is assessed and mitigatory measures for this option are recommended.

Environmental scoping is the process by which projects undergo a preliminary assessment by the CEA to identify environmental impacts in order to determine whether the project requires an EIA or IEE and thereby define the scope of the study required.

According to the information of CEA, the process of the PI screening needs approximately one week. In the meantime, the periods for preparation of IEE and EIA report are one and half months and three-four months respectively.

Project Approval from Other Relevant Agencies

Apart from CEA approval, project approval from each agency mentioned below is necessary depending on the project locations and/or project components.

<u>Urban Development Authority (UDA) Approval</u>

Projects planned in urban areas require approval from UDA. To obtain approval, preliminary information (using UDA forms) must be submitted to UDA's Director of Enforcement. UDA guidelines for the project will then be given to the proponent. A copy of the guidelines and application will be forwarded to the concerned local authorities.

<u>Coastal Conservation Department (CCD) Approval</u>

If a project lies within a coastal zone, defined as 300 meters from the ocean, environmental clearance should be sought from the Coastal Conservation Department (CCD), rather than from the CEA. Upon submission of preliminary information, the necessary requirements will be outlined by the CCD.

Approval from the Local Authority

The relevant municipality has to be informed if a new project is to be implemented in its jurisdiction. A letter should be sent to the municipal commissioner who will forward it to the planning committee for their approval and guidelines. Previous experience shows that it is better to adhere to the existing street alignment as defined by the local authority so as to cause minimal land acquisition.

Involuntary Resettlement

It was revealed that all of the Pre-FS projects require some land acquisition and resettlement, although it varies among the projects. Necessary considerations on land acquisition for Pre-FS projects are as follows.

Resettlement Action Plan

According to the National Involuntary Resettlement Policy (NIRP), a comprehensive Resettlement Action Plan (RAP) is required where twenty or more families are affected. If less than twenty families are affected, a less detailed plan should be prepared. The content and level of detail required for a RAP will vary depending on the complexity of the project and magnitude of its effects. Where large numbers of people are displaced, a detailed RAP is required.

Considering that all the Pre-FS projects will affect more than twenty families, it is highly recommended that RDA consult with the Ministry of Land about the necessity of a RAP for the selected projects as early as possible.

Present Status of Land Acquisition Procedures for the Pre-FS Projects

As mentioned in above in section 24.2, land acquisition procedures have been already started in two projects, i.e. northern part of the Marine Drive extension and B152 Widening.

As for the extension of Marine Drive, ground surveys and negotiations for compensation cost have been completed. Payment of the compensation has been done for 75%. The demolition of properties started at the beginning of October 2006 and was finished by the end of that same month. According to the information of the Land Acquisition Department of RDA, which is responsible party for land acquisition, no environmental/social problems have yet been identified.

With regard to the B152 widening, ground survey has been started in the first 5 km stretch recently. Other activities including negotiation will be commenced after the completion of the ground survey. As in the extension of Marine Driver, no environmental/social problems have yet been identified.

Suggestions Based on the Experiences on Land Acquisition in Road Development Sri Lanka

Southern Transport Development Project (STDP) was the main road developments which involve involuntary resettlement in Sri Lanka. The delays in payment of compensation were one of the main constraints in land acquisition procedure for the project. The land acquisition procedure for the Outer Circular Highway Project (OCH), which has been under process in the section of southern 12km of OCH, has been improved based on the experiences of the STDP.

In the OCH, a new system will be created for paying the ex-gratia payment[1]. In the STDP, this payment was called as "LARC[2] payment" and the amount was determined in the discussion at LARC meetings. In the OCH, on the other hand, the payment amount is to be determined by the Chief Valuer, who is the head of the Valuation Department, and the LARC will decide only on the administrative matters.

The new system is expected to expedite the payment procedure, since the LARC meeting will be held only one time for each Affected Peoples (APs), and if there is no agreement by APs, those cases will be transferred to the Super LARC.

In order for the new system to work well, the Valuation Department of the Ministry of Land should show the transparent breakdown of the replacement costs in specific places in order to make a credible argument to the APs. In addition, the number of valuation officers and vehicles should be increased to expedite the payment procedure.

All the payments must be approved by the Chief Valuer. However, there may be another alternative, such as the designation of certain tasks to other officials in the Valuation Department, in order to expedite the payment procedure.

Stakeholder Meeting

RDA should hold stakeholder meetings to ensure that information about the proposed projects and their environmental implications are understood by the public. The meetings may include government officials, religious leaders, and representatives from non-government organizations. It is recommended that RDA prepare a concise packet of information to distribute to participants prior to gathering or be prepared to devote a considerable amount of time in the meetings to provide background information and to answer questions.

[1] Ex-gratia payment = the difference between the statutory compensation and the replacement cost
[2] Land Acquisition and Resettlement Committee

Chapter 25 Financing Options

25.1 Background and Objectives

The objective of this chapter is to examine trends in financing for the transport sector in Sri Lanka and to discuss potential funding mechanisms. Then, based on the findings of this examination, make suggestions for possible financial options for the high-priority projects proposed by the Study.

25.2 Recent Trends in Domestic Budget for Transport

(1) General

Table 25.1 indicates the expenditures by the major organizations responsible for the provision of transportation policy, services, and facilities in Sri Lanka between 2000 and 2005. Note that data sufficient for summarizing expenditures for the provincial councils was not available, but there are indications that it ranges from 10-12% of the total for the nation.

Table 25.1 Trends in Expenditures by Sri Lankan Transportation Entities

Unit: Rs. Millions

Entity[1]	2000		2001		2002		2003		2004		2005	
	Capital	Recur	Capital	Recur	Capital	Recur	Capital	Recur	Capital	Recur	Capital	Recur
SLR	6,243	2,685	4,673	3,020	1,666	3,328	1,437	3,383	2,307	4,350	2,663	5,511
SLCTB	3,514	616	207	947	171	1,448	219	1,577	185	2,841	3,862	1,285
DMT	16	62	23	155	21	183	27	171	70	242	20	50
NTC	3	22	2	25	2	29	0.466	29	13	34	32	49
MOT	1,180	1,274	451	1,433	1,066	1,299	906	476	312	2,540	813	1,225
MOH/ RDA	9,152	277	10,006	436	8,034	32	9,105	34	11,759	520	14,346	588
Total[2]	20,108	4,936	15,362	6,016	10,959	6,319	11,694	5,670	14,646	10,527	21,736	8,708
Grand Total	**25,044**		**21,379**		**17,279**		**17,365**		**25,174**		**30,444**	

Excluding the 2000 and 2001 data for the Provincial Councils, which is quoted from the November 2001 *Transport Sector Pilot Study* by PriceWaterhouseCooopers, data has been obtained directly from the entities listed in the table.

1) SLR: Sri Lanka Railways; SLCTB: Sri Lanka Central Transport Board; DMT: Dept. of Motor Traffic; NTC: National Transport Commission; MOT: Ministry of Transport; MOH: Ministry of Highways; RDA: Road Development Authority
2) Excludes Provincial Council data as it is insufficient.

As the above table indicates, between 2000 and 2004 there was essentially no increase in total expenditure for the transport sector (Rs.25.0 billion in 2000 and Rs.25.2 billion in 2004). In 2005, however, there was a relatively large increase in capital expenditures that pushed the total to 30.4 billion, which can probably be attributed to the effects of the tsunami. Note that during these six years total capital and recurrent spending accounted for approximately 69% and 31% of total expenditures, respectively, indicating that a large portion of Sri Lanka's transport sector budget is being utilized for development purposes. On average annually, about Rs.15.7 billion is spent on capital expenditures, with Rs.7.0 billion spent on recurrent expenditures, for a total of Rs.22.7 billion. This shows that capital expenditures are more than double recurrent expenditures.

In Table 25.2, the share of the total expenditures of the transport sector spent by each entity for 2000-05 is shown. As the table demonstrates, there are three organizations that account for the large majority of the expenditures: Sri Lanka Railways (SLR), which on average was responsible for about 30% of the total, and Ministry of Highways (MOH) and the Road Development Authority (RDA), which were responsible for about 47% of the total. This can be explained by the fact that these organizations are responsible for the construction and maintenance of much of the country's transportation infrastructure (i.e., the rail and national highway network). Together, these organizations accounted on average for 77% of all outlays. Note that the SLCTB and the MOT made up 12 and 10% of the all spending in the transport sector, with the DMT and the NTC comprising a small 1 and 0.1%, respectively.

Table 25.2 Share of Total Expenditure by Entity

Entity	2000	2001	2002	2003	2004	2005
SLR	35.6%	36.0%	28.9%	27.8%	26.4%	26.8%
SLCTB	16.5%	5.4%	9.4%	10.3%	12.0%	16.9%
DMT	0.3%	0.8%	1.2%	1.1%	1.2%	0.2%
NTC	0.1%	0.1%	0.2%	0.2%	0.2%	0.3%
MOT	9.8%	8.8%	13.7%	8.0%	11.3%	6.7%
MOH/RDA	37.6%	48.8%	46.7%	52.6%	48.8%	49.1%

(2) National Roads

RDA is responsible for the construction and maintenance of the national road network, which consists of Class A and Class B roads totaling slightly more than 12,000 km in length. Although more than 40% of the money spent in the transport sector is by MOH/RDA, this is not reflected in the state of its roads. As Table 25.3 indicates, as of the year 2005, 35% of RDA's roads were in poor condition and only 14% are in good condition. This seems to suggest that the current level of expenditure on maintenance is insufficient for the proper upkeep of the national highway network.

Table 25.3 Condition of RDA Roads (2005)

Type of Road	Road Condition		
	Good	Fair	Poor
Class A	9%	21%	13%
Class B	5%	30%	22%

Source: RDA Dept. of Planning

(3) Western Province Roads

Management of Western Province's roads, like all provincial roads, is the responsibility of the Provincial Road Development Authority (PRDA). According to the PRDA of Western Province (WPRDA), there is insufficient funding to maintain the 1922 km of roads that come under its jurisdiction.[1] In fact, as Table 25.4 illustrates, 35% of all Class C and D roads are in poor condition and only 20% are in good condition.

Table 25.4 Condition of WPRDA Roads (2005)

Type of Road	Road Condition		
	Good	Fair	Poor
Provincial Roads (Class C & D)	20%	45%	35%

Source: WPRDA

[1] The Central Bank of Sri Lanka states in its *2005 Annual Report* that the lack of funds is more severe at the provincial and local government levels than at the national level, which has resulted in a low level of rural and provincial road maintenance.

(4) Colombo Municipal Council Roads

Like the previous two entities, Colombo Municipal Council (CMC) also claims that its budget is woefully inadequate to meet the needs of maintaining its 480-km road network in proper condition. For the year 2005, 30% of CMC's road network was in poor condition and 20% in good condition (see Table 25.5).

Table 25.5 Condition of CMC Roads (2005)

Type of Road	Road Condition		
	Good	Fair	Poor
CMC Roads	20%	50%	30%

Source: CMC Traffic and Design Division

The preceding seems to indicate that funding for road maintenance at all levels (national, provincial, and municipal) is insufficient and needs to be increased. This is not easy to do and could perhaps be done by reducing capital expenditures, but this could result in adverse impacts on national development. Of course, foreign donor funding is also a possibility and is discussed below, but according to one source already over one half of total expenditure on highways is financed this way and it might be difficult to increase this share by any more.[2]

(5) Public Transport

Public transport is regulated, managed, and operated by several agencies, including the private sector. In addition to state financing of public transportation, there is a large level of investment from private sector bus operators and owners of other modes of public transportation, such as taxis, vans and three-wheelers. Private sector financing and investment are extremely difficult to ascertain, due to the individual nature of ownership, and is not considered here, although as indicated in Chapter 7, the size of private sector investment is indeed quite large.[3] The private sector receives no subsidy from the Government to provide traditional bus services.[4,5]

With regards to the public bus operator, SLTB, it receives 12% of the transport sector budget (see Table 25.2), but according to the Central Bank, SLTB operates at a large loss and is heavily dependent on government assistance. The Bank further indicates that the major weaknesses of SLTB is a shortage of operational buses, deteriorating revenue, an excessive staff, poor management, inadequate working capital, and low investment.

SLR, which is also publicly operated, is also heavily dependent on government subsidies for both capital and recurrent expenses. Despite receiving an average of 30% of total transport sector expenditures, the railway only comprises 5% of Sri Lanka's passenger-kilometers. In 2005, SLR had capital expenditures of Rs. 2.663 billion and recurrent expenditures of Rs. 5.511

[2] *Transport Sector Pilot Study- Issues Paper*, Public Sector Expenditure Management System (PEMS) Project PriceWaterhouseCoopers, November 2001

[3] See Chapter 7 of this Report. For example, 71.5% of passenger-kilometers in Western Province are provided by the private sector, with the rest provided by the public sector (SLTB)

[4] They are supposed to receive a subsidy for providing school transport services, as per the NTC contract outlined in Chapters 7 and 14, although currently this is not the case.

[5] According to a 2003 study carried out in Colombo that was sponsored by the UK's Dept. for International Development (DFID), the profit margin for private buses is very thin and the Government is not prepared to offer incentives to them in terms of fuel quotas or spare parts without levying taxes etc. This study recommended that either concessions be given to private bus owners or that they be allowed to increase bus fares.

billion. This accounts for 12.25% and 64.25% of total transport sector expenditures for capital and recurring costs, respectively.[6]

As the Study indicates, there are multiple challenges facing public transport. Although increased spending may be necessary in certain cases, there is also a strong need for improving management, implementing reforms, and promoting progressive practices in SLR and SLTB to reduce the burden on government finances and provide value-for-money services. Unfortunately, previous attempts to improve the public transport sector through reforms have been met with resistance or external influences, thus creating a lack of interest to invest by the private sector and external donors.

25.3 Recent Trends in External Funding for Transport

Table 25.6 shows the external funding provided for the transport sector from 2001-05. Note that the main donors consist of the Asian Development Bank (ADB), the Japan Bank for International Cooperation (JBIC), and the World Bank.

Table 25.6 External Funding for Transport by Year

Year	Amount of External Funding (US$ Millions)
2001	167.37
2002	10.01
2003	160.09
2004	27.22
2005	16.74
Total	381.43
Average	76.29

Source: External Resources Dept., Ministry of Finance and Planning

As the above table indicates, the variation in external funding for the transport sector is large, with US$160.1 million provided in 2003 and only US$10.0 million in 2002. The total funds committed by external sources from 2001-05 equaled about US$381.4 million (Rs.39.2 billion), while on average the annual amount available from external sources was about US$76.3 million (Rs.7.8 billion). Note that the total amount of external funding is equivalent to 52.7% of the total capital expenditure (Rs.74.4 billion) for Sri Lanka's transport sector for the same period.

The thinking of Sri Lanka's main sources of external funding regarding future investment in its transport sector is described in Table 25.7.

Table 25.7 Donor Thinking in Regards to Sri Lanka's Transport Sector

Issue	WB	ADB	JBIC
Overall Strategy	Country Assistance Strategy is prepared every three years and gives guidance on a sector-by-sector basis for development assistance purposes. Sector interests have been changing as can be seen by the different priorities of the WB's	A Country Strategy Program (CSP) is available and gives guidance on a sector-by-sector basis. The CSP is upgraded each year for three-year periods. However, there are indicative areas in which ADB will respond to when sector assistance is considered.	There is no country strategy preparation similar to the WB and ADB, but the indicative sector interests of JBIC have been made known to the Government of Sri Lanka (GoSL), and GoSL investment priorities are given due consideration in providing assistance, which is a cooperative

[6] Recurrent expenditures for SLTB and SLR are based largely on excessive staff levels, which remain due to the strength of the trade unions. The government has undertaken numerous negotiations with the unions, but no substantial progress has been made and the situation continues to deteriorate.

	transport sector now (rural transport) and in earlier times (urban transport).		exercise undertaken by the GoSL and JBIC on a continuous basis.
Transport Sector	Currently not much involvement is observed in the urban Transport Sector.	Minimal involvement has been observed in the railway transport sector. Although ADB is not asking for privatization of railways, it is demanding management improvement through efficient and effective strategies. On the other hand, ADB is heavily involved in the road sector (e.g., Road Sector Master Plan, Southern Highway Construction, etc.)	Rolling plans are acceptable for implementation of transport sector projects. Current interests in the transport sector in Sri Lanka are limited to roads, ports and air transport. There was interest in Sri Lanka's railways in the past but this has disappeared. In regards to roads, JBIC is very active and is involved in the Southern Highway Construction and the planning of the Outer Circular Highway (OCH). It is also interested in the Baseline extension.
Colombo and Urban Area Investment	It is unlikely that the Colombo Metropolitan Region (CMR) would become an area of investment priority in the near future. Current programs are supportive of other regions, as urban transport is not a priority.	An Urban Transport Strategy Improvement study is underway, and its recommendations are to be implemented in 2007. Colombo and other cities will be considered for assistance based on the study's recommendations.	JBIC is open to considering urban transport development and its involvement in the OCH, area traffic control, policy recommendations on urban private bus management, etc. are indicative of this.
Private Sector Participation	Public Private Partnerships (PPPs) are established and equity support to the GoSL given on specific projects. Private sector lending is undertaken by the International Finance Corporation (IFC).	PPP for public transport (i.e. buses) was previously prepared by ADB but did not materialize, as there were conflicts between the clients and consultants. However, ADB offered US$40 million for developing the Colombo-Katunayake Expressway via a PPP initiative. Any feasible project to be implemented by the private sector is open for lending from ADB. Note that no government guarantee is required for such a commitment, as can be seen in the case of the Colombo Port Development Project (P& O Project), in which ADB invested equity capital and the Colombo Representative of ADB sits as a member of the Board of Directors. At present, PPP for Highways is under study by a team of consultants from India working in liaison with RDA. Note that ADB is also considering applying remaining TA funds for developing a bus franchising scheme and pricing mechanism for the BRT	PPP is not an instrument utilized in JBIC. However, private sector lending via the International Finance Department (IFD) from which export credit is given is possible. Note that direct investment is undertaken by the Corporate Finance Department of the IFD, with project finance managed by its Project Finance Department.

		proposed in this Study.	
Borrowing Agencies[1)]	WB has in the past provided funding to both national agencies as well as to provincial councils, and there is no problem in having entities at either of these levels act as an Executing Agency. At lower levels of government (Local Authorities), it is possible for them to be Implementation Agencies.	Like the WB, ADB has had national agencies and provincial councils act either as Executing or Implementation Agencies, with lower levels of government sometimes acting as Implementation Agencies.	Lending in the past for the transport sector has gone to agencies connected to the Central Government, such as the RDA, SLR, etc. However, there are now plans to involve provincial and municipal councils as project execution or implementation units via programs such as SIRUP. Note that in the field of health care, this is already being done.

1) Lending to the Ministry of Defense is not possible for any of the above-mentioned international donors. It should be possible to lend to the Police, but the current situation would most likely have to be considered.

25.4 Need for Alternative Funding Mechanisms

(1) General

Public sector investment in roads and highways remained a low priority until the early 1990s. Following the introduction of open economic policies in the late 1970s, the priority of government spending was primarily on irrigation development, hydropower, domestic agriculture and industry. However, due to low economic growth, widespread poverty, and rising unemployment particularly among the youth, a new development strategy to stimulate higher economic growth became the top priority of the Government. Unfortunately, roads were not initially considered an important priority for realizing this goal. In addition, there was also no agency responsible for road maintenance, rehabilitation or reconstruction.

Prior to the early 1990s roads were managed by the Ministry of Transport. However, this ministry had limited interest in the maintenance and rehabilitation of roads, since its main responsibility was to prepare overall transport policy and facilities for the general public. Although the Ministry attended to minor repairs and the maintenance of national highways, there were no large-scale investments for rehabilitation or for constructing roads or highways to keep up with the increasing demand for network expansion or improved road conditions. With very limited investment in the road sector, the standard of most national roads as well as provincial roads continued to deteriorate. With increasing vehicle population and the rising use of the existing roads, road congestion became a major problem that resulted in travel delays and higher vehicle operating costs. By the early 1990s, the entire road network (i.e., national, provincial, and local roads) was in need of upgrading and rehabilitation due to long-term negligence. In particular, the prolonged neglect of road maintenance resulted in heavy expenditures for rehabilitation.

The creation of the Road Development Authority (RDA) to maintain and construct national highways in 1986 was the first step towards formalizing direct investment in the road sector in the early 1990s. In 1996, it designed the first two major highways: the Colombo-Matara Highway and the Colombo-Katunayka Expressway. In addition, it was also given the responsibility of maintaining the nation's bridges, which number about 4,200.

With the devolution of power in 1988, the maintenance of all provincial roads was handed over to the Provincial Councils while local roads became the responsibility of the Local Authorities. Note that although the management of roads has been distributed among different government agencies, funding for all roads still comes from one source (i.e., the Central Government). Ultimately, the development of new roads or improvement of existing roads remains the responsibility of the Central Government. RDA's allocation for road investment is provided directly in the annual budget, while the investment requirements of provincial and local roads are transferred to the relevant authorities from the annual budget via the Finance Commission with the consent of the Ministry of Provincial Councils.

Since the mid-1990s, there has been a significant acceleration in road sector investment, with the primary focus on the rehabilitation and widening of existing roads with foreign assistance. Provincial roads also have been receiving increasing attention via the implementation of small-scale infrastructure rehabilitation and upgrading (SIRUP) projects funded by JBIC. In addition to JBIC, the World Bank and ADB are the other main international funding agencies in the road sector.

(2) Road Fund

Almost all capital investments involving large-scale infrastructure, such as irrigation, construction of new roads or rehabilitation of existing roads, hydro/thermal power, are financed by the Government, with some of these projects receiving foreign assistance. In the case of projects receiving foreign assistance, the availability of local funds for counterpart funding requirements is a key determinant for mobilizing foreign contributions. Note that roads, unlike some projects, require continuous maintenance and rehabilitation in order to maximize their effectiveness and benefits.

Despite the massive funding requirements of the road sector, there is no direct recovery of costs from road users. The Government, however, collects revenue indirectly via the following methods: (1) vehicle license and registration fees, (2) excise duties on vehicle imports and petroleum products, (3) value-added tax (VAT) on vehicle imports and petroleum products and (4) customs duties on vehicle imports. In 2003, these sources contributed an estimated Rs.52 billion to Government revenue, with nearly 50% of this coming from the VAT and excise duties on petroleum products. As these monies go into the Consolidated Fund of the Government, all ministries are entitled to this revenue although it has been collected from vehicles and fuel.

The amount of investment required for roads can be substantial and the lack of resources to meet the needs of the road sector is a common problem shared by many countries. Some countries have found a solution to this problem by establishing appropriate mechanisms to recover costs from road users for the costs of road maintenance, rehabilitation and sometimes even new construction. This collection from road users is directed into a separate fund which is termed the 'Road Fund'. Unlike general revenue, the collection from road users by the Road Fund is strictly limited to investments in the road sector. In general user cost in the road sector includes license fees, an access fee to the road net work, and a fuel tariff, a fee for the use of the network. In addition, a heavy vehicle fee is also imposed by some countries as a separate levy on heavy vehicles which cause more damage to roads than most other vehicles.

The idea for a Road Fund in Sri Lanka was first considered in the late 1990s as a solution to meet the rising cost of road maintenance and the urgent need to expand the road network. In 2001, the Treasury set up a committee to draft a plan for implementing a Road Fund. The Committee recommended that an Interim Road Fund be limited to the funding of only routine and periodic maintenance of national, provincial, and local roads. Initially the contribution to the interim fund was proposed to be by way of a levy on vehicles at the time of annual vehicle licensing. The committee envisaged that future road user charges would comprise levies on fuel and vehicles and, in addition, considered the introduction of other separate charges on vehicles.

The 2003 national budget proposed the formation of a Road Fund. The 2003 Central Bank report states that the Road Fund received Rs.630 million in 2003 from the fuel tax, which consisted of levies of Rs.1.00 on petrol and Rs.0.50 on diesel. On the other hand, a 2005 Central Bank report states that the Road Fund has not been established, though the above levy from petrol and diesel continues to be collected from the Ceylon Petroleum Corporation. Since the Fund has not been established, the collection of fuel tax is deposited in the Consolidated Fund contributing to the general revenue of the Government.

The Road Sector Master Plan, funded by the ADB (TA 4315-SRI) in May 2005, concludes that the country's road network is highly inadequate to meet the rapidly rising demand of road users and the growing imports of motor vehicles to the country. The report recommends that investment in the new construction of roads, highways, and expressways, together with the rehabilitation and upgrading of existing roads, be significantly increased to meet deal this demand. According to estimates provided in the Master Plan, the average annual requirement from 2006-15 for routine and periodic maintenance, upgrading, rehabilitation and reconstruction of national roads will be about Rs.50 billion.

The Road Sector Master Plan also examined the usefulness of the Road Fund, and recommended the introduction of a fuel charge and an annual access charge on vehicles. The fuel tax can be either a common charge applied equally to petrol and diesel or a differentiated charge for petrol and diesel users. The recommended common charge is Rs.3.50 per liter and the differentiated charge is Rs.1.60 for petrol and Rs.4.60 for diesel per liter. The charge would be used to cover variable costs in the routine and periodic maintenance of roads. The annual access charge is determined by three parameters: standard axel (ESAL)-km, passenger car space equivalent (PCSE-km)-km, and annual vehicle kilometers. The annual access charge would cover the fixed costs of maintenance.

(3) Private Sector Investment

Traditionally roads are considered as public goods and they are therefore the responsibility of the Government. However, in a number of countries the private sector plays a more active role in the management and construction of new roads. Although the Sri Lankan economy follows liberal economic principles, the private sector has not yet played any major role in infrastructure development projects, with the exception of power generation. In the case of roads such arrangements do not exist.

The importance of private sector investments in road development has come under serious consideration by the Government during the last few years. Although the Government recognizes the role that the private sector could play in the maintenance of roads, it is also quite aware of the limitations of the local private sector to provide adequate technical and managerial support for large-scale road projects involving highways and expressways. The mobilization of large-scale investment from the local private sector is also severely limited. In this context, the Public Private Partnership (PPP) mechanism received the attention of the Government as a possible option to meet the investment requirements of the road sector. Such mechanisms have been in operation in more developed economies since the mid-1980s to support large-scale infrastructure facilities involving roads, railways, and bridges.

PPP is an arrangement between a government and a private sector operator to provide or manage a public facility or service. The key element in a PPP partnership is the sharing of the responsibilities regarding risk between the two partners. Usually a private sector entity will undertake a major share of the financial risks and expects to be compensated by potential rewards for this. While the government can provide basic facilities such as land and can also get involved in the design stage of the partnership arrangement, the private sector is usually responsible for the design, construction, operation, management, and financing of the new facility. The provision of public facilities through PPP partnership arrangements relieves the government of the burden of large-scale investments, and provides an opportunity to build the facility in the event that the government is not in a position to raise funds on its own. Note that there are some PPP contracts where the facility is built by the Government and the private sector takes over the management contract for a specified period.

There are many variations of a PPP arrangement, with the most commonly employed PPP arrangements being: (1) Build-Operate-Transfer (BOT), (2) Build-Transfer-Operate (BTO), (3) Build-Own-Operate-Transfer (BOOT), and (4) Concessions. The building of a facility in all these variations is the responsibility of the private sector via its own funds.[7] The key difference is in the manner in which rewards are negotiated by the private sector. Under a BOT arrangement, the private operator owns the facility for a specified period until the operator recovers his cost of investment with a reasonable return. At the end of the contract, the facility is transferred to the government. A BTO variation transfers the facility to the government after the construction of the facility. The government then transfers the facility back to the operator under a long-term lease to allow it to recover its investment. The BOOT arrangement allows the operator to own the facility in perpetuity and the recovery of the cost of investment is entirely collected from users of the facility. A concession arrangement usually involves an annuity payment by the government since the potential return of most infrastructure facilities undertaken by the private sector under this arrangement is below the cost of the facility.

The Sri Lankan Government has actually proposed a PPP arrangement for the implementation of the Colombo-Katunayaka Expressway, and an agreement was expected to be prepared in late 2005 between the Government of Sri Lanka and a selected bidder on an availability payment (annuity) basis. However, there has been little progress so far, and it is reported that some of the conditions attached to the proposed PPP for the expressway are not attractive to international bidders, including the requirement of a guarantee by the Sri Lankan Government from the respective Governments of the bidders. Note that it is unclear whether the lack of progress is due to lack of interest from international bidders or that the Government is unwilling to accept the terms and conditions of bidders.

(4) Self-Financing Schemes

Self-financing schemes in the road sector in Sri Lanka are very limited and non-existent in the case of large-scale road development. However, small-scale schemes are operated to a very limited extent for rural roads in the estate sector, with these roads maintained by plantation companies from their own revenue. Some rural roads in the Mahaweli irrigation settlements are also maintained by the agencies responsible for the management of the Mahaweli Development. Apart from these there are no self-financing schemes involving maintenance, rehabilitation or new construction of national, provincial or local roads. Note that in urban areas possible self-financing schemes could include road pricing and parking pricing, which is being carried out to a limited extent in Colombo (see Chapter 6 and Appendices 10 and 11). Tolling is also another possibility given the right circumstances (see 25.5).

[7] A major share of these funds would be financed by the banking system. Therefore, when assessing potential rewards, the private sector would account for the costs of borrowing as well.

25.5 Financing Options

Prior to considering financing options, a summary of the funding required for the high priority projects of the Study should be given. As Table 25.8 indicates, approximately Rs.32.29 billion is needed to implement all the high priority projects, which excludes pipeline projects and the Marine Drive extension, Rajagiriya Flyover, and the Nugegoda-Katiya Junction- Pepiliyana Road widening scheme, which were shown to be infeasible in Chapter 23.

Table 25.8 Amount of Investment for High Priority Projects

Type of High Priority Project	Project Cost (US Million)	Amount of Investment (Rs. Billion)
Public Transport	*132.3*	*13.6*
Infrastructure	120.0	12.3
Non-Infrastructure	2.3	0.2
Capacity Building	10.0	1.0
Traffic Management and Safety	*29.6*	*3.0*
Infrastructure	26.8	2.7
Non-Infrastructure	1.2	0.1
Capacity Building	1.6	0.2
Road Improvement	*152.1*	*15.6*
Infrastructure[1)]	142.4	14.6
Capacity Building	9.7	1.0
Environment	*0.7*	*0.1*
Capacity Building	0.7	0.1
Institutional	*0.3*	*0.031*
Non-Infrastructure	0.3	0.031
Total	**315.0**	**32.29**

1) Excludes the Marine Drive extension, Rajagiriya Flyover, the Nugegoda-Katiya Jct-Pepiliyana Road widening, and the B152 & B452 Road widening, as these were found to be unfeasible in Chapter 23.

In principle, all the high priority projects should be completed by 2015 at the latest in accordance with the time frame of this study. The Study Team recognizes the ambitiousness of this plan and the associated costs and therefore recommends that at a minimum, feasibility studies be undertaken for all high priority infrastructure projects in order to gauge their feasibility before going forward for funding.

In the case of the capacity building and non-infrastructure projects, because they are inexpensive and necessary for creating an environment to move forward, they should be implemented fully and their results in place by the end of 2010. The total of these projects is Rs. 2.6 billion, which would require Rs. 0.66 billion annually (16.8% of Sri Lanka's entire annual transport sector capital budget).

Given this time frame, if all high priority projects (infrastructure, non-infrastructure, and capacity building) are implemented, approximately Rs. 4.04 billion would be required annually. As previously explained in 25.2, this level of expenditure would require resources equivalent to 25.7% of Sri Lanka's entire annual transport sector capital budget. This is a substantial sum of money and would require significant and diverse methods to achieve.

If pipeline projects are included in the calculation above (while still excluding three infeasible projects), the total amount of investment would be Rs. 74.0 billion. This amounts to Rs. 9.24 billion annually or 58.9% of Sri Lanka's entire annual transport sector budget.

Potential Financing Options

Essentially, there are seven options that could be implemented for generating additional revenue to assist in financing the implementation of the high priority projects and they are as described below.[8]

- **Foreign Funding:** This has and will have to continue to be one of the country's main sources for reliable funding, as Sri Lanka does not have the resources to fund large-scale infrastructure entirely on its own. On the other hand, due to large deficits in the annual budget, which remain around 8-10% of GDP, there is a limit to the number of additional foreign loans that can be accessed and grant funding is almost non-existent. For this reason, it is also important that efforts be made to tap into the other financing options as well.
- **Better Use of Existing Revenue:** Existing revenue could be more efficiently utilized to produce greater impacts and could consist of a number of measures that would include improvements in the procurement system, strengthening of administrative and financial auditing functions, and more effective and broader use of outsourcing. Note that the ADB has been actively involved in promoting this type of reform.
- **Lower Technical Standards:** The budget for roads could be reduced by lowering standards, but this would also mean lowering the quality of the roads themselves. One example of this would be to lower maintenance standards. However, given that in actual practice standards are already relatively low, the practicality of this option is in question.
- **Increase Road User Charges:** Raising road user charges, especially on heavy vehicles, is a common way to generate further revenue for the transport sector. On the other hand, the problem is that these charges in many cases do not find their way to the transport sector and go into the general account. Therefore, unless there is a mechanism to ensure that these charges benefit road users, the effectiveness of this option is in doubt.
- **Tolling:** The use of some sort of tolling is common throughout the world to generate revenue for road maintenance and construction. However, this option is effective only for roads with high traffic volumes and therefore its application is limited. On the other hand, setting tolls to finance a defined network, including roads with low traffic volumes, is a possibility and is done in Japan. However, this option can only cover a small portion of a country's overall network (e.g., expressways and other high-grade roads); although, these roads are usually the most expensive to maintain and carry the heaviest traffic volumes.
- **Private Sector Finance:** Utilizing the know-how of the private sector to help in the construction and operation of transport infrastructure has also been applied in many countries and is an effective method for supporting a country's transport sector budget. However this option, like the tolling option, can only be applied to a small percentage of a country's transport infrastructure capable of attracting private sector interest.
- **Earmarking:** This mechanism tries to ensure that a certain proportion of road related taxes and charges go directly to an earmarked fund such as a Roads Fund to ensure proper road upkeep. This has been tried in Sri Lanka, but as described in 25.4 the Roads Fund is still not in operation and money intended for it is going into a general account. In many cases, finance ministries are reluctant to accept earmarking on the grounds that it adversely impact on fiscal flexibility. In this case, it has been recommended that road development and maintenance be clearly defined and that the Roads Fund deal with the latter only.[9] For reference, the State of Karnataka in India

[8] Based in part on World Bank material: see *Options for Generating Additional Revenue* at http: web.worldbank.org
[9] ADB's *Road Funds and Road Maintenance: An Asian Perspective* (July 2003) recommends that road maintenance be taken out of the government budget process.

has been earmarking tax revenue for the development of a rail mass transit system since 1995, and the Government of India now considering establishing an earmarked fund for urban transport.

Based on the preceding, it is the opinion of the Study Team that a combination of the financing options mentioned above would have to be applied by Sri Lanka in order for it to achieve its infrastructure goals. Excluding foreign funding, which is already highly utilized, more attention should be given to the better use of existing revenue, tolling, private sector finance, and earmarking to realize this.

Financing Strategy

Table 25.9 contains an indicative financing strategy for the implementation of this study's high priority projects, which are described in tables 17.1, 17.3, and 17.4 of Chapter 17.

Table 25.9 Indicative Financing Strategy for High Priority Projects

Type of Funding / Type of Project	Foreign Funding	Central Gov't Funding (From General Acct)	Local Gov't Funding (From General Acct)	Private Sector Finance	Road User Charges
Infrastructure					
Public Transport					
Bus		○	○	⦿	
Rail	○	⦿			
Traffic Mgt & Safety					
ATC	⦿	○	○		○
Other Projects			⦿		○
Road Improvement					
Flyovers	⦿	○	○		○
Road Widening	⦿	○	○		○
Construction	⦿	○	○	○	○
Non-Infrastructure					
Institutional	○	⦿	⦿		
Public Transport	○	⦿	⦿		
Traffic Management	○	⦿	⦿		
Capacity Building					
Public Transport	○	⦿	⦿		
Road Improvement	○	⦿	⦿		
Traffic Mgt & Safety	○	⦿	⦿		
Social & Natural Environment	○	⦿	⦿		

Note) ⦿: Main contributor for funding; ○: Supporting contributor for funding

As the above table indicates, the main contributor for the funding of non-infrastructure and capacity building projects should be the central or local government, with support to be provided by a foreign donor when a relatively substantial investment for equipment is required to facilitate the effectiveness of these projects. This means that the relevant Sri Lankan government agencies can take the lead immediately in implementing these projects.

On the other hand, in the case of infrastructure projects, the government for the most part would play a supporting role in terms of financing. The exceptions to this would be rail projects and traffic management measures (excluding the ATC system). The reasons for this are that the current status and strategy for rail is unattractive to donors and the private sector, while traffic management measures are of a scale that should be carried out by the relevant government entity (mostly local) that could also perhaps tap into funds from road user charges (such as the fuel tax) for financing. The ATC, because of its expense and required technical expertise, would have a foreign donor as the main contributor of funds, with support funding to come from the general account of the central and local governments as well as from road user charges. As for bus transport infrastructure, because the bus transport market is highly competitive with a large degree of private sector participation, it is thought the major contributor to funding should be the private sector via concessioning or some other modality, with support to be provided by the relevant central and local government entities as necessary for facilitation purposes. Finally, in the case of road development (i.e., flyovers and widening), because of the costs involved, foreign donors would be the major contributor with support funding to come from central government agencies mostly with some local government support when possible as well as from road user charges. In the case of road construction, private sector financing could also play an important supporting role via the use of tolls, as could be the case for the Outer Circular Highway.

Chapter 26 Conclusions

26.1 Introduction

The overall objectives of this study were threefold: (i) identify the Colombo Metropolitan Region's (CMR) urbanization and urban transport issues; (ii) formulate a high priority improvement measures/projects for CMR; and (iii) conduct pre-feasibility (pre-FS) studies for projects to be funded by international donor agencies and propose implementation methodologies to ensure realization of the proposed high priority measures. The study was divided into two phases in accordance with the objectives. Phase I occurred from November 2005 to March 2006 wherein high priority issues and improvement measures were identified. Phase II occurred from May to September 2006 and involved proposing improvement measures for high priority projects, with corresponding pre-FS studies, which can be executed and made operational by 2015.

Based on the findings presented in the previous chapters, the following conclusions can be made regarding the *high priority projects* and *pre-FS projects* considered in this study.

26.2 High Priority Projects

First, the Study Team summarized six high priority issues of urbanization and urban transport in CMR through discussion with the working groups and local experts. In order to alleviate these issues, the Study Team proposed five policy objectives under the overall approach, which was to "improve the public transport system in order to be less dependent on private vehicle use."

High Priority Issues	Policy Objectives
• Rapid urban growth; • Increasing income and car ownership; • Low quality of public transport; • Incomplete road network; • Inadequate traffic management measures; and • Weak policy coordination.	• Improve policy coordination and administrative capacity; • Promote transit-oriented urban development; • Promote public transport system development and use; • Improve urban road systems particularly arterials; and • Utilize existing infrastructures and facilities better.

Figure 26.1 High Priority Issues and Policy Objectives for CMR

Secondly, the Study Team reviewed existing proposals for CMR and formulated a long list of projects (209 projects) and selected 46 shortlist projects. The selection process was designated to realize the policy objectives[1].

Among the 46 short list projects, the Study Team finalized a list of 36 high priority projects as shown in Table 26.1. The total amount of implementation costs are 32.29 billion Rs. (315.0 million USD)[2]. The Study Team recommends setting up necessary funding arrangement including foreign funding taking domestic financial capacity into consideration.

[1] Another objective, i.e. "Promote transit-oriented urban development", was not discussed in this section because it covers long-term projects which do not fit to the project scheme.
[2] Excluding pipeline projects and pipeline portions.

Table 26.1 List of High Priority Projects

	Project	**Implementation Agency**	**Cost (million USD)**
Policy Coordination			
1.	Inst-1 Technical Assistance to Establish the Presidential Committee on Urban Transport (PCUT) and Secondary Coordination Mechanisms	MoRT	0.3
Public Transport			
2.	Bus-1Technical Assistance to Lay Groundwork for Bus Route Concessioning and Undertake a Pilot Concessioning Project	NTC, WPRPTA	0.4
3.	Bus-2 Project to Increase Intermodal and Intramodal Coordination by Timetable Creation, Implementation and Enforcement	WPRPTA	0.8
4.	Bus-3: Strengthening of NTC on Transport Planning and Operations/ Management	NTC	1.5
5.	Bus-4: Strengthening of SLTB on Operations/ Management	SLTB	1.9
6.	Bus-5: Develop a Training Center at WPRPTA and Undertake Strengthening of WPRPTA	WPRPTA	1.7
7. .	Bus-8: Develop Bus Stop Facilities on High Demand Corridors	CMC, RDA	0.8
8. .	BRT-1: Bus Rapid Transit System	UDA	0.8
9.	Rail-1: Rehabilitation of Rail Siding & Rail Facilities on the Coastal, Main, KV, and Puttlam Lines	SLR	51.4
10.	Rail-2: Rehabilitation of Signaling, and Communications System on the Coastal, Main, KV, and Puttlam Lines	SLR	67.8
11.	Rail-3: Strengthening of Sri Lank Railways on Planning and Operations/Management	SLR	4.0
12.	PT-1 Project to Improve School Transport Services	NTC	0.2
13.	Road-49: Intermodal Transport Center [Suburban Area]	UDA	12.2
14.	Road-50: Intermodal Transport Center [CMC Area]	UDA	
15.	3W-1: Strengthen the WPRPTA to Implement and Strengthen the Three-Wheeler Services Bureau and Outline Three-Wheeler Regulations	WPRPTA	0.9
Road Improvement			
16.	*Road-1: Outer Circular Highway (OCH) Construction – Pipeline*	*RDA*	--
17.	Road-6: Baseline Road Improvement - *Construction Phase III – Pipeline* - Orugodawatte Flyover and Borella-Kanatta Flyover	RDA	71.4
18.	Road-15: Improvement of Colombo-Horana Road - *Road Improvement - Pipeline* - Kohuwala Flyover	RDA	9.1
19.	*Road-16 Improvement of Kirulapone-Kottawa Road (A4 Road) – Pipeline*	RDA	--
20.	Road-17: Improvement of Kandy Road - Phase I (Kelani Railway Flyover and Armour Street Flyover)	RDA	30.5
21.	Road -18 Improvement of Kandy Road – Phase II – *Pipeline*	RDA	--
22.	Road-21: Improvement of Road from Pannipitiya to Battaramulla	RDA	11.7
23.	Road 48: Capacity Building of CMC - Drainage Maintenance	CMC	7.5
24.	Road-54: Capacity Building of RDA – Land Acquisition & Resettlement	RDA	0.2
25.	Road-55: Capacity Building of RDA – Road Design Standards and Maintenance Coordination	RDA	0.8
26.	Road-WP2 Improvement of Pittakotte–Thalawathugoda–Hokandara–Kokadawila Road	WPRDA	7.5

	Project	Implementation Agency	Cost (million USD)
27.	Road-WP4 Improvement of Pannipitiya–Moralatiya–Tumbowila Road	WPRDA	
Traffic Management and Safety			
28.	TM-1: Intersection Geometric Improvement	CMC, RDA	3.7
29.	TM-2: Area Traffic Control System	CMC, Traffic Police	16.5
30.	TM-6: Corridor Traffic Mgt Improvement	CMC, RDA	2.1
31.	TM-11: Study on Stagged School/Office Start Times and Traffic Management Options	MoRT, Traffic Police, and CMC	0.1
32.	TM-13 Road User Education Program	National Council for Traffic Safety, MoRT, and CMC	0.2
33.	TM-14 Traffic Safety Improvement Project	National Council for Traffic Safety, MoRT	0.6
34.	TM-17: Capacity Building of CMC and RDA - Traffic Management & Safety	CMC	0.4
35.	TM-19: Capacity Building of Traffic Police	Traffic Police	1.0
Social and Natural Environment			
36.	Env-1: Cross-Sector Capacity Building - For Personnel and Equipment for Vehicle Inspection, Roadside Inspection, Emission Inspection, & Monitoring	CMT, Police, RDA, CPC, CEA	0.7

Note: Pipelined projects and pipelined portions are shown in Italics

Of the 36 high priority projects, there are three categories, i.e. 11 for capacity building, 7 for non-infrastructure, and 18 for infrastructure development. It is recommended the high priority capacity building and non-infrastructure projects should be fully implemented by 2010 because they are highly cost-effective and necessary for creating the environment to move forward, and they are also vital to implement infrastructure projects. The total cost of these projects is Rs.2.6 billion, which would require Rs.0.66 billion annually, therefore, some of portion can be implemented by domestic budget arrangement and private funding.

Explanation of major projects and how they could contribute to the reduction of traffic congestion in CMR along with their implementation strategies are briefly illustrated below:

(1) Projects to Improve Policy Coordination and Administrative Capacity

Technical Assistance to Establish the Presidential Committee on Urban Transport (PCUT) and Secondary Coordination Mechanisms (Inst-1), which is a representative project under the first objective, aims at establishing a policy coordination body to enhance project implementation under the leadership of the Presidential Office. It is designated to establish a central high-level body that represents the main political decision makers in urban transportation, including Western Provincial Council (WPC). It should be chaired by a high-level official with direct access to the President. A Secretariat will support PCUT and will be located in the Ministry of Railways and Transport (MoRT). The PCUT will alleviate the existing bottlenecks of policy coordination, i.e. too many institutions involved, little harmonization of policies, etc.

Establishing PCUT and commencing the Secretariat and its activities is vital to the effective implementation of many of the high priority projects of this study. Therefore, PCUT should start its activities within the 2007 fiscal year. However, delays in passing laws for establishment, policy changes, and acceptance of operational changes by stakeholders will be considered as risks for implementation. Policy coordination will be particularly beneficial for these projects. PCUT can also be utilized to handle the more delicate issues of transport sector coordination, bus concessions, trade unions, and other politically challenging topics such that clear policies and directives can be issued and the challenges of the transport sector addressed.

(2) Promote Public Transport System Development and Use

As discussed in Chapter 10, there are several issues regarding the weaknesses of operations and institutions in public transport sector. Therefore, half of projects were designated for institutional strengthening to accomplish this objective. Note that the PCUT establishment is also vital of this perspective. The others are related to facility improvement, including terminal, new transport system, and railway facility improvement; are necessary to keep present modal share.

Regulatory Improvements and Capacity Development

Technical Assistance to Lay Groundwork for Bus Route Concessioning and Undertake a Pilot Concessioning Project (Bus-1), prepared for WPRPTA, aims to restructure the bus system, as has been highlighted in a number of previous reports and studies. It is critical to improving the transport environment in the CMR. It will improve quality of service and reduce the number of buses on the road, thereby reducing overall traffic congestion. Successfully undertaking a pilot project to concession a few bus routes, recommended by the Study Team, will provide the necessary incentives to encourage other operators to participate in full concessions in the future. However, there will be potential dissatisfaction of private sector operators and crews as a risk associated with the pilot project's implementation.. It is envisaged that 3 years are expected for the pilot project, 5 and half years are expected for the concessioning of whole routes.

Develop a Training Center at Western Province Road Passenger Transport Authority and Undertake Strengthening of WPRPTA, Private Bus Owners/Operators, and Crew (Bus-5), also prepared for WPRPTA, will support education programs for concessioning, marketing, intermodalism, service level improvement, owner and operator education and private crew training. It will minimize the risk of the Bus-1 project and make it easier to disseminate concessioning schemes to other routes in the future.

Strengthen the WPRPTA to Implement and Strengthen the Three-Wheeler Services Bureau and Outline Three-Wheeler Regulations (3W-1), will assist WPRPTA to form a task force to implement and strengthen the Three-Wheeler Services Bureau, which was formed under WPRPTA. The Three-Wheeler Services Bureau, which is primarily responsible for the registration of vehicles as well as drivers' licenses and enforcing PTSP conditions, was created under the Three-Wheeler Act of 2002. Three-wheelers operate unsafely – swerving into and out of traffic to pick up passengers, making illegal turns, allowing passengers to disembark from the right side – and increase congestions levels. Currently, the three-wheelers are almost completely unregulated. The outcome of this project will help to increase the capacity for oversight.

BRT and Rail System Improvements for Faster/Reliable Service

Bus Rapid Transit System Development (BRT-1), will develop bus rapid transport from Galle Road (Dehiwala)- Pettah- Battaramulla over a 20 km alignment that will include 24 intermediate stops under a PPP scheme. This project will covers detail planning portion only and UDA will handle the main implementation portion.

Construction of a BRT system is especially relevant for developing public transport corridors within the city center, thereby reducing traffic congestion in CMR. Modern technology enables BRT systems to carry passenger loads comparable to LRT systems with substantially lower costs; although, the corridor should be built taking into account the long-term possibility of upgrading when demand increases. As no feasibility studies or surveys have been undertaken, the high priority project for the BRT is to fund a feasibility study to assess the best corridor(s) and implementation method for such a system. As has been seen in Latin America, BRT development can also be used as a catalyst to bring about the restructuring of the regular bus system, but creating a trunk and feeder network, integrated ticketing, and other higher service level provisions. This project will assist in accommodating future travel demand and overcoming pertinent issues passengers are facing, such as overcrowding on buses, irregular or unpredictable service frequencies particularly during off-peak hours, lack of interchange facilities for the efficient transfer of passengers from bus to rail and vice versa, and lack of adequate regulation to ensure that services are operated in line with government policy.

The two rail high priority infrastructure projects (i.e. Rail-1: Rehabilitation of Rail Siding and Rail Facilities and Rail-2: Rehabilitation of Rail Signaling and Communications System) are also important to reducing traffic congestion in CMR. As shown in Chapter 3, the railway shares 20 to 30% of passengers on major arterials, therefore, it is necessary to maintain its level of service in order to keep up its share. However, the rail sector has suffered from insufficient investment over the past twenty to thirty years, which has led to a severe reduction in regular maintenance and postponement of facility and communications upgrades as well as reduced safety and reliability. With the introduction of these high priority rail projects, railways in CMR will maintain – if not surpass – their share of passengers which will ultimately result in the reduction of congestion on urban roads.

It is important to note that the feasibility of these projects was not evaluated, because without capacity building (which is recommended in Chapter 14) and reform of the rail sector, the impacts of these projects would most likely not be sustainable. Although the rail sector is crucial to the smooth operation of urban transport, capacity building should first be achieved and then the feasibility of these projects revisited in a separate study.

Increased Intermodal Coordination

Project to Increase Intermodal and Intramodal Coordination by Timetable Creation, Implementation and Enforcement (Bus-2), will be undertaken by WPRPTA and aims to create timetables for both privately operated and jointly operated bus routes, with a focus on high demand corridors and those routes that have high transfer rates with SLR. This will be implemented within 2 years. Political interference for timetable creation will be handled under the PCUT scheme. The importance of this project lies in the fact that the availability, cost and frequency of services and information as to how passengers can connect is essential for a journey to be made on time and with the maximum convenience.

Intermodal Transport Center (Road-49 and Road-50), undertaken by UDA, aims to develop intermodal facilities. Road-49 will cover intra-city traffic at three locations along Baseline Road. The Road-50 will develop Intermodal Transfer Center (ITC) facilities at Moratuwa, Kottawa, and Ragama locating within 15 to 20 km radius of CMR to realize a gradual modal shift towards public transport and create a rail-based polycentric urban and regional structure. This project will fundamentally encourage ease and efficiency of transfer between different transport modes, such as rail to bus and vice versa, and lead to an overall reduction in traffic congestion. P&R or K&R parking facilities, taxi stops, motorcycle parking will be developed and land acquisition is required. This project is expected take three and half years.

This study recommends an implementation timeframe (2007-08 and after 2009) for sub sectors as follows;

Table 26.2 Implementation Schedule for Projects to Promote Public Transport System

Year	Projects to be Implemented and Required Actions
2007 to 2008	• Capacity building projects (Bus-3, 4, and 5), the route concessioning project (Bus-1), and the timetable development project (Bus-2) are to be implemented; they will contribute to improve operational quality and ineffective operation. • Also funding coordination for bus infrastructure projects should be started. • Capacity building project (Rail-3), the timetable development project (Bus-2) and intermodal terminal development (Road-49 and 50) should be arranged to implement. • Implement the consulting service (3W-1) to rationalize regulation of the three-wheeler services
After 2009	• Implement the bus infrastructure projects (intermodal terminal development (Road-49 and 50), bus stop development (Bus-8, TM-6), and BRT development (BRT-1) • Expand route concession activities (Bus-1) into other routes • Railway infrastructure improvement projects (Rail-1 and 2) should be coordinated to implement.

(3) Projects to Improve Urban Road Systems Particularly Arterials

Importance of Completing Pipeline Projects at an Early Stage

The network of major arterials is still incomplete and there are insufficient links with its capacity. The Outer Circular Highway (OCH) Construction (Road-1), Baseline Phase-III Construction (Road-6) and other three widening projects on Kandy, A4 and Horana Road (Road-15, 16, 18), all of which are pipeline projects, are designated to form a complete major road network with sufficient capacity. The construction of the OCH will result in a continuous expressway extending from the International Airport to the southern part of the country through connections with both the Colombo – Katunayake Expressway and the Southern Highway, and has potential to reduce incoming traffic to Colombo and alleviate existing traffic congestion. The Study Team strongly recommends it should be arranged to start immediately.

Additional Road Widening and Flyover Projects to Reduce Traffic Congestion

Three widening improvements and five flyover constructions projects, which were assessed their feasibility, will support the projects above. Note that the improvements can benefit both private and public transport vehicles due to increases in capacity and throughput.

Thalawatugoda-Pannipitiya Widening (Road-21), Thalawatugoda-Koskadwila Widening (Road-WP2) and Pannipitiya-Tumbowil Widening (Road-WP4**)** are projects involving the widening of four-lane or two-lane roads for sequential 14km sections in the growing southeastern suburb of CMR. The road widening projects will reduce running time and save vehicle operation cost, which will be reflected in the overall reduction in traffic congestion along these roads. It will take 4.5 years for the implementation of Road-21 which will be undertaken by RDA. There is no implementation risk but relocation, therefore, Resettlement Action Plan (RAP) and stakeholder meetings prior to implementation to avoid conflict of the project. For the other two sections, it will take 2.5 years and be managed by WPRDA. These two projects not require relocation because width of the road widening was designated to avoid any resettlement. (Please see Section 26.4 for economic feasibility)

There are five flyovers, Orugodawatte Flyover (Baseline Road) (Road-6), Borella-Kanata Flyover (Baseline Road) (Road-6), Kohuwala Flyover (Road-15), Armour Street Flyover (Road-17), and Kelaniya Railway Flyover (Road-17), recommended to be accomplished by 2015. These projects will be undertaken by RDA and will take 4 to 6 years to complete. The Study Team designated specific conditions for the flyovers to minimize social and environmental impacts (i.e., the alignment was shifted to avoid cutting of sacred Bo trees along intersections, and steel infrastructure was selected instead of reinforced concrete in order to minimize construction period). The Study Team also recommends preparing a Resettlement Action Plan (RAP) and holding stakeholder meetings prior to the implementation to avoid conflicts during the actual project implementation period. The outcome of these projects will ensure sufficient capacity for future traffic flows. (Please see Section 26.4 for economic feasibility)

Reducing Congestion Caused by Maintenance Problems

Maintenance capacity is another critical issue of road development in CMR. The two capacity building projects related to road maintenance (Road-48 for Drainage Maintenance and Road-55 for Utility Maintenance and Road Design) should be implemented at an early stage. In order to maintain drainage for storm water overflows, the methods, skills, and equipment necessary to do this effectively will be provided through capacity building. The successful implementation of these projects will undoubtedly lead to a significant decrease in traffic congestions, particularly during the rainy season.

Table 26.4 shows scheme for urban road system improvement perspective.

Table 26.3 Implementation Schedule for Projects to Improve Urban Road System

Year	Projects to be Implemented and Required Actions
2007 to 2008	• Pipeline projects (Road-1 for OCH, Road-6 for baseline extension, and Road 15, 16, 17 for arterial improvement should be arranged to start. • Capacity building project (Road 48,54 and 55) should be implemented • Land acquisition and resettlement, stakeholder meetings, foreign funds arrangement and D/D implementation funds arrangement should be prepared for flyovers and widening projects.
After 2009	• D/D for flyovers and widening projects should be implemented when the appropriate funds are ready. • Infrastructure projects should be accomplished by 2015.

(4) Projects to Better Utilize Existing Infrastructures and Facilities

To accomplish this policy objective, the Study Team proposed physical packages and demand management measures as well as safety and environmental projects.

ATC and Corridor Improvement

The biggest project in this sub section is Area Traffic Control System Project (TM-2) which introduces an area traffic control (ATC) system to Colombo. The objectives of the ATC system are to realize smooth and safe traffic and prevent congestion where possible through the use of sensory technology at key locations in the road network. To attain these goals, an ATC system maximizes intersection capacity and creates balanced and predictable traffic conditions. On its implementation, a Project Management Unit (PMU) will be setup in the Western Provincial Council to implement the project. PMU staff will be manned by CMC, Traffic Police and possibly RDA in addition to WPC staff. This project will take 2.5 to 3 years to complete.

Intersection Geometric Improvement (TM-1), which builds the capacity of traffic engineering and management staff while at the same time improves the intersection flow at 120 intersections, should be implemented keeping accordance with the ATC project. The project also includes regulatory measures such as banning right turns and implementing one-way, no parking, or no parking and stopping near intersections. These measures are necessary to increase the effective capacity of intersections and prevent traffic congestion. This project will be handled by CMC and RDA. It is estimated that this project will take 1.5 years.
Capacity Building of CMC and RDA - Traffic Management and Safety (TM-17) is vital to implementing TM-1 and TM-2. This portion is designated to strengthen the capacity of CMC and RDA in traffic management and safety by increasing manpower, conducting training and providing the necessary facilities to operate the proposed ATC system. According to the result of pre-FS, the ATC system is highly viable. It should be put into place as quickly as possible.
Corridor Traffic Management Improvement (TM-6) will cover two arterials of CMR, i.e. A0 Road and Galle Road, which involve comprehensive improvements to traffic management. Major components of the improvement include: intersection geometric improvements; sidewalk construction/improvements; signalization; pedestrian overpasses/underpasses installation; pelican crossings installation. It will be undertaken by RDA and is expected to take 1 year to complete. (Please see Section 26.4 for economic feasibility)

There are no implementation risks from these projects under the fourth objective because all projects will be installed within the right-of-way.

Addressing Congestion Caused by School Traffic

School traffic concentration in peak hour brings chaos and confliction to the traffic environment in CMR. To alleviate the congestion associated with school traffic, the Study Team proposes the following two projects: the Project to Improve School Transport Services (PT-1), and the Study on Staggering School/Office Start Times and Traffic Management Options (TM-11). Both projects aim to alleviate concentration of traffic during peak periods. The PT-1 envisages shifting private vehicle users and van users to school buses, and the TM-11 plans to expand time staggering and apply physical traffic management measures in the areas surrounding schools. The PT-1 will be directed by NTC, and MoRT and the TM-11 will be led by Police.

Improving Traffic Safety and Vehicle Inspection Systems

To sustain a better transport environment, it is necessary to implement and apply safety measures and emissions controls.

Traffic Safety Improvement Project (TM-14) aims at eliminating the existing and potential hazardous accident-prone locations by conducting a safety audit and implementing physical as well as regulatory measures. Accident records indicate that there are safety issues in the design and conditions of existing roads and therefore, the project will investigate accident records, identify accident prone locations, identify causes of accidents, conduct a safety audit of accident prone locations and sections, develop improvement programs, and implement improvement measures. An accident database kept by the Traffic Police will be utilized in the identification and analysis of accidents. Capacity Building of Traffic Police (TM-19) and the TM-17 contain capacity building components for safety improvements in road design and traffic control. These projects emphasize the role safer roads play in decreasing conflicts to traffic through improvements in traffic flow and reductions in traffic accidents.

Cross-Sector Capacity Building - for Personnel and Equipment for Vehicle Inspection, Roadside Inspection, Emissions Inspection, & Monitoring (Env-1) aims at managing manage the urban environment. The proposed capacity building measures include vehicle inspection; roadside inspection; emissions inspection; and monitoring of transport operations will be facilitated for vehicle increase in near future. The Center for Motor Traffic (CMT), Police, RDA, CPC, and CEA are the major stakeholders in this project, which should be initiated and consequently coordinated under PCUT's direction. The project period will be 1 year.

This study recommends an implementation timeframe (2007-08 and after 2009) as follows:

Table 26.4 Implementation Schedule for Projects to Better Utilize Existing Infrastructures

Year	Projects to be Implemented and Required Actions
2007 to 2008	• Capacity building project (TM-17 and 19, Env-1) should be implemented. • Funding arrangement for ATC project (TM-2) should be started. • Funding by domestic resources should be considered for the small-scale improvements (TM-1 for intersection improvement and TM-6 for corridors)
After 2009	• ATC project (TM-2) should be started when its fund is ready.

26.3 Pre-Feasibility Studies

Of the 40 projects nominated as potential high priority projects in PART II, twelve infrastructure-related projects were selected for pre-feasibility studies (pre-FS). Design drawings, economic analyses based on forecasted traffic flows, and a rough assessment of social and environmental impacts were prepared for each project. The results of the pre-feasibility studies will be used for funding arrangements by international donor agencies. Projects that were either already in the Government's pipeline or faced implementation or serious sustainability problems were eliminated from the pre-FS list. The pre-FS contained six road widening or extension projects, four grade separation projects (consisting of six flyovers), and two traffic management projects. The study result can be summarized as follows;

(1) Feasibility of Road Construction and Widening Projects

Among six road project evaluated in pre-FS, three projects **(**Road-21, Road-WP2, and Road-WP4**)** were evaluated as feasible in Table 26.7. Their EIRR is 17.50 % and NPV is 940 million Rs. for all sections. The EIRR value remains in feasibility position even with a 20 % decrease in benefits or 20 % increase in costs.

The other three projects were evaluated as unfeasible, as expensive resettlement and land acquisition costs thwarted their feasibilities. However, for Marine Drive, the Study Team recommends amending the engineering specifications to reduce/minimize land acquisition, or create another land acquisition scheme like value-capturing.

Likewise, the Study Team recommends a revision of engineering specifications for B152/B425. Since B152/B425 runs along the canal bank, improvements will have to be made to increase the level of the road bed, thereby increasing the engineering costs of the project. As a result, the benefits of flood–proofing should be evaluated and engineering specifications should be revised. According to sensitivity analysis, the EIRR will increase up to 9.98 in the case of a 20% decrease in costs, and up to 9.60 in the case of a 20 % increase in benefits.

On the other hand, Road-20 can simply be altered by implementation of Road-15 and Road-16 projects. Therefore, the Study Team does not find it necessary to reevaluate the feasibility of this project.

Table 26.5 Feasibility of Road Extension and Widening Projects (1/2)

Item	Road-7: Marine Drive Extension Construction	Road-14: B152/B425 Widening	Road-20: Nugegoda-Katiya Junction-Pepiliyana Widening
1.Implementation Bodies	RDA	RDA、WPRDA	RDA
2. Project Outline	Marine Drive (2km to the north & 1.75km to the south) to be extended to alleviate congestion on Galle Road by providing a viable alternative route along the coastline	To increase the connectivity of the coastal industrialized area of Gampaha District with Colombo Port, and to provide an alternative route for local traffic accessing Colombo from coastal Gampaha	Widening of existing road either to a standard 4-lane or standard 2-lane road facility will increase accessibility between the three important arterials of Horana Road, and A4
3.Implementation Cost (Construction cost)	3,444 Million Rs (226)	2,708 Million Rs (1,049)	1,470 Million Rs (100)
4. Timeframe	4 to 4.5 years	4 to 4.5 years	4 to 4.5 years
5.Economic Analysis	EIRR = 0.75%, NPV = -1,648.5 mil. Rs.	EIRR = 7.94%, NPV = -608.1 mil. Rs.	Not calculated due to its low effect of time saving
6. Implementation Risks	Residential relocation for over 100 households; noise, vibration and waste management during construction period	Residential relocation for over 100 households; major utility relocation	Residential relocation for over 100 households; major religious relocation of religious facilities
7. Final Recommendation	**Not feasible** due to low return in economic aspects. Biggest issue is some type of value-capture scheme which would be necessary, where land owners would relinquish a certain portion of their land based on future increases in property prices owing to development	**Not feasible** due to low returns in economic aspects. Project scope should be revised because the development of this section will play an important role for congestion alleviation of Negombo Road	**Not feasible** due to low return in economic aspects. Road-15 and -16 improvements may control the role of this road section

Table 26.5 Feasibility of Road Extension and Widening Projects (2/2)

Item	Road-21: Thalawatugoda-Pannipitiya Widening	Road-WP2: Thalawatugoda-Koskadwila Widening	Road-WP4: Pannipitiya-Tumbowil Widening
1.Implementation Bodies	RDA	WPRDA	WPRDA
2. Project Outline	4 lane widening for 3.2km between two growth centers (Pannipitiya and Battaramulla) in Eastern area of CMC	Proper two lane widening of collective road for 4.2km in growing Thalawatugoda area	Proper two lane widening of collective road for 7.2km in growing Pannipitiya area
3.Implementation Cost (Construction cost)	1,195 (220)	259 (112)	508 (185)
4. Timeframe	4 to 4.5 years	2.5 years	2.5 years
5.Economic Analysis	EIRR = 17.50%*, NPV = 940.4 mil. Rs. *	EIRR = 17.50%*, NPV = 940. mil. Rs. *	EIRR = 17.50%*, NPV = 940.4 mil. Rs. *
6. Implementation Risks	Residential relocation for over 100 households	No implementation risk because it was designated to minimize land acquisition	No implementation risk because it was designated to minimize land acquisition
7. Final Recommendation	**Feasible.** Recommended as high priority project due to its high value of return; Should be implemented quickly if funds are available	**Feasible.** Recommended as high priority project due to its high value of return; Should be implemented quickly if funds are available	**Feasible.** Recommended as high priority project due to its high value of return; Should be implemented quickly if funds are available

*) The three project scopes (Road-21, Road-WP2: Road-WP4) are evaluated as one road project because they can form a continuous link.

(2) Feasibility of Flyover Projects

Among six flyovers, five were found its feasibility.

Regarding sensitivity analysis, four projects remain in feasible positions even with a 20% decrease in benefits or a 20% increase in costs, though the Borella-Kanata Flyover (Road-6) will be unfeasible due to a 10% decrease in benefits or a 10% increase in costs. It is recommended to monitor its implementation carefully.

The other unfeasible project is Rajagiriya Flyover (Road-43). Its benefit was smaller than expected because the cross traffic is not enough to install a flyover even though the traffic on A0 Road exceeds 60 thousand PCU per day. The EIRR increases up to 8.24 in case of a 20% decrease in costs and up to 7.88 in the case of a 20% increase in benefits. The Study Team recommends that ATC and geometric shape improvement (TM-1 and TM-2) should be implemented.

Table 26.6 Feasibility of Flyover Projects (1/2)

Item	Road-6: Orugodawatte Flyover (Baseline Road)	Road-6: Borella-Kanata Flyover (Baseline Road)	Road-15: Kohuwala Flyover
1. Implementation Bodies	RDA	RDA	RDA
2. Project Outline	Flyover construction at Orugodawatte (Baseline Road-Avissawella Road) crossing, where attract freight traffic from Northern corridor; put a viaduct (4lanes for 435m) on Baseline Road	Over-bridging for three intersections of Ward Place, Horton Place, and Bauddhaloka Mw on Baseline Road; put a viaduct (4lanes for 1.4 km) on Baseline Road	Over-bridging of Kohuwala intersection, which is operated without traffic signals; put a viaduct (2lanes for 175m) on Horana Road
3.Implementation Cost (Construction cost)	1,339 (1,091)	5,996 (4915)	930 (269)
4. Timeframe	5.5 to 6 years	5.5 to 6 years	4 to 4.5 years
5.Economic Analysis	EIRR = 19.38%, NPV = 631.3 mil. Rs.	EIRR =12.74%, NPV = 212.8 mil. Rs.	EIRR = 21.75%, NPV = 846.6 mil. Rs.
6. Implementation Risks	Sacred Bo tree located near the intersection; land acquisition is easy as it is surrounded by public space	Residential relocation for over 100 households; sacred tree cutting; use steel viaduct and basement to minimize working period	Construction in density area; the bridge length can be minimized due to vertical geometric condition of intersection
7. Final Recommendation	**Feasible.** Recommended as high priority project due to its high value of return	**Feasible.** Recommended as high priority project due to its high value of return; recommended to monitor implementation carefully as it becomes unfeasible in case of a 10 % decrease in benefits or a 10 % increase in costs	**Feasible.** Recommended as high priority project due to its high value of return

Table 26.6 Feasibility of Flyover Projects (2/2)

Item	Road-17: Armour Street Flyover	Road-17: Kelaniya Railway Flyover	Road-43: Rajagiriya Flyover
1. Implementation Bodies	RDA	RDA	RDA
2. Project Outline	Flyover construction on Kandy Road intersection at port access road; put a viaduct (2lanes for 280m) for right turning movement from South to East	Flyover construction on Kandy Road and SLR main line crossing; put an over-bridge (4lanes for 330m) on Kandy Road	Flyover construction on A0; Road and Nawala Road crossing; put an over-bridge (4lanes for 200m) on A0 Road
3.Implementation Cost (Construction cost)	1,812 (525)	1,381 (744)	1,499 (918)
4. Timeframe	5 to 5.5 years	5 to 5.5 years	4 years
5.Economic Analysis	EIRR = 20.61%, NPV = 1,364.5 mil. Rs.	EIRR =16.31%, NPV = 336.9 mil. Rs.	EIRR = 6.35%, NPV = -401.6 mil. Rs.
6. Implementation Risks	Residential relocation for over 100 households; sacred tree cutting; use steel viaduct and basement to minimize working period and traffic congestion	Worker safety is an issue due to the proximity of the railway; existing utility infrastructure such as telephone and power lines, as well as some water supply lines, will need to be relocated	Sacred Bo tree located near the intersection
7. Final Recommendation	**Feasible.** Recommended as high priority project due to its high value of return	**Feasible.** Recommended as high priority project due to its high value of return	**Not feasible** due to low return in economic aspects; ATC installation and geometric shape improvement should be installed to solve existing problems

(3) Feasibility of Traffic Management Projects

Three projects were evaluated as shown in Table 26.8. The ATC system is highly viable and should be put into place as quickly as possible. The corridor improvement looks positive, however, the EIRR will be unfeasible in the case of a 10% decrease in benefits or a 10% increase in costs. It is recommended to monitor its implementation carefully.

Table 26.7 Feasibility of ATC and Intersection Improvement Projects

Item	TM-2 Area Traffic Control System Project	TM-6: Corridor Traffic Management Improvement (A0)	TM-6: Corridor Traffic Management Improvement (A2)
1. Implementation Bodies	A PMU will be setup in Western Provincial Council to implement the project; PMU staff will be manned by CMC, Traffic Police and possibly RDA in addition to WPC staff	RDA	RDA
2. Project Outline	Introduce an area traffic control (ATC) system to Colombo; the objectives of area traffic control (ATC) system are to realize smooth and safe traffic and prevent congestion where possible.	Comprehensive improvement of traffic management from Baseline Road to Battaramulla (5.2 km)	Comprehensive improvement of traffic management from Dehiwala to Ratmalana (3.6 km)
3.Implementation Cost (Construction cost)	207 (207)	114 (114)	72 (72)
4. Timeframe	2.5 to 3 years	1.5 years	1.5 years
5.Economic Analysis	EIRR = 41.30%, NPV = 1,904.2 mil. Rs.	EIRR = 14.27%, NPV = 9.9 mil. Rs.	EIRR =13.70 %, NPV = 11.5 mil. Rs.
6. Implementation Risks	No implementation risk	No implementation risk	No implementation risk
7. Final Recommendation	**Feasible.** Recommended as high priority project due to its high value of return	**Feasible.** Recommended as high priority project due to its high value of return; recommended to monitor implementation carefully as it becomes unfeasible in the case of a 10% decrease in benefits or a 10% increase in costs	**Feasible.** Recommended as high priority project due to its high value of return; recommended to monitor implementation carefully as it becomes unfeasible in the case of a 10 % decrease in benefits or a 10 % increase in costs.

In principle, all high priority projects should be completed by 2015 at the latest in accordance with the time frame of this study. The Study Team recognizes the ambitiousness of this plan and its associated costs, and therefore recommends that these projects be prioritized using a concept such as NPV to ensure that projects with the greatest impacts are executed first (see Section 26.4 for NPV). However, the Study Team recommends that further detailed design be carried out on all feasible projects based on the results of a re-confirmation of project prioritization. Additionally, the Study Team recognizes analysis of the future social and political environment will need to be considered prior to the implementation of the high priority projects.

26.4 Implementation Strategy

(1) Funding Options

In theory, all the high priority infrastructure projects should be completed by 2015 at the latest. However, the Study Team recognizes the ambitiousness of this plan and recommends that, at a minimum, feasibility studies be undertaken and those projects deemed feasible be implemented. Capacity building and non-infrastructure high priority projects, however, should be finished by the end of 2010 as they set the basis for implementing the large infrastructure projects and they are relatively inexpensive (Total Rs. 2.6 billion or Rs. 0.66 billion annually). Given this time frame, if all feasible high priority projects are to be implemented, approximately Rs.4.04 billion will be required annually – 25.7% of the annual capital expenditures in the transport sector.

Clearly, the amount of investment required for transport infrastructure is substantial and the lack of resources to meet the needs of the sector is a common problem shared by many countries. Some countries have found a solution to this problem by establishing appropriate mechanisms, such as road funds, to recover costs from road users for the costs of road maintenance, rehabilitation and sometimes even new construction. Others utilize the private sector to play an active role in infrastructure development, operations, and maintenance through public-private partnerships. Neither of these options is currently extensively used in Sri Lanka, although they have been widely discussed. External funding sources are heavily utilized to support the transport sector – about Rs. 7.8 billion annually. Therefore, alternative funding mechanisms need to be found, including better use of existing revenue, tolling, private sector finance, and earmarking funds for transport use.

- **Foreign Funding:** This has and will have to continue to be one of the country's main sources for reliable funding, as Sri Lanka does not have the resources to fund large-scale infrastructure entirely on its own.
- **Better Use of Existing Revenue:** Existing revenue could be more efficiently utilized to produce greater impacts and could consist of a number of measures
- **Increase Road User Charges:** Raising road user charges, especially on heavy vehicles.
- **Tolling:** The use of some sort of tolling is common throughout the world to generate revenue for road maintenance and construction.
- **Private Sector Finance:** Utilizing the know-how of the private sector to help in the construction and operation of transport infrastructure
- **Earmarking:** This mechanism tries to ensure that a certain proportion of road related taxes and charges go directly to an earmarked fund such as a Roads Fund to ensure proper road upkeep.

(2) Political Interference and Institutional Bottleneck

In order to alleviate political interference to the development of the transport sector, the Study Team proposed a mechanism of combining top-down and bottom-up approaches. The former is a PCUT proposal which realize interministeral coordination and project implementation under leadership of Presidential Office. The latter is a series of proposals for capacity building.

(3) Socio and Environmental Issues

Land acquisition/resettlement

Resettlement for over 100 families will be expected at three sites: Thalawatugoda-Pannipitiya widening, Borella-Kanata Flyover construction, and Armour Street Flyover construction. It is highly recommended that RDA consult with the Ministry of Land about the necessity of a RAPfor the selected projects as early as possible.

Environment Impact during Execution and Operation

Environmental impacts including air pollution, noise and vibration, road blockage, utility relocation, social conflict, etc, can be expected for all sites of the projects. Therefore, the study team proposed to carry out necessary mitigation measures; on-site training for workers, periodical wetting for construction materials, installation of low emission vehicles and noise reduction devices, garbage control, etc. There are also 'religious' trees around the site. The Study Team adjusted the alignment to minimize branch pruning of such trees.

During the operation period, it is that expected traffic accidents, air pollution and noise will increase, therefore, the Study Team recommended to introduce pedestrian safety measures, signs, and crossings, and to maintain road conditions.

Stakeholder Meeting

RDA should hold stakeholder meetings to ensure that information about the proposed projects and their environmental implications are understood by the public. The meetings may include government officials, religious leaders, and representatives from non-governmental organizations. It is recommended that RDA prepare a concise packet of information to distribute to participants prior to gathering or be prepared to devote a considerable amount of time in the meetings to provide background information and to answer questions.

26.5 Concluding Remarks

This project aimed at identifying improvement measures for CMR's transport sector that can be effectively implemented by the year 2015. The main points of the Study Team's recommendations are to (i) implement and make operational high priority projects, such as capacity building and other institutional and regulatory projects, by the end of 2010; (ii) establish immediately the Presidential Committee on Urban Transport (PCUT) as it is crucial for the facilitation of all other projects; (iii) complete all feasible high priority projects by 2015, in particular, by completing road widening, flyover constructions, ATC and corridor improvement;; and (iv) in the medium- and long-term, consider developing a mass rapid transit system along major corridors. It is also recommended to undertake the BRT feasibility study as soon as possible to develop the public transport corridors within the urban area, and putting capacity building and reform measures into action prior to implementing rail projects.