
5.5 Culverts

5.5.1. Introduction

This clause describes culvert structures including boxes and pipes.
And box culverts consist of under-pass for the minor roads and drainage opening.

5.5.2. Basic Policy

(1) Application

1) Shape and Extent

i Under pass

Generally, box culvert is applicable its inner width is less than 14m.
Bridge structure may be more economical than box structure when the inner width exceeds 14m.

ii Drainage culvert

Type of the drainage culvert which transfers water across the road was selected by drainage capacity calculation.
If the discharge volume was relatively small, pipe culvert was adopted.
On the other hand, if the volume is significant, box culvert was required.

2) Minimum Diameter of Pipe Culvert

Minimum diameter of pipe culvert crossing the OCH main highway was decided as 900 mm taking the maintenance works into account.
However, for the minor road, smaller diameter such as 450 mm could be used.

(2) Consideration of the Future 6 Lane

Culverts were designed for the future 6-lane condition.
Especially in structural design, cover height at the 6-lane stage was taken into account.

5.5.3. Box Culverts

(1) Inner Dimensions

1) Under Pass Culverts

Following descriptions explain about under-pass (box culverts for road), which has side-ditches on both sides.

i Track-Clearance

In this study, all box-culverts were classified as C or D.

Details of culvert's inner dimensions for D-class road are shown in **Fig. 5.5.1**.

Fundamentally, minimum track-clearance (H_c) for all minor roads is 5.1m in the design, taking doable-decker bus into account. However, 4.8m of track-clearance is also acceptable to adopt where the track-clearance is restricted by the vertical alignment of the main highway.

ii Pavement and Super Elevation

■ Pavement

SBST that was adopted for the normal section of the frontage/approach road (refer to Chapter 2.4 "Pavement") was used.

■ Super Elevation

Upgrade from both portal, and 3.0% grade is provided.

iii Drainage

Minimum widths of the ditches along the major underpass culverts are 0.45m.

Depths of them were adopted by drainage design and also were adjusted to existing roadside elevation. Minimum depth for drainage is 0.3m.

Drainage wall widths of side ditch were considered as follows:

- If ditch's wall height (H_d) was equal or less than 0.8m, then wall was set inside the shoulder (see **Fig. 5.5.1**).
- If ditch's wall height (H_d) was more than 0.8m, then safety fence was considered on top of the wall and wall was set outside of shoulder.

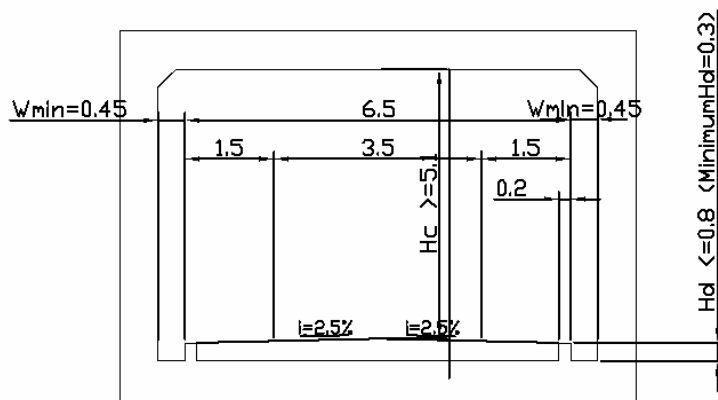


Fig. 5.5.1 Details of Inner Box Culvert (Class-D Road)

2) Drainage Culverts

Inner Dimensions of drainage culverts were decided in the “Chapter-4 Drainage”.

To discharge water effectively, culverts’ inner width / height ratios tend to become bigger than the ones that are designed for the normal condition such as ones in the hilly area, since the water flow condition on this flat and wet land is quite shallow of its depth.

(2) Intersection Angle

Generally, more than 70 degree of intersection angle (IA) between the mainline and culvert is desirable.

Where IA was less than 70 degree, both edge of the culvert were set 70 degree.

(3) Foundation

The spread foundations were adopted in every case in the design and settlement’s influence to the inner dimensions were not considered.

For the most of culverts’ sites, countermeasure for the soft ground will be executed for the embankment prior to the culvert construction. In general, culvert’s weight is lighter than the embankment soil, because of the hollow.

Therefore, the culverts’ stabilities must be ensured by adopting the spread foundation.

“Replacement of soft soil with sand material” and “Replacement plus preloading method” were mainly planned for the embankment onto the soft soil area in the detailed design, and culverts’ sections must adopt the same method as the embankment section. The culverts planned on the preload sections must be installed after the soil is consolidated. Surcharge fills are excavated before the culverts are installed.

(4) Design Criteria

1) Barrel

i Structural Design Standard

- British Standard “BS 5400”
- British Standard “BS 8110”
- “BD 31/01 The Design of Buried Concrete Box and Portal Frame Structures”,

ii Design Principles

■ Nominal Load

- Dead Load
- Superimposed Dead Load
- Temperature Effect
- Earth Pressures
- Primary Live Loads
- Secondary Live Loads
- Live Load Surcharges

■ The Partial Safety Factors for Loads

The partial safety factors for loads, γ_{FL} is tabulated in the **Table 5.5.1**, which is prescribed in the BD31/01. γ_B for SLS and ULS are 1.0 and 1.1 respectively.

■ Load Combinations

The three major load combinations were to be considered in design, which is given in the BD31/01.

■ Frame Analysis

Frame analysis using computer software was conducted to figure out the stress in each member.

Calculation is conducted one-cell, two-cells and three-cells. Even for the culverts whose numbers of cells are more than three, calculations on three cells were conducted, since the tendency of the stress distribution must not be different significantly.

iii Design Loads

■ Dead Loads

The nominal dead load consists of the weight of the materials and parts of the structure that are structural elements excluding superimposed materials.

■ Superimposed Dead Load

The nominal superimposed dead load consists of the weight of the road construction materials and soil cover above the structure and shall be applied as a uniformly distributed load.

$$\text{Maximum superimposed dead load intensity} = 1.15 \gamma H \quad (H < 8m)$$

$$\text{Minimum superimposed dead load intensity} = \gamma H$$

Where γ : bulk density of compacted fill or road construction materials, as appropriate.
H: height of cover from the top of the structure to the finished surface level.

Table 5.5.1 Load Combinations and γ_{fl}

LOADS		Limit State	γ_{fl} for Combinations		
			1	3	4
PERMANENT LOADS					
Weight of concrete	3.1.1	ULS*	1.15*	1.15*	1.15*
		SLS	1.00	1.00	1.00
Superimposed pavement construction (top 200mm)	3.1.2	ULS**	1.75	1.75	1.75
		SLS	1.20	1.20	1.20
Superimposed fill including pavement construction in excess of 200mm	3.1.2	ULS	1.20	1.20	1.20
		SLS	1.00	1.00	1.00
Horizontal earth pressure (using default earth pressure coefficients)	3.1.3	ULS	1.50	1.50	1.50
		SLS	1.00	1.00	1.00
Horizontal earth pressure (using earth pressure coefficients calculated in accordance with BS8002)	3.1.3	ULS	1.20	1.20	1.20
		SLS	1.00	1.00	1.00
Hydrostatic pressure and buoyancy	3.1.4	ULS	1.10	1.10	1.10
		SLS	1.10	1.10	1.10
Settlement	3.1.5	ULS	1.20	1.20	1.20
		SLS	1.00	1.00	1.00
LIVE LOADS					
Vertical Live Loads					
HA carriageway loading	3.2.1	ULS	1.50	1.25	
		SLS	1.20	1.00	
HB carriageway loading	3.2.1	ULS	1.30	1.10	
		SLS	1.10	1.00	
Footway and cycle track loads	3.2.2	ULS	1.50	1.25	
		SLS	1.00	1.00	
Accidental wheel loading	3.2.3	ULS	1.50		
		SLS	1.20		
Construction traffic	3.2.5	ULS	1.15	1.15	
		SLS	1.00	1.00	
Horizontal pressure due to live load surcharge	3.2.6	ULS	1.50	1.50	1.50
		SLS	1.00	1.00	1.00
HA traction and associated vertical	3.2.7	ULS			1.25
		SLS			1.00
HB traction live loads	3.2.7	ULS			1.10
		SLS			1.00
Temperature range	3.2.8	ULS		N/A	
		SLS		1.00	
Differential temperature	3.2.8	ULS		1.00	
		SLS		0.80	
Parapet collision and Skidding associated vertical	3.2.9 3.2.10	In accordance with BD 37			
		ULS			1.25
Centrifugal load live loads	3.2.11	SLS			1.00
		ULS			1.50
		SLS			1.00

- (1)* γ_{fl} shall be increased to at least 1.20 to compensate for inaccuracies when dead loads are not accurately assessed.
(2)** γ_{fl} may be reduced to 1.2 and 1.1 for ULS and SLS respectively subject to the approval of the appropriate authority.

■ **Load Effects Due to Temperature**

Buried structures with widths less than 5 times the span are to be considered as being open to the atmosphere and the effects of temperature are to be taken into account in accordance with BS 5400: Part 2.

For buried structures of a width greater than or equal to 5 times their span, the requirements of BS 5400: Part 2 are modified as shown in table below according to the BD31/01.

Table 5.5.2 Load Effect due to Temperature

Span to Width Ratio	Cover	Minimum and maximum effective temperature		Differential temperature	
				Temperature difference	Reduction factor
X_{clear}/L_t	H (m)	T_{min}	T_{max}		η
$\geq 0.2^*$	All depths	In accordance with BD 37		In accordance with BD 37**	N/A
< 0.2	$H \leq 0.6$	In accordance with BD 37		In accordance with BD 37**	N/A
	$0.6 < H \leq 0.75$	0°C	20°C	From BD 37, Figure 9, Group 4	0.5
	$0.75 < H \leq 1.0$	4°C	16°C	From BD 37, Figure 9, Group 4	0.33
	$1.0 < H \leq 2.0$	7°C	13°C	From BD 37, Figure 9, Group 4	Zero
	$H > 2.0m$	Temperature effects may be neglected			

■ **Earth Pressures**

The nominal horizontal earth pressures on the side walls of the structure shall be taken as follows:

- For Combination 1 and 3 loads
Maximum earth pressure = 0.6 yH
Minimum earth pressure = 0.2 yH
- For Combination 4 with traction
Disturbing earth pressure = 0.33 yH
Restoring earth pressure = 0.6 yH

where y = bulk density of compacted fill or road construction materials, as appropriate.
H = height of cover above the point of calculation.

■ **Primary Live Loads**

HA wheel load and the 30 units of HB load is applied for the OCH main carriageway including the ramp way in accordance with BS 5400: Part 2.

On the other hands, only HA wheel load is considered for the minor road in case its class is C/D.

■ **Secondary Live Loads**

The structure shall be designed to resist longitudinal loads and accidental skidding loads unless provision has been made for the transfer of such loads by the road slab. These loads shall be in accordance with BS 5400: Part 2 and only HB loading is to be considered. The load shall be multiplied by the following factor before it is applied directly to the top of the structure:

$$factor = \frac{span - height\ of\ cover}{span - 0.6m} \text{ but } > 0 \text{ and } < 1$$

2) **Parallel Wing Wall**

i **Structural Design Standard**

- British Standard “BS 5400”
- British Standard “BS 8110”

ii **Design Principles**

■ **Nominal Load**

- Earth Pressure
- Live Load Surcharges

■ **Methodology**

Active earth pressure (including live load surcharge) acting to the wing wall was analyzed by the Sliding Plate Method. Passive earth pressure was not taken into account.

Segments are assumed whose width is Δx (10cm was adopted in the design). And, earth pressure for the each segment is calculated (see **Fig. 5.5.2**).

Moment force at the joint is estimated as a sum of the earth pressure of each segment multiplied by each lever arm length.

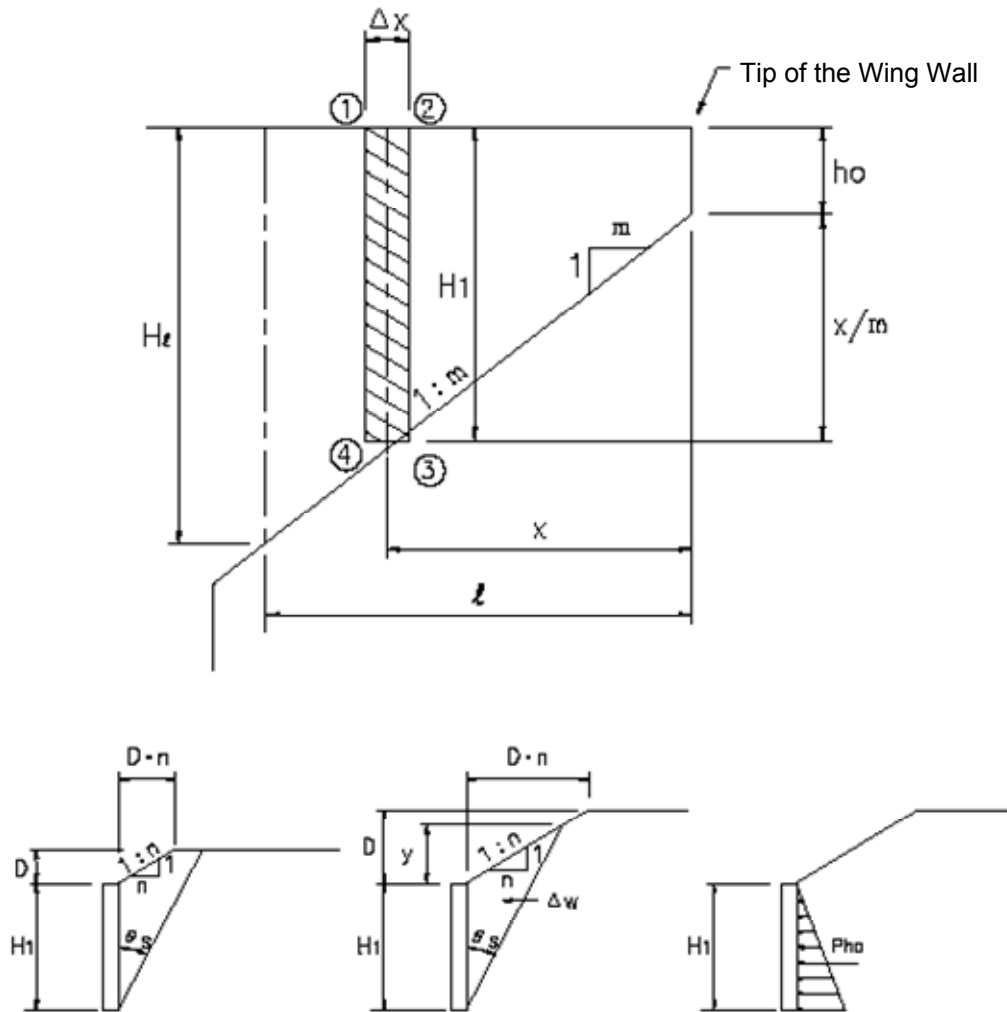


Fig. 5.5.2 Segment of Wing Wall

■ The Partial Safety Factors for Loads

The partial safety factors for wing wall followed the load case, which is prescribed as combination-1 in the “BS5400”.

■ Live Load Surcharge

Distributed horizontal/vertical surcharge force due to HA live load was considered in the design.

(5) List of Box Culvert

The Box Culverts for main carriageway crossing and for minor road and ramp way crossing are listed in **Table 5.5.3** and **Table 5.5.4** respectively.

Table 5.5.3 List of Box-Culverts (for Main Carriageway Crossing)

STA	Skew Angle	Culvert Dimensions in Metre				Remarks
		NB of Cells	B	H	Total Length	
16+920.0	90	5	2.5	1.50	68.5	
16+990.0	90	1	7.4	5.20	35.5	
17+460.0	90	1	2.5	2.00	50.0	
17+640.0	90	1	2.5	2.00	46.0	
18+700.0	90	3	3.0	2.00	56.5	
19+900.0	90	4	3.0	2.00	53.0	
20+104.7	94	1	7.4	5.20	36.0	
20+750.0	90	2	3.0	2.00	50.0	
21+600.0	90	6	2.5	2.00	57.0	
21+640.0	90	1	7.4	5.20	35.5	
22+500.0	90	3	2.5	1.50	49.5	
26+150.0	90	3	3.0	2.00	36.0	
26+620.0	90	4	2.5	1.50	36.0	
26+900.0	90	1	2.0	2.00	50.5	
27+061.2	84	1	10.9	5.60	36.0	
27+255.0	90	1	2.0	2.00	68.5	
28+170.0	90	2	4.0	3.00	51.5	

Table 5.5.4 List of Box-Culverts (for Minor Road and Ramp Way Crossing)

STA		Skew Angle	Culvert Dimensions in Metre				Remarks
			NB of Cells	B	H	Total Length	
<i>A4 Ramp-5</i>							
0+305		103	2	4.50	3.00	80.5	
0+560		90	2	4.50	3.00	46.0	
0+900		90	2	4.50	3.00	38.5	
<i>Minor Road</i>							
16+990	-00+045	90	4	2.50	1.50	12.5	
16+990	00+050	90	2	2.50	1.50	13.5	
16+990	00+115	90	2	2.50	1.50	9.0	
20+105	-00+056	90	2	2.50	1.50	9.0	
20+105	00+046	90	3	2.50	1.50	9.0	
21+640	-00+040	90	2	2.50	1.50	10.0	
21+640	00+045	108	6	2.50	1.50	14.5	
23+940	-00+036	90	3	2.50	1.50	37.0	
23+940	00+032	90	1	2.50	2.00	31.5	
23+940	00+220	90	1	2.50	2.00	8.5	
25+650	-00+032	90	1	2.50	2.00	36.0	
25+650	00+032	90	2	2.50	2.00	34.0	
26+299	-00+034	90	4	3.00	2.00	41.5	
26+684	-00+043	96	5	3.00	2.00	38.0	
26+684	-00+142	90	1	3.50	2.00	15.5	
27+061	-00+044	97	4	3.00	2.00	7.5	
27+901	13+330 (A4)	90	2	4.50	3.00	36.5	

(6) Summary of the Calculation Results

Summary of the calculations for Box Culverts is shown in **Table 5.5.5**.

“Member” in the table is indicated in the sketch below.

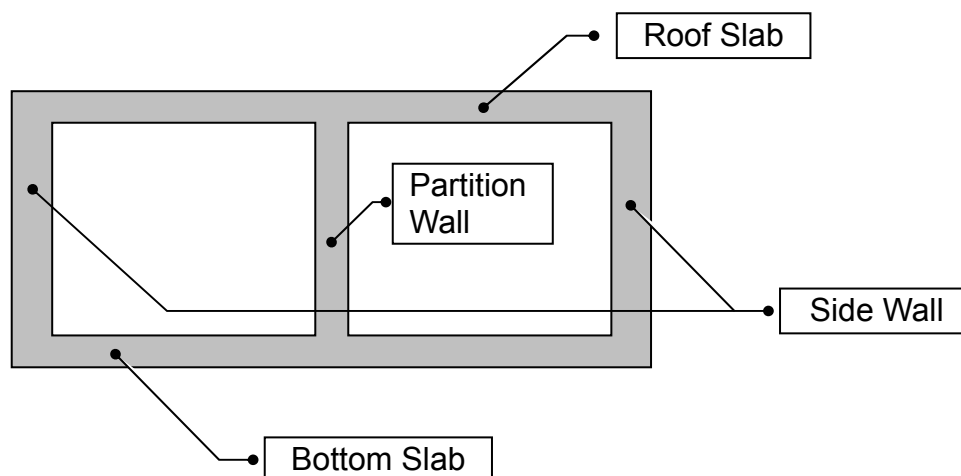


Table 5.5.5 Stress Calculation Summary (1/6)

Type	Inner Dimension	Cover Depth (m)	Member	Thickness (cm)	Tension Side	Working Force			Steel Bar Arrangement	Crack Width (mm)	Moment of Resistance (kNm)	Shear Resistance (kN)			
						Moment (kNm)	Axial (kN)	Shear (kN)				Concrete Only	Concrete & Stirrups		
						SLS	ULS	ULS							
Single 2000x2000		6.0	Roof Slab	400	Inner	68.3	93.2	34.4	D16 @ 150	0.25	169.16	152.43	227.83	D12 @ 600	
			Side Wall	350	Inner	16.8	41.7	156.4	D16 @ 300	-0.09	111.95	178.00	240.84	D12 @ 600	
			Partition Wall												
			Bottom Slab	450	Outer	56.0	84.7	262.3	D20 @ 150	0.20	210.68				
Single 2000x2000		9.0	Roof Slab	500	Inner	83.4	113.5	33.9	D16 @ 150	0.24	229.82	165.50	240.90	D12 @ 600	
			Side Wall	450	Inner	22.4	61.0	238.0	D20 @ 300	-0.37	157.6	171.84	272.38	D12 @ 600	
			Partition Wall												
			Bottom Slab	550	Outer	89.8	133.0	418.0	D20 @ 150	0.19	328.31	204.79	292.76	D12 @ 600	
Double 2500x1500		0.4 [HA]	Roof Slab	400	Inner	77.9	132.7	-6.4	D20 @ 150	0.21	230.76	186.57	287.11	D12 @ 600	
			Side Wall	300	Inner	13.5	56.5	237.6	D16 @ 300	-0.03	86.55	192.05	267.45	D12 @ 600	
			Partition Wall	300	Outer	40.2	39.1	22.4	D20 @ 150	0.20	160.74	162.20	212.47	D12 @ 600	
			Bottom Slab	500	Inner	77.1	102.4	71.3	D16 @ 300	0.13	197.78	110.94	161.18	D12 @ 600	
Multi 2500x1500		1.0 [HA]	Roof Slab	400	Inner	82.7	108.6	34.0	D20 @ 150	0.24	276.67	204.79	292.76	D12 @ 600	
			Side Wall	300	Inner	46.5	96.8	-12.4	D16 @ 300	0.21	106.98	165.50	240.90	D12 @ 600	
			Partition Wall	300	Inner	3.9	22.0	53.9	D16 @ 300	0.19	85.59	139.77	190.04	D12 @ 600	
			Bottom Slab	450	Outer	29.6	42.3	158.7	D16 @ 150	0.18	120.43	110.94	161.18	D12 @ 600	
Multi 2500x1500		0.4 [HA]	Roof Slab	400	Inner	47.4	64.7	21.3	D16 @ 300	0.08	176.36	192.05	267.45	D12 @ 600	
			Side Wall	300	Inner	76.1	133.6	-25.4	D20 @ 150	0.21	228.69	192.05	267.45	D12 @ 600	
			Partition Wall	300	Inner	33.2	45.2	97.3	D16 @ 150	0.22	119.90	139.77	190.04	D12 @ 600	
			Bottom Slab	500	Outer	84.1	115.2	25.8	D20 @ 150	0.25	275.23	204.79	292.76	D12 @ 600	
Multi 2500x1500		1.0 [HA]	Roof Slab	400	Inner	47.8	99.3	25.7	D16 @ 300	0.23	111.73	165.50	240.90	D12 @ 600	
			Side Wall	350	Inner	6.7	32.7	123.9	D16 @ 300	0.23	106.61	153.39	216.23	D12 @ 600	
			Partition Wall	300	Outer	18.5	30.6	130.1	D16 @ 300	0.08	83.37	110.94	161.18	D12 @ 600	
			Bottom Slab	400	Inner	37.0	47.3	87.4	D16 @ 300	0.09	168.11	178.00	240.84	D12 @ 600	

Table 5.5.5 Stress Calculation Summary (2/6)

Type	Inner Dimension	Cover Depth (m)	Member	Thickness (cm)	Tension Side	Working Force			Steel Bar Arrangement	Crack Width (mm)	Moment of Resistance (kNm)	Shear Resistance (kN)			
						Moment (kNm)	Axial (kN)	Shear (kN)				Concrete Only	Concrete & Stirrups		
						SLS	ULS	ULS							
Multi	2500x1500	9.7	Roof Slab	600	Inner	153.0	278.1	9.0	D20 @ 150	0.20	401.55	291.54	54.87	D12 @ 300	
			Side Wall	350	Outer	210.0	278.6	44.7	D25 @ 150	0.20	599.27	291.54	54.87	D12 @ 300	
			Partition Wall	300	Inner	14.1	34.8	271.8	D25 @ 150	0.19	123.35	294.41	206.56	269.39	D12 @ 600
			Bottom Slab	700	Outer	70.9	108.7	463.2	D16 @ 300	-0.15	145.68	110.94	161.18	161.18	D12 @ 600
Double	2500x2000	3.5	Roof Slab	450	Inner	169.0	226.2	45.0	D20 @ 300	0.25	330.36	310.66	448.90	D12 @ 600	
			Side Wall	350	Outer	193.0	254.3	45.0	D25 @ 150	0.21	667.13	204.79	292.76	292.76	D12 @ 600
			Partition Wall	300	Inner	44.6	68.7	17.9	D16 @ 300	0.05	127.82	153.39	216.23	216.23	D12 @ 600
			Bottom Slab	500	Outer	89.2	131.0	17.9	D20 @ 150	0.18	273.53	110.94	161.18	161.18	D12 @ 600
Single	2500x2000	4.5	Roof Slab	450	Inner	6.9	24.3	129.9	D16 @ 300	-0.25	107.15	140.07	228.04	D12 @ 600	
			Side Wall	350	Outer	46.5	70.0	205.9	D16 @ 150	0.21	155.66	178.00	240.84	240.84	D12 @ 600
			Partition Wall	300	Inner	0.1	2.9	402.6	D16 @ 300	-	105.32	192.02	292.76	292.76	D12 @ 600
			Bottom Slab	500	Outer	52.7	82.7	28.7	D16 @ 300	0.01	192.02	204.79	292.76	292.76	D12 @ 600
Single	2500x2000	6.0	Roof Slab	450	Inner	82.4	119.9	28.8	D20 @ 150	0.24	275.80	192.05	267.45	D12 @ 600	
			Side Wall	400	Outer	59.1	86.2	164.8	D20 @ 150	0.20	253.30	148.08	248.62	248.62	D12 @ 600
			Partition Wall	300	Inner	114.0	154.1	29.9	D20 @ 150	0.20	232.61	192.05	267.45	267.45	D12 @ 600
			Bottom Slab	500	Outer	69.1	100.7	177.1	D16 @ 300	0.17	167.19	148.08	248.62	248.62	D12 @ 600
Single	2500x2000	7.5	Roof Slab	550	Inner	7.8	34.2	195.9	D16 @ 300	-0.31	133.62	160.58	273.68	D12 @ 600	
			Side Wall	450	Outer	77.2	111.4	305.6	D20 @ 150	0.21	266.18	192.05	267.45	267.45	D12 @ 600
			Partition Wall	300	Inner	124.0	166.7	41.4	D20 @ 150	0.22	348.60	204.79	292.76	292.76	D12 @ 600
			Bottom Slab	600	Outer	77.2	111.4	205.3	D20 @ 150	0.21	305.63	160.58	273.68	273.68	D12 @ 600
Double	2500x2000	7.5	Roof Slab	600	Inner	134.0	181.4	44.4	D20 @ 150	0.19	363.31	251.24	376.90	D12 @ 600	
			Side Wall	400	Outer	87.1	127.0	220.2	D16 @ 300	0.19	192.99	192.05	267.45	267.45	D12 @ 600
			Partition Wall	300	Inner	9.0	42.6	244.7	D16 @ 300	-0.36	158.50	192.05	267.45	267.45	D12 @ 600
			Bottom Slab	600	Outer	87.1	131.1	244.2	D20 @ 150	0.18	305.09	204.79	292.76	292.76	D12 @ 600
Double	2500x2000	7.5	Roof Slab	600	Inner	158.0	213.0	44.2	D20 @ 150	0.19	221.96	160.58	273.68	D12 @ 600	
			Side Wall	400	Outer	88.7	131.0	244.0	D16 @ 300	0.21	203.49	192.05	267.45	267.45	D12 @ 600
			Partition Wall	300	Inner	93.6	126.3	39.9	D20 @ 300	0.09	235.85	251.24	376.90	376.90	D12 @ 600
			Bottom Slab	650	Outer	22.4	48.9	235.1	D20 @ 150	-0.11	137.93	192.05	267.45	267.45	D12 @ 600
Double	2500x2000	7.5	Roof Slab	600	Inner	80.0	123.8	350.8	D20 @ 150	0.22	268.83	192.05	267.45	267.45	D12 @ 600
			Side Wall	400	Outer	0.1	0.2	734.9	D16 @ 300	-	127.73	110.94	161.18	161.18	D12 @ 600
			Partition Wall	300	Inner	107.0	144.2	51.1	D20 @ 300	0.07	302.80	251.24	376.90	376.90	D12 @ 600
			Bottom Slab	650	Outer	145.0	194.4	51.1	D20 @ 150	0.23	409.75	192.05	267.45	267.45	D12 @ 600

Table 5.5.5 Stress Calculation Summary (3/6)

Type	Inner Dimension	Cover Depth (m)	Member	Thickness (cm)	Tension Side	Working Force				Steel Bar Arrangement	Crack Width (mm)	Moment of Resistance (kNm)	Shear Resistance (kN)		
						Moment (kNm)	Axial (kN)	Shear (kN)	Concrete Only				Concrete & Stirrups		
						SLS	ULS	ULS	ULS						
Single	2500x2000	8.5	Roof Slab	600	Inner	170.0	230.0	51.2	274.0	D20 @ 150	0.22	408.49	199.41	325.07	D12 @ 600
			Outer	97.3	144.7	253.4	274.0	D20 @ 300	0.11	280.68	199.41	325.07	D12 @ 600		
			Side Wall	450	Inner	14.9	52.5	274.8	166.0	D16 @ 300	-0.33	162.56	204.79	292.76	D12 @ 600
			Outer	97.6	147.5	277.1	166.0	D20 @ 150	0.23	309.57	204.79	292.76	D12 @ 600		
Multi	2500x2000	8.5	Partition Wall												
			Bottom Slab	650	Inner	196.0	264.1	49.7	289.0	D20 @ 150	0.22	471.90	199.41	325.07	D12 @ 600
			Outer	97.7	147.5	277.1	289.0	D20 @ 300	0.10	292.55	199.41	325.07	D12 @ 600		
			Roof Slab	600	Inner	121.0	246.5	87.5	344.6	D16 @ 150	0.16	284.59	251.24	376.90	D12 @ 600
Multi	2500x2000	8.5	Side Wall	450	Outer	171.0	227.8	43.0	269.6	D20 @ 150	0.22	406.75	204.79	292.76	D12 @ 600
			Inner	22.0	54.4	265.0	171.0	D16 @ 300	0.22	161.24	204.79	292.76	D12 @ 600		
			Partition Wall	300	Outer	101.0	151.6	412.0	171.0	D20 @ 150	0.22	327.54	110.94	161.18	D12 @ 600
			Bottom Slab	700	Inner	6.6	8.1	878.0	3.7	D16 @ 300	-0.18	136.53	110.94	161.18	D12 @ 600
Multi	3000x2000	0.3 [HA]	Roof Slab	450	Inner	135.0	182.1	58.0	267.0	D20 @ 300	0.11	313.61	230.70	368.94	D12 @ 600
			Outer	151.0	196.1	58.0	267.0	D16 @ 150	0.25	314.61	230.70	368.94	D12 @ 600		
			Side Wall	400	Inner	115.0	197.4	-26.0	269.6	D25 @ 150	0.18	390.57	237.65	325.61	D12 @ 600
			Outer	106.0	141.5	-33.0	269.6	D25 @ 150	0.18	389.67	237.65	325.61	D12 @ 600		
Multi	3000x2000	0.7	Roof Slab	450	Inner	75.5	143.7	23.0	170.9	D16 @ 150	0.20	199.80	162.20	212.47	D12 @ 600
			Outer	111.0	126.3	29.0	170.9	D25 @ 150	0.17	397.70	237.64	325.61	D12 @ 600		
			Side Wall	350	Inner	17.0	55.8	151.0	85.1	D16 @ 300	-0.08	113.46	206.56	269.39	D12 @ 600
			Outer	71.6	97.1	192.0	85.1	D25 @ 150	0.19	277.41	206.56	269.39	D12 @ 600		
Multi	3000x2000	1.2	Partition Wall	300	Outer	38.0	48.2	150.0	26.3	D25 @ 300	0.23	136.06	149.39	199.65	D12 @ 600
			Bottom Slab	500	Inner	64.6	80.5	117.0	148.2	D16 @ 300	0.12	203.35	251.24	351.77	D12 @ 600
			Outer	99.1	111.3	65.0	148.2	D25 @ 150	0.23	281.86	251.24	351.77	D12 @ 600		
			Roof Slab	450	Inner	67.4	131.8	-34.0	167.0	D20 @ 300	0.21	160.06	204.79	292.76	D12 @ 600
Multi	3000x2000	6.0	Side Wall	350	Outer	97.3	123.4	42.0	167.0	D20 @ 150	0.21	277.76	178.00	240.84	D12 @ 600
			Inner	6.7	40.2	74.0	79.6	D16 @ 300	-0.39	104.92	178.00	240.84	D12 @ 600		
			Partition Wall	300	Outer	60.6	82.9	179.0	21.4	D20 @ 150	0.22	203.43	128.74	179.00	D12 @ 600
			Bottom Slab	500	Inner	30.2	34.7	150.0	135.9	D20 @ 300	0.23	107.85	128.74	179.00	D12 @ 600
Double	3000x2000	6.0	Roof Slab	550	Inner	64.3	71.7	59.0	135.9	D16 @ 300	0.12	203.68	237.64	325.61	D12 @ 600
			Outer	93.9	107.2	78.0	135.9	D25 @ 150	0.22	405.90	237.64	325.61	D12 @ 600		
			Side Wall	350	Inner	109.0	145.5	35.3	318.2	D25 @ 300	0.18	298.94	271.76	384.86	D12 @ 600
			Outer	198.0	263.5	35.2	318.2	D25 @ 150	0.23	531.13	271.76	384.86	D12 @ 600		
Double	3000x2000	6.0	Partition Wall	300	Inner	16.3	37.8	209.9	137.8	D16 @ 300	-0.56	118.30	206.56	269.39	D12 @ 600
			Outer	68.6	106.3	329.2	137.8	D25 @ 150	0.18	286.48	206.56	269.39	D12 @ 600		
			Bottom Slab	650	Inner	1.2	1.5	795.2	0.3	D16 @ 300	-0.30	131.52	110.94	161.18	D12 @ 600
			Outer	178.0	237.6	39.7	313.6	D20 @ 300	0.17	308.28	291.54	417.20	D12 @ 600		

Table 5.5.5 Stress Calculation Summary (4/6)

Type	Inner Dimension	Cover Depth (m)	Member	Thickness (cm)	Tension Side	Working Force			Steel Bar Arrangement	Crack Width (mm)	Moment of Resistance (kNm)	Shear Resistance (kN)		
						Moment (kNm)	Axial (kN)	Shear (kN)				Concrete Only	Concrete & Stirrups	
						SLS	ULS	ULS						
Multi	3000x2000	7.0	Roof Slab	600	Inner	135.0	270.8	-12.2	D25 @ 300	0.21	322.74	291.54	417.20	
			Outer	229.0	280.6	27.9	281.1	D25 @ 150	0.23	596.91	291.54	417.20		
			Side Wall	500	Inner	19.4	31.7	25.7	D16 @ 300	0.21	180.93	251.24	351.77	
			Outer	154.0	163.9	402.8	154.5	D25 @ 150	0.21	517.47	251.24	351.77		
			Partition Wall	300	Inner	25.4	12.7	808.0	2.1	D16 @ 300	0.23	132.30	110.94	161.18
			Bottom Slab	650	Outer	141.0	190.8	56.2	338.9	D20 @ 300	0.23	310.42	291.54	417.20
Multi	3000x2000	8.0 [HA]	Roof Slab	650	Inner	151.0	304.7	-8.4	D20 @ 150	0.13	438.86	267.72	544.19	
			Outer	214.0	285.7	-3.4	377.5	D20 @ 150	0.25	439.15	267.72	544.19		
			Side Wall	500	Inner	5.8	39.4	283.0	D16 @ 300	-0.45	184.62	317.04	461.18	
			Outer	120.0	174.3	435.0	166.2	D20 @ 150	0.21	383.26	216.51	317.04		
			Partition Wall	300	Inner	6.9	10.7	897.0	4.1	D16 @ 300	-0.17	137.65	110.94	161.18
			Bottom Slab	700	Outer	160.0	221.6	20.0	324.97	D20 @ 300	0.22	324.97	310.66	448.90
Multi	3000x2000	11.0 [HA]	Roof Slab	800	Inner	193.0	256.5	20.0	D25 @ 150	0.21	680.80	409.41	736.15	
			Outer	281.0	512.7	0.9	624.1	D20 @ 150	0.21	567.52	409.41	736.15		
			Side Wall	500	Inner	22.8	66.6	385.1	D20 @ 300	-0.17	247.82	251.24	351.77	
			Outer	161.0	240.6	725.8	216.1	D25 @ 150	0.22	560.41	251.24	351.77		
			Partition Wall	300	Inner	4.5	9.7	1570.0	3.3	D16 @ 300	-0.23	162.79	110.94	161.18
			Bottom Slab	800	Outer	288.0	385.0	84.1	620.2	D20 @ 150	0.22	624.62	409.41	736.15
Single	3500x2000	2.5 [HA]	Roof Slab	500	Inner	100.0	137.9	10.1	D16 @ 150	0.23	218.09	145.08	248.62	
			Outer	69.2	103.5	72.8	167.9	D16 @ 300	0.17	147.70	145.08	248.62		
			Side Wall	450	Inner	-	3.0	137.7	D16 @ 300	-	107.40	176.48	264.44	
			Outer	72.2	110.4	200.5	80.0	D16 @ 150	0.18	218.78	176.48	264.44		
			Partition Wall	300	Inner	122.0	165.9	8.1	259.04	D16 @ 150	0.23	259.04	145.08	248.62
			Bottom Slab	550	Outer	72.2	110.4	42.7	181.9	D16 @ 300	0.20	143.83	145.08	248.62
Double	4000x3000	5.5	Roof Slab	800	Inner	189.0	254.0	40.7	D20 @ 300	0.15	325.65	364.85	540.78	
			Outer	333.0	442.8	40.8	386.2	D25 @ 150	0.19	864.37	364.85	540.78		
			Side Wall	550	Inner	37.2	87.9	292.1	D20 @ 300	-0.14	261.54	271.76	384.86	
			Outer	168.0	253.5	468.6	205.7	D25 @ 150	0.18	604.40	271.76	384.86		
			Partition Wall	300	Inner	0.8	1.0	938.2	0.1	D16 @ 300	-	140.03	110.94	161.18
			Bottom Slab	850	Outer	220.0	293.5	72.9	385.2	D25 @ 300	0.13	549.46	364.85	540.78
Double	4500x3000	2.0	Roof Slab	650	Inner	148.0	279.2	-3.2	D16 @ 150	0.18	303.22	310.66	440.90	
			Outer	255.0	301.5	131.5	227.9	D25 @ 150	0.22	685.59	310.66	440.90		
			Side Wall	400	Inner	24.2	49.0	142.4	D16 @ 300	-0.09	129.72	222.86	298.26	
			Outer	99.4	149.8	298.1	136.0	D25 @ 150	0.21	357.22	222.86	298.26		
			Partition Wall	300	Inner	6.2	42.1	501.2	16.7	D16 @ 300	-0.19	112.19	110.94	161.18
			Bottom Slab	750	Outer	172.0	226.2	62.3	221.4	D20 @ 300	0.18	356.55	329.22	480.02

Table 5.5.5 Stress Calculation Summary (5/6)

Type	Inner Dimension	Cover Depth (m)	Member	Thickness (cm)	Tension Side	Working Force				Steel Bar Arrangement	Crack Width (mm)	Moment of Resistance (kNm)	Shear Resistance (kN)		
						Moment (kNm)	Axial (kN)	Shear (kN)	Concrete Only				Concrete & Stirrups		
						SLS	ULS	ULS	ULS						
Double	4500x3000	4.5	Roof Slab	800	Inner	206.0	275.7	37.6		D20 @ 300	324.70				
			Outer	366.0	487.3	37.2	384.6			D25 @ 150	863.28	364.78	716.64	D12 @ 300	
			Side Wall	500	Inner	33.8	76.6	265.7			D16 @ 300	182.97			
			Outer	148.0	226.0	437.8	185.3			D25 @ 150	522.09	251.24	351.77	D12 @ 600	
			Partition Wall	300	Inner	1.5	9.1	615.9	0.3		D16 @ 300	119.96	110.94	161.18	D12 @ 600
			Bottom Slab	900	Outer	321.0	428.2	59.4	386.2		D20 @ 300	424.02	387.02	759.02	D12 @ 300
Double	4500x3000	6.0	Roof Slab	900	Inner	257.0	339.0	47.6		D20 @ 300	372.02				
			Outer	448.0	596.1	47.6	467.0			D25 @ 150	999.64	398.82	599.89	D12 @ 600	
			Side Wall	600	Inner	34.4	91.6	347.1			D20 @ 300	301.11			
			Outer	199.0	299.4	550.5	212.3			D25 @ 150	696.58	291.54	417.20	D12 @ 600	
			Partition Wall	300	Inner	0.7	1.0	1150.0	0.1		D16 @ 300	151.27	110.94	161.18	D12 @ 600
			Bottom Slab	1000	Outer	306.0	408.5	78.9	471.4		D20 @ 300	475.09			
Double	4500x3000	7.0	Roof Slab	950	Inner	378.0	504.8	78.9		D25 @ 150	1060.22	415.27	628.90	D12 @ 600	
			Outer	295.0	599.3	3.6	694.19			D20 @ 150	694.19				
			Side Wall	650	Inner	499.0	663.2	54.9	520.8		D25 @ 150	1069.03	415.27	628.90	D12 @ 600
			Outer	34.1	100.8	400.9				D20 @ 300	343.19				
			Partition Wall	300	Inner	233.0	348.7	628.1	230.9		D25 @ 150	791.60	310.66	448.90	D12 @ 600
			Bottom Slab	1050	Outer	349.0	471.2	140.4	509.9		D25 @ 300	158.39	110.94	161.18	D12 @ 600
Single	7500x5500	0.5	Roof Slab	700	Inner	367.0									
			Outer	239.0											
			Side Wall	600	Inner	71.4									
			Outer	300.0											
			Partition Wall												
			Bottom Slab	800	Inner	451.0									
Single	7500x5500	1.3	Roof Slab	700	Inner	406.0	611.0	24.7		D32 @ 150	1142.00				
			Outer	113.0	404.0	175.0	308.0			D25 @ 150	765.00	329.20	480.00	D12 @ 600	
			Side Wall	600	Inner	65.0	217.0	216.0			D20 @ 300	275.00			
			Outer	329.0	489.0	328.0	309.0			D32 @ 150	965.00	343.70	469.40	D12 @ 600	
			Partition Wall												
			Bottom Slab	800	Inner	509.0	682.0	76.3			D32 @ 150	1349.00			
Single	7500x5500	2.3	Roof Slab	750	Inner	329.0	489.0	165.0		D32 @ 150	1294.00				
			Outer	489.0	658.0	65.0	418.0			D32 @ 150	1261.00	380.90	544.20	D12 @ 600	
			Side Wall	650	Inner	353.0	507.0	315.0	386.0		D25 @ 150	873.00	347.30	510.60	D12 @ 600
			Outer	59.9	201.0	304.0				D20 @ 300	322.00				
			Partition Wall												
			Bottom Slab	900	Inner	384.0	565.0	621.0	332.0		D32 @ 150	1129.00	366.30	504.50	D12 @ 600
Single	7500x5500	2.3	Roof Slab	900	Inner	665.0	892.0	80.0		D32 @ 150	1569.00				
			Outer	384.0	565.0	459.0	614.0			D32 @ 150	1618.00	450.40	638.90	D12 @ 600	

Further calculation was omitted. Steel Bar Arrangement for 1.3m of Cover Depth was adopted.

Table 5.5.5 Stress Calculation Summary (6/6)

Type	Inner Dimension	Cover Depth (m)	Member	Thickness (cm)	Tension Side	Working Force				Steel Bar Arrangement	Crack Width (mm)	Moment of Resistance (KNm)	Shear Resistance (KN)			
						Moment (KNm)		Axial (KN)					Shear (KN)		Concrete Only	Concrete & Stirrups
						SLS	ULS	ULS	ULS				ULS	ULS		
Single	11000x5600	0.5	Roof Slab	1060	Inner	713.0										
					Outer	508.0										
			Side Wall	900	Inner	1.4										
					Outer	508.0										
Single	11000x5600	1.2	Partition Wall													
			Bottom Slab	1550	Inner	1378.0										
					Outer	454.0										
			Roof Slab	1060	Inner	807.0	1269.0	51.0		D32 @ 150	0.24	1908.00				
Single	11000x5600	1.2	Roof Slab	1060	Outer	577.0	811.0	316.0	451.0	D25 @ 150	0.23	1314.00	447.20	546.70	D12 @ 600	
			Side Wall	900	Inner	-	118.0	365.0		D25 @ 300	-	652.00				
					Outer	577.0	811.0	614.0	268.0	D32 @ 150	0.21	1752.00	489.60	578.60	D12 @ 600	
			Partition Wall													
Single	11000x5600	1.2	Bottom Slab	1550	Inner	1508.0	1838.0	91.0		D32 @ 150	0.25	2995.00				
					Outer	463.0	717.0	439.0	637.0	D32 @ 300	-0.07	1756.00	433.10	684.40	D12 @ 600	

Further Calculation was Omitted. Steel Bar Arrangement for 1.2m of Cover Depth was adopted.

5.5.4. Pipe Culvert

(1) Inner Diameter

Inner diameters of pipe culverts were mentioned in “Chapter-4 Drainage”.

(2) Design Criteria

1) Structural Design Standard and Manual

- British Standard BS 5911
- Design Manual for Roads and Bridges (British Highway Agency, 1989)
- A Design Manual for Small Bridges (Transport and Road Research Laboratory Overseas Unit; UK)

2) Pipe Strength Class

Pipe strength classes were followed the British Standard 5911:Part100.

Table 5.5.6 Crushing Test Loads for Concrete Pipe (KN/m)

NOMINAL SIZE OF PIPE DN	CLASS L		CLASS M		CLASS H	
	Works Proof Load	Maximum Load	Works Proof Load	Maximum Load	Works Proof Load	Maximum Load
450	20	25	35	44	41	52
600	20	25	46	58	54	68
900	46	58	67	84	85	106
1200	58	72	87	109	110	138
1500	63	79	96	120	122	153

3) Bedding Types

Bedding types were selected from the ones that normally used in the British Standard (see **Table 5.5.7**).

Table 5.5.7 Bedding Factors

Bedding Class	Description	Bedding Factors
B	180° Granular Bed	1.9
S	360° Granular Bed	2.2
A	120° Plain Concrete Cradle	2.6

But in case the cover soil depth was seriously big or seriously small, 360° concrete (plain or reinforced) surrounded type was used. Dimensions of 360° concrete surrounded type pipes were designed according to “A Design Manual for Small Bridges (Transport And Road Research Laboratory)”.]

(3) Selection of the Combination of Pipe Class and Bedding Class

In the design, combinations listed in the table below were adopted.

Table 5.5.8 Combination Types and Applicable Range of Cover Depth (in meter)¹

Pipe Strength Class	L	L	M	M	M	H	L
Bed Class	C-1	C-2	B	S	A	A	C-1
Bedding factor			1.9	2.2	2.6	2.6	
0.45	~0.5	~0.9	~3.0	~3.9	~4.9	~5.9	>5.9
0.6	~0.5	~0.9	~2.9	~3.8	~4.8	~5.8	>5.8
0.9	~0.5	~0.9	~3	~3.9	~4.9	~6.6	>6.6
1.2	~0.5	~0.9	~2.8	~3.7	~4.7	~6.3	>6.3
1.5	~0.5	~0.9	~2.8	~3.5	~4.5	~6.2	>6.2

note: "C-1" means reinforced concrete surrounded type and "C-2" means plain concrete surrounded type

(4) List of Pipe Culvert

Pipe Culverts are listed in **Table 5.5.9**.

Table 5.5.9 List of Pipe-Culverts

STA.	Skew Angle	No.of Cells	Inner ϕ in metre	Length in metre	Remarks
Mainline					
16+560	90	2	1.2	80.0	
18+160	90	1	0.9	43.0	
18+320	90	1	1.5	44.5	
24+480	90	1	0.9	43.5	
24+680	90	1	1.5	41.5	
27+360	90	2	1.2	90.0	
Minor Road					
A110	0+070	90	1	1.5	22.0
16+990	-0+215	90	1	0.9	14.0
21+640	-0+100	90	2	0.9	9.0
21+640	-0+250	90	2	0.9	8.0
22+770	0+039	104	1	1.5	13.5
25+650	-0+111	126	1	0.9	15.0
26+299	-0+137	73	1	1.5	13.5
27+061	0+035	90	1	1.2	7.5
27+901	13+090	120	1	1.2	44.5

¹ Source: "A Design Manual for Small Bridges (Transport and Road Research Laboratory Overseas Unit; UK)", "Depth of cover charts (from ARC Pipes Company Catalog) "

CHAPTER 6

CONSTRUCTION PLANNING

CHAPTER 6 CONSTRUCTION PLANNING

6.1 General

Construction planning is mainly comprised of establishing a construction method and preparing a construction time schedule. The results of this work are utilized in estimating construction costs and establishing a project implementation schedule.

6.2 Construction Area

The embankment work of the OCH southern section has become a huge volume for the construction of a highway with total length of 12km., because the route of the OCH southern section has been planned mainly along the low line land such as marsh and paddy fields in order to reduce a demolition of existing buildings and houses and resettlement. High embankment is planned to avoid damage to road structures from floods and also to allow for the clearance for the underpass structures.

Southern section (package 3) starts from Sta. 16+500 and ends at Sta. 28+500, between the route AB010 (Kaduwela) and the Interchange with route A4 (Kottawa).

6.3 Major Work Items

Quantities of major construction works are as shown Table 6.3.1. Layout of structures, bridges, box coverts and pipe culverts are shown Fig. 6.3.1.

Table. 6.3.1 Quantities of Major Construction Works of Each Package

Item		unit	Southern (DD) Package 3	
Road Works	Cutting & Filling	cu.m	268,000	
	Embankment (Borrow material)	cu.m	*3,221,000	
	Countermeasure of soft soil	Replacement	cu.m	1,004,000
		RC Piling	m	107,700-
	Aggregate Base	cu.m	83,500	
	Sub base	cu.m	68,700	
	Selected Martial	cu.m	72,900	
Asphalt Concrete	t	91,600		
Bridges	Highway & Ramp Bridges	No.	7	
	Overpass Bridges	No.	6	
Box Calvert	Underpass & Drainage	No.	37	
Interchange		No.	2	

* Including Horizontal Gravel Mat for soil improvement [2,540,000(borrow)+681,000(gravel mat)]

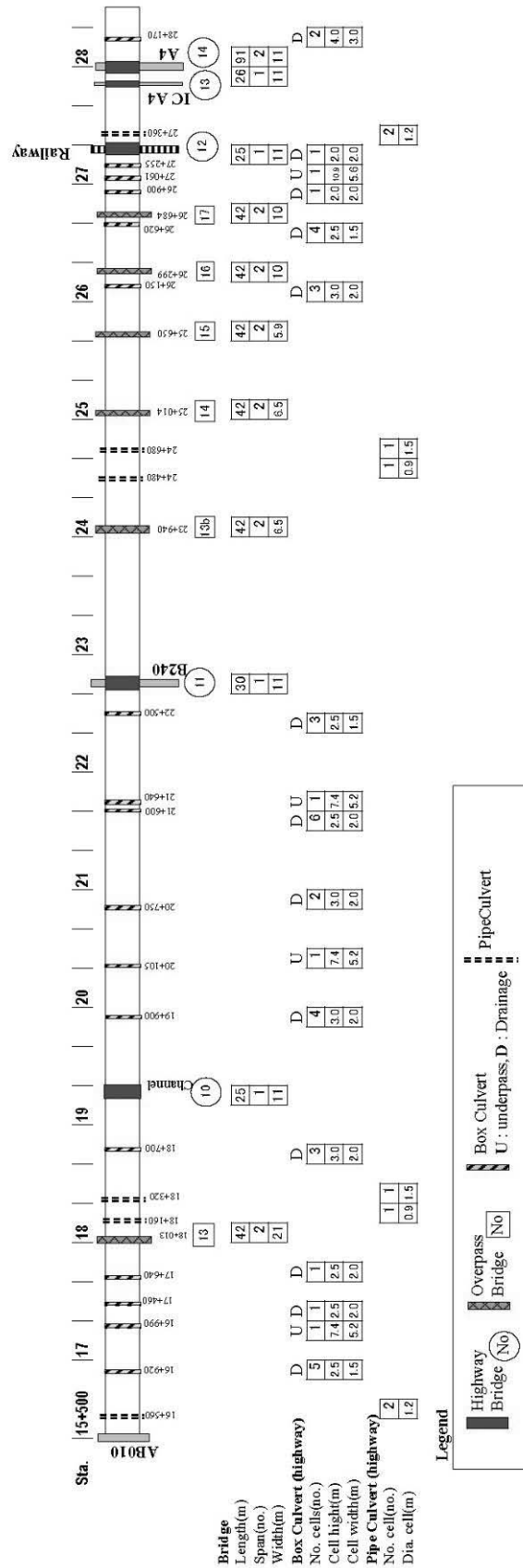


Fig. 13.3.1 Layout of Structures of Package 3 (Detail design section)

6.4 Highway Construction

6.4.1. General

In the southern section of OCH, a large quantity of embankment materials is to be hauled from several borrow pits. The construction work should be carried out in such a manner to use main roads (AB010, B240 & A4) to transport material from borrow pits or suppliers' material to the intersection of the OCH. At the job site, construction of temporary road under the OCH as a pilot shall be used as much as possible for transportation of material. Where local roads are used for transportation, pavement strengthening/repairing of local roads will be necessary during the construction period.

Highway construction will be executed after land acquisition is completed as shown below flowchart.

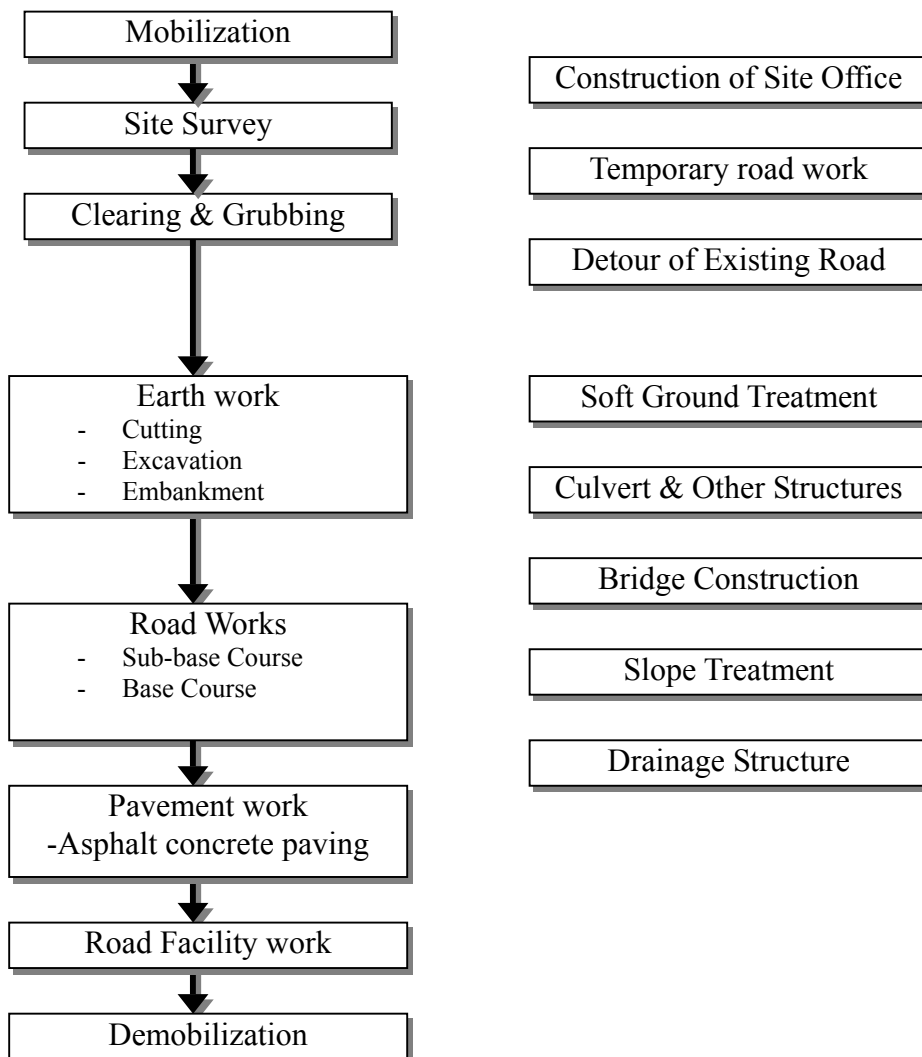


Fig. 6.4.1 Highway Construction Flow

6.4.2. Borrow Material Plan

The earthwork volumes are shown in the Table. 6.3.1. The large quantity of borrow material shall be hauled from several borrow pits. The existing borrow pits are shown in Fig. 2.3.4 and Table 2.3.7 of Chapter 2.3.

The borrow pits are located at distances between 10 km and 20 km (average 15km) from OCH. The haulage of material from borrow pits shall be transported via main-roads, Route AB010 and B240 to OCH in order to minimize disturbance to public traffic. Route A4 road shall be used minimally in consideration of its heavy volume of public traffic.

The haulage quantities of borrow/quarry materials, and the total numbers of dump trucks (10t) for Package 3, required are shown in Fig.6.4.2.

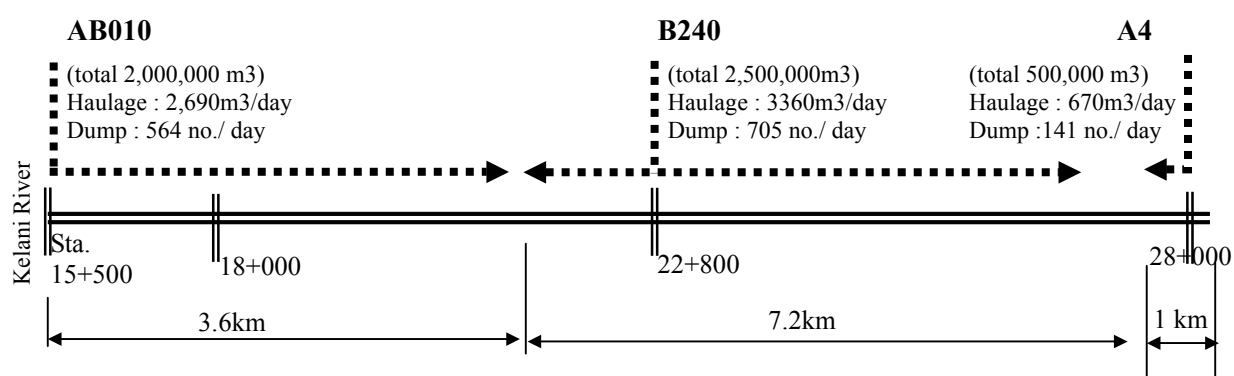


Fig. 6.4.2 Borrow/Quarry Material Haulage Plan

6.4.3. Quarry Plan

There are several operating quarry sites around the OCH route and are located at distances between 2 km and 18 km from OCH. The quarry sites are shown in Fig.2.3.4 and Table 2.3.8 of Chapter 2.3. The required volume of quarry materials including concrete works for Package 3 is estimated at 2,100,000 m³.

6.4.4. Pavement Works Plan

There are several companies producing and supplying asphalt concrete and their details and capacity are given in Table 6.4.1, and Fig.6.4.4.

Table 6.4.1 Asphalt Suppliers

No.	Supplier	Address	Max capacity (ton /hour)
1	International Construction Consortium Ltd.	Madapatha	60
2	Maga Engineering	Homagama	60
3	Fumihiko Engineering Construction Pvt.Ltd.	Paliyagoda	100

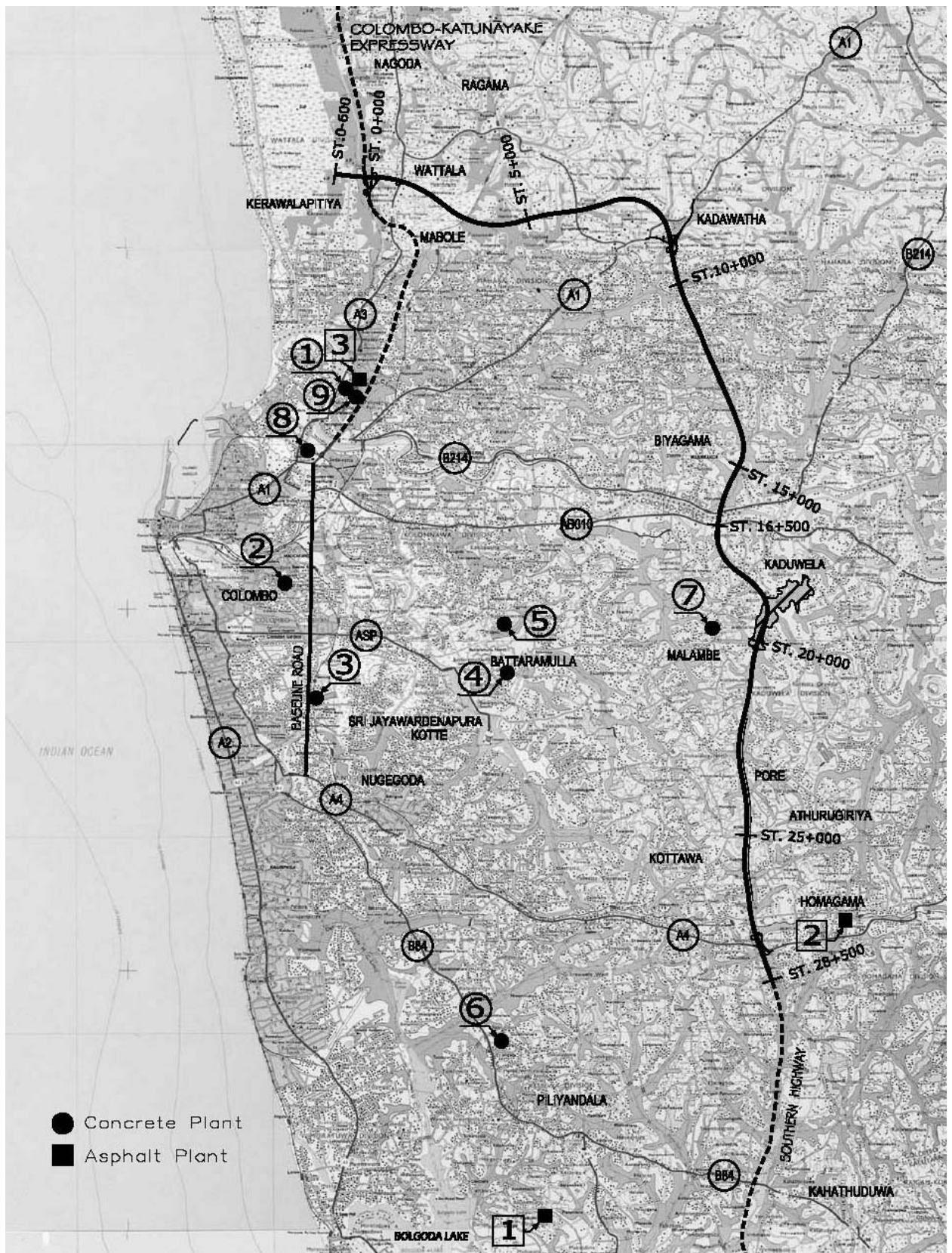


Fig. 6.4.3 Location of Asphalt and Concrete Plants

6.4.5. Soft Soil Mitigation Plan

The replacement method and/or Geotextile reinforcing method will be mainly used for the soft ground improvement in the OCH Project. Piling method will also be adopted in consideration of the geological conditions.

For replacement method and geotextile reinforcing method, the following procedure is recommended.

(1) Clearing and grubbing

Excavation for replacement method shall be carried out by using backhoe (with long boom) and removal soft soil shall be as per Engineer's instructions.

Prior to laying of the geotextile material, the surface of the compacted ground shall be leveled to avoid causing damage to the geotextile material.

When geotextile is used directly on existing ground, the grubbing work shall be carried out efficiently. Perished or spoiled grub will be the cause for the subsiding of the embankment.

(2) Laying Geotextile

Geotextile material will be laid on the filled ground in level. The geotextile material shall be fixed on ground by any skewers. The jointing method and the joint position of geotextile material shall be executed in accordance with the manufacturer's recommendation and approved by the Engineer.

(3) Spreading and Compaction Embankment Materials

When spreading the embankment materials on geotextiles, it will be necessary to take care to protect against causing damage to geotextiles. It is therefore absolutely necessary that no machines should be allowed on geotextiles directly, and any sharp gravel/pebbles shall be removed from the surface of the filling material.

The thickness of compaction and machines to be used shall be determined by trial construction. Machines such as tamping rollers shall not be allowed for the compaction work so that no concentric loads are caused.

6.5 Bridges

Pre-stressed Concrete (PC) girder bridges are selected for main highway bridges and overpass bridges in the Package 3. Two type of PC bridges, PC I girder-bridge and box girder-bridge have been designed. PC I girder bridge is selected for short span bridge (span length equal and less than 33 m) and box girder bridge is selected for long span bridge (span length more than 33 m). Abutments and piers are selected reversed T type and foundations are spread type and pile foundations, designed to suit geological conditions.

6.5.1. Concrete Procurement

There are several companies produce and supply ready-mixed concrete in the Colombo region, the details of the companies and their capacities are given in Table 6.5.1.and Fig. 6.4.3.

Table 6.5.1 Concrete Suppliers

No.	Suppliers	Address	Capacity (m ³ /hour)
1	Sanken Lanka (PVT) Ltd	Colombo 14 & Peliyagoda	20
2	Informax Construction (PVT) Ltd	Colombo 10	60 & 90
3	Tudawa Brothers	Colombo 5	25
4	Sunbee Ready Mix	Battaramulla	60
5	Maga Engineering	Gothatuwa	60
6	International Construction Consortium	Bokundara	50
7	Keangnam Ready Mix	Malabe	120
8	Oru Mix Lanka Pvt. Ltd.	Wellampitiya	20
9	Tokyo Cement Co.	Peliyagoda	120

6.5.2. Foundation Works

(1) Excavation

Excavations shall be carried out in accordance with the most practical methods at each bridge location. In general, foundation works for concrete structures shall not be programmed during wet seasons. The general method of excavation will be an open cut excavation.

For foundation works of the railway crossing bridge (Highway bridge No.12) sheet pile cofferdams, strut and wale are required in order for minimize the effects on the railway tracks.

The excavation works will require the use of sheet pile cofferdams to protect the sides of the excavation as shown in Fig. 6.5.1

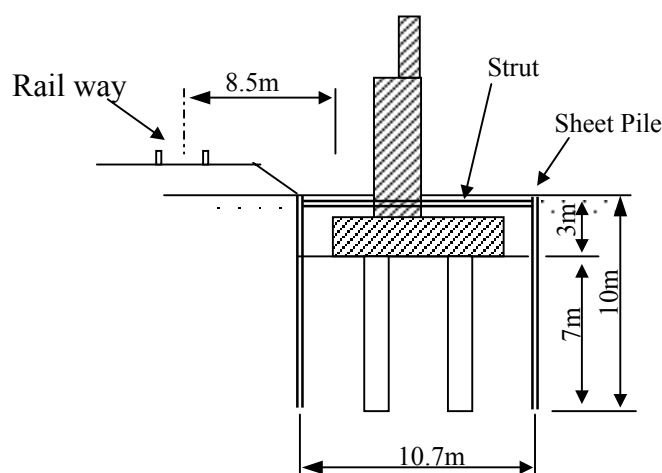


Fig. 6.5.1 Sheet Pile Cofferdam for Substructure HW No.12 (Railway)

(2) Bored Piles

In consideration of the geological conditions, Reverse-Circulation Method or Earth drill method will be adopted for the execution of bored pile. The following methodology may be recommended.

i Setting up

Establish working platform by earthwork operations by cutting, filling and levelling to the required elevation. Mobilise piling machine system and arrange appropriately over the established work platform.

ii Excavation

Piling machine to be placed over the pile point and the verticality of the rig checked prior to the commencement of drilling. To ensure the stability of the ground around the drilled hole, bentonite stabilizing fluid, and/or water-head pressure method shall be adopted.

iii Placing of Reinforcement

After the completion of excavation procedure, the cleaning bucket shall be used to clean the sludge at the bottom of the bored hole. During the excavation work, reinforcement shall be mobilised to site or stored in close proximity.

The first cage shall be lowered into the hole and the upper end shall be kept protruding out of the hole to enable the splicing of the subsequent cage onto it. Welding shall be used to secure the splice.

iv Concreting

Tremie pipes shall be used for the concrete casting, and will be assembled to reach the bottom of the bored hole. Sediment and slurry inside of bored hole will be pumped out

from bottom of the bored hole. Concrete will be transported to site in mixer trucks from the approved concrete batching plants. When casting concrete, the tremie pipe will be kept 3m into the concrete at all times and the rising concrete level will push up the water out of the hole. The concreting will be terminated approximately 0.5m above the cut-off level.

6.5.3. Sub-structure

The progressive completion of the foundation works will enable the subsequent works to proceed with the construction of the reinforced concrete substructures. The construction of these substructures shall be in conventional reinforced concrete construction up to the superstructure.

(1) Formwork

Ordinary water proofing quality plywood or coated plywood will be used for formwork as allowed by the Specification. Form ties with plastic cones will be used for securing of forms in place. Lift height will be determined in accordance with the construction joints approved by the Engineer. Generally, the walls and piers shall be 1 to 5 lifts.

(2) Steel Reinforcement

All reinforcement will conform to the requirements of BS 4449 Grade 460, Type 2 and will be purchased from local manufacturers or imported. Cutting and bending bars shall be carried out on site at a bar bending yard and shall be carried out in accordance with the specifications and the code of practice. All bars will be securely fixed with annealed wire and spacer blocks (mortar or concrete) made with the same quality of placed concrete and will be tied to reinforcement to ensure required concrete cover.

(3) Concreting

In general, concrete shall be placed in accordance with the requirements of Technical Specifications and in a manner to suit the various conditions which may be encountered, using any or combination of the following techniques: concrete pump cars, cranes equipped with skip buckets of appropriate sizes, bins, chutes, or manually. In all methods used, slump values specified shall be maintained during placing and care shall be given to prevent segregation of the constituents. Compaction of concrete shall be by electric, mechanical or pneumatic drive, immersion type vibrators or formwork mounted type in accordance with the Technical Specifications. When concrete has sufficiently hardened, construction joint surfaces will be green cut by wire brush and water jets.

6.5.4. Superstructure

Initially, land near to the bridge approaches will be reserved for the beam casting activities. The land will be levelled by cutting and/or filling.

For bridges using PC post-tensioned I-girders, a system of rails will be installed to enable the movement of girders with chain block to handle the beams. Steel formwork will be manufactured to conform to the cross-section of the PC I-girders and will be rotated around the bridge sites to cast the PC I-girders. Post-tensioning of the PC I-girders will

be carried out in one step after they have reached adequate strength and prior to their erection. The pre-stressing of the beams will be in accordance with the requirements of the detailed design and the specification requirements.

Alternatively, for those bridges using cast in-situ post-tensioned box type girders, the pre-casting yard at the abutments will not be provided, as there is no requirement for such facilities.

(1) PC I-girder Bridge

As for the pre-cast post-tensioned I girder-bridge, the I-girders shall be constructed in an area offset from each bridge abutment under the supervision of the specialised staff. The PC I-girders will be erected by truck crane or crawler crane. Once transported to the span being erected, the girder will be shifted into their final position over the elastomeric bearing pads with the aid of lateral winching system on rollers.

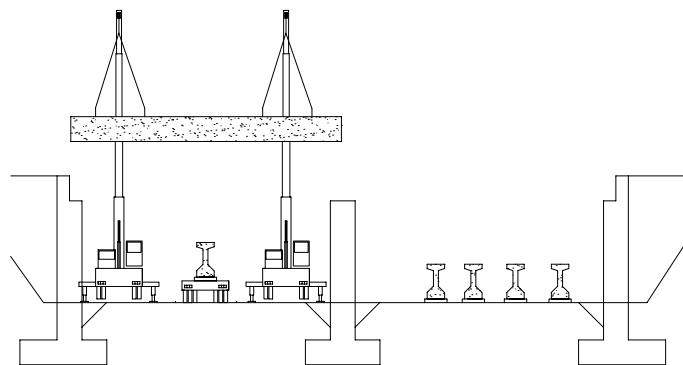


Fig. 6.5.2 Erection of PC I-Girder by Mobile Crane

The cross beams will then be cast-in-site and post-tensioned after the required time and strength have been achieved. The construction of the deck slab is on the 75mm thick pre-cast reinforced concrete panel (RC panel) that is placed in between the PC I-girders as shown on Figure 6.5.3.

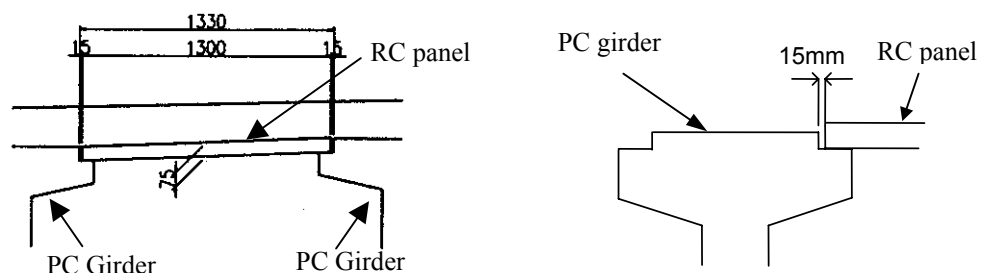


Fig. 6.5.3 RC Panel

For the cantilevered slabs, steel brackets shall be installed on the side of PC I-girder, or shall provide the support from bottom for formwork and the scaffolding for the slab construction.

The slab shall have a broom finish to enhance adherence between the concrete and the wearing course to follow. Finishing works including the approach slabs, reinforced concrete barrier and other miscellaneous construction shall be completed following the slab construction.

(2) Cast In-situ PC Box Girder Bridge

For the cast in-situ post-tensioned box girders bridges, (Highway bridge No.14, Ramp bridge No.6 and 7), the superstructure is constructed over a working platform as long and wide as the superstructure and required working space around as shown in Fig. 6.5.4. This platform is supported by a scaffolding system placed underneath and founded on the ground level. With traffic, if any, diverted around the bridge through a temporary road, and the working platform thus erected, the construction of reinforced concrete box girder can then proceed.

This scaffolding system shall consist of a 15 mm coated plywood deck over a series of timber/steel beams. The height of scaffolding is approximately 6 m.

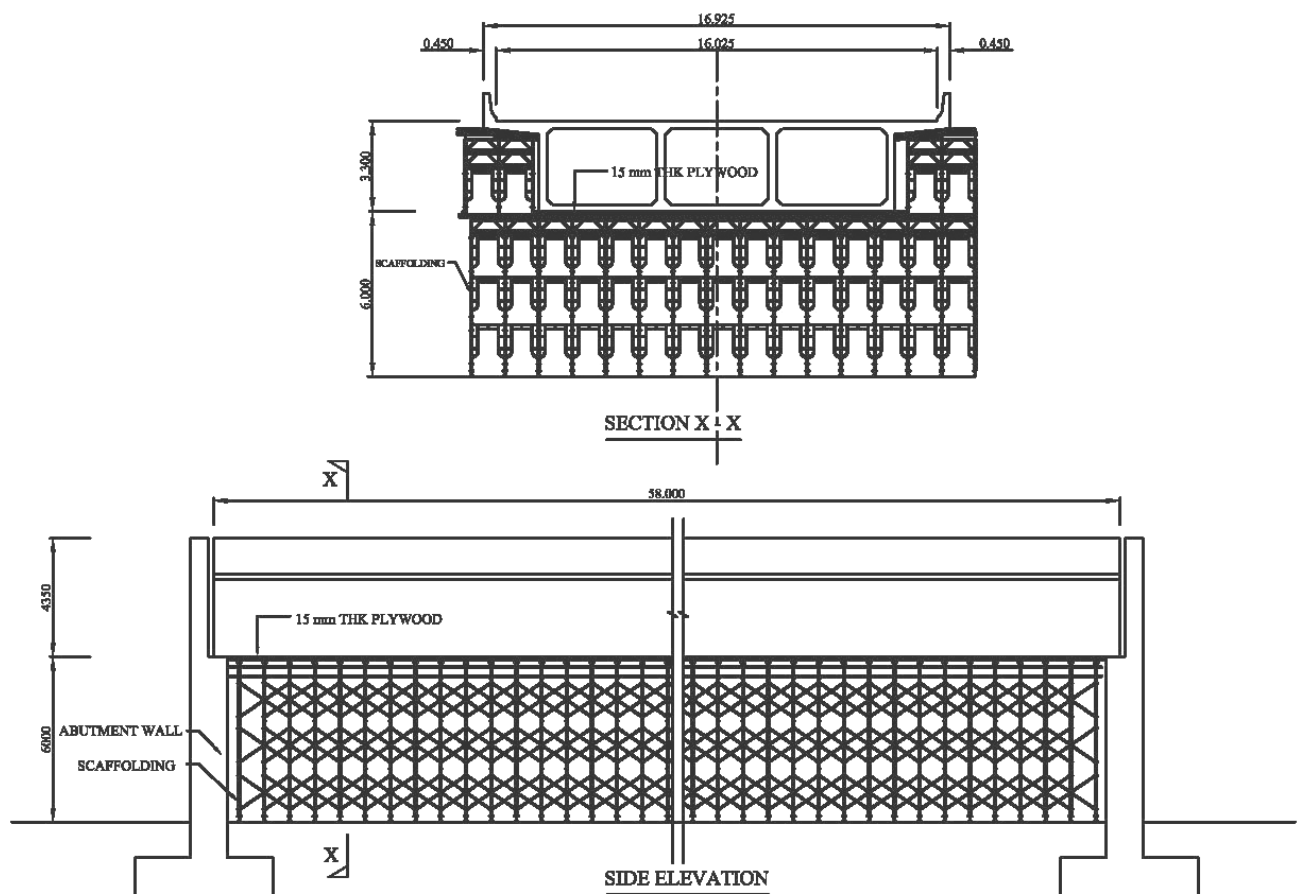


Fig. 6.5.4 Supporting System for Post-tensioned PC Box Girder

6.6 Diversion Road Plan

During construction of OCH - Package 3, for the Highway Bridge No.14 and Ramp Bridge No.6 at A4 interchange, it is necessary to provide diversion roads for the public traffic. The plan of the diversion is shown in Fig. 6.6.1, and also diversion roads should be provided during the construction of Overpass bridges and Underpass box culverts, particularly at the Overpass Bridge No.13 at B263 road, a sufficiently wide diversion road is required for the public traffic.

6.7 Diversion Channels Plan

The OCH which is mainly passing through the marshy area, divides the flood plain into two parts on the left and the right sides. Under the existing conditions, shallow flow can be seen in main watercourse and both sides get, simultaneously inundated with heavy rainfall. According to the OCH alignment, main watercourse shall be realigned at some locations as the existing waterway will be filled by road embankment. Therefore, drainage canals have been designed with hydrological calculations. However, during the construction it is required to provide temporary waterways in small scale at some locations in order to have a continuous water flow from upstream to down stream.

6.8 Construction Schedule

6.8.1 Construction Period

Taking into account the large volume of earthwork, and the public road traffic disturbance to be caused by the haulage of borrow material, the possible construction period shall be set at 4 years. The construction time schedules for all packages are planned as shown in Table 6.8.2 and the schedule for required heavy vehicle and machineries are shown in Table 6.8.3.

6.8.2 Effective Working Days

Working days ratio for the project is estimated according to rainy days (daily rainfall over 10mm), including Sundays and holidays. The following table shows the data for the above factors.

Table 6.8.1 Working Days Rate

Month		1	2	3	4	5	6	7	8	9	10	11	12
Rainy Day (Over 10mm)		5.75	3.25	5.75	8.00	11.50	6.50	4.00	4.25	6.00	12.50	11.50	5.25
Holiday	Sunday	4	4	4	4	4	4	4	5	4	4	4	4
	National Holiday	2	2	1	3	3	1	2	0	1	1	1	2
	Other Holiday				4								
Dates of overlapping holiday & rainy day		1.11	0.70	0.93	2.93	2.60	1.08	0.77	0.69	1.00	2.02	1.92	1.02
Monthly dates		31	28	31	30	31	30	31	31	30	31	30	31
Number of days worked		20.4	19.4	21.2	13.9	15.1	19.6	21.8	22.4	20.0	15.5	15.4	20.8
Rate of operation		0.66	0.69	0.68	0.46	0.49	0.65	0.70	0.72	0.67	0.50	0.51	0.67
Ave. of Operation Rate		0.62											

Rainy Season Average (4, 5, 10, 11) : **0.491**
Dry Season Average (1, 2, 3, 6, 7, 8, 9, 12) : **0.681**

* Rainfall data: Average btw. 2001 & 2003 (Homagama)

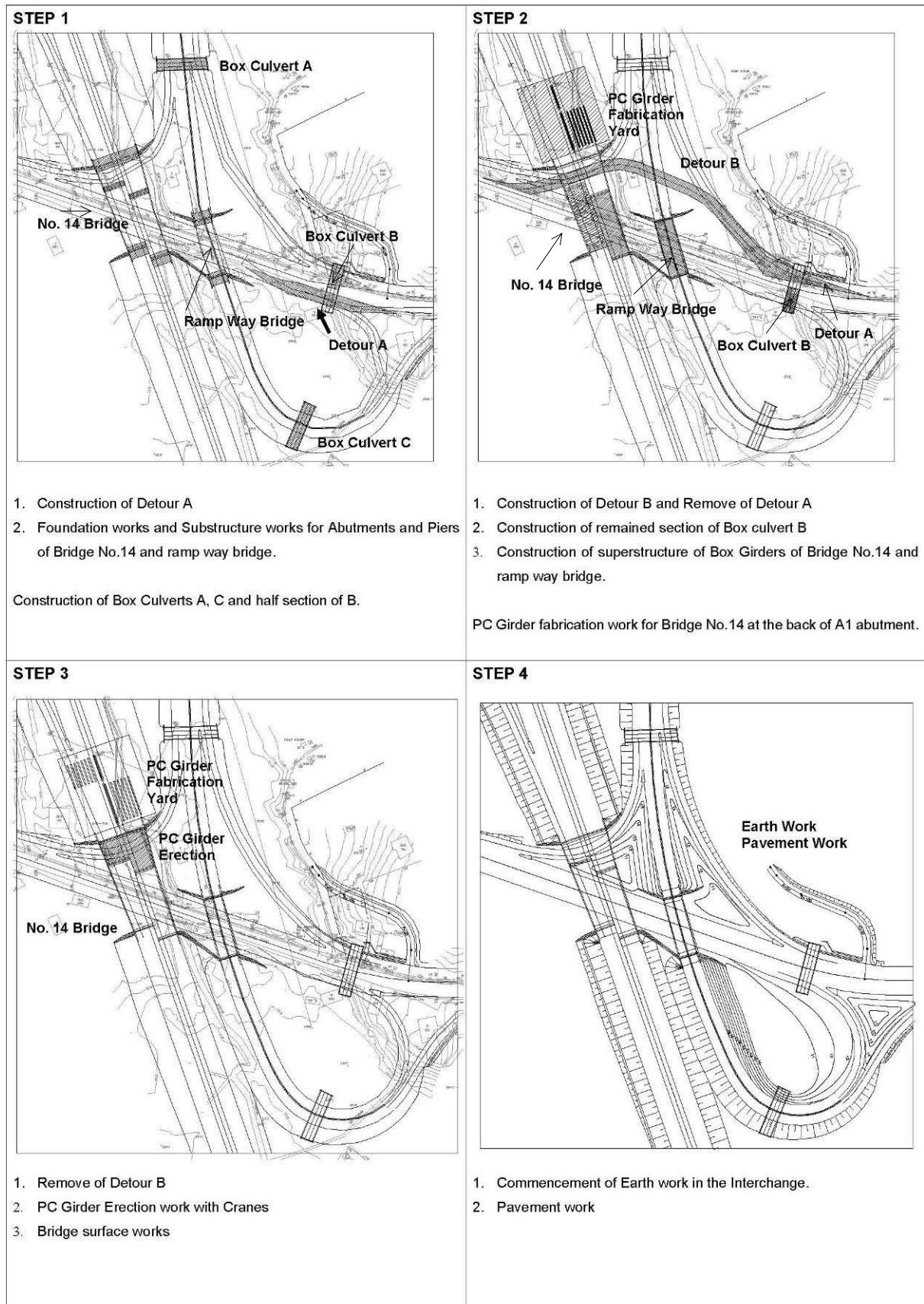


Fig. 6.6.1 Divert Road Plan for A4 Interchange

Table 6.8.3 Preliminary Schedule for Required Heavy Vehicle and Machineries

No.	Equipment	Capacity	Required No. (estimate)
01	Bulldozer	15 t	10
02	Bulldozer	21 t	10
03	Ripper Bulldozer	32 t	1
04	Backhoe	0.8 m ³	8
05	Backhoe	1.4 m ³	17
06	Motorizes Grader	3.1 m	4
07	Dump Truck	10 t	350
08	Road Roller	12 t	6
09	Tired Roller	20 t	12
10	Asphalt Paver	2.4-6.1 m	2
11	Water Bowser	5000 L	8
12	Mobile Crane	25 t	3
13	Rock braker	1300 kg	2
14	Vibration Pile Hammer	60kW	1
15	Bored Pile Machine	1.5m, 1.0m dia.	2
16	Crawler Crane	40 t	1
17	Crawler Crane	50 t	2
18	Crawler Crane	80 t	2
19	Crawler Crane	100 t	1
20	Track Crane	150 t	1
21	Pre-stressing pump/jack	7S12.7	7
22	Pre-stressing pump/jack	15S12.7	2
23	Pre-stressing pump/jack	1S21.8	1
24	Pre-stressing pump/jack	12S15.2	2
25	Pre-stressing pump/jack	1S28.6	1
26	Generator	20 KVa	11
27	Flatbed Truck	4 t	3
28	Truck with crane	10 t	2

CHAPTER 7
ENVIRONMENTAL STUDY

CHAPTER 7 ENVIRONMENTAL STUDY

7.1 General

The Environmental Impact Assessment (EIA) was carried out in the Feasibility Study (FS) for the OCH granted by JICA in 2000 (2000 EIA). The environmental study was conducted on the alignment selected in the FS as preferable trace based on the concept of urban sustainability, which consists of the three factors of economic, social and environmental sustainability.

The EIA report was approved by the Sri Lankan Central Environmental Authority (CEA) in February 2001 with three years validity. The validity was extended until May 2007 based on the request from RDA. In the conditional letter of the approval issued to the RDA, CEA has recommended a deviation of the trace based on the findings of the 2000 EIA. The recommended deviation, from station 17+000 to station 21+800, a distance of 4800m, was through marsh and paddy lands except for a length of 500m in intermittent high ground.

It was decided that fresh approval is required for the above deviations as stipulated in section 23 EE of the National Environmental Act at the Monitoring Committee of the CEA held in March 2003. The CEA requested RDA to prepare the Supplementary Environmental Impact Assessment (SEIA) report for the deviation route.

The purpose of the SEIA is to ensure that the potential environmental consequences of the proposed deviation of the OCH are recognized early for required mitigatory action, which will be taken into consideration in project planning and design. The SEIA study has been conducted for Kaduwela deviation section based on the Terms of References (TOR) prepared by the CEA since July until September 2004. As of December 2004, the SEIA report for the deviation has been under public inspection in accordance with regulation of National Environmental Act. It has been approved by CEA in May 2005.

Subsequent to the findings of the 2000 EIA, further studies have been conducted on the specific environmental impacts of the project and the required mitigation measures. The Environment Management Plan (EMP) including the Environmental Monitoring Action Plan (EMAP) for the OCH Project has been formulated based on these additional considerations and EIA findings. The EMP for the OCH Project presents the implementation details of the environmental protection measures recommended for the pre-construction, construction and operational phases of the Project.

On the other hand, Basic Resettlement Implementation Plan (RIP) for the OCH Project was prepared under the responsibility of RDA. Since involuntarily resettlement is considered critical issue for the Project, the review of the preparation activities had been conducted in the course of environmental study.

7.2 Supplemental Environmental Impact Assessment (SEIA)

7.2.1. Description of the Proposed Deviation

(1) Proposed Deviation Route

The proposed deviation from station 17+000 to station 21+800 (JICA Study, 2001), a distance of 4800m, is through marsh and paddy lands except for a length of 500m in intermittent high ground. The deviated trace runs parallel and in close proximity to the main drainage in the area, namely “Maha Ela”, a left bank tributary of Kelani river which flows in a north-easterly direction from station 19+200 in the deviated trace, confluences with the river about 400m upstream of Kaduwela bridge. The Fig. 7.2.1 and Fig. 7.2.2 shows the Project area and deviation route.

The Fig. 7.2.3 shows the existing ground levels and the proposed road levels in the deviated trace. It could be seen that in the deviated trace, the ground levels are low and varies from +4.00 m m.s.l. at 21+800 to +2.00 m m.s.l. at 19+200, except near Malabe – Kaduwela road crossing, where the existing ground elevation increases to +17.00 m m.s.l.

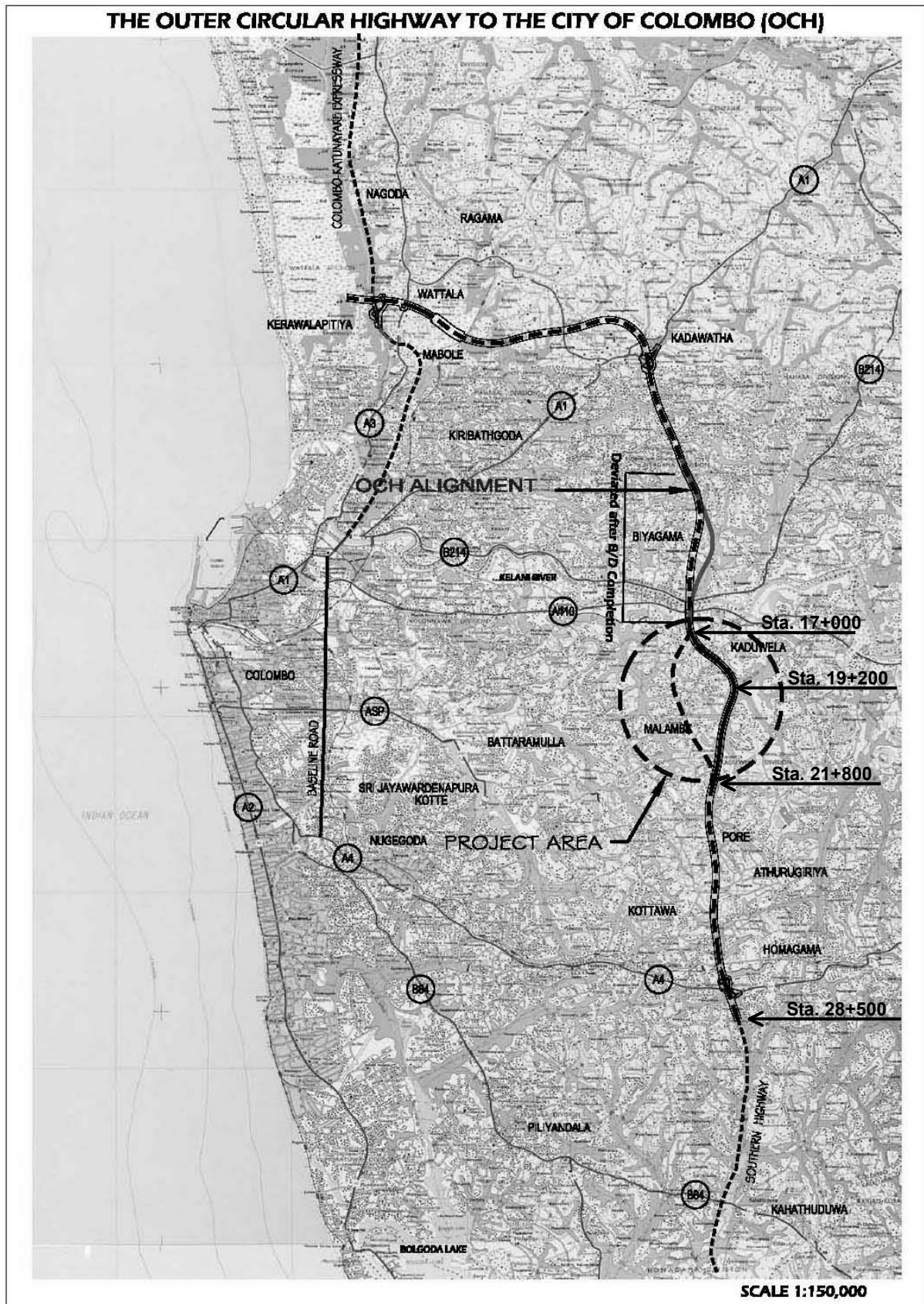


FIG 7.2.1 PROJECT LOCATION MAP

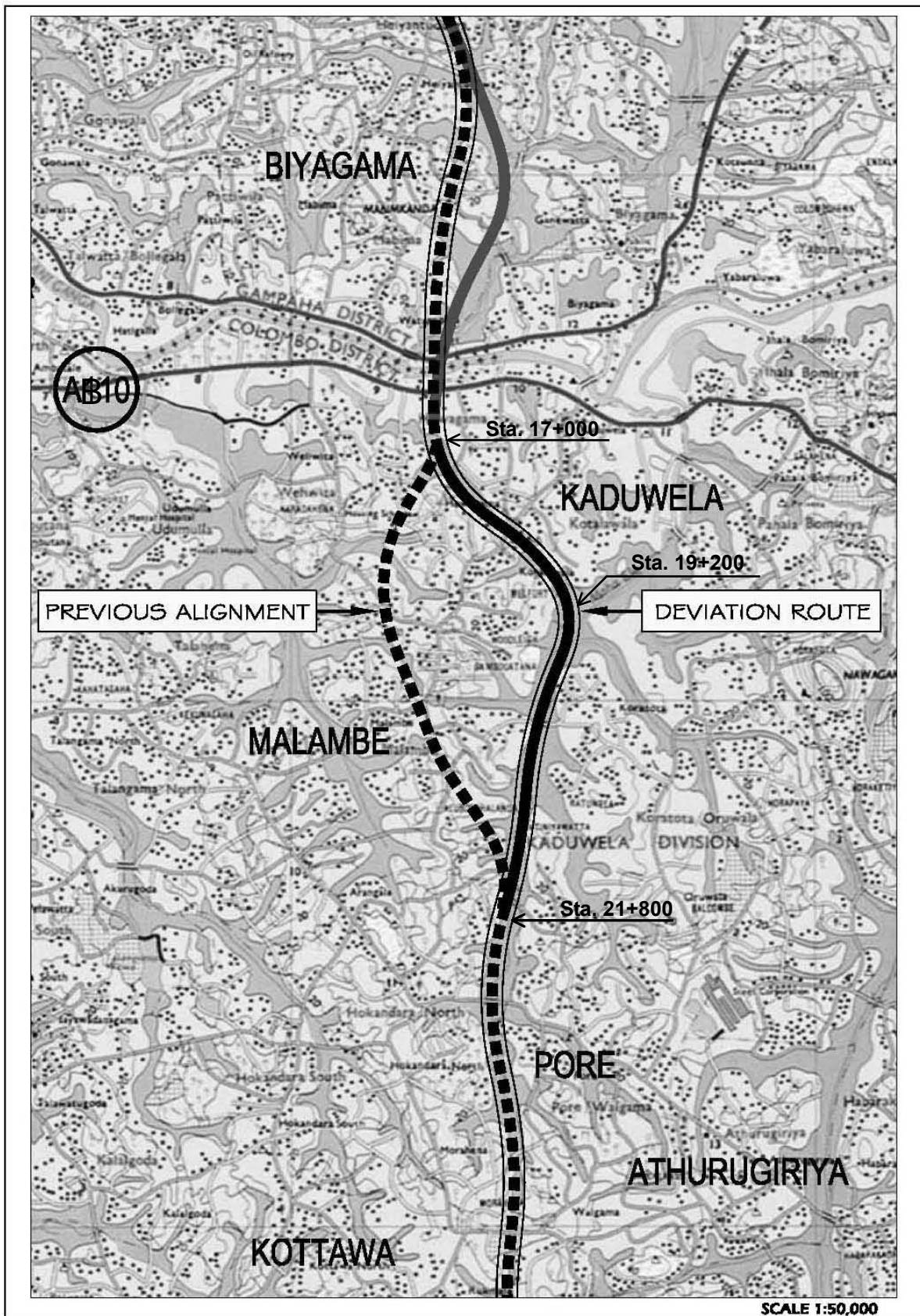


FIG 7.2.2 DEVIATION ROUTE & PREVIOUS ALIGNMENT

(2) Description of the area of the proposed deviations

1) Physical Environment

i Existing Drainage Pattern Across the Proposed Deviation

The storm water in the deviated trace flows into Kelani river via “Maha Ela” (the one of main drainage stream), left bank tributary of Kelani river about 400 meters upstream of the Kaduwela bridge. About 73% of the deviated trace runs parallel to the Maha Ela. In the deviated trace Maha Ela has two major right bank tributaries meeting the Maha Ela at stations 19+800 and 20+600 and one left bank tributary meeting the Maha Ela at station 20+300. On its way to Kelani river the Maha Ela meets another major stream called “Hettige Ela” about 1 km upstream of the confluence point with the Kelani river.

The Fig.7.2.4 shows the existing drainage pattern across the proposed deviation. At present the section of the Maha Ela from station 21+800 up to 19+200 is in a marsh state due to poor drainage conditions in the deviated trace and the Maha Ela lower areas. In this stretch clear demarcation of the Maha Ela is not visible due to existing marsh conditions. The Maha Ela drains a catchment area of about 12.6km² at station 19+200 turns in a north easterly direction away from the proposed road trace.

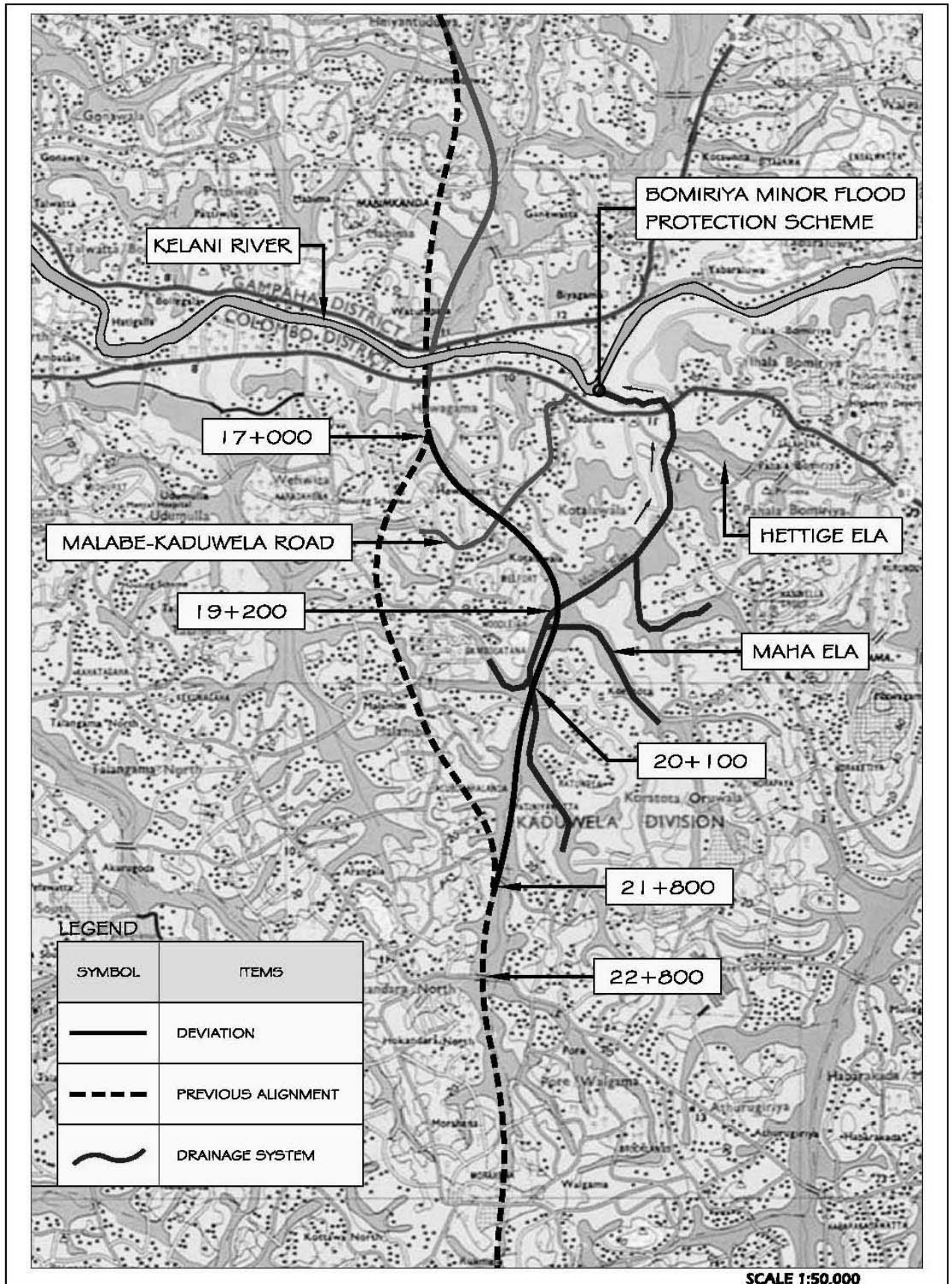


FIG 7.2.4 EXISTING DRAINAGE SYSTEM

ii Flood Peak Values, Inundation Levels, Inundation Periods for Different Rainfall Events

The flood peak values in the deviated trace area are mainly dependent on the Kelani river flood levels. The Kelani flood levels observed for 1947, 1967 and 1989 are given below:

1947 ¹	11.2 m m.s.l.
1967	7.4 m m.s.l.
1989	7.9 m m.s.l.

(m.s.l. : mean sea level)

The frequency analysis carried out using distribution function (extreme value distribution type – Gumble) for observed flood records at Glencourse upstream of Kelani river (maintained by Irrigation Department) indicates that 1967 floods is close to 20 year return period and 1989 close to 35 year return period.

Based on model studies and observed flood values, the flood level of Kelani river for a 50 year return period is estimated to be 8.3m m.s.l. in the deviated trace area and 8.2m m.s.l. below Kaduwela Bridge.

Modelling also indicate that, 50 year return period flood simultaneously occurring in both the Maha Ela and Kelani river will not significantly increase (about +10cm) the flood level in the deviated trace area due to domination of flood level by the Kelani river.

The Maha Ela sub catchment was modeled by hydrological model (HEC-HMS model) for flash storms and long duration storms. For flash floods, 3 hr storm duration was considered as the time of concentration in the sub catchment is about 3 hours. However for long durations flood storm, standard 24 hr storm duration was taken into account.

The hyetographs for 3 hour and 24 hour storms for different return periods were derived using Intensity Duration – Frequency curves (IDF Curves) at Colombo and design storm hyetographs used in the “Study on Storm Water Drainage Plan for Colombo Metropolitan Region 2003” by JICA Study are given in Appendix 7.1 and A.7.2.

The peak discharges along OCH deviated trace obtained from HEC – HMS modeling is given in Table 7.2.1

¹ The 1947 flood levels recorded from people hearing would not be very realistic and the topographic conditions and river cross sections are quite different from the present configuration and therefore not taken in the high water level analysis.

Table 7.2.1 Peak Discharges along OCH Deviated Trace

Return Period	Station	Flash Flood (3hr) m ³ /s	Long Duration Flood(24 hr) m ³ /s	Remarks
10 year	21+600	27.6	34.8	Stations given here are close to the start of deviation(21+800), up stream of road crossing the Maha Ela" at 20+100 and Maha Ela marsh area19+800
	20+700	44.5	56.5	
	19+800	49.9	63.4	
25 year	21+600	35.4	50.9	
	20+700	57.3	84.5	
	19+800	64.2	92.4	
50 year	21+600	41.3	69.1	
	20+700	66.9	112.2	
	19+800	74.7	123.0	

Source: JICA Study Team for OCH

According to above results, long duration (24hr) storms are the critical storms. Hydraulic Model (HEC-RAS) was used to evaluate the inundation depths for different return periods for existing conditions are given in Table 7.2.2 below.

Table 7.2.2 Inundation Levels for Existing Conditions

Return Period (Years)	Station	Flash Flood (3hr) m m.s.l.	Long Duration Flood (24 hr)m m.s.l.	Remarks
10 year	21+800	4.88		-21+800 start of deviation trace -20+100 Road crossing point in the deviation trace
	20+100	4.19		
	19+500	2.98		
25 year	21+800	5.09	8.31	-19+500 about 300m upstream of Maha Ela turning point.
	20+100	4.31		
	19+500	3.13		
50 year	21+800	5.29	8.30	
	20+100	4.41		
	19+500	3.26		

Source: JICA Study Team for OCH

- Inundation Depths

The inundation depths due to the Kelani flooding for 50, 25 and 10 year return periods in the deviated trace at station 21+800, 20+100 and 19+200 are given in Table 7.2.3.

Table 7.2.3 Inundation Depths for Different Return Period Floods

Return Period	Station	Existing Ground Level (m m.s.l.)	Inundation Depth (m)	Flood Level (m m.s.l.)
50 Year	21+800	5.00	3.30	8.3
	20+100	2.67	5.63	
	19+200	2.30	6.00	
25 Year	21+800	5.00	2.70	7.7
	20+100	2.67	5.03	
	19+200	2.30	5.40	
10 Years	21+800	5.00	1.30	6.3 ²
	20+100	2.67	3.63	
	19+200	2.30	4.00	

Source: JICA Study Team for OCH

- Inundation Periods

The inundation period for Kelani floods is generally about 3-5 days depending on the downstream conditions of the Kaduwela Bridge.

During local flooding in the Maha Ela area, the existing road in the deviated trace at station 21+750 goes under water for about three hours due to inadequate drainage provision across the road.

iii Retention Areas, Marsh Lands, Water Bodies

Due to low ground elevation along the deviated trace from station 22+500 to 18+500, and the stretch along Maha Ela from station 19+200 to up to (Kaduwela-Homagama Road Bridge), the area below +5.00 m m.s.l. contour acts as a retention basin for the storm water in the Maha Ela catchment, prior to discharge into Kelani River. This area thus acts as a flood detention basin of the area from station 25+000 to station 18+500 about 6.5 km stretch of the OCH in the Kelani river basin.

- Marsh Lands and Water Bodies

According to people in the area the low areas referred above were cultivated with paddy about 15-20 years before. However, due to stagnation of water and construction of access roads without adequate drainage provisions has created marsh conditions specially the area below station 21+800. According to the Irrigation Engineer, Colombo limited dredging has been carried out in this area on request made by farmers in the area. The inquiries made during recent inspection reveals that the limited paddy cultivation carried out near station 21+800 area in 2004 were not successful due to poor drainage conditions in the area below.

There are no water bodies except this marsh area along the deviated trace.

iv Existing Irrigation / Drainage / Flood Protection Schemes

There are no irrigation schemes or structures encountered along the deviated trace. The

² As per LHI Study for Kelani Conservation Barrage – 2003 September

paddy tracts along the deviated trace in the past have been cultivated under rain fed conditions. This area has been abandoned for the last 15-20 years. However, paddy cultivation is being done in the upper reaches. The Maha Ela is being considered as the main drainage canal for draining of excess water during paddy cultivation period.

The paddy tracts in the Maha Ela and the Hettige Ela are being protected by a minor flood protection scheme with two rows of eight flap-gated structure at the confluence point maintained by the Irrigation Department. According to the Irrigation Department, the total extent protected under this scheme is 3,000 acres with 2,400 acres under the Hettige Ela and 600 acres under the Maha Ela. This flood protection scheme is named as “Bomiriya – Koratota” minor flood protection scheme and has been designed to protect the area from Kelani floods up to a level of +5.64 m m.s.l. According to Regional Director of Irrigation, Colombo, proposals have been made to improve the drainage conditions in the lower areas and people in the area are keen to commence the agricultural activities. During the survey one irrigation canal coming above the Malambe – Athurugiriya Road near station 22+700 was observed.

v Drainage Capacity of the Existing Waterways and Flood ways Across Proposed Deviation

At present the Maha Ela acts as the waterway discharging floods in the Maha Ela catchment along the deviated trace. The existing sheet flow conditions will change with the proposed road and flood waters will be diverted through culverts to one side of the road as per the proposed road alignment and to maintain the existing drainage pattern.

The existing flood discharge of the Maha Ela due to short duration rain events (3hr) for different return periods along the deviated trace are given in Table 7.2.4 below:

Table 7.2.4 Flood Discharge of the Maha Ela

Station	Flood Discharge m ³ /s		
	50 year	25 year	10 year
21+600	41.3	35.4	27.6
20+700	66.9	57.3	44.5
19+800	74.7	64.2	49.9

Source: JICA Study Team for OCH

As the Maha Ela turns north-easterly direction at station 19+200, this point will act as the flood way across the proposed deviation to discharge flood waters to Kelani river.

vi Present Flood Detention Capacity on Either Side of the Roadway

The entire extent of the OCH in the deviated trace from station 22+500 to station 18+300 the ground levels are less than +5m m.s.l. and act as the flood detention area of the Maha Ela catchment (12.6 km²)

The total length of the Maha Ela catchment along the deviated trace is 7.2 km. Out of which about 3500m is in the deviated trace and the flood waters are detained in the lower areas of the Maha Ela. In the event of a 50 year return flood of Kelani river, the flood waters extend beyond the Malabe – Athurugiriya Road Bridge (Station 22+800).

The total retention area available in the OCH from station 16+300 to 25+000 (from Kelani to start of Maha Ela catchment) up to +5.00 m m.s.l. and +10 m m.s.l. is shown in Fig. 7.2.4 and the areas computed are given below:

Up to +5.00 m m.s.l.	410 hectares
Up to +10.00 m m.s.l.	813 hectares

The total area lost in the deviated trace due to OCH is 21 hectares out of total of about 410 hectares of lowlands (up to +5 m m.s.l.) in the area. Thus existing retention area of about 5% is lost due to construction of the OCH along the proposed deviation.

vii Existing Flood Problems on Either Side of the Road

The floods in the deviated trace are dominated by flood levels of Kelani River. The deviated trace area is protected by a minor flood protection scheme at Bomiriya on the left bank of Kelani river. The minor flood protection level in the Maha Ela area is about +5 m m.s.l. The flood protection level as maintained by the Irrigation Department is +5. m m.s.l. When the Kelani river water level goes above this level, the entire low-lying area in the “Maha Ela” catchment including the deviation trace area goes under water. During such flooding, the existing culverts provided across roads crossing in Maha Ela are not effective and all low level roads including two roads crossing the deviated trace area goes under water restricting access to residents on both sides. During local flooding due to high rainfall in the Maha Ela catchment, these roads will go under water for about three hours due to inadequate drainage provisions provided.

viii Present Uses of Groundwater, Groundwater Quality and Groundwater Levels

The groundwater in the deviated trace area is used mainly by the residents living in the area for drinking purposes. The quality of water is found suitable for drinking and the groundwater levels are dependent on the water level in the Kelani river and that of the marsh around the Maha Ela. The groundwater levels fluctuate during the year with the rainfall.

ix Present Uses of Surface Waters including Water Supply Intakes

The surface waters in the area are mainly used for paddy cultivation. However, as the paddy cultivation is presently limited to the high-elevated areas (above +5m m.s.l.), the use of surface waters are marginal. The surface waters are used at present to maintain the ecological balance in the Maha Ela marsh area.

There are no water supply intakes in the deviated trace area. The water supply intake at Ambatale supplying water to the city of Colombo is located about 2.5 km downstream of the proposed road crossing location of Kelani River.

x Surface Water Quality of the Water Bodies along the Trace

The objective of the establishment of surface water quality parameters in the Maha Ela marsh area is to estimate the potential impacts on surface water quality due to construction of OCH in the deviated trace during construction stage and subsequent operational stage.

The water quality of the Kelani river at Kaduwela Bridge analyzed by CEA in June, July and August 2004 is given in Table 7.2.5. The sampling point is at immediately below the confluence point of “Maha Ela” with Kelani River. It is necessary to establish the water quality parameters in the marsh area to assess the direct impact of OCH in the deviated trace.

Table 7.2.5 Water Quality of the Kelani River at Kaduwela Bridge

Parameter	Unit	June 2004	July 2004	August 2004
pH		7.8	7.4	7.4
EC	mS/cm	0.04	0.09	0.04
Turbidity	NTU	27	24	31
Temperature	°C	27.2	27.8	27.7
Dissolved Oxygen	mg/l	7.6	7.1	5.2
COD	mg/l	12	15	03
BOD ₃	mg/l	03	01	20
Chloride	mg/1	3.7	4.0	4.0
Dissolved Chromium	mg/1	<1	<1	1
Dissolved Lead	mg/1	<1	<1	<1
NO ₃ as N	mg/1	0.32	0.35	0.32
PO ₄ as P	mg/1	0.93	<0.01	0.58
Total Coliform	MPN/100 ml	3500	9000	3000
Faecal Coliform	MPN/100 ml	P	P	P

Source: Central Environmental Authority

<Abbreviations>

EC	Electrical Conductivity
NO ₃ as N	Nitrate as Nitrogen
PO ₄ as P	Phosphate as Phosphorus
COD	Chemical Oxygen Demand
BOD ₃	Bio Chemical Oxygen Demand

xi Soils and General Geology of the Area

■ Soil Type of the Area

Generally the deviated trace area could be divided into three types of landscape facets.

- Gently undulating to undulating and rolling terrain

Generally this area consists of soft and hard laterite soil which is the sub group of the red yellow podzolic (RYP) soils. This type of soils is available in the deviated trace near Malabe – Kaduwela road crossing from station –18+000 to –18+300.

- Flat or nearly level plan

Generally this area consists of low humic gray (LHG) soils, associated with alluvial soils. This type of soil is available in most parts of the deviated trace, mainly from station 21+800 to 18+300.

- **Flood plains**

These areas mainly consist of alluvial soils of variable textures. Alluvial soils mainly occur along the flood plains of Kelani river and its tributary Maha Ela within the deviated trace area from station 21+800 to 19+200.

The groundwater levels are high and almost close to ground level except near Malambe – Kaduwela road crossing area where groundwater level is about 6 meters below the ground level. In the marsh area, south of Malambe – Kaduwela road, the borehole data indicates that organic clay is available to a depth of about 0.5 m and thereafter consists of sand clay (alluvial soils) and the rock level is shallow and is about 3 to 5 meters below the ground level. It is observed that peat soils are not available in the Maha Ela marsh area. The groundwater level is low and is about 0.5 meters below the ground level indicating that the groundwater level is dependent on the water level of the marsh.

The type of soils available in the deviated trace of OCH area described below:

- **Yellow Podzolic Soils**

Soils of this group should have hard laterite formed in situ within the depth of 125 cm and soft laterite within the depth of 250 cm.

The soils of this sub group are well developed and the weathered zone is deeper. The deeper subsoil of this category contains soft laterite, which gets hardened massively or gravely. In locations, which were subjected to erosion activities, laterite gravels could be seen on the surface.

- **Low Humic Gley (LHG) Soils**

LHG soils could be located within valleys adjoining the highland area along the paddy areas of the deviated trace.

The surface soils of LHG are usually dark grey to dark greyish brown in colour. The textures are either sandy loam or sandy clay loam. The sub surface horizons have heavier textures than the surface horizon such as sandy clay, clay loam or clay and colours are greyish to yellowish. Water movement through these soils is very slow.

Generally, these soils remain in a saturated condition with water, for a greater part of the year.

- **Alluvial Soils**

The alluvial soils usually occur within the flood plains of the rivers and tributaries. With the overflowing process coarser material is deposited on levees and finer textured material in back swamps and basins. Within the same valley, texture may vary according to the physiographic positions. This type of soil is available along the major drainage stream “Maha Ela” in the deviated trace.

■ General Geology of the Study Area

The geology in the study area essentially consists of unconsolidated deposits of Quaternary age overlying metamorphic bedrock of Precambrian age.

The tabulation below shows the main types of deposits and rocks and their relative age:

Age	Lithology
Quaternary	Laterite Alluvium Littoral Sands Sand Stone
Palaeozoic	Banded gneiss
Precambrian	Charnockite

Metamorphic rocks [gneiss] form the most extensive rock type in the study area. They appear light in colour [shades of black and white] with noticeable banding and veins of granite and quartz.

Lastly, but not less importantly, is the secondary product called laterite and represents the “in-situ” weathering of the underlying metamorphic rocks. Due to the nature of these bedrocks and the variability of the alternation process as the laterite is extensive but non-uniform in both nature and thickness. The typical laterite material grades downward from a hard brown ironstone crust at the surface, via a hard cellular red zone containing noticeable cavities, to a soft, variegated clayey mass which overlies the crystalline parent material. The profile may attain thicknesses in excess of 25m, but has suffered considerable erosion.

Structural features of direct geological significance to the project is the availability of laterite while river alluvium and peat would necessitate special engineering considerations for the design of highways / roads.

xii Mineral Resources in the Deviated Trace Area

The inquiries made from the people in the deviated trace area revealed that no minerals of any significant value are encountered along the 4800 km length of the deviated trace area. However the clay available in the area is used for manufacture of bricks.

2) Ecological Resources

i Methodologies

■ Literature Survey

A literature survey was conducted initially to collect the available secondary data on flora and fauna of the area encompassing the deviation trace of the proposed OCH to the City of Colombo. The applicable report was the Environmental and Social Impact Assessment Study on the Outer Circular Highway to the City of Colombo prepared in February 2000 (JICA study team 2000). According to the report, the project area and its vicinity within 2 km range have been surveyed along the entire trace for identification of

ecological habitats and resources. However, this survey has been done about three years ago and many changes to some terrestrial habitats had taken place. Therefore, the secondary information available in these reports is limited in use. In this context, collection of primary data was a prerequisite in reporting the existing situation with regard to present ecology of the environment.

■ Field Surveys

The study area considered for the ecological survey was a 2 km wide corridor which includes an area of 1 km on either side of the deviation route extending from the interception point on Malambe–Athurugiriya road at Pore to Kelani river. The deviation route is 4.8 km in length and the total area studied was 9.6 km².

The methodology employed to assess the ecology of the study area was based on the reconnaissance surveys, field observations and the interviews held with people in the area. These were carried out in July-August 2004. The 1:50000 land-use map produced by the Survey Department and the 1:10000 map prepared by OCH project in 1999 using aerial photographs were also used for the survey. Field surveys were carried out to collect primary data on flora and fauna and their habitats to complement the existing data available in the former report prepared for the deviation route in 2001. Site-specific information was collected during these field surveys carried out in the study area.

The ecological habitats in the study area were identified during the field surveys following the map prepared by the OCH project using aerial photographs in 1999. The variations in the habitats recorded in 1999 were noted and the extents of different habitats were approximately determined using a planimeter.

Floral diversity in each ecosystem was identified during these surveys. The plant species in different habitats were listed for each ecosystem separately. The floral species were identified in the field as much as possible using available literature and experience.

Amphibians, reptiles, birds and mammals in the area were identified and recorded in the field surveys conducted in evenings and early mornings. The fish from the aquatic habitats of the study area were collected using a cast net of 1.5 cm stretched mesh. Macro-invertebrates, amphibians, reptiles, birds and mammals were identified by visual observations and rechecked and verified using Dutta and Mamamendra-Arachchi (1996), Kotagama and Fernando (1995), Pethiyagoda (1991) and Phillips (1980-1984). Community consultations were also helpful to gather information on the presence of mammals, reptiles and fish in the study area. The degree of threat of fauna and flora in these habitats were determined using Ekaratne *et al.* (2003).

ii Existing Ecosystems in the Study Area

Several types of ecosystems, both terrestrial and wetland, exist in the study area. These are as follows.

Terrestrial ecosystems

- Home gardens
- Rubber plantations
- Coconut plantations
- Vegetable plots

-
- Scrublands
- Wetland ecosystems
 - Paddy fields
 - Marshy areas
 - Aquatic habitats

Table 7.2.6 gives the relative extents of these ecosystem types within the study area.

Table 7.2.6 Relative Extents of Ecosystems Found within 2 km Belt along Proposed Deviation

Type of Ecosystem	2km Wide Corridor			Along the Highway route	
	Extent (ha)	Cover as a % of Terrestrial Ecosystem extent	Cover as a % of Total Extent	(km)	Cover as a % of Total Extent
Terrestrial Ecosystems	738				
Home gardens	697	94.4	72.6	0.5	10.4
Rubber Plantations	18	2.4	1.9	-	-
Coconut Plantations	16	2.2	1.7	-	-
Scrub lands	1	0.1	0.1		
Vegetable plot	6	0.8	0.6		
Wetland Ecosystem	222		23.1	4.3	89.6
Total	960		100.0	4.8	100.0

Source: SEIA Survey 2004

The study area does not include any protected area such as wildlife reserves, conservation forests, RAMSAR sites, man and biosphere reserves, world heritage sites, forest reserves or proposed forest reserves declared under Forest Ordinance or Fauna and Flora Protection Acts. The deviation route traverses through man made ecosystems such as home gardens and wetlands such as paddy fields and abandoned paddy fields.

At the northern end of the trace deviation close to Rajasinghe Mawatha, there is a housing scheme in close proximity. Then, the trace deviation traverses through the edge of Pannagure paddy field up to Gemunupura 3rd Lane, which is a residential area. The trace again runs through an abandoned paddy field near Isurupura. This abandoned paddy field known as “Mahawela”, is a semi natural ecosystem as paddy has not been grown there for nearly two decades. The highway runs through the edge of Mahawela and crosses the Malambe -Kaduwela Road and Kahantota - Arangala Road after passing through a paddy field.

The proposed deviation lies in the floristic region 5 identified in the Strategy for the Preparation of Biodiversity Action Plan for Sri Lanka, Ministry of Transport, Environment and Women’s Affairs. The natural climax vegetation of this region is tropical wet evergreen forest. Although this region has been identified as one of the

least represented floristic regions, the combination of climate, topography and geological history has resulted in a diversity of species rich associations.

Natural vegetation of the study area is adapted to high rainfall. Most of the plant species in the study area have pointed leaf tips with prominent mid ribs and secondary veins. Most of the trees have dark green foliage with brightly coloured flowers, fruits and young leaves. However, the natural habitats have been decimated from most of the study area due to settlement expansion geared by rapid urbanization. The natural vegetation has been cleared and replaced with mixed vegetations associated with home gardens. A few wild plant species have been observed in undisturbed habitats such as scrublands, large home gardens and roadsides in the area.

■ Terrestrial Ecosystems

A total of five terrestrial ecosystem types were recorded in the study area during field survey. These are home gardens, rubber plantations, coconut plantations, vegetable plantations and scrublands.

Along the highway route only home gardens and wetlands were recorded. About 10% of the route passes through home gardens and the rest passes through abandoned paddy fields. Of the study area, nearly 73% are home gardens, about 1.7% is a coconut plantation and about 1.9% is a rubber plantation. Vegetable plots and scrublands contribute to 0.1% and 0.6% of the study area respectively. No coconut plantations, rubber plantations, scrublands and vegetable plots are present along the deviation route.

- Home gardens

According to the land use map prepared in 1982, only 55% the study area consisted of home gardens. However, the field survey revealed that most of the rubber plantations had been converted into home gardens. Home gardens contribute to about 73% of the total extent of the study area, which is about 94% of the total extent of land of the terrestrial ecosystems in the study area. Along the highway route, all terrestrial habitats present are home gardens (Table 7.2.6).

In the study area, there are two types of home gardens, i.e., newly established home gardens and traditional home gardens. The average land extent of a newly established home garden varies between 10 to 15 perches, whereas the traditional home gardens are larger and their land extent varies within a range of 20 to 40 perches.

The home gardens are rich in floral diversity. These home gardens are not only ecologically important for *ex-situ* conservation, but also economically important to support subsistent cultivation. They are ecologically important as feeding, nesting and roosting areas of many species of birds, some species of small mammals and few species of reptiles. Home gardens provide timber, food, fuel and medicinal plants for domestic use and the excess of these products is often sold to neighborhood service centers. A total of about 150 species of plants were recorded in the home gardens during the present survey. They are listed in Appendix 7.3.

Most of the recently established home gardens have emerged due to subdivision of land, especially rubber plantations, by property developers. The small plot size only allows

growing few plant species, which are useful as fruits, medicines, vegetables or ornamental plants. These home gardens are often found at locations where accessibility and land value are high.

No threatened plant species were recorded in these home gardens. Of the plant species listed in Appendix 7.3, six species are endemic. None of these endemic plant species are rare or threatened. All plant species recorded in home gardens, including the endemics are widely distributed throughout the wet zone of the country.

- **Rubber Plantations**

The other major terrestrial ecosystem in the study area is rubber plantations. According to the land use map prepared in 1982, nearly 19% of the total extent of the study area was under rubber plantations. According to the aerial photographs taken in 1999, this has declined to about 10% of the total land extent. The field survey indicates that rubber plantations are now confined to about 1.5% the total study area (Table 7.2.6). All other areas of rubber plantations, which existed in 1999 are cleared, blocked out and auctioned for residential development. Therefore, these areas are now small home gardens.

The deviation route does not pass through any rubber plantation. Most of the rubber plantations in the study area belong to smallholders. The plots of smallholder plantations are smaller in extent. During the field visits, young rubber plantations were not observed and most of the existing plantations were old.

Rubber plantations in the undulating lands of the study area play a significant role in conserving soil. It also maintains a green cover. These mono-cultured plantations are not rich in floral diversity. However, it was noted that the ground is covered with grass and a few plant species grown in the wild could be noticed at the hedges and as undergrowth vegetation. The thick canopy formed by rubber trees and the grass cover performs important functions such as soil conservation.

These rubber plantations also provide habitats for large number of bird species. They use these trees for roosting and some use these for nesting too. Several species of reptiles, few species of amphibians and some small mammal species inhabit these rubber plantations.

- **Coconut Plantations**

Another major ecosystem in the study area is coconut plantations. According to 1982 land use map about 3.4% of the study area had been coconut plantations. However, according the survey carried out in July-August 2004, the coconut plantations cover only about 1.7% of the study area. These are mainly located in the Ratuwela estate.

These ecosystems are poor in biodiversity. The ground of these lands is covered with grass. Few species birds, reptiles and small mammals inhabit these habitats.

- Scrublands

A scrubland of about 1 ha in extent is found in Pathiniyawatte area. In addition, scrubs are found along hedges of home gardens, rubber plantations and coconut plantations. It is important to note that the plant species found in these scrub areas are the plants available in the secondary forests of the wet zone. Although these scrublands are found within the 2 km corridor of the proposed deviation of the OCH, these habitats do not fall on the ROW of the highway (Table 7.2.6).

These scrublands are rich in biodiversity. A total of 110 species of plants were recorded in these habitats during the present survey. These are listed in Appendix 7.3.

A total of 10 endemic plant species were recorded in these habitats. None of these species are rare, threatened or endangered. These plant species are found in other parts of the wet zone of the country and some are found in the dry zone too.

The scrublands are rich in animal diversity too. Many species of birds, several species of reptiles, especially the serpentoid reptiles, several species of amphibians and few species of mammals were recorded in these habitats. Of the reptile species recorded in these habitats, five species are endemic and four species are threatened (Appendix 7.4). None of the mammal species recorded in these habitats are endemic but for species are threatened. One species is listed in the Vulnerable category of the 2003 IUCN Global red list of threatened species (IUCN 2004) (Appendix 7.4). Of the amphibians recorded in these scrublands, three species are endemic. Of these endemics, two species are listed as threatened animals (IUCN 2000). These two species are and also protected under FFPA (Ekaratne *et al.* 2003).

- Vegetable plots

In some low lying lands adjoining the marshy areas, paddy fields and abandoned paddy fields of the study area, vegetable cultivation is carried out by some people. The total extent of vegetable plots was around 6 ha which is about 0.6 % of the total extent of lands in the study area (Table 7.2.6). The plant species grown in these vegetable plots are *Cucumis sativus* (Cucumber), *Melanagromyza hibisci* (Okra), *Momordica charantia* (Karawila), *Solanum melongina* (Brinjal), *Trichosanthes anguina* (Pathola) and *Vigna cylindrical* (Maa karal).

■ Wetland Ecosystems

The wetland are defined as the areas of marsh, fen, peat land or water, whether natural or artificial, temporary or permanent, with water that is static, flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed 6 meters (RAMSAR Convention 1987). Accordingly, paddy fields, abandoned paddy fields, marsh areas and the small stream which flows into the Kelani river in the study area fall into the category of wetlands.

In the study area, the wetlands have become ecologically important ecosystems as surrounding highlands have been converted to built-up areas. They absorb and retain pollutants, sediments and nutrients in the surface runoff. Therefore, these ecosystems in the study area play a significant ecological role. They are also important because they

retain storm water and act as storage areas for sudden influxes of surface runoff during the rainy season. These wetlands also serve as buffer areas to detain overflows of the Kelani River as well.

Wetlands in the study area occupy about 23% of the total land area. That is nearly 222 ha. However, the ROW of the deviation of the OCH passes only through 4.3 km of these wetlands. If a stretch of about 50 m is to be reclaimed for the construction of the ROW, only about 21.5 ha have to be reclaimed.

- **Paddy Fields**

Some paddy fields are environmentally sensitive as they assist in the detention of floodwater in the area. These paddy fields are located along the streams and canals. They are also economically important as they provide some income to farmers. The ecological function that such lands play is important to keep the environmental balance in a flood plain with high intensity of rainfall.

Paddy fields along the deviated trace are found at close proximity to the Rajasinghe Mawatha and Kahantota-Arangala Road. They are linked with one another as a network. These paddy fields are cultivated mainly during the Yala season under rain fed conditions. As such, the rainfall often becomes a determinant factor for the production of paddy. Increase or decrease of rainfall affects negatively resulting in a decrease in the paddy yield. Hybrid varieties of paddy are cultivated in these fields. Application of agrochemicals for the cultivation of paddy affects the fauna and flora in these habitats.

The paddy lands also serve as feeding and resting grounds for many species of birds. Small canals, which run through the rice fields, provide habitats for several species of fresh water fish including two endemic species too (Appendix 7.4). However, the most of the paddy fields in the study area are abandoned due to various reasons, the main reason being high cost involved and the less income generated compared to the cost involved. Some of the areas are abandoned due to poor drainage.

The main abandoned paddy field, which is known as “Mahawela”, spreads through a large area. Since Mahawela is situated in the flood plain of the Kelani River, it detains overflow of the river during heavy rains. It was revealed at the interviews with the local residents that this low-lying area has been abandoned for the last 20 years due to poor drainage. High water levels during the rainy seasons and prolonged inundation periods do not allow paddy cultivation in this low-lying area.

In some locations, people intentionally abandon the paddy fields. The small paddy fields closer to the main roads are frequently reclaimed for the expansion of residential and commercial activities. The forcing factor for such reclamation is high demand for land that is indicated through high land value. Some of the abandoned paddy fields serve as grazing grounds for cattle.

Many species of plants are found along the edges of paddy fields and also in abandoned paddy fields. These plants, which grow on the edges of paddy fields and abandoned paddy fields provide feeding and roosting grounds for many bird species. Grasses and weeds are found on the edges of these paddy fields both cultivated and abandoned. These weeds and grasses, which have a short lifecycle, colonize paddy fields during

shorter fallow periods. There are no threatened, rare or endangered plant species recorded in these abandoned paddy fields. The recorded species are also available in large numbers in the adjoining areas and in the wetlands of both wet and dry zones of the country.

These paddy fields both cultivated and abandoned, also harbour few species of amphibians, reptiles and small mammals. None of the mammal and amphibian species recorded in these habitats are endemic or considered as threatened animals. Of the reptile species recorded in these habitats, four species are endemic and four species are listed in the 1999 IUCN list as threatened animals (IUCN 2000) (Appendix 7.4). Five species of reptiles recorded in the paddy field habitats namely *Xenochrophis asperrimus* (Diya naya), *Varanus salvator* (Water monitor), *Varanus cepedianus* (Land monitor), *Lissemys punctata* (Soft shelled terrapin) and *Melanochelys trijuga* (Rock terrapin) are protected by FFPA (Ekaratne *et al.* 2003)

- **Marshy Areas**

The marshy lands in the study area are rich in faunal and floral diversity. True marsh species such as *Phragmites karka* (Nala bata), *Cyperus corymbosus* (Gal eha) and *Lepironia articulata* (Elu pan) are occasionally found in these marshy areas. In these marshy areas where water is stagnated, species such as *Cryptocoryne* (Ketala) and *Aponogeton crispus* (Kekatiya) and invasive aquatic weeds such as *Pistia stratiotes* (Water lettuce), *Eichhornia crassipes* (Water hyacinth) and *Salvinia molesta* (Japan pasi), are found. Grasses and sedges form a dense cover in the shallow areas of these marshy lands.

In the marshy lands, water stagnant areas as well as areas with slow flowing water are also found.

Plant species such as *Nelumbo nucifera* (Nelum), *Nymphaea lotus* (Olu), *Aponogeton natan* (Kekatiya) and *Salvinia molesta* (Salvinia) are found in lentic habitats. *Vallisneria spiralis* was recorded from lotic habitats. On the edges of the marshes, several species of plants were recorded. These are also listed in Appendix 7.3. None of the plant species recorded from the marshes and edges of marshes are endemic or considered to be threatened.

- **Aquatic habitats**

The main natural aquatic habitat in the study area is the Maha Ela, which is a stream that flows through the marshy lands northward and joins the Kelani River slightly east of Kaduwela junction. It drains water that run off from the neighbouring terrestrial habitats as well as from paddy fields. The aquatic plants recorded from these habitats are listed in Appendix 7.3).

In some places, the water remained as non-flowing stagnant water bodies. None of the plant species recorded from aquatic environments in the study area are endemic or threatened.

Many species of fish inhabit these aquatic ecosystems. They include two endemic species, which are also listed as nationally threatened species (IUCN 2000) (Appendix

7.4). Some bird species also frequent these aquatic habitats. None of the bird species recorded in these habitats are endemic or threatened.

Three species of reptiles that inhabit these habitats, namely *Varanus salvator* (water monitor), *Xenochrophis asperrimus* (Diya naya) and *Xenochrophis piscator* (Checked keelback) are endemic. Four species of reptiles that are listed as threatened species inhabit these habitats (IUCN 2000) (Appendix 7.4). These species are also protected under FFPA (Ekaratne *et al.* 2003).

Several species of toads are also associated with these aquatic habitats (Appendix 7.4). All amphibians, which are listed in Appendix 7.4 have to come to water for breeding as their larval stage is aquatic. These include three endemic species, which are threatened in the national context (IUCN 2000) (Appendix 7.4). These three species are also protected by FFPA (Ekaratne *et al.* 2003).

One mammal species, which inhabit these aquatic habitats, namely *Lutra lutra* (Eurasian otter), is threatened in the national context (IUCN 2000) and listed in the 2003 IUCN global red list in the Vulnerable category (IUCN 2004).

iii Flora

High diversity of flora was observed in the study area during the present study. The highest diversity was noted in home gardens followed by scrublands. A total of 150 species of plants were recorded in the home gardens and 110 species were recorded in the scrublands (Appendix 7.3). In the abandoned paddy fields 43 plant species were recorded and in the edges of wetlands, 22 plant species were noted. The number of plant species recorded in the marshes and aquatic habitats were 29.

No threatened plant species as well as protected species under FFPA (Ekaratne *et al.* 2003) were recorded in the study area. However, a total of 10 species of endemic plant species were recorded in the home gardens, scrublands and edges of wetlands (Appendix 7.3). These endemic plants are also abundant in other parts of the wet zone while some are found in the dry zone too.

No endemic plants were recorded along the ROW of the OCH.

Some plant species recorded in the study area are economically important. The two main species important economically are *Havea brisiliensis* (Rubber) and *Cocos nucifera* (Coconut). These plants are grown as plantations in the study area. In addition, coconut is also grown in home gardens.

About 40 species of plants in home gardens bear fruits that are edible. Some plants grown in the home gardens are used as vegetables and many species are used in indigenous medicine. Some species including *Artocarpus altilis* (Breadfruit) and *Artocarpus heterophyllus* (Jak) are important as timber species.

iv Fauna

High diversity of fauna was also noted in the study area. The diverse ecosystems in the

study area provide habitats for many faunal species.

A list of the animals found in these habitats is given in the Appendix 7.4. It is clear that the animals recorded in the study area are also found elsewhere in the wet zone and many are found even in the dry and intermediate zones of the country.

- **Mammals**

A total of 25 species of mammals are found in the corridor of the deviated trace. Their scientific names and common names are given in Appendix 7.4. Of these, four species are threatened in the national context (IUCN 1999) (Appendix 7.4). Two species, namely *Loris tardigradus* (Slender loris) and *Lutra lutra* (Eurasian otter), are also listed in the vulnerable category of 2003 global red list (IUCN 2004) Appendix 7.4 and are protected under Conservation on the International Trade in Endangered Species of wild fauna and flora (CITES) (Ekaratne *et al.*, 2003). These two species are found in different parts of the wet zone and other climatic zones of the country.

A total of five species of bats were also recorded in the study area during the survey carried out in July–August 2004 (Appendix 7.4). Bats are one of the nocturnal mammal species that play a significant ecological role to maintain the balance of the biological environment. Most of the abundant bats are insectivores and they control nocturnal insect population. They also act as pollinators. In addition, they play the role of dispersants of seeds as the frugivorous bats carry fruits. One species of bats recorded in the study area, namely *Pteropus giganteus* (Flying fox) is protected under FFPA (Ekaratne *et al.* 2003).

None of the species of mammals recorded in the study area are endemic.

- **Reptiles**

A total of 18 species of snakes, two species of terrapins and eight species of lizards were recorded in the study area during the present survey carried out in July-August 2004 (Appendix 7.4). Five species of reptiles recorded in the study area are endemic. Four species of reptiles including two endemic species are included in the 1999 national list of threatened fauna (IUCN, 2000) (Appendix 7.4).

Five species, namely *Xenochrophis asperrimus* (Diya naya), *Lissemys punctata* (Soft shelled terrapin), *Melanochelys trijuga* (Rock terrapin), *Varanus salvator* (Water monitor) and *Varanus cepidimus* (Land monitor) are protected under FFPA. One species, namely *Naja naja* (Cobra) is protected by CITES (Ekaratne *et al.* 2003).

The reptiles present in the study area, including endemic, threatened and protected species are found in other regions of the lowland wet zone and dry zone of Sri Lanka.

- **Amphibians**

A total of 12 species of amphibians were recorded in the study area (Appendix 7.4). Amphibians are present mainly in wetland habitats such as paddy fields and marshes. But some species are also found in terrestrial habitats such as home gardens. Three species of amphibians recorded in the study area are endemic to Sri Lanka While two species are listed as threatened species in the national context (IUCN 2000) (Appendix

7.4). These two threatened species are protected under FFPA too (Ekaratne *et al.* 2003). However they are not confined to the study area and are found also in other areas of the wet zone.

- **Avifauna**

The study area is rich in avifauna. A total of 58 species of birds was recorded from the study area during the present survey. These are also listed in Appendix 7.4. Of these, 17 species are water birds. None of them are endemic. None of these birds are forest dwellers, but they live in close association with human habitats and activities. Water birds could be observed in the marshy areas associated with Mahawela and abandoned paddy field. These marshy areas provide breeding and foraging habitats for coots, egrets and storks. A considerable number of egrets, white-breasted water hens, purple coots and cormorants were found in these habitats.

None of the bird species recorded in the study area are listed as threatened species. All the bird species recorded in these habitats are abundantly found elsewhere in the wetlands of the lowland areas of Sri Lanka.

- **Invertebrates**

All species of invertebrates that are present in both aquatic and terrestrial habitats in large numbers could not be identified during the present survey. The most diverse and dominant group of invertebrates present in the study area is insects, which occupy almost all the habitats. In the aquatic habitats of the study area, rotifers, crustaceans, insects and molluscs are the most abundant invertebrate groups. The species of invertebrates recorded in the study area during the limited period of the present survey are listed in Appendix 7.4. None of these species are endemic and considered to be threatened.

- **Fish**

A total of 22 species of freshwater fish were recorded in the streams and irrigation canals in the study area during the present survey. Of the species recorded, *Clarias brachysoma* (Walking Catfish) and *Aplocheilus dayi* (Day's killifish) are endemic. These two species are also listed in the 1999 IUCN list as threatened species (IUCN 1999). The information provided by the fishermen in the area indicated that about 25 people catch fish in the Mahawela area after floods. However, their income from fishing is irregular, as it is seasonal. They engage in fishing as a part time economic activity.

3) **Socio-economic Aspects**

i **General**

The objective of the social impact study is to identify the likelihood impacts due to construction of proposed stretch of the outer circular road on the communities and the other properties of the socio-economic environment in the project area. The project area includes 200m corridor of the proposed road and about 100m belt from both sides of the 200m corridor. The area falls under these 100m wide two belts is defined as immediate vicinity of the road corridor. In this report this area is considered as project

influential area while 200m road corridor is considered as project impact area. The project influential area or the immediate vicinity of the road corridor is referred as out side corridor though out in this report.

- **Methodology of the study**

Six sample locations on the proposed road deviation were studied to evaluate the likelihood impacts. The main criterion used for selecting 6 locations was degree of environmental sensitiveness (from the social point of view) in each location. These locations have access and therefore, communities have established houses and other social infrastructure facilities needed to manage their livelihood activities. Evaluation of 6 sample locations provides opportunity to conduct comprehensive assessment. The properties available in 200 meter corridor and in the immediate vicinity of the corridor (out side corridor) were looked in to in each study point:

- Houses
- Land
- Businesses and industries
- Other service delivery and significant centers (schools, religious places, historically significant locations, health centers, roads, and so on)

In each location sample households were selected for the study. The 6 sample locations are found in six Grama Niladhari divisions (GN divisions) in which the proposed road deviation falls. (refer to Fig.7.2.5)

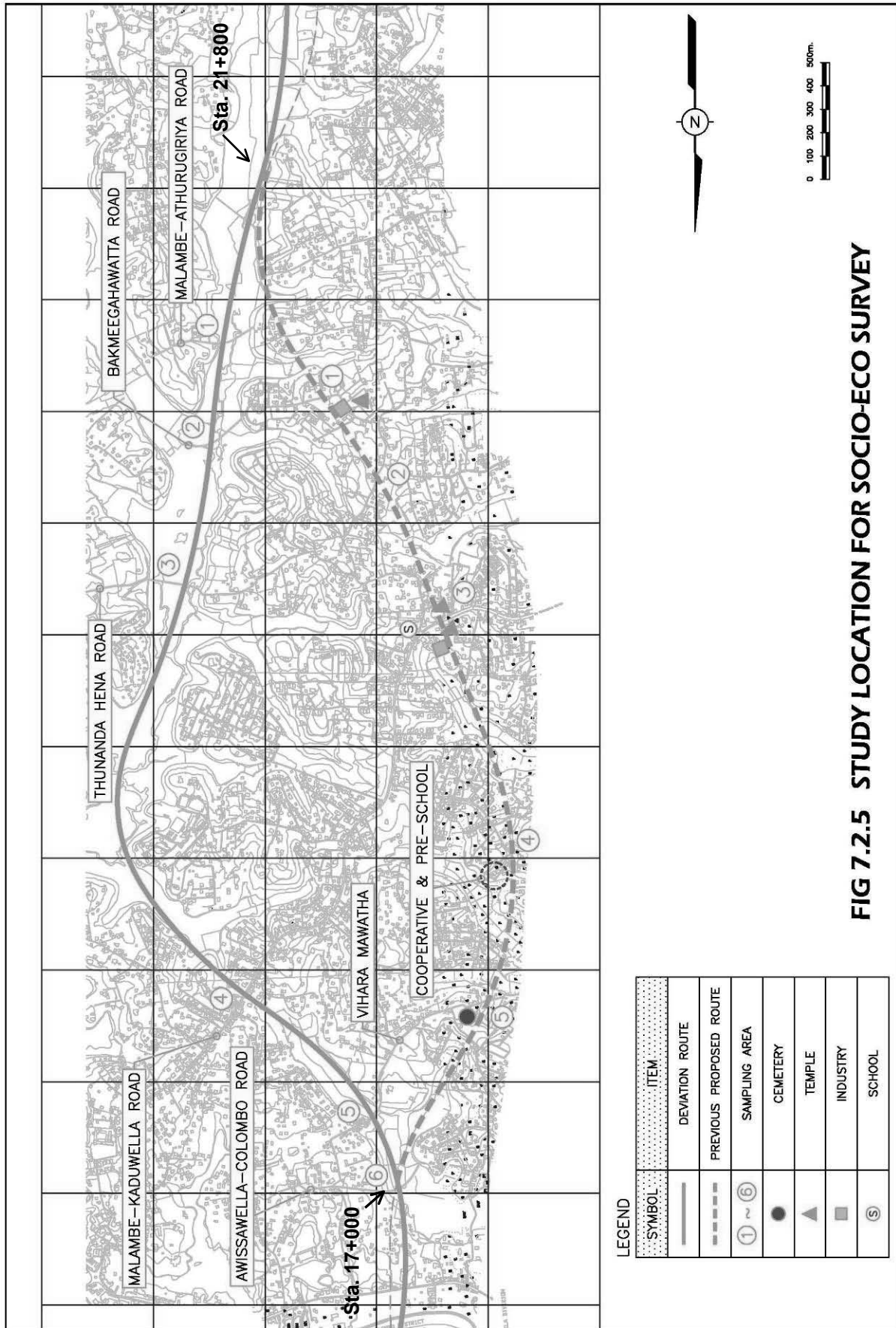


FIG 7.2.5 STUDY LOCATION FOR SOCIO-ECO SURVEY

The GN divisions, the locations selected for the study and sample households are shown in Table 7.2.7.

Table 7.2.7 GN Divisions, Study Locations and Sample Households

No.	Location	GN division	Households in corridor	Houses out side corridor	Total sample households
1	Pore wela on Malambe -Athurugiriya road	Hokandara-East	None	10	10
2	Bakmeegahawatta road	Hokandara-North	1	9	10
3	Mahawela on Thun anda hena road	Malabe-east	None	8	8
4	Mahila samithiya on Kaduwella –Malambe road	Kotalawela	5	7	12
5	Vihara Mawatha	Hewagama	3	5	8
6	1 st lane on Ramahera road- near Awissawella –Colombo road	Raggahawatta	13	4	17
	Total		22	43	65

Source: Social impact study team (SIA Team)

Note: In locations 1 and 3 there are no houses found within 200 m corridor.

In each point 58% of houses within corridor and 47% of houses out side corridor was selected for the study (significantly larger percentage). Table 1 in Appendix 7.5 shows this information. The other properties such as industries and other significant centers were also studied. The availability of such centers in and out side of the road corridor is shown in Table 2 in Appendix 7.5.

During the field study many community members informally made comments on the proposed road but the sociologist formally interviewed 6 Grama Niladharies (GNs) of sample locations and 7 community leaders.

- Justification of the proposed deviation

Five representative locations (most are parallel locations on both road traces old and new) from each road trace were studied to evaluate the nature of properties that will be affected if the road is constructed. The sociologist found that more socio-economic properties such as houses and economic activities would be affected if the old road trace were chosen for implementation. But in terms of other infrastructure such as roads, electricity and telecommunication distribution lines there are no significant differences between two traces as shown in Table 7.2.8.

Table 7.2.8 Infrastructure Facilities in Two Traces

Location and the GN divisions		Roads and electricity lines run across the road trace	
Old trace	New trace	Old trace	New trace
1.Malambe-North- Hokandara road	Hokandara-North-Malambe -Athurugiriya road (Pore wela)	Koshena road electricity line	Malambe-Athurugiriya road-Electricity and telecommunication lines
2.Malabe-North -I. Jothipala Mawatha	Hokandara- North-Bakmeegahawatta road	Kahantota road, I Jothipala Mawatha, Electricity and telecommunication lines	Bakmeegahawatta road
3.Malambe-west- Pittugala Junction (near Amawathura Asapuwa)	Malambe –East-Thun anda hena road (Mahawela)	Kaduwela- Malabe road- Electricity and telecommunication lines	Thun anda hena road-Electricity line
4.Weliwita Suhada Mawatha (Weliwita road)	Kotalawela-Kaduwellal-Malabe road (Near Mahila samithiya)	Weliwita road- Electricity and telecommunication lines	Kaduwellal-Malabe road- Electricity and telecommunication lines
5.Hewagama Vihara Mawatha	Hewagama Vihara Mawatha	Etambagaskanda Vihara Mawatha – Electricity and telecommunication lines	Vihara Mawatha- Electricity and telecommunication lines

Source: Observations of SIA team and Grama Niladharies of each location

In terms of roads affected there are no significant differences between two traces. In location 2 one road is affected in new trace but not other infrastructure; in location 3 also no telecommunication lines get affected in new trace. In general there are no significant differences between two traces.

The Information on houses, industries, other significant locations and land affected in two traces clearly shows that the negative impact in old trace is more significant than the new trace. This information is shown in Table 7.2.9.

Table 7.2.9 Houses, Economic Activities, Other Significant Centers and Lands Directly and Indirectly Affected in Two Traces

Location	Houses Number		Industries		Religious and other places		Agriculture land- Acers		Service delivery centers	
	Old	New	Old	New	Old	New	Old	New	Old	New
1	30	None	Nilwala Factory-150 employees	No	No	No		10	No	No
2	28	1	No	No	No	No			No	No
3	35	None	Paint factory-350 employees	No	Amawathura Asapuwa-Sudarsan aramaya	No			Retail shops-5, Medical centres-2 and SANASA-1	No
4	30	10	No	No	No	No			Coop-1, Pre-school-1	Mahila samithiya-1
5	24		No	No	No	No			Retail shops-1, Cemetery-1	No

Source: Observations of SIA team and Grama Niladharies of each location

The lands affected in old trace are highlands where as in new trace most of the lands are abandoned paddy lands. Some paddy lands have not been cultivated for about 20 years in new trace.

ii Existing Socio-economic Environment

Although the project area is close to Colombo town in general it can be categorized as rural area. Significant numbers of people from original residents of these areas are farmers. (Not the new migrants from other places of the country who have migrated to Colombo for employments and have constructed houses in these areas). The composition of employed persons in 6 GN divisions in which road corridor falls is shown in Table 3 in Appendix 7.5.

■ Existing Settlements and Other Land Use:

The proposed deviations of the road runs across less populated villages where negligible number of coconut lands and mostly abandoned paddy lands are found. The names of the villages and the nature of land use in the proposed road corridor area are shown in Table 7.2.10.

Table 7.2.10 Villages and Land Use

Location	Villages	Land use in the road trace area (acres)			
		Coconut	Rubber	Paddy	Other
1	Bogahawatta- Malasingha goda road and area close to Athurugiriya-Malabe road	No	No	10	No
2	Bakmeegahawatta road- Kahantota	No	No	7	No
3	Thun anda hena road	No	No	No	No
4	Kotalawela	1	No	3	No
5	Vihara Mawatha	No	No	3	No
6	Ramahera road	1.5	No	2.5	No
Total		2.5	No	25.5	No

Source: Observations of SIA team and Grama Niladharies of each location

Note: The sizes of the paddy lands through which road trace runs are shown in the Table 7.2.10.

The entire extent of these paddy lands will not be affected due to interventions under the proposed road. The land use of the households interviewed (both of within the road trace and the vicinity of the trace) indicates that negligible percentage of householders has paddy lands. All have home gardens where houses are constructed but only few have other highlands (other highland means land suitable for construction of houses that each family owns other than their home gardens).

In 55% home gardens some perennial crops are found. Only 12% of the sample householders have highlands other than home gardens. Even these land lots are small in size (less than 25 perches). Only 5% of the other high lands are grown with some trees even it is not so significant. Only 4 householders of the sample have paddy lands. Two lands are less than 25 perches in size and out of other two one is about 80 perches and the other is about little more than 100 perches. Occasionally some of these paddy plots are cultivated. But most are abandoned. The sizes of the home gardens are shown in Table 4 in Appendix 7.5

■ Demographic Characteristics

The proposed road deviation runs through 6 GN divisions. The population in each GN divisions through which the road trace runs is shown in Table 7.2.11.

Table 7.2.11 Population of GN Divisions

Location	GN division	Male	Female	Total
1	Hokandara-East	1,817	1,925	3,742
2	Hokandara-North	1,756	1,796	3,552
3	Malabe-east	2,342	2,683	5,025
4	Kotalawela	2,241	2,264	4,505
5	Hewagama	1,735	1,795	3,530
6	Raggahawatta	1,771	1,877	3,648
Total		11,662	12,340	24,002

Source: Office of Grama Niladhari (GN) in each location

Significant feature of population is female population is little more than the male. This is a new trend in the country and it reflects in this area too.

The population among the 65 households surveyed is 281 in total. It means the average family size is about 4. The population among sample households in terms of age categories is shown in Table 5 in Appendix 7.5.

■ Educational Levels

The project affected and influential areas have better access to good schools in Colombo and sub-urban areas. A significant percentage among young population is holding higher education qualifications (though it is small in the table since it is calculated against the total population in each GN division). The information about the educational levels and the percentage of persons educated under each level are shown in Table 6 in Appendix 7.5. The information on educational levels of population in sample households also indicates the significant of education in the area. Table 7.2.12 includes the information on education among sample households.

Table 7.2.12 Educational Levels among Sample Households

Education levels-grades -studied up to	In corridor		Out side corridor	
	Number	%	Number	%
0-5	22	24	28	18
5-10	36	40	42	28
O/L	21	24	50	33
A/L	7	8	32	20
University	4	4	1	1
Total	90	100	153	100

Source: Household survey (HHS) of SIA team

■ Economic Activities and Income of People:

The percentage of families entitled for Samurdhi benefits (Samurdhi is a national program launched by the government to provide support- including welfare and development for poor families in the country) is low compared to other areas of the country. Most of the families residing now are migrates from other areas for employments in Colombo. This means many families have regular income sources. The number of families entitle for Samurdhi benefits are shown in Table 7 in Appendix 7.5. Most of the families draw more than Rs 5000 of income per month. This is due to regular income sources of these families. Table 7.2.13 includes the information on income levels of families in GN divisions.

Table 7.2.13 Income Levels of Families in GN Divisions (families and %)

GN division/income levels-Rs per month	Less than 5000		5000-10,000		10,000-15,000		15,000-20,000		More than 20,000	
	NO	%	NO	%	NO	%	NO	%	NO	%
Hokandara-East	102	10	428	44	218	22	112	11	125	13
Hokandara-North	58	6	358	41	275	31	160	18	42	4
Malabe-east	490	52	132	14	122	13	110	11	91	10
Kotalawela	304	31	310	33	110	11	125	13	115	12
Hewagama	92	11	352	42	248	30	115	14	28	3
Raggahawatta	55	6	349	42	288	34	128	15	28	3

Source: Offices of GN divisions

The employable people in sample families are involved in various income generation activities. Large number of persons is reported from private sector employments. The information of employees in sample families is shown in Table 7.2.14.

Table 7.2.14 Employment of the Persons in Sample Households

Employment	In corridor		Out side corridor (Vicinity)	
	Number	%	Number	%
Government	6	24	11	22
Private	10	40	28	55
Farming	3	12	1	2
Daily labor	2	8	7	13
Self employment	4	16	4	8
Total	25	100	51	100

Source: HHS of SIA team

The income levels of sample families reflect that most of them have regular income generation activities. Most of them draw more than Rs 10,000 per month. The information on monthly incomes is shown in Table 7.2.15.

Table 7.2.15 Monthly Income of the Sample Families

Income levels(Rs/per month)	In corroder		Out of corridor	
	Number	%	Number	%
Less than 5000	1	6	2	5
5000-10,000	10	45	18	42
10,000-15,000	5	23	9	20
15,000-20,000	3	13	6	14
More than 20,000	3	13	8	19
Total	22	100	43	100

Source: HHS of SIA team

■ Income from Home Gardens

Some householders can earn small income from the home gardens. Out of 65 households 62% (40 home gardens) do not have income from home gardens. About 32% (21 home gardens) receive less than Rs 2500 per year. Another 2 householders

(3%) receive about Rs. 2500-5000 per year. The rest, 3% (2 home gardens) receive Rs 10,000 per year from the home gardens.

■ **Income from Business Centers:**

Seven householders out of 65 interviewed have business activities. The income from such activities and the location of business centers are shown in Table 7.2.16.

Table 7.2.16 Business Centers

Location	In corridor		Out of Corridor		
	Nature of business	Income per month-Rs	Nature of business	Income per month-Rs	Distance from Corridor (km)
1	No	-	Retail shop	35,000	15
2	No	-	Electrical work shop	12,000	0.25
3	No	-	Dress making	10,000	0.25
4	2 centers one on Retail business and other on Coconut timber processing centers	60,000-10,000	Retail shop	25,000	15
5	No	-	No	-	-
6	Blacksmith's work shop	30,000	No	-	-
Total	3		4	-	-

Source: SIA team and GNs (Grama Niladharies) – The Grama Niladhareis are the officers in charge of lowest administrative division in the country called Grama Niladhari Division.

■ **Houses in the Affected Area:**

Most of the houses affected are either permanent or semi-permanent. The nature of houses and their sizes are shown in Table 7.2.17.

Table 7.2.17 Nature of Houses to be affected

Nature	Number	%
Permanent	17	77
Semi-permanent	5	23
Temporary	None	-
Total	22	100

Source: HHS of SIA Team

The values of houses varied from less than Rs. 5 million to more than Rs. 20 million, with 63% of houses being less than 5 million, according to the calculation of householders themselves. The affected householders valued their houses and such information is included in the Table 7.2.18.

Table 7.2.18 Values of Houses to be affected

Values of house (Rs)	Number of houses	%
Less than 5.0millions	14	63
5-10 millions	2	9
10-15 millions	4	18
15-20 millions	1	4
More than 20 millions	1	4
Total	22	100

Source: HHS of SIA team

■ Land and Property Ownership:

All the sample householders interviewed within the corridor have their home gardens. Out of 22 interviewed inside the corridor 20 householders live in their own houses and only 2 live rented in houses. Except one house built in encroached land all the other houses are built in lands with free hold titles. (The government of Sri Lanka has granted different legal statues for different land. The free hold is the permanent deed that has provisions to sell mortgage to an institution like banks or to any individual. The second category is Land development permits, called LDO permits, that are given for people to do cultivation only and such lands cannot be sold or mortgaged. The last category is encroached land that is government lands encroached by people)

The values of different categories of lands in different locations studied according to the on going local land markets are shown in Table 7.2.19.

Table 7.2.19 Values of Lands (Rs/ per perch)

Location	Home gardens	Other highlands	Paddy lands
1	35,000-80,000	30,000-50,000	1,500-3,000
2	35,000-45,000	35,000-40,000	1,000-2,500
3	50,000-60,000	30,000-60,000	1,000-2,500
4	50,000-100000	30,000-70,000	1,500-3,500
5	50,000-75,000	40,000-60,000	1,500-3,500
6	40,000-90,000	35,000-50,000	2,000-3,500

Source: SIA team/GNs (Grama Niadharies) and community leaders in the project area

■ Communication Facilities:

The project area as whole has access to telecommunication facilities although majority of the houses located in the corridor do not have telephone facilities connected to houses. The percentages of houses have house connected telephone facilities depict this situation. Except locations 2 and 3 all other locations telephone lines run across the corridor. The Table 7.2.20 includes the information on number of houses have telephone facilities in each location studied and the telephone lines run across the road corridor.

Table 7.2.20 Number of Houses with Telephone Facilities

Location	Houses have telephone connections and the %			Telecommunication lines run across
	Number	%	Total sample	
1	2	20	10	Malambe –Athurugiriya road line
2	2	20	10	No
3	4	50	8	No
4	1	8	12	Malambe- Kaduwela road line
5	1	12	8	Vihara Mawatha line
6	1	6	17	Kaduwela-Colombo road line

Source: The observations of SIA team.

There is no post office buildings located in side the corridor. The communities have access to post offices located out side the corridor. But the distance to such post offices is not long and it ranges from 0.5 km to 3 km maximum.

■ Water Supply and Sanitation

Though the project area is close to Colombo urban centers most of the households do not have access to pipe water. Therefore, they depend on wells constructed in home gardens. The water supply facilities for communities in the project area are shown in Table 7.2.21.

Table 7.2.21 Water Supply Facilities

Location	Pipe water		Wells in home gardens		Wells in neighboring home gardens		Sample households
	NO	%	NO	%	No	%	
1	2	20	8	80	No	-	10
2	2	20	7	70	1	10	10
3	2	25	6	75	No	-	8
4	7	58	5	42	No	-	12
5	6	75	2	25	No	-	8
6	1	9	10	58	6	33	17

Source; HHS of SIA team

The percentages are worked out on the total sample households of the study at each point. Out of 45 wells reported from the sample households only 15 wells are located in side the corridor. Water supply tanks are not located either inside the corridor or in the vicinity. All the householders mentioned that water in the wells is good for domestic use (drinking and other use).

All the households have water sealed latrines. The sanitary facilities among sample households surveyed are included in Table 7.2.22.

Table 7.2.22 Sanitary Facilities among Sample Households

Location	Water sealed latrines		Latrines attached to houses		Sample households
	No	%	No	%	
1	4	40	6	60	10
2	8	80	2	20	10
3	8	100	No	-	8
4	8	67	4	33	12
5	7	88	1	12	8
6	16	94	1	6	17

Source: HHS of SIA team

Note: percentages are worked out on the total sample in each point.

■ **Agricultural Activities:**

About 1-3 % of population in the project area can be regarded as agriculture communities depending on the data available in GN Offices. This situation is fast changing and in near future the percentage of agriculture communities will become negligible if not zero. There are no families in side the corridors that are fully depending on income from agriculture. Even among the families surveyed in the immediate vicinity only one family was reported as agriculture family but there is agricultural land in each location studied. The current situation of agriculture in each location is described in Table 7.2.23.

Table 7.2.23 Agriculture in Each Location

Location	Agriculture
1	About 10 acres of paddy land is found in this location but it is cultivated occasionally. In home gardens few coconut, banana, and other fruit trees can be seen
2	About 7 acres of paddy land is found but the performance of agriculture is quite similar to location 1.
3	About 10 acres of paddy land is found. It has not been cultivated for about 20-30 years. Now it is marshy type land. Coconut. Banana and so on can be seen in home gardens.
4	About 3 acres of paddy land is found, It is cultivated occasionally. The situation in home gardens is similar to other locations (1,2 and 3)
5	About 3 acres of paddy land is found. The situation is similar to location 4.
6	About 5 acres of paddy land is found. But now this is marshy land due to long-term abundance.

Source: SIA team and the GNs (Grama Niradharies) and community leaders in each study location

■ **Road Net Work in the Project Area**

Number of good roads is found in side and out side of the road corridor area (refer to Fig. 7.2.5). The information on the roads run across corridor and also falling in the vicinity are as follows:

- Location 1- Athurugiriya- Malambe road (B Type) runs across and Malasingha Goda road (D type) falls in the vicinity
- Location 2- Bakmeegahawatta road (D) runs across and Kahantota road (C) falls in the vicinity
- Location 3- Thun Anda Hena road (D) runs across and Kahantota (C) falls in the vicinity
- Location 4- Malabe –Kaduwela road (B type) runs across
- Location 5- Vihara Mawatha (D) runs across and Colombo-Avissawella road (B) falls in the vicinity
- Location 6- Rama Hera lane (D) and Colombo- Avissawella run across and Rama hera road falls in the vicinity

The Definitions of road categories are as follows:

- Type A- Managed by Road development Authority (RDA), Paved road, Design width ranges from 5.5 to 7.3 m
- Type B- Similar to Type A with different design width of 5.5 to 6.7 m
- Type C- Managed by Provincial Road Development Authority (PRDA), about 99% paved and design width ranges from 4.0 to 5.5 m
- Type D – Managed by PRADA and mostly paved and design width ranges from 3.05 to 4.0 m

■ Other Infrastructure Facilities:

Except Mahila Samithiya (Mahila samithiya is a local Non Governmental organizations-NGO) in location 4 there are no other significant places such as schools, temples etc in side the corridor. Many common service delivery centers such as schools; temples and other government offices are located in the vicinity of the corridor area (refer to Fig. 7.2.5). The names of such places and the distance of these places are shown in Table 8 in Appendix 7.5. There are no industries located inside the corridor. But some industries are found in the vicinity as shown in Table 9 in Appendix 7.5. There are no proposals for new development of industries or any other projects in the area according to our informants.

7.2.2. Development of Alternatives

In 1999, the JICA Study Team conducted the comprehensive development of alternatives for the OCH in the Feasibility Study (FS). In the study the JICA Study team examined 9 alignments for the OCH taking into consideration the following factors with the aim of selecting the most appropriate alternative in technical, economical and social terms as follows;

1. Construction cost
2. Land acquisition and compensation cost
3. Traffic impacts

The FS concluded that the alignment A5 was most preferable in the 9 alignments. An Environmental Impact Assessment was conducted by the JICA Study Team on the trace. The EIA report was submitted in February 2000.

In the conditional letter of approval on the EIA report issued to the RDA (February 2001), the Central Environmental Authority (CEA) has recommended a re-designing to deviate from the Kaduwela – Malambe Road crossing point of OCH at Pittugala junction towards Kaduwela by taking the route to pass through the Maha Ela paddy field to minimize the social impacts based on the findings of the EIA report.

Based on the request from the letter, the JICA Detailed Design Study Team decided deviation route running through marshy area of Maha Ela in Kaduwela section in 2001 in the course of Basic Design.