2.6 Other Transportation Infrastructure

2.6.1 Parking Facilities

Traffic problems in the CBD are to some extent common to other large metropolitan areas in the world but a problem unique to Calcutta is the scarcity of off street parking facilities and the overflow of pedestrians onto the roadway.

According to the "Traffic and Transportation Plan for CMD 1966-1984" there were only 104 off street parking facilities with a total capacity of 1,348 vehicles, corresponding to an average of 13 vehicles per facility. These facilities are mostly privately owned courtyards attached to old houses. (the study area was wider than in this Study)

The number of parking facilities in the study of 1962 and 1975 is shown in Table 2.6.1. The corresponding sectors are shown in Figure 4.1.4. The total number of 3,385 on-street vehicle spaces in 1962 increased to 5,027 by 1975. This was achieved by providing on-street parking in streets which were not considered so important for handling traffic, or by converting streets from parallel parking to perpendicular parking to meet parking demand pressures.

Table 2.6.1 Parking Facilities

	1962 study			1975 study(on-street)		
Sector No.	On-str.	Off-str.	total	fee	free	total
5	268	49	317	13	795	808
7	152	2	154	203	588	791
8	256	158	414	56	273	329
9	506	141	647	142	85	227
10	1,148	125	1,273	1,048	338	1,386
11	322		322	87	678	765
12	733	340	1,073	523	198	721
total	3,385	815	4,200	2,072	2,955	5,027

2.6.2 Pavement Conditions and Road Markings

No detailed investigation of road pavement conditions was carried out as part of the Study but some general observations were made during Phase II and discussions were also held with the road maintenance authority (CMC) in Calcutta.

While the pavement markings were in excellent condition on some of the main arterials (eg Park Street), pavement markings generally were in poor condition and in some locations they were either unreadable or nonexistent.

For the pavement itself conditions again varied substantially on the main arterial roads in Calcutta but the pavement riding surface was generally in average to poor condition. Substantial lengths of some of the main arterials suffered from pot-holing, stripping and separation of the surface layers, and general unevenness. As a result ride quality tended to be poor and there would be adverse effects on fuel consumption and vehicle maintenance costs.

From limited observations the actual pavement strength appeared to be adequate in many locations since there was little evidence of longitudinal or transverse cracking which would indicate movement in the supporting layers. However, pavement strength deficiencies may be more apparent during and after the monsoons when moisture levels within and under the pavement would be highest.

Pavements are often very uneven in the vicinity of tram lines and it is necessary at many intersections for vehicles to cross the tram lines very slowly. The rails are often lower than the adjacent pavement as the rails are not usually lifted when resheeting is carried out. Some tram tracks were also observed to move under the weight of the trams.

Provision for pavement surface drainage generally seemed to be poor and substantial areas are inundated during the monsoon. This problem is compounded since in Calcutta the water table is quite high, averaging 1.5m below the surface in the dry season and 1m below in the wet season. Areas subject to flooding are shown in Figure 2.6.1. (source; Plan for Metropolitan Development by CMDA, 1990.)

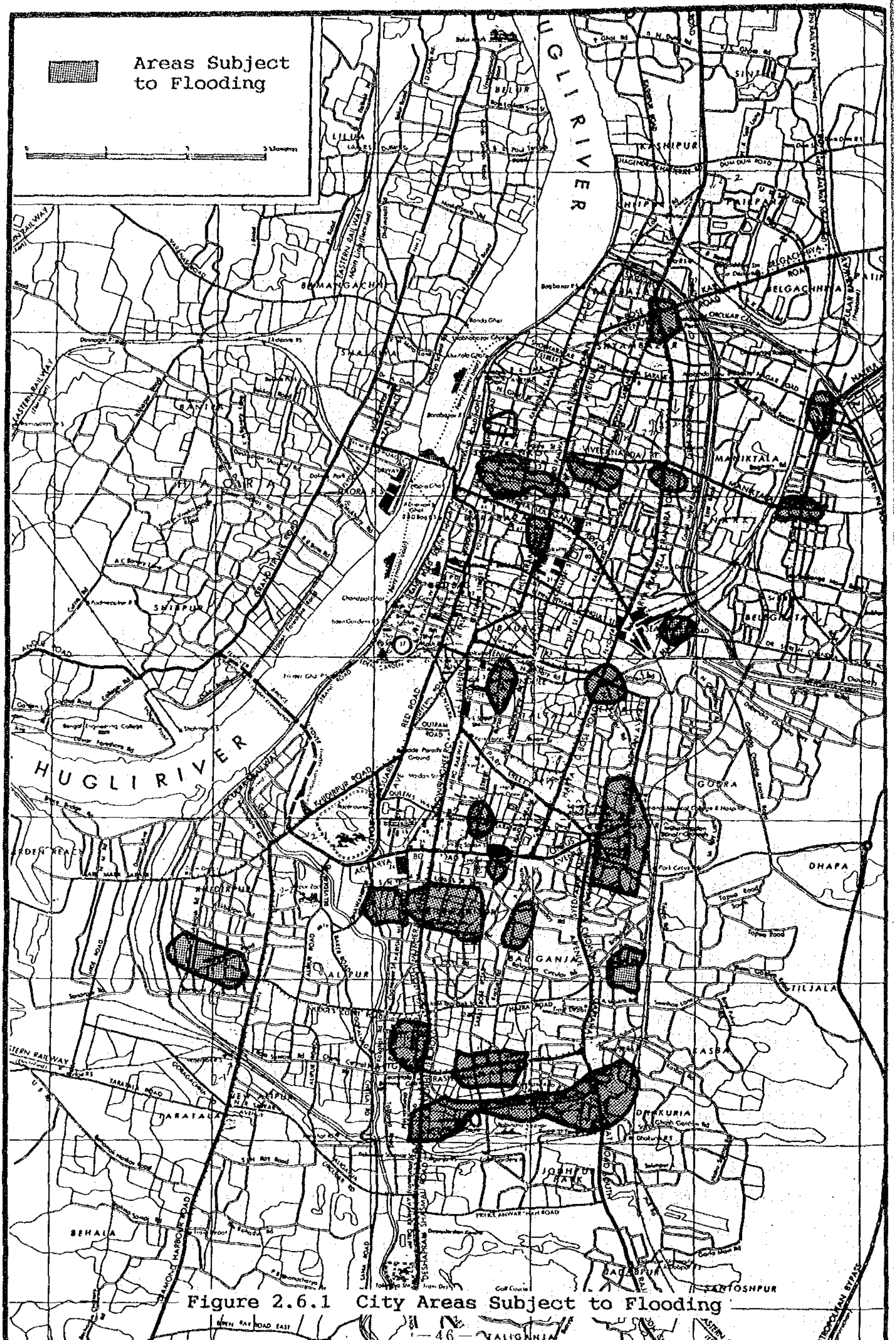


Figure 2.6.1 City Areas Subject to Flooding

2.7. Transportation Projects Under Implementation or Committed

Transportation projects which are either under construction or committed are listed below and are shown in Figure 2.7.1.

1) Durgapur Bridge Reconstruction
2) Garia Bridge Reconstruction
3) Widening of Eastern Metropolitan Bypass to 4 lanes
4) Widening 2-lane Bridge No. 4 to 4 lanes
5) Addition of 3 lane underpass adjoining 2 lane underpass on Ultadanga Main Road below railway line
6) Improvement of Foreshore Road in Howrah
7) Circular Canal Road
8) Improvement of Canal West Road
9) Extension of Canal West Road to Govinda Khatic Road
10) Widening and improvement of C.I.T.Road, Moulali
11) Improvement of A.P.C.Roy Road-A.J.C.Bose Road north and south of Sealdah Flyover
12) Improvement of Chowringhee Road
13) Improvement of a large number of road junctions
14) Signalization of a number of road junctions
15) Flyover on G.T. Road at Salkia, Howrah
16) Long distance bus terminal at Ultadanga
17) Re-sectioning of roads and road junctions with tram lines
18) Jadavpur Road Flyover over rail lines
19) Lake Garden Flyover
20) Bandal Gate Flyover
21) A number of traffic management and safety measures
22) A number of pedestrian overpasses at congested road junctions
23) Truck Terminal at Kona
24) Kona Expressway
25) Belghoria Expressway
26) 2nd Hooghly Bridge
27) New Khidirpur Bridge
28) Link road between Strand Road and 2nd Hooghly Bridge
29) Improvement of Andul Road

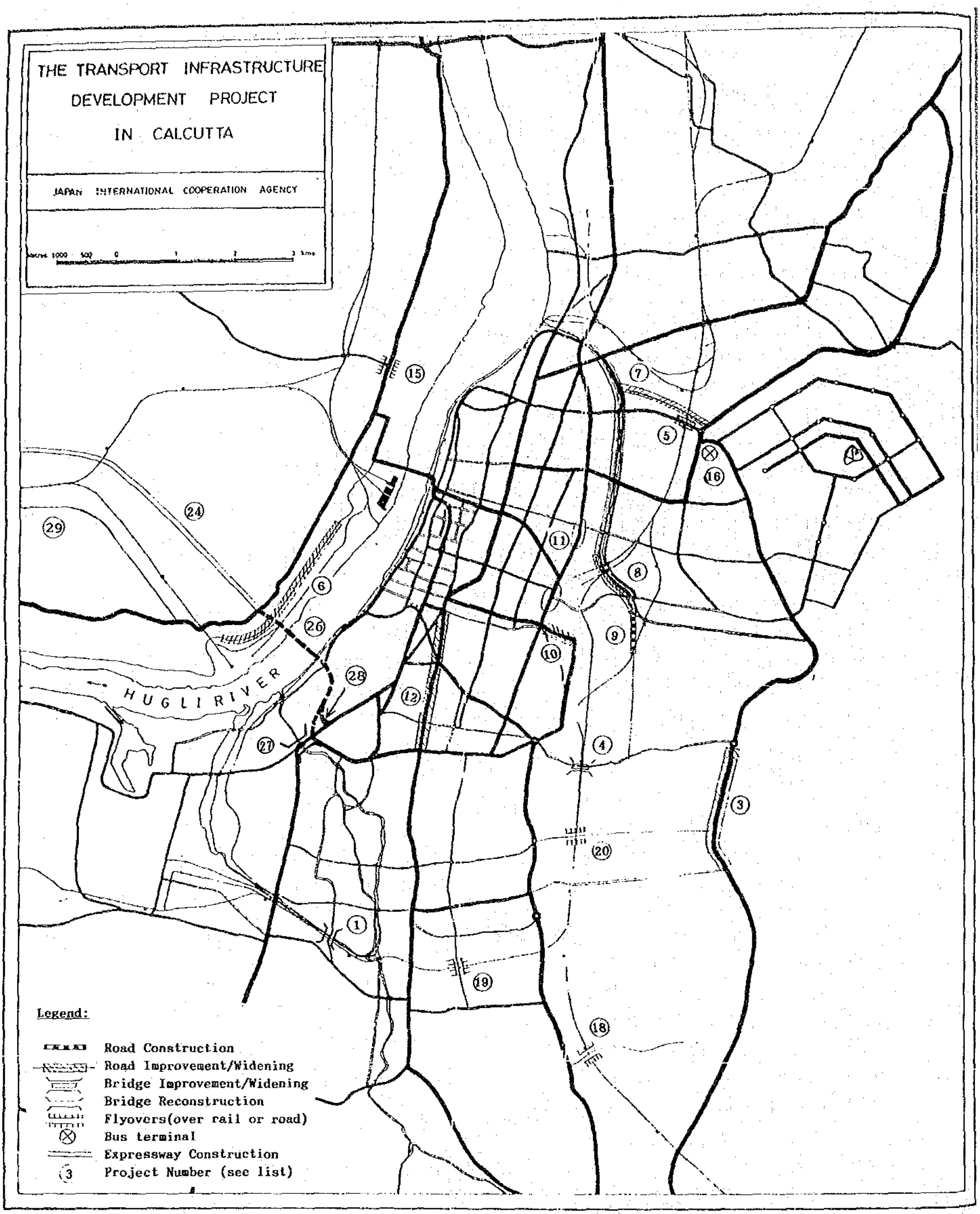


Figure 2.7.1 Transport Infrastructure Projects Committed or Under Construction

2.8 Environment

2.8.1 Air Pollution

Several studies of air quality have been carried out in Calcutta during the last two decades by various departments and organizations to ascertain the level of pollution. Calcutta was included in the Global Environment Monitoring System and was surveyed by the National Environmental Engineering Research Institute (NEERI) for more than a decade. The systematic study indicated Calcutta is one of the worst polluted cities in the world particularly with regard to suspended particular matter (SPM), Sulphur Dioxide (SO_2) and Oxides of Nitrogen (NO_2). Carbon Monoxide (CO) levels are also high. Air pollution effects not only the city core but also the suburbs of Calcutta, though in reduced magnitude. The dangers of pollution to the health of inhabitants have been well documented, as have the adverse effects on vegetation and trees.

The test results of NEERI indicated that the Suspended Particulate Matter (SPM) was 418 micrograms/cubic meter while the allowable limit is 90 micrograms/cubic meter. Similarly SO2 and NO2 also far exceeded the tolerable limits. (Source: A Perspective Plan for Calcutta:2011)

Further details of the measured pollution levels at various locations in Calcutta are provided in Table 2.8.1 below:

Table 2.8.1 Measured Air Quality at Traffic Junctions
(Impact of auto exhaust emissions on air quality)

No.	Traffic Junction	SO_2	NO_2 (ug/m^3)	NOx	TO	CO (ppm)	No.of Vehicles per min.
1.	Chowranghee and	230	354	198	213	50	40
	S.N.Banerjee Road	280	179	256	514	100	36
	Junction	568	551	226	436	100	43
2.	Acharya Jagdish Bose	97	261	-	166	-	-
	Near Ballygunge	73	201	-	122	-	-
	Circular Road	122	317	-	51	-	-
	Crossing						
3.	Gariahat & Rashbihari	290	720	205	200	60	45
	Ave. Crossing	195	572	370	309	50	34
		318	374	587	220	40	25
4.	Acharya Jagdish Bose	203	514	232	184	100	14
	Road and Mahatma	291	432	158	153	200	14
	Gandhi Road Crossing	261	280	196	28	100	13
	at Sealdah						
5.	Howrah in front of	330	434	-	-	200	41
	Howrah Bridge	1,136	273	-	-	50	37

SO_2 - Sulphur Dioxide
NO_2 - Nitrous Dioxide
NOx - Oxides of Nitrogen
CO - Carbon Monoxide
ug/m^3 - Micrograms per cubic metre

(Source: A Perspective Plan for Calcutta 2011)

The same report rated air pollution levels in various areas of Calcutta as shown in Table 2.8.2 below.

Table 2.8.2 Pollution Zones in Calcutta & Suburbs

AREA	POLLUTION LEVEL
Alipore, New Alipore, Salt Lake	Minimal Pollution
Lake Town, Ballygunge, Rashbehari	Marginal Pollution
Entally, Park Circus, CIT Road, VIP Road	Tolerable Pollution
Kasba, Dhakuria, Jadavpur, Garia, Manicktala, Hyde Road	Considerable Pollution
Esplanade, B.B.D. Bag, Dum Dum, Watgunge, Behala, Bhawanipore, Cossipur, Shyam Bazar, Shova Bazar	High Pollution
Tangra, Parts of Beliaghata, Garden Reach, Paharpur, Sealdah, Barra Bazar	Alarming Pollution

(Source: A Perspective Plan for Calcutta 2011)

Data from "A Perspective Plan for Calcutta: 2011" shows that motor vehicles are major contributors to the air pollution in Calcutta. In particular, vehicles are responsible for 87% of carbon monoxide (CO), 15% of hydro carbons (HC) and 25% of oxides of nitrogen (NOx) emissions.

A more detailed breakdown of the emissions from motor vehicles shows that petrol driven vehicles are major contributors of CO and HC emissions while diesel vehicles are major contributors of NOx, smoke (Particulate Matter) and Sulphur Dioxide(SO_2).

2.8.2 Historic Buildings

The "Outline Development Plan for the Calcutta Municipal Corporation Area" by CMDA included a schedule of the areas and or buildings requiring preservation and conservation from historical, architectural, environmental or ecological points of view.

The schedule includes a number of buildings located close to the proposed project sites, and these buildings are shown on the attached Figure 2.8.1.

The buildings are concentrated around the middle of the Central Business District (CBD) and in the Esplanade area. The latter area also has a number of 18th century palaces which, while not listed, do have some historic and architectural merit.

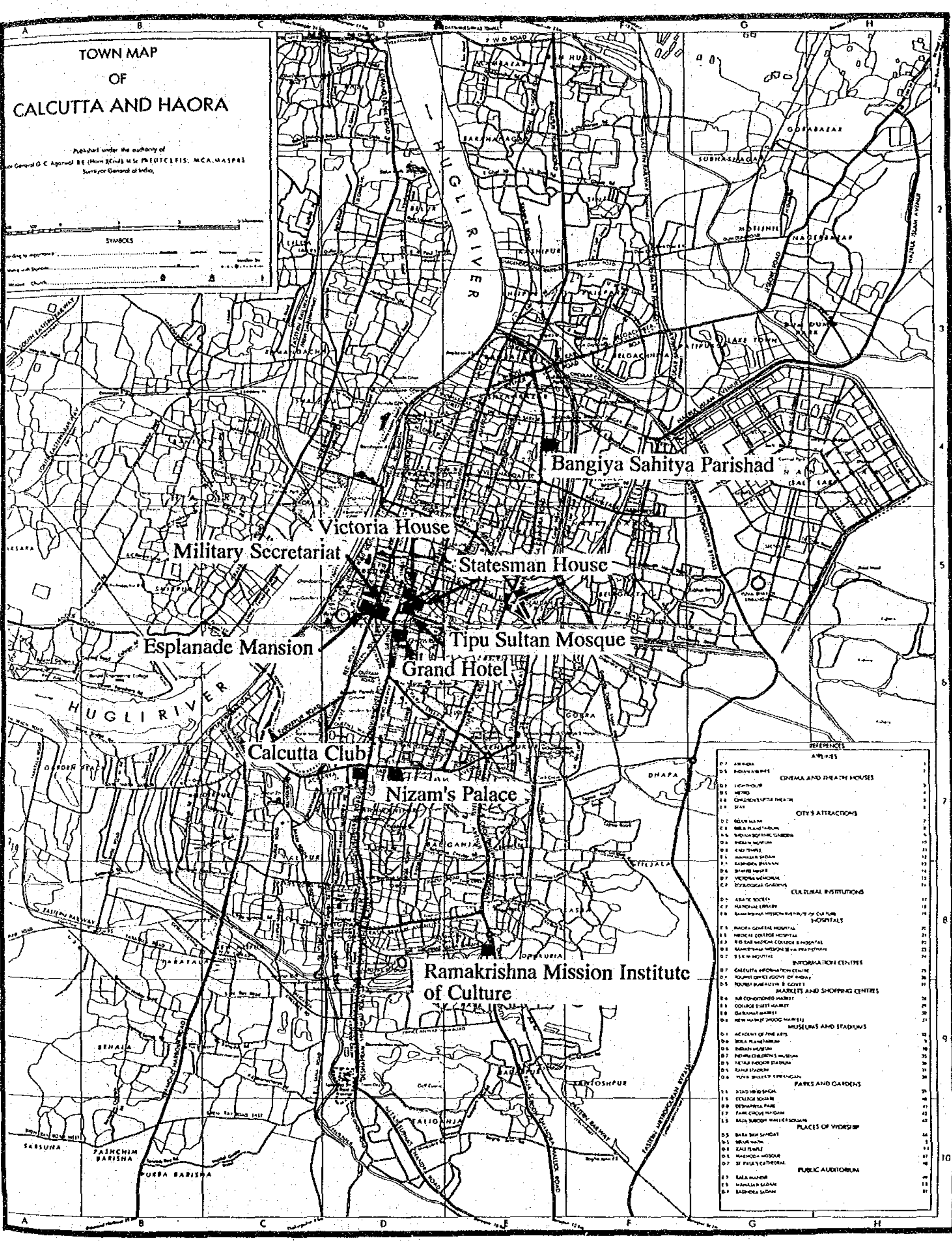


Figure 2.8.1 Historic Buildings Near Project Sites

CHAPTER 3
FIELD SURVEY

CHAPTER 3 FIELD SURVEY

3.1 Soil Investigation

3.1.1 Survey Methodology

(1) Field Survey

The field survey was conducted at the ten Study intersections in order to obtain a preliminary understanding of the sub-soil conditions. Such an understanding is essential for selecting the most economical and technically suitable flyover structure at the surveyed intersections, should a flyover be deemed necessary.

One bore hole, of diameter 150 mm and depth 40.0 meters below ground level, was executed at each of the locations shown in Figure 3.1.1. Standard penetration tests were conducted at each hole at one-meter intervals, undisturbed samples collected, and laboratory tests of soil samples were executed.

(2) Collection and Review of Previous Reports

Previous soil reports for bore holes executed in Calcutta by reliable authorities were collected to supplement the field survey carried out under this Study. Reports prepared on the soil conditions along the metro project route in 1970 and 1973 were very helpful in determining the soil conditions for the Study intersections No.2, 4, 5 and 8.

The reports collected and reviewed were as follows;

a. Geology and Groundwater Resources of the Greater Calcutta Industrial Area, prepared by Geological Survey of India in 1964.
b. Calcutta Mass Transit Study, prepared in 1970-1971, by the Governmental commission set up for studying the metro report.
c. Metropolitan Transport Project, Rapid Transit System, prepared in 1973, for the design and execution of the metro project.

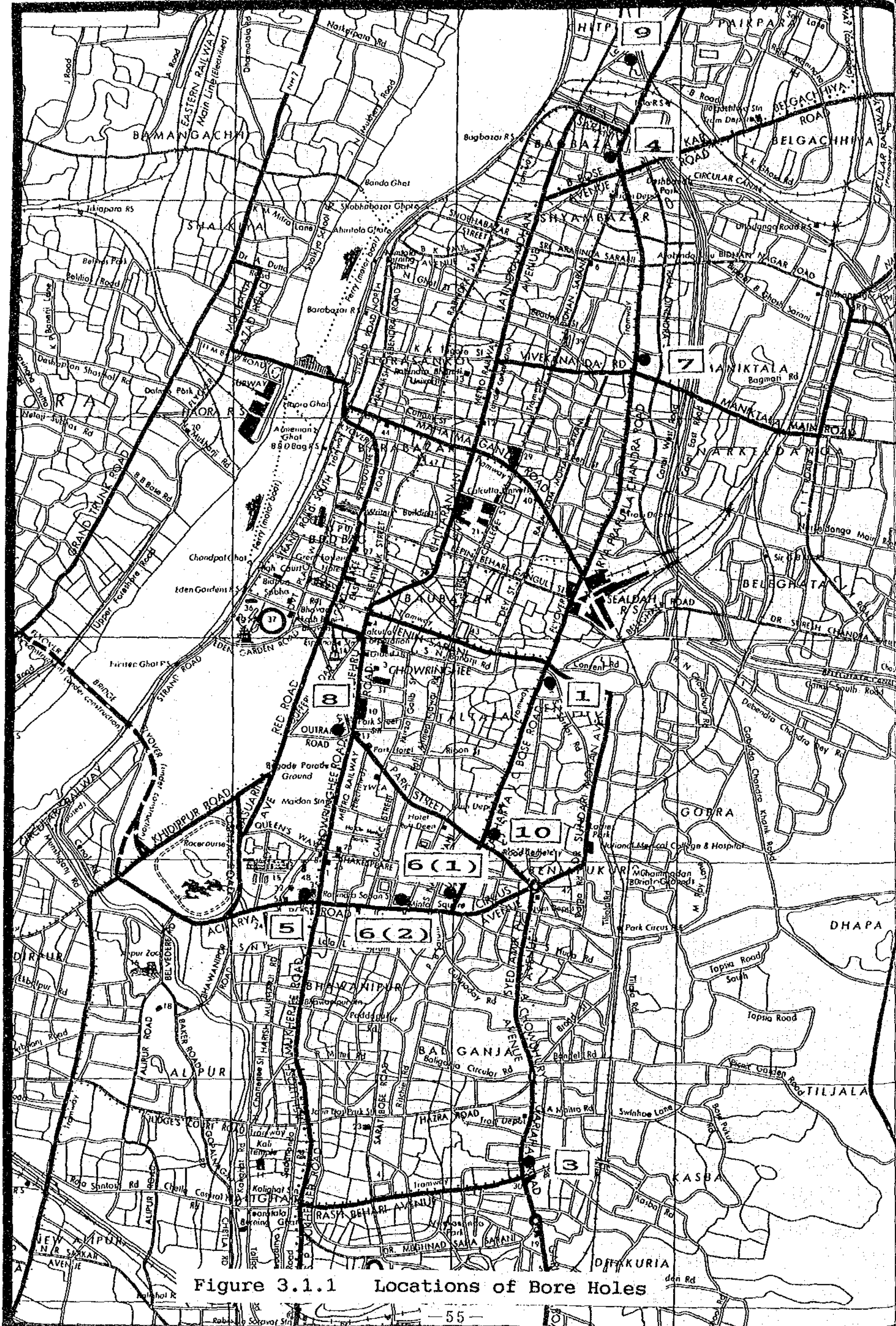


Figure 3.1.1 Locations of Bore Holes

3.1.2 Field Survey Results

The results of the field survey are shown in Figure 3.1.2 and Table 3.1.1. Figure 3.1.2 shows the soil layers classification, N values obtained from the SPT, and the unconfined compression strengths in kg/cm^2 obtained from the laboratory testing. Table 3.1.1 shows a description of the various soil layers and their thicknesses. The soil layers, as observed from the soil investigation at the ten bore holes, can generally be classified as follows;

Layer I : Grayish yellow or bluish gray soft silty clay at depths ranging from 0.4m to 17.0m.

Layer II: Bluish gray, bluish/yellowish gray, or grayish blue medium stiff silty clay (with traces of sand, kankar, and brown patch) at depths ranging from 7.50m to 21.0m. At bore hole #5 this layer was observed just 2.0m below the ground surfaces for a depth of about 4m.

Layer III:Bluish gray, or yellowish brown stiff silty clay (with traces of sand, kankar, and yellow/brown patch) at depths ranging from 12.20m to 40.5m.

Layer IV: Yellowish/gray or yellowish/brown stiff sandy silt clay or silty sand at depths of 15.0m to 40.0m.

The findings of the study reports collected and reviewed are summarized in the Technical Report.

SOIL INVESTIGATION RESULTS AT TEN BOREHOLE LOCATIONS

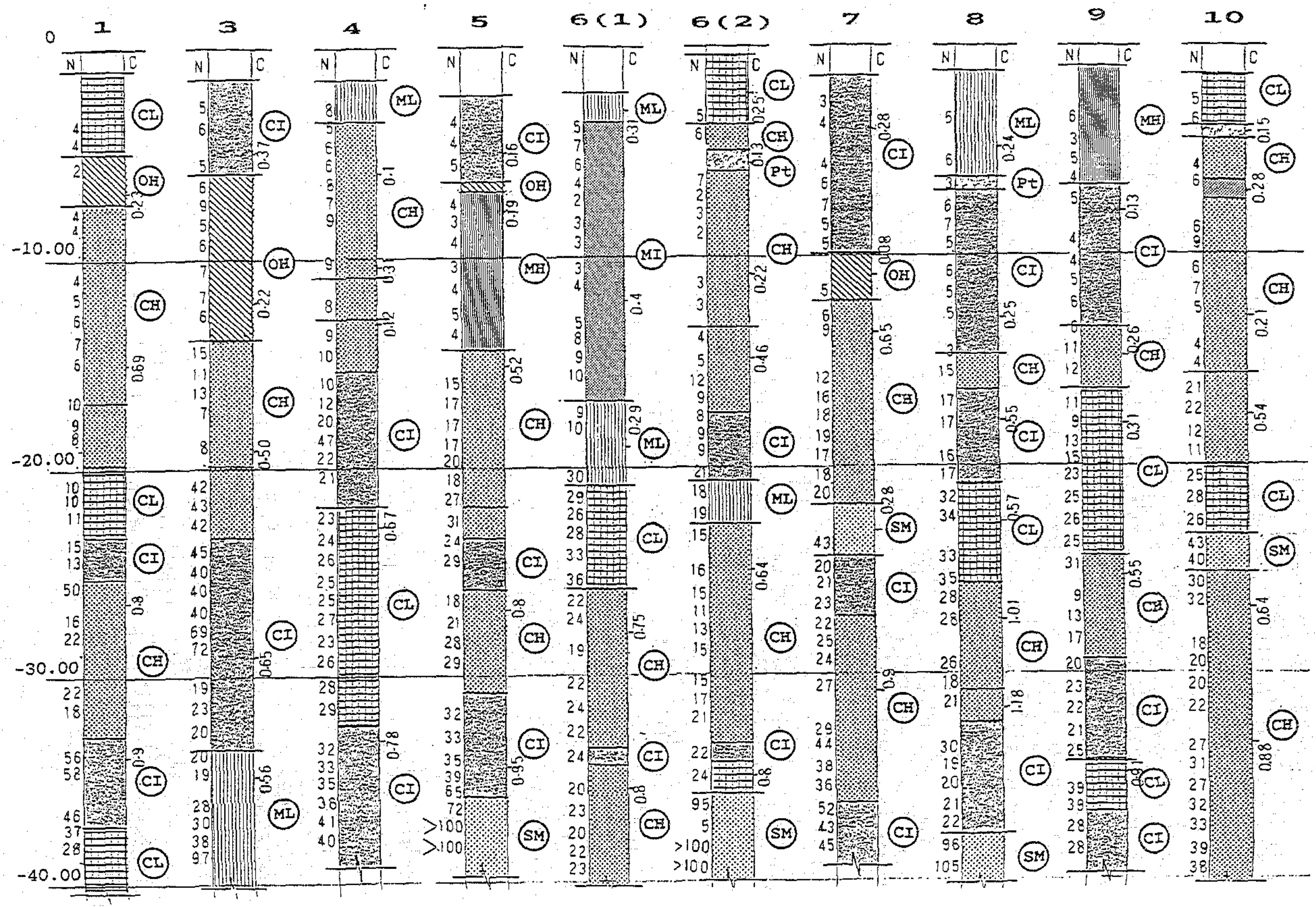


Table 3.1.1 (A) Study Bore Holes Sub-soil Layers Description

Layer	Bore Hole 1		Bore Hole 3		Bore Hole 4		Bore Hole 5		Bore Hole 6(1)	
	Depth (m)	Layer Description	Depth (m)	Layer Description	Depth (m)	Layer Description	Depth (m)	Layer Description	Depth (m)	Layer Description
I	1.00	Fill	1.50	Fill	1.50	Fill containing brick bats, fine sand, etc.	2.20	Fill	2.10	Fill containing brick bats, fine sand, etc.
II	4.00	Thick silty clay layer of low compressibility in soft state	4.50	Intermediate plasticity and low compressibility	2.00	Sandy silt layer in loose state	4.20	Medium stiff silty clay layer of low compressibility and intermediate plasticity	14.90	Thick clayey silt of soft to medium stiff consistency and low to intermediate plasticity, and intermediate compressibility
III	2.40	Silty clay with organic matter in the form of decomposed wood having very high moisture content as well as liquid limit	8.00	Organic clay in the form of decomposed wood of soft to very soft consistency and high plasticity and compressibility	7.50	Silty clay of high compressibility, with the top portion having soft consistency while that near the bottom is of medium stiff consistency	8.10	Thin lense (0.45m) of very soft organic silt in form of decomposed wood, followed by thick deposit of soft clayey silt with traces of decomposed wood, of high compressibility and plasticity	4.00	Non-plastic silt
IV	33.14 min.	Silty clay with variable compressibility. Top 18m high to intermediate plasticity and soft to medium stiff consistency. Below that material has stiff to very stiff consistency	19.70	Silty clay with high to intermediate plasticity and stiff consistency	2.00	Silty clay containing organic matter in the form of decomposed wood having very soft consistency	21.10	Silty clay where consistency increases from medium stiff to stiff to to stiff to hard with increase in depth and high to intermediate plasticity	5.00	Stiff sandy silty clay of low plasticity and compressibility
V			6.30 min.	Dense to very dense sandy silt of low plasticity and medium to stiff consistency	9.00	Silty clay with variable consistency. Intermediate compressibility and stiff consistency in the upper portion and very stiff consistency near the bottom	4.40 min.	Very dense silty sand	14.00 min.	Stiff to very stiff silty clay with high to intermediate plasticity and compressibility
VI					18.00 min.	Silty clay with some sand and very stiff consistency. Upper portion material has low compressibility while lower portion material is of intermediate compressibility				
VII										

Table 3.1.1 (B) Study Bore Holes Sub-soil Layers Description

Layer	Bore Hole 6(2)		Bore Hole 7		Bore Hole 8		Bore Hole 9		Bore Hole 10	
	Depth (m)	Layer Description	Depth (m)	Layer Description	Depth (m)	Layer Description	Depth (m)	Layer Description	Depth (m)	Layer Description
I	0.40	Fill	1.50	Fill containing brick bats, rubbish, etc.	1.20	Fill	1.00	Fill containing brick bats, coal ash, etc.	1.40	Fill
II	3.35	Thick silty clay of soft consistency	8.50	Silty clay of intermediate compressibility with soft consistency	5.10	Clayey silt of soft consistency and low plasticity	5.70	Clayey silt of high plasticity and soft consistency	2.50	Mixed soil containing various percentage of silt, sand and clay
III	9.75	Thick silty clay containing organic matter in the form of decomposed wood, of high compressibility and soft consistency	12.00	Silty clay of high compressibility. Top 2.2m contains organic matter in form of decomposed wood and has very soft consistency. LL in the lower part is greater than 50 but consistency is very stiff	0.70	Thin lense of black peat	6.50	Silty clay with intermediate compressibility and soft consistency, containing organic matter in the form of decomposed wood	11.90	Silty clay with organic matter in the form of decomposed wood and peat of very soft to soft consistency and intermediate to high compressibility
IV	7.30	Silty clay of medium stiff consistency and high compressibility	2.50	Non-plastic sandy silt	7.80	Soft silty clay with occaisonal presence of decomposed and intermediate plasticity	3.00	Silty clay with high plasticity and soft consistency	4.30	Silty clay of medium stiff consistency and high plasticity
V	2.10	Non-plastic sandy silt in medium dense state	15.50 min.	Silty clay of variable compressibility with very stiff consistency	23.20	Silty clay of consistency increasing from medium stiff to very stiff with increase in depth, varying degree of plasticity, and intermediate to high compressibility	8.00	Silty clay of low plasticity and medium consistency	3.40	Silty clay with low compressibility
VI	13.10	Silty clay of stiff consistency and varying compressibility. Top portion has high compressibility while lower part has low compressibility			2.00 min.	Dense silty sand	10.00	Silty clay with high plasticity and stiff consistency in the upper part, and intermediate plasticity and very stiff consistency in the lower part	1.30	Non-plastic dense silty sand
VII	4.00 min.	Dense to very dense non-plastic silty sand					5.50 min.	Silty clay with intermediate plasticity and very stiff consistency	14.70 min.	Silty clay of stiff consistency, intermediate compressibility and high plasticity

3.2 Topographic Survey

3.2.1 Topographic Survey Extent and Methodology

(1) Survey Locations

The topographic field survey conducted under the Study covered the ten intersections where there are proposals to construct flyovers or execute at-grade intersection improvement projects.

(2) Survey Methodology

The sequence under which this survey was implemented is described hereafter;

a. Collection of available maps

Through the assistance of the Counterpart Team, maps were collected for some of the Study intersections, of varying levels of detail. From these maps, for each intersection a base map was prepared to be used on site and verified.

b. Execution of the field survey

The heavily congested traffic conditions at nine of the ten intersections undermined any possibility that field surveys could be executed during the daytime, and consequently the surveys were done during the hours of 11 PM to 5 AM of the following morning. The survey was executed by the theodolite traversing, offsetting and plane table method.

c. Preparation of preliminary maps and field check

Upon the preparation of the preliminary topographic maps for the intersections, these drawings were taken to site for checking of the accuracy of measurements and for confirmation that all necessary information was recorded on the maps.

d. Finalization of maps

The final maps were prepared using a CAD system and plotters.

3.2.2 Topographical Mapping Produced

(1) Topographic Survey Maps

Topographic maps were prepared for the Study intersections in sufficient detail and extent to allow for the planning and design of various intersection improvement schemes.

Alongside the road dimensions, the maps identify the existing road furniture and other utilities occupying the road space. Features such as light posts, electricity posts, tram related utilities, manholes, electricity and telephone boxes, drainage gutters, statues, etc. are clearly identified on the maps. Hawkers and stalls erected on the pavement and medians at some of the intersections are shown on the maps, as well as tram tracks where applicable.

Building elevations and their types, and religious places are also clearly shown on the maps. Maps were mainly prepared at a scale of 1/500, with the exception of Intersections No.1 and 10 where a scale of 1/1000 was adopted. Via reduction or enlargement in Tokyo, maps were prepared for each intersection at scales of 1/1000 and 1/500.

(2) Longitudinal Sections

Pavement and sidewalk elevations were recorded at twenty meter intervals. Maps were prepared for each intersection showing the longitudinal profiles of the roads leading into the intersection.

(3) Cross Sectional Drawings

Cross-sections were taken at 20m intervals. Drawings identifying the type of road cross-section, dimensions of the cross section, and levels were then prepared for each cross section.

(4) General Layout Maps

The available maps were checked and a site reconnaissance of the roads surrounding the Study intersections was conducted to verify that all relevant roads were indicated on the maps. These maps were prepared at a scale of 1/500.

3.3 Underground Utilities Survey

3.3.1 Methodology

The objective of the survey was to identify the types and locations of subsurface utilities at the ten Study intersections. The following surveys were undertaken by the Study Team.

(1) Interview Survey and Mapping
(2) Subsurface Radar Survey
(3) Excavation of test pits for verification of utility locations detected by Radar

The execution methods of these surveys and their results are reviewed in the Technical Report.

3.3.2 Survey Results

(1) Interview Survey and Mapping

Through the cooperation of the Counterpart Team, the following authorities and companies were contacted to collect data and available maps related to the Study intersections;

a. Calcutta Municipal Corporation
   Water supply and drainage
b. Metro Railway
   Information on extent of utilities diversionary works executed during the metro construction
c. Calcutta Electric Supply Corporation (CESC)
   Electric power supply network
d. Calcutta Telephones
   Telephone network
e. Greater Calcutta Gas Supply Corporation
   Gas supply network
f. Calcutta Metropolitan Development Authority (CMDA)
   Water supply and drainage network
g. Calcutta Investment Trust (CIT)
   Various available utilities mapping at some of the Study intersections

The data and information obtained from the above mentioned authorities were compiled onto the topographic maps prepared by the topographic survey at a scale of 1/500. A summation of this interview survey is shown in Table 3.3.1.

(2) Subsurface Radar Survey

The Subsurface Radar emits electromagnetic waves into the earth through the transmitting antenna. Transmitted electromagnetic waves reflect at boundaries of electrically foreign materials, such as pipes and cavities, and return to the ground surface where they are detected by a receiving antenna. The depth to the reflecting surface can be calculated from the elapsed time for the electromagnetic wave to travel from and back to the surface. As the antenna is moved along a line, utilities underneath that line up to depths of around 2 meters can be mapped.

In order to obtain high resolution, the time period between successive pulses needs to be very short, no more than as a few nanoseconds. The process under which the subsurface detector operates is schematically shown in Figure 3.3.1.

The Subsurface Radar can be used effectively up to a depth of 2 meters under favorable conditions where the surrounding soil layers are electrically homogeneous. Since electromagnetic waves are attenuated by induced eddy currents in the transmitting medium, detection depth becomes shallower in the more conductive soils such as beach soil filled with brine.

On the basis of the Interview Survey results, survey lines were set across the road where the flyover was likely to be constructed at 20m or 40m intervals for a distance of 160 meters from the intersection in each direction (as shown in Figure 3.3.2). The survey was carried out continuously and results recorded on magnetic cassette tape. Color printouts were also produced at the time of survey as necessary.

Table 3.3.1 (1) Underground Utilities Interview Survey Results

	Intersection/Road Name	Water Line (F) Filter (U) Unfilter	Sewer Line	Gas Line	Electricity (H) H.T.Cable (L) L.T.Cable	Telephone
#1	MOULALI A.P.C. Roy Road	φ 229mm (U) φ 457mm (U) φ 152mm (F) φ 610mm (F) φ 1524mm (F)	2845x2210 mm φ 305mm	φ 457mm φ 305mm φ 305mm φ 152mm	3 nos. (L) 2 nos. (H) 4 nos. (L)	1 no.
#1	D.R.L. Bhattacharjee Road	φ 152mm (F) φ 152mm (U) φ 762mm (F) φ 305mm (F) φ 381mm (U) φ 152mm (U) φ 152mm (F)	φ 203mm φ 1676mm φ 305mm	φ 152mm	7 nos. (H) 2 nos. (L) 4 nos. (L)	1 no.
#2	ESPLANADE Chowringhee Road	φ 229mm (F) φ 305mm (F) φ 305mm (U) φ 229mm (U) φ 152mm (F)	1650x1100 mm φ 202mm	φ 457mm φ 102mm φ 150mm (C) φ 152mm (C)	2 nos. (H) 1 no. (L)	
#2	Esplanade Row East from Lenin Sarani	φ 152mm (F) φ 452mm (F) φ 152mm (U) φ 452mm (F) φ 152mm (F)	2464x1905 mm	φ 150mm φ 229mm φ 150mm φ 152mm	2 nos. (L) 2 nos. (H)	
#3	GARIAHAT Rash Behari Avenue	φ 152mm (F) φ 152mm (U) φ 305mm (U) φ 152mm (U) φ 152mm (F)	φ 229mm φ 2896mm φ 229mm φ 152mm	φ 150mm φ 229mm φ 305mm φ 102mm	2 nos. (L)	2 nos.
#3	Gariahat Road	φ 152mm (F) φ 152mm (U) φ 305mm (F) φ 305mm (U) φ 152mm (F) φ 152mm (U)	φ 229mm φ 991mm φ 1067mm φ 229mm φ 914mm φ 1219mm φ 152mm φ 152mm	φ 305mm φ 205mm φ 152mm φ 102mm φ 305mm φ 229mm φ 305mm φ 305mm φ 152mm	2 nos. (L) 2 nos. (H)	2 nos.
#4	SHYAMBAZAR A.P.C. Roy Road	φ 152mm (F) φ 152mm (U) φ 762mm (F) φ 305mm (U) φ 762mm (F) φ 1829mm (F) φ 1524mm (F) φ 152mm (F) φ 102mm (F)	1219x 813 mm	φ 76mm φ 305mm φ 200mm φ 152mm φ 102mm	7 nos. (L) 7 nos. (H)	1 no. (C)
#4	R.G. Kar Road	φ 152mm (U) φ 102mm (F) φ 152mm (U) φ 102mm (F) φ 152mm (F) φ 457mm (U) φ 684mm (F) φ 152mm (U) φ 152mm (U) φ 152mm (F)	φ 305->225mm φ 375mm φ 225mm	φ 102mm	2 nos. (L) 2 nos. (H)	

Table 3.3.1 (2) Underground Utilities Interview Survey Results

	Intersection/Road Name	Water Line (F) Filter (U) Unfilter	Sewer Line	Gas Line	Electricity (H) H.T.Cable (L) L.T.Cable	Telephone
#5	RABINDRA SADAN Chowringhee Road	φ 152mm (F) φ 150mm (U) φ 305mm (U) φ 102mm (F)	φ 525mm φ 200mm φ 300mm φ 150mm φ 1500mm	φ 152mm φ 229mm φ 305mm φ 102mm	3 nos. (L) 8 nos. (H)	
	A.J.C. Bose Road	φ 305mm (U) φ 152mm (F) φ 610mm (U) φ 102mm (F) φ 152mm (U) φ 533mm (U)	1219x 813 mm φ 762mm φ 610mm	φ 381mm φ 102mm	2 nos. (L) 7 nos. (H)	1 no. (C)
#6	BECK BAGAN A.J.C. Bose Road at Bally-gunge Circular Road x-ing A.J.C. Bose Road at Sarat Bose Road x-ing	φ 152mm (U) φ 533mm (F) φ 1524mm (F) φ 533mm (U) φ 102mm (F) φ 152mm (U)	2464x1905 mm φ 229mm	φ 381mm φ 32mm	2 nos. (H)	
#7	MANIKTALA A.P.C. Roy Road	φ 152mm (U) φ 305mm (U) φ 610mm (F) φ 610mm (F) φ 1524mm (F) φ 102mm (F)	2464x1905 mm φ 203mm	φ 229mm	5 nos. (L) 7 nos. (H)	2 nos.
	Vivekanada Road	φ 152mm (F) φ 152mm (U) φ 762mm (F) φ 152mm (U) φ 102mm (F) φ 1219mm (U)	2972x2134 mm φ 305mm φ 1143mm φ 203mm	φ 152mm φ 100mm	4 nos. (L) 11 nos. (H)	2 nos.
#8	PARK STREET Chowringhee Road	φ 533mm (U) φ 457mm (F) φ 150mm (F) φ 300mm (F) φ 914mm (F) φ 300mm (F) φ 150mm (U)	1524x1016 mm 1200x 800 mm φ 457mm	φ 457mm φ 305mm	4 nos. (L) 2 nos. (H)	1 no. (Park st. cross)
	Park Street	φ 300mm (F) φ 914mm (F) φ 300mm (F) φ 150mm (U)	1200x 800 mm φ 600mm	φ 229mm φ 76mm φ 150mm	4 nos. (L) 2 nos. (H)	
#9	LOCK GATE Lock Gate Road	φ 102mm (F) φ 533mm (F)	2134x1524 mm φ 457mm	φ 76mm φ 51mm	1 no. (L)	
#10	MULLIKBAZAR A.J.C. Bose Road	φ 152mm (U) φ 305mm (U) φ 533mm (F) φ 152mm (F) φ 152mm (F)	1845x2210 mm φ 457mm	φ 457mm φ 305mm φ 32mm φ 229mm φ 305mm	2 nos. (L) 1 no. (H)	
	Park Street	φ 102mm (F) φ 152mm (U) φ 305mm (F) φ 152mm (U) φ 102mm (F)	φ 1321mm 1981x1321 mm φ 1372mm	φ 305mm φ 152mm φ 305mm φ 229mm φ 76mm φ 150mm	3 nos. (L) 1 no. (H)	1 no.

Figure 3.3.1 Schematic Presentation of Subsurface Detector Process

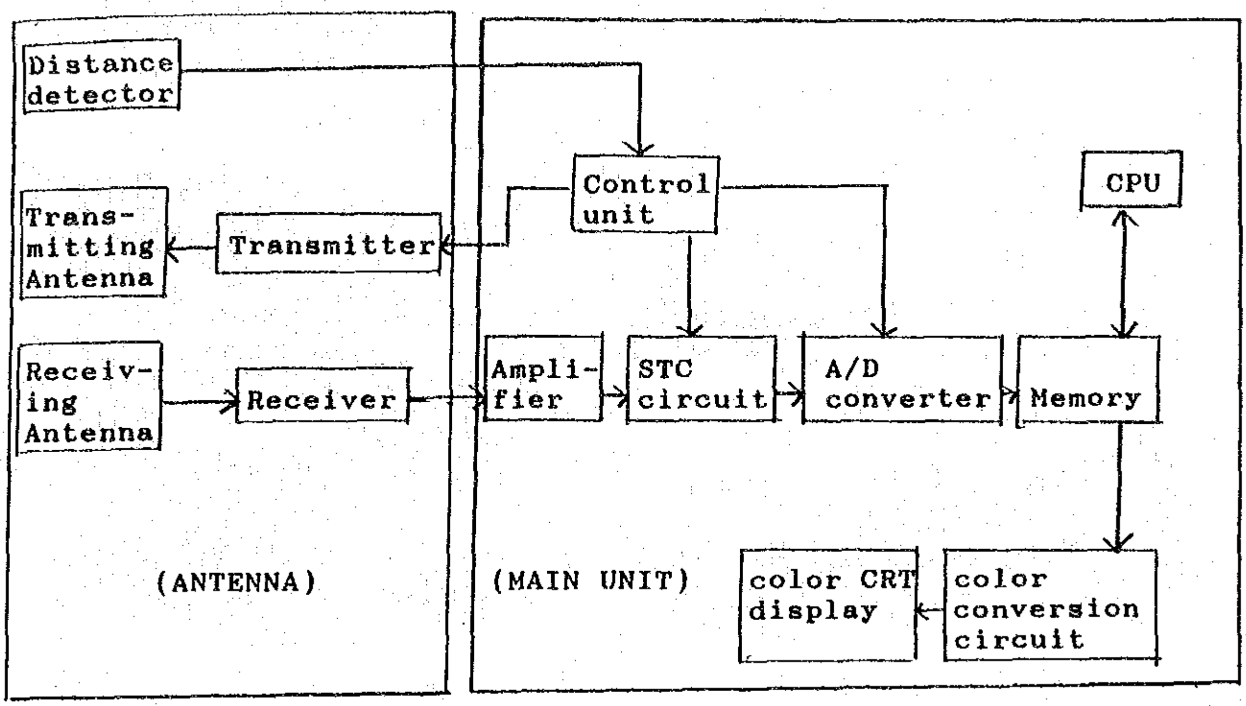
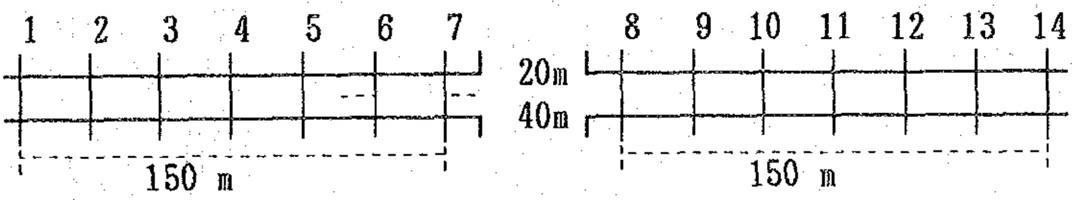
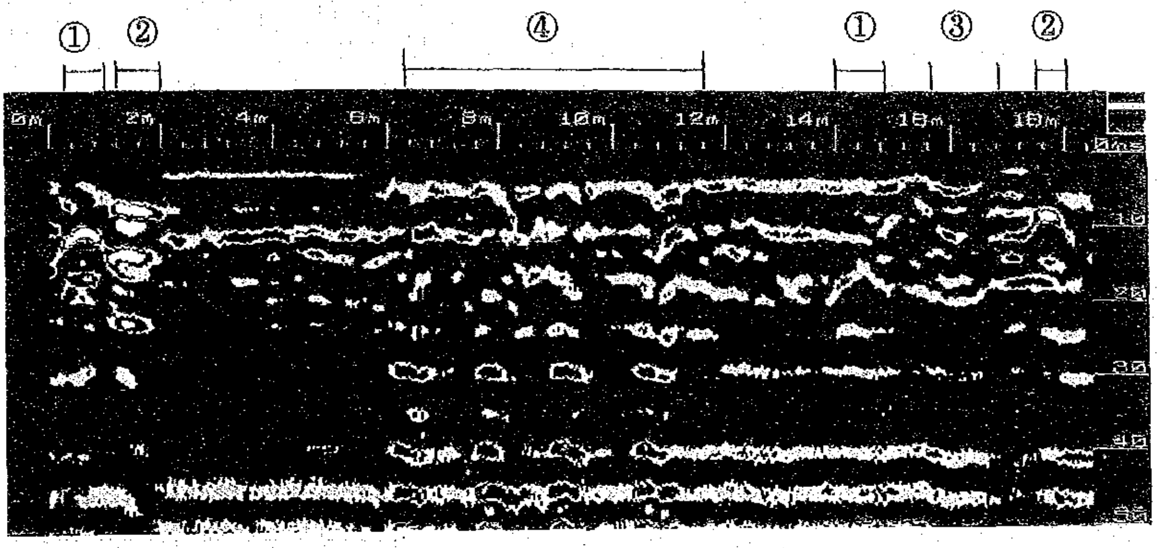


Figure 3.3.2 Intervals of Surveyed Cross Sections



Recorded survey results were played back at the office and color hard copies of each survey lines were made. The original color copies will be forwarded separately to the Government of West Bengal. An example of a color printout recorded at Intersection No. 10 is shown on Figure 3.3.3.



(1) Cylindrical Pipe
(2) Square Box
(3) Discontinuity near the surface
(4) Multiple reflection of tram rail

Figure 3.3.3 Example of Colour Printout of Underground Section along Survey Line

The above printout is quite typical and shows that at both edges of the road, strong reflecting bodies were detected near the ground surface. Buried objects were both cylindrical and square shaped. Buried pipes of diameters over 50 cm were easily detected by the Radar but anything under 30 cm was not readily discernible.

Many discontinuous reflecting bodies were detected in artificially filled earth, but some could not be identified as buried pipes in brick fragments filled earth. Utilities buried near tram rails and manholes could not be easily detected because of the strong reflection of the electromagnetic waves by the rails and manholes.

The results of the radar survey are summarised in Table 3.3.2.

Table 3.3.2 The Radar Survey Results

Location Numbers	Crossing's Name / Road's names	Water Line Filter (F) Unfilter (U)	Sewer Line	Gas Line	Electrcity Line H.T.Cable (H) L.T. (L)	Telephone Line	?
1	A.P.C. Roy Road and Lenin Sarani Crossing (Moulali)	φ 457mm (U) φ 610mm (F) φ 610mm (F) φ 762mm (F) φ1524mm (F) φ 229mm (F)	2845×2200mm (B) φ 305mm φ1892mm 2845×2200mm (B) ?(B)	φ 457mm φ 305mm φ 305mm φ 305mm φ 305mm φ 152mm	3NOS (HB) φ 533mm φ?(B) ?(LB)		φ? ? ?(B)
2	Chowrighee Road and Lenin Sarani Crossing (Chowrighee Road)	φ 305mm (U) φ 229mm (F) φ 457mm (U) φ 305mm (F) φ 229mm (U)	1570× 700mm (B) φ 200mm φ 305mm 1650×1100mm (B) φ1100mm ?(B) φ 202mm φ?	φ 457mm			φ? φ? φ? φ? φ? φ? φ? φ? φ?
3	Gariahat Intersection on Rash Behari Avenue (Rash Behari Avenue)	φ 305mm (F)	φ2744mm				φ? φ? φ? φ? φ? φ? φ?
	(Gariahat Road)	φ 305mm (F) φ 305mm (U) φ 152mm (U) φ 152mm (F) φ 152mm (U) φ 152mm (U)	φ 229mm φ 991mm φ1067mm φ1219mm φ 914mm φ 152mm φ?				φ? φ? φ? φ?
4	A.P.C. Roy Road at Shyambazar Crossing (A.P.C. Roy Road)	φ 152mm (U) φ 152mm (F) φ 610mm (F) φ1892mm (F) φ1524mm (F) φ 152mm (U)	1219×813mm (B)	φ 152mm	1NO(L)		φ? φ? φ?
5	A.J.C. Bose Road and Chouringhee Road Crossing (Chouringhee Road)	φ 225mm (U) φ 152mm (F) φ 305mm (U)	φ? φ 200mm φ? φ 525mm φ1500mm φ 150mm φ 300mm	φ 305mm			φ? φ? φ? φ? φ? φ?
	(A.J.C. Bose Road)	φ 152mm (F) φ 152mm (U) φ 610mm (U) φ 533mm (U) φ 150mm (F)	φ 762mm 2425×1875mm (B) φ 610mm		1NO(H) 2NOS(L)		φ? φ?
6	A.J.C. Bose Road at Ballygunge Road Crossing A.J.C. Bose Road at Sarat Bose Road Crossing	φ 533mm (F) φ1524mm (F) φ 152mm (F) φ 533mm (U) φ 102mm (F) φ 152mm (U)	2845×2210mm (?) 2464×1985mm (B) φ 229mm (?) ?	φ 102mm φ 381mm	φ?(B) φ75×3mm (B) 1NO(HB)		φ? φ? ?(B)
7	A.P.C. Roy Road at Maniktala Crossing (A.P.C. Roy Road)	φ1524mm (F) φ 610mm (F) φ 457mm (F) φ 305mm (U)	2464×1985mm (B)	φ 229mm	2NOS (HB) 2NOS (LB) 3NOS (HB)		φ? φ? φ? φ?
8	Park Street and Chowrinhee Road Crossing (Chowrinhee Road)	φ 320mm (U) φ 914mm (F) φ 300mm (F) φ 152mm (F) φ 457mm (F) φ 150mm (U) φ 533mm (U) φ 150mm (F)	1524×1016mm (B) 1200× 800mm (B)	φ 305mm			φ? φ? φ? ?(B) ?(B)
9	Lock Gate Road Flyover on the railway lines	φ 533mm (F) φ 152mm (F)	2134×1524mm (B) φ 533mm (F)	φ 76 mm φ 150mm	φ?(LB)		φ? φ? φ?
10	A.J.C. Bose Road and Park Street Crossing (A.J.C. Bose Road)	φ 150mm (U) φ 305mm (U) φ 152mm (U) φ 152mm (U) φ 533mm (F) φ 152mm (F)	2845×2200mm (B) φ1892	φ 457mm φ 305mm φ 229mm φ 229mm (B) φ 305mm	φ?(LB) 1NOS (HB) 2NOS (LB)		φ?

(3) Verification Excavation Survey

In order to check and verify the findings from the radar survey primarily but also the interview survey, test pits of dimensions 1.5m x 1.5m with a depth of 2.0m were excavated at the ten Study intersections. The pits were excavated manually to avoid any damage to existing underground utilities.

It was not possible to try to verify all of the underground utilities detected by radar. One pit at each intersection was considered sufficient to check the interpretation of the radar survey results.

Sketches were made on site showing measurements surveyed to identify the positions of any uncovered utilities and their depth below ground level. Drawings were then prepared in the office and shown on the topographic maps for each respective intersection. Table 3.3.3 summarises the results of this survey.

At 8 of the 10 surveyed intersection utilities were identified from the test pits. At the remaining 2 intersections only buried fragments of bricks were found.

(4) Integration of the Three Survey Results

The results of the three surveys at the Study intersections were integrated and examined. Figure 3.3.4 shows as an example, the integration of the results for Intersection No.10. The verification survey generally confirmed the results of the subsurface radar survey. However, there are some discrepancies between the results of the interview survey and the results of the radar and verification surveys which should be checked during the detail design.

Table 3.3.3 Verification Excavation Survey Results

No.	Water Line Cross (C)	Sewer Line	Gas Line	Electricity Line	Telephone Line
1	ϕ75 mm h = 0.60 m (C)	ϕ1830 mm h = 1.75 m		ϕ500 mm h = 1.45 m	
2	ϕ457 mm h = 1.60 m				
3	Fragments of Bricks				
4				750×100 mm h = 1.85 m ? (Masonary Box)	
5	ϕ150 mm h = 1.75 m			ϕ75 mm(L) h = 1.45 m ϕ75 mm(L) h = 1.45 m ϕ150 mm(L) h = 0.75 m (covered with Tiles)	
6				ϕ25 mm(L) h = 0.75 m ϕ75 mm(L) h = 1.10 m ϕ75 mm(L) h = 1.10 m ϕ75 mm(L) h = 1.10 m	
7	ϕ457 mm h = 0.75 m			600×100 mm h = 1.75 m ? (Masonary Box)	
8	Fragments of Bricks				
9	ϕ457 mm h = 1.50 m		ϕ305 mm h = 0.90 m	ϕ25 mm(L) h = 1.60 m ϕ25 mm(L) h = 1.60 m ϕ25 mm(L) h = 1.60 m ϕ25 mm(L) h = 1.60 m ϕ25 mm(L) h = 1.60 m (L.T.Cable)	600×300 mm h = 1.15 m ? (Masonary Box)
10	ϕ457 mm h = 1.20 m (C)	ϕ1829 mm h = 1.90 m	1000×450 mm h = 0.00 m (Masonary Box)		

Names of Crossings
1. A.P.C Roy Road and Lenin Sarani Crossing (Moulali)
2. Chowringhee Road and Lenin Sarani Crossing
3. Gariahat Intersection on Rash Bihari Avenue
4. A.P.C Roy Road at Shyambazar Crossing
5. A.J.C Bose Road and Chowringhee Road Croosing
6. A.J.C Bose Road at Ballygynge Circular Road Crossing
   A.J.C BOSE Road at Sarat Bose Road Crossing
7. A.P.C Roy Road at Maniktala Crossing
8. Park Street and Chowringhee Road Crossing
9. Lock Gate Road Flyover on the railway lines
10. A.J.C Bose Road and Park Street Crossig

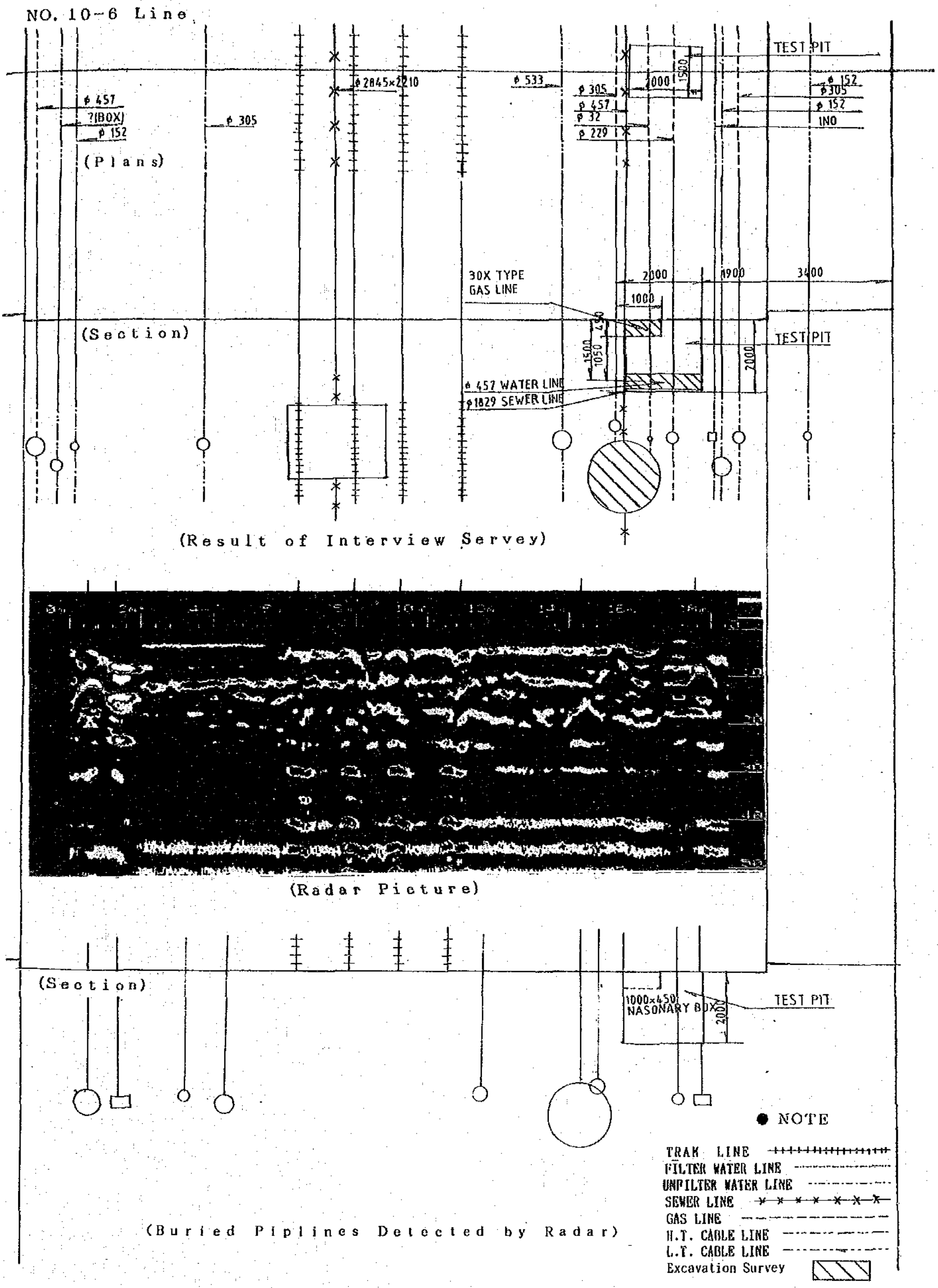


Figure 3.3.4 Results (No.10-6 Line)

CHAPTER 4

TRAFFIC SURVEYS AND FUTURE TRAFFIC ESTIMATES

CHAPTER 4 TRAFFIC SURVEYS AND FUTURE TRAFFIC ESTIMATES

4.1 Surveys

4.1.1 Background

The Study Team carried out the following traffic surveys to allow a better understanding of the present traffic conditions in Calcutta.

- Traffic Volume Surveys
- Roadside Origin-Destination Survey on Howrah Bridge
- Travel Speed Survey
- Parking Survey
    - Parking Interview Survey
    - Parking License Plate Survey
    - Parking Volume Count
- Pedestrian Survey on B.B. Ganguly Street and M.G. Road

Various relevant traffic reports and traffic surveys which were conducted by West Bengal or other organizations were collected with the assistance of the Counter-part Team and reviewed for possible utilization in the Study.

4.1.2 Survey Methodology

(1) Traffic Volume Surveys

The traffic volume count was carried out during the period from November 18 to 28, 1991 excluding holidays. The traffic flows at each approach of each of the 16 intersections and at Howrah Bridge (see Figure 4.1.1) were counted and recorded in 15 minute intervals according to vehicle classification. At Howrah Bridge the counting was carried out for 24 hours, while for the other 16 locations the survey duration was 12 hours, from 8:00 in the morning to 20:00 in the evening. The vehicle classifications adopted were as follows;

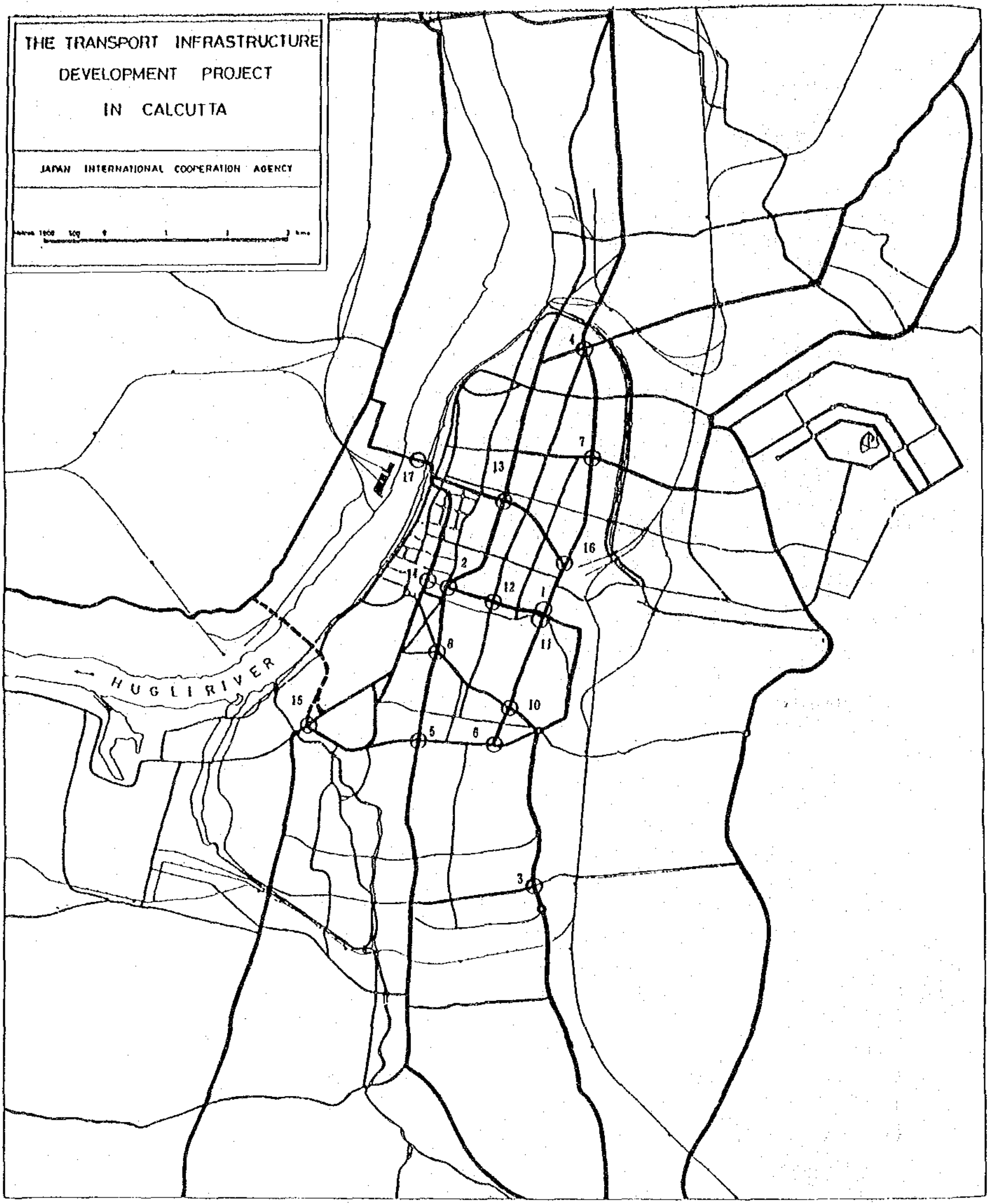


Figure 4.1.1 Location of Traffic Volume Surveys

- Fast Vehicles (motorized vehicles)
    - Passenger car/Jeep
    - Taxi
    - Truck
    - Mini Truck
    - Bus
    - Mini/Midi Bus
    - Motor Cycle/Scooter/Moped
    - Tram
    - Other motorized vehicle
- Slow Vehicles (non-motorized vehicles)
    - Cycle
    - Cycle Rickshaw/Hand Rickshaw
    - Animal-drawn/Hand Cart
    - Wheelbarrow
- Other non-motorized vehicles

(2) Supplementary Origin-Destination Survey

An Origin-Destination survey (O-D survey) was carried out at Howrah Bridge to provide information to assist in the assignment of traffic after the opening of the 2nd Hooghly Bridge.

The method adopted was to carry out driver interviews on the Calcutta side bridge approaches over a continuous 24 hours period on November 27, 1991. Traffic in both directions was surveyed and the target sampling ratio was more than 15% of the traffic volume for the fast (motorized) vehicle classifications in (1) above.

For vehicles classified as Buses, Mini/Midi Buses and Trams the drivers were not interviewed. The O-D survey for these classifications covered recording the origin and destination zone according to the route number and the number of passengers were estimated by occupancy rate only.

Interview items were as follows;

- Origin
- Destination
- Purpose
    - To Work
    - Business

- To School
- Private (Shopping, etc.)
- To Home
- Number of Passengers including driver
- Vehicle classification
- Sampling Time

(3) Travel Time Survey

The travel time survey was carried out on the 7 corridors shown in Figure 4.1.2 between November 18 and 28, 1991 but excluding holidays. In order to collect information on commuting times, the survey was carried out during the morning and evening peak hours.

The survey method adopted was the "Test car method". Test cars were driven at an assumed average traffic speed, and the elapsed time when passing the designated check points was recorded.

(4) Parking Surveys

Three types of parking survey were carried out to provide data to assist in evaluation of proposals for car parking structures.

(a) Parking Interview Survey

The parking interview survey method was by driver interview at the 8 road sections shown in Figure 4.1.3. Counts were taken for morning and evening peak hours between November 18 and 28, 1991 for morning and evening peak hours.

(b) Parking License Plate Survey

The parking license plate survey method was by patrol and recording of license plate numbers at 15 minutes intervals. The survey was carried out on the 13 road sections shown in Figure 4.1.3 between November 18 and 28, 1991 for 12 hours from 8:00 in the morning to 20:00 in the evening.

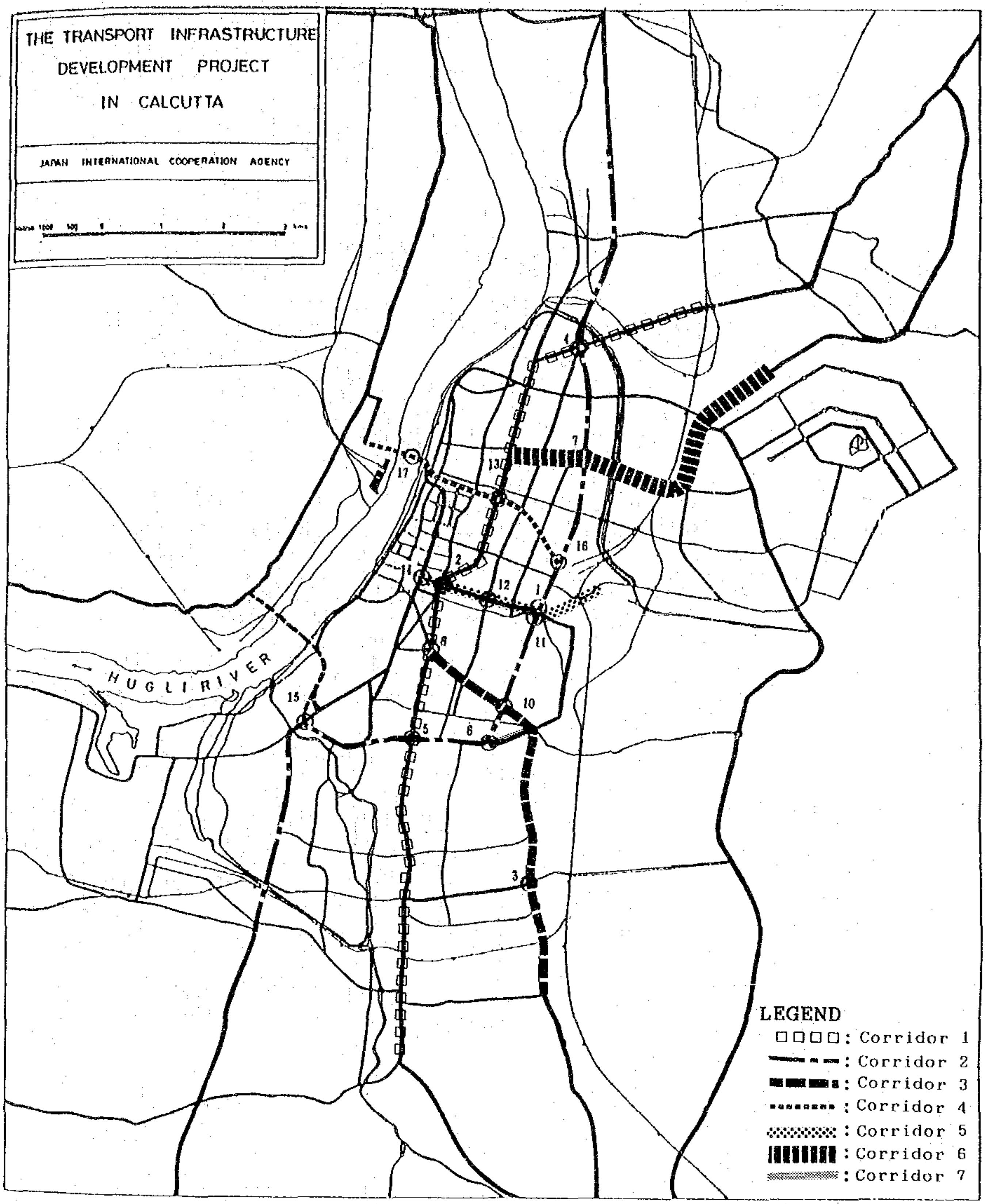


Figure 4.1.2 Travel Time Survey Corridors

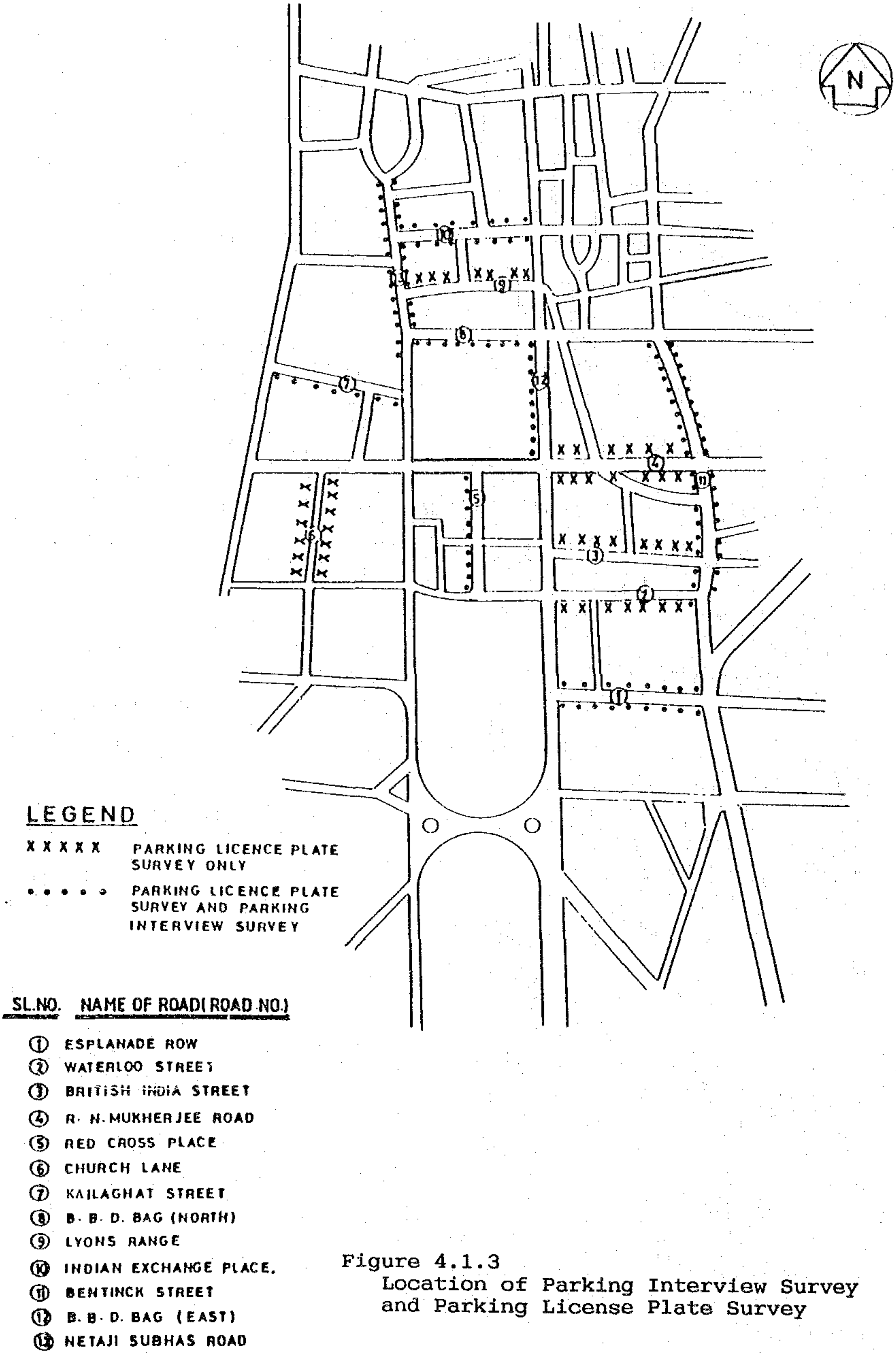


Figure 4.1.3
Location of Parking Interview Survey and Parking License Plate Survey

(c) Parking Volume Survey (Parking Volume Count)

The parking volume survey was conducted by counting the number of parked vehicles according to vehicle classification at periodic intervals for 12 hours from 8:00 in the morning to 20:00 in the evening. The surveyed areas and the sectors are shown in Figure 4.1.4. The definition of the sectors follows the "PARKING STUDY CENTRAL AREA, CALCUTTA JULY 1975" prepared by "CALCUTTA METROPOLITAN PLANNING ORGANISATION". On Bentinck Street the counting was carried out over 7 days between November 18 and 24, 1991, while for the remaining areas counts were taken on one weekday and on one holiday.

(5) Pedestrian Survey

The pedestrian survey was carried out on December 24, 1991 and January 30, 1992. Pedestrians were counted in 15 minute intervals along by M. G. Road and B. B. Ganguly Street (see Figure 4.1.5). The counting was carried out for 12 hours from 8:00 in the morning to 20:00 in the evening.

4.1.3 Results of Traffic Surveys

(1) Traffic Volume Surveys

(a) Volumes in Vehicles

Figure 4.1.6 shows the hourly traffic volume fluctuations for fast vehicles at each approach of the Study intersections. The traffic volume counts are summarized in Table 4.1.1. Details of the remaining intersections are included in the Technical Report.

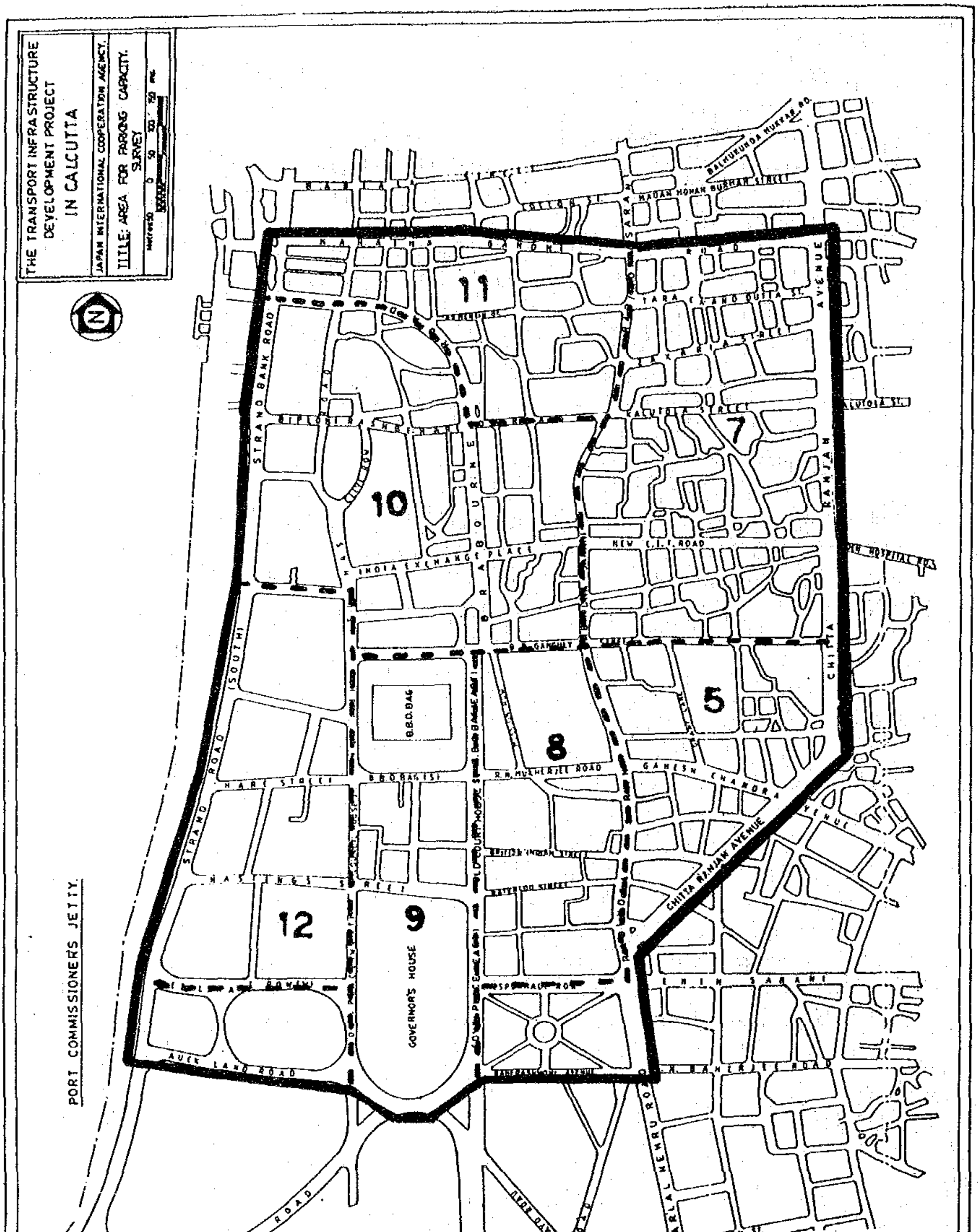


Figure 4.1.4 Area for Parking Volume Survey

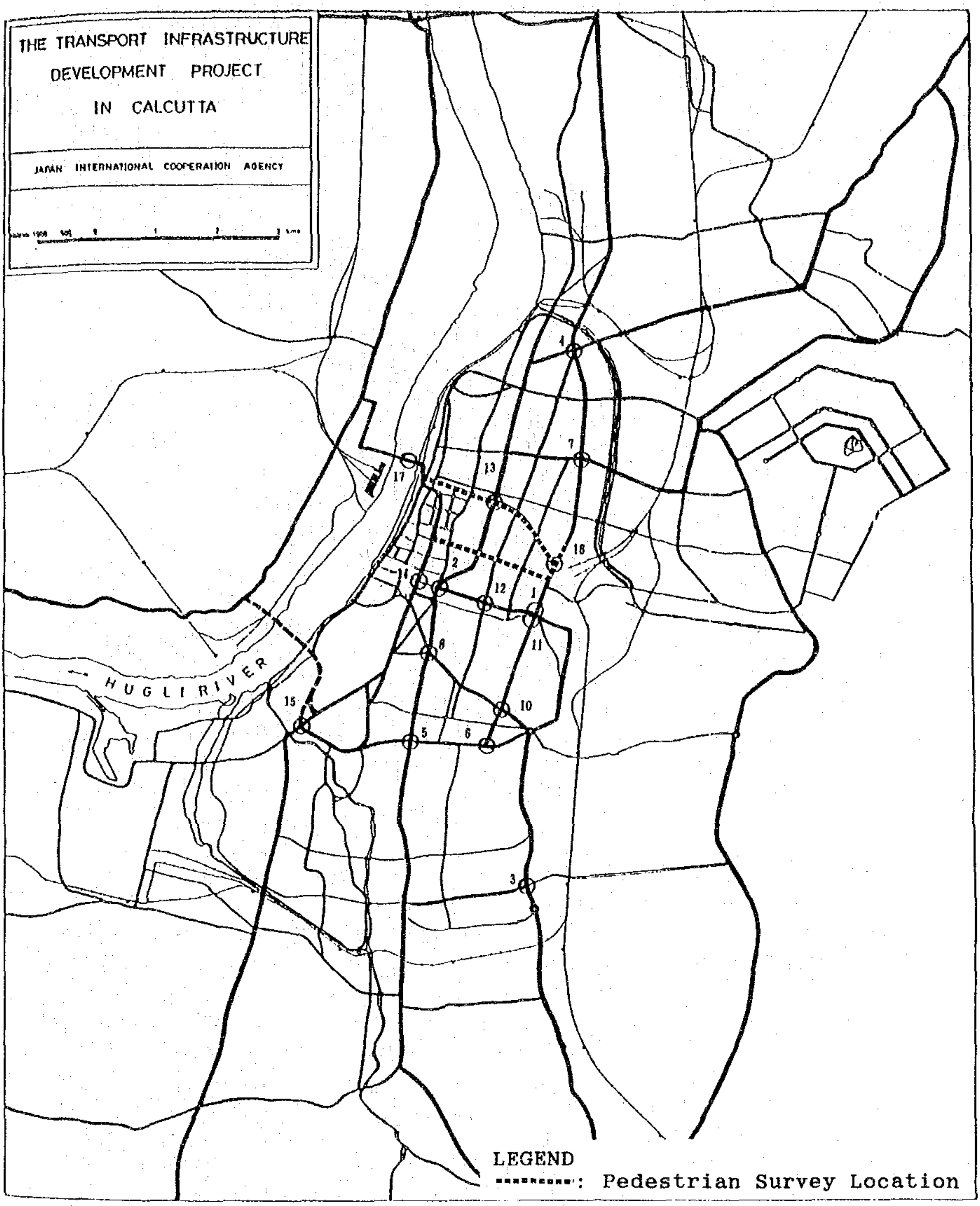


Figure 4.1.5 Location of Pedestrian Survey

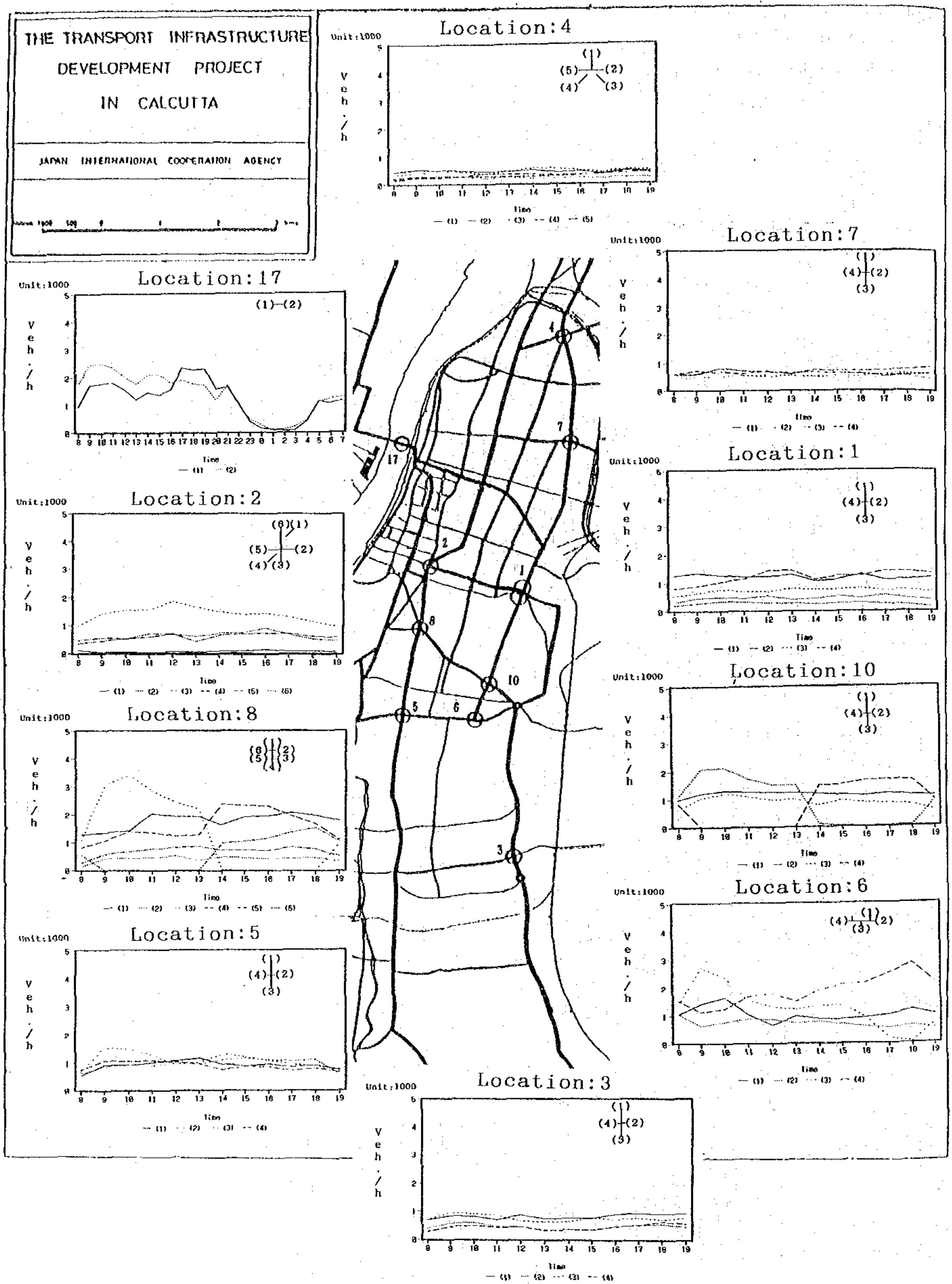


Figure 4.1.6 Fluctuation of Fast Vehicle Traffic Volumes in 1991

Table 4.1.1 Summary of Traffic Volume Count Survey

Location Number	Peak Hour Morning	Peak Hour Evening	PHF(%/12hours) Morning	PHF(%/12hours) Evening	Major Flow(12hours) Direction	Major Flow(12hours) Vehicles
1	12:00 -13:00		9.2		North -South	10,000 (1510)*
2	12:00 -13:00		10.2		South -North	7,000 (150)
3	9:00 -10:00	18:00 -19:00	9.8	9.0	North -South	9,000 (770)
4	10:00 -11:00	18:00 -19:00	8.6	9.0	A.P.C.Roy- Bidhan Sarani	4,000 (260)
5	9:00 -10:00		9.7		South -North	12,000 (460)
6	10:00 -11:00	15:00 -16:00	10.3	8.5	North -South	8,000 (210)
7	10:00 -11:00		9.6		West -East	8,000 (1,140)
8	11:00 -12:00	17:00 -18:00	9.7	8.6	South -North	15,000 (580)
9	-	-	-	-	-	-
10	10:00 -11:00		9.9		North -South	10,000 (730)
17	10:00 -11:00	17:00 -18:00	6.7 (PHF%/24	6.6 hours)	-	71,000# (9,140)#

* The 10,000 includes 1,510 slow vehicles etc.
# Total for both directions over 24 hours.

The peak hour factors (PHF) correspond to the maximum hourly volume for the major traffic flow direction divided by the 12 hour volume for that direction. In the case of Howrah Bridge only, where counts were taken over 24 hours, the PHF is the maximum hourly volume divided by the 24 hour volume. The night hour factor (from 20.00 to 08.00) was 45% of the 24 hour volume count at Howrah Bridge.

At some intersections, where separate morning peak and evening peak hours have not been given in the above table, it is evident that saturation is occurring since the flow through these intersections reaches a peak value which is maintained for several hours in some cases, and the AM and PM peaks were virtually the same.

(b) Volumes in PCU's

The traffic flow in vehicles from the traffic counts have been converted to passenger car units (PCU's) by applying the conversion factors in Table 4.1.2.

Table 4.1.2 Passenger Car Units - Conversion Factors

Vehicle Type	PCU
Passenger Car	1.00
Taxi	1.00
Truck	3.09
Mini Truck	1.63
Bus	3.09
Mini/Midi Bus	1.63
Motorcycle	0.50
Auto Rickshaw/Van	1.00
Tram	7.20
Other(motorized)	1.00

Source : Based on Transport Department Study carried out in Calcutta and Indian Road Congress

Figure 4.1.7 shows the vehicle type composition at each of the intersections. After adjusting each vehicle type according to the above PCU conversion factors the existing traffic volumes in PCU's have been calculated and are shown in Figure 4.1.8.

The streets with high traffic volumes were;

1) A.J.C. Bose Road with 20,000-50,000 PCU/12 hours
2) Park Street with 20,000-30,000 PCU/12 hours
3) J.L. Nehru Road with 25,000-50,000 PCU/12 hours
4) Howrah Bridge with 90,000 PCU/24 hours

(2) Roadside O-D Survey

The sampling ratio for each vehicular type varies from 16.5% for passenger cars to 83% of trams so the target sampling ratio of 15% was achieved in all cases.

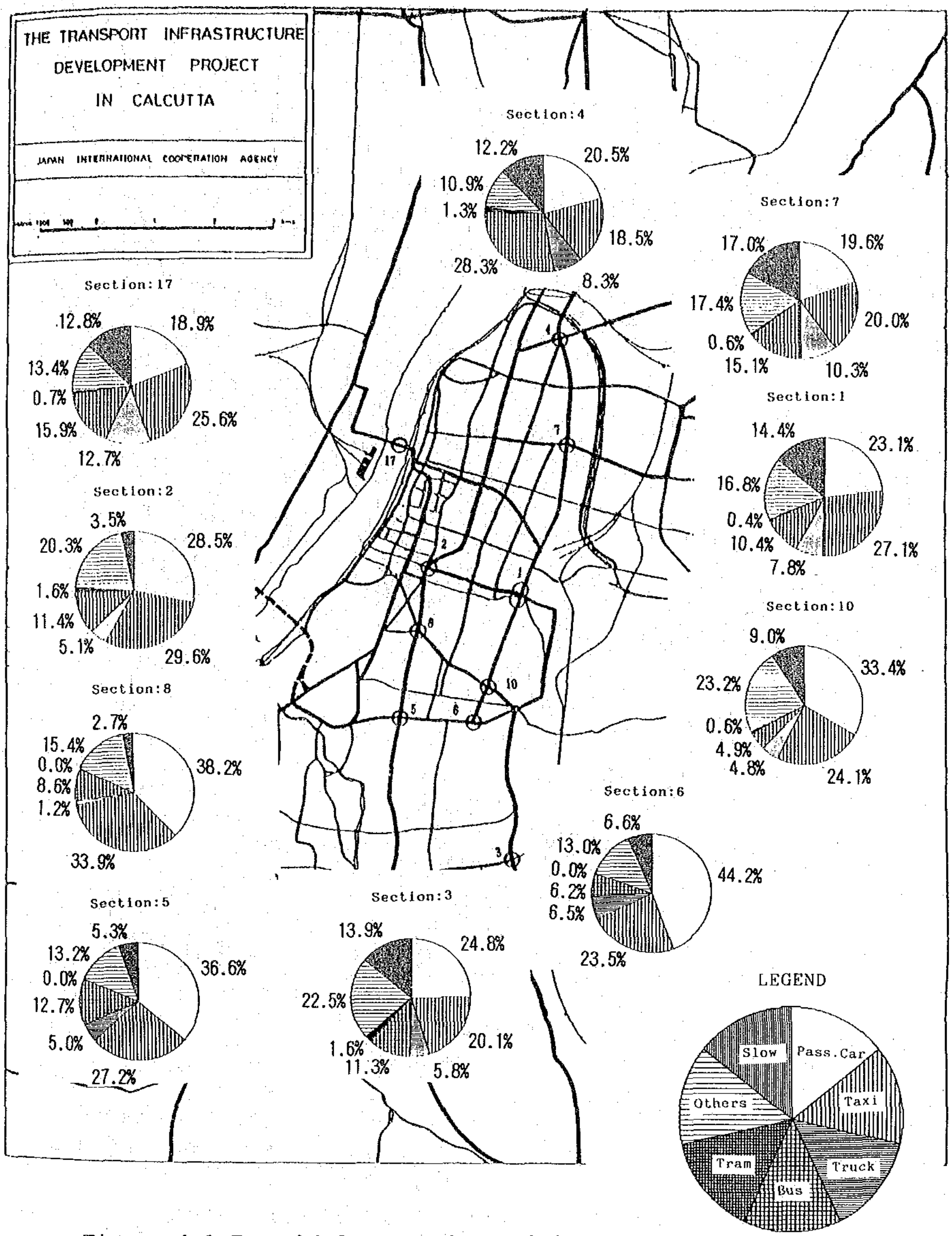


Figure 4.1.7 Vehicle Type Composition

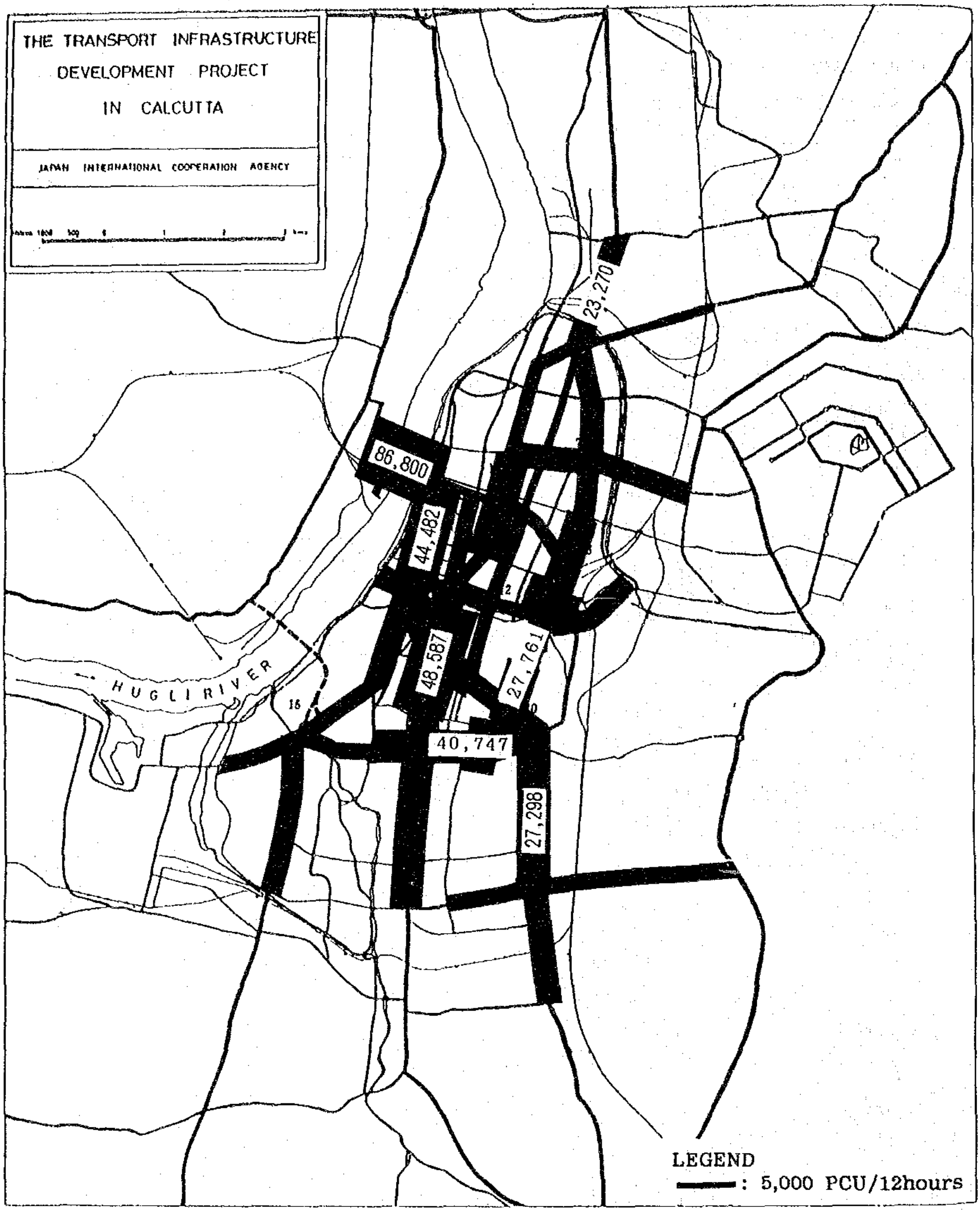


Figure 4.1.8 Traffic Volume by PCU/12hours in 1991

Figure 4.1.9 shows the findings of the O-D survey with regard to trip purpose and Figure 4.1.10 shows the assignment of the Hooghly River crossing traffic in 1991 to the existing road network.

(3) Travel Time Survey

The travel time and the average travel speed for the corridors shown in Figure 4.1.2 are summarized in Table 4.1.3.

Table 4.1.3 Travel Time by Corridor

Corridor	Direction	Distance (km)	Average Time (min.'sec.")	Average Speed (km/h)
1 Deshpran Sasmal Rd. -S.P.Mukherjee Rd. -A.T.Mukherjee Rd. -J.L.Nehru Rd. -C.R.Avenue	1 South -North	15.5	88'30"	10.51
-J.M.Avenue -Bhupen Bose Rd. -R.G.Kar Rd. -Raja Manindra Rd.	2 North -South	15.5	87'15"	10.66
2 Diamond Harbour Rd. -A.J.C.Bose Rd.	1 South -North	17.0	86'26"	11.80
-A.P.C.Roy Rd. -Bidhan Sarani -B.T.Rd.	2 North -South	17.4	75'04"	13.91
3 Gariahat Rd. -Syed Amir Ali	1 North -South	6.5	25'24"	15.35
-Park Street	2 South -North	6.5	34'25"	11.33
4 Howrah Bridge -M.G.Rd. (Part of one way)	1 West -East	3.9	20'19"	11.52
5 Lenin Sarani -Convent Lane (Part of one way)	1 West -East	3.8	23'23"	9.75
6 Najrul Islam Ave. -Manicktala Main Rd.	1 East -West	5.7	22'31"	15.19
-Vivekananda Rd.	2 West -East	5.7	21'43"	15.75
7 Circus Avenue	1 West -East	0.5	2'07"	14.20
	2 East -West	0.5	2'03"	14.69

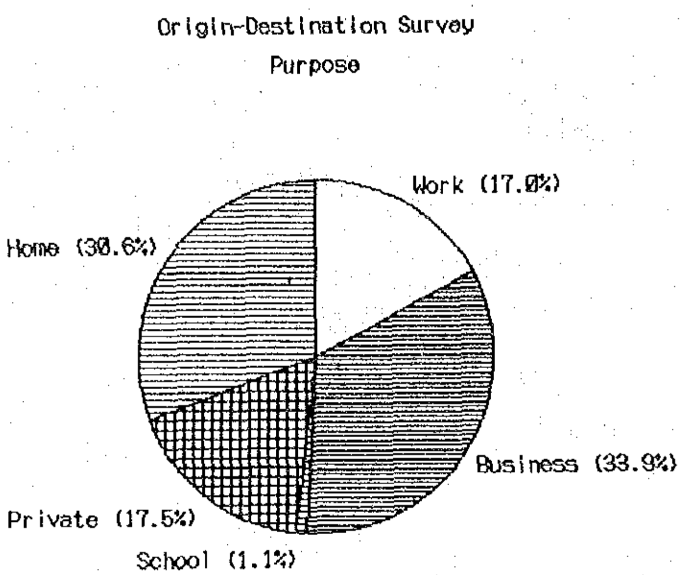


Figure 4.1.9 Trip Purpose

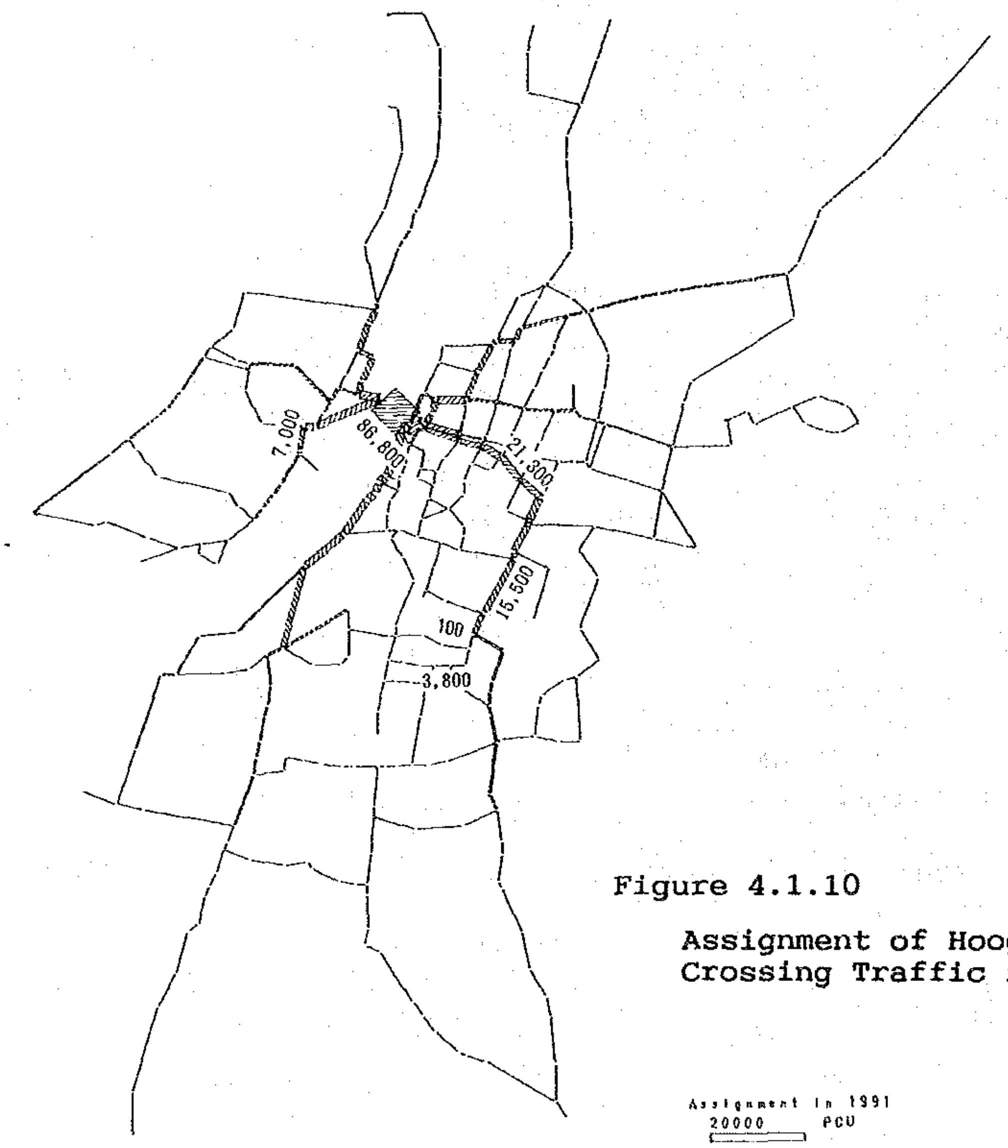


Figure 4.1.10

Assignment of Hooghly River Crossing Traffic in 1991

The average speed from the city center to Beliaghata Main Road (3.8 km) via Lenin Sarani was 9.8 km/h, lower than that for corridor No.4 from Howrah Bridge to A.P.C.Roy Road via M.G.Road which had an average speed of 11.5 km/h. This may be attributed to the narrow road width of Lenin Sarani, the road side friction caused by commercial activities and Sealdah flyover on M.G. Road and A.P.C. Roy Road crossing.

The average speeds from south to north direction were always lower than the average speeds from north to south direction on corridor No.1, No.2 and No.3.

(4) Delays at Intersections

(a) Definition of Delay at Each Intersection

Total delay at each of the study intersections are determined to indicate the extent of delay. The total delay at each intersection is calculated based on data gathered from the traffic volume and travel speed surveys. Delay at an intersection approach is defined as the traffic volume at that approach multiplied by the difference between travel time at the observed speed and at free speed.

The computational equation used is:

$$D = V \times (T_t - T_f)$$

where,

D : Delay of an intersection approach in veh. hours
V : Traffic volume on the approach
T_t : Travel time measured on link
T_f : Travel time at free speed on the link

(The free speed in this computation is taken as 36.7 km/hr.)

The total delay at the intersection is the sum of delays on all approaches.

(b) Total Delay For 8 Hours

The total 8 hours delay for two time periods between 8-12 and 16-20 hours are computed for the target intersections and ranked into categories as below:

Category	Intersection Number and Name
>3,000 veh. hours	No.2 : Esplanade No.8 : Park Street No.1 : Moulali
2,000-3,000	No.4 : Shyambazar* No.5 : Rabindra Sadan
1,000-2,000	No.6 : Beck Bagan No.7 : Maniktala
<1,000	No.10: Mullik Bazar No.3 : Gariahat*

(Note: * The total delay at intersections No.3 and 4 do not include delays at all approaches. The traffic volume on the excluded approaches were relatively low in comparison to the main traffic volume. Therefore, the effect on the total delay time at the intersection would not be very significant.)

The average hourly delay in the morning and evening at the target intersections have also been computed and are shown along with the total 8 hour delay in Table 4.1.4 below;

Table 4.1.4 Total Delay in Vehicle Hours

Intersection	Morning. Ave.for one hour	Evening. Ave.for one hour	Total for Eight Hrs.
No.1: Moulali	397	451	3,392
No.2: Esplanade	237	957	4,776
No.3: Gariahat*	80	137	868
No.4: Shyambazar*	224	307	2,124
No.5: Rabindra Sadan	305	199	2,016
No.6: Beck Bagan	209	263	1,888
No.7: Maniktala	230	159	1,556
No.8: Park Street	474	572	4,184
No.9: Lock Gate**	NA	NA	NA
No.10:Mullik Bazar	29	74	412
Total	2,185	3,119	21,216

Note: * Total does not include all approaches
** No road connection at present

Morning Period : 8:00-12:00
Evening Period : 16:00-20:00

(c) Average Hourly Delay at Each Approach

Figures 4.1.11 and 4.1.12 show the average hourly delay in vehicle hours for each of the intersection approaches at the study intersections during morning and evening hours.

In the morning, the greatest hourly delay of 247 veh. hour is calculated for the southbound approach to Intersection No.8, followed by the southbound approach at Intersection No.1 with 209 veh. hours.

In the evening, the greatest hourly delay of 691 veh.hours is calculated for the northbound approach at Intersection No.2, followed by 503 veh. hours for the northbound approach at Intersection No.8.

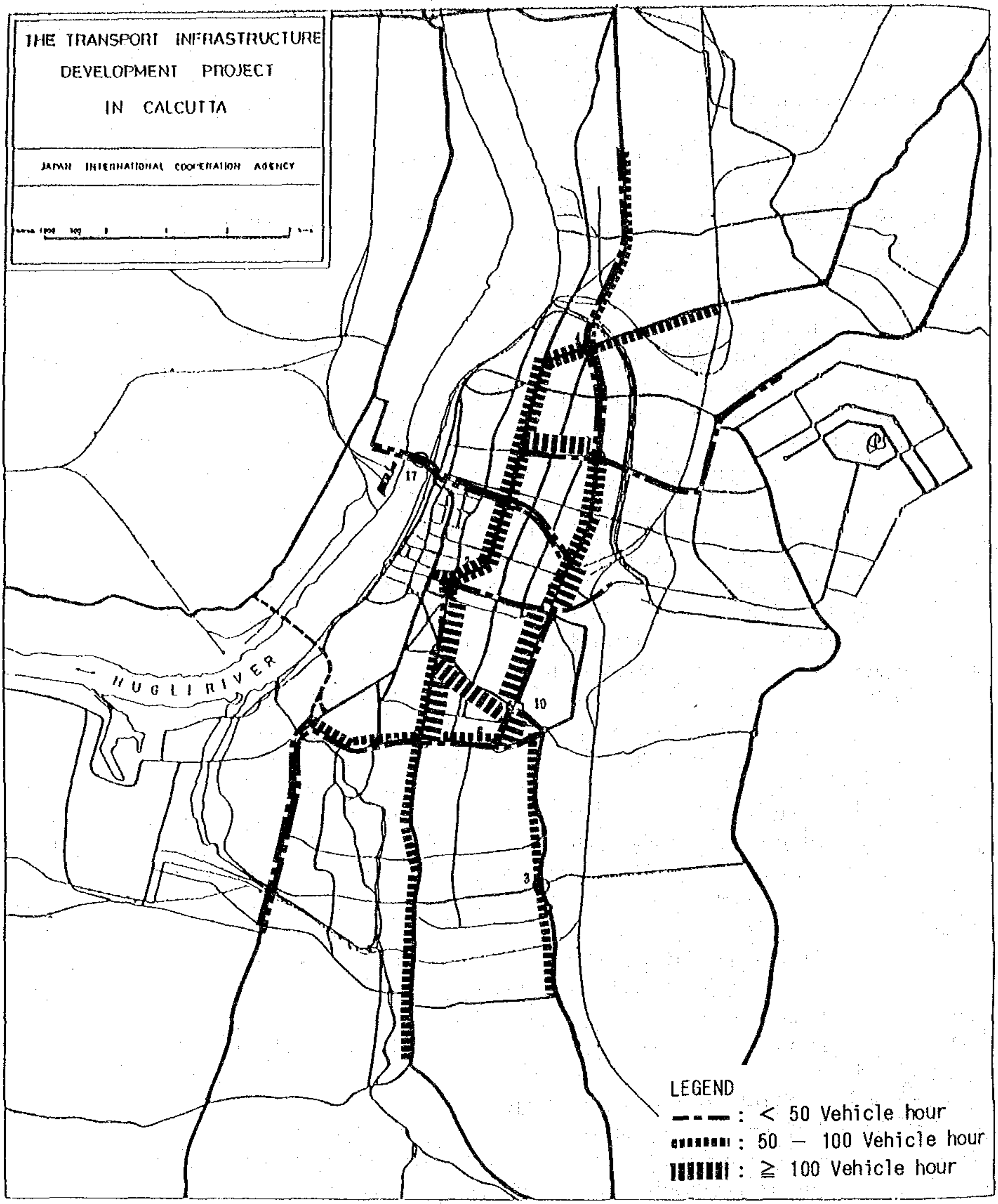


Figure 4.1.11 Average Hourly Delay During Morning Hours
(Average value for the period 8:00-12:00)

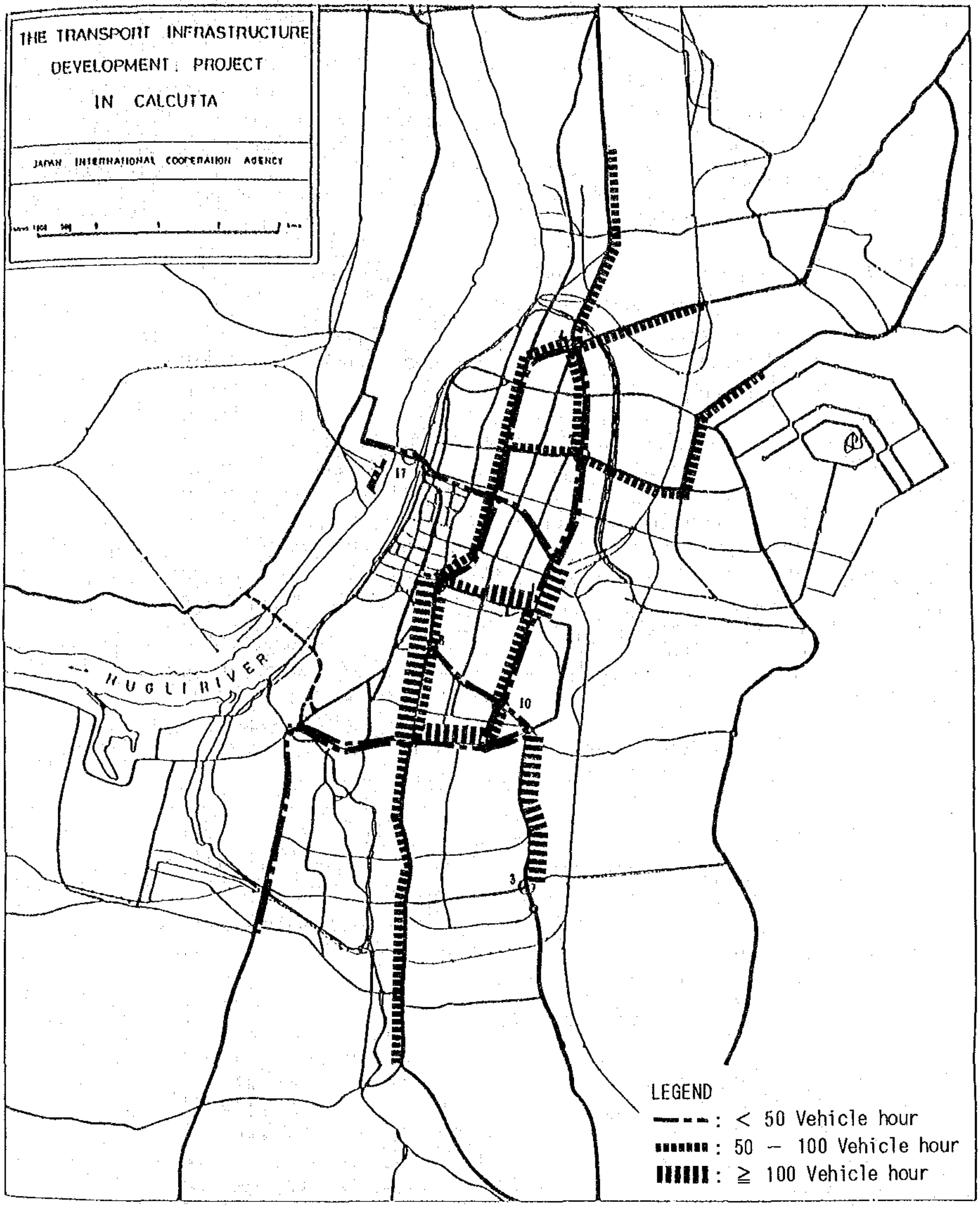


Figure 4.1.12 Average Hourly Delay During Evening Hours (Average value for the period 16:00-20:00)

4.1.4 Results of Parking Survey

Table 4.1.5 shows the average parking duration, turnover (12 hr) and parking volume obtained by license plate survey. Table 4.1.6 shows the average turnover by sector compared with the value obtained in 1962. Regarding T/O rate the value for 1962 is nearly equal to the 1991 value. (A)x(C) in sectors 5, 7 and 11 were estimated using the 1962 turnover values.

Table 4.1.5 Average Parking Duration, Turnover (12 hr) and Parking Volume

Sl.No.	Road Name	Total	Cap.	Duration	T/O	Sector No.
1	Esplanade Row East	366	54	80	6.00	8
2	Waterloo St.	380	55	94	6.91	8
3	British India St.	481	108	126	4.45	8
4	R.N.Mukherjee Road	720	126	93	5.71	8
5	Red Cross Place	346	85	136	4.07	9
6	Church Lane	342	93	108	4.12	12
7	Koila Ghat St.	657	103	78	6.38	12
8	B.B.D.Bag North	648	125	95	5.18	9
9	Lyons Range	641	166	175	3.86	10
10	Indian Exchange Place	567	87	72	6.52	10
11	Bentinck St.	731	111	52	6.59	8
12	B.B.D.Bag East	309	86	161	5.59	9
13	N.S.Road	781	130	107	6.00	10

Table 4.1.6 Estimate of Parking Volume

Sector No.	T/O(A) (1991)	T/O(B) (1962)	Capacity (C)	Duration (D)	Parking Volume(A)x(C)
5	-	10.50	661	-	6,940*
7	-	9.10	776	-	7,062*
8	6.08	6.60	639	98.9	3,885
9	4.48	4.00	329	121.5	1,474
10	5.30	5.80	1,655	118.9	8,772
11	-	4.70	519	-	2,439*
12	5.40	4.40	1,284	88.3	6,934
Total			5,863		37,506

Note: * (A)x(C) estimated using the 1962 value

Figure 4.1.13 shows the 12 hours parking volume by sectors. The sector parking volume of passenger cars was always higher than other vehicle types.

Figure 4.1.14 shows the weekly parking fluctuation on Bentinck Street. Sunday parking volume was quite low, and Thursday parking volume was less than other weekdays because of the market holiday.

4.1.5 Results of Pedestrian Surveys

Figure 4.1.15 shows the pedestrian volumes counted over 12 hours (8:00-20:00), morning peak hour (10:00-11:00) and evening peak hour (18:00-19:00).

The results indicate that a significant proportion of the pedestrians are commuting between Sealdah station and the CBD district by foot since;

1) The highest pedestrian volumes were on east west streets near Sealdah station and volumes remained high through to Chittaranjan Avenue.
2) In the morning peak hour pedestrian volumes from Sealdah towards B.B.D. Bag were higher than the volume from B.B.D. Bag towards Sealdah Station.
3) In the evening peak hour pedestrian volumes from B.B.D. Bag to Sealdah were higher than the volume from Sealdah to B.B.D. Bag .

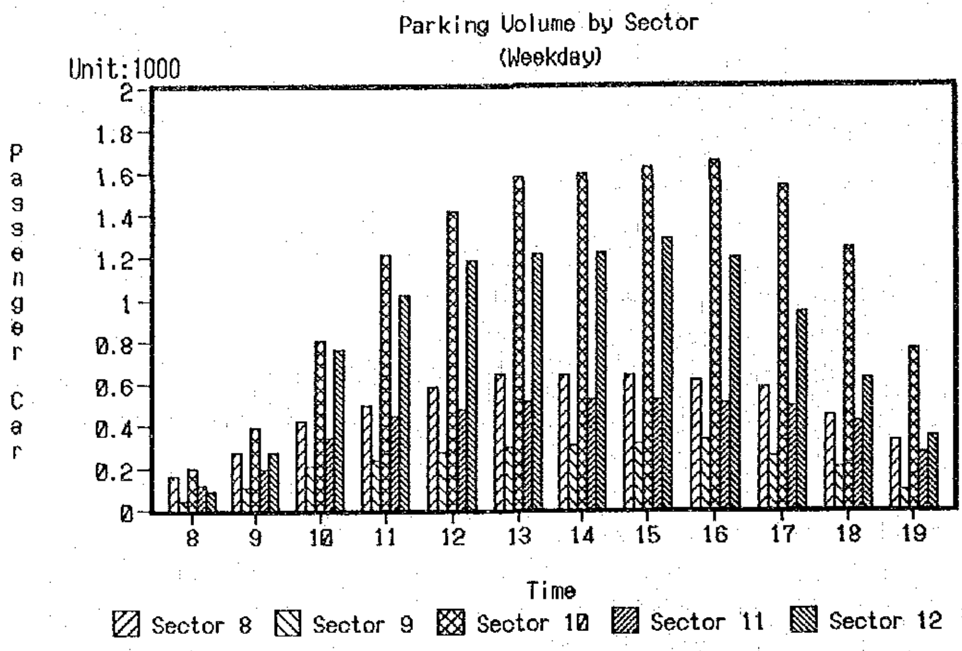


Figure 4.1.13 12 hours Parking Volume by Sectors

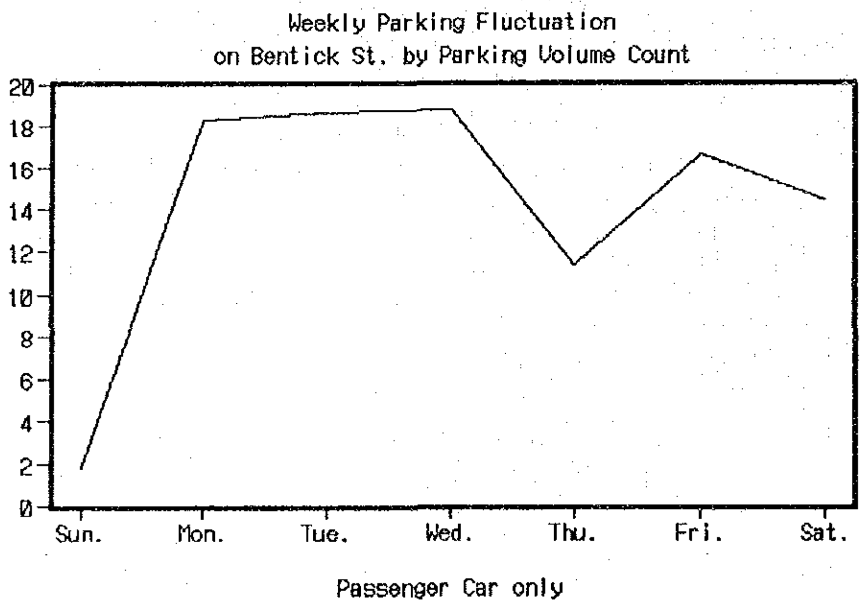


Figure 4.1.14 Parking Weekly Fluctuation on Bentinck St.

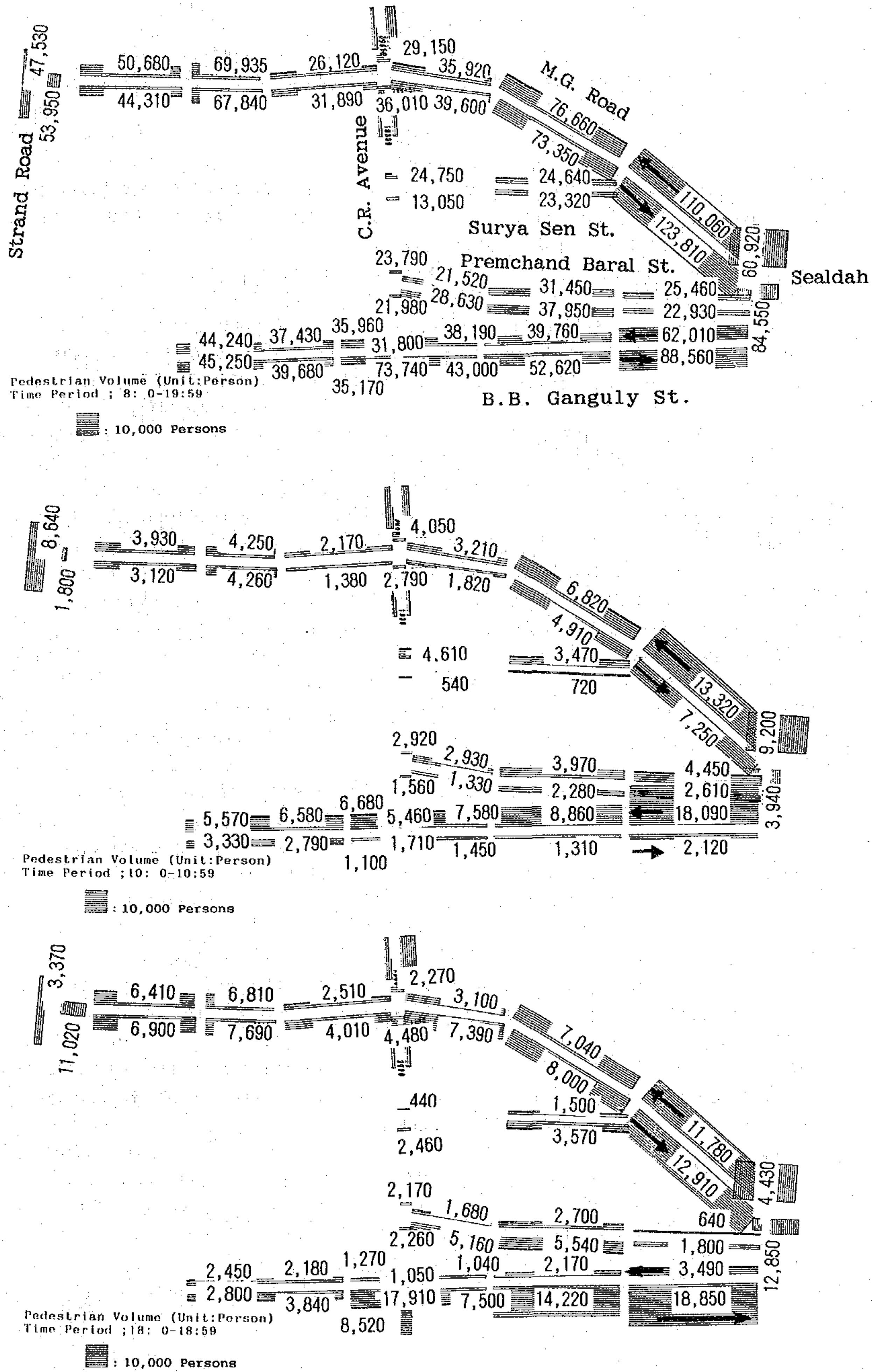


Figure 4.1.15 Pedestrian Volumes in 1991