- Intra-area demand: 27,500 passengers/day
- Feeder traffic demand: 53,500
- Inter-area demand between north and east: 31,600

Total: 112,600 passenger/day

It is to be noted that the estimated traffic demand do not include that of Ang Mo Kio new town which is studied separately.

3) Sectional Traffic

Sectional traffic volume was estimated based on the assignment of OD traffic. The traffic density varies from about 50,000 passengers a day along the section near Ang Mo Kio and 30,000 along the section near Macperson Road. Assuming that the peak hour ratio of 12% and the percentage of heavy directional traffic 60%, the peak hour sectional traffic for heavy direction will be about 3,600 passengers per hour per direction.

7.1.3 System Plan

1) Selection of the System

To comply with the operation of the Ang Mo Kio system, it is assumed that the same one be introduced. However, it is necessary and useful to increase the power of vehicles in view of the route function, not only as a feeder to MRT but also as a secondary transport route in the region with an average station spacing of about 700 meters.

2) Alignment

The alignment of the route (refer to Figure 7) shows a starting point at Ang Mo Kio sta., then pass CTE expressway and ends around ECP. A cross section of the proposed system for Ang Mo Kio-Hougang-Marine Parade route is shown in Figure 7.2.

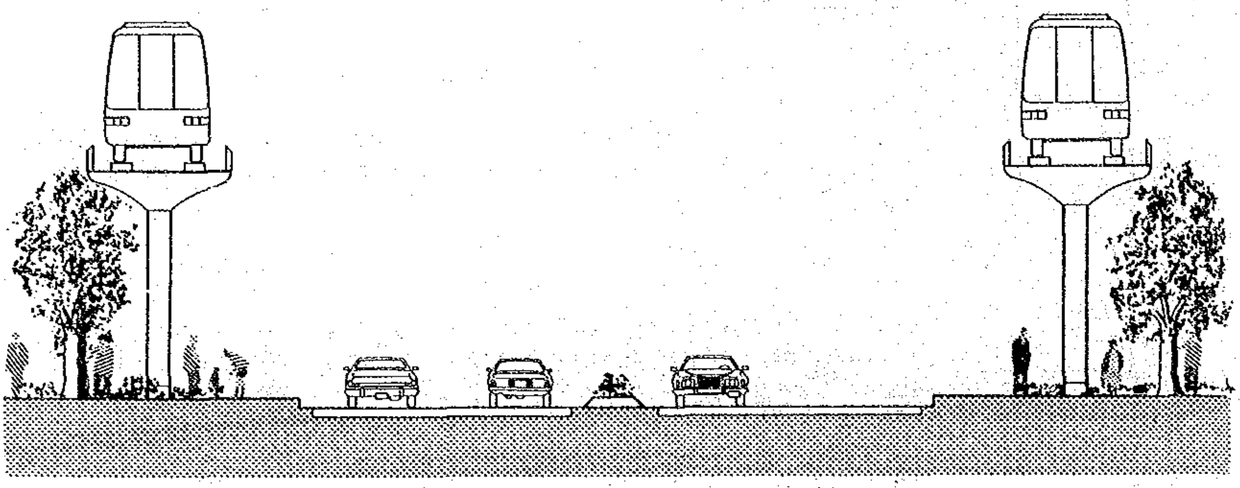
The total route length is 12.6 km (double-track: 10.8 km, single-track: 1.8 km). There are a total of 18 stations.

The distance between stations should be far enough to maintain a high system performance (faster travel speed). Aiding this objective is the fact that no sharp curvature and steep slope exist along the route.

However, an express as well as a local operation (stop at every station) should be adopted for the efficient function of a circumferential route.

Figure 7.2

Cross Section of the Proposed System for Ang Mo Kio-Hougang-Marine Parade Route

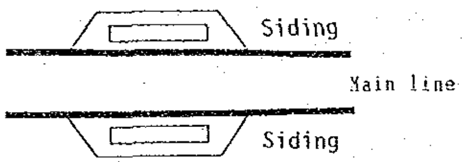


3) Facilities

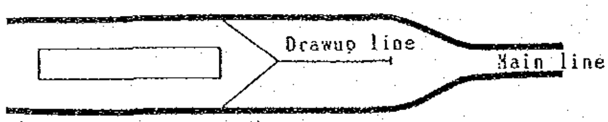
a) Carri ageway Structure: An elevated structure is necessary due to the space available and the crossing of road. No problem of great magnitude is foreseen in the construction of the carriageway.

Concerning the geometric factors for alignment, it is possible to clear the maximum gradient of 6% and the minimum curvature of 100 m.

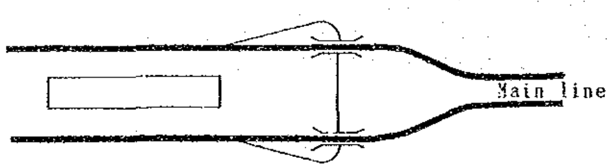
b) Station and Terminal: The planning consideration is basically the same as the Ang Mo Kio syste. The planned operation syte requires the following types of stations to meet express services and turning back.



Shunting Station



Turning Back Station



c) Depot: The maintenance depot can be located at JIC's industrial complex where the depot for Ang Mo Kio system is also planned.

4) Operation Plan

The operation plan for the proposed system is outlined as shown in Table 7.3. The system provides two-car trains with a passenger capacity of 150, running at a three-minute interval during peak hours and at a 5 to 6-minute interval during off-peak hours. The train can be expanded to four cars as demand increases.

Table 7.3

Outline of the Proposed System
Ang Mo Kio/Hougang/Marine Parade

Item	Amount
1) No. of trains	17 + 3 (spare)
2) No. of cars/train	2
3) No. of cars required	40
4) Headway : peak	3 minutes
: off-peak	5 - 6 minutes
5) Scheduled Speed	28.6 kph
6) Scheduled Time	24.5 min/one-way
7) Frequencies	243/day
8) Train-kms	5,703/day
9) Car-kms	11,406/day

5) Cost Estimate

Estimated costs for investment and operation and maintenance are summarized as shown in Table 7.6 and 7.7, respectively.

The total construction cost is about S$310 million or S$13.3 million per km (single track). Operating cost is about S$17,950 a day or S$6.6 million a year.

Table 7.4

Summary of Investment Costs for Proposed
Ang Mo Kio-Hougang-Marine Parade Route System

Item	Amount S$ 000	% to Total
1) Civil Works	141,900	45.7
2) Station/Building	9,700	3.1
3) Depot	24,400	7.9
4) Vehicles	41,600	13.4
5) Power Supply	50,750	16.4
6) Control/Signalling/ Telecommunications	42,000	13.5
7) Other Subsystems		
Total	310,350	100.0
Cost/Km	13,260	

Table 7.5

Estimated Operating Cost for Proposed
Ang Mo Kio-Hougang-Marine Parade Route System

Item	Amount S$ 000	% to Total
1) Vehicle Maintenance	900	13.7
2) Maintenance of Equipment and Facilities	2,810	42.9
3) Electric Consumption	1,130	17.3
4) Manpower	1,110	17.0
5) Overhead : 10% of 1), 2), 3), and 4)	600	9.1
Total: per year	6,550	100.0
per day (S$)	17,950	-

7.1.4 Project Evaluation

1) Economic Viability

Economic viability of the project was examined by comparing the annual average cost of the project with the estimated annual average benefits. The average cost of the project is estimated as follows:

i) Investment cost at a discount rate of 5%: S$ 20.3m/year
2%: 14.1m/year
ii) Operating and maintenance cost : 6.6m/year

Total Average Annual Cost of the Project: S$ 34.4m/year (at 5% discount rate)
S$ 26.9m/year (at 2% discount rate)

On the other hand, the benefits expected from the project vary and are extensive and it is difficult to quantify, as discussed for Ang Mo Kio new town. However, the most significant and tangible direct benefit i.e., "time saving" alone, is estimated to be large enough to justify the project, as summarized below:

i) Assumptions:

- estimated no. of passengers: 100,000/day
- average time value during the project life: S$6.2/hr (average of 4.0 for 1992 and 8.4 for year 2012)
- estimated average time saving per trip: 10 minutes

ii) Estimated time saving: 100,000 x 10 x 1/60 x 6.2 x 365 = S$37.7 million/year.

Accordingly, the B/C ratio at 2% discount rate is about 1.4.

At the same time, it is important to discuss the justification of the project with particular regard to the following:

a) At present, major transit network is not developed such that the circumferential movements are benefitted, although demand exists. The project would diversify the concentration of traffic along radial roads to some extent.

b) If this project is associated with the urban development direction mentioned in the Concept Plan i.e., to encourage the growth of sub-centres, it is most likely that the introduction of high-grade transit system along the proposed route would bring about a strong impact in the areas where relatively high concentrations of the population are anticipated and are isolated from the MRT system.
Possible areas for strategic developments are Ang Mo Kio town centre, the Hougang area where the Serangoon road intersects with the proposed system, the Eunos MRT station area and the Katong/Marine Parade area.

2) Financial Viability

Financial analysis was done by comparing the expected fare revenue with the costs to be shouldered under different scenarios. The results are summarized as shown in Table 7.6.

a) If the government shoulders all investment costs except vehicles, the project will produce high FIRR of 23.6% with a 50-cent fare level.

b) If the government shoulders only civil work and station costs, the resulting FIRR is 4.7% with a 50-cent fare level but will increase to 10.1% with a 70-cent fare.

Table 7.6

Summary of Financial Analysis

Description of Case / Item	Base Case: All costs except vehicles shouldered by Govt.		Alternative Cases					
			Civil Work/ Station Costs shouldered by Govt.		Base case with increased fare		Case A with increased fare	
No. of Pass/day	100,000		100,000		100,000		100,000	
Fare (¢)	50		50		70		70	
Revenue: (S$000/yr)	18,250		18,250		25,550		25,550	
Invest Cost (S$ million)	41.6		158.8		41.6		158.8	
Open & Maint. (S$000/yr)	6,550		6,550		6,550		6,550	
Depreciation (S$000/yr)	2,080		6,685		2,080		6,685	
Operating Profit (S$000/yr)	9,620		5,015		16,920		12,315	
FIRR (%)	23.6		4.7		35.7		10.1	
Equity (%)	15	30	15	30	15	30	15	30
Interest Rate (%)	7.0		7.0		7.0		7.0	
First Year Net Profit Generated	1992	1992	2011[1/]	2002	1992	1992	1992	1992
First Year Accumulated Net Profit Generated	1992	1992	-	2010	1992	1992	1993	1993
Remarks			[1/] deficit in 2012 and 2021					

7.2 Orchard-Sentosa Route

7.2.1 Profile of the Proposed Route and Influence Area

The route links Orchard commercial area with Sentosa Island via Paterson Road, River Valley Road and Delta Road. The 5.6 km long route runs through gently undulating terrain and areas mostly residential and mixed use. The route connects with the MRT stations at Orchard and Tiong Bahru and with Expressway. (See Figure 7.3) The major expected function of this route are as follows:

a) To provide a direct link between the two major tourist attraction centres of Sentosa Island and Orchard areas.

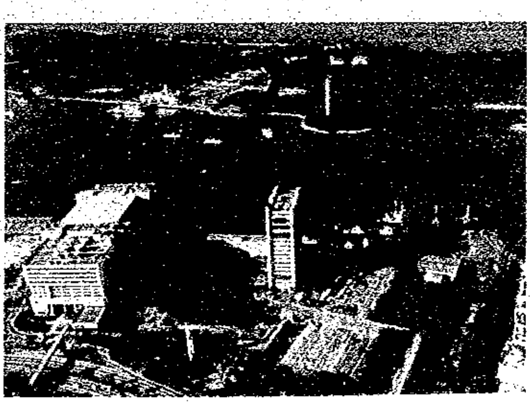
b) To provide an improved feeder service for the residents in the influence area, especially for those living in HDB new towns such as Bukit Merah and TK. Blangah.

c) To encourage the development of a new urban development axis along the route which centres Orchard.

The population within 500 meters from one route was approximately 150,000 in 1981, which is estimated to decrease to 106,000 by 1990. It is expected that the area would grow more for commercial and industrial activities.

The southern part of the route boasts of the recreational area of Mount Faber which serves as an important preface to Sentosa Island. Sentosa Island is one of the largest tourism destinations of Singapore both for local and foreign visitors. At present (1987/88), the island receives a total of 2.1 million visitors which is estimated to increase to approximately 4 million by early 1990's when causeway and a number of planned developments are completed.

The causeway is being designed to connect Sentosa Island and Mainland with a branch to P. Brani where container yard will be constructed. It is foreseen that the completion of the causeway would improve the accessibilities by car to Sentosa Island considerably.



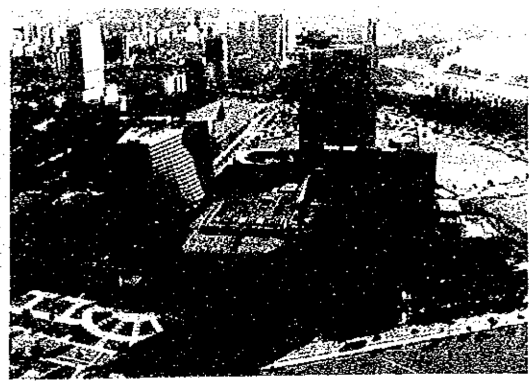
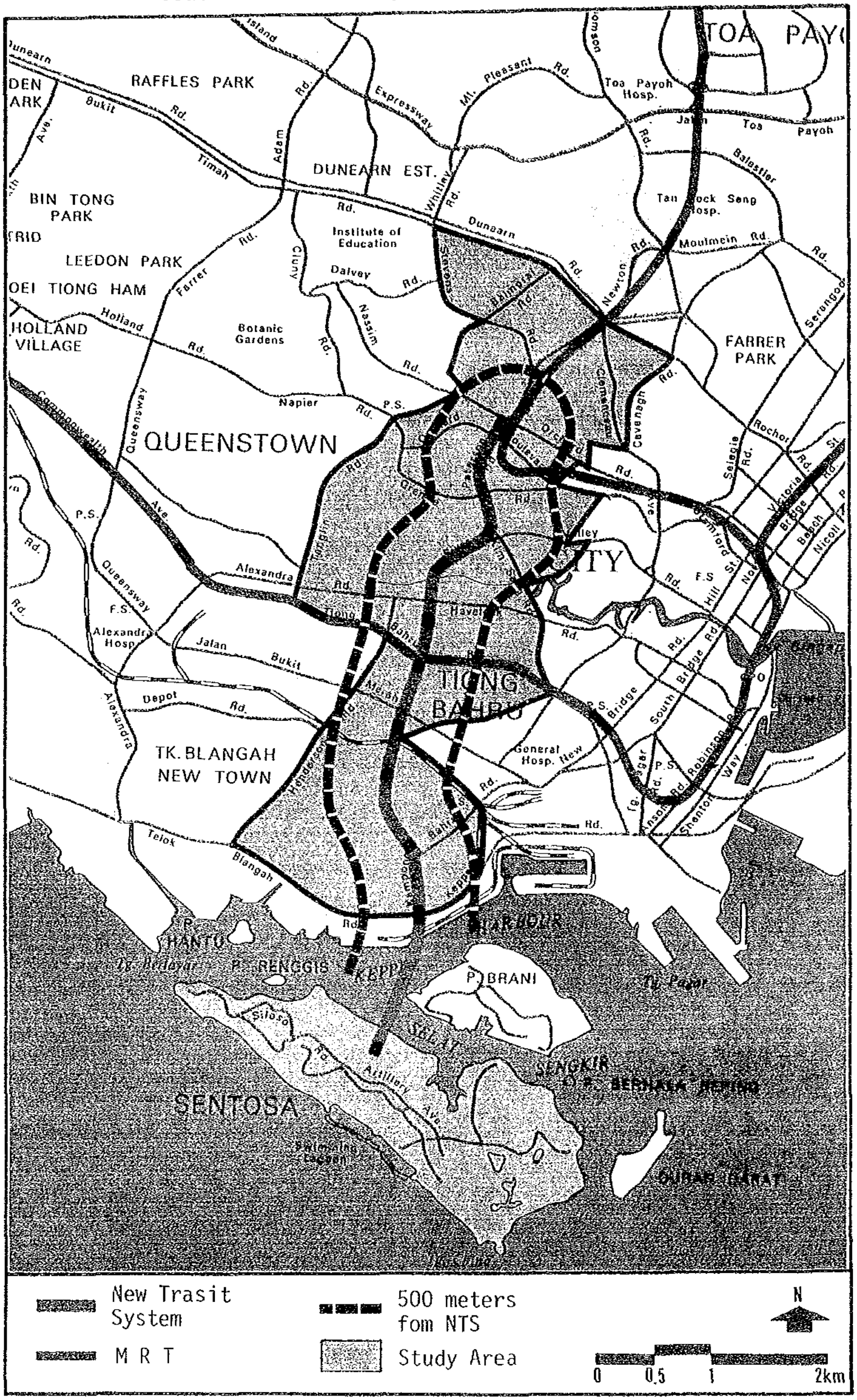


Figure 7.3

Location of the Study Area and Proposed Route



7.2.2 Traffic Demand

1) Estimated Number of Potential Passengers

Total traffic demand for the influence area comprises the following:

a. The traffic moving within the influence area

b. The traffic moving between the influence area and outside the influence area

c. The traffic moving to/from Sentosa Island

The intra-area traffic would use the proposed system for the internal movement, while the external traffic to/from the area use it mainly for access/egress to/from the MRT. The traffic to/from Sentosa Island would be greatly attracted by the proposed system.

2) Non Tourism Related Traffic

According to the CTS 1981 OD data, the total traffic demand in the influence area is approximately estimated to be 436,000 trips/day. Of the total, intra-area traffic is about 41,000 trips/day or 9.3%, while the inter-area traffic 395,000 trips/day. It is to be noted that these figures do not include the tourism traffic to/from Sentosa. When it is assumed that 30% of the public mode users and 10% of the private mode users will partly or entirely the new transit syste, the estimated no. of passengers be a total of 89,700 per day as shown in Table 7.7

Table 7.7

Estimated Non Tourism Traffic Demand of the Proposed System

Demand Type	Mode	No. of Trips/day	Assumed % of Diversion to Proposed System	No. of NTS Passengers/ day
Traffic Demand Within Study Area	Public Private	21,700 19,200	30 10	6,500 1,900
Traffic Demand Between Study Area and Outside	Public Private	209,200 185,400	30 10	62,800 18,500
Total		435,500	-	89,700

3) Tourism Traffic to/from Sentosa Island

Visitors profile of Sentosa Island is Summarized in Table 7.8 and characterized by the following:

- Foreign visitor share 40% of the total
- 82% of the visitors use ferry but foreign visitors use cable cars considerably
- There is a significant fluctuation in visitor arrivals by day. Sunday shows the peak, five times higher than an average weekday.

Table 7.8

Visitor Profile of Sentosa, 1987/88

Particular		Total	Local	Tourist
		No: 000 (%)	No: 000 (%)	No: 000 (%)
1) Total Visitor Arrivals		2,100 (100.0)	1,260 (60.0)	840 (40.0)
2) Average Daily Visitorship	Saturday	8.0 (100.0)	6.4 (80.0)	1.6 (20.0)
	Sunday	15.0 (100.0)	12.0 (80.0)	3.0 (20.0)
	Weekday	3.0 (100.0)	1.2 (20.0)	2.4 (80.0)
3) Visitor Arrivals by Mode of Transport	Ferry	1,720 (82.0)	1,180 (93.7)	540 (64.3)
	Cable Car	380 (18.0)	80 (6.3)	300 (37.7)

Source: Sentosa Development Corporation

When the new transit system has been constructed directly, visitors can reach Sentosa Island from Orchard within 15 minutes. This is faster than car and any transfer is required.

Considering that the ride on the grade-separated system will be a joyful one this route would attract more foreign visitors. With connection at MRT in two locations, Orchard and Tiong Bahru, it is estimated that the combined use of the proposed system and MRT would be a major access mode of Sentosa Island. When it is assumed that about 70% of the total visitors use the proposed system, the estimated no. of passengers of the proposed system is about 42,000 a day on Sundays/public holidays and 8,400 a day on weekdays, as shown in Table 7.9.

Table 7.9

Estimated Tourism Traffic Demand of the Proposed System

Day	No. of Visitors to Sentosa/day 1/	No. of NTS Passengers/day
Weekday	6,000	8,400
Saturday	16,000	22,400
Sunday/Public holiday	30,000	42,000

1/ A total no. of visitors is assumed to be 4 million a year.

4) Total Traffic Demand of the Proposed System

Two types of potential demand for the proposed system are significantly different from each other. Sentosa related traffic has a very high peak on Sundays, while the non tourism related traffic would have a peak on weekdays. This is a favorable factor for the effective utilization of system capacity. (Assuming that a Sunday traffic of non-tourism related traffic is 70% of the average daily, the average total Sunday traffic will be approximately 105,000 passengers (89,700 x 0.7 + 42,000), while the average weekday traffic be 98,000 passengers.

5) Sectional Traffic Volume

Based on the available 1981 HCS OD data, the distribution of the non-tourism traffic demand was estimated along the proposed route. For Sentosa related traffic, it was assumed that 50% of the demand moves over the entire route between Orchard and Sentosa, while the remaining 50% along the section between Tiong Bahru MRT station and Sentosa. This will give the approximate sectional traffic volume shown in Table 7.10.

Table 7.10

Estimated Sectional Traffic Volume of Sentosa-Orchard Route

Item	Day	Sentosa-Tiong Bahru Section	Tiong Bahru-Orchard Section
No. of Passengers/ day/both directions	Weekday	30,000	27,000
	Sunday	56,500	36,700
No. of Passenger for peakhour and heavy direction 1/	Weekday	2,700	2,400
	Sunday	5,100	3,300

1/ Estimates based on the assumption that % of heavy is 60% and peak hour ration is 15%.

7.2.3 System Plan

1) Selection of the System

In selecting a system for the proposed route, the following aspects were considered:

a) The system for the route should be separated from the existing or future system in Sentosa Island due to the following reasons:

- Performance required for the proposed route is higher than the one needed for Sentosa. The terrain is not that and users requirements are severe and different.

- Management of visitors and control of entrance will also require physical separation of passenger movements.

- Two systems might not be constructed and managed on the same bais.

b) The system should contribute to the enhancement of visual efects not only for the community alongside but also passengers, especially tourists.

Options for the system will include the following:

a) Mini-monorail (straddle type): The uniformity of the system with the existing one of Sentosa will add to the aesthetic appeal pervading in the area. The system would require longer platform length than the other system. (Refer to Sydney Mini-monorail in Figure 4.4)

b) Mini-monorail (suspension type): This will maximize the visual effects of passengers along the route. (Refer to H-bahn in Figure 4.4)

c) IMCT (Intermediate Capacity Transit): The same system studied for Ang Mo Kio new town. This sytem has slightly larger transport capabilities than the above two systems.

It is considered that the construction costs do not vary much among the three systems. From the aesthetic viewpoint, a mini-monorail type may be preferred.

2) Alignment

The proposed double track route runs through 5.6 kms. It starts at MRT Orchard, then Tiong Bahru MRT station after passing Paterson Road and River Valley Road, Delta Road, World Trade Centre, and finally passes the proposed causeway to reach Sentosa. It is assumed the Sentosa terminal will be constructed at the entrance of the Island near the existing ferry terminal, where the proposed system is interchanged with the intra island system. (Refer to Figure 7.4 and Figure 7.5)

The section of Delta Road has two overpass points at Expressway and Malaysia Railroad. It might become necessary to look into the need of detouring traffic when construction is underway or the provision of an access road to the station along River Valley Road and Hoot Kian due to the narrow road width and lack of sidewalk.

The route links 10 stations with spacing of 620 meters.

3) Facilities

Steel structure is preferred in the case of mini-monorail from the aesthetic viewpoint, though concrete structure is less expensive and easier for construction. Careful studies are required in constructing structures at the crosspoints of expressway and the railway.

Stations should be designed in such a way as to maximize the accessibilities of passengers. This is particularly important at the stations where the proposed system meets with MRT, Orchard and Tiong Bahru. Smooth transfer should be assured. Orchard and Tiong Bahru has great potentials of integrated commercial development at and around the station which alone could be a strategic development project.

A depot is to be constructed. Possible location is along Delta Road.

4) Operation Plan

Trains with passenger capacity of 150/train at three minutes intervals are required to meet a weekday peak hour, while two minutes intervals are necessary for a Sunday peak hour. The demand can also be met with larger capacity train at longer headways.

Considering that this route has to serve considerable number of tourists it may be worthwhile to provide more comfortable in-vehicle space of the cars. Alternative concepts can be illustrated shown in figure 7.6.

Figure 7.4

Interface of the Proposed System with Intra-island Systems

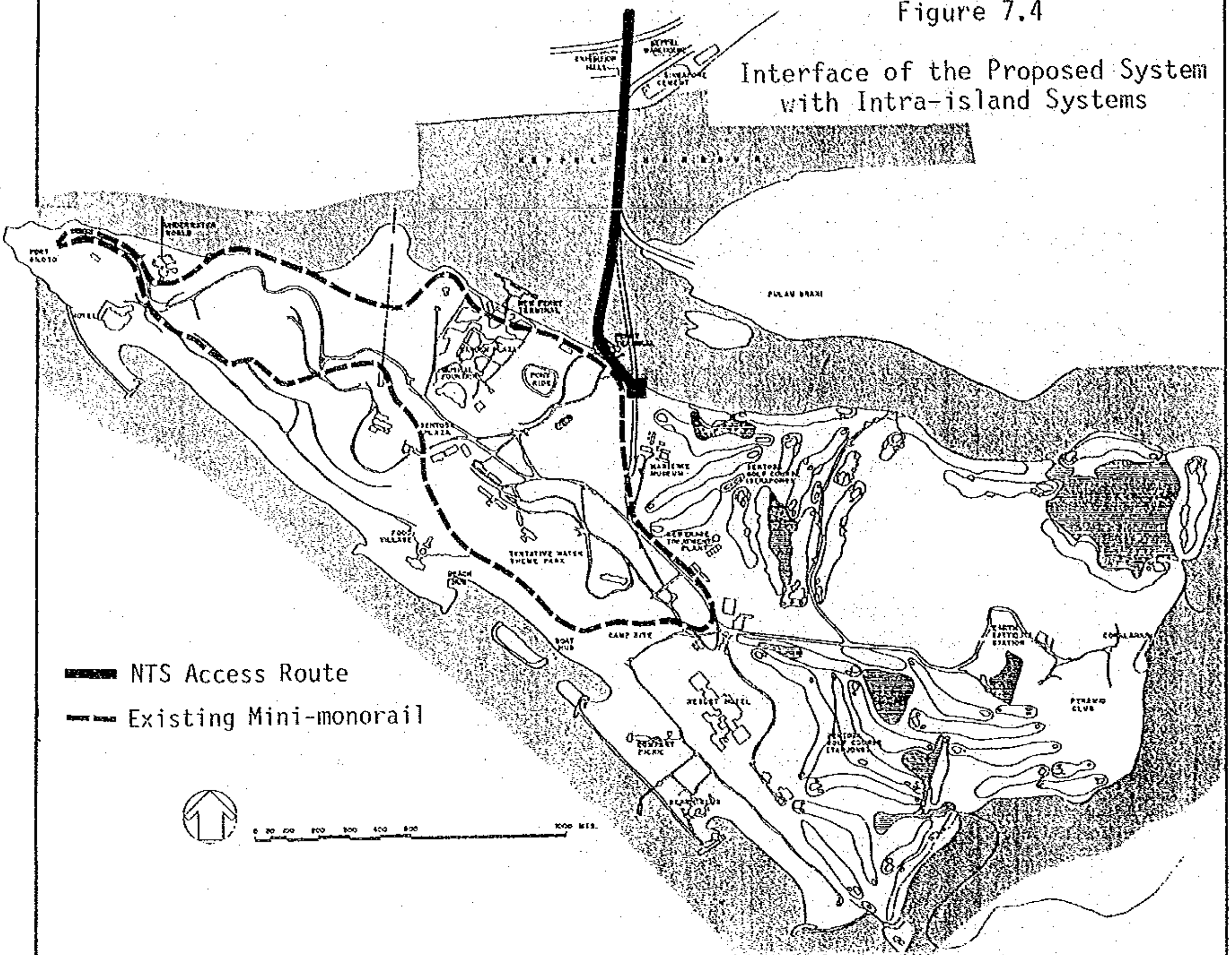
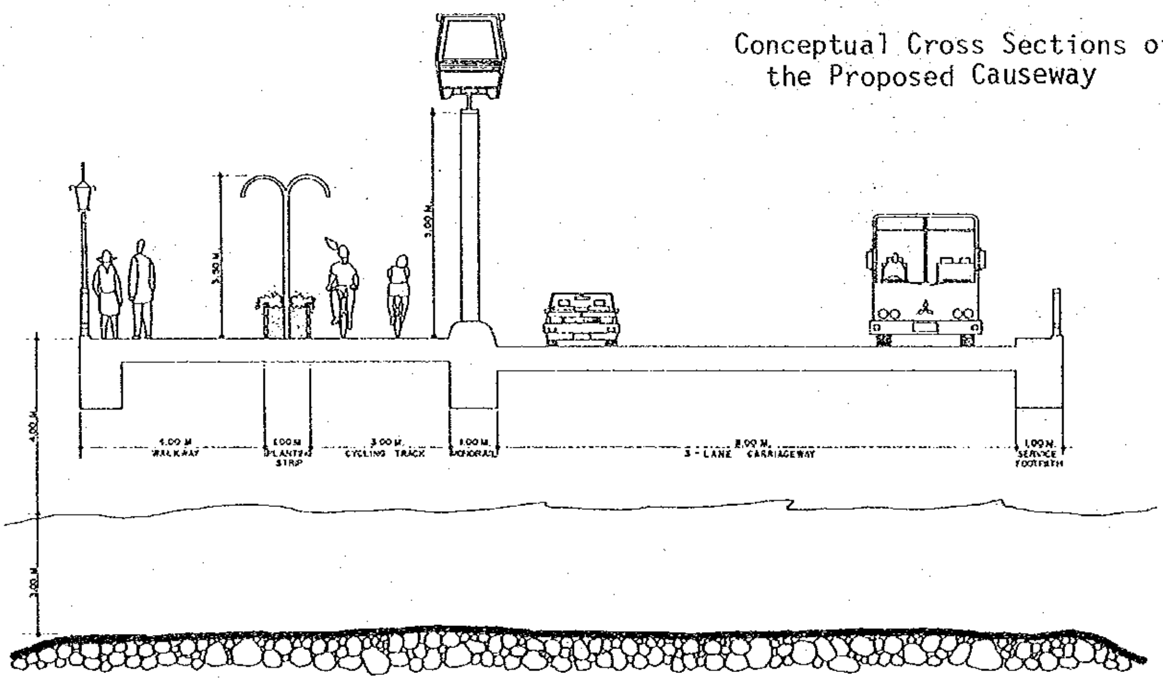


Figure 7.5

Conceptual Cross Sections of the Proposed Causeway

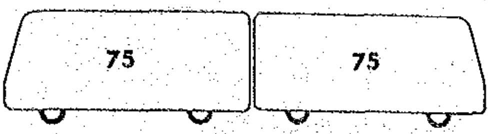


Source: Sentosa Development Corporation

Figure 7.6

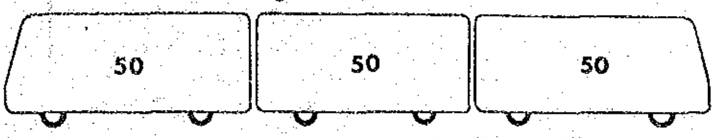
Alternative Train Composition

A. Normal solution



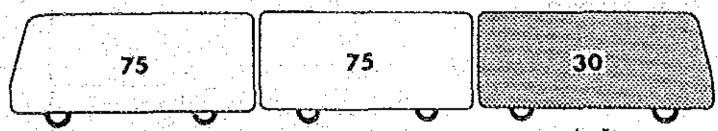
150 passengers

B. Comfortable seating arrangement with higher fare



150 passengers

C. Normal solution plus additional special car with different fare



180 passengers

special car

The operation plan for the proposed system was worked out based on Ang Mo Kio system for which cost information is relatively well provided and outlined in Table 7.11. The system provides services at three minutes intervals during peak hours and five to six minutes during off-peak hours on weekdays.

Table 7.11

Outline Operation Plans of the Proposed System for Orchard - Sentosa Route 1/

Item	Amount
1) No. of trains	10 + 2 (spare)
2) No. of cars/train	2
3) No. of cars required	24
4) Capacity of a Car	75
5) Headway : peak	3 minutes
: off-peak	5 - 6 minutes
6) Scheduled Speed	27 kph
7) Scheduled Time	12.5 minutes (One Way)
8) Frequencies	243/day
9) Train-kms	2,722/day
10) Car-kms	2,722/day

1/ Worked out based on normal solution and weekday operation.

7) Cost Estimate

Estimated costs for investment and operation and maintenance are summrized as shown in Table 7.12 and 7.13, respectively.

Table 7.12

Summary of Investment Costs for Proposed Orchard-Sentosa Route System

Item	Amount S$ 000	%
1) Civil Works	65,850	41.5
2) Station/Building	9,100	5.7
3) Depot	22,900	14.4
4) Vehicles	22,800	14.4
5) Power Supply	19,630	12.4
6) Control/Signalling/ Telecommunications	18,500	11.6
Total	158,780	100.0
Cost/Km	14,180	-

1/ Including site investigations, engineering and project management, testing and training.

Table 7.13

Estimated Operating Cost for Proposed Orchard-Sentosa Route System

Item	Amount S$ 000	%
1) Vehicle Maintenance	538	15.0
2) Maintenance of Equipment and Facilities	1,344	35.0
3) Electric Consumption	270	7.1
4) Manpower	1,100	28.7
5) Overhead	325	9.1
Total: per year	3,577	100.0
per day (S$)	9,800	-

7.2.4 Project Evaluation

1) Economic Viability

Economic viability of the project was examined by comparing the annual average cost of the project with the estimated annual average benefits. The average cost of the project is estimated as follows:

i) Investment cost at a discount rate of	5%:	S$10.4m/year
	2%:	S$ 7.2m/year
ii) Operating and maintenance cost	:	S$ 3.8m/year
Total Average Annual Cost of the Project:		S$14.2m/year (at 5% discount rate)
		S$11.0m/year (at 2% discount rate)

On the other hand, the benefits expected from the project vary and are extensive and it is difficult to quantify, as discussed for Ang Mo Kio New Town. However, the most significant and tangible direct benefit i.e., "time saving" alone, is estimated to be considerably large as summarized below:

i) Assumptions:

- estimated no. of passengers: 100,000/day
- average time value during the project life: S$6.2/hr (average of 4.0 for 1992 and 8.4 for 2012)
- estimated average time saving per trip: 5 minutes

ii) Estimated time saving: 100,000 x 5 x 1/60 x 6.2 x 365 = S$18.9 million/year

Accordingly, the B/C ratio of the project is calculated at 1.7 at 2% discount rate.

The significant features of this project is not only to provide feeder services for the residents but also to encourage the movement of tourists and recreational activities by linking two major tourist destinations/amusement centres of Sentosa and Orchard areas.

2) Financial Viability

Financial analysis was done by comparing the expected fare revenue with the costs to be shouldered under different scenarios. The results are summarized as shown in Table 7.14.

a) If the government shoulders all investment costs except vehicles, the project will produce high FIRR of 26.7% under a 30-cent fare.

b) If the government shoulders only civil work and station costs, the project generates 6.6%, 15.5% and 22.9% of FIRR under different fare levels of 430, ¢50 and ¢70, respectively.

Table 7.14

Summary of Financial Analysis

Description of Case / Item	Base Case: All costs except vehicles shouldered by Govt.		Alternative Cases					
			Case A Civil Work/ Station Costs shouldered by Govt.		Case A with increased fare		Case A with increased fare	
No. of Pass/day	100,000		100,000		100,000		100,000	
Fare (¢)	30		30		50		70	
Revenue: (S$000/yr)	10,950		10,950		18,250		25,550	
Invest Cost (S$ million)	22.8		83.8		83.8		83.8	
Open & Maint. (S$000/yr)	3,577		3,577		3,577		3,577	
Depreciation (S$000/yr)	1,140		3,483		3,483		3,483	
Operating Profit (S$000/yr)	6,233		3,890		11,190		18,490	
FIRR (%)	26.7		6.6		15.5		22.9	
Equity (%)	15	30	15	30	15	30	15	30
Interest Rate (%)	7.0		7.0		7.0		7.0	
First Year Net Profit Generated	1992	1992	1999	1994	1992	1992	1992	1992
First Year Accumulated Net Profit Generated	1992	1992	2007	1998	1992	1992	1992	1992
Remarks								

7.3 Orchard-Marina Centre Route

7.3.1 Profile of the Study Area

Figure 7.7 shows the study area. The influence area of the proposed route encompasses the following: Orchard, Bras Basah and Marina Centre.

Orchard is the biggest centre for commercial activity in Singapore. It is teeming with commercial complexes and hotels and not only foreigners but also Singaporeans enjoy a stroll around the area. (Refer to Figure 7.8)

Adjacent to the Orchard area is Bras Basah. This area has a lot of open spaces. However, it is gradually starting to emerge as one of the newest commercial areas in Singapore with the construction of Raffles Shopping Centre and some hotels.

Similarly, Marina Centre, a reclaimed area, is headed towards the same direction as Bras Basah, with the presence of new hotels and shopping centres.

Table 7.15 shows the population, employment and estimated daytime population of the influence area for 1981 and 1990. The forecasted 1990 population and employment total the number of population. Hence, daytime population has been estimated to be approximately 114,000 as compared to only 70,000 in 1981.

Table 7.15

Population, Employment and Daytime Population of the Influence Area

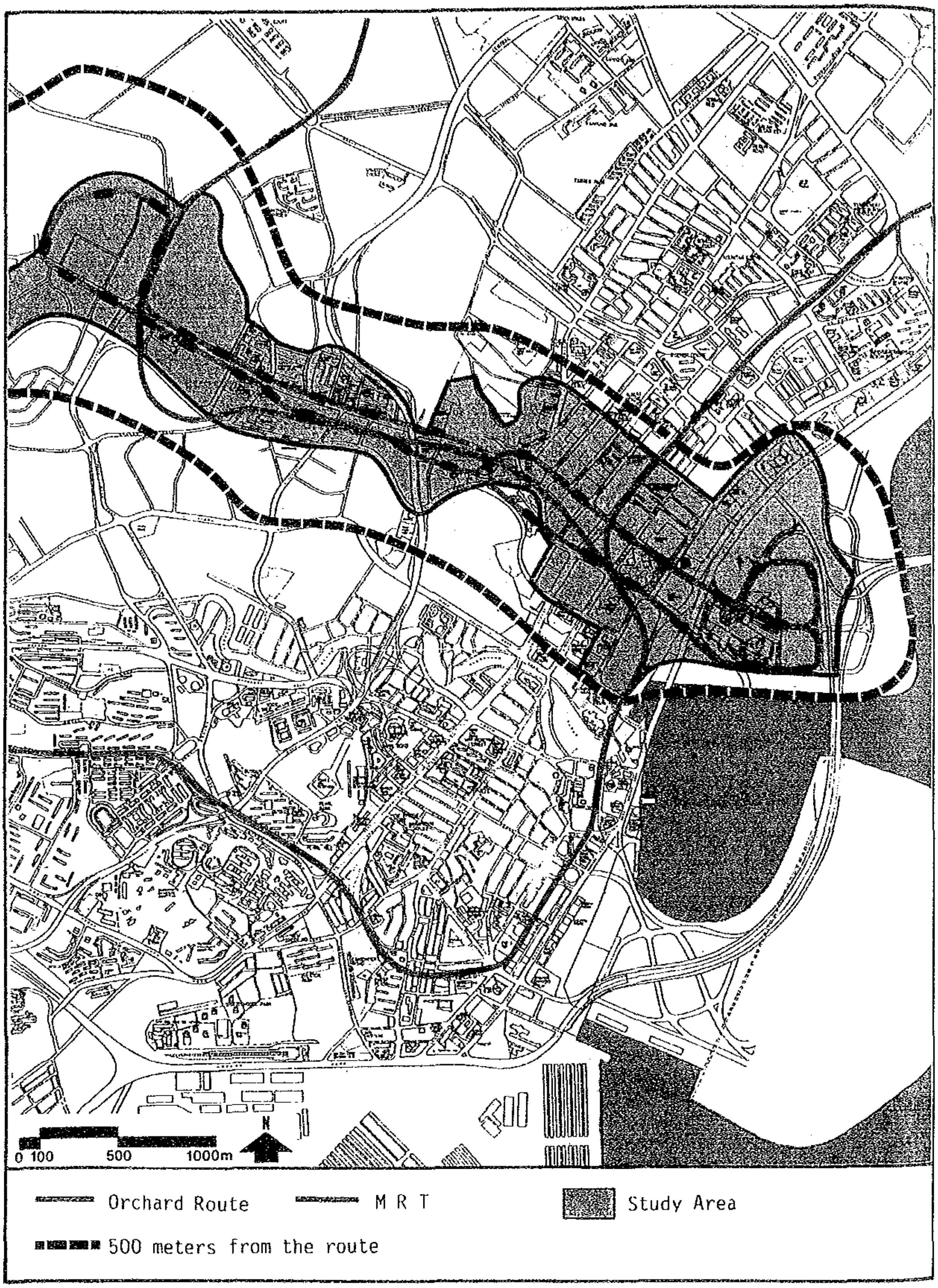
Item		Orchard	Bras Basah	Marina Centre	Total
1981	Population Employment	4,750 50,600	13,320 13,400	- -	18,070 64,000
	Daytime Population 1/	52,300	18,100	-	70,400
1990	Population Employment	6,050 66,400	7,450 34,450	- -	13,500 100,850
	Daytime Population 1/	68,500	37,100	8,350	105,600
1990/1981	Population 1/ Employment	1.27 1.31	0.56 2.57	- -	0.75 1.58
	Daytime Population 1/	1.31	2.05	-	1.50

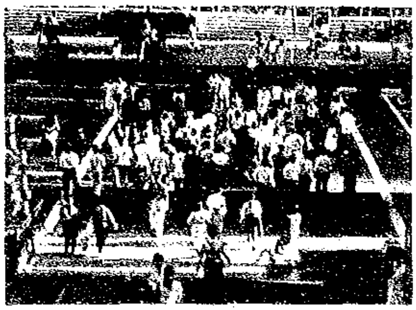
Source: CTS

1/ Estimated based on the following: Population x 5% (infants/childre) + population x 95% x 32% (housewives) + employment.

Figure 7.7

Orchard-Marina Centre Route





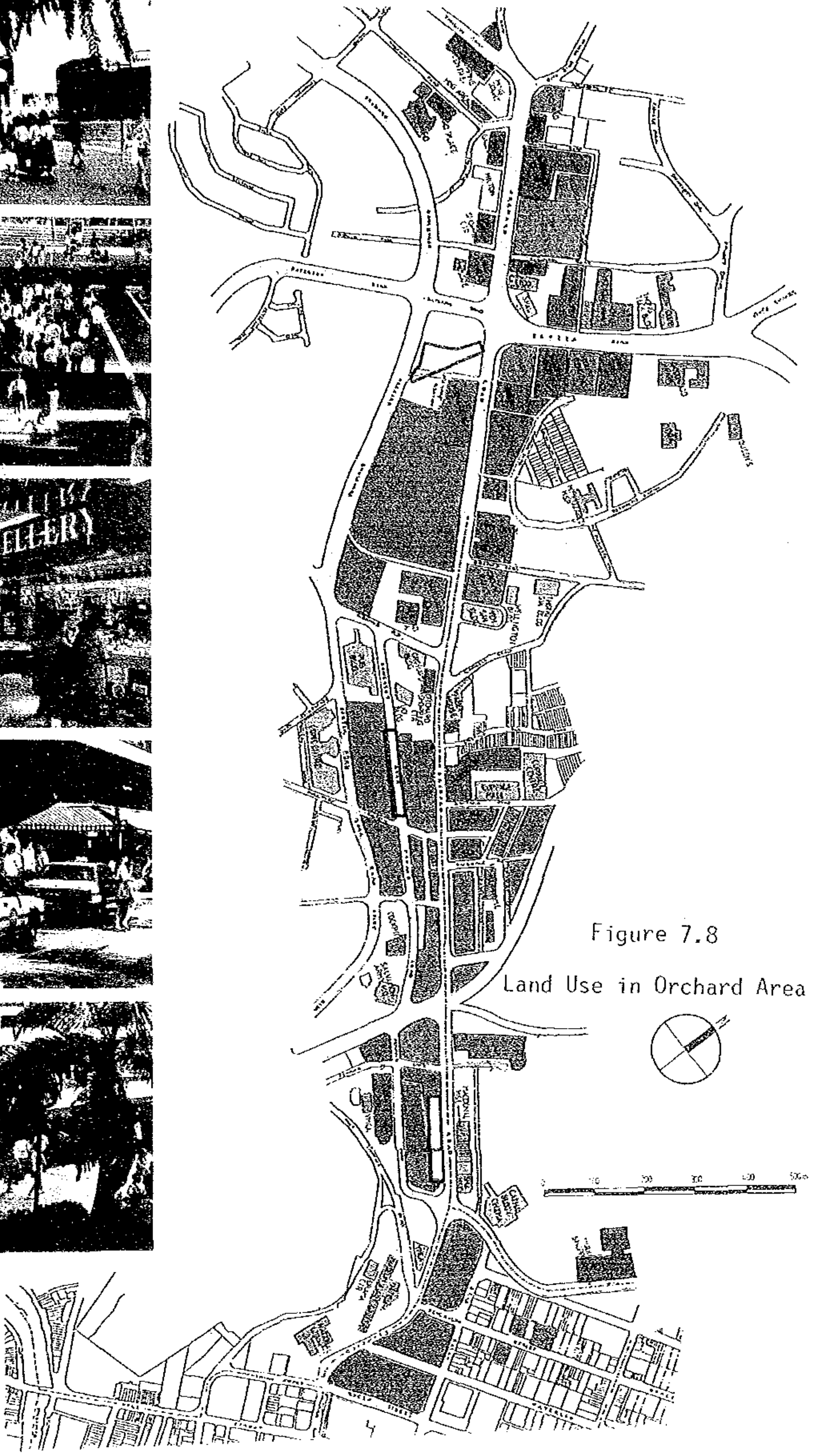


Figure 7.8

Land Use in Orchard Area

The proposed system will be located along the thoroughfare by linking major commercial complexes, hotels and MRT stations. The route comprising two separate loops totals to 8.8 kms.

7.3.2 Traffic Demand

1) Total Potential Traffic Demand

The total traffic demand related to the study area is approximately 417,000 trips/day as shown in Table 7.16. Of the total, the traffic moving within the study area is only 18,000 (7,950 + 1,900 + 8,100) trips/day while the majority of the traffic is to/from the external areas.

Table 7.16

Estimated Total Traffic Demand of the Study Area

	Within Area		No. of Motorized Trips/day (to/from)		
Area	Orchard	Bras Basah	CBD	Other Areas	Total
Orchard	7,950 (3.6)	8,100 (3.7)	16,600 (7.6)	185,800 (85.1)	218,450 (100.0%)
Bras Basah	8,100 (4.1)	1,900 (1.0)	5,550 (2.8)	183,000 (92.2)	198,000 (100.0%)
Marina Centre	-	-	-	-	-
Total	16,650 (3.8)	10,000 (2.4)	22,100 (5.3)	368,800 (88.5)	416,950 (100.0%)

Source : Worked out based on MRTC 1981 OD data.

The SBS survey results also give infomation on the traffic demand of the areas as shown in the Table 7.17. The total number of bus passengers generated is about 102,000 trips/day of which the number moving within the area is only 9,400 trips/day.

Table 7.17

Bus Passenger Trips To/From the Orchard Area

Time Period	Within Orchard	To/From				Total
		CBD	North	East	West	
Evening Peak	1,315	6,039	8,059	9,332	10,914	35,659
Afternoon Off Peak	1,120	3,440	4,589	4,745	6,532	20,426
All Day (Estimated)	9,400	16,400	21,800	23,600	30,500	101,700

Source: 1985 SBS Bus Survey

The types of passengers expected to use the proposed system in the area are:

- Traffic (motorized) moving within the area
- Feeder traffic to/from MRT
- Pedestrian traffic in the area

2) Estimated Traffic Demand for the Proposed System

a) Traffic Moving Within the Area

It is likely that the 1981 traffic level of 18,000 trips/day has grown considerably due to the overall traffic growth and the developments that took place within the area. It can be assumed that a half of the intra-area motorized traffic are attracted to the system, say, 9,000 trips/day.

b) Feeder Traffic

At present, the number of boarding and alighting passengers at three MRT stations is about 120,000 a day as shown in Table 7.18.

Table 7.18

Number of Boarding/Alighting Passengers at Orchard, Somerset and Dhoby Ghaut MRT Stations

Name of Stations	Name of Boarding/Alighting Passengers of MRT/day	% to Total
Orchard	61,681	51.4
Somerset	27,849	23.2
Dhoby Ghaut	30,443	25.4
Total	119,973	100.0

As the proposed system can fairly provide efficient door-to-door services among major buildings and complexes, including MRT stations, it can be expected that quite a few traffic vehicles will be attracted to the system. Assuming that 10% of the traffic moving between the influence and other areas would use the system, the number of passengers will be about 39,000 a day.

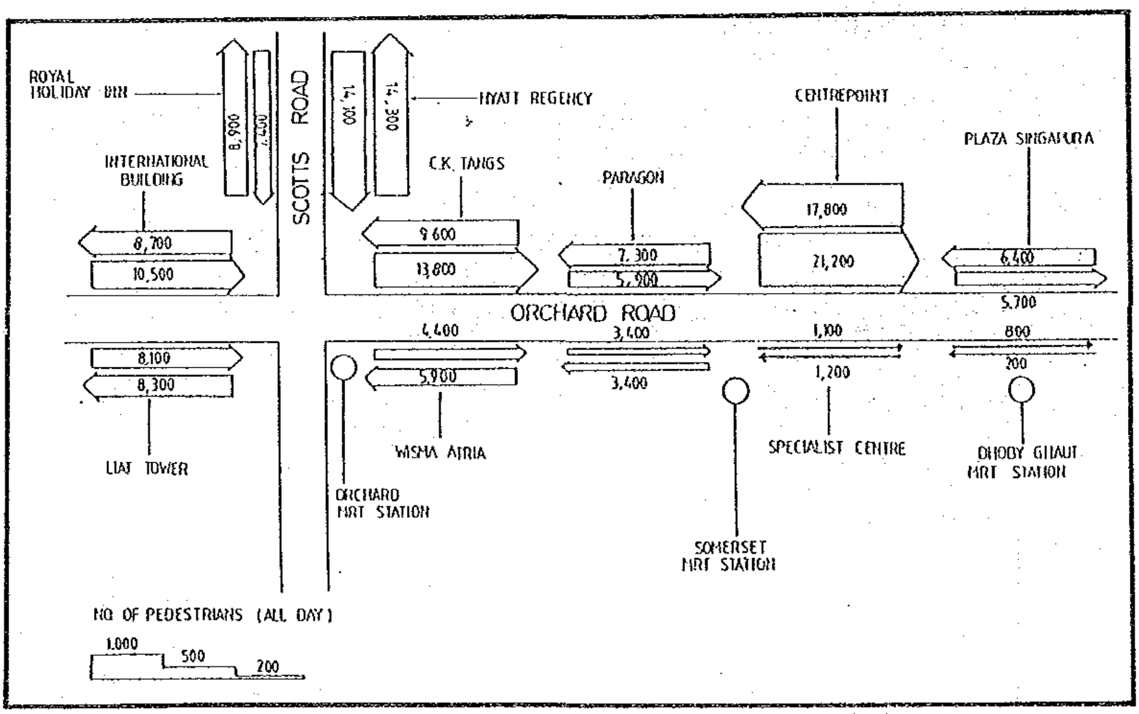
c) <u>Diversion from Pedestrian Traffic</u>

The proposed system intends to attract pedestrians in the Orchard area. With a convenient transport means, it is expected that pedestrians can expand their areas and intensifies of activities. When pedestrians move, the influence areas comprising Orchard, Bras Basah and Marina Centre which currently spread beyond walking distance would be closely integrated. The system would, then, affect the overall land use pattern and location of new establishments.

A pedestrian survey was conducted to estimate the quantity and characteristics of pedestrian movement in the area. The study estimated the total number of pedestrian traffic at approximately 150,000 a day. The largest sectional traffic volume was recorded near the Orchard and Somerset MRT stations, about 40,000 pedestrians/16 hours for each. Pedestrian traffic low in the area is shown in Figure 7.9.

Figure 7.9

Pedestrians Traffic Flow Along Orchard Road and Scotts Road: 0700 - 2200 Hrs



The proposed grade-separated system to be constructed along the sidewalk of Orchard Corridor alone would be a great attraction for the pedestrians, especially tourists. It could be assumed that at least 10% of the pedestrians in the Orchard area would use the system. In Marina Centre where walking environments are not well developed as the Orchard area, more pedestrians would be attracted to the system. It is, therefore, estimated that about 20,000 pedestrians would divert to the proposed system.

d) Estimated Total Number of Passengers

The total traffic demand for the proposed system, therefore, is as follows:

- Diversion from intra-area motorized traffic:	9,000	passengers /day
- Feeder traffic:	39,000	
- Diversion of pedestrian traffic:	20,000	
Total	68,000	passengers /day

2) Sectional Traffic

The sectional traffic varies by section between 25,000 to 10,000 passengers/day, judging from the present traffic characteristics. The section with the heaviest traffic is the upper portion of Orchard Road, around Orchard MRT station and towards Somerset MRT, while that with the least traffic is seen around Dhoby Ghaut MRT station. However, it is considered that the traffic pattern and behavior will change when the system is introduced. At present, there are three peak periods in the area -- morning peak, evening peak and mid-day peak. Assuming a peak hour ratio of 10% and 60% of the total traffic for heavy direction, the peak traffic volume is about 1,500 passengers/hour.

7.3.3 System Plan

1) Selection of the System

Both the performance and functional appearance are important factors for selecting a system for this area. The ideal one is a personalized type of transit system which has a relatively small passenger capacity, high frequency and flexible routing. However, the systems of this category are not fully tested and realized. Therefore, amongf the existing and tested systems, a suspension type mini-monorail as shown in Figure 7.10 is selected for the case study.

2) Route Plan and Alignment

The route was determined by taking into account the following factors:

a) Users requirements: With all transport modes available in the area, the proposed system should meet varied and high-grade needs of local movements. There are many toursits, car users and other users with different private trip purposes. Concern for their convenience would be more attractive than the fare. This will specifically relate to the location and type of stations. It is necessary to provide direct and smooth access and travel between the majordestinations. One idea is to construct the system close to the building whereby the passengers can have access to the system directly.

b) Flexible operation: Demand varies and changes according to the area. It is not advisable to construct a long-distance link but to have a combination of short-distance links as illustrated in Figure 7.11. The pedestrial survey conducted in Orchard area supports this concept which will facilitate the system to operate more flexibly. If the routes are connected with interface stations having directs transfers at the same platform level, the system can be expanded without reducing accessibility.

c) Aesthetic aspect: This is a critical factor not only in minimizing the negative impact on the existing landscape but also in enhancing the creation of a new image and attraction in the area.

d) Urban development aspect: Orchard area is the centre of attraction for both foreigners and Singaporeans. In order for Singapore to be one of the major destinations for tourism and international activities, further strengthening and upgrading of services, facilities and amenities in the area will continuously be an issue. The introduction of a new transit system will form an important part of the total urban development strategy in the area.

The route comprises the following two loops shown in Figure 7.11.

<u>Loop A: (Total Route Length is 5.1 km)</u>

Link with Tanglin Road (Ming Court) - MRT Orchard Station - Somerset Road - Penang Road - MRT Dhoby Ghaut St. - Orchard Road - Scotts Road - Draycoff Drive - Orchard Hotel - Tanglin Road

<u>Loop B: (Total Route Length is 3.75 km)</u>

MRT Dhoby Ghaut - Bras Basah Road -- Raffles Blvd. - Raffles Avenue - Standord Road - MRT Dhoby Ghaut St.

3) Carriageway

A steel structure is the optimum choice with its minimum space performance, ease in construction and efficient handling of sharp curvature. Further, it is necessary to examine the construction method, traffic management, infrastructure and removal of obstructions, such as trees.

Figure 7.10

Profile of the Selected System

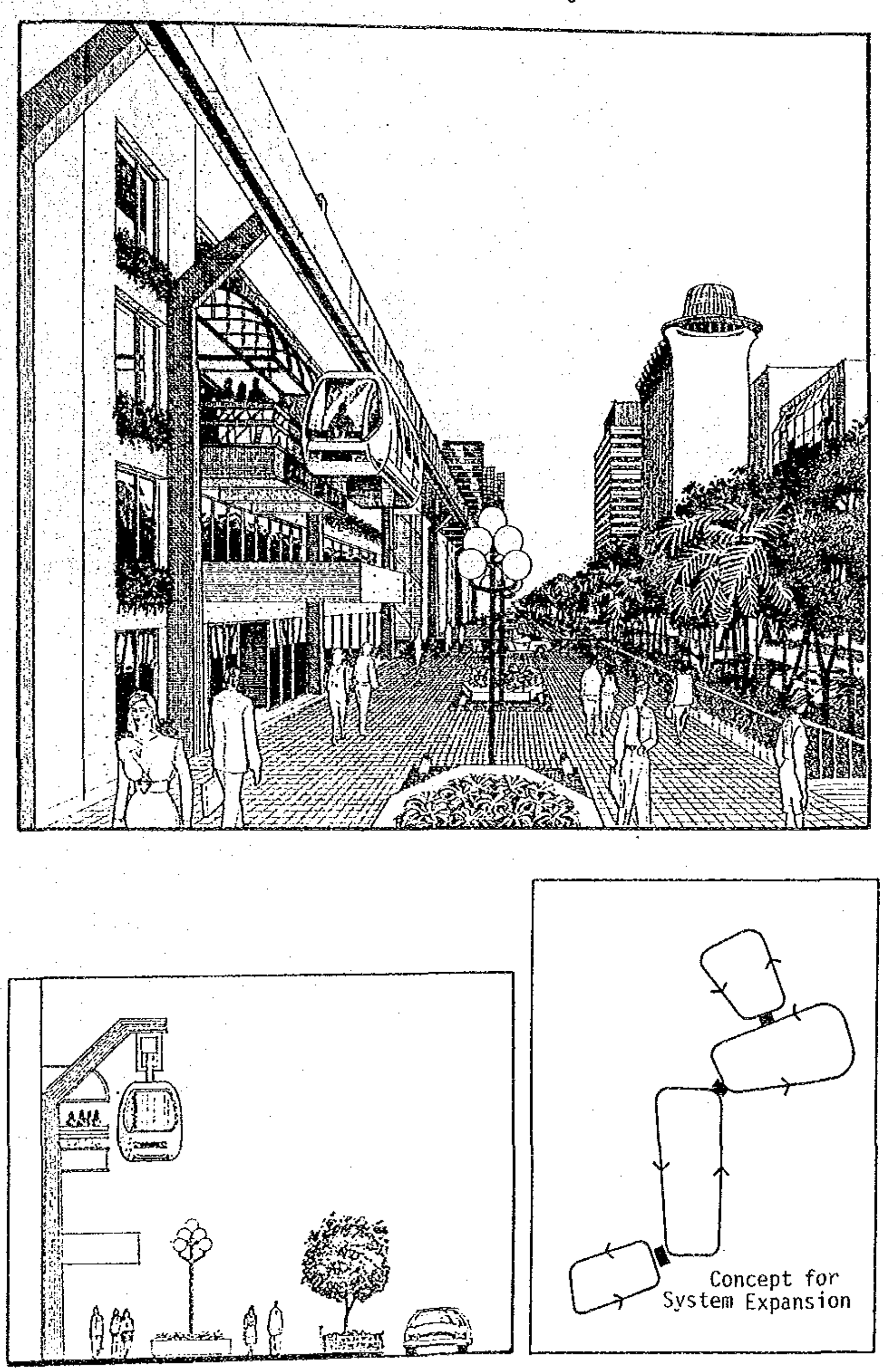
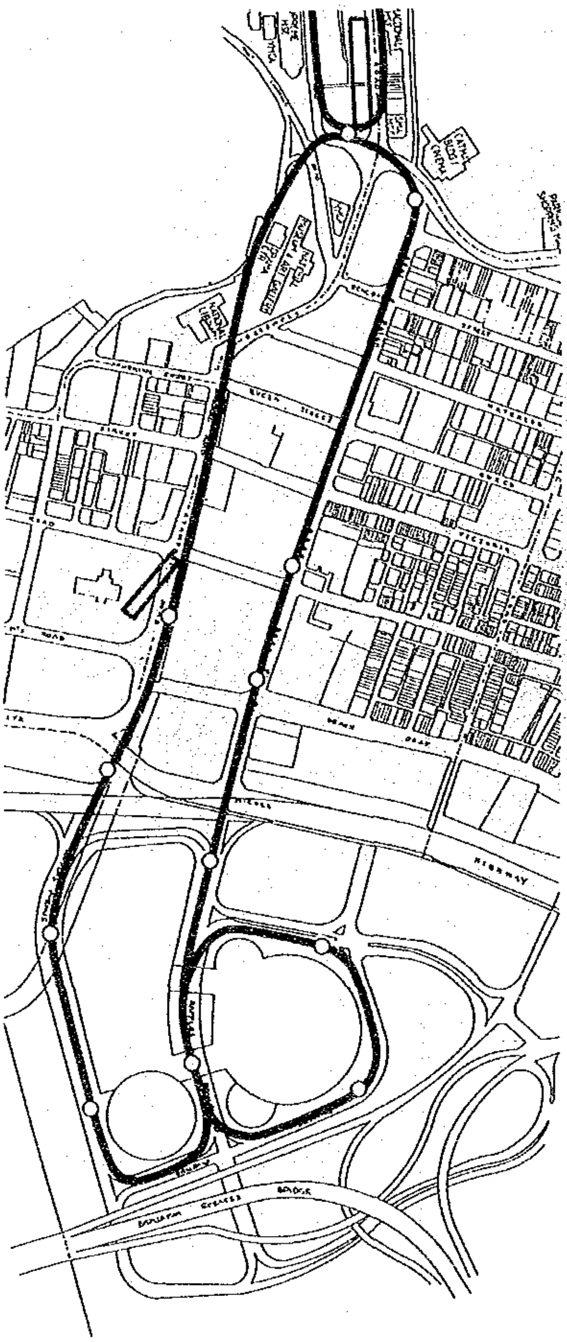
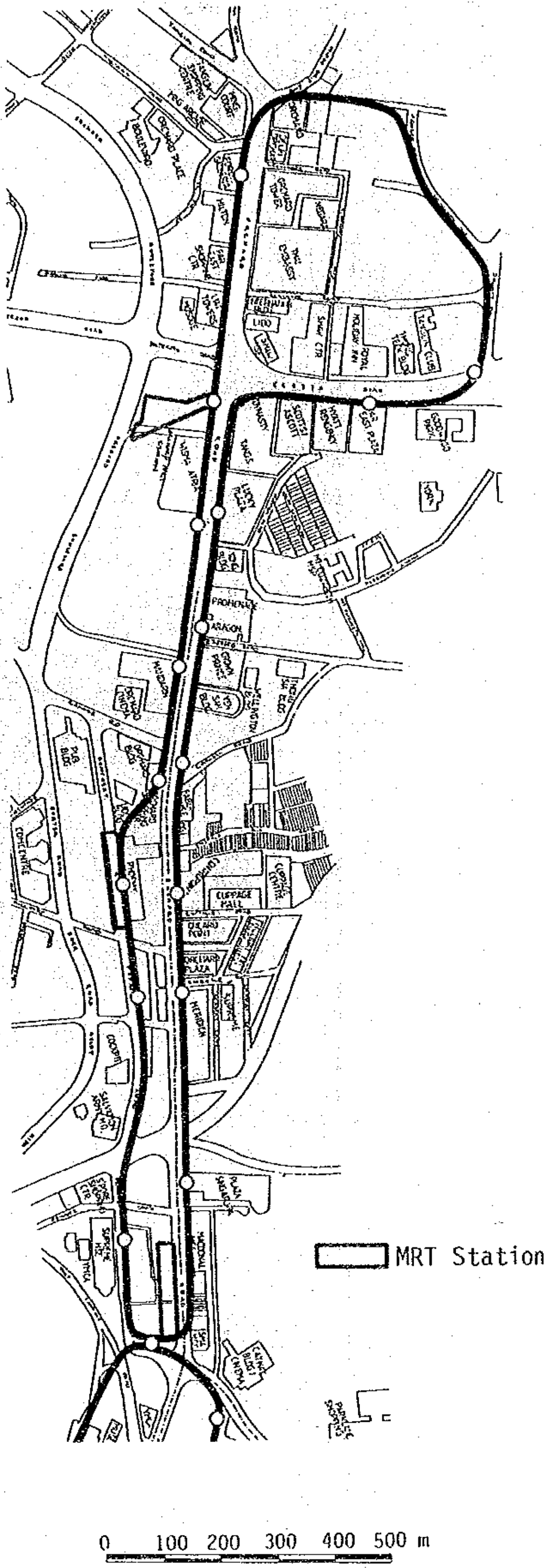


Figure 7.11

Location of Orchard-Marina Centre Route





4) Station

The distance between stations is 300 meters. Accessbility should be the first priority to be worked out in order to attract prospective users. Hence, the introduction of a low-type platform would be ideal. In addition, direct access from the second level of buildings should also be considered.

There is a need to blend the design of the station exterior with shopping centres and existing historical structures.

5) Operation Plan

Outline of the operation of the proposed system is shown in Table 7.19. The system provides frequent services with small capacity cars.

Table 7.19

Outline of the Operation of the Proposed System for Orchard Corridor Route

Item	Loop A	Loop B
1) Route of Length	5.1 km	3.7 km
2) No. Stations	21	13
3) Ave. Section Spacing	245	280 meters
4) No. of Trains	11 + 2 (spare)	7 + 2 (spare)
5) No. of Cars/Trains	1	1
6) No. of Cars Required	13	9
7) Capacity of a Car	45 passengers	45 passengers
8) Headway : peak	1.5 -2	1.5 -2
: off-peak	3 - 5	3 - 5
9) Scheduled Speed	14.7	15.6
10) Turn Around Time	21 minutes	14 minutes
11) Frequencies	370/day	370/day
12) Train-kms	2,000/day	1,360/day
13) Car-kms	2,000/day	1,360/day

7) Cost Estimate

Estimated costs for investment and operation and maintenance are summarized as shown in Tables 7.20 and 7.21, respectively.

Table 7.20

Summary of Investment Costs for the Proposed Orchard-Marina City Route System

Item	Loop A :S$000	Loop B :S$000	Total :S$000	%
1) Civil Works	64,530	45,580	110,110	46.8
2) Station/Building	21,950	14,390	36,340	15.5
3) Depot	13,280	10,730	24,010	10.2
4) Vehicles	15,200	10,450	25,650	10.9
5) Power Supply	8,160	5,360	13,520	5.7
6) Control/Signalling/ Telecommunication	15,000	10,500	25,500	10.9
Total Cost	138,120	97,010	235,130	-
Cost/Km	27,080	26,220	26,720	-

1/ Including site investigations, engineering and project management, testing and training.

Table 7.21

Estimated Operating Cost for Proposed Orchard-Marina City Route System

Item	Loop A S$ 000	Loop B S$ 000	Total S$ 000	%
1) Vehicle Maintenance	510	352	862	29.8
2) Maintenance of Equipment and Facilities	617	438	1,055	36.4
3) Electric Consumption	248	176	424	14.6
4) Manpower	179	115	294	10.1
5) Overhead	155	108	263	9.1
Total : per year	1,709	1,189	2,898	100.0
per year (S$)	4,680	3,260	7,940	-

7.3.4 Project Evaluation

1) Economic Viability

Economic Viability of the project was examined by comparing the annual average cost of the project with the estimated annual benefits. The average cost of the project is estimated as follows:

i) Investment cost at a discount rate of	5%:	S$15.0m/year
	2%:	S$10.1m/year
ii) Operating and maintenance costs	:	S$ 2.9m/year
Total Average Annual Cost of the Project:		S$17.9m/year (at 5% discount rate) S$13.0m/year (at 2% discount rate)

In addition to the estimated time saving of S$9.4 million (50,000 passengers x 5 minutes x 1/60 x S$6.2/hr x 365 days), there are extensive benefits which are, however, difficult to quantify. They are:

a) Strengthening the integration of the facilities and activities in the area. Visitors/tourists can expand their coverage of comfort of transport. This will not only benefit the existing visitors/tourists but also induce additional users. The facilities and destinations in the area would be linked more effectively.

b) Encouragement of new urban development. The proposed system would increase the accessibility of a considerable number of areas and in turn, new commercial developments can become more attractive ventures.

c) Reorganization of intra-corridor transport system. This will not only facilitate public transport users or pedestrians but can particularly aim at restructuring private car users. If the NTS stations are strategically developed as interchanges between private cars by constructing adequate car parks, this will reduce their excessive movements within the corridor. There can be better and more frequent use of the existing road space by pedestrians on activities other than transport.

2) Financial Viability

Financial analysis was done by comparing the expected fare revenue with the costs to be shouldered under different scenarios. The results are summarized as shown in Table 7.22. As seen in other cases, fare alone can generate attractive revenues if the infrastructures cost is shouldered by the Government. The cost for stations should be by the beneficiaries. An alternative or additional way of generating revenue could be to impose a certain amount of association dues to shops and establishments in the area which will greatly benefit from the project.

Table 7.22

Summary of Financial Analysis

Description of Case / Item	Base Case: All costs except vehicle costs shouldered by Govt.		Alternative Cases: Case A: Civil work/ Costs shouldered by Govt.		Alternative Cases: Case B: Station Costs shouldered by Govt.	
No. of Pass/day	50,000		50,000		50,000	
Fare (¢)	50		100		100	
Revenue: (S$000/yr)	9,125		18,250		18,250	
Invest Cost (S$ million)	2.57		125.0		88.7	
Open & Maint. (S$000/yr)	2,898		2,898		2,898	
Depreciation (S$000/yr)	1,283		4,616		3,809	
Operating Profit (S$000/yr)	4,944		10,736		11,543	
FIRR (%)	20.6		10.6		15.3	
Equity (%)	15	30	15	30	15	30
Interest Rate (%)	7.0		7.0		7.0	
First Year Net Profit Generated	1992	1992	1992	1992	1992	1992
First Year Accumulated Net Profit Generated	1992	1992	1992	1992	1992	1992
Remarks						

APPENDICES

APPENDIX 5.A

INFOMATION ON ANG MO KIO BUS

TRUNK BUS SERVICES TO/FROM ANG MO KIO BUS INTERCHANGE

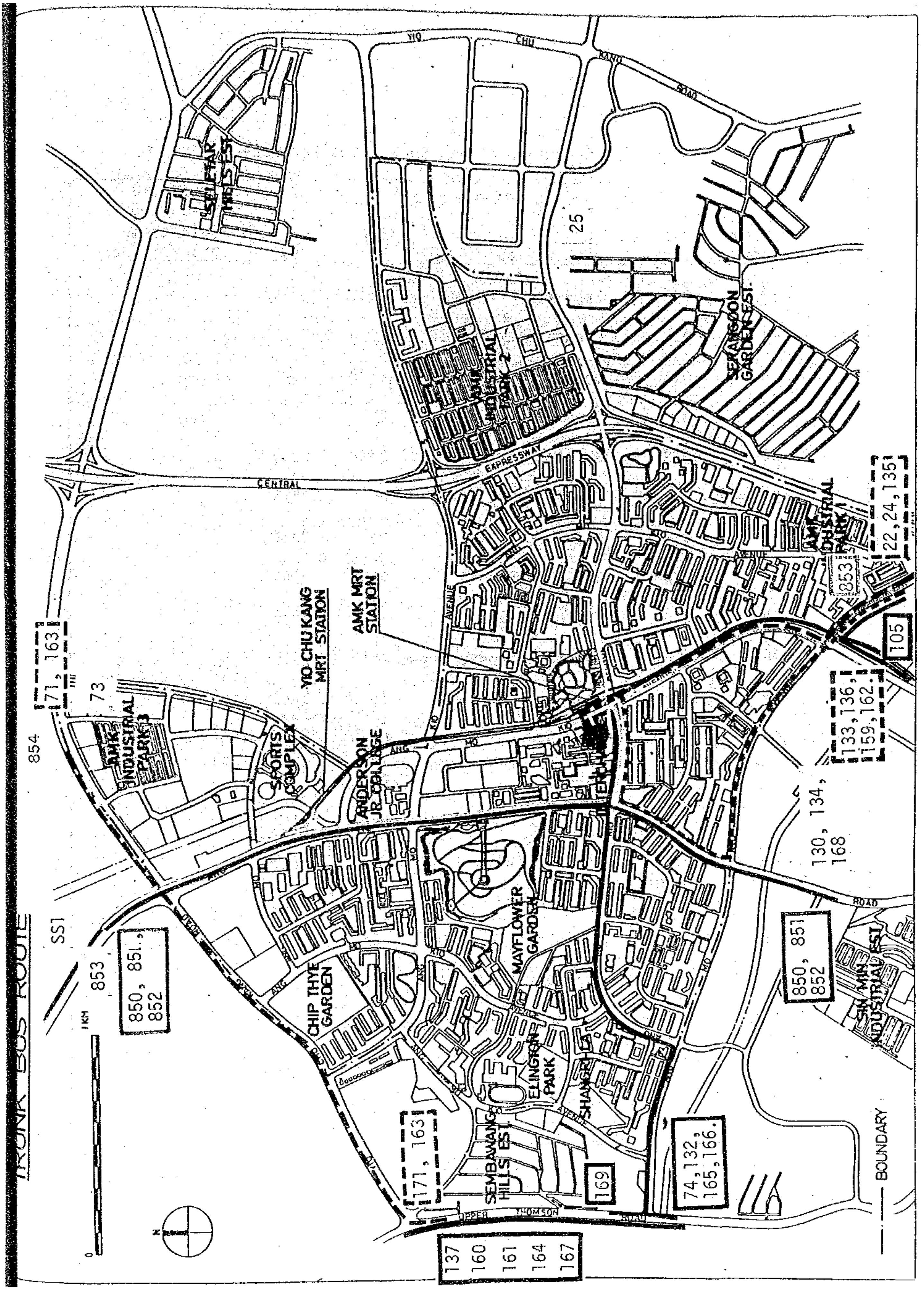
S/no.	Service No.	Service Name (Destination)	Roundtrip Distance (km)	No. of Bus Stops Served	Roundtrip Running Time(mins)	Average Speed (km/h)	Scheduled Trips/day	Frequency Peak/ Off Peak (mins)	No. of Buses Allocated	Bus Type	Daily Cash Rides in 1987
1	22	Tampines	34.55	81	123	16.9	202	9.5/11	14	SD	New Service
2	24	Changi Airport PTB	50.79	94	144	21.2	182	4/7	29	SD	21,754
3	25	Bedok	29.47	70	100	17.7	463	3/5	28	DD	25,806
4	74	Clementi	38.64	91	120	19.3	257	5/8.5	21	DD	8,783
5	130	Shenton Way	32.13	77	130	14.8	207	7.5/11	15	SD	11,861
6	132	Bukit Merah	36.13	80	127	17.1	214	8/10.5	16	DD	10,848
7	133	Marina Centre	27.12	62	107	15.2	304	5/8	21	DD	11,031
8	134	New Bridge Road	25.12	65	108	14.0	271	5.5/8.5	20	DD	10,942
9	135	Marine Parade	33.37	76	131	15.3	226	7.5/10	16	DD	10,463
10	136	Upper Serangoon Rd.	23.94	56	88	16.3	122	5.5/9.5	17	SD	6,808
11	159	Toa Payoh	15.36	26	63	14.6	164	5.5/7	10	DD	10,558
12	162	Sims Avenue	25.21	53	95	15.9	112	7.5/9.5	11	DD	5,690
13	165	Jurong	50.90	112	148	20.6	262	4.5/12	25		13,499
14	166	Labrador	41.85	106	152	16.5	197	8.5/13	16	DD	16,701
15	168	Orchard Road	23.33	57	85	16.5	146	6/7.5	14	SD	9,635
16	169	Woodlands	45.55	97	110	24.8	354	4.5/10	26	SD	23,157
	Total of 16 Services		533,46	1.203	1.831	-	3,683	-	299	-	192,252
	Average of 16 Services		33,34	75	114	17.5	230	5.5/8.8	19	-	12,016

Source : SBS

Trunk Bus Services Passing Ang Mo Kio New Town

Road Name	Service No.	Service Name (Destination)	Roundtrip Distance (km)	No. of Bus Stops Served	Roundtrip Running Time(mins)	Average Speed (km/h)	Scheduled Trips/day	Frequency Peak/ Off Peak (mins)	No. of Buses Allocated	Bus Type	Daily Cash Rides in 1987
AMK Ave 6	73	Yio Chu Kang MRT-Toa Payoh	30.17	74	100	18.1	186	9/12	11	SD	5.571
	850	Yishun-Bukit Merah	53.27	120	148	21.6	279	5.5/9.5	27	SD	19.456
	851	Yishun-Bukit Merah	47.39	110	138	20.6	260	5.5/9.5	23	SD	17.365
	852	Yishun-Jurong	64.74	142	164	23.7	256	6.5/10.5	25	SD	15.589
	853	Yishun-Geylang	38.50	82	118	19.6	218	7.5/10.5	16	SD	10.034
	SS1	Yio Chu Kang MRT-Yishun	16.70	14	39	25.7	106	5/10	8	SD	(249)
	Sub total		250.77	542	707	-	1,305	-	110	-	68.262
	Average		41.80	90	117.8	21.3	218	6.2/10.3	18	-	(11,377)
AMK Ave3	(853)	Yishun-Geylang					(218)	(7.5/10.5)			
AMK Ave8	(853)	Yishun-Geylang					(218)	(7.5/10.5)			
AMK Ave9 St.63 /64	(73)	Yio Chu Kang MRT-Toa Payoh					(186)	(9/12)			
	TOTAL : within Ang Mo Kio						1,305	(6.2/10.3)			68,262
AMK Ave1	105	S'goon-Clementi	48.10	98	141	20.5	193	10/12	15	SD	New Service
Yio Chu Kang	71	Geylang-Old Upper Thomson	35.17	93	118	17.9	126	9.5/15.5	9	SD	3.368
	(73)	Yio Chu Kang MRT-Toa Payoh					(186)	(9/12)			
	163	Jalan Kayu-World Trade Centre	49.11	125	163	18.1	191	8.5/12	18	SD	6,570
	854	Yishun-Bedok	44.25	105	120	22.1	267	6.5/9.5	19	SD	10.629
Yio Chu Kang Rd. Sub total											
Sub total of 3 services (71,163,854)			128.53	323			584 (770)	7.9/11.9	46	-	20.567
Average of 4 service			42.8	108	134	19.2	195		15	-	6.856
Upper Thomson Rd	137	Toa Payoh-S'pore Zoo	38.99	82	93	25.2	79	12/13.5	8	SD	4.503
	160	Admiralty Rd.W Crawford St.	47.42	121	124	22.9	215	7.5/13.5	18	SD	9.370
	161	Sembawang Rd End -Shenton Way	51.53	127	132	23.4	192	8/14	17	SD	8.120
	164	Sembawang Rd End -New Bridge Rd	49.05	126	124	23.7	199	8.5/13.5	15	SD	7.686
	167	Admiralty Rd.W -World Trade Centre	60.30	152	154	23.5	201	7.5/12.5	19	SD	13.223
	(71)	Geylang-Old Upper Thomson	n.a.	n.a.	n.a.	n.a.	(126)	(9.5/15.5)	n.a.		n.a.
	(163)	Jalan Kayu-World Trade Centre	n.a.	n.a.	n.a.	n.a.	(191)	(8.5/12)	n.a.		n.a.
	Sub total		247.29	608	-	-	886 (1,203)	-	77		42.902
	Average:to/from Ang Mo Kio		49.46	122	125	23.7	1.470 (1.973)				

Source : SBS



TRUNK BUS ROUTE
YIO CHU KANG ROAD
CENTRAL EXPRESSWAY
SELETAR HILLS EST.
SERANGOON GARDEN EST.
AMK INDUSTRIAL PARK 2
AMK INDUSTRIAL PARK 1
AMK INDUSTRIAL PARK 3
SPORTS COMPLEX
YIO CHU KANG MRT STATION
AMK MRT STATION
ANDERSON JR. COLLEGE
MAYFLOWER GARDEN
CHIP THYE GARDEN
ELINGTON PARK
SHANGRI-LA
SEMBAWANG HILLS EST.
SIN MING INDUSTRIAL EST.
UPPER THOMSON ROAD
BOUNDARY
25
854
73
71, 163
853
851
850, 851, 852
171, 163
169
137 160 161 164 167
74, 132, 165, 166.
850, 851 852
130, 134, 168
133, 136, 159, 162.
105
853
22, 24, 135
1KM
0
N

Bus Operation at Ang Mo Kio Bus Interchange

	Bus Service Number	Fare System	Destination	1st Bus	Last Bus	Scheduled Frequency (minutes) Peak/Off-Peak
1	22	OTS	Tampines	0545	2330	
2	24	OTS	Changi Airport PTB	0530	2300	
3	25	OTS	Bedok	0530	2345	
4	74	OTS	Clementi	0530	2330	
5	130	OTS	Shenton Way	0530	2330	
6	132	OTS	Bukit Merah	0525	2315	
7	133	OTS	Marina Centre	0530	2330	
8	134	OTS	New Bridge Road	0600	2300	
9	135	OTS	Marine Parade	0530	2330	
10	136	OTS	Upper Serangoon Road	0545	2330	
11	159	Flat Fare	Toa Payoh	0550	2345	
12	162	OTS	Sims Avenue	0540	2300	
13	165	OTS	Jurong	0530	2320	
14	166	OTS	Labrador	0530	2315	
15	168	OTS	Orchard Road	0545	2300	
16	169	OMO-DRF	Woodlands	0530	2345	
17	261	Flat-Fare	Industrial Park 1	0510	0100	
18	262	Flat-Fare	Ang Mo Kio Ave 2	0530	0015	
19	265	Flat-Fare	Ang Mo Kio Ave 10	0530	0030	
20	266	Flat-Fare	Ang Mo Kio Ave 4/5	0530	2400	
21	267	Flat-Fare	Industrial Park 2	0530	2400	
22	269	Flat-Fare	Ang Mo Kio St. 61	0530	0015	

SOURCE : BUS GUIDE (1988), SBS

APPENDIX 5.B

An Exercise to Assess the Impact of Vehicle Size on the Structure Dimension and Cost

A. Introduction

With the assistance of PWD's Structure Division, an exercise was made to determine the impact of vehicle size on the cost of structure, particularly the carriageway. Normally, the smaller the vehicle, the lesser is required for infrastructure cost. However, smaller vehicles with higher frequencies increase the service level of transport but push the rolling stock cost. The objective of this exercise is to estimate the carriageway cost for vehicles with different passenger carrying capacity.

B. Assumptions

As shown in Figure 1, assumptions were made on loading condition, car capacity and certain dimensions of the structure.

C. Results of Analysis

1) Bending Moment and Vehicle Capacity

Figure 2 shows the relationship between car capacity and bending moment. Bending moment does not decrease in proportion with the reduction in car passenger capacity. The bending moment for a 75-passenger capacity car load is 4,077 KNm, while that for a 35-passenger capacity car is 3,197 KNm which accounts for only 20% reduction. The percentage of the above reduction for longer span (l=30m) is smaller than for shorter span (l=25m).

2) Comparison of case 1-3 (two-car train with 75 passengers/car) and case 2-1 (four-car train with 35 passengers/car), which are almost similar showed that the latter case has a less bending moment by 16%. This means the impact of a train composed of smaller cars on the structure is less than that of longer capacity cars.

3) Table 1 summarizes the results of analysis, including estimated costs. The cost estimate was made based on the assumption that side-wall, support surface, guidance and other minor structures are the same in all the alternatives. The results did not vary much among the alternatives for the following reasons:

a) The area required for girder due to live load is smaller than that of dead load/self weight.

b) As the girders have the same concrete volume, the same bending moment are produced by self weight. The effect of the live load, therefore, is limited.

APPENDIX 5.C

Comparison of Structural Design Between Singapore and Japan

A. Introduction

It is commonly observed that structures made in Japan according to its design standards tend to become massive and heavy. This short paper intends to clarify the background and differences in design standards and practices between the two countries. Major factors investigated are:

a) Difference in design method
b) Difference in horizontal load due to earthquake and typhoon
c) Influence of temperature difference

B. Comparison

1) Design Standards

"Ultimate Limited State Method" established based on British Standards is applied in Singapore, while allowable stress method is being used in Japan. In the former method, a certain safety coefficient is multiplied with dead load and live load to estimate stress. As the safety coefficient is set such that the area becomes similar in size with that determined by the allowable stress method, the difference in the results is therefore negligible.

2) Influence of Earthquake and Typhoon

Road and Rail bridges in Singapore are constructed using girders. Bridges with ramen type structures have been constructed except for MRT stations. Column section of this structure type is significantly affected by horizontal load. An exercise was undertaken to estimate the column section based on the assumption that loading is of 2-car train with a capacity of 75 passengers per car, with a weight of 18 tons per car, and horizontal load coefficient due to earthquake of Kn = 0.24 for Japan and Kn - 0.1 for Singapore. Wind is also another factor for horizontal strength but Kn = 0.1 is large enough for Singapore circumstance to cover the impact of wind. The result indicates that the 2m x 2m column section designed according to Japanese standards can be reduced to 1.5m x 1.5m.

3) Influence of Temperature

A girder type structure popularly practiced in Singapore is hardly affected by temperature difference.

Accordingly, the major factors which cause significant differences in section size of structures between Singapore and Japan are earthquake and typhoon.

C. Considerations for Reduction of Structure Section

For economy and aesthetics, space occupancy of structures need to be minimized. Possible measures include:

a) Reduction in loading by simplifying vehicle design, use of lighter materials, removal/simplifying of side-wall and inspection of walkway, etc.

b) Reduction in dead load of girder by using steel materials, pre-stress, etc.

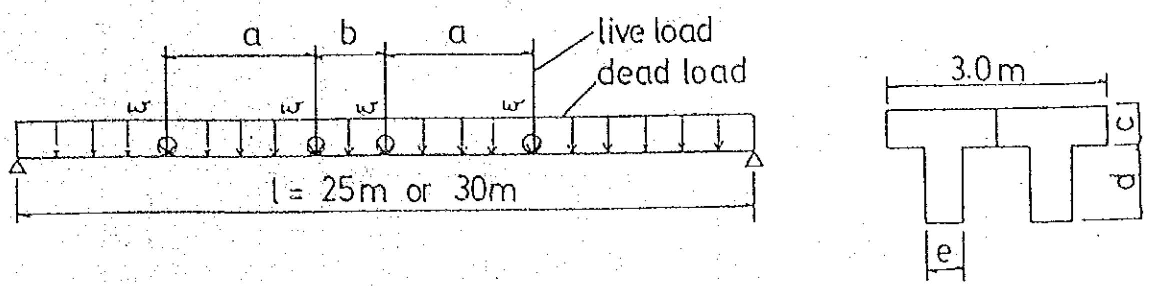
c) Effective use of girder section.

d) To lower the height of structures: the higher the structure becomes the larger bending moment is generated; thus the section size increases.

e) To improve visual design: structures need to be designed with careful consideration of the visual aspect. The same size of structures look completely different depending upon the design.

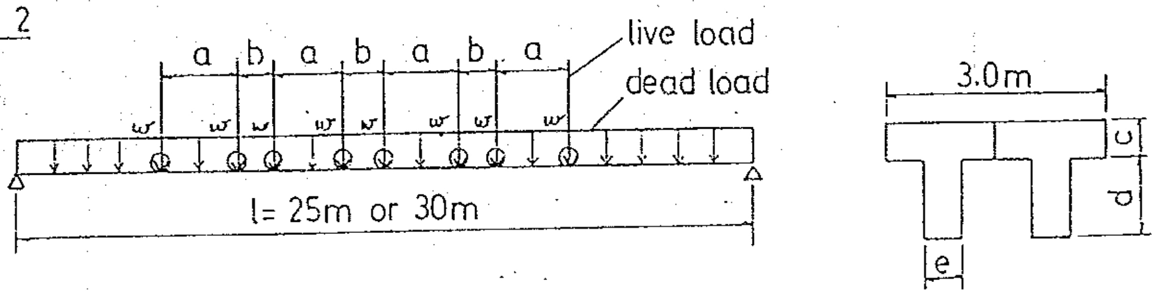
Figure 1 Assumed Load Condition

CASE 1



Case	Car Capacity (No. of pass)	w (tons)	a (meter)	b (meter)
1-1	35	4	4	2
1-2	50	6	4	3
1-3	75	9	5	3
1-4	100	12	10	3

CASE 2



Case	Car Capacity (No. of pass)	w (tons)	a (meter)	b (meter)
2-1	35	4	4	2
2-2	50	6	4	3
2-3	75	9	5	3
2-4	100	12	10	3

Figure 2 Vehicle Capacity and Bending Moment

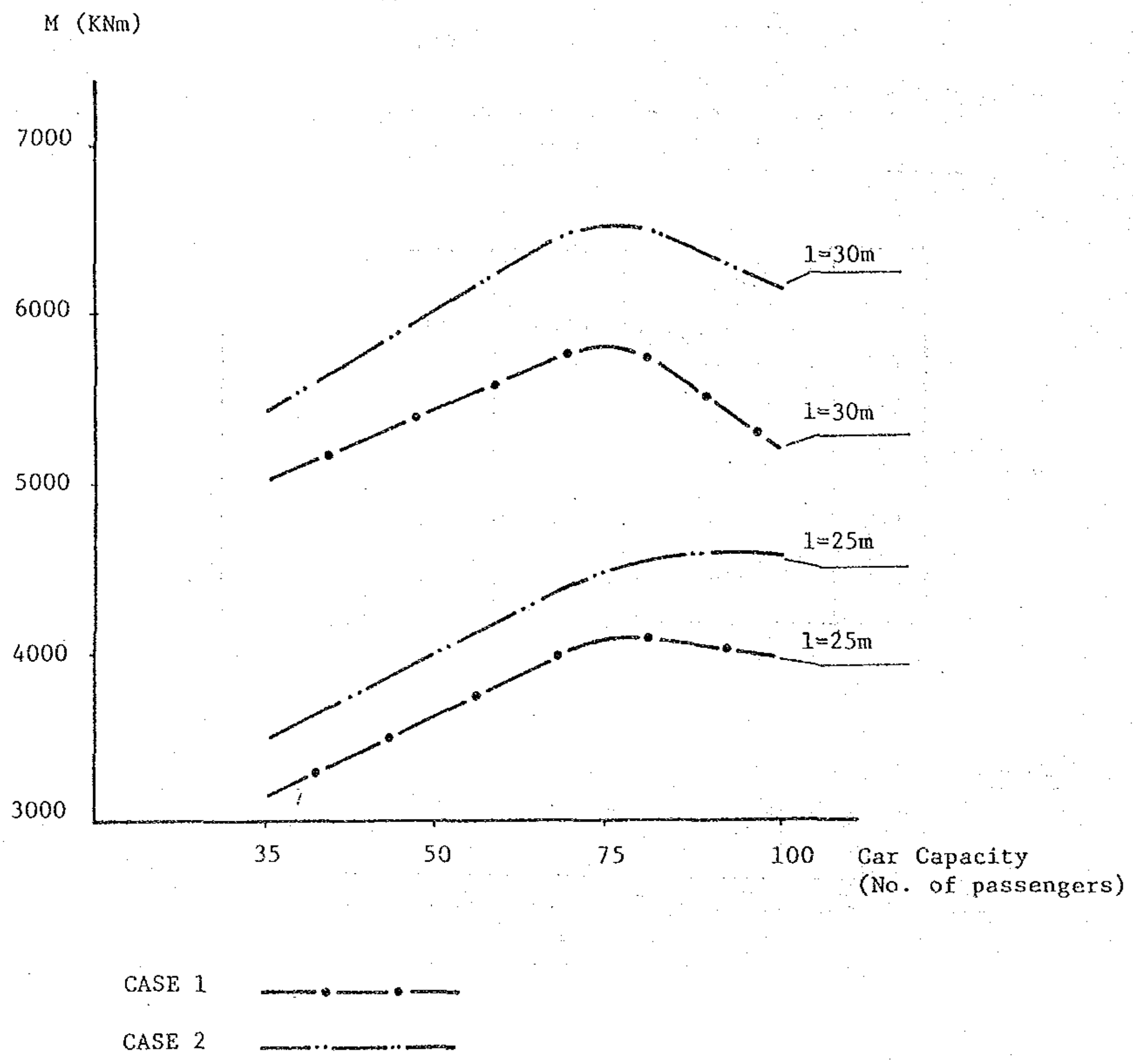
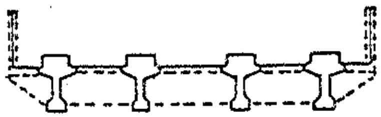
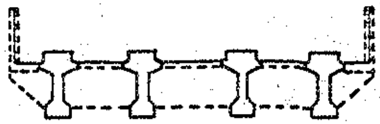
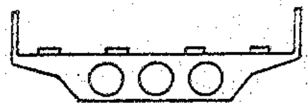
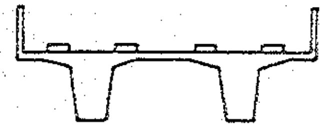


Table-1 Summary of Estimated Carriageway Dimension and Cost

	SPAN: l = 25 m								SPAN: l = 30 m							
	CASE 1				CASE 2				CASE 1				CASE 2			
	Car Capacity (No. of passengers)				Car Capacity (No. of passengers)				Car Capacity (No. of passengers)				Car Capacity (No. of passengers)			
	35	50	75	100	35	50	75	100	35	50	75	100	35	50	75	100
Moment:																
Md (KN m)	2437	2547	2547	2547	2547	2547	2547	2547	3991	3991	3991	3991	3991	3991	4172	4172
Ml (KN m)	760	1080	1530	1440	960	1380	1980	2040	1040	1320	1800	1440	1440	1920	2520	2100
M (KN m)	3197	3627	4077	3987	3507	3927	4527	4587	5031	5311	5791	5431	5431	5911	6692	6272
Girder:																
c (mm)	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
d (mm)	900	1000	1000	1000	1000	1000	1000	1000	1200	1200	1200	1200	1200	1200	1300	1300
e (mm)	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Area (m2)	1.14	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.32	1.32	1.32	1.32	1.32	1.32	1.38	1.38
Cost: S$/m																
Girder	1047	1098	1113	1098	1098	1098	1113	1113	1215	1215	1231	1215	1215	1231	1297	1297
Sub structure	355	355	377	377	367	367	377	377	332	332	361	361	361	361	384	384
Total	1402	1453	1490	1475	1465	1465	1490	1490	1547	1547	1592	1576	1576	1592	1681	1681

APPENDIX 5.D

COMPARISON OF SUPERSTRUCTURE

SUPERSTRUCTURE	PRE-TENSIONED SIMPLE T GIRDER	POST-TENSIONED SIMPLE T GIRDER	3 SPAN CONTINUOUS CELLULAR SLAB BEAM	3 SPAN CONTINUOUS TWO GIRDERS
ILLUSTRATION				
SPAN LENGTH (M)	20.0	25.0	3 x 25.0 = 75.0	3 x 25.0 = 75.0
SUMMARY OF SUBSTRUCTURE	Boring pile d800x23mx5 Pier, RC T Shape Bearing (F, M)	Boring pile d1000x23mx4 Pier, RC T Shape Bearing (F, M)	Boring pile d1000x23mx4 Pier, RC T Shape Reaction force dispersion system (1:2:2:1)	Boring pile d1000x23mx4 Pier, RC T Shape Reaction force dispersion system (1:2:2:1)
LAUNCHING	Track crane	Track crane	Erection Girder	Erection Girder
SUPPORT SURFACE	Top of Girder	Top of Girder	Cast in Place Concrete	Cast in Place Concrete
ACCURACY OF SURFACE	10 to 15mm allowance per 1 Girder will be required		Around 10mm allowance per 3 spans will be required	
HORIZONTAL CURVES	Impossible (Folding by every span)		Possible by R=500m	
VERTICAL CURVES	Impossible	Around 100mm Shift possible	Adjusted by support surface	
FLOOR SLAB	Pre-cast RC Slab		Structural Slab	
SIDE WALL	Pre-Cast RC column + Pre-cast Slab		Cast in place	
BEAM MANUFACTURE	At specified factory	At produce yard near site	Cast in site	
CONSTRUCTION SCHEDULE	Possible from any part		In order	
TRAFFIC PROBLEM	Beam carry into site, erection		Very rare	
EXPANSION JOINT REQUIRED	Every 20m	Every 25m	Every 75m	
AESTHENIC HARMONY	Complex	Complex	Simple	A little complex
CONSTRUCTION COST — SUBSTRUCTURE	62.2%	70.4%	100	96.0%
CONSTRUCTION COST — SUPERSTRUCTURE	112.0%	95.8%	100	106.6%
CONSTRUCTION COST — TOTAL	77.3%	78.1%	100	99.2%

APPENDIX 5.E

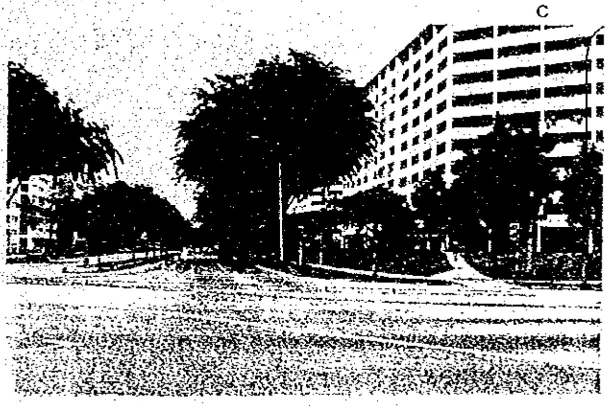
VIEWS OF THE PROPOSED SITES FOR NTS STATIONS

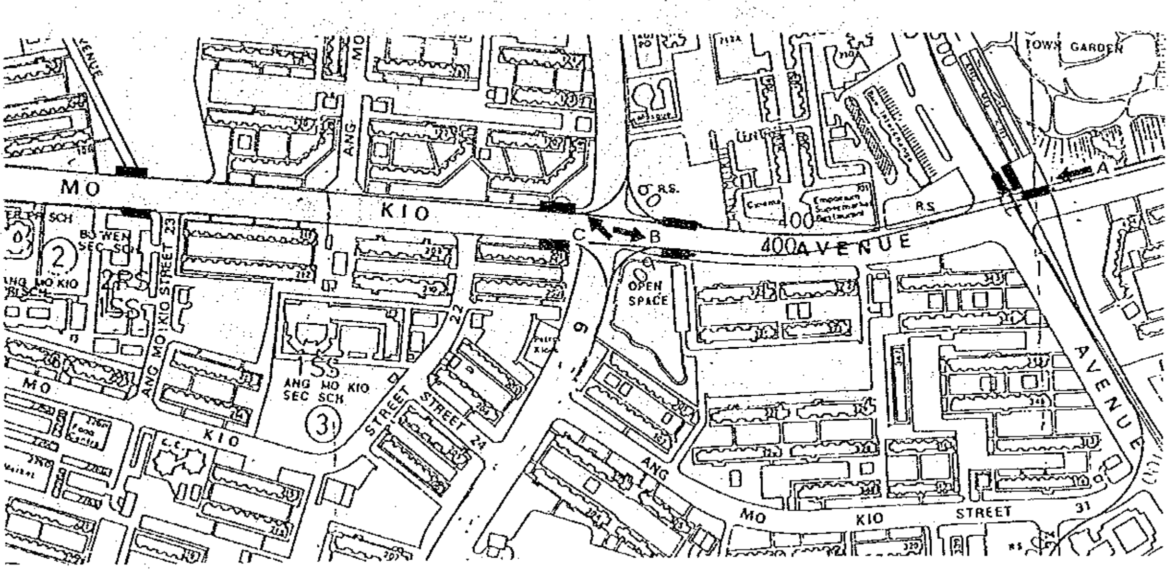
IN ANG MO KIO

A

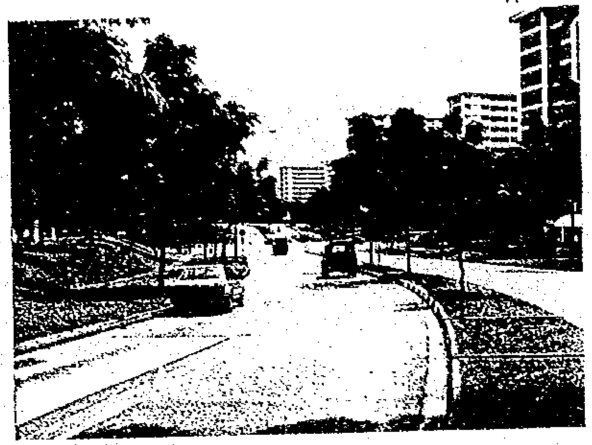
B

C



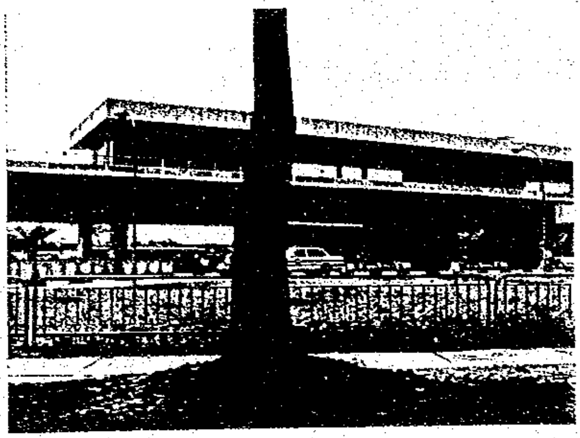

MO
KIO
400 AVENUE
AVENUE
TOWN GARDEN
R.S.
A
B
C
BOWEN SEC SCH
ANG MO KIO STREET 23
ANG MO KIO SEC SCH
STREET 22
STREET 24
OPEN SPACE
MO KIO STREET 31

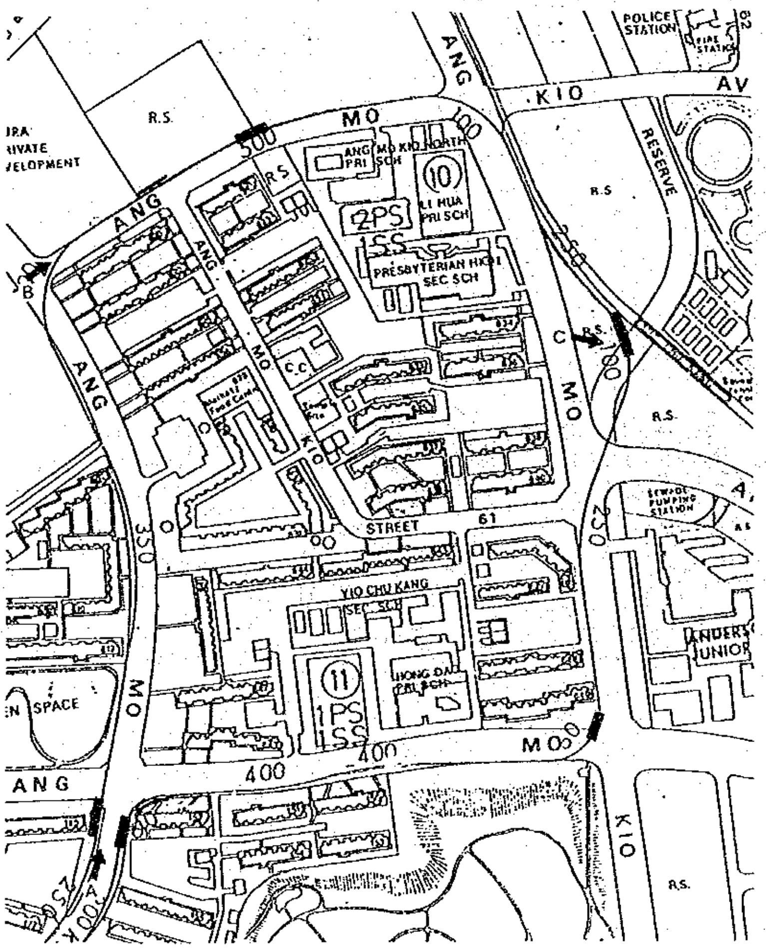
A



B

C

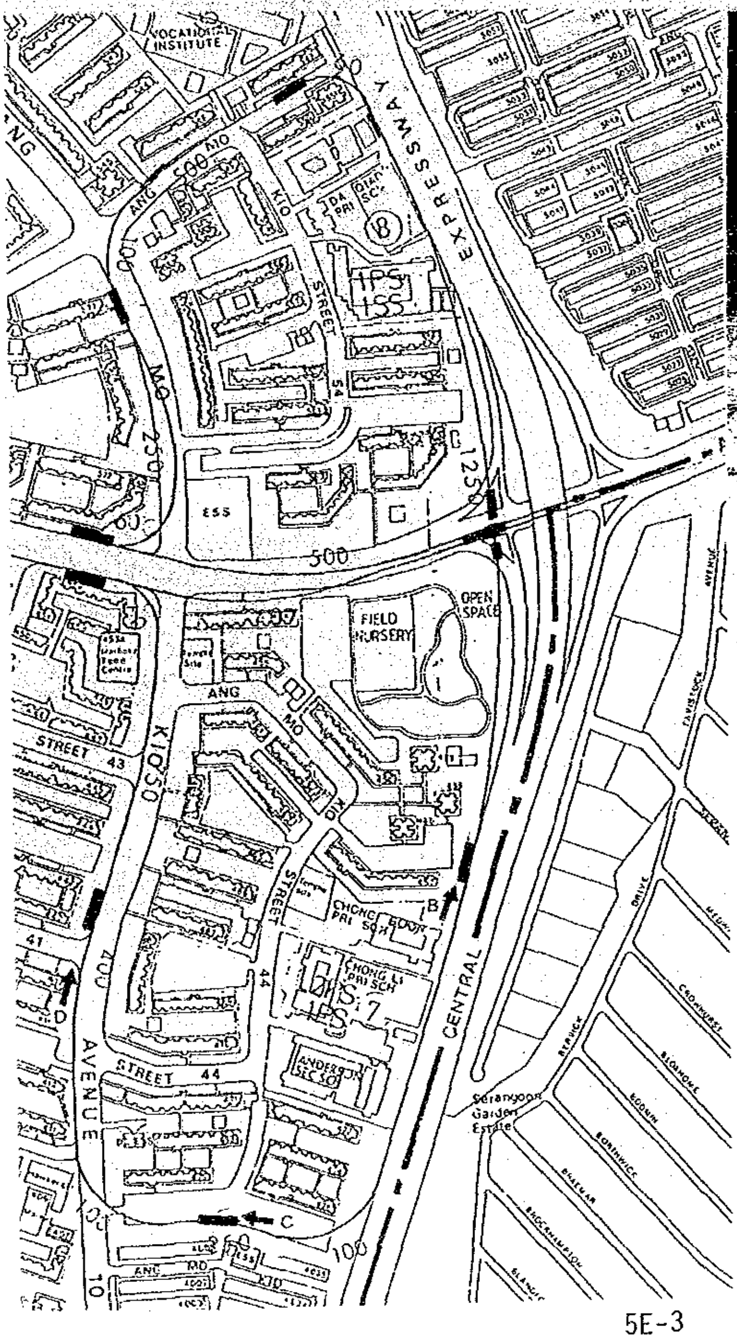



POLICE STATION
KIO
AV
RESERVE
ANG
MO
500
100
R.S.
LI HUA PRI SCH
PRESBYTERIAN HIGH SEC SCH
STREET
61
YIO CHU KANG SEC SCH
SEWAGE PUMPING STATION
SPACE
350
400
250
KIO

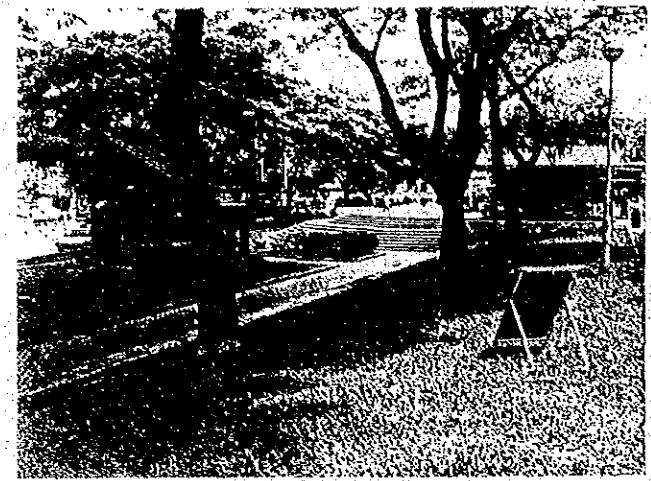
A

B

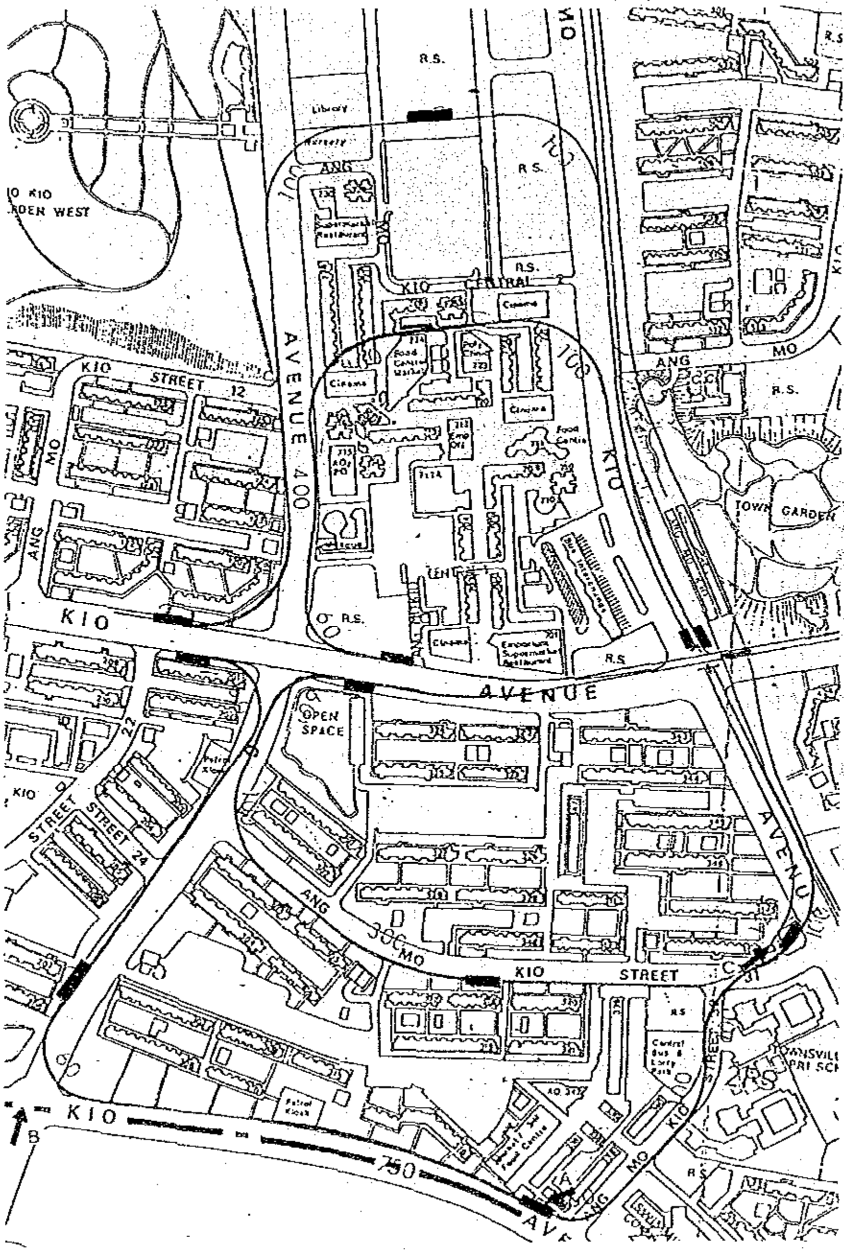
C


VOCATIONAL INSTITUTE
EXPRESSWAY
ANG MO KIO
STREET
500
125
FIELD NURSERY
OPEN SPACE
STREET 43
CENTRAL
AVENUE
STREET 44
100
Serangoon Garden Estate
DRIVE
B
C

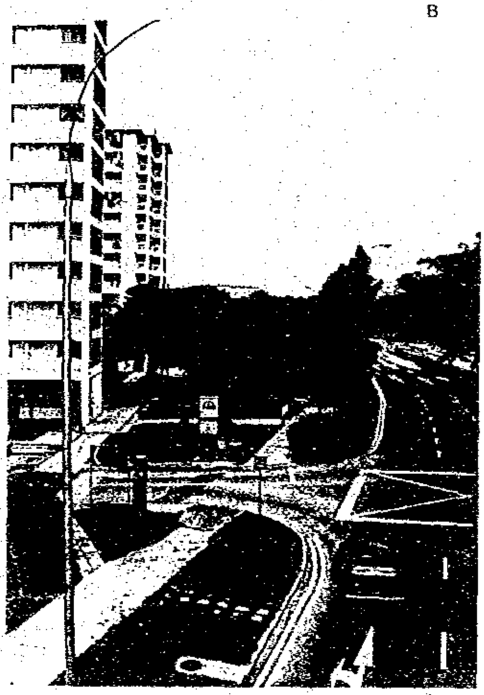
A



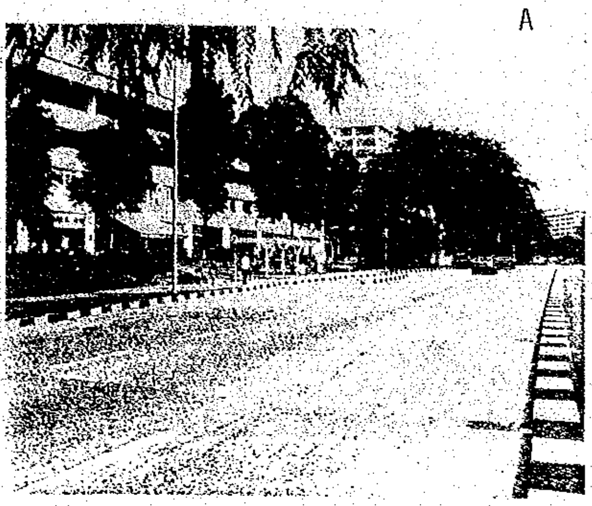
C


R.S.
Library
Nursery
ANG
MO
KIO
CENTRAL
Cinema
AVENUE 400
KIO STREET 12
AVENUE
OPEN SPACE
TOWN GARDEN
KIO STREET 31
KIO
B
A

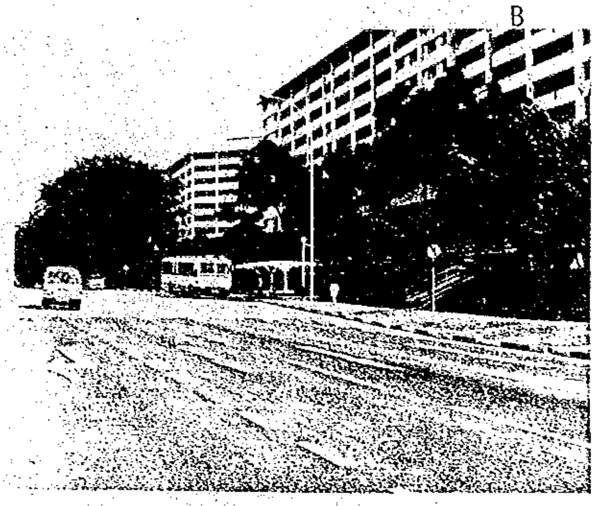
B

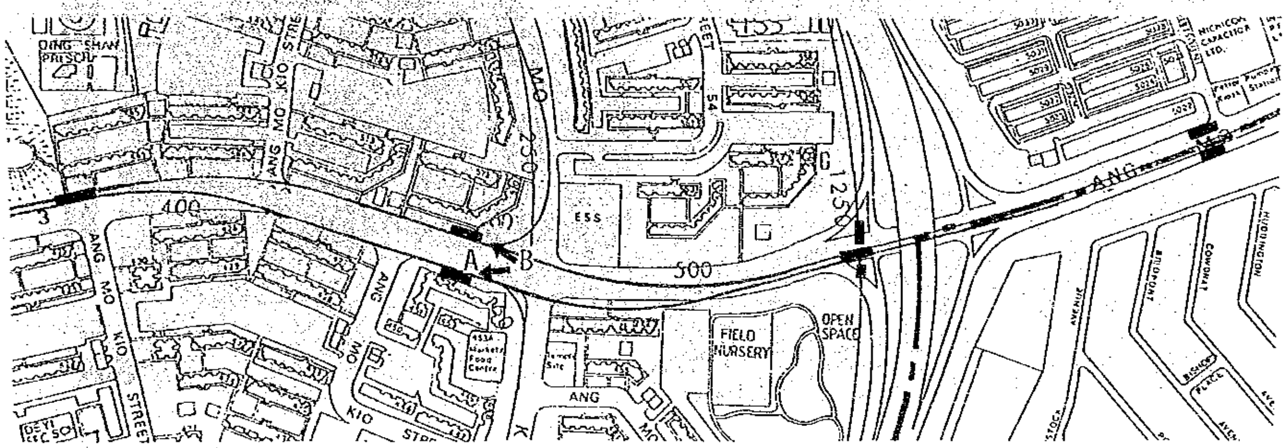


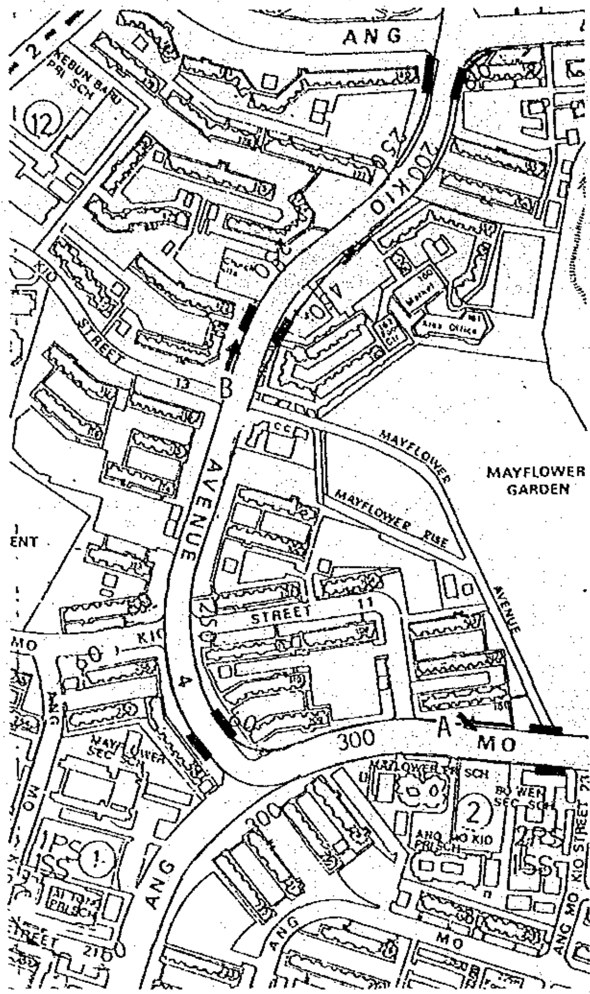
A



B




ANG MO KIO STREET
ANG MO KIO
400
A
B
500
ESS
FIELD NURSERY
OPEN SPACE
ANG
ANG MO
KIO
STREET
ANG

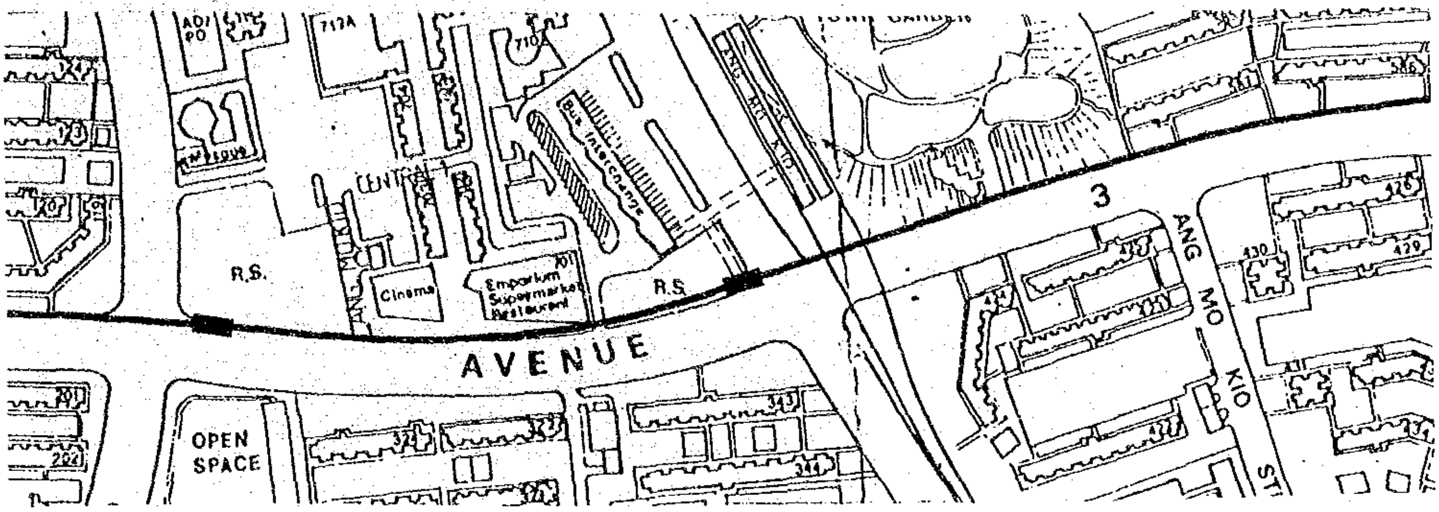

ANG
KEBUN BARU PRI SCH
AVENUE
STREET
MAYFLOWER
MAYFLOWER GARDEN
MAYFLOWER RISE
AVENUE
STREET
300
MO
B
A
MAYFLOWER SEC SCH
MAYFLOWER PRI SCH
BO WEN SEC SCH
ANG MO KIO PRI SCH
ANG

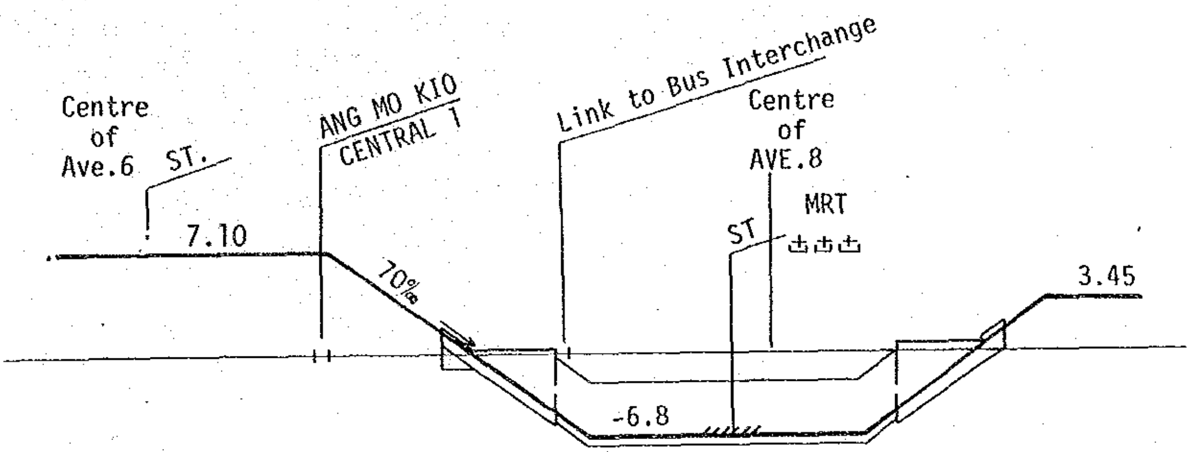
A

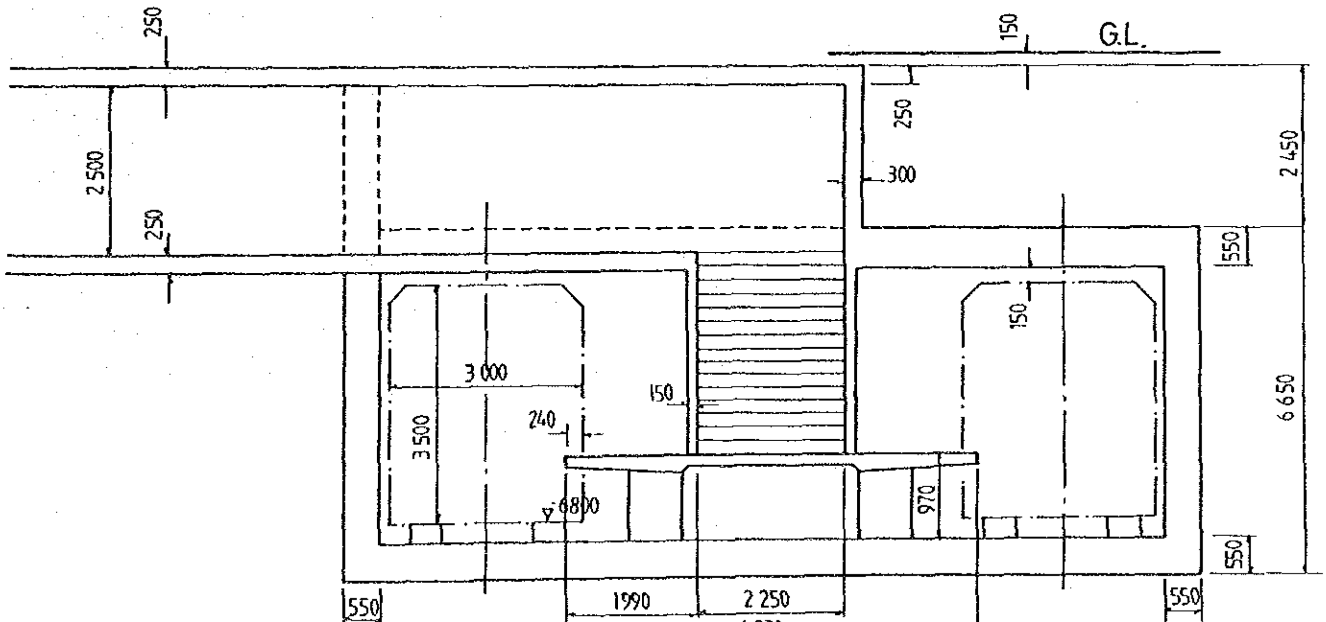
B

APPENDIX 5.F

Ang Mo Kio Station (Underground)





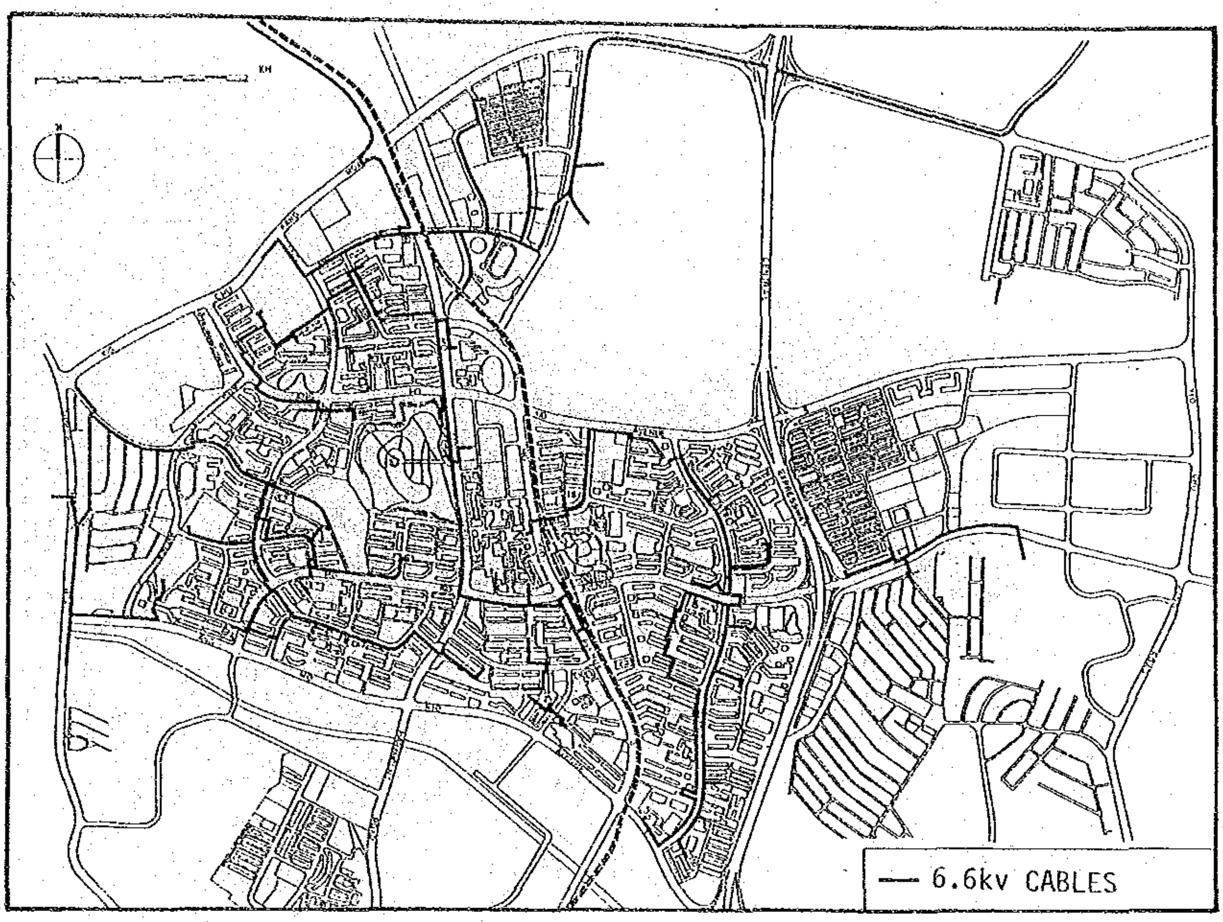


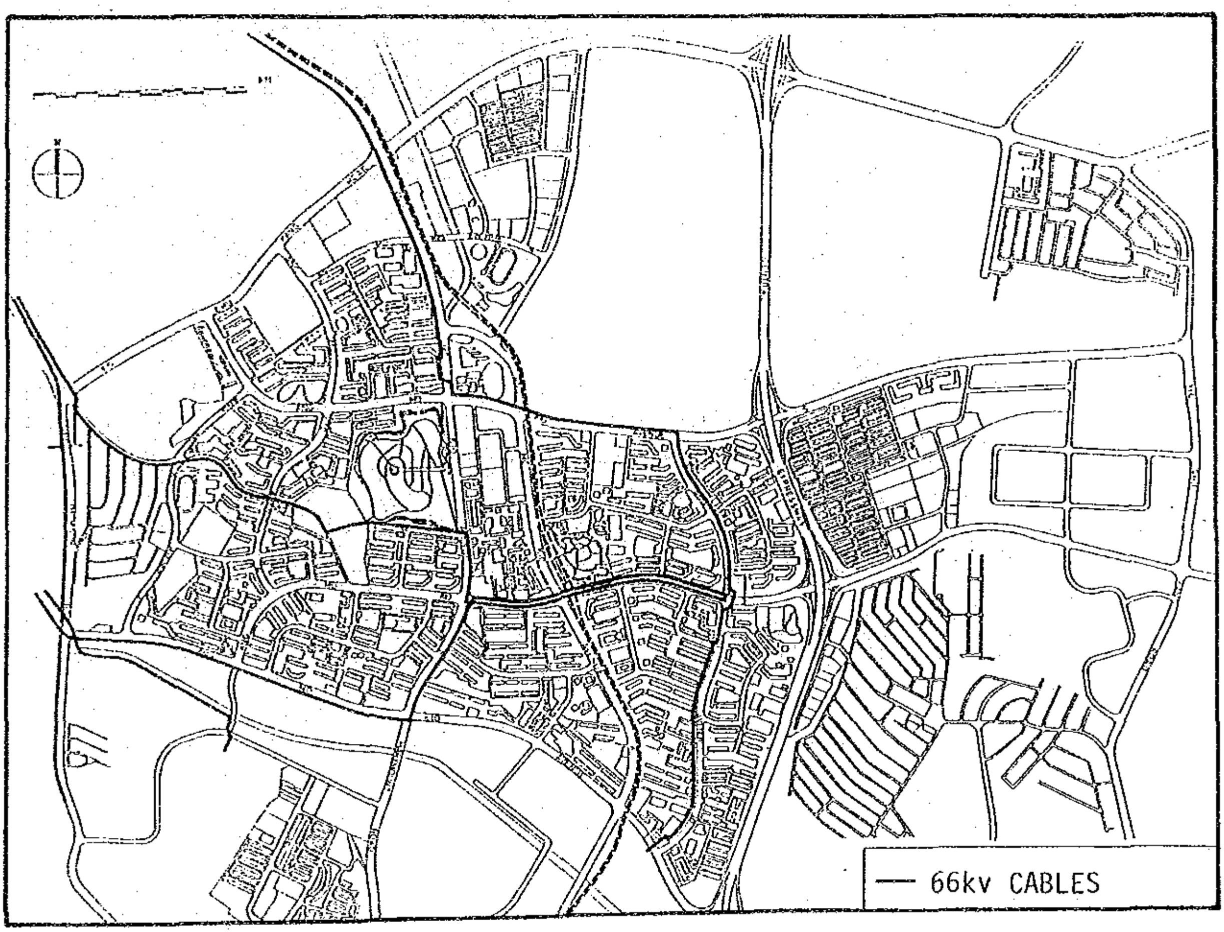
APPENDIX 5.G

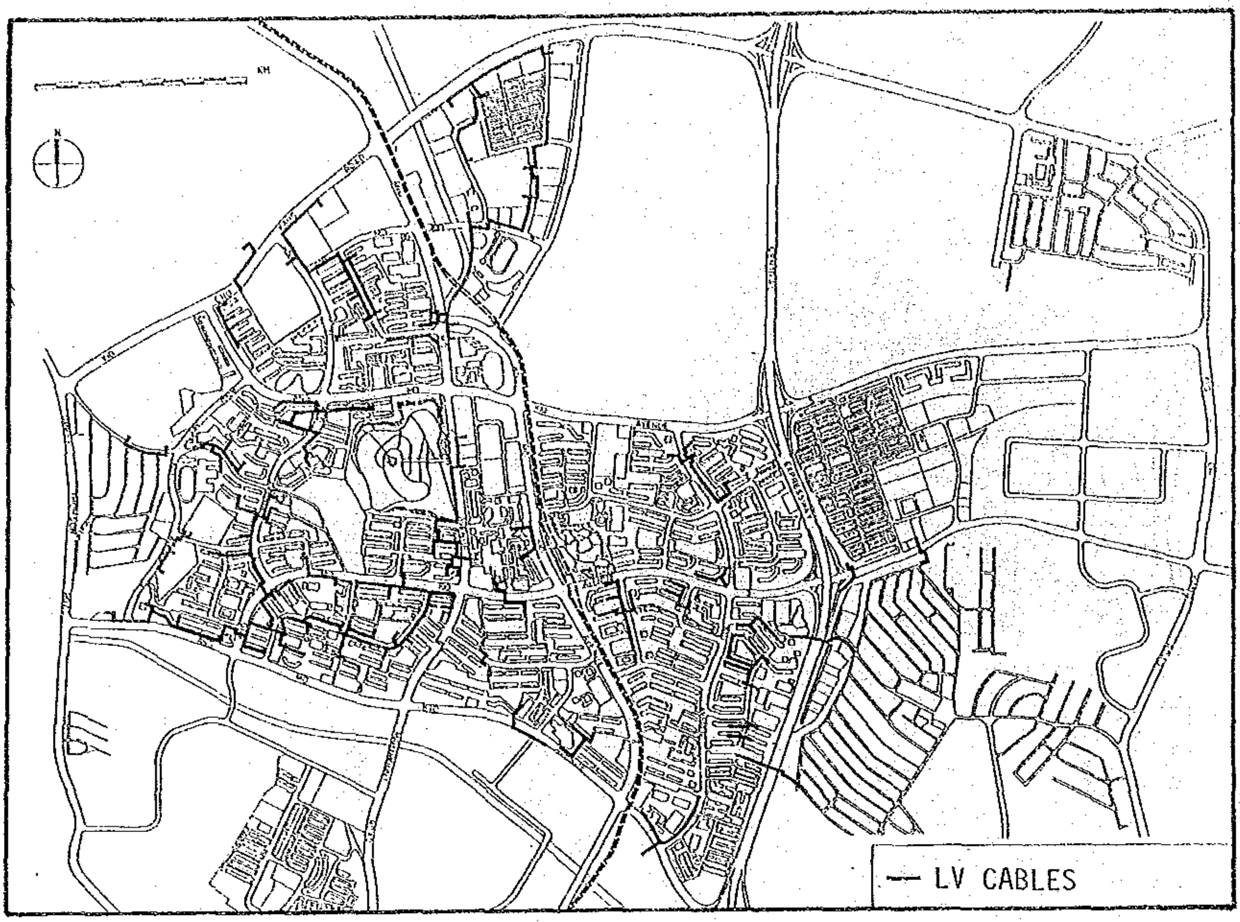
LOCATION OF UNDERGROUND UTILITIES

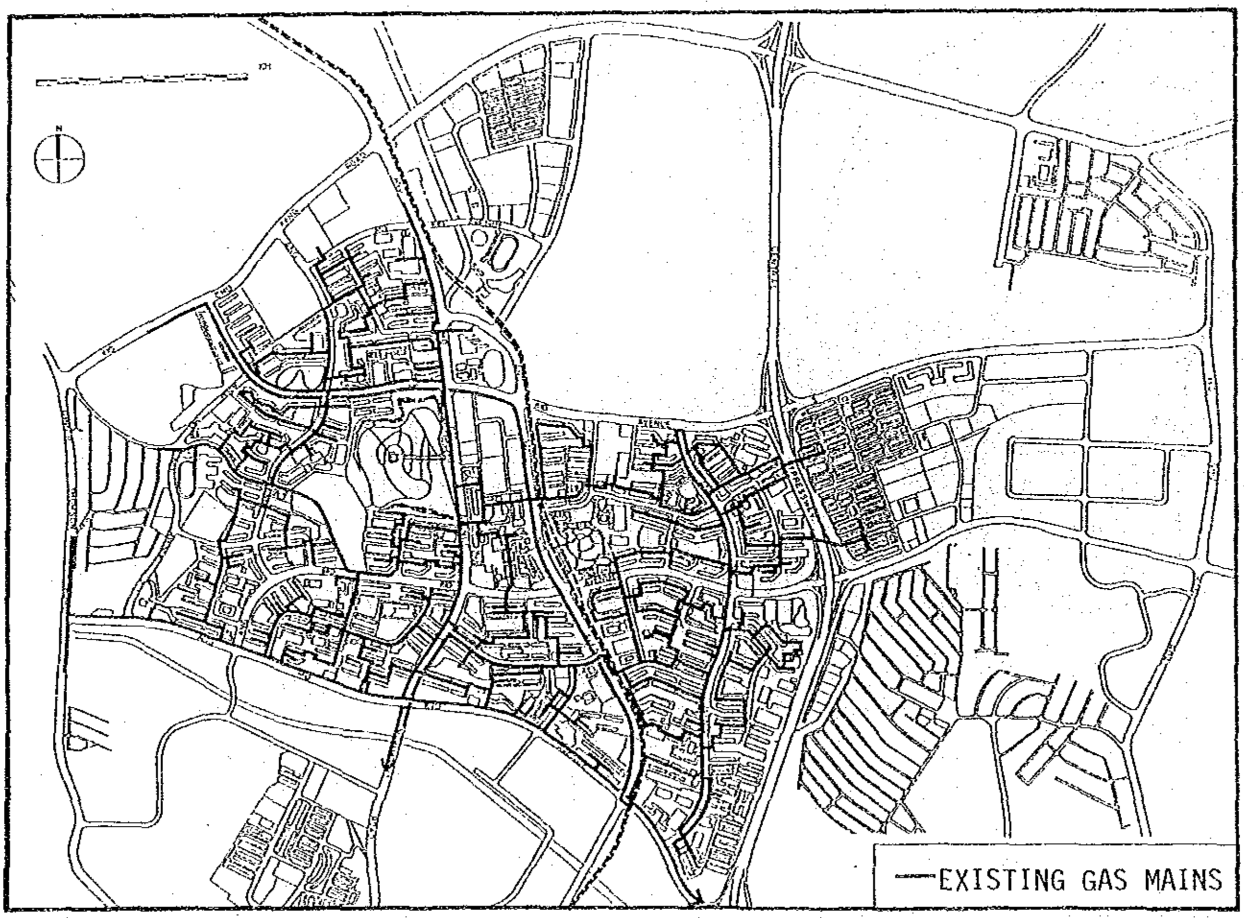
APPENDIX 5.G

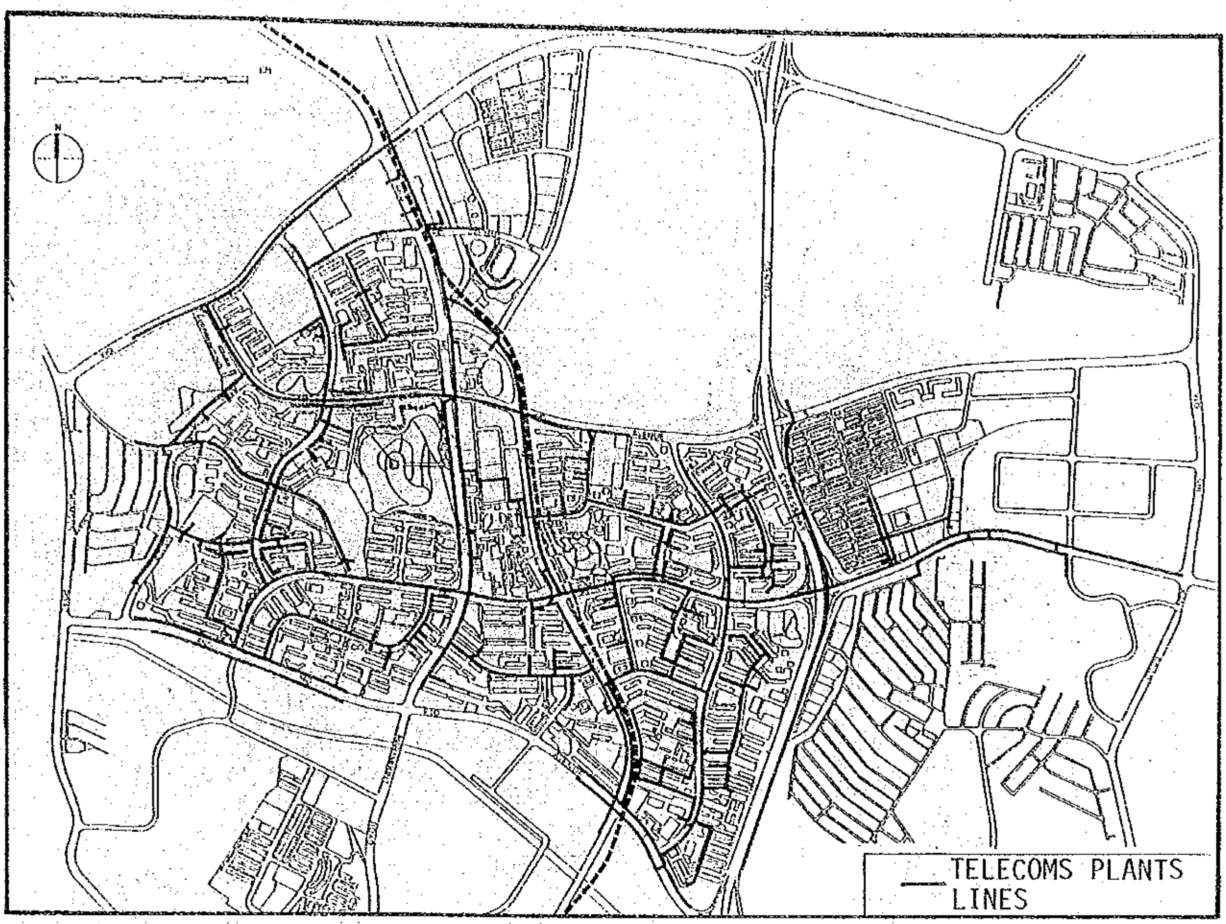
LOCATION OF UNDERGROUND UTILITIES

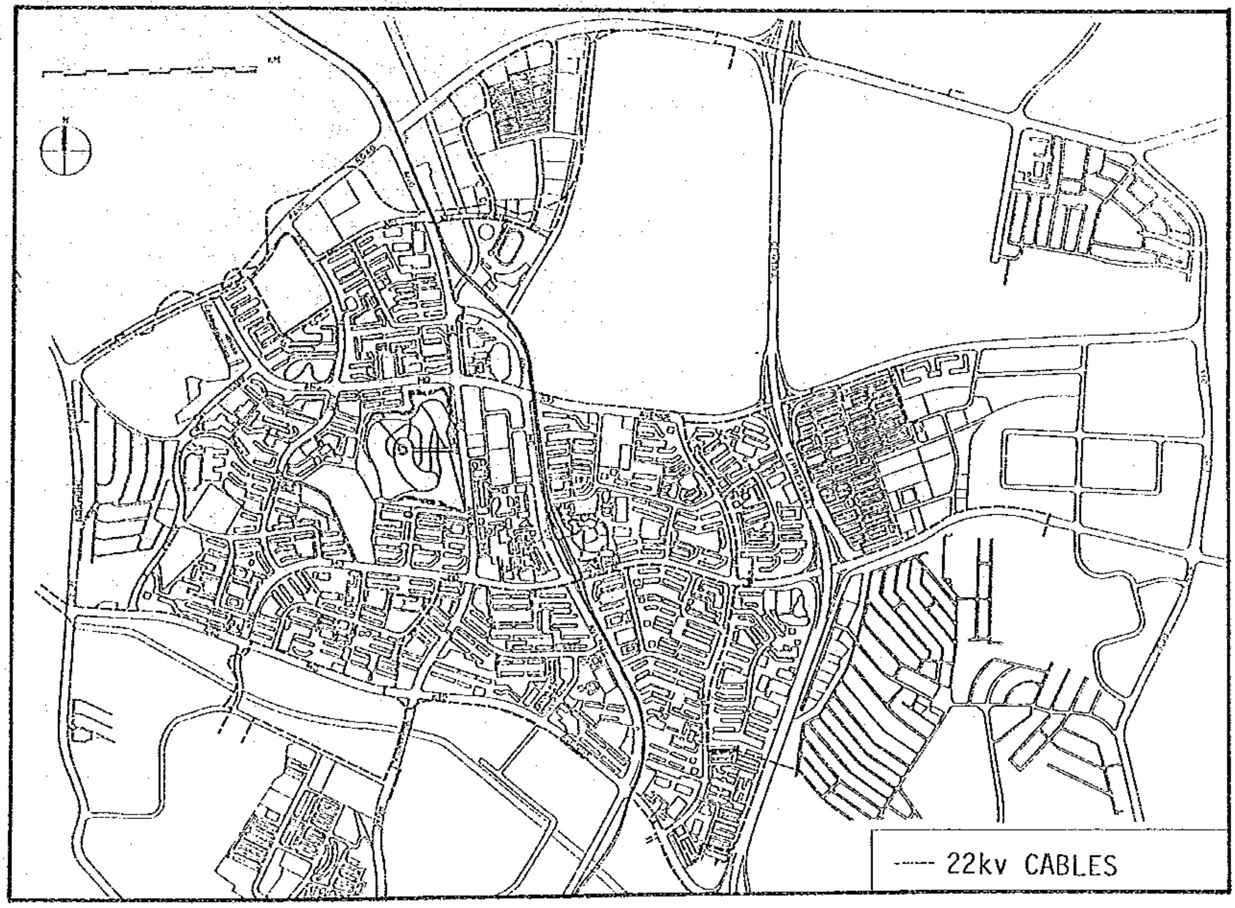


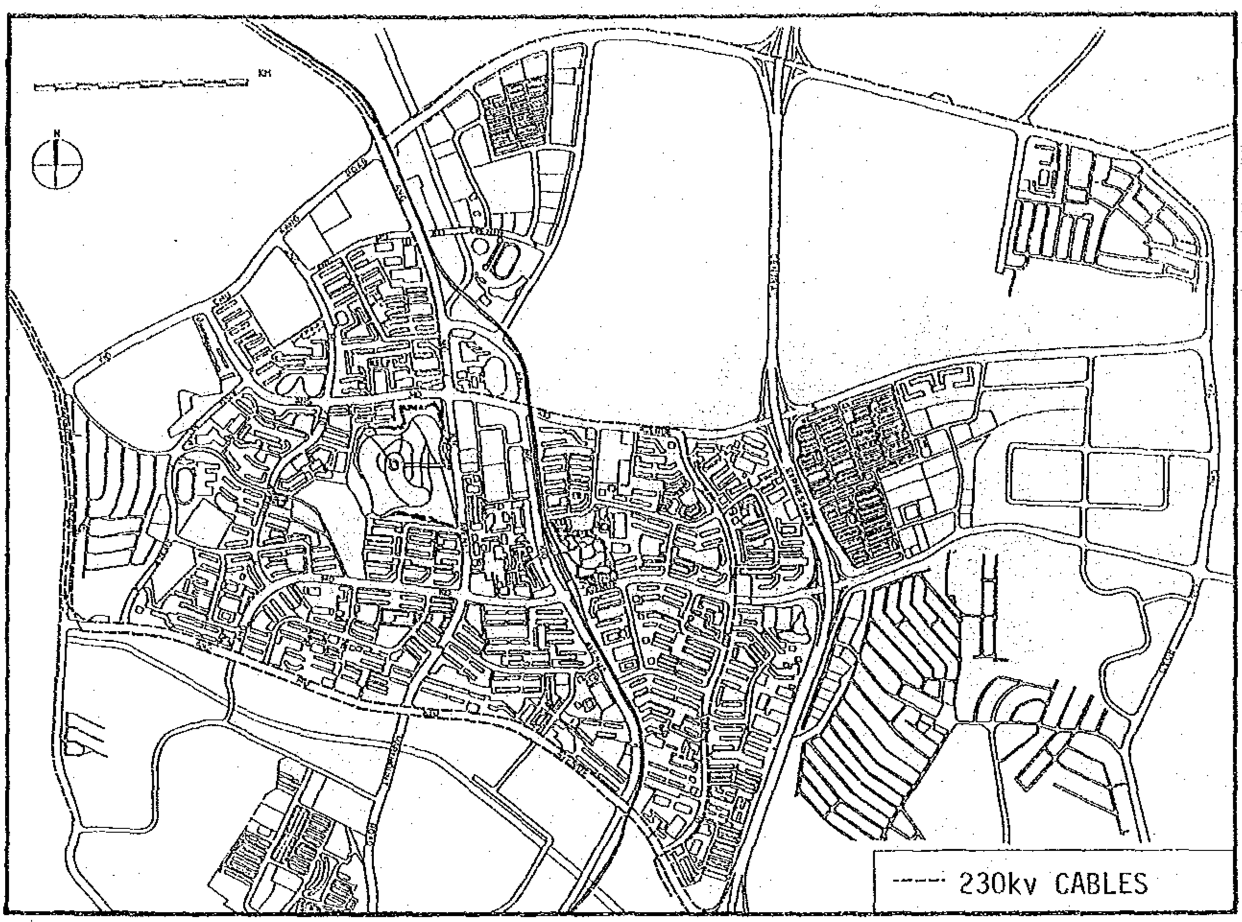



LV CABLES


EXISTING GAS MAINS


TELECOMS PLANTS
LINES


22kv CABLES


KM
N
---- 230kv CABLES

APPENDIX 5.H

Price of Major Work Items

	I T E M	PWD	Private Company
1.	Post-tension concrete bridge Unit price per concrete volume	850 $/m^3$	
2.	Prestressed concrete bridge Unit price per concrete volume	850 $/m^3$	
3.	Reinforced concrete for pier Unit price per concrete volume	450 $/m^3$	
4.	Reinforced concrete for footing Unit price per concrete volume	450 $/m^3$	
5.	Precast concrete pile foundation Unit price per piling length		30 $/m
6.	Cost-in-place pile foundation Unit price per piling length	ϕ600 110$/m ϕ1000 220$/m	
7.	Steel pile foundation Unit price per piling length	N.A.	
8.	Steel bridge Unit price per unit bridge weight		7000 $/t ~ 8000
9.	Railway track laying Unit price per single track length		
10.	Pavement removing and rebuilding in depot of 0.60m Unit price per unit surface area	50 $/m^2$	
11.	Building for ordinary office Unit price per floor space		500~700$/m^2$
12.	Building for workshop & inspection shed Unit price per floor space		750~800$/m^2$
13.	Building for warehouse Unit price per floor space	N.A.	
14.	Architectural finish for station Unit price per inside floor space Unit price per outside wall area	950 $/m^2$ 1200 $/m^2$	
15.	Shelter on platforms and mezzanines Unit price per unit area	N.A.	

APPENDIX 5.I

Comparison of Estimated Construction Cost
for Single Track and Double Track Structures

(in million)

Item	Unit	Unit Price	Single		Double	
			Quantity	Amount	Quantity	Amount
1. Girder (including super structure)	M^3	1,080	2,830	3.056	6.320	6.826
2. Substructure	M^3	600	1.040	0.624	2.110	1.266
3. Boring Pile (Double ø800 / Single ø600)	M	P. 260 S. 240	2.400	0.576	3.000	0.780
4. Earthwork (including trench sheet)	M^3	980	520	0.510	670	0.657
5. Pavement (including demolition of old pave.)	M^2	145	1.400	0.203	1.900	0.276
6. Underground Utilities	L.S	-	-	0.191	T	0.298
7. Others	L.S	-	-	0.516	-	1.010
8. Contingency	L.S	-	-	0.568	-	1.111
9. Engineering	L.S	-	-	0.733	-	0.733
Total				6.977 (13.954)		12.957

A figure in ( ) shows in a case of same operation length with double track.

APPENDIX 5.J

ESTIMATED CONSTRUCTION COST FOR ANG MO KIO
NEW TRANSIT SYSTEM
(TOTAL ROUTE LENGHT OF 21.6Km:SINGLE TRACK LENGTH)

ITEM	UNIT	U.PRICE (S$)	QUANTITY	AMOUNT (S$000)
1.Carriageway				
1.1 Girder (P.C Conorete)	M 3	1,080	80,000	84,800
1.2 Substructura R.C	M 3	600	22,100	13,260
1.3 Boring Pile	M	240	58,600	14,064
1.4 Farthwork	M 3	15	63,500	953
1.5 Sheetpile	M	540	19,600	10,584
1.6 Pavement	M 2	145	28,600	4,147
1.7 Others	L S			11,200
1.8 Contingency	L S			12,300
Sub-total				131,308
2.Station & Building				
2.1 Central Station	N 0	2,740,000	1	2,740
2.2 Intermediate Station	N 0	448,000	35	15,680
2.3 Other major Station	N 0	1,344,000	2	2,688
2.4 Building	M 0	700	3,000	2,100
Sub-Total				23,208
3.R.O.W				
3.1 Land aquistion	M 2			
3.2 Conpensation	L S			
3.3 Undergrand Utility	L S			4,300
Sub-Total				
4.Depot				
4.1 Track facility	L S			16,964
4.2 Shed	L S			1,796
4.3 Equipment	L S			8,040
Sub-Total				26,800
Total				185,616

Appendix 5.K

Price of Optional Station Facilities

Item/Description							
Escalator	Type	Overall Width i cm	Width of Step i cm	Standard Capacity: Pass/hour	Speed m/min	Gradient	Cost S$000
	One Person	80	60	6,000	30	1:2	350/unit
	Two Persons	120	100	9,000	30	1:2	400/unit
Elevator	11 passenger capacity Speed of 45m/min						230/unit
Screen Door	screen door						38/door
	control at station						10/sta-tion

Source: various price lists of equipment, 1988 version, Japan.

APPENDIX 5.L

Economic Evaluation (For Ang Mo Kio New Town System)

Time Saving	3 minutes	EIRR	0.04603
No. of Passenger	180 thousand	B/C	1.490103

S$000

Time Value/h	Year	Cost	Benefit			Net Benefit	Discounted Cost(2%)	Discounted Time(2%)
			Time Saving Cost	Saving	Total			
3.1	1988				0	0		
3.3	1989	52,930			0	-52,930	56,170	
3.5	1990	127,060			0	-127,060	132,193	
3.8	1991	174,150			0	-174,150	177,633	
4.0	1992		13,145	526	13,671	13,671	0	13,671
4.3	1993		14,009	526	15,535	14,535	0	14,250
4.5	1994		14,929	526	15,455	15,455	0	14,855
4.8	1995		15,907	526	16,433	16,433	0	15,485
5.2	1996		16,948	526	17,474	17,474	0	16,143
5.5	1997		18,055	526	18,581	18,581	0	16,829
5.9	1998		19,232	526	19,758	19,758	0	17,545
6.2	1999		20,484	526	21,010	21,010	0	18,291
6.6	2000		21,816	526	22,342	22,342	0	19,169
6.8	2001		22,257	526	22,783	22,783	0	19,063
6.9	2002		22,706	526	23,232	23,232	0	19,058
7.1	2003		23,164	526	23,690	23,690	0	19,053
7.2	2004		23,631	526	24,157	25,157	0	19,047
7.3	2005		24,107	526	25,633	24,633	0	19,042
7.5	2006		24,592	526	25,118	28,118	0	19,037
7.6	2007		25,088	526	25,614	25,614	0	19,031
7.8	2008		25,593	526	26,119	26,119	0	19,026
7.9	2009		26,108	526	26,634	26,634	0	19,021
8.1	2010		26,633	526	27,159	27,159	0	19,016
8.3	2011		27,169	526	27,695	27,695	0	19,011
8.4	2012		27,715	526	28,241	28,241	0	19,005
8.6	2013		28,272	526	28,798	28,798	0	19,000
8.8	2014		28,840	526	29,366	29,366	0	18,995
9.0	2015		29,420	526	29,946	29,946	0	18,990
9.1	2016		30,011	526	30,537	30,537	0	18,985
9.3	2017		30,613	526	31,139	31,139	0	18,980
9.5	2018		31,228	526	31,754	31,754	0	18,975
9.7	2019		31,854	526	32,380	31,380	0	18,970
9.9	2020		32,493	526	33,019	33,019	0	18,966
10.1	2021		33,145	526	33,671	33,671	0	18,961
Total		354,140	729,164	15,780	744,944	390,804	365,998	545,372

Economic Evaluation (For Ang Mo Kio Town System)

Time Saving	5 minutes	EIRR	0.084945
No. of Passenger	180 thousand	B/C	2.461648

S$000

Time Value/h	Year	Cost	Benefit			Net Benefit	Discounted Cost(2%)	Discounted Time(2%)
			Time Saving Cost	Saving	Total			
3.1	1988				0	0		
3.3	1989	52,930			0	-52,930	56,170	
3.5	1990	127,060			0	-127,060	132,193	
3.8	1991	174,150				-174,150	177,633	
4.0	1992		21.908	526	22,434	22,434	0	22,434
4.3	1993		23,349	526	23,875	23,875	0	23,407
4.5	1994		24,882	526	25,408	25,408	0	24,421
4.8	1995		26,512	526	27,038	23,038	0	25,478
5.2	1996		28,246	526	28,772	28,772	0	26,581
5.5	1997		30,091	526	30,617	30,617	0	27,731
5.9	1998		32,053	526	32,579	32,579	0	28,930
6.2	1999		34,141	526	34,667	34,667	0	30,179
6.6	2000		36,361	526	36,887	36,887	0	31,482
6.8	2001		37,094	526	37,620	37,620	0	31,479
6.9	2002		37,843	526	38,369	38,369	0	31,476
7.1	2003		38,606	526	39,132	39,132	0	31,472
7.2	2004		39,384	526	39,910	39,910	0	31,469
7.3	2005		40,178	526	40,704	40,704	0	31,462
7.5	2006		40,987	526	41,513	41,513	0	31,458
7.6	2007		41,813	526	42,339	42,339	0	31,455
7.8	2008		42,655	526	43,181	43,181	0	31,451
7.9	2009		43,513	526	44,039	44,039	0	31,451
8.1	2010		44,389	526	44,915	44,915	0	31,447
8.3	2011		45,281	526	45,807	45,807	0	31,444
8.4	2012		46,192	526	46,718	46,718	0	31,440
8.6	2013		47,120	526	47,848	47,848	0	31,436
8.8	2014		48,067	526	48,593	48,593	0	31,432
9.0	2015		49,033	526	49,559	49,559	0	31,428
9.1	2016		50,018	526	50,544	50,544	0	31,424
9.3	2017		51,022	526	51,548	51,548	0	31,420
9.5	2018		52,046	526	52,572	52,572	0	31,416
9.7	2019		53,091	526	53,617	53,617	0	31,412
9.9	2020		54,156	526	54,682	54,682	0	31,406
10.1	2021		55,242	526	55,768	54,768	0	31,104
Total		354,140	1,215,273	15,780	1,231,503	876,913	365,996	900,942

Economic Evaluation (for Ang Mo Kio New Town)

Time Saving 7 minute EIRR 0,116175
No of Passenger 180 thousand B/C 3,433133

S$000

Time Value/h	Year	Cost	Benefit			Net Benefit	Discounted Cost(2%)	Discounted Cost(2%)
			Time Saving	Cost Saving	Total			
3.1	1988				0	0		
3.3	1989	52,930			0	-52,930	56,170	
3.5	1990	127,060			0	-127,060	132,193	
3.8	1991	174,150			0	-174,150	177,633	
4.0	1992		30.671	526	31,197	31,197	0	31,197
4.3	1993		32,689	526	33,215	33,215	0	32,563
4.5	1994		34,834	526	35,360	35,360	0	33,987
4.8	1995		37,117	526	37,643	37,643	0	35,472
5.2	1996		39,545	526	40,071	40,071	0	37,019
5.5	1997		42,127	526	42,653	42,653	0	36,832
5.9	1998		44,875	526	45,401	45,401	0	40,314
6.2	1999		47,797	526	48,323	43,323	0	42,068
6.6	2000		50,905	526	51,431	51,431	0	43,896
6.8	2001		51,932	526	52,458	52,458	0	43,895
6.9	2002		52,980	526	53,506	53,506	0	43,893
7.1	2003		54,048	526	54,574	54,574	0	43,892
7.2	2004		55,138	526	55,664	55,664	0	43,891
7.3	2005		58,249	526	56,775	55,775	0	43,889
7.5	2006		57,382	526	57,908	57,908	0	43,887
7.6	2007		58,538	526	59,064	59,064	0	43,885
7.8	2008		59,171	526	60,243	60,243	0	43,883
7.9	2009		60,918	526	61,444	61,444	0	43,881
8.1	2010		62,144	526	62,670	62,670	0	43,879
8.3	2011		63,394	526	63,920	63,920	0	43,877
8.4	2012		64,669	526	65,195	65,195	0	43,874
8.6	2013		65,969	526	66,495	66,495	0	43,872
8.8	2014		67,646	526	67,820	67,820	0	43,869
9.0	2015		68,646	526	69,172	69,172	0	43,866
9.1	2016		70,025	526	70,551	70,551	0	43,863
9.3	2017		71,341	526	71,957	71,957	0	43,860
9.5	2018		72,865	526	73,391	73,391	0	43,857
9.7	2019		74,327	526	74,853	74,853	0	43,853
9.9	2020		75,818	526	76,344	76,344	0	43,850
10.1	2021		77,339	526	77,865	77,865	0	43,847
Total		354,140	1,701,382	15,780	1,717,162	1,363,022	365,996	1,256,513

APPENDIX 5.M

Estimation of Time Value

A. Introduction

A time value for the residents of Ang Mo Kio New Town was estimated through disaggregate modal choice analysis. This value represents the average cost to a resident of using public transport for a one hour trip. the estimated value is to be used to simulate trip assignment of public transport mode passengers to each transport facility.

B. Disaggregate Model

The disaggregate model has been developed to explain individual choice in trip making activity. It analyses the choice by individual. Aggregate models on the contrary deal with zonal aggregated activities. In other words, the former deals with individual behaviour considering his socio-economic characteristics and the level-of- service of the transport modes of which he is going to choose. Whereas the latter analyses relations between average level-of-service of transport modes and aggregated results of modal choice, such as "modal share" of a certain mode.

To date, most of the work of disaggregate analyses has been concentrated in modal choice category.

The advantages of the disaggregate model over the aggregate model are stated as follows:

(1) Sensitivity to change of variables is superior.
(2) Being free from zoning because the method does not rely on zonal indicators.
(3) Ability to estimate parameters from small sample size comparing with aggregate models.
(4) Ability to estimate parameters that are statistically reliable when the number of independent variables increases.

The disadvantages are:

(1) Aggregation Problem

This problem arises mainly in the phase of future modal choice forecast because of the difficulty in estimating future individual indicators.

(2) The available data, in terms of "level-of-service" of transport services, can only be obtained for zones and not for each individual resident. The advantages of the model may not be effective in this case.

A typical expression of disaggregate model is shown as follows. It is called "binary logit" disaggregate model which deals with modal choice between two competing transport modes.

$$P_R = \frac{e^{f(X\ R)}}{e^{f(X\ b)} + e^{f(X\ R)}}$$

$$f(X_i^R) = a + {}_{i=1}^{n}\ b_i X_i^R \qquad (1)$$

where, P_R : Probability to choose R mode for an individual
X_i^R : The ith explanatory variable which affects *modal choice of the individual*
a, b_i: Parameters

C. Estimation of Time Value

The process of estimating the time value is divided into two steps. Firstly, parameters of the disaggregate model are estimated. Secondly, the time value is estimated in accordance with these parameters.

Equation (1), above, is modified to estimate parameters dividing the denominator and the numerator by $e^{f(X_i R)}$ as follows:

$$P_R = \frac{1}{1 + e^Z}$$

$$Z = \quad + {}_{i=1}^{n} \quad i(X_i^b - X_i^R) \qquad (2)$$

The explanatory variables adopted for this analysis were travel time and travel cost other than the actual choice by each individual. Thus, Z in the equation (2) is expressed as follows:

Z = + (Travel time by B mode - Travel time by R mode)
+ (Travel cost by B mode - Travel cost by R mode)

These parameters are estimated by maximum likelihood method.

Supposing mode B as bus and mode R as MRT, the estimated parameter _ represents the effect to Z which occurs from the difference of *one unit of travel time between the two competing modes, while* _ represents the effect to Z by one unit of travel cost difference between them. Therefore, if _ is greater than _, the effect of the one unit time difference is greater than that of the cost difference. Time value can, therefore, be calculated by dividing _ by _.

D. Data Processing Procedure

The information necessary for the analysis is the modal choice, and its chosen mode, and travel time and cost by the alternative on each trip. The former two were obtained from trip information questionnaire sheets of Ang Mo Kio HIS which was conducted in 1988 by the study team. Information on alternative was estimated by refering to time tables and fare tables of MRT, bus route map, bus fare table and bus operation schedule. The number of samples used for this analysis is shown in Table-1.

Table-1 Number of Samples

Trips by MRT	167
Trips by bus	141
Total	308

E. Result of the Analysis

The estimated disaggregate modal choice model between public transport modes is shown as follows.

$$Z = 0.09296 - 0.01947 \text{ (Bus time - MRT time)} - 0.00377 \text{ (Bus cost - MRT cost)}$$

Hit ratio: 69.8(%)
_ : 0.1083

The hit ratio represents the proportion of correct estimates among all sample modal choices by the estimated disaggregate model. The _ shows a goodness of fit measure of maximum likelihood method. The time value derived from the parameters is S¢5.16/minutes. It is equivalent to S$3.10/hour.

ECONOMIC GROWTH OF SINGAPORE IN RESENTYEARS

YEAR	GDP 1985 price	Growth Rate (%)	Population (000)	Growth Rate (%)	GDP S$ per capita	Growth Rate (%)	Mediam Gross Per Capite income month	Growth Rate (%)
1975	18960.7	-	2262.6	-	8380	-	-	-
1976	20378.0	7.47	2293.3	1.36	8886	6.40	-	-
1977	21986.7	7.89	2325.3	1.40	9455	6.41	-	-
1978	23886.6	8.64	2353.6	1.22	10149	7.33	435	-
1979	26130.1	9.93	2383.6	1.27	10963	8.02	441	1.38
1980	28832.5	10.34	2413.9	1.28	11944	8.95	480	8.84
1981	31697.5	9.94	2443.3	1.22	12973	8.61	469	2.29
1982	33708.5	6.34	2471.8	1.17	13637	5.12	535	14.07
1983	36537.2	8.39	2501.0	1.22	14603	7.08	577	7.85
1984	39572.5	8.31	2529.1	1.08	15647	7.15	616	6.76
1985	38923.5	1.64	2558.0	1.14	15216	2.75	654	6.17
1986	39605.1	1.75	2586.2	1.10	15314	0.64	676	3.36
1987	43095.3	8.81	2612.8	1.03	16494	7.70	-	-

Estimation of Future Time Value

YEAR	Per Capita GDP	Per Capita Income Level S$/Month	Time Value/h
1987	16493.9		
1988	17538.0	724.3	3.1
1989	18648.3	772.1	3.3
1990	19828.6	822.8	3.5
1991	21092.4	877.2	3.8
1992	22436.7	935.0	4.0
1993	23866.7	996.5	4.3
1994	25387.8	1061.9	4.5
1995	27005.9	1131.5	4.8
1996	28727.1	1205.5	5.2
1997	30558.1	1284.2	5.5
1998	32505.7	1367.9	5.9
1999	34577.4	1457.9	6.2
2000	36780.6	1551.8	6.6
2001	37508.9	1583.1	6.8
2002	38251.7	1615.0	6.9
2003	39009.1	1647.6	7.1
2004	39781.6	1680.8	7.2
2005	40569.3	1714.7	7.3
2006	41372.7	1749.2	7.5
2007	42192.0	1784.5	7.6
2008	43027.4	1820.4	7.8
2009	43879.5	1857.0	7.9
2010	44748.4	1894.4	8.1
2011	45638.1	1971.3	8.3
2012	46538.1	1971.3	8.4
2013	47459.7	2011.0	8.6
2014	48399.5	2051.4	8.8
2015	49357.9	2092.6	9.0
2016	50335.3	2134.6	9.1
2017	51332.0	2177.5	9.3
2018	52348.5	2221.2	9.5
2019	53385.1	2265.8	9.7
2020	54442.2	2311.2	9.9
2021	55520.3	2357.6	10.1
2022	56619.7	2404.9	10.3
2023	57740.9	2453.1	10.5

APPENDIX 6.A

Breakdown of Civil Work, Station/Building and Depot Construction Costs for Simpang System

Item	Unit	Unit Price S$	Quantity	Amount S$x000	Remarks
1. Viaduct and Bridge					
1.1 P.C. Girder	M3	1.080	18,330	19.800	
1.2 Steel Girder	T	8.160	630	5.140	
1.3 Pier R.C. (A)	M3	600	6.060	3.640	
1.4 Pier R.C. (B)	M3	600	690	0.410	
1.5 Driving Pile ø600	M	170	7.680	1.310	
1.6 Earthwork	M3	980	2.150	2.110	Trenchsheet
1.7 Others	L.S			3.240	
1.8 Contingency	L.S			3.570	
Sub-total				39.220	
2. Carriageway on ground					
2.1 Earthwork	M3	18	184.000	3.310	
2.2 Driving Pile ø600	M	170	131.200	22.300	
2.3 Drainage	M	131	13.120	1.720	
2.4 Slope surface	M2	40	42.500	1.700	
2.5 Slab Concrete	M3	500	15.750	7.880	
2.6 Others	L.S			3.690	
2.7 Contingency	L.S			4.060	
Sub-total				44.660	
3. Station and Building					
3.1 Yishun Station	NO	1,000,000	1	1.000	
3.2 Junction Station	NO	800.000	2	1.600	
3.3 Intermediate Station	NO	670.000	11	7.370	
3.4 Building	M2	700	4.200	2.940	
Sub-total				12.910	
4. Depot					
4.1 Track Facilities	L.S			14.760	
4.2 Shed	L.S			0.890	
4.3 Equipment	L.S			6.110	
Sub-total				21.760	
TOTAL				118.550	

Appendix 6.B

Estimated Average Annual Cost of Investment

	Total Invest-ment Cost (S$000)	Useful Life (years)	Factor at Assumed Discount Rate			Average Annual Cost (S$000)		
			2%	5%	7%	2%	5%	7%
1) Civil Work	83,880	40	0.037	0.058	0.075	3,103	4,865	6,291
2) Station/Bldg.	19,370	45	0.034	0.056	0.073	659	1,085	1,414
3) Depot	27,850	30	0.045	0.065	0.081	1,253	1,810	2,256
4) Vehicles	71,760	20	0.061	0.080	0.094	4,377	5,743	6,745
5) Power Supply	53,420	30	0.045	0.065	0.081	2,404	3,472	4,327
6) Control/ Signalling/ Telecoms System	49,590	20	0.061	0.080	0.094	3,025	3,967	4,661
Total	305,870	–	–	–	–	14,821	20,940	25,694

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