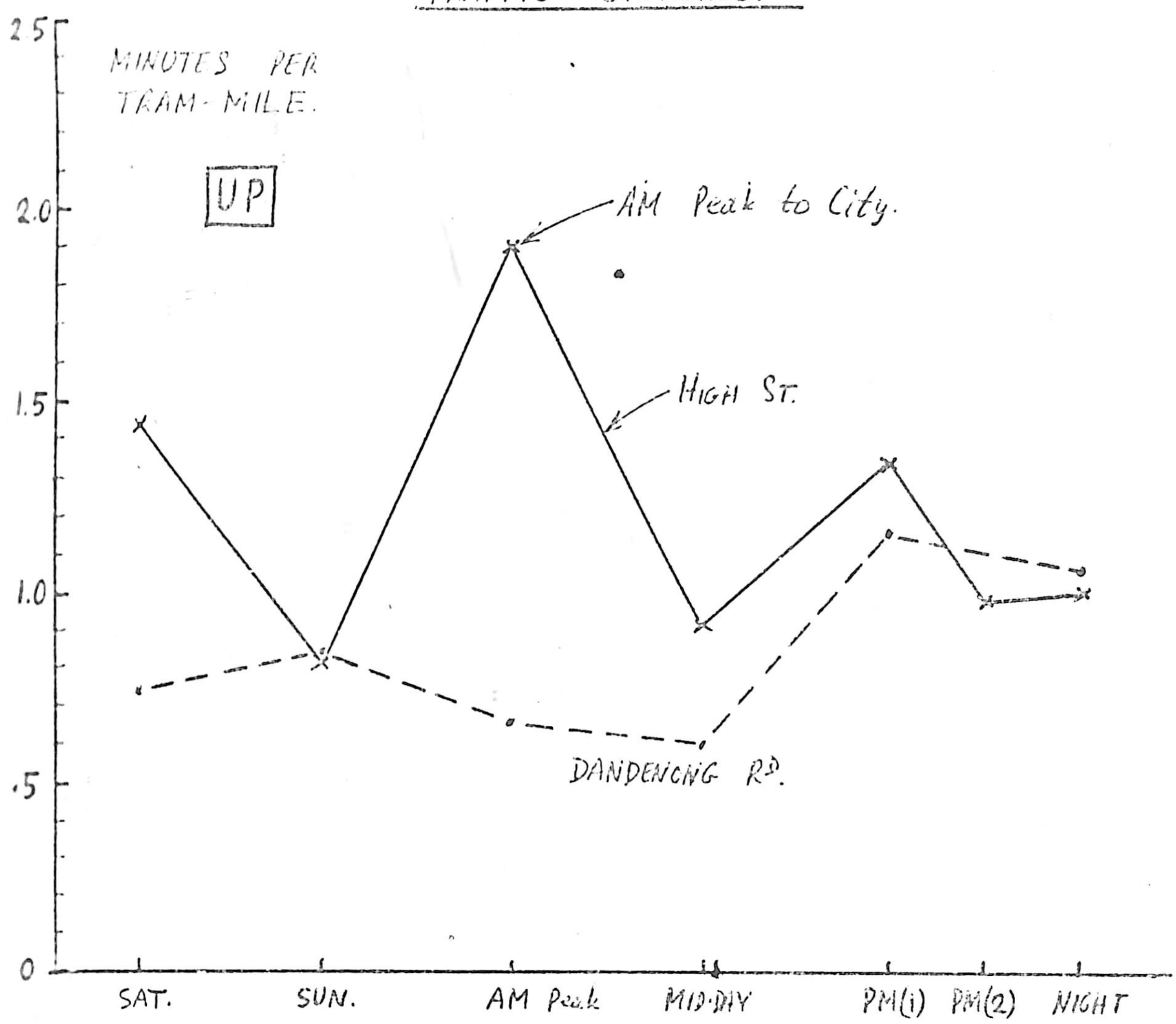
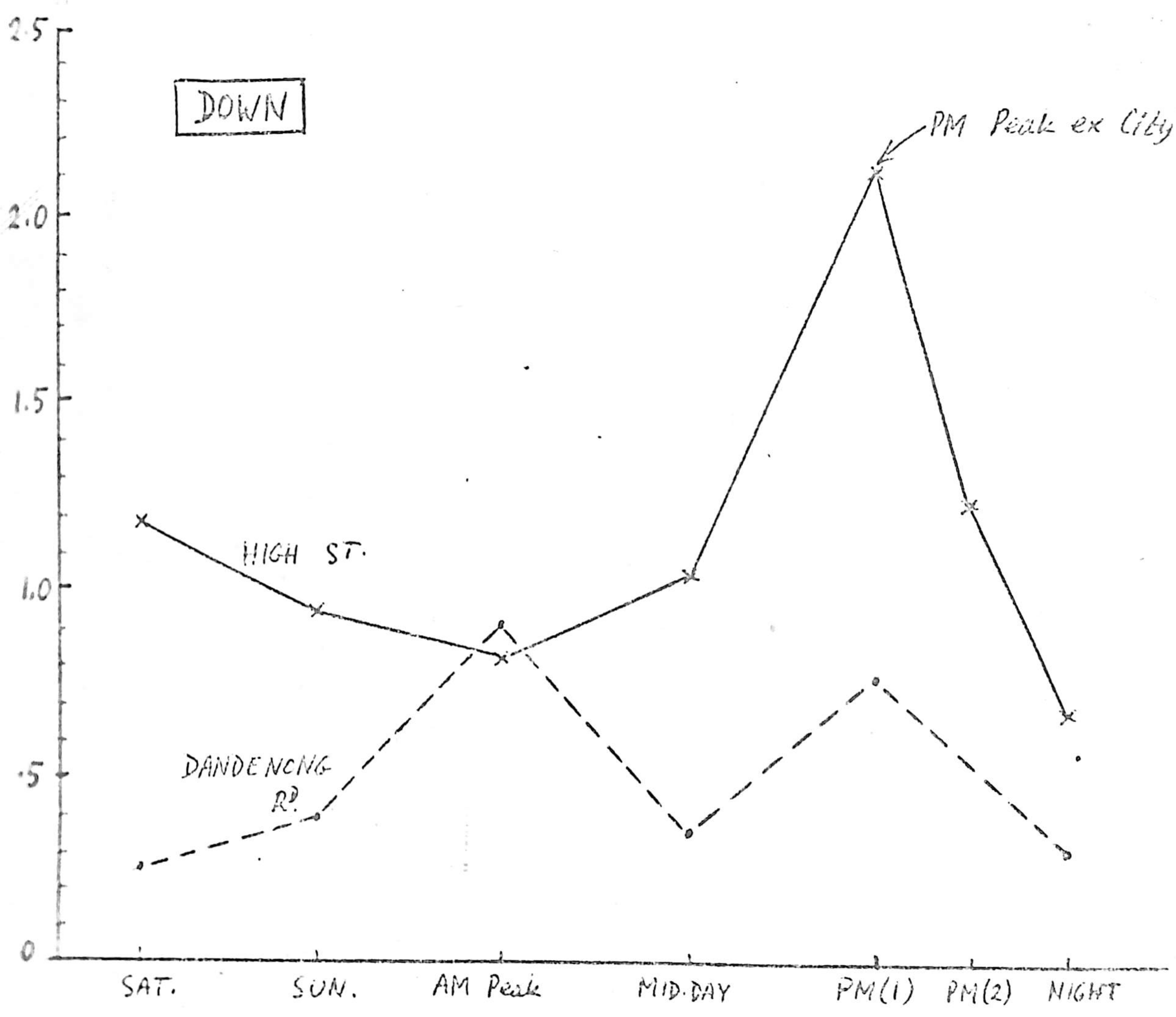
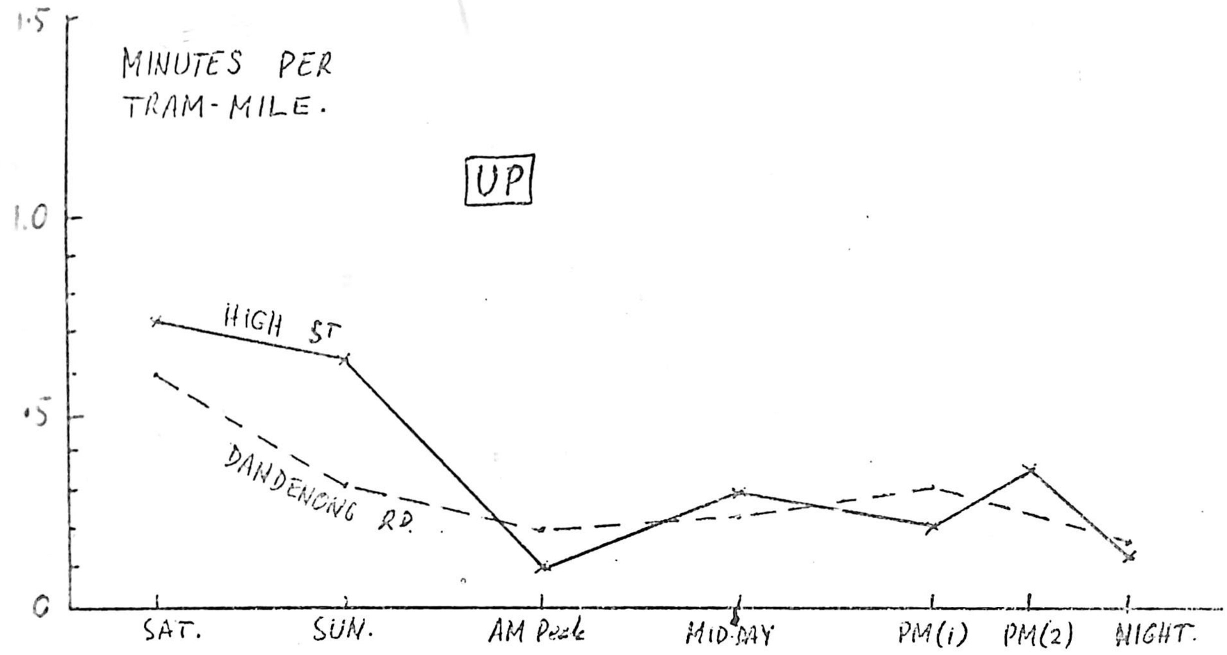
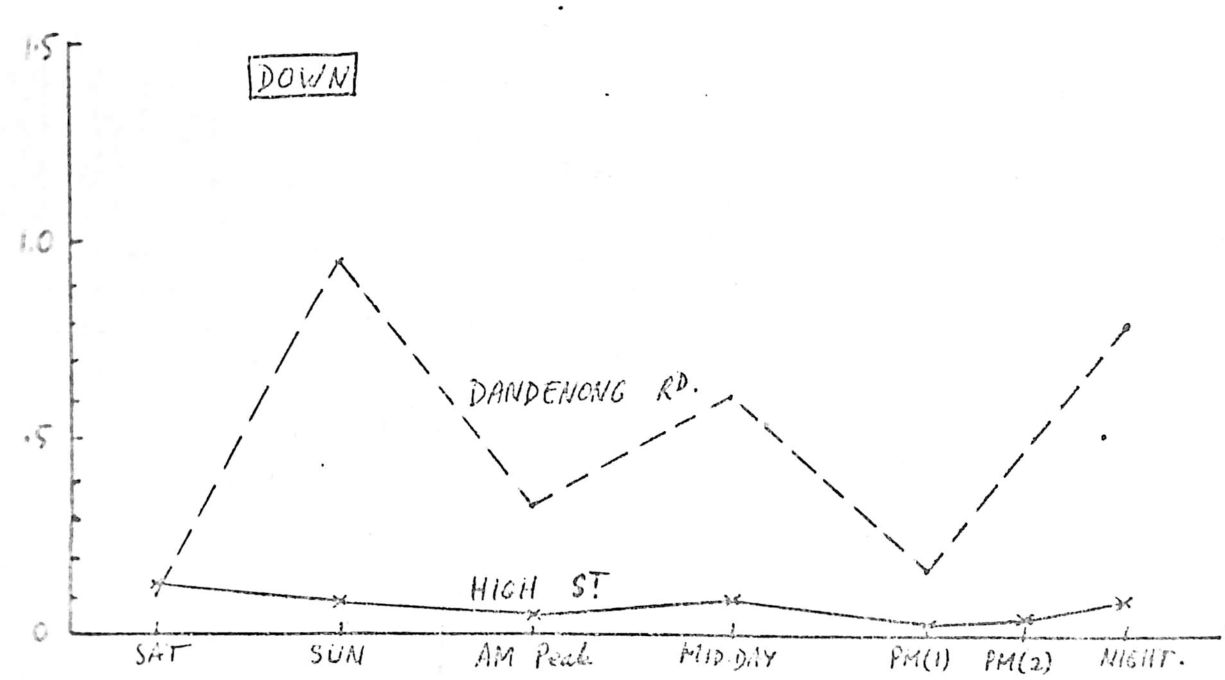
DELAYS DUE TO MOTOR TRAFFIC AND TRAFFIC SIGNALS.



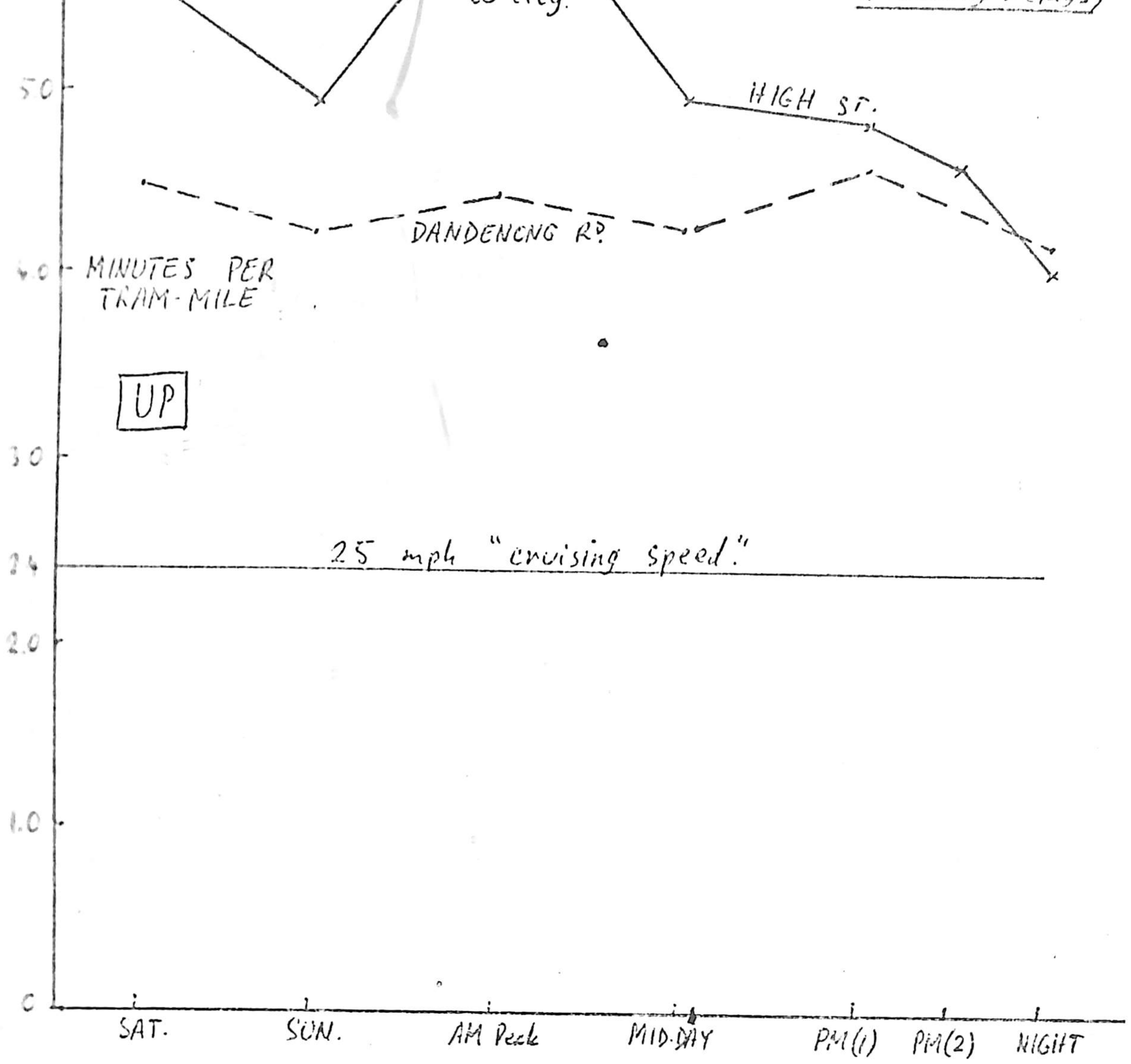


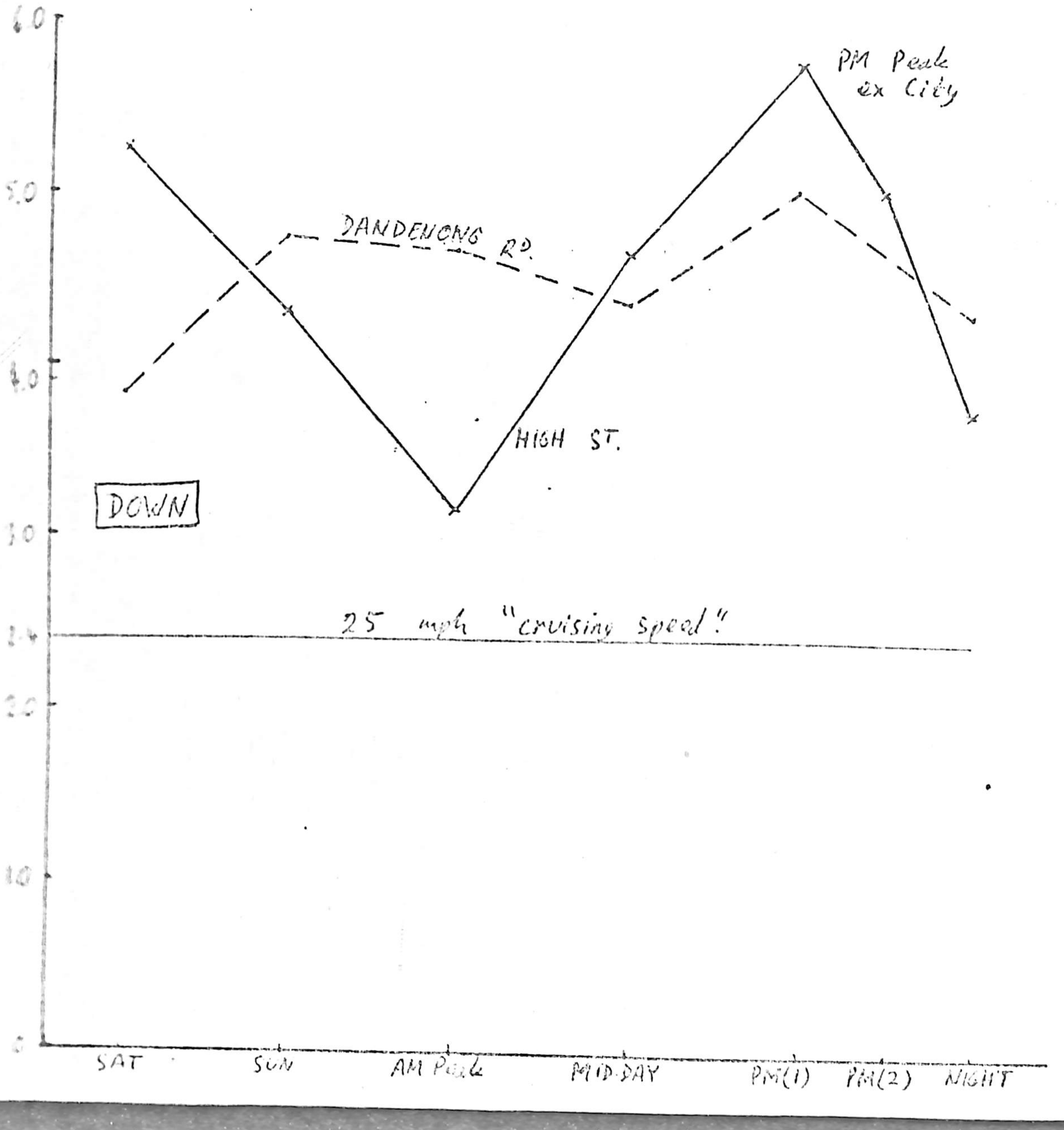
DELAYS DUE TO "OTHER" CAUSES



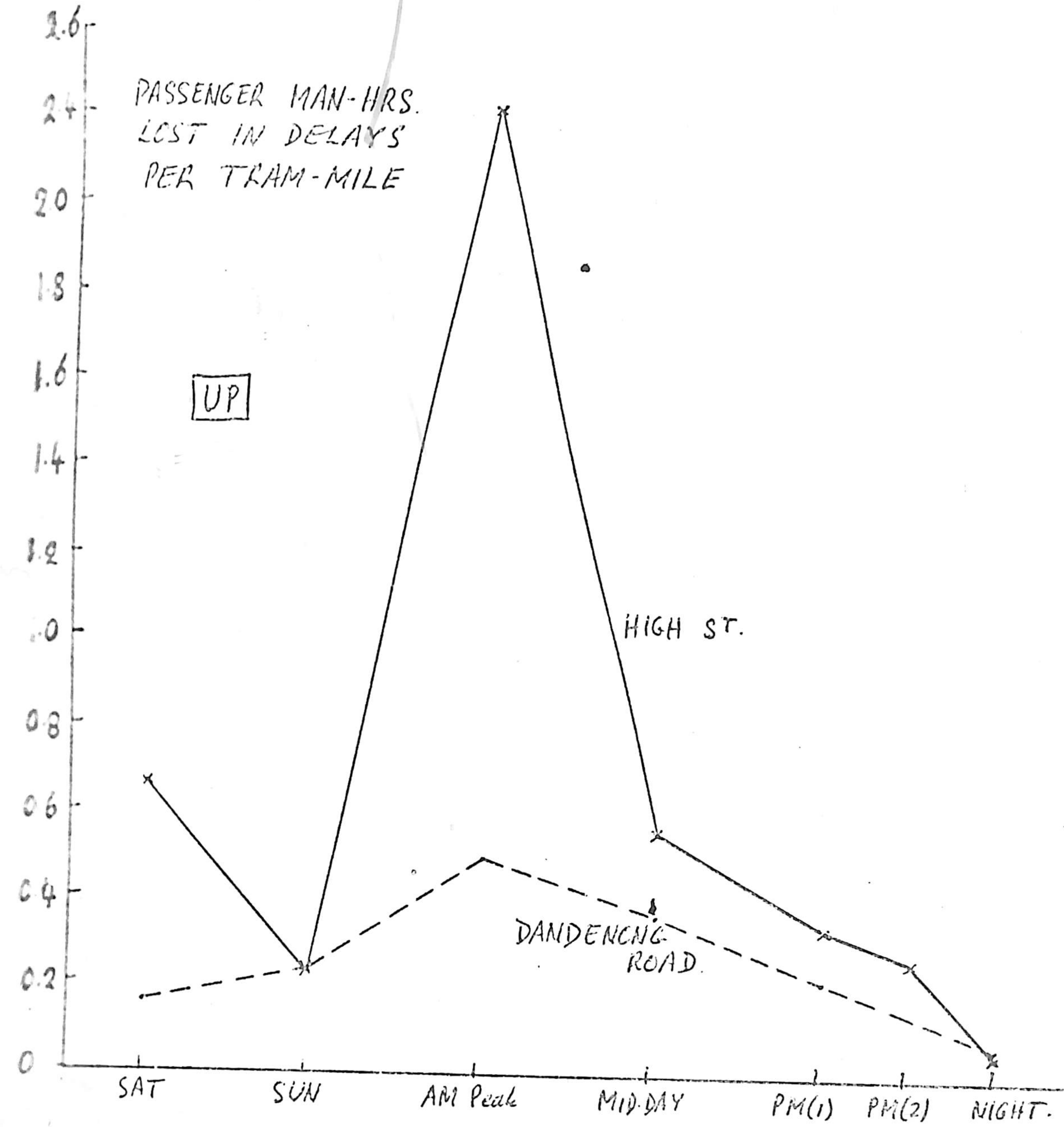


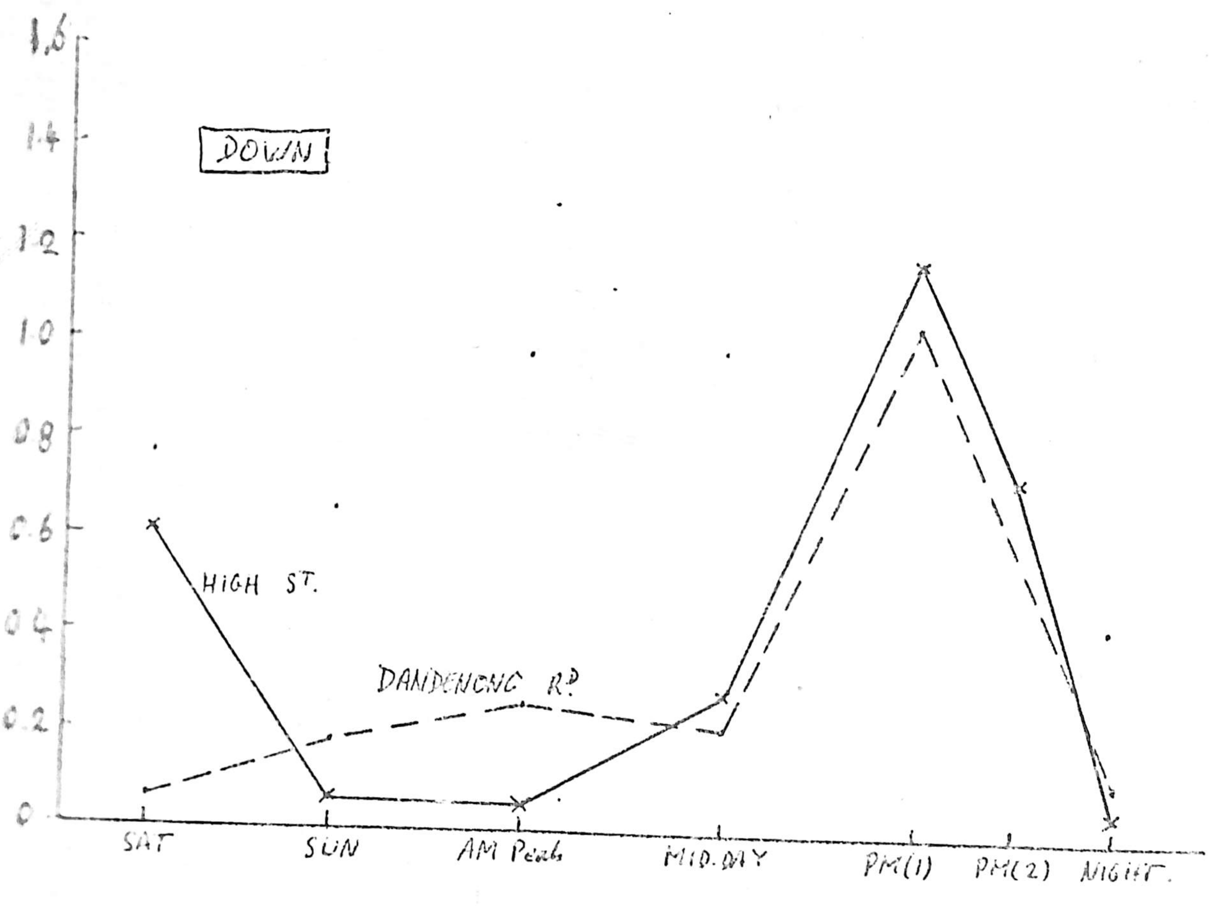
OVERALL TRAVEL TIME
(Including Delays)





PASSENGERS' TIME LOST THROUGH DELAYS.





(6) (cont'd) COMPARISON OF COSTS:

In assessing the relative merits of the two systems, the following cost items are considered:

(1) Crew's time.
(2) Passengers' time.
(3) Capital outlay on tracks.
(4) Maintenance of tracks.
(5) Capital outlay on tram-cars.
(6) Maintenance of tram-cars.
(7) Electrical power for traction.
(#) (8) Accidents involving motor vehicles and trams.
(9) Motorists' time.
(#) (10) Purchase of extra land for reserved tracks.

Items for which the M&MTB is responsible.

In the following text, "saving" shall refer to that saving of reserved tracks over "Centre-of-the-road" tracks.

In order to simplify the calculations we shall take all time, etc., savings for Up trips only, then double the result.

(1) Crew's Time: Since the M&MTB is paying crews on a time rate of pay, any saving in the total trip time will result in a saving in the running costs.

TIME-SLOT	Av. Delay Saving	Mult^{n}.Factor *	DELAY SAVING/Week
Sat.	126.sec/2.5miles	X 85	10,700 secs.
Sun.	45. " "	X 36	1,620 "
AM Peak	174. " "	X 160	27,800 "
Mid-Day	54. " "	X 125	6,750 "
PM Peak	10. " "	X 155	1,550 "
Night	0. " "	X 110	0 "

TOTAL TIME SAVING = 48,420 "

* See App.'D', p.41

Hence, saving in crew's time = 13.5 hrs/wk/2.5 miles (Up only)
= 27.0 " " " (Up & Down)

Assuming an hourly rate of $ 2.50 for the whole crew (conductor and driver) we get:

Savings in crew's wages = $ 68 per wk.
= $ 3,500 p.a. (over 2.5 miles)
= $ 1,400 p.a./route-mile.

(2) Passengers' Time: Assuming that a large number of small time savings is valued at the same rate as the average person's normal rate of pay, we get:

TIME-SLOT	Av. Passenger Man-Hrs. saved	Multⁿ. Factor	Passengers' Time Saved in Delays.
Sat.	1.26	X 85	107. Man-Hrs.
Sun.	0.	X 36	0. "
AM peak	4.32	X 160	691. "
Mid-Day	.49	X 125	61. "
PM Peak	.29	X 155	45. "
Night	0.	X 110	0. "

Passengers' Time Saved (Up only) = 904. "/wk/2.5miles.

Assuming the average passenger's normal rate of pay is $ 1.50 per hour, we get:

Total Savings to Passengers = $ 1,350 /wk/2.5 miles (Up only)
= $ 140,000 p.a./2.5 route miles.
= $ 56,000 p.a./route-mile.

(3) Capital Outlay on Tracks:

Construction costs per mile are: (double track)
Electrical equipment: $ 72,400 (same for both systems)
Paved Concrete tracks: $ 127,000
Open Ballast tracks: $ 198,000

Thus, Extra Cost of Open Ballast = $ 71,000 /route-mile.

Assuming a useful life of 20 yrs.:

Extra Cost of Open Ballast = $ 3,600 p.a./route-mile.

(4) Maintenance of Tracks:

Concrete (Paved) $ 1,160 p.a./route-mile.

Open Ballast $ 5,000 " " (equivalent to replacement of rails&sleepers(50%cost) after 20 years.)
Paved Ballast $ 7,200 " " (joints & grinding)

Thus, comparing Open Ballast with concrete construction, we get:

Extra Cost of Open Ballast = $ 3,800 p.a./route-mile.

(5) CARS:

TIME-SLOT	TOTAL DELAY SAVING /wk. (Up)	AV. TRIP TIME (over 2.5 miles)	No of EXTRA TRIPS possible per week	No of EXTRA TRIPS possible per day	PRESENT No of TRIPS/day	% IMPROVED SERVICE
Sat.	10,700 sec.	670 sec.	16.0	16	85	20 %
Sun.	1,620 "	632 "	2.6	3	36	8 %
AM Peak	27,800 "	668 "	41.6	8	32	25 %
Mid-Day	6,750 "	639 "	10.7	2	25	8 %
PM Peak	1,550 "	687 "	2.3	0	31	0 %
Night	0 "	627 "	0.	0	22	0 %

Since the AM Peak requires the maximum number of cars within a period of only one hour's duration (approx.)(which is greater than the turn-round time possible, even with reserved trackage) we cannot reduce the Capital Outlay on cars, unless routes are less than 7 miles in length.

However, as shown above, we can improve the service by up to 25 %, with no extra equipment needed.

(6) Maintenance of Tram-cars:

(i) Brake Shoes: $ 9 per 1,000 miles/tram

Now, total number of trips per week (Up+Dwn)= 1,342 on each route. Thus:

Cost of brake shoes = $ 12.1 /wk/route-mile.
= $ 630. p.a./route-mile.

Assuming that use of reserved track reduces the equivalent number of full applications of the brakes by 50 %, we get:

Saving in brake shoes = $ 300 p.a./route-mile.

(ii) Wheel Sets: $ 7.2 per 1,000 miles/tram.

Thus, Cost of Wheel Sets = $ 9.7 /wk/route-mile.

= $ 500. p.a./route-mile-

Again, assuming that: Saving = ½.Cost ,we get:

Saving in Wheel Sets = $ 200 p.a./route-mile.

(iii) Trucks: (incl. braking equipment)

Total Annual Cost = $ 360,000.

Total miles travelled = 16,480,000

Thus, Cost of trucks = $ 1,530. p.a./route-mile.

Again, assuming that: Saving = ½.Cost ,we get:

Saving in Trucks = $ 800. p.a./route-mile.

(7) Electrical Power for Traction:

By studying (App. 'B', p.35) (" 'C' " 70) the average distance (13,210 ft.) of each study route and the average "Base Times" (368 sec.) for these, we can estimate the free "cruising speed" of the trams on these two routes, as:

$$\doteq \frac{13{,}210 \text{ ft.}}{368 \text{ sec.}} = 25 \text{ m.p.h. exactly}$$

Now, by graphical intergration, the power used in starting a loaded tram from rest to 25 mph. can be found as follows:

Volts = 575 (mean)

Amp-Secs. = 3,900

Thus, kW-Hrs. = 0.623 for each new start.

But, the cost of electrical power to the M&MTB is: 1.71 ¢ /kWH.

Thus, Cost of starting loaded tram = 1.07 ¢

and: Cost of cruising at 25 mph. = 0.016 kWH/sec.

= 1.64 ¢ /minute.

Now, assuming the minimum number of starts (over 2.5 miles) is 15, we get: Min^m Cost of power used in starting = 15 x 1.07

= 16.0 ¢ per trip.

Now, the Base Running Time is: B= 360 secs.

= 6 mins.

Thus, minimum cost of free running = 10.0 ¢ per trip.

That is, Total Minimum Power Cost = 26 ¢ per trip (over 2.5m)

If, however, we double the number of starts required (eg. because of stop-start conditions in heavy traffic) so that we now require to make 30 new starts:

Cost of Power = 42 ¢ per trip

i.e. Using reserved track results in a saving of 16¢/trip

So: Power Saving = $ 0.16 x(1342 x 52)

= $ 11,200 p.a./2.5 miles

= $ 4,500 p.a/route-mile.

(8) Accidents involving motor vehicles and tram-cars:

Accident rates obtained from the M&MTB for the year ending 1968/69 are(over the two study sections):

Dandenong Road: 35 p.a.

High Street : 47 p.a.

(i.e. 34 % increase in accident rate by using "centre-of-the-road" tracks).

Assuming that the average cost per accident (all types) is:

$ 1,500

the use of reserved track causes a saving of 12 accidents, or

$ 18,000 p.a. over 2.5 miles.

i.e. Saving in Accidents = $ 7,200 p.a./route-mile.

(9) Motorists' Time (Ref:I):

It has been found (in Melbourne and Brisbane) that trams reduce the saturation flow by:

16 % in the tram lane

5 % " " other lanes.... so that the saturation flow, for two lanes (one shared) is 3,000 veh's/hr., or 50 veh's per minute in each direction along High Street.

In the PM Peak of Mon 8th. Sept., car travel times along both High St. and Dandenong Rd. were measured in the Down direction:

High St. 18 min's } over 2.5 miles
Dandenong Rd. 10 min's. }

Thus, Dandenong Rd. saves each motorist 8 min's travel time. Assuming this saving takes place during 3 hrs. of each weekday, we get: (assuming wage rate of $ 1.50 /hr., again)

Saving to Motorists = 15 hrs./week
= $ 47,000 p.a. (over 2.5 miles)
= $ 19,000 p.a./route-mile.

(10) Extra Land Required for Reserved Trackage:

Minimum extra width required = 33 ft.
" " area per route-mile = 174,000 squ. ft.
At a cost of (say): $ 1.60 per squ. ft.

Extra Cost (land only) = $ 278,000 per route-mile
= $ 14,000 p.a./route-mile.
(taken over 20 years, approx.)

RESERVED TRACKS (Open Ballast)

SAVINGS PER ANNUM / ROUTE-MILE:

(1)	Crew's Time	$ 1,400.
(2)	Passengers' Time	$ 56,000.
(3)	Capital Outlay on Tracks ($constr^n$)	$(Extra Cost)
(4)	Maintenance of tracks	(" ")
(5)	Capital Outlay on Tram-cars	$(not significant)
(6)	Maintenance of Tram-cars (i)Shoes:	$ 300.
	(ii)Wheels	$ 200.
	(iii)Trucks	$ 1,500.
(7)	Electrical Power (Traction)	$ 4,500.
(8)	Accidents involving motor veh's.	$ 7,200.
(9)	Motorists' Time	$ 19,000.
(10)	Purchase of Extra Land	$(Extra Cost)

SAVINGS: $ 90,000. p.a./route-mile

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CIVIL ENGINEERING DEPARTMENT

RESERVED TRACKS (Open Ballast) (cont'd)

EXTRA COSTS PER ANNUM / ROUTE-MILE:

(3)	Construction of Tracks	$ 3,600.
(4)	Maintenance of Tracks	$ 3,800.
(10)	Purchase of Extra Land	$ 14,000.
	EXTRA COST:	$ 21,000. p.a./route-m.

NET SAVINGS TO THE COMMUNITY:

SAVINGS	$ 90,000. p.a./route-mile
Extra COST	$ 21,000. " "
NET SAVINGS:	$ 69,000. p.a./route-mile

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(7) DISCUSSION OF RESULTS:

The measurements made in the delay study were very accurate (within ± 1 second in most cases), but passenger counts were only approximate due to the difficulties in performing several tasks at the same time - especially where large numbers of passengers were involved.

It was found that total trip times varied quite markedly from one day to the next - some of this variation being due to pure chance (that is, 'catching all the lights' one day; then having 'a bad run ' on the next day), and much of it due to the road traffic conditions - on wet days especially. Generally, however, the Dandenong Road reserved trackage seemed to give more consistent results than High Street, except that Dandenong Road trams were more prone to delays of the " OTHER " types, while High Street trams suffered the expected traffic and traffic signal delays but were remarkably free of many other delays. For this reason it happens that High Street trams show a better performance than those in the reserve during off-peak periods... the main delaying factor in Dandenong Road being the need to transfer passengers to and from the Route 5 trams at Orrong Road - but this is a 'system delay', and is not a characteristic of reserved tracks. Therefore, it should have been ommitted!

It should not be thought that the only reason why High Street trams take so much longer in peak periods is that traffic is the only cause of a longer trip time - quite a large part of this extra time is taken up by the increased numbers of people boarding and alighting at these times, and the seemingly fast travel times along Dandenong Road, even in peak periods, are largely attributable to the smaller numbers of people using these trams.

Further work should be done on the statistical side of this project to discover the liklihood of getting 'a good run with the lights.'

contd →

(7) (cont'd) Further Work Required:

So far, no attempt has been made to correlate delays to cars caused by trams, nor to determine the relationship between traffic flows and delays to trams. In order to establish these relationships we would need to measure both of these interacting systems simultaneously so as to overcome problems of differing conditions from one day to the next.

Also, some attempt should be made to discover the optimum spacing of at-grade crossings along tramway reserves - taking due regard to the delays to trams, as well as to the motor traffic. Along Queen's Way there are no crossings at all, and trams are able to maintain high speeds in safety - thus operating at capacity under all conditions.

The spacing of tram stops seems to be the most dominating influence on travel time, as each time the tram is brought to a halt and re-started, atleast 10 - 12 seconds are wasted in "acceleration Noise" - not to mention the accumulating costs of each stop(in power & maintenance). As far as the individual is concerned, the optimum distance between stops (which results in the minimum total "walk and travel" time) is about 400 yds. (c.f. Inter-stop distances of only 200 yds. in Dandenong Rd. and High St..), but this depends on distance from destination (usually, the C.B.D., for trams). Research into this field would be worthwhile.

R. Varselow

(8) CONCLUSIONS:

Apart from discovering the major causes of delay to trams, and measuring these delays at some critical points in time - and them comparing the two systems of trackage with respect to time and cost, perhaps most was learned about HOW we can go about analysing our tramways - something which (it would appear) has never before been attempted at this level.

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(9) ACKNOWLEDGEMENTS:

The following M&MTB staff; for their every assistance;

Mr. Heart (Chief Civil Engineer)

Mr. Painter (Drawing Office)

Mr. Whitehill (Accidents&Claims)

Mr. Hall (Preston Workshops Manager)

Mr. Aird (Secretary), for the issue of the Tramways Pass.
... and also:

Mr. Fouvy (Metro. Transpn. Study)

Mr. C. Brown , for duplicating the Running Sheets

The Transport Section, for use of a stop watch.

(10) REFERENCES;

I. Aust. Road Research Board (1968)....Bulletin No. 4.

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(11) APPENDICES FOLLOW:

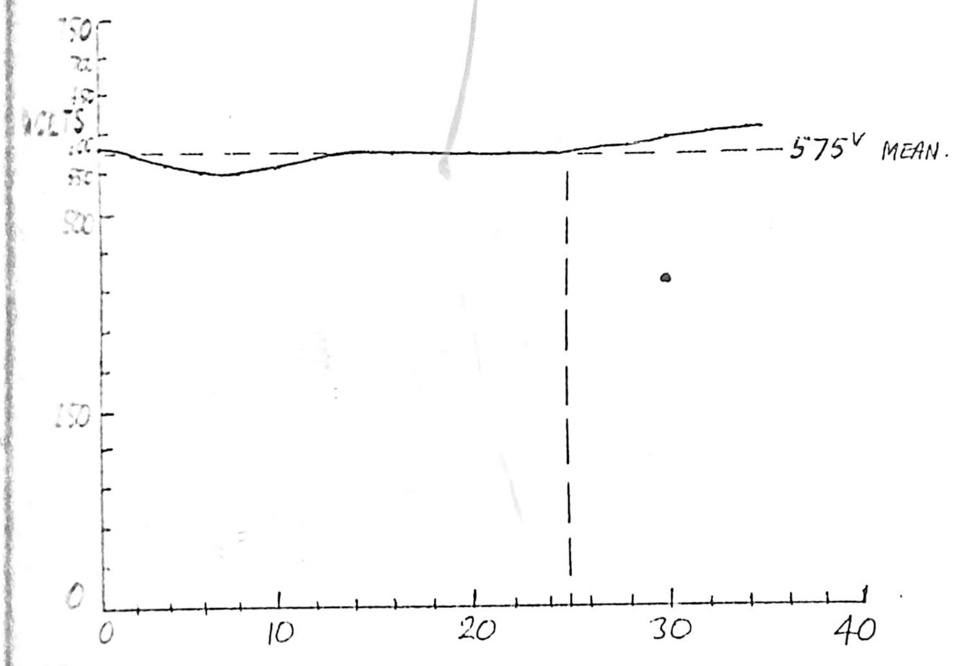
NOISE AND AESTHETICS:

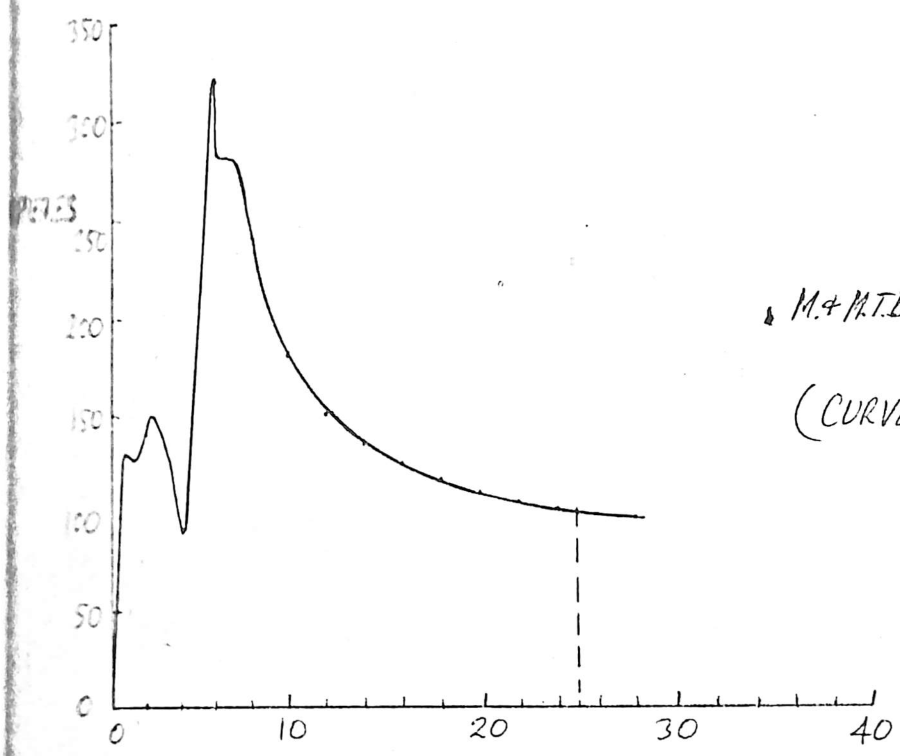
Despite the hard fact that Open Ballast construction costs $ 71,000. per route-mile to install above the cost of a paved concrete track, it is nevertheless preferred because of its superior absorption of noise, and (possibly) its more pleasing appearance. Thin (9-inch) concrete pavements can be used in tramway reserves , in order to reduce the construction (and maintenance) costs, but over long distances, are avoided when possible.

Tramway reserves lend themselves admirably to landscaping development, and when sufficiently wide, can be used as a linear park, with the one-way carriageways passing along each side,& with the tramway along the centre, often separated by low hedges. Even when the reserve is too narrow to carry vegetation, the smooth sweeping curve down the centre of a high speed road is far superior to rutted "centre-of-the-road" tracks such as Melbourne has experienced.over most of its tramway system.

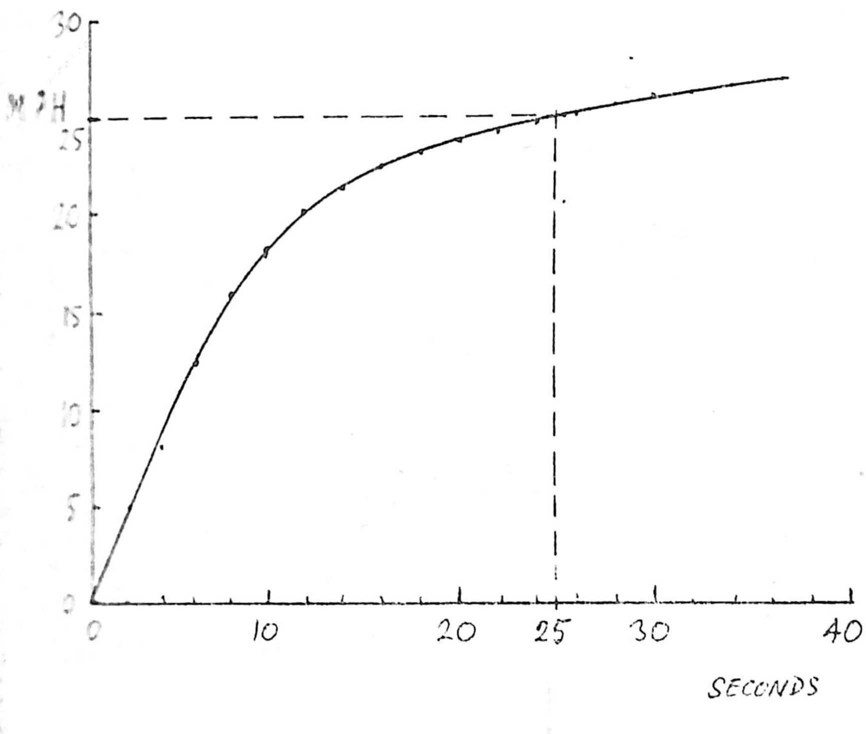
Open Ballast Reserved Tracks
Victoria Parade, East Melbourne.

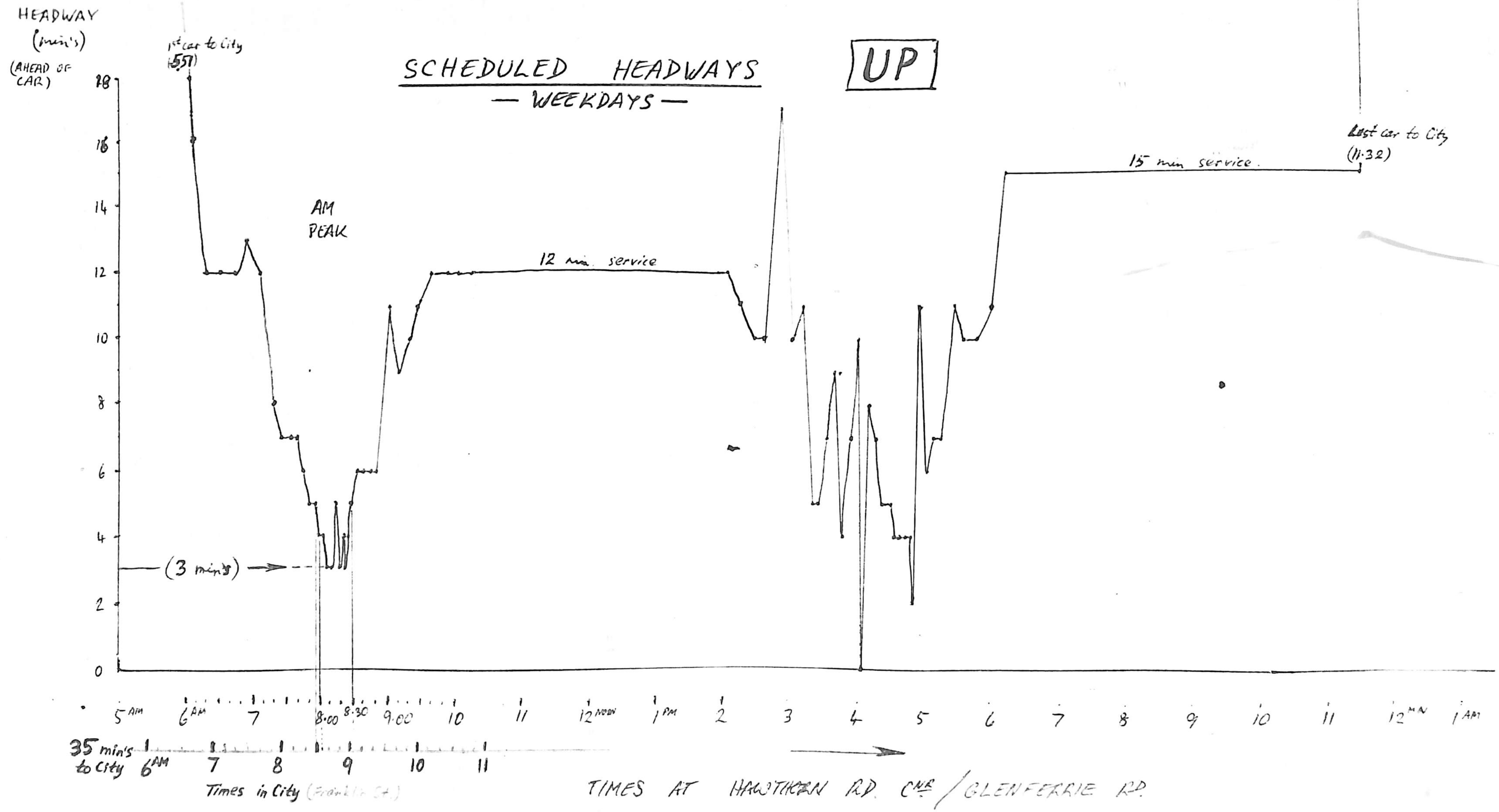
ACCELERATION TESTS — S.W.6. CAR Nº 888
SEATED LOAD (48 Nº PASSENGERS).



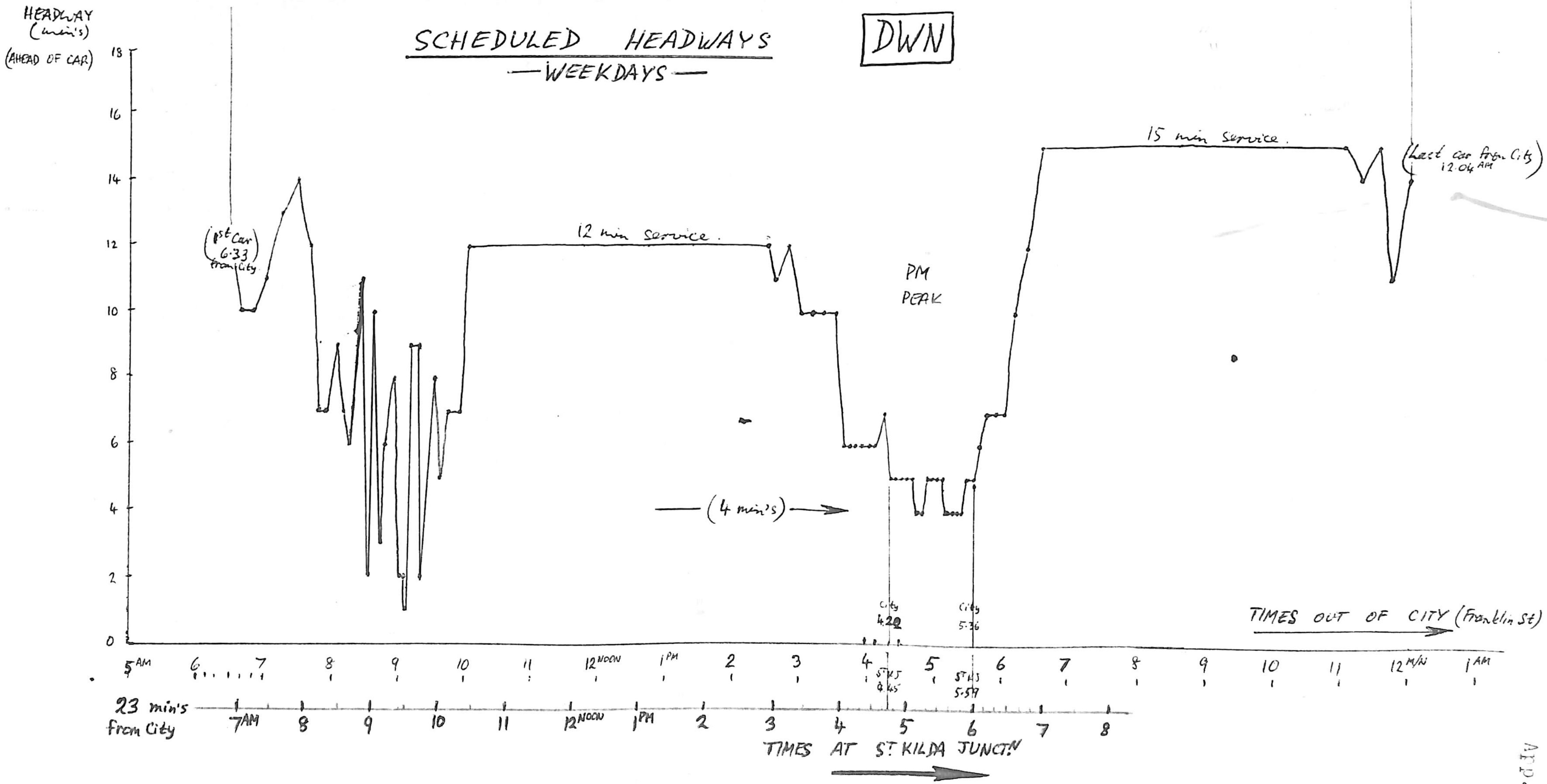


M.& M.T.B. LABORATORY REPORT
OCTOBER 1945
(CURVES FROM MURDAY RECORDER)




SCHEDULED HEADWAYS
— WEEKDAYS —
UP
HEADWAY (min's) (AHEAD OF CAR)
1st car to City (5.51)
AM PEAK
(3 min's)
12 min service
15 min service.
Last car to City (11.32)
0
2
4
6
8
10
12
14
16
18
5 AM
6 AM
7
8.00
8.30
9.00
10
11
12 NOON
1 PM
2
3
4
5
6
7
8
9
10
11
12 MN
1 AM
35 min's to City
6 AM
7
8
9
10
11
Times in City (Franklin St)
TIMES AT HAWTHORN RD. CNR / GLENFERRIE RD.

App. 'C'


SCHEDULED HEADWAYS
— WEEKDAYS —
DWN
HEADWAY (min's) (AHEAD OF CAR)
18
16
14
12
10
8
6
4
2
0
(1st Car 6·33 from City)
12 min Service.
15 min Service.
(Last car from City 12·04 AM)
PM PEAK
— (4 min's) →
City 4·20
City 5·36
TIMES OUT OF CITY (Franklin St)
5 AM 6 7 8 9 10 11 12 NOON 1 PM 2 3 4 5 6 7 8 9 10 11 12 M/N 1 AM
St KJ 4·45
St KJ 5·57
23 min's from City
7 AM 8 9 10 11 12 NOON 1 PM 2 3 4 5 6 7 8
TIMES AT ST KILDA JUNCTN

APP. 1C

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SUMMARY OF SCHEDULED RUNNING TIMES:

App. 'C'

DANDENONG ROAD

	UP (Minutes) WEEKDAYS, SAT., SUN. 1st car – 8.09PM	UP (Minutes) WEEKDAYS, SAT., SUN. 8.10PM – Last car.	DOWN (Minutes) WEEKDAYS, SAT., SUN. 1st car – 9pm	DOWN (Minutes) WEEKDAYS, SAT., SUN. 9pm – Last.
Hawthorn Rd. Cnr.	–	–	11.	9.
Orrong Rd.	3.	3.	8.	6.
CLOCK (Up/Down) (Landsdowne Rd)	4.	4.	7.	5.
Chapel Street	9.	7.	2.	2
St Kilda Junction.	11.	9.	–	–

HIGH STREET

	UP ALWAYS	DOWN SAT: 1st – 6.00pm / WEEK: 1st – 6.00am	DOWN SAT: 6.01pm – Last / SUN & HOLIDAYS (all) / WEEK: 6.01pm – last
Malvern Town Hall	– min's	13 min's.	12 mins
Orrong Road.	2.	10	10
CLOCK (Up) (Chomley St)	5.	7	7
Chapel St.	9.	3	3
Prahran Rly Stn CLOCK (Down).	10.	2	2
St Kilda Rd.	12.	–	–

TABLE OF "MULTIPLICATION FACTORS":

App. 'D'

TIME-SLOT	Period	Av. services.	No. OF CARS IN SERVICE (per week) DOWN	No. OF CARS IN SERVICE (per week) UP
Weekdays:				
AM Peak	(6.30A – 10A)	7.8 min	(× 27 × 5) = × 135	(× 32 × 5) = × 160
MID-DAY	(10A – 3P)	12.0 min.	(× 25 × 5) = × 125	(× 25 × 5) = × 125
PM Peak	(3P – 6.30P)	5.8 mins.	(× 36 × 5) = × 180	(× 31 × 5) = × 155
NIGHT	(6.30P – 12.00)	15.0 min's	(× 22 × 5) = × 110	(× 22 × 5) = × 110
Saturday	(all day)	(~ 13 min)	× 85	× 85
Sunday	(. . .)	(~ 25 min)	× 36	× 36

∴ No. of trips per week, on each route, is 1,342

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DETAILS OF TRIPS STUDIED:

Route	Direction	Time-Slot	Tram Run No.	Trip Nos.	Day of Week	Time of Departure: Scheduled	Time of Departure: Actual	Weather	Car No.
[illegible]	UP	SAT.	GH 16	08	Sat.		1.44 PM	Fine	561
		SUN.	GH 2	12	Sun.		3.25 PM	Fine	954
			GH 2	16	Sun.		3.24 PM	Fine	917
		AM Peak	GH 27	26	Tues.		8.51 AM	Fine	914
			GH 27	40	Wed.		8.51 AM	Fine	538
			GH 45	54	Thur.		9.03 AM	Very Wet	497
			GH 27	64	Fri.		8.50 AM	Fine	901
		MID-DAY	GH 28	44	Wed.		10.58 AM	Fine	653
		PM Peak	GH 46	20	Mon		5.05 PM	Fine	360
			GH 46	30	Tues.		5.05 PM	Fine	314
			GH 43	48	Wed.		5.12 PM	Wet.	582
			GH 46	58	Thur.		5.05 PM	Fine	575
		NIGHT	GH 35	36	Tues.		11.30 PM	Fine	721
High St	UP	SAT	M 44	02	Sat		11.41 AM	Fine	897
			M 40	04	Sat		12.31 PM	Fine	869
			M 44	06	Sat		1.12 PM	Fine	897
		SUN.	M 13	10	Sun		2.38 PM	Fine	899
			M 13	14	Sun		2.37 PM	Fine	897
		AM Peak	M64	24	Tues.		8.12 AM	Fine	847
			M64	38	Wed.		8.12 AM	Fine (wet roads)	845
			M64	52	Thur.		8.15 AM	Very Wet	920
			M64	62	Fri.		8.12 AM	Fine	833
		MID-DAY	M 54	42	Wed.		10.12 AM	Fine	847
		PM Peak (1)	M59	18	Mon		4.27 PM	Fine	301
			M59	28	Tues.		4.26 PM	Fine	358
			M59	46	Wed.		4.30 PM	Mod. Wet	293
			M59	56	Thur.		4.27 PM	Fine	362
		PM Peak (2)	M56	22	Mon.		5.46 PM	Fine	899
			M56	32	Tues.		5.46 PM	Fine	897
			M56	50	Wed.		5.47 PM	Mod. Wet.	776
			M56	60	Thur.		5.47 PM	Fine	455
		NIGHT	M 66	34	Tues.		10.44 PM	Fine	834

CONT'D OVER →