

LEES

MELBOURNE AND METROPOLITAN TRAMWAYS BOARD

ENGINEERING DEPARTMENT

PLANNING BRANCH

SWANSTON STREET UNDERGROUND TRAMWAY

CITY ROAD TO BOUVERIE STREET

SWANSTON ST 0/1G

JUNE 1972



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CITY ROAD TO BOUVERIE STREET.

1. ROUTE.

The basic assumption is that this underground tramway is to serve the areas at present served by the surface trams in Swanston Street. The following routes enter Swanston Street from the south :-

South Melbourne Beach  
St.Kilda Beach  
Carnegie  
East Malvern  
East Brighton  
Malvern  
Glen Iris  
Camberwell  
Toorak

The following routes enter Swanston Street from the north :-

East Coburg  
Moreland

The Batman Avenue routes could also be included to advantage as this would permit services to be operated to Prahran, Burwood and Wattle Park. Apart from the greater convenience to the passengers on these routes the following factors are of importance :-

- (a) Trams from the north may be reversed in Batman Avenue without delaying St.Kilda Road traffic and at the same time serve Flinders Street Railway Station. The Batman Avenue line could also be used as a short term lay-up siding as well as a reversing siding.
- (b) It would be a highly desirable access during construction. There are a number of areas along Batman Avenue that are likely to be suitable for construction base sites.

The Elizabeth Street routes could also be included to considerable advantage particularly as they would give a better balance of vehicles, and would permit services to be operated to North Coburg, West Coburg, Essendon Aerodrome and West Maribyrnong.

On the other hand it is not suggested at this stage that the abandonment of the tram services in Elizabeth Street should even be contemplated.

However, even if the Elizabeth Street routes are included a separate reversing and storage siding (or sidings) would be necessary somewhere north of La Trobe Street to enable trams from the south to be reversed and at the same time serve the proposed underground railway station at La Trobe Street.

The extent of the area that could be served is shown on Figure No.1. Here it is found that approximately 40 square miles of the metropolitan area is within  $\frac{1}{4}$  mile of at least one of the above tram routes.

## 2. OBSTRUCTIONS.

### 2.1 Major Obstructions.

The major obstructions to tunnels are :-

River Yarra.

18" dia. sewer in Flinders Street.

21" dia. sewer in Swanston Street.

The Postal Department tunnel along Swanston Street.

The Postal Department tunnel along Little Collins Street.

The Postal Department tunnel along Little Bourke Street.

The proposed underground railway in La Trobe Street.

The buildings at and near the intersection of Victoria and Swanston Streets.

### 2.2 Obstructions to Passenger Access Passageways.

These consist of a number of small diameter services under the footpaths which are generally within 3 feet of the surface. They consist of :-

- |                                          |                                                                                                                                                                            |
|------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Postal Department</u>                 | - Cables generally in nests of conduits.                                                                                                                                   |
| <u>Gas and Fuel Corporation</u>          | - Gas mains.                                                                                                                                                               |
| <u>M.C.C. Electric Supply Department</u> | - Low voltage power lines generally in nests of conduits.                                                                                                                  |
| <u>M.M.B.W.</u>                          | - Water pipes.                                                                                                                                                             |
| <u>M.C.C.</u>                            | - Stormwater drains. It may be necessary to lower the stormwater drains at both Bourke and Collins Street intersections to obtain convenient passenger access.             |
| <u>M.M.B.W.</u>                          | - Sewers. Collecting sewers on each side of the tunnel and at a greater depth than at present may be necessary for the section from Little Bourke Street to Flinders Lane. |

As most of the minor services are comparatively shallow their re-location would be unnecessary provided that the top of passageways are not higher than about three feet below the street surface, however a number will require moving transversely under footpaths to permit stairways and ramps to reach street level.

### 2.3 Drawings of Major Services.

Most of the major services are shown on the following

drawings (not included in this report) :-

Swanston St.	- Flinders Street Intersection	- Drawing U20
"	" - Flinders Lane	" - Drawing U21
"	" - Collins Street	" - Drawing U22
"	" - Little Collins Street"	- Drawing U23
"	" - Bourke Street	" - Drawing U24
"	" - Little Bourke Street "	- Drawing U25
"	" - Lonsdale Street Intersection	- Drawing U26
"	" - Little Lonsdale Street "	- Drawing U27
"	" - La Trobe Street	" - Drawing U28
"	" - A'Beckett Street	" - Drawing U29
"	" - Victoria St.&Franklin St."	- Drawing U30
"	" - Queensberry Street	" - Drawing U32
Victoria St.	- Bouverie Street	" - Drawing U65

#### 2.4 Crossing the River Yarra.

The theoretical river bed is understood to be at RL minus 15 feet, that is the level to which the river is dredged.

The top of the tunnel has therefore been designed to meet this requirement. Though it is considered that a shallower river bed at the underground crossing may be approved at a later date, and as any such concession is likely to be of the order of only one or two feet it is not likely to have any significant effect on the preliminary design.

The geology at this region is of interest. The river bed is in a slab of quaternary basalt that in turn rests on silt. This is set out in "Preliminary Report on the Geology between Princes Bridge and Victoria Street", prepared by the Department of Mines Victoria - 27th June, 1963 - refer Figure 2 which is copied from this report.

In view of the low bearing pressure of the silt beneath the ~~basalt~~ it may be necessary to drive some piles to support the tunnel. This would be most difficult or almost impossible to do along the centre line of Princes Bridge. Furthermore present day practice indicates that the submerged tunnel type of construction may be the most economical, that is, the tunnel is constructed on dry land, floated into position and then submerged into a pre-dug trench.

The tunnel route has therefore been located on the upstream side of Princes Bridge. Upstream rather than downstream because of greater convenience during construction. The distance upstream of course should be the minimum to permit construction and operation without interfering with the foundations of Princes Bridge.

#### 2.5 18" dia. Sewer in Flinders Street.

This is the main sewer for serving east of Swanston Street. It would be out of the question to either raise or lower it without resorting to pumping. A possibility would be to turn it north along Swanston Street on the east side until it could cross beneath the tunnel and then return to Flinders Street on the west side.

At this stage it is considered that such expenditure

could not be justified.

2.6 21" dia. Sewer in Swanston Street.

As this is on the west side it could be avoided by designing the route of the underground tramway to the east of this sewer.

2.7 Postal Department Tunnels.

These are large tunnels, the internal dimensions are about 7 feet high by 5 feet wide, they each carry about 30 large lead sheath cables some which have 800 pairs of telephone lines and some are co-axial cables.

The one along Swanston Street can be avoided. Those in Little Bourke and Little Collins Streets are mid-way between stops so that tracks designed as "momentum grades" will pass beneath them without necessitating the platforms at Collins and Bourke Streets being further lowered to any appreciable extent.

The practical minimum for the rail level below the city intersections appears to be of the order of 30 feet - two floors in our Head Office Building.

Refer Drawing No. U94, this drawing indicates that the street level to rail level is 28 feet, however an additional 2 feet at least would be desirable to clear shallow services.

3. GRADIENTS.

The preliminary design has been based on the following grades.

3.1 Where the average grade between two stops is uphill a minimum limiting uniform grade of  $1/20$  (5%) has been assumed.

3.2 Where the average grade between two stops is downhill the following limiting grades have been assumed.

(i) Acceleration portion - limiting grade of  $1/15$  (6-2/3%) has been assumed. This may be regarded as being conservative when one considers that the present tram routes have grades steeper than  $1/12$  and the departure line for goods trains on the Victorian Railways new hump yard is  $1/19$ , however allowance should be made for emergency braking to avoid collisions.

(ii) Coasting portion - a limit of  $1/15$  (6-2/3%) has again been assumed to make allowance for emergency braking.

(iii) Retardation portion - a uphill grade of  $1/20$  (5%) for a distance of approximately 120 feet has been assumed. A vehicle approaching this grade at 20 ft. per second would not have sufficient momentum to reach the top. Hence braking of a tram would be a simple matter on such a grade.

3.3 When a vehicle is to be held stationery a limiting gradient of  $1/50$  has been assumed.

These matters are discussed in "A discussion of Fundamental Aspects of Underground Tram Operations that are of Importance for the Preliminary Design" - July 1966.

4. STOPPING PLACES.

The following are considered to be the desirable

stopping places along the proposed route in order from south to north.

- (i) Cultural Centre. A stop at this location is essential for junction purposes i.e., for the Nolan Street Junction, it would also serve City Road, Sturt Street, South Gate, the Alexander Gardens and the Cultural Centre including its car park. Passenger access from the City Road underpass could be readily provided.
- (ii) Flinders Street. Tram/train passenger interchange is of great importance here. It is also essential for junction purposes ie., for the Batman Avenue Junction.
- (iii) Collins Street. Essential for Collins Street.
- (iv) Bourke Street. Essential for Bourke Street.
- (v) La Trobe Street. Tram/train passenger interchange with the proposed underground railway is of ~~great~~ importance here.
- (vi) Victoria Street/Franklin Street. This stop is essential for junction purposes.

Lonsdale Street has been eliminated chiefly because of the problem of grade as the tunnel must rise from beneath the Postal Department tunnel in Little Bourke Street to above the proposed underground railway in La Trobe Street.

However, tram passengers wishing to get to Lonsdale Street could alight at La Trobe Street at about the same levels as the street level in Lonsdale Street and reach street level via the Railways escalators and ramps.

Passengers from Lonsdale Street would board the trams at the Bourke Street stop via a downhill approach.

## 5. PASSENGER ACCESS.

While it is appreciated that the design of passenger access will directly involve other organizations the suggestions indicated on Drawing No. U94, are to indicate feasibility rather than as recommendations.

Passenger access is assumed to be from public property i.e., not from behind present day "title lines of buildings", in other words the design is not based on the aquisition of private property.

Access passageways are arranged to minimize the horizontal (and also the vertical) projected journey distance to trams from the journey origin (and vice versa).

It has been assumed that each stopping place should have a ramp for at least one access path for the convenience of people using prams, and wheel chairs, and for maintenance personnel who may be required to wheel equipment in and out.

In some cases the passenger access passageways could be incorporated with pedestrian subways for busy traffic inter-sections.

They may also incorporate shops as well as access to the basement floors of commercial houses.

Access passageways for tram/train modal interchange at La Trobe Street will be dependent upon the design finally adopted for the access passageways to the underground railway station.

Ramps are based on a maximum gradient of 1/8. Figure No.3 and Figure No.4, are included as being representative of typical arrangements.

6. ESTIMATES OF COSTS.

Estimates at this stage can only be indicative of the likely order of costs, as the design to date is little more than a preliminary feasibility study.

The following are the estimated costs based on present day (1971) costs.

6.1 Re-arrangement of services.

6.1.1 Water Mains.

Though it is not anticipated that any major pipe line will be affected, it will be necessary to disturb a number of shallow services under the footpaths to make way for passenger access passageways.

Estimated cost \$420,000

6.1.2 Sewers.

The estimated cost of relocating a sewer where it is first necessary to excavate a tunnel was \$1,000,000 per mile in 1965. If an allowance is made for 2 miles of such construction estimated cost today is then 2 miles x \$1,000,000 x (1.04)<sup>6</sup> = \$2,500,000.

\$2,500,000

(Assuming cost increase of 4% per annum).

Also allow for miscellaneous connections.

\$600,000

6.1.3 Postal Department.

It is assumed that the main tunnels will not be disturbed (apart maybe from the spur tunnels at Collins Street and Flinders Lane). The work would largely entail a re-arrangement of the shallow services under the footpaths for passenger access passageways.

Estimate \$2,000,000

6.1.4 State Electricity Commission.

Two high voltage lines, one 22KV and one 67KV cross Swanston Street - they are buried in sand. It may be necessary to alter their level.

Estimate \$100,000

6.1.5 Gas and Fuel Corporation.

Estimate \$250,000

6.1.6 M.C.C. Electrical.

These are located in conduits between terminal pits and they are generally shallow. They may require moving short distances to make way for passenger access passageways.

Estimate \$600,000

6.1.7 Stormwater Drains.

A new stormwater drain will probably be



required from north of Bourke Street to Flinders Street, a distance of approximately 1/3 miles. It will involve tunnelling.

Estimated cost at \$800 per foot	-	\$1,400,000
Other smaller drains	-	\$300,000

6.1.8 Miscellaneous Services.

These could include traffic light cables, abandoned services and some work to protect building foundations.

Assumed Estimate \$300,000

6.1.9 Total Cost of Re-arrangement of Services.

Water mains	\$ 420,000
Sewers	3,100,000
Postal Department services	2,000,000
S.E.C. services	100,000
Gas mains	250,000
M.C.C. Electrical	600,000
Stormwater drains	1,700,000
Miscellaneous	<u>300,000</u>
	\$8,470,000
	÷ \$8,500,000

6.2 Tunnels.

Here again estimates can only be indicative of the likely order of the cost. Apart from the river crossing it is assumed that all tunnelling will be by underground methods. It is considered that open cut methods would disrupt the activity of the central business area to an extent that would not be acceptable.

The question of whether a boring machine can be successfully used for such shallow tunnels is unlikely to have a large bearing on the preliminary estimate of costs - on the other hand it may have a large bearing on the construction time table.

The following lengths of single track tunnel have been assumed for the estimate of the portion.

City Road to Queensberry St.	2.30 miles
Victoria St. Junction to Bouverie St.	0.30 "
Flinders St. Junction to surface in Batman Avenue.	0.40 "
Reversing storage siding at Victoria St.	0.40 "
	<u>3.40 miles</u>

The sections beyond Queensberry Street and Bouverie Street are to form part of another report.

The length and nature of these sections would be influenced to a considerable extent by prevailing authoritative opinion. The construction cost per unit length would also be less because -

- (a) underground services would be a much smaller problem, and
- (b) construction could be carried out much more cheaply by taking full possession of the roadway and thus permitting open cut construction.

6.2.1 M.M.B.W. Costs as a Basis for Estimates.

The M.M.B.W. estimated in 1965 that the cost of constructing a 9'-3" internal diameter tunnel - with an excavated diameter of approximately 11'-0" was \$3.00 per cu.foot excavated.

If one applies the "Engineering News - Record" ratio of 402 to 212 (refer section 6.2.2) for the cost per foot of 19 ft. diameter unlined tunnel to a 11 ft. diameter unlined tunnel and an inflation factor of 4% per annum, the cost per foot run would be -

$$95 \text{ ft.}^3 \times \$3 \times \frac{402}{212} \times \frac{(1.04)^6}{(100)} = \$680 \text{ per run}$$

(95 ft.<sup>2</sup> is the area of a 11'-0" diameter circle).

However, the M.M.B.W. engineers stated that our costs may be considerably higher because of the shallow nature of the tunnel and the proximity of other services. If one therefore allows 50% to 60% excess, the cost would be \$1,020 to \$1,090 per foot run.

6.2.2 Engineering News Record Estimates.

A survey of the costs of 99 tunnels was made in the U.S.A. and a summary of the results were published in Engineering News - Record 17th December, 1959.

Results from this are as follows for a 19'-0" diameter excavation to give a 16'-0" diameter lined tunnel.

<u>Labour</u>	- \$142 per foot run at \$3.50 per hour, adjusted to \$2.00 per hour.	\$ 83
<u>Equipment</u>	- (assume costs are similar).	82
<u>Power</u>	- \$6.85 per foot run based on 1c per HP - hour, adjust to double this figure.	14
<u>Track, Pipe Work etc.</u>		
	\$21/ft. run increase to \$25/ft.run	25
<u>Explosives.</u>		
	\$16/ft.run suggest approx. double	30
<u>Steel Supports.</u>		
	\$300/ft.run Steel at \$78/ton, adjust to \$100 per ton.	400
<u>Timber.</u>		
	Concrete Lining \$200 per ft.run at \$35/cu.yd. and grout at \$3.5/cu.ft., adjust by 150%.	300
		984
Contingencies	- 15%	146
		\$1,130

6.2.3 Assumed Cost.

The above two estimates are based on two circular tunnels, however it is assumed that if a twin tunnel is used or if the cross-section is horseshoe or rectangular, instead of circular the effect on the cost of the scheme is not likely to affect a preliminary estimate to an appreciable extent.

The estimated cost is assumed to be \$1,100 per foot run of single tunnel.

i.e. \$5,800,000 per mile ÷ \$6,000,000 per mile.

Hence the estimated cost for 3.40 miles would be \$20,000,000.

It is assumed that any variation in the cost per lineal foot of tunnel for the part under and south of the River Yarra would have no major affect on the above estimate.

6.3 Access Stations.

Here estimates could be very much astray until a detail design has been prepared as it would depend on -

- (a) the elaborate nature such as maybe eight street openings per intersection, escalators or "moving footpaths" for each, access to basements of buildings plus amenities provided,
- (b) the proportion of the cost chargeable to this scheme. Such subways could greatly reduce pedestrian congestion at street intersections,

A preliminary estimate is an average of \$2,500,000 per "station", hence for the five stations the estimate would be \$12,500,000 of which \$10,000,000 could be a charge against the underground tramway project.

The Degrave Street subway under Flinders Street is believed to have cost 1/3 million pounds. The Board's work in this connection was completed in October 1954, and since that date the average cost of labour has increased from \$0.67 to \$1.55 per hour - an increase of 130%, while materials have increased from 50% upwards. It is therefore reasonable to assume that the cost of a similar project in 1971 would be of the order of \$1.5 million.

6.4 Track Work, Overhead Power Supply etc.

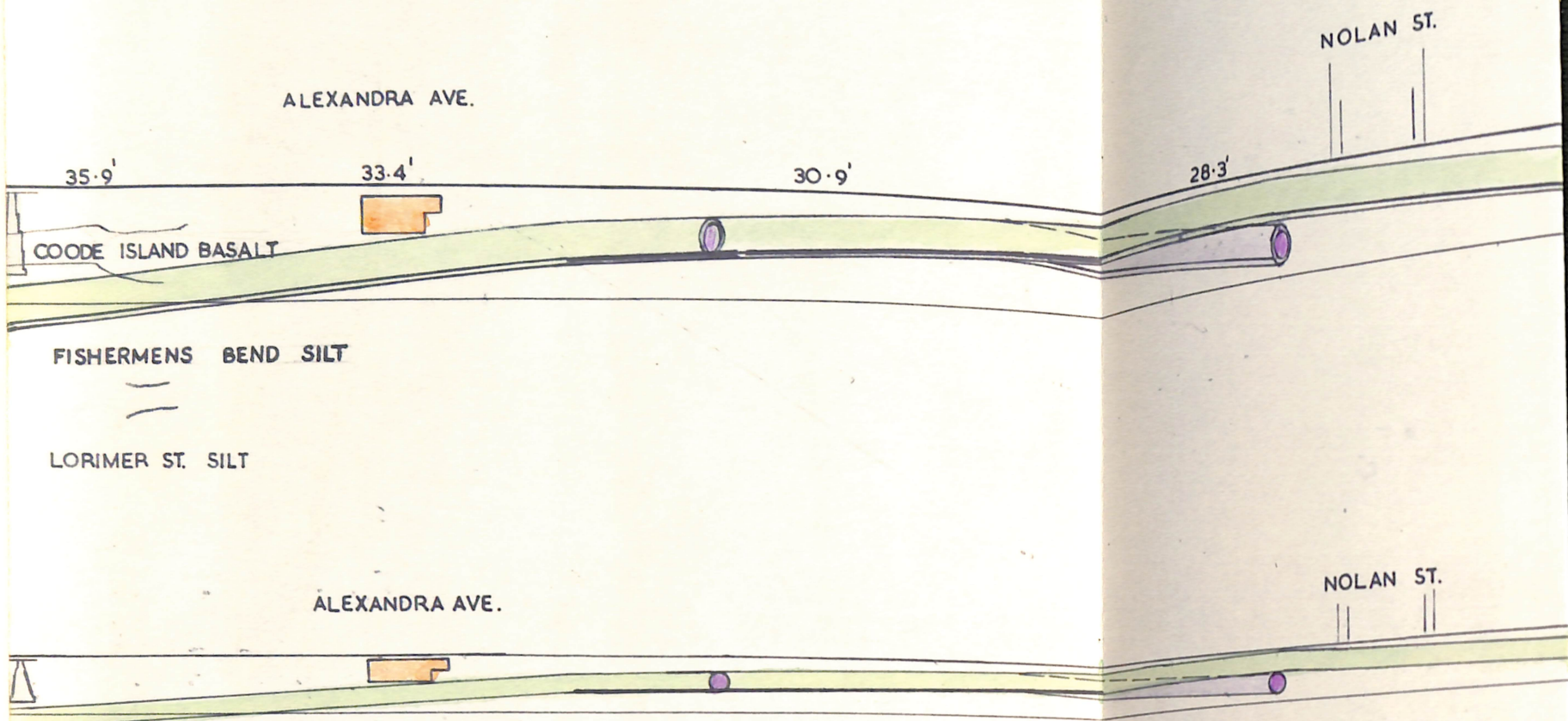
It is assumed that \$400,000 per mile should be adequate to cover the cost of permanent way, overhead wiring (or conductors), illumination, fire services, drainage, and pumping stations. \$1,500,000

6.5 Summary of Estimated Costs.




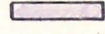
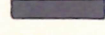

Re-arrangement of services	\$ 8,500,000
Tunnels	20,000,000
Access stations	10,000,000
Track work, overhead etc.	<u>1,500,000</u>
	<u>\$40,000,000</u>

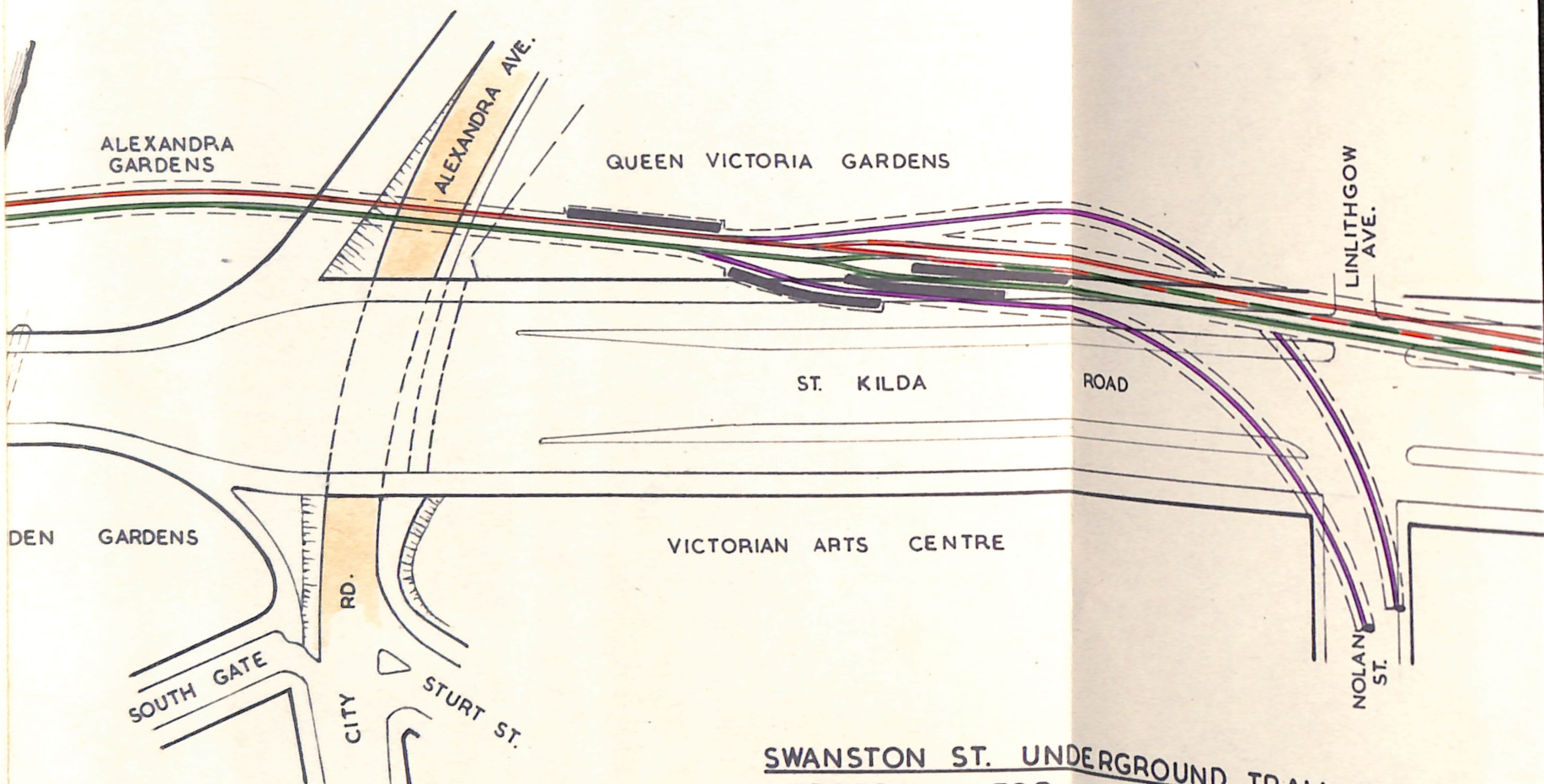
	B/F	\$40,000,000
Supervisors, planning etc. 10%		4,000,000
General provision 10%		4,000,000
General day labour jobs 5%		<u>2,000,000</u>
		<u>\$50,000,000</u>

*D. W. Lees*  
16-6-72



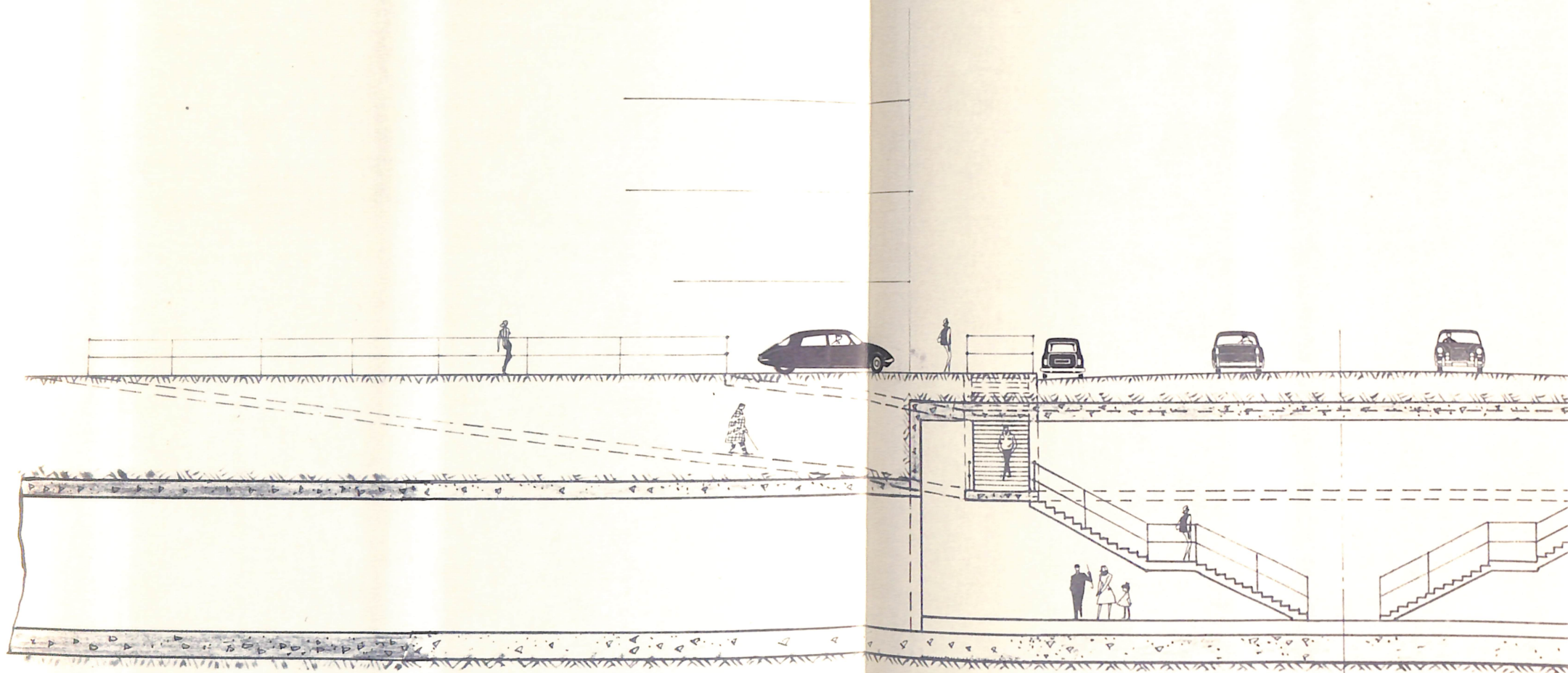
**LEGEND:**

- |                                                                                      |                 |                                                                              |
|--------------------------------------------------------------------------------------|-----------------|------------------------------------------------------------------------------|
|  | ( RED )         | DENOTES SOUTH BOUND TRAM                                                     |
|  | ( RED / GREEN ) | DENOTES EXPRESS TRAM                                                         |
|  | ( GREEN )       | DENOTES NORTH BOUND TRAM                                                     |
|  | ( PURPLE )      | DENOTES BRANCH                                                               |
|  | ( BLACK )       | DENOTES LOADING PLATFORM                                                     |
|  | ( YELLOW )      | DENOTES PASSENGERS ACCESS RAMPS, STAIRWAYS, SUBWAYS ETC. (OMITTED FROM PLAN) |



**SWANSTON ST. UNDERGROUND TRAM ROUTE  
PROPOSAL FOR ULTIMATE DEVELOPMENT  
NOLAN ST. TO QUEENSBERRY ST.**

MELBOURNE & METROPOLITAN



UNDERGROUND TRAM  
PROPOSED BASIC ARRANGEMENT A  
TYPICAL LONGITUDINA