6-1977

Banfield Transitway Project Downtown Circulation Alternatives

Tri-County Metropolitan Transit District

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BANFIELD TRANSITWAY PROJECT

DOWNTOWN CIRCULATION ALTERNATIVES

JUNE 1977
BANFIELD TRANSITWAY PROJECT

DOWNTOWN CIRCULATION ALTERNATIVES

JUNE 1977
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BANFIELD TRANSITWAY PROJECT
DOWNTOWN CIRCULATION ALTERNATIVES

SECTION 1 - SUMMARY

The focus of long range transportation planning in the Portland region since 1973 has been on the development of exclusive transit corridors radiating from downtown Portland. The Interim Transportation Plan adopted in June 1975 described a transportation system for 1990 in which public transit plays a key role in providing high quality mobility for people in the urban area. Three major corridors were identified as priority candidates for investment in express transit facilities. In these corridors, the Sunset, Banfield, and Oregon City corridors, the plan calls for the development of "rapid and convenient transit service" to serve activity centers along the lines and provide access to downtown, together with supporting Tri-Met bus services, suburban transit stations, and park-and-ride facilities.

Preliminary planning has now reached an advanced stage in the Banfield corridor, the corridor with the greatest patronage potential, and also, because of the withdrawal of the Mount Hood Freeway from the regional highway plan, a corridor facing a significant future highway capacity deficiency. For these reasons it has been assumed in this report that the Banfield corridor would probably be the initial corridor improvement, and that any subsequent corridor development would expand into the other two priority corridors.

Downtown Portland is the main destination and terminus of the Banfield corridor, as well as the focal point of the three corridor system, and the existing Tri-Met bus operations. Downtown Portland is also the principal commercial and employment center in the region and is expected to maintain this regional dominance in the 1990 design year. Clearly, therefore, future transportation plans are of primary significance to the downtown area.
INTRODUCTION

Early in 1977, Tri-Met initiated the Central Area Transit Circulation Study to develop alternative transit circulation configurations in the CBD for the design year 1990. The study was to develop recommendations for each of the most probable combinations of bus and light rail modes in the Central Area.

For the purposes of this study the central area is defined as that part of downtown bounded by the Stadium Freeway and the Willamette River. The entry points of the three priority corridors to the central area are on the Steel Bridge for the Banfield corridor, in the vicinity of Jefferson-Columbia couplet for the Sunset corridor, and on either the Hawthorne Bridge, or on the Southern Pacific's Jefferson Street branch, for the Oregon City corridor. Figure 1 shows the study area and corridor access points.

Activity in the central area is concentrated along a commercial core running north/south from Burnside to Harrison Street, with its axis along the transit mall, with a secondary perpendicular axis running from Portland State University in the west to the Willamette River, generally along Market Street. Within these two belts, most of the retail and employment activity in the central area is concentrated, as has been the majority of the urban renewal and redevelopment investment. Future projections estimate little change in this activity distribution, apart from some extension of redevelopment activity to fringe areas, primarily along the waterfront, and north of Burnside.

While the regional land use plans call for a continuation of modest but sustained growth of central Portland, and its continuation as the regional center, the regional transportation plans call for a de-emphasis on automobile travel region-wide, and particularly to the central area.
These goals are summarized in the Downtown Parking and Circulation Policy, adopted by the City Council in 1975, which calls for a ceiling on the number of parking spaces in downtown Portland, the conversion of long term parking for commuters to short term parking for shoppers and other commercial users, and assigns long term functions to each of the streets in the central area, as:

1) traffic access streets
2) local service streets
3) non-automobile oriented streets

The implementation of this policy, and a concurrent investment in transit facilities, will result in Tri-Met's patronage, which almost doubled between 1969 and 1976, doubling again before the design year of 1990. Even then transit will be carrying only about six percent of the total trips within the region, leaving considerable potential for growth beyond 1990. New equipment, better schedules, increased service area, free transit in the central area, concessionary fares, and now the transit mall are all contributing to this rise in patronage.

At the same time it has become clear that the operation of greatly increased numbers of buses in the downtown will introduce problems both of street capacity and of conditions inconsistent with downtown environmental goals. Long term energy considerations, and the spiraling costs of providing better transit service have led to the consideration of light rail transit as an alternative mode in the major corridors.

Light rail transit (LRT) uses large electric vehicles running on rails, and can operate either on streets or along freeway, railroad, or other alignments. A less costly form of rapid transit, LRT offers potentially lower operating costs on major transit routes, together with higher capacity, and less noise and air pollution.
The LRT mode has evolved from the old time street cars, but just as the buses of today only superficially resemble the buses of the 1920's, so LRT of the 1970's bears little resemblance to the street cars that once operated in Portland. The development of LRT has occurred primarily in Western Europe, where some countries continued to invest in public transit facilities during the 1950's and 60's. Today it forms the primary urban transit mode in medium and large cities in Belgium, Holland, Germany, Austria, and Switzerland, and is attracting renewed attention in cities around the world. In the U.S., Boston and San Francisco are engaged in upgrading the remnants of their streetcar systems to LRT, and other cities have similar plans. The City of Buffalo, New York is constructing a new system, while in Canada, the City of Edmonton will open the first segment of its new LRT system next year. Both Calgary and Vancouver are in the advanced stages of planning new systems. Parallel events are occurring in other cities across the world as the need to develop more effective transit, at a minimum cost, becomes more generally realized.

BASIC TRANSIT ALTERNATIVES

Several basic transit alternatives were considered for the year 1990, and compared to the reference condition, that expected to exist in late 1977, (when the transit mall is completed).

The Null alternative essentially consists of the 1976 system expanded to 1990 in proportion to population growth. This alternative is contrary to local and regional policies, and is not therefore considered a viable option.

The second alternative calls for a minimum investment approach to an all-bus system, including selected street improvements necessary to maintain a satisfactory level of operation. This alternative is known
as the Low Cost Improvement, or Transportation Systems Management (TSM) bus option. All the subsequent alternatives incorporate relevant portions of this alternative.

The third alternative envisages maximized development of an all-bus system, with exclusive busways or "high occupancy vehicle" (HOV) facilities in each of the three priority corridors, and emphasis on achieving the highest quality of bus service. So far as the Central Area is concerned, both all-bus options lead to similar numbers of buses in the CBD in the 1990 design year.

The fourth alternative calls for a light rail transit line in the Banfield corridor, with the rest of the regional transit system to remain bus operated. It is assumed that the non Banfield part of the system would develop bus transit in a manner generally similar to the low cost, or TSM alternative.

The fifth alternative considers an expanded LRT system to serve the other two priority corridors, with residual transit service to downtown, (as well as all circumferential and feeder service) remaining bus operated.

While a three corridor LRT system forms the planning horizon for this study, it is well to recognize that in the long term an LRT system could be expanded to serve other major regional corridors.

STUDY SUMMARY

Bus Alternatives

The Null alternative will result in little direct change in 1977 conditions on the transit system. Bus routing in the downtown would continue
to concentrate on the transit mall. Indirectly this alternative would lead to increased auto traffic downtown and require re-examination of present planning objectives.

The two bus-development alternatives will generate a 1990 peak hour bus flow considerably in excess of the estimated capacity of the transit mall. The excess buses must therefore be displaced to other streets. The displaced buses must be routed on streets that provide a reasonable level of accessibility to major destinations and provide for effective transferring between lines. These requirements are met by any street crossing the Mall near the retail center, Morrison and Yamhill Streets being selected on account of their designation as non "Traffic Access" streets.

For the Banfield element of the "Busway" bus alternative, a series of improvements will be required between Burnside and the Steel Bridge to accommodate bus flow, consisting of bus lanes, parking removal, and street improvements generally as indicated in Figure 13.

Local circulation needs in the CBD should be met by an independent circular bus route, and not by line haul buses. Figure 2 outlines the proposed 1990 circulation concept of an all-bus system. The proposed route network would have insufficient capacity to accommodate further growth in transit ridership in the CBD beyond 1990, requiring eventual displacement of buses to additional streets, or the conversion of the Mall streets to two way operation, or both.

LRT Alternatives - 3 Corridor System

Two feasible long range alternatives were developed for a 3 Corridor LRT system. The first alternative would follow an on-Mall routing, generally as shown in Figure 3. With the first of two options under the on Mall alternative, LRT would use the Fifth Avenue Mall in both directions, and
Figure 2
PROPOSED CIRCULATION CONCEPT
FOR ALL-BUS SYSTEM
Figure 3
PROPOSED CIRCULATION CONCEPT
FOR LRT - ON-MALL ALTERNATIVE
LRT on Fifth Avenue
the Sixth Avenue Mall would become a two-way bus mall. The increased capacity of the Transit Mall operated thus would require little bus displacement to other streets. A second on Mall option would operate LRT one way on both Fifth and Sixth Avenues while maintaining bus traffic on those streets. Figure 3A shows this option. Continued patronage growth on the LRT part of the system under either option could be accommodated without change to well over twice the estimated 1990 patronage.

Growth of the bus part of the system would require some bus displacement to the Morrison/Yamhill alignment proposed for the 1990 all-bus system.

In the second alternative, LRT would be routed to cross the Mall near its mid-point, using First Avenue, Morrison and Yamhill Streets, and Tenth and Eleventh Avenues, generally as shown in Figure 4. This alignment would leave the bus mall to operate unchanged, creating a second transit artery in the CBD, intercepting the Mall.

Continued growth of the LRT part of the system could be accommodated without change. The bus part of the system however would need to be rearranged to two-way operation, or expanded onto other streets if patronage continued to increase.

For either alternative, a circular shuttle route would provide the most economic way to meet secondary circulation needs in the CBD. It should be noted that the LRT would not be through-routed on First Avenue, all trains going to Pioneer Square.

Application of the evaluation criteria discussed in Section 3 suggests a balance of advantages in favor of an on-Mall alignment for LRT in the long term.
Figure 3A
PROPOSED CIRCULATION CONCEPT FOR LRT
ON-MALL ALTERNATIVE
LRT on Fifth and Sixth Avenues One-Way
LRT Alternatives - Banfield Corridor Only

For light rail in the Banfield corridor only, a routing configuration in the CBD must be adopted that can be readily expanded to a three corridor configuration, and yet will not interfere with the operation of the bus system during the interim period. Several operationally viable alternatives were developed and tested, three of which are proposed as satisfactory alternatives for the first phase LRT line.

The first Banfield LRT alignment would be an on-Mall alignment developed to minimize changes to the Mall, and yet provide a reasonable level to access to the CBD. It would run one-way, with-flow, on both Fifth and Sixth Avenues as far south as Oak Street, generally as indicated in Figure 5, and in greater detail in Figures 23 and 24.

The second Banfield LRT alignment would also be an on-Mall alignment, using Fifth Avenue in two directions as far as Pioneer Square. Both Fifth and Sixth Avenue Malls would operate two-way, with buses and LRT sharing the Fifth Avenue Mall north of Yamhill, generally as indicated in Figure 6 and shown in more detail in Figures 23 and 25. This alternative offers better CBD access, and can be readily expanded to a 3 Corridor on-Mall system.

The third Banfield LRT alignment uses First Avenue and a loop on Morrison and Yamhill to Sixth Avenue. This route requires no changes in the Mall operation, offers good CBD access and can be readily expanded to a 3 Corridor cross-Mall system. Conversion from this alignment to a 3 Corridor on-Mall alignment would involve substantial investment write-off. Figure 7 shows this concept, and Figures 26 and 27 illustrate it in more detail.
Figure 5
BANFIELD LRT - TO MALL
SUMMARY OF IMPACTS

Both the light rail and bus alternatives provide operationally viable long term options for transit within the CBD. But while the bus alternatives require substantially less capital investment in the CBD, and are readily implemented without any new major policy decisions concerning the central area, the Light Rail alternatives offer a number of advantages with regard to environmental, transportation, city, state, and national policy goals, which, taken together, must be weighed against the cost.

So far as Downtown is concerned, it is not sufficient to consider the Banfield corridor on its own, without also considering it in the context of the multi-corridor options, and with some awareness of the consequences of a time scale expanded beyond the 1990 design year. The continued expansion of a bus-only transit system will also eventually require a retreat from the design concepts that led to the Mall, and the re-distribution of buses to other downtown streets.

The light rail alternative, while it requires more physical construction and greater costs, offers distinct advantages in terms of environmental quality and both traffic and transit capacity in the long term. These distinctions are clear when only a single corridor is considered. Table 1 summarizes a general comparison of impacts for the proposed 1990 CBD networks for the two alternative modes.
Table 1
SUMMARY OF IMPACTS IN THE CBD

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<td>Over 100% Reserve Capacity in 1990</td>
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<td>Expansion Potential</td>
<td>Needs Additional Street Space</td>
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<sup>1</sup> The Impacts of the LRT On-Hall and Cross-Mall alternatives on the CBD are generally similar in character and magnitude when compared to the bus alternatives.

<sup>2</sup> The Cross-Mall Alternative may conflict with part of the Downtown Plan.

<sup>3</sup> Not in Cross Mall Alternative.
SECTION 2 - CENTRAL AREA SETTING

LAND USE

Figure 8 illustrates the land use plan for the Central Area, as described in the Portland Downtown Plan. Office development has become the dominant land use in the downtown area. During the 1960's, office space doubled and it is still rapidly increasing. The Portland Downtown Plan calls for a reinforcement of the existing high density concentration of offices extending from Burnside to Market between Fourth and Broadway, oriented to the transit mall, together with medium density office development adjacent to major access points to downtown, and related to peripheral parking structures. Office development is specifically discouraged adjacent to the waterfront and the South Park blocks.

Although there is some retail activity throughout the downtown area, it is particularly concentrated in the "retail core", bounded by Third, Tenth, Stark, and Yamhill Streets. After a period of decline in the 1950's and 60's, retail activity in downtown Portland stabilized. The recent attraction of new retail stores to downtown is indicative of the continuing confidence in the vitality of Portland's retail center. The Portland Downtown Plan seeks to strengthen this retail activity.

Housing, as a downtown land use, has been steadily declining and now stands at around ten thousand units. However, for many people, downtown remains an attractive place to live. Residential land use has been gradually displaced by other more intensive activities. Housing is now largely restricted to the area north of Burnside, west of Tenth Avenue, and around the PSU campus. The Downtown Plan seeks to increase the number of residents downtown by rehabilitating existing housing stock and encouraging new development.
PLAN CONCEPT

1. HIGH DENSITY OFFICES RELATED TO NORTH-SOUTH TRANSIT
2. STRONG, COMPACT RETAIL CORE RELATED TO N-S AND E-W TRANSIT
3. MEDIUM-DENSITY OFFICE RELATED TO MAJOR ACCESS & PERIPHERAL PARKING
4. LOW-DENSITY MIXED USES INCLUDING HOUSING, OFFICES & COMMUNITY FACILITIES
5. SPECIAL DISTRICTS
   a. PORTLAND CENTER
   b. PORTLAND STATE UNIVERSITY
   c. GOVERNMENT CENTER
   d. SKIDMORE FOUNTAIN/OLD TOWN
   e. INDUSTRIAL

→ MAJOR VEHICLE ACCESS
■■■■ MASS TRANSIT
--- MAJOR PEDESTRIANWAYS
■■■■■■■■ MAJOR OPEN SPACE

Figure 8
PORTLAND DOWNTOWN PLAN CONCEPT

Source: "Planning Guidelines - Portland Downtown Plan"
There is little industrial use in the downtown area apart from some warehousing and light industry north of Burnside. However, in this area, high property values, poor freight access, and antiquated buildings has led to a gradual decline which is anticipated to continue. The Downtown Plan calls for the gradual replacement of light industry in this area by medium density office and residential development.

It should be observed that the enhancement of the waterfront area by the removal of Harbor Drive has led to increasing developmental pressures on the area east of the Transit Mall. High density development near the waterfront is contrary to the goals of the Downtown Plan. It remains to be seen how this pressure for more intense development can be reconciled with the goals of the Portland Downtown Plan.

TRAFFIC CIRCULATION AND PARKING

The central fact of traffic circulation in the Portland central area has been the dramatic decrease in through traffic resulting from the completing of the freeway ring around the central area. Figure 9 illustrates the change in traffic flow between 1971 and 1975 on major downtown Portland streets and bridges. The gradual replacement of on-street parking spaces with parking structures, is contributing to the reduction of traffic, since fewer automobiles now circulate in search of on-street parking spaces. Adoption of a ceiling in the number of downtown parking spaces, and the encouragement of short term rather than all day parking, may prevent future traffic increases matching greater downtown activity, particularly in the peak period.

The Downtown Parking and Circulation Policy, adopted by the City Council in 1975, designates each street in the CBD by one of three functions. Traffic access streets will become the principal downtown routes for automobile traffic providing auto access to major downtown destinations.
DOWNTOWN TRAFFIC TRENDS 1971-1975

Figure 9

00 1975 Volumes in Thousands
(00) 1971 Volumes in Thousands
Local service streets are an intermediate category providing local collection and distribution for the traffic access streets. The third category, non-automobile oriented streets, is designated for non-auto traffic use and includes transit malls, pedestrian malls, and local property access. No new vehicular access may be constructed to streets in this third category.

Figure 10 shows the designation of each downtown street under this policy. It is anticipated that the policy will form the principal guideline for future street development, and that the measures called for in the Portland Downtown Plan, and in the Parking and Circulation Policy, will be gradually implemented.

TRANSIT ACTIVITY

Tri-Met is the public agency responsible for all transit in the Portland region. Tri-Met currently operates a 500 vehicle all-bus system. When Tri-Met took over the transit operation from a failing private operator, it reversed a record of falling patronage that had continued unbroken since World War II. A continuing program of service expansion and improvements, new vehicles, and an aggressive marketing program has lead to a steady rise in patronage ever since. The combined effect of further improvements in service, constraints on highway construction and parking, particularly in the downtown area, and the influence of a national energy policy is expected to lead to a continuation and even acceleration of this trend. Figure 11 shows the trend in Tri-Met patronage during the past decade.

The existing bus operations in the Portland region are predominantly radial in nature, reflecting the dominance of downtown as a transit trip destination. Almost eighty-five percent of transit trips in the region are to or through the downtown area. As a result, high loading and
Figure 11
TRI-MET PATRONAGE TREND

Annual Passengers (Millions)
Figure 10

DESIGNATION OF CENTRAL AREA STREETS

Source: Portland Downtown Parking and Circulation Policy, 1975
transfer volumes are experienced on many downtown streets. The major current transit project in the region, the completion of the Downtown Transit Malls on Fifth and Sixth Avenues, is planned to provide more convenient access to the transit system, and a more pleasant and readily identified environment for passengers boarding or transferring between buses in the downtown area. When the malls are complete at the end of 1977, most buses serving downtown will be routed onto the transit mall. A small number will continue to operate east/west across the mall.

Long range regional transit planning is directed largely towards the refinement and evaluation of possible transit options up to the design year 1990. This time horizon is now only 13 years away. It is incumbent to look beyond this planning horizon to consider, at least qualitatively, the implications of a continuation of transit growth beyond the design year.

Banfield Corridor Studies

As part of the regional transportation planning process, a number of alternative scenarios are being studied by Tri-Met and the Oregon Department of Transportation (ODOT) for the Banfield Corridor. These alternatives have the following basic characteristics:

A. The Null alternative. This envisages no significant changes in the transit system from 1977 onwards. The number of buses entering downtown in the AM peak hour would increase from 345 to approximately 400 by 1990 (A similar volume of buses would leave the downtown in the PM hour.). This option is contrary to numerous City and regional policies, which are based on increasing the role of transit in future years, and could only be implemented if additional highway and parking facilities were committed to accommodate the non-transit demand thus stimulated. The consequences of such a change of policy on the CBD, in terms of increased traffic and parking, have not been fully evaluated, but would clearly be of far greater significance than the increase in the transit volumes.
B. The Transportation Systems Management (TSM) or Low Cost Improvement Alternative. This alternative envisages continued development of an all-bus network to serve the region up to 1990, with emphasis on low capital cost improvements in the vehicle fleet and infrastructure on an "as-needed" basis. Transit lanes, signal preemption, and High Occupancy Vehicle (HOV) lanes are envisaged under this option. By the year 1990 the number of buses entering downtown Portland will be approximately double the 1977 figure. This is referred to as the TSM alternative in this report, and corresponds to Alternatives 2a and 2b in the Draft Environmental Impact Statement. This alternative also represents the most probable scenario if no major policy decisions are made to change the direction of present trends. Applicable portions of this option are assumed to be components of all subsequent alternatives.

C. The "Busway" Alternative. Several options to construct improved bus facilities are also being considered. These include - 1) extending the HOV lanes (Alternative 3 in the DEIS), 2) extending the HOV lanes and providing a minimum of six lanes on the Banfield Freeway (Alternative 4a), 3) Alternative 4b, same as 4a, but with full shoulders added, 4) constructing an exclusive busway together with six freeway lanes and full shoulders (Alternative 5).

For the purpose of the Downtown studies, a similar high investment approach is assumed in the other corridors, leading to a regional all-bus system referred to in this report as the "Busway" alternative. The impact of this option on downtown would be only slightly different from the TSM bus option. Approximately the same number of buses would enter downtown in the year 1990. However, construction of bus roadways would have the effect of concentrating bus activity in specific corridors so that some access routes would experience increases in bus numbers; while others would experience fewer buses than with the "TSM" alternative.
D. **Light Rail in the Banfield Corridor.** Under this alternative a light rail line would be developed in the Banfield corridor. Some bus service would be diverted to provide feeder service to this line.

The rest of the regional bus system would continue to develop as in the TSM alternative, as far as the Downtown is concerned. This option would lead to a substantial reduction in the number of buses entering downtown from the northeast, and their replacement by a much smaller number of light rail vehicles or trains. The LRT line would enter downtown over the Steel Bridge and circulate at grade on the city streets. This is equivalent to Alternatives 6a and 6b in the DEIS.

E. **Three Corridor Light Rail.** In this alternative the three priority corridors would be developed as light rail lines by the year 1990, leading to a substantial reduction in the number of buses entering downtown. Under the three corridor light rail option, the capacity of the transit system would be substantially increased, while the number of buses would be approximately the same as those entering downtown in 1977. While this alternative is not addressed directly in the DEIS, it has a central significance to both the route selection process and the long term impacts of alternative transit policies on the Downtown.

Table 2 summarizes the estimated number of bus and light rail vehicles leaving downtown in the PM peak hour under each of the five scenarios. Aggregating these numbers and also allowing for 10 percent of the buses looping the Mall shows the number of buses potentially allocated on the Mall by the design year 1990 for each scenario.

It should be noted that the bus volumes shown in Table 2 may be considered conservative estimates, based on:

- No rationing or other availability constraint of gasoline supplies.
- No disproportionate increase in gasoline prices (compared to income).
### Table 2
ESTIMATED TRANSIT VEHICLES LEAVING CBD IN THE PM PEAK HOUR

<table>
<thead>
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<td>BUSWAY BUS</td>
<td>LRT IN BANFIELD</td>
<td>3 Corridor LRT</td>
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<td>20</td>
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<td>20</td>
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<tr>
<td>Hawthorne Bridge</td>
<td>70</td>
<td>120</td>
<td>125</td>
<td>105</td>
<td>50 (9 LRT)</td>
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<td>30</td>
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<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
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<td>60</td>
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<td>100</td>
<td>100</td>
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<tr>
<td>Sunset Corridor</td>
<td>25</td>
<td>100</td>
<td>110</td>
<td>100</td>
<td>0 (9 LRT)</td>
</tr>
<tr>
<td>N.W. Portland</td>
<td>20</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
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<td><strong>585</strong></td>
<td><strong>630</strong></td>
<td><strong>500</strong></td>
<td><strong>345</strong></td>
</tr>
</tbody>
</table>

| Mall Southbound¹   | 200                        | 370  | 385  | 345 (12 LRT) | 190 (15 LRT) |
| Mall Northbound¹   | 150                        | 255  | 290  | 185 (12 LRT) | 170 (15 LRT) |

Note: - Based on manual adjustment of preliminary Tri-Met estimates.
- The Null alternative will result in 400 buses leaving the CBD in the p.m. peak hour, and 230 southbound and 175 northbound on the Mall.
- Volumes would be similar for transit vehicles entering the CBD in the AM peak hour except that the Mall southbound and northbound totals would be reversed.

¹ Mall totals include allowance for 10% looping.
- No disproportionate change in transit fares.
- No substantial increase in population or employment density along transit priority corridors.
- No community behavioral changes affecting choice of travel mode.

Any one of several possible events could render these estimates too low.

THE TRANSIT MALL

The conversion of Fifth and Sixth Avenue, between Burnside and Madison Streets, into transit malls has been the largest public improvement undertaken so far by Tri-Met. The project consists of combining features of a pedestrian mall such as, wide sidewalks and landscaping with bus only roadways, and on certain blocks, limited auto access.

Located along the commercial axis of Portland's downtown, the malls will provide a high level of accessibility to downtown destinations for transit riders. Construction has required the lowering of street crowns, the widening of sidewalks, and provision of shelters, trees, and other landscape features. Two lanes on each street are used by buses alone, but on 16 of the 22 mall blocks an additional lane is provided for auto use. The project was constructed under an 80 percent UMTA capital grant, and is scheduled for completion in late 1977.

The operating plan for the Mall calls for almost all buses entering or leaving downtown to travel on the Mall, except for a small number of east/west buses which will intercept the Mall at Morrison and Yamhill Streets. As many as possible of the Mall routes will be through routed to minimize looping. Buses will stop every two blocks at one of a group of four stops. Each stop group will serve a particular sector of the region. The system will thus acquire enhanced simplicity for the user and all buses will be routed over a few, clearly identified streets in the downtown.
The capacity of the transit mall to accommodate future increases in bus traffic is an issue central to the development of long range transit plans for the downtown area. Under the present operating plan (one-way on both streets), the transit mall may not have capacity to handle all the buses scheduled onto it beyond the early 1980's. This was generally recognized in earlier studies,* and mitigation proposals were developed. However, during the conversion of the mall from a concept to a reality, these mitigation proposals were largely foreclosed, or found operationally impractical, or politically unattainable. Thus the option of adding a third counter-flow lane has been effectively foreclosed by the construction of two lane sections, and by the need for permanent access to certain properties. The option of "platooning" does not offer significant increased capacity because:

1. Capacity calculations already assume informal platooning at the Mall entry points.
2. The installation of an electronic control system to enforce more extensive platooning would actually delay some buses while speeding up others, leading little net gain.
3. Mall capacity is presently constrained by stop spacing and signal cycle characteristics throughout the Mall, so that increased entry volumes would not increase overall capacity.

The environmental desirability of rebuilding the six two lane mall blocks to accommodate major increases in buses (by building a third counterflow lane) is also questionable.

The option of adding light rail to the mall has never been subjected to a rigorous technical analysis. The vehicle and performance characteristics of LRT suggest that substantial gains in passenger capacity can be

Final Environmental Statement, Fifth and Sixth Avenues Transit Mall, City of Portland, Oregon, U.S. Department of Transportation, Urban Mass Transportation Administration, 1975.
attained without significant environmental penalties. To verify the extent of such capacity gains, and to explore and compare possible alternative configurations, a series of capacity analyses were performed on each of the operationally feasible permutations. These are set out in detail in Study Working Paper #3, for various permutations of transit mode, signal cycle, minor physical modifications and vehicle performance.

Case 1 examined the existing condition (when the Mall is complete), with one-way bus flow on each Mall, and conventional buses. It was the same for either Mall Street.

Case 2 was the same, but substituted articulated buses.

Case 3 considered a two-way operation with conventional buses on Fifth Avenue, a) using three lanes where available, b) reduced to two lanes, and c) widened to three lanes for one block south of Burnside.

Case 4 repeats this analysis for Sixth Avenue, with the same alternative modifications, except that the Hilton Hotel and Standard Insurance Parking Garage access lanes are retained for auto use.

Case 5 considered an exclusive LRT mall on Fifth Avenue, with stops at three block intervals, and auto lanes removed only at stops.

Case 6 considered a similar arrangement on Sixth Avenue.

Case 7 tested LRT and buses going one-way on Fifth Avenue, optimized first for LRT (a1) and then for LRT with the first block south of Burnside widened (a2). This arrangement was also tested for LRT on five minute headways, both for the existing street (b1), and with widening the block south of Burnside (b2).

Case 8 considered the same conditions on Fifth Avenue, but with light rail reversed (counter-flow). Again four variations of LRT headway and Mall widening were tested.
Case 9 considered one-way operation of buses and LRT on Sixth Avenue, again for one minute and five minute LRT headways, with and without widening the block south of Burnside (this time for storage at the Burnside approach).

Case 10 examined mixed bus and LRT operation two-way on Fifth Avenue. a) for LRT headway at five minutes, on the existing street, b) with the mall narrowed to two-lanes, and c) for the first block south of Burnside widened to three-lanes.

Case 11 ran a single LRT track on Fifth Avenue, with-flow, as far as, a) Oak Street and b) Morrison Street, in the left lane, without a stop.

Case 12 ran a single LRT track on Sixth Avenue, with-flow, from a) Oak Street and b) Morrison Street, in the left lane, without a stop.

Table 3 summarizes estimated Mall capacity for each of these operating options.

While predictive capacity calculations always contain a small degree of numerical uncertainty, a comparison of Tables 2 and 3 shows that, given continued transit system expansion, the Mall will have insufficient capacity to operate as presently proposed for more than a few years.

Several operational changes can increase the number of routes using the Mall, or the Mall capacity. First, the number of buses looping (that is, passing up one Mall and looping back on the other, instead of leaving the CBD after one pass through the Mall) will be minimized if through routing is adopted wherever possible. Some unavoidable unbalanced headways will always prevent total through routing.
Table 3
ESTIMATED MALL CAPACITY

<table>
<thead>
<tr>
<th>Case</th>
<th>Operating Concept</th>
<th>Lane Use</th>
<th>Hourly Capacity</th>
<th>Modifications*</th>
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<tbody>
<tr>
<td>1</td>
<td>Existing (when complete)</td>
<td></td>
<td>220 - 260</td>
<td>1</td>
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<tr>
<td>2</td>
<td>Existing, articulated buses</td>
<td></td>
<td>170 - 190</td>
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<td>3</td>
<td>2-way bus Mall on 5th Ave</td>
<td></td>
<td>a. 230</td>
<td>1</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>b. 230+</td>
<td>1</td>
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<td></td>
<td>c. 300</td>
<td>2</td>
</tr>
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<td>a. 220 - 225</td>
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</tr>
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<td></td>
<td></td>
<td></td>
<td>b. 220 - 225</td>
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<tr>
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<td></td>
<td></td>
<td>c. 290</td>
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<td>5</td>
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<td>90</td>
<td>3</td>
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<td>7</td>
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<td>3 + 5</td>
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<td>c. Buses: 240</td>
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<td>a) to Oak;</td>
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<td>b) to Morrison on 5th Ave</td>
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<td>b1 Buses: 115</td>
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<td>2 + 4</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>LRT: 12</td>
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</tr>
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* Modifications
1. None
2. The first block south of Burnside widened to 3 lanes.
3. Construction of new curb and sidewalk between Pine and Oak, Washington and Alder, and between Main and Madison.
5. Modification of curb at southwest corner of 5th Avenue and Burnside.
6. Construction of new curb and sidewalk between 5th and 6th Avenue.
7. Requires LRT preemp at 6th and Burnside or 5th and Pine.
Second, maximum use of the Mall will be achieved by changing the direction of approach for buses from the east and west, so that they enter the Mall from the north rather than the south, and thereby redress the present directional imbalance. It seems probable that some buses from the Sunset corridor in particular could be re-routed to enter the Mall from the north with the minimum of out of direction travel or increased trip time.

The reduction of dwell time through the use of rear door boarding, wider front doors, and clearly identified stops will also increase capacity, mainly by reducing the frequency of delayed buses.

However, these measures of themselves can do little more than extend for a few years the period during which the Mall operation has sufficient capacity to carry the peak hour bus demand. Beyond that period more substantial changes become necessary. These could consist either of developing major bus routes on additional, non-Mall CBD streets, or of converting one or more major corridors to a higher capacity mode.
SECTION 3 - DOWNTOWN TRANSIT CIRCULATION ALTERNATIVES

CRITERIA AND DETERMINANTS FOR TRANSIT CIRCULATION PLANNING IN THE CENTRAL AREA

A methodology was developed to identify and evaluate the factors influencing route selection in the central area, with particular emphasis on those factors which provide a distinction between alternative routing configurations, as opposed to factors which are common to all alternatives. The salient factors in route selection may be grouped by technical discipline, but are numbered consecutively to facilitate subsequent reference.

Urban Planning Considerations

1. Compatibility with the Downtown Plan and the Parking and Circulation Policy.
2. Effective realization of potential environmental benefits from increased transit utilization or electrification, etc.
3. Sensitivity to urban development trends in the central area, and supportive of city development policies.
4. Practicality of introducing a new transit mode, or of expanding an initial one-corridor system to three or more corridors.
5. Opportunities for fixed transit investments to influence land use development in a manner consistent with city planning policies.

Transit Operating Considerations

6. Alignment to be compatible with the capabilities of the design vehicle. Directional changes to be minimized, and disturbance of the existing street patterns to be avoided where possible, particularly at directional changes.
7. Impact on transit service from outside the priority corridors, or on secondary bus circulation. The continued operation of the regional transit system must be considered at every phase.

8. Options for secondary transit circulation in the central area.

9. Propose solutions to the capacity deficiency of the Transit Mall for the 1990 design year. Options to accommodate additional transit growth beyond 1990 must also be addressed.

10. Accessibility to major trip destinations in the CBD, and transfers between regional transit routes.

11. Routing configurations, particularly for the LRT alternatives, must emphasize operating efficiency. Consideration shall include emergency links, turnbacks, and layover trackage.

12. User orientation shall remain a primary goal.

Traffic Circulation Considerations

13. The auto and truck traffic circulation system must continue to function satisfactorily. Congestion points shall be studied and alternative routing for any displaced traffic capacity developed.

14. Vehicular access to properties along or adjoining proposed transit alignments must be maintained. Alternative means of access may be developed.

15. Maintain effective and barrier-free pedestrian circulation in the CBD.

16. Emphasize safety of traffic, pedestrians, and transit riders. Guidelines for the safe and effective design for bus and LRT operations shall be applied.

17. Use existing street rights-of-way, and street paved areas wherever feasible.

Installation and Operating Costs

18. Minimize construction costs. Use existing street right-of-way and grades, existing bridge ramps etc. Also existing sidewalks for
loading platforms, eyebolts in buildings to support overhead, and other cost mitigating features where practical.

19. The LRT alternatives, shall use the minimum possible length of trackage consistent with operating requirements.

20. Minimize utility modification or relocation.

21. Minimize redundant investment as a single corridor is expanded to a multi corridor system.

Other Considerations

22. Discussion of any changes to the Transit Mall or to other CBD streets, at a time so close to the completion of the Mall should be considered with the greatest sensitivity.

23. The CBD represents major investment by a great number of individuals, corporations, and public agencies. The role of the transit system in reinforcing the existing development patterns, or in stimulating further development should be outlined.

24. Continued UMTA funding is dependent in part upon the use made of previous investments. Any proposal that results in changing the role or down grading the Transit Mall should be reviewed carefully.

These criteria and determinants formed the basis for the selection, screening and analysis of possible transit circulation configurations as described in the rest of this section.

BUS ALTERNATIVES

The "Null" bus alternative would result in an increase of buses on the Mall up to approximately Mall capacity in one direction (but not the other) by the 1990 design year (see Table 2). By changing the direction of approach for a few buses, a closer directional balance could be achieved, well within Mall capacity in both directions. Thus no change would be required from the 1977/78 bus circulation plan.
Both the "TSM" bus alternative and the three corridor "busway" alternative will introduce approximately the same number of buses into the CBD in the 1990 design year. Table 2 indicated the estimated number of buses leaving downtown in the PM peak hour. It is assumed that some of the Sunset corridor buses could be re-routed to enter the CBD from the north in order to achieve better directional balance on the mall. Since the mall capacity is approximately 230 buses per hour in each direction, alternative routing must be found for about 130 buses each way in the 1990 peak hour.

The development of routing proposals for these "residual" buses was guided by several important considerations:

1. That the transit mall represents a committed primary transit alignment in the CBD, and be used at or close to its capacity in the peak hour.

2. That connectivity between all routes serving the CBD be maintained by each route intercepting the mall at least once.

3. System simplicity, from both the user and operator points of view, should be retained by avoiding the diffusion of buses onto a great many streets.

4. That "cross mall" routes should intercept near the center of the mall to maximize direct access and facilitate transferring (Mall buses are seldom full at the Mall midpoint).

5. That the location of the mall results in a deficiency in local CBD transit circulation, primarily in the north/south direction along the waterfront and, to a lesser extent, in the north/south direction west of the mall, between the mall and the freeway. Other studies have proposed a shuttle bus service within the CBD to meet this circulation deficiency.

---

"Residual" Bus Routing

Potentially satisfactory routing for the residual buses can be achieved on any street crossing the Mall between Yamhill and Washington Streets. The streets north and south of this group are designated Traffic Access Streets (Figure 10). The volume of buses requires the use of at least one bus lane each way, which should preferably, for operating reasons, be counter-flow lanes. Based on the street designations and the more spacious pedestrian environment at the Pioneer Courthouse, the Morrison/Yamhill couplet is proposed for the cross Mall route. Figure 12 shows the estimated peak hour bus loadings on the linehaul elements of the downtown bus system for the design year 1990, based on Table 2, "Busway" data.

Since the estimated capacity of counter-flow bus lanes on Morrison and Yamhill Streets is 160 buses per hour each way, it can be seen that the Figure 12 network is near its capacity, both on-Mall, and cross-Mall. Thus if 1990 bus demand is greater than estimated, or if transit growth continues beyond 1990, additional bus lanes will be needed on other downtown streets.

Secondary Circulation

The need for secondary circulation in the CBD is a constantly recurring theme, both in earlier studies and at meetings held during the Central Area Transit Circulation Study. What are the dimensions of this problem?

- The areas "requiring" service include the South Auditorium area, The Waterfront, Old Town, The Medical Office District, and P.S.U.
- The normal methods of patronage estimating are not applicable to a "convenience" service within a small area.
- The service parameters of speed, cost, headway, image, and routing will determine patronage.
- Walking is the probable alternative mode for many.
Figure 12

A.M. PEAK HOUR BUS LOADINGS ON 1990 ALL-BUS NETWORK

Note:
1. Calculated for the "Busway"
2. Mall and Cross Mall loadings include 10% allowance for looping.
3. AM and PM bus loadings are assumed numerically the same.
Attempts were made to devise routing concepts that would meet the need for secondary transit circulation as an incidental of linehaul buses entering or leaving downtown. As these ideas were refined several facts emerged:

1) That useful off-Mall routings for linehaul buses (i.e., forming part of a loop around the CBD) increased bus miles thereby adding to service cost, and also would take many passengers out of their way.

2) That linehaul routes could not circle the CBD without offering degraded service to the Mall area, and that partial loops would degrade the shuttle service.

3) That linehaul routes experience major peaks, while the shuttle would need a more constant level of service all day. Thus there would be excess bus miles in the peak period.

4) That a smaller vehicle would suffice, and would even be mandatory for crossing P.S.U. campus.

Based on these considerations, a 2 way loop shuttle route is proposed around the CBD, intercepting all the linehaul routes. The shuttle should be operated by a small bus, similar to the DART or Lift buses, possibly battery propelled, permitting penetration through the pedestrian part of P.S.U. and at close, regular headways, perhaps of five minutes each way. Such a service would require about ten vehicles. Figure 2 indicated a conceptual route layout, but additional study and coordination with P.S.U. and the City of Portland would be required before implementation.

The shuttle would have little or no direct revenue potential, being wholly within the "Fareless Square". However even if fareless square did not exist, most riders would be travelling on transfers or passes, and the service would be hardly more remunerative. More significantly, by making all of the CBD more readily accessible for transit riders and facilitating mid-day trips, the shuttle bus may encourage greater overall transit use to access downtown, and make the auto unneeded for secondary trips within the CBD.
The potential demand for this service could be demonstrated by running a trial service during the day between peak periods using equipment not needed outside the peaks, prior to making a commitment to special vehicles.

Banfield Bus Element

A major part of the Tri-Met system converges on the CBD, so that it is not practical to separate all elements attributable to the Banfield corridor from those of the rest of the region. Thus the need for major cross-Mall bus routing is the cumulative impact of the all-bus system rather than a result of developing Banfield bus facilities. However it is possible to focus on the changes needed on the Steel Bridge and between the Steel Bridge and the Mall, segments not used by other corridors.

While the TSM and Busway alternatives generate similar numbers of buses in the CBD, the Busway alternative concentrates buses onto the Steel Bridge, instead of distributing them over the Broadway, Hawthorne, Steel and Burnside Bridges.

For either bus alternative, the Steel Bridge will require extensive repair. From field inspection, confirmed by a report from ODOT*, the Steel Bridge will need extensive overhaul repairs to replace corroded steel supports and rotting wooden deck members, regardless of future transit mode. Thus even the Null bus alternative will require repairs to the Bridge. At the time the bridge is redecked, the curve of the top of the Glisan Street ramp should be improved as a safety measure.

Between the Steel Bridge and the Transit Mall, the Null alternative would require no changes. The TSM alternative would require minor traffic improvements such as parking removal on Fifth and Sixth Avenues between Burnside and Everett, and some curb setbacks at intersections.

*Preliminary Design Check of Steel Bridge and Approaches. ODOT April 1977.
The Busway alternative will require bus lanes between the Mall and the Steel Bridge, together with a shared second lane (since 160 buses per hour is the approximate capacity of a single bus lane with stops). Parking removal would be needed on at least one side of the affected blocks of Glisan, Everett, Fifth, and Sixth Avenues. At many locations pavement repair will also be required to improved ride quality, while curb set back will be required at certain intersections, including the Mall entry point on Burnside. Figure 13 shows the basic traffic measures required between the Steel Bridge and Burnside.

LIGHT RAIL ALTERNATIVES

The selection of network configurations for LRT in the downtown for both the one and three corridor systems, is a more complex task than for the all-bus alternatives, because there is no existing routing commitment (in the way the bus system is committed to use the Mall), and because of the implications and permanent nature of the installations. It is therefore, discussed in somewhat greater detail in order that the main points of the selection process can be more clearly understood.

The permanent nature of LRT, and the probability of eventual expansion made it clear that the three corridor system options must be established before an alignment for the Banfield segment could be determined. The initial effort, therefore, was devoted to establishing probable configurations for a three corridor system which could then be scaled back to initial segments.

A large number of potential alignments were developed for preliminary screening, and the more clearly deficient alternatives were dismissed. These included:

- Routes based on minimum impact alone, that failed to serve a useful transportation function (i.e., along Front Avenue or 12th Avenue)
FIGURE 13
"BUSWAY" ALTERNATIVE
STREET IMPROVEMENTS - STEEL BRIDGE TO THE MALL
(REVISED JULY 27, 1977)
Routes that failed to interface the Mall (lack of regional connectivity)
Routes using one street of the Mall in one direction only (unbalanced loss of bus capacity, and lack of significant environmental benefits)
Routes that significantly impacted traffic flow or property access
Routes with long loops (poor orientation, excess trackage and out of direction travel)

From this preliminary review, three conclusions were reached:

1. That there was no viable configuration that had not been discussed in previous studies.
2. That in the first analysis, no one configuration was clearly superior to the alternatives.
3. That a basic and far reaching choice had eventually to be made between a north/south alignment, generally following the axis of the CBD (along or near the Mall) or a cross-Mall alternative, following an alignment near the waterfront, probably on First Avenue, and penetrating the CBD in an east/west direction through the retail core. (Figure 14)

It is important here to consider the long range potential for LRT in Portland beyond the 1990 design year. The three corridor LRT system would carry about as many people into the CBD as the remaining bus network, yet would not represent a fully developed LRT system for a city the size of Portland. Thus, in the long term, LRT, if selected at all, will probably become the dominant transit mode for access to the CBD. Even before that, because of its improved performance and environmental characteristics it would become Tri-Met's "premier mode." Recognizing this, if Portland does decide to develop LRT, and does not put it on the
Figure 14
LRT ROUTING CONCEPTS
Mall, then the Mall could eventually become a less important transit focal point, and the major concentration of transit riders and activity would be channeled to other streets. Yet those other streets, close to the waterfront, or west of the Park Blocks, are not intended for high density development, under the Portland Downtown Plan. Thus a cross-Mall alignment could encourage trip making and development contrary to existing development patterns and the Portland Downtown Plan.

A review of trip end distribution in the CBD confirms that the transit Mall is optimally located on the employment and retail axis of the city, and that a Mall routing would reinforce existing development in the CBD as well as providing maximum convenience to transit riders. (Figure 15) A mall alignment would also confirm the commitment that led to building the transit mall in the first place. For the mall alignment, the principal redevelopment opportunity would consist of infilling the remaining underdeveloped blocks close to the mall, and stimulating the redevelopment of the area north of Burnside, an area considered suitable for this purpose, and already expected to undergo some changes as a result of the concentration of regional transportation terminals near Sixth and Glisan.

Figures 16 and 17 show the prototypical Mall and cross-Mall alignments, and Table 4 compares the accessibility to employment, underdeveloped sites and selected public facilities for the two alternative LRT alignment concepts.

An access distance of 700 feet is the standard normally considered satisfactory in the location of parking garages, while an access distance of 1,300 feet, (a quarter of a mile), represents a standard widely used in transit planning, and approximately five minutes walking time. It can be seen that while both alignments pass within a quarter of a mile of most employment trip ends in the CBD, the on-Mall alignment passes
Figure 15
EMPLOYMENT DENSITY

Trip Ends per Block
- 800 and over
- 400 - 799
- 100 - 399
Table 4
1990 ACCESSIBILITY COMPARISON - MALL AND NON-MALL ALIGNMENTS FOR 3 CORRIDOR SYSTEM (Figures 16 and 17)

<table>
<thead>
<tr>
<th></th>
<th>On-Mall (Fig. 16)</th>
<th>Cross-Mall (Fig. 17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment Trip ends within 700 feet</td>
<td>49,000</td>
<td>30,300</td>
</tr>
<tr>
<td>Employment Trip ends within 1300 feet</td>
<td>66,000</td>
<td>63,800</td>
</tr>
<tr>
<td>Underdeveloped Blocks within 700 feet</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Underdeveloped Blocks within 1300 feet</td>
<td>80</td>
<td>66</td>
</tr>
<tr>
<td>Distance to Greyhound Station</td>
<td>200 feet</td>
<td>1,900 feet</td>
</tr>
<tr>
<td>Distance to Medical Center (11th/Yamhill)</td>
<td>1,500 feet</td>
<td>400 feet</td>
</tr>
<tr>
<td>Distance to Park/Montgomery (PSU)</td>
<td>1,300 feet</td>
<td>1,900 feet</td>
</tr>
<tr>
<td>Distance to City Hall</td>
<td>200 feet</td>
<td>1,300 feet</td>
</tr>
<tr>
<td>Distance to South Auditorium (Second/Market)</td>
<td>700 feet</td>
<td>1,300 feet</td>
</tr>
</tbody>
</table>

Note:
1. Distances measured from stations.
2. Total Employment Trip ends estimated at 70,000+.
close (within 700 feet) to far more than does the cross-Mall alignment. Moreover the locations served closely by the cross-Mall route are precisely those locations (on the waterfront, or west of Broadway) where high intensity development would be contrary to the Downtown Planning guidelines. Thus the quality of access and the land use implications of the Mall alignment are both superior to the cross-Mall alignment.

In addition the access grade to the Steel Bridge from First Avenue, in excess of seven percent, may foreclose on certain car procurement or rebuild options, most notably conventional eight axle designs. Table 5 presents a qualitative comparison of these factors and some of the others outlined at the beginning of this section, for the alternative on-Mall and cross-Mall alignments.

On-Mall Design Options

LRT operation on the Mall can be accomplished in several ways. The selection of a preferred configuration requires the consideration of a variety of operational, architectural environmental, and engineering considerations.

1. Operational. Mall capacity was discussed in Section 2. Extrapolating Table 3 data, and assuming a minimum of 15 LRVs or pairs of LRVs each way in the 1990 peak hour (for a 3 Corridor LRT System), the estimated capacity of the existing Mall is:

<table>
<thead>
<tr>
<th>Capacity of:</th>
<th>Configuration</th>
<th>2-Way LRT on 5th</th>
<th>Bus + LRT on both, counterflow</th>
<th>Bus + LRT on both, with flow</th>
<th>2-Way Bus on 6th</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRT on 5th</td>
<td>-</td>
<td>15</td>
<td>15</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Bus on 5th</td>
<td>230</td>
<td>115</td>
<td>115</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>LRT on 6th</td>
<td>90</td>
<td>15</td>
<td>15</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Bus on 6th</td>
<td>-</td>
<td>145</td>
<td>145</td>
<td>220</td>
<td></td>
</tr>
</tbody>
</table>

Widening the block south of Burnside on both Mall streets would increase Mall bus capacity (Table 3).
<table>
<thead>
<tr>
<th></th>
<th>On-Mall</th>
<th>Cross-Mall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downtown Plan</td>
<td>Conforms</td>
<td>May conflict in part</td>
</tr>
<tr>
<td>Parking and Circulation Plan</td>
<td>Compatible</td>
<td>Compatible</td>
</tr>
<tr>
<td>Accessibility</td>
<td>Good</td>
<td>Fair</td>
</tr>
<tr>
<td>Single Track Length</td>
<td>21,400 feet</td>
<td>25,000 feet</td>
</tr>
<tr>
<td>Capital Cost (Including Steel Bridge)</td>
<td>about $10.4 million</td>
<td>about $11.5 million</td>
</tr>
<tr>
<td>Banfield Element Implementation</td>
<td>Least overall</td>
<td>Impact</td>
</tr>
<tr>
<td>Property Access</td>
<td>Least interference</td>
<td></td>
</tr>
<tr>
<td>Parking Removal</td>
<td>300 spaces</td>
<td>500 spaces</td>
</tr>
<tr>
<td>Steel Bridge Ramp</td>
<td>6%+</td>
<td>7%+</td>
</tr>
</tbody>
</table>
Additional Mall bus capacity could also be gained by running buses in the LRT lanes. However this would degrade LRT operation, and restrict the architectural design options. A cross-Mall routing could be used to accommodate additional buses in the CBD (if required) without increasing the number on the Mall.

For the 2-way LRT options, either Mall street could be used. LRT on Sixth offers slightly greater bus capacity, because the required auto lanes at the Hilton and adjacent parking garage remove bus capacity when Sixth is used two-way for buses. These lanes do not affect LRT capacity on Sixth.

Fifth Avenue is located closer to the "center of gravity" of the downtown core, and thus would be the preferred location for the major transit carrier which, for a 3 corridor system or more would be LRT.

Sharing Malls, with the LRT moving with flow would require doors on both sides of the cars, increasing car cost and lowering the number of seats per car.

Sharing Malls with the LRT moving counterflow would not require doors on both sides, and would not significantly change the Mall capacity either.

2. Architectural. The controlled path of LRT permits the use of street design features not possible with buses. For instance street curbs are not essential, and could be replaced by flush pavement on non station blocks (thereby potentially saving track costs). Contrast pavement, such as rough cobbles are possible outside crosswalk areas, and serve to discourage pedestrians from straying onto the track area.

3. Environmental. LRT offers potential for improvements in noise and air quality on city streets. If those streets are shared with large numbers of buses, these benefits are eroded. Separating LRT from buses offers the opportunity to develop an LRT mall in Portland equal to the best in Europe.
It should also be noted that while single contact wire overhead of the type proposed in downtown is not conspicuous, the poles and span wires are the same in number and size whether for one or two tracks. If the tracks are separated overhead support will be required on both Mall streets.

4. Engineering. The construction of two single tracks is more costly than the construction of double track.

Fifth Avenue was formerly used by streetcars, which influenced the number and location of utilities under the street, although Mall construction has modified this situation.

Accessing Sixth Avenue requires extra track construction with possible property acquisition or additional changes of direction at the north end of the Mall. At the south end it makes no difference.

The setting of signal cycles, vehicle detection and timing modification options are much wider if the modes are separated onto different Mall streets.

These preliminary considerations suggest that the most advantageous configuration for the on-Mall, 3 Corridor LRT alternative would be a two-way bus mall and a two-way LRT mall. Although either mall street could be modified, Fifth Avenue is proposed for an LRT mall because: 1) Fifth Avenue has marginally higher accessibility; 2) use of Fifth Avenue requires less right-of-way acquisition at Glisan Street; 3) Fifth Avenue, being a former streetcar route, may require less utility relocation prior to track installation.

Given the public investment in the Transit Mall, it is obvious that considerable additional study is needed to determine in detail the most prudent on Mall option for a three corridor LRT system.
LRT Malls

It is appropriate here to review the status and experience of other cities with LRT malls. At the present time, none of the LRT systems in North America have introduced LRT malls. The new Buffalo, New York, LRT system will construct a one-mile LRT mall through the CBD. This project is now in the design stage. LRT malls are also under consideration in Pittsburgh and in Calgary. In Europe, where LRT systems are more common, LRT malls have become a wide-spread treatment in recent years, and are now considered by many European planners as an ideal technique to integrate high transit accessibility with a pedestrian environment. Many recent mall designs in Europe include elaborate details and landscaping treatments, in the manner of the Portland bus malls. While perhaps half of all the (60) West European LRT systems now have some kind of mall, particularly well developed examples can be found in Zurich, Mannheim, Kassel, and Bremen. Ongoing studies sponsored by UMTA are investigating the operating experience of European mall installations, and will eventually lead to publication of safety and design guidelines for new LRT mall installations in the U.S.

Banfield Corridor LRT Access

Once alternative alignments for a 3 Corridor system had been established the next task was to explore how to introduce LRT into the existing downtown transit system and what interim alignment or alignments should be considered for the initial Banfield Corridor line. Key determinants included:

- Sufficient penetration of the CBD to provide convenient access to the downtown for Banfield transit riders during the period with only one LRT corridor, (perhaps indefinitely);

- A minimum of temporary track construction or other temporary capital facilities;
To explore these issues, a series of test networks were developed, each of which could be logically expended to a 3 Corridor system. These are shown in Figures 18 through 22. Figure 18 represents a minimum penetration alignment, turning back at the Transportation Terminal on Glisan. Figure 19 extends this alignment on Fifth Avenue as far as Burnside. Figure 20 extends the alignment along Fifth Avenue to the vicinity of Oak Street, while Figure 21 extends to a loop round the Pioneer Courthouse at Yamhill Street. Figure 22, represents an alternative alignment, using First Avenue and a Morrison/Yamhill couplet which would form the Banfield segment for an eventual cross-Mall alignment. Table 6 shows how the accessibility to trip destinations in the downtown changes with each of these alignments. Not surprisingly, the maximum penetration produces the maximum accessibility to the downtown trip destinations.

Traffic and operational studies were made to determine alternative configurations for penetrating to the vicinity of the Pioneer Courthouse without using the Mall. These included a one-way counterflow couplet on Fourth and Broadway, a two-way bus mall on Sixth Avenue together with a two-way mixed bus and LRT mall on Fifth, and operation on First Avenue and the Morrison/Yamhill couplet as far as Sixth Avenue. Each of these alternatives were found to be operationally feasible and to cause no undue problems with property access or traffic capacity. The route on the Fourth and Broadway couplet involved extensive construction of temporary facilities not required for any of the 3 Corridor alternatives and could not be easily expanded to a 3 Corridor system using Fourth and Broadway. The alignment on Fifth Avenue involved no construction not needed for the 3 Corridor on-Mall system on Fifth Avenue, while the Morrison/Yamhill route involved no construction not needed for the 3 Corridor cross-Mall system. Test Network 5 (Morrison/Yamhill) would

58
Figure 22
BANFIELD LRT TEST 5
### Table 6
1990 ACCESSIBILITY COMPARISON FOR BANFIELD LRT TEST NETWORKS

<table>
<thead>
<tr>
<th>Test Network</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment Trip Ends within 700 feet</td>
<td>400</td>
<td>6,500</td>
<td>11,800</td>
<td>21,700</td>
<td>16,200</td>
</tr>
<tr>
<td>Employment Trip Ends within 1300 feet</td>
<td>6,000</td>
<td>14,900</td>
<td>23,600</td>
<td>48,700</td>
<td>46,000</td>
</tr>
<tr>
<td>Underdeveloped Blocks within 700 feet</td>
<td>13</td>
<td>28</td>
<td>18</td>
<td>29</td>
<td>28</td>
</tr>
<tr>
<td>Underdeveloped Blocks within 1300 feet</td>
<td>33</td>
<td>51</td>
<td>51</td>
<td>61</td>
<td>45</td>
</tr>
<tr>
<td>Distance in feet to - Greyhound</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>1,900</td>
</tr>
<tr>
<td>Medical District (11th/Yamhill)</td>
<td>4,800</td>
<td>3,500</td>
<td>2,600</td>
<td>1,500</td>
<td>1,300</td>
</tr>
<tr>
<td>Park/Montgomery (PSU)</td>
<td>6,600</td>
<td>5,300</td>
<td>4,600</td>
<td>3,500</td>
<td>3,300</td>
</tr>
<tr>
<td>City Hall</td>
<td>4,400</td>
<td>3,300</td>
<td>2,500</td>
<td>1,000</td>
<td>1,300</td>
</tr>
</tbody>
</table>

**Note:**

1. Calculations based on consideration of blocks having 100 or more employees only, and existing plus known committed development.

2. Distances measured from stations.

3. Total employment trip ends estimated at 70,000.
involve substantial capital write-off if it formed the first phase of an on-Mall alignment.

The reduction in bus capacity on Fifth due to conversion to 2-way operation mixed with LRT would be more than compensated by the increased capacity of the LRT. The Morrison/Yamhill route would have no effect on bus capacity or operations on the Mall.

Recognizing a need for an effective on-Mall alignment with minimum impact on Mall operations during the first phase (Banfield only) the Test Alignment 3 (turn back to Oak Street) was refined further. By using the second or third mall lanes in the with flow direction, it is possible to leave the bus operations unchanged, and lose almost no bus capacity.

Three options are proposed for the Banfield LRT line, generally as indicated in Figures 20, 21, and 22. These options were further developed to ascertain their implementation feasibility, including dimensions, property access, stations, parking and traffic impacts. Figures 23 and 24 show the On-Mall Alignment to Oak Street. Figures 23 and 25 show the On-Mall Alignment to Pioneer Square, and Figures 26 and 27 show the Cross-Mall Alignment. Table 7 outlines the basic comparative characteristics of these three alignments.

**BANFIELD LRT - ROUTE DESCRIPTIONS**

(1) **On-Mall to Oak Street.** The first of the alternative routes for the downtown segment of the Banfield LRT line is the on-Mall alignment to Oak Street, generally as shown in Figures 23 and 24. The Banfield Corridor enters the downtown area on the Steel Bridge. LRT would occupy the center lanes, which would be shared with traffic. At the west end of the bridge, the tracks would use the south side of the Glisan Street
FIGURE 24
LRT ALTERNATIVE - ON-MALL ALIGNMENT
PHASE I (BANFIELD LINE ONLY) TO
OAK STREET LOOP

SECTION A - A

SECTION B - B
FIGURE 25
LRT ALTERNATIVE - OR-PHILL ALIGNMENT
PHASE I (BAINFIELD LINE ONLY) TO
PIONEER SQUARE LOOP
FIGURE 27
LRT ALTERNATIVE
CROSS-MALL ALIGNMENT, SOUTH OF DAVIS STREET
<table>
<thead>
<tr>
<th></th>
<th>Test Network</th>
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</thead>
<tbody>
<tr>
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<td>3 (Figure 20)</td>
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<tr>
<td>Employment Trip Ends within 700 feet</td>
<td>11,800</td>
</tr>
<tr>
<td>Employment Trip Ends within 1,300 feet</td>
<td>23,600</td>
</tr>
<tr>
<td>Impact on Bus Capacity</td>
<td>None</td>
</tr>
<tr>
<td>Steel Bridge Cost</td>
<td>$3.5m</td>
</tr>
<tr>
<td>Other Construction Costs</td>
<td>$2.4m</td>
</tr>
</tbody>
</table>
ramp, the westbound track shared with traffic, but the eastbound track in an exclusive counter-flow LRT lane separated by a raised curb or, at the curve, a barrier. The present left turn at the west end of the bridge, leading to the Front Avenue off-ramp, would interfere with LRT operation, particularly in the morning peak. If the turn was permitted from the westbound track lane, it would block westbound LRV's, whenever an eastbound LRV passed. Alternatively, a left turn lane clear of the tracks could be installed only if the track on the bridge was exclusive, which is not otherwise required for the type of LRT operation envisaged.

To permit traffic from the Steel Bridge to access Front Avenue southbound, it is therefore proposed to construct a new link street between Third Avenue and Front Avenue on the north side of Glisan Street, across property owned by the Portland Traction Company. The intersection of Glisan and Third Avenue would be signalized, and a left turn permitted from Glisan onto Third from the westbound track lane. To prevent an eastbound LRV from blocking a westbound LRV by delaying traffic at this intersection, the LRT signal at Fourth and Glisan would be connected to a detector on the Steel Bridge.

To control traffic merging from Front Avenue northbound onto the Steel Bridge track lane eastbound it is proposed to reverse the direction of the present off-ramp from the Steel Bridge, and to signalize the merge of this ramp with the eastbound LRT track. The existing on-ramp would then be no longer required, and could be left in place and used for pedestrians and cyclists, and for possible reactivation for traffic if it is ever decided to make the LRT lanes on the bridge exclusive. By switching the ramps in this manner, the major traffic movement, from Everett Street, is granted unrestricted access to the bridge while the lesser movement, from Front Avenue, is restricted once every five minutes, whenever an LRV preempts the signal.
West of Fourth Avenue the Glisan Street right-of-way is reduced to 60 feet, insufficient for a station plus traffic needs. It is proposed to purchase the northern half of the block on the south side of Glisan Street to provide space for a station, and to maintain traffic capacity on Glisan Street (a designated Traffic Access Street). The layout proposed would also permit improvement of the curve into Fifth Avenue, and provide space for an electrical sub-station and possibly for parking a service vehicle. The site could subsequently be redeveloped above the LRT tracks. It is also proposed to provide a turning loop at this point to provide vehicle storage and turnback facilities. When the three corridor system is completed, this turning circle will enable LRV's from the two southern corridors to run the length of the mall and turn back at the Transportation Center. As part of the Banfield LRT system, the loop would have only a minor function, for storage.

From the station, the line would go southwards on Fifth Avenue as far as Davis Street, occupying the center of the street. This would permit vehicular access to adjoining properties, and the provision of loading zones by setting back the curb line by two feet. South of Davis Street the inbound line would continue along Fifth Avenue, transitioning to the east side of the street to avoid interfering with buses converging on the Mall. The track location would be suitable for subsequent development as part of a double track alignment. From Burnside to Oak Street the LRT line would occupy the left lane, which is also the auto lane south of Ankeny Street. The auto lane would remain open to auto use. The LRV turn across Fifth Avenue into Oak Street would be controlled by the traffic signal, which would require an additional signal phase for the LRT turning movement.

The Oak Street station would occupy the north side of the street, adjoining the U.S. National Bank plaza. The only physical change would be the widening of the sidewalk into the parking bay to form an LRT platform. When an LRV is at the station, there would be one 20 foot
traffic lane on Oak Street, and when an LRV was not at the station, the track lane would be available for traffic use also. The LRT line would then complete a loop by continuing from Sixth Avenue to Davis Street and along Davis to Fifth, with each intersection controlled by traffic signals.

(2) On-Mall to Pioneer Square. The second alignment is an on-Mall alignment as far as Pioneer Square, generally as shown in Figures 23 and 25. This alignment would be identical to that just described as far as the Fifth Avenue, Davis Street intersection. From here it would continue south on Fifth Avenue to Morrison Street.

The block between Couch and Burnside would become an LRT station, and be closed to traffic other than buses. There would in any case be less bus traffic on this section of Fifth Avenue than with the all bus alternatives, and the visual effect would be that of extending the mall for one block further northwards. The line would continue as a double track LRT line along the Fifth Avenue mall with stops between Pine and Oak Streets and between Washington and Alder Streets. At these locations, the east sidewalk would be extended to serve as an LRT platform. Most of the auto lanes would be required for bus or LRT stops. The track would terminate with a loop around the Pioneer Courthouse, going with-flow on Morrison Street, and skirting Pioneer Square southbound between the curb and the park, displacing the sidewalk into the park. It would then turn east, with-flow on Yamhill Street. The south sidewalk of Yamhill Street would be widened to provide an LRT loading platform.

Both the malls would become two-way, Fifth Avenue shared by buses and LRT, and Sixth Avenue with buses only. To accommodate bus loading at the major stops on Sixth Avenue southbound, it is proposed to widen the sidewalk between Alder and Morrison Streets, to enable loading to take place without interference with other sidewalk users.
(3) Cross-Mall to Pioneer Square. The third Banfield LRT alternative would use First Avenue and Morrison and Yamhill Streets, generally as shown in Figures 26 and 27. This alignment, too, would commence on the Steel Bridge, and a similar rearrangement of the Front Avenue ramps would be required to avoid a conflicting left turn at the west end of the bridge. A new exclusive LRT ramp would be constructed from the west end of the bridge to First Avenue at Everett Street. This would require that the First and Everett intersection be raised by a maximum of three feet to secure suitable grades and vertical curves for the LRT line. Even so, the ramp grade may preclude use of certain LRV designs. Immediately south of the Everett Street intersection would be a station, and a turnback/storage loop constructed around the back of the taxicab storage yard. This could also be a site for a power sub-station, which alternatively could be located beneath one of the Steel Bridge ramps.

The line would continue southward on First Avenue in the center lanes, thereby permitting continued access to adjoining properties. The section of First Avenue from Davis to Stark Street would be converted to two-way operation, shared by LRT and traffic, except for the block between Ash and Pine Street, which would become an LRT station, closed to traffic. Access would be maintained into the Firehouse between Ash and Ankeny Streets. This access is only used by returning equipment and not for emergency purposes, so that LRT would not have significant effect on the functioning of the firehouse. The station between Ash and Pine Streets would occupy the entire street right-of-way, providing generous pedestrian space, and blocking First Avenue to through traffic except to the Firehouse.

South of Stark Street the tracks would transition to the east side of the street, and First Avenue remain one-way southbound. The tracks would use the underpass beneath the Morrison Bridge, which would be closed to vehicular traffic. The in-bound line would continue to Yamhill Street and then turn west along the north side of the street, as
a counter-flow lane. In this instance, a counter-flow lane offers a more satisfactory design treatment, particularly at intersections, and has the minimum impact on property access and left turning traffic from the opposing direction. There would be loading platforms between Second and Third Avenues, and between Fifth and Sixth Avenues in both directions. The track would turn back at Sixth Avenue, using the third lane on the Sixth Avenue Mall. Since the entire turning movement would normally take place in a single Sixth Avenue red phase, this would have no significant impact on the operation of the bus mall. The loop would be completed along Morrison Street, again with a right-hand side counter-flow lane. Existing vehicular access would be maintained on both sides of the street where necessary.

On both Morrison and Yamhill Streets, all parking would be removed on blocks with platforms, but one lane of right-hand parking would be permitted in the non-platform blocks. The track location within the street would accordingly vary between platform and non-platform locations to provide space for parking where possible.

Figures 28 and 29 illustrate the appearance of these types of design treatment at locations where they have been used, and suggest where, in downtown Portland, similar treatments might be applicable.

Construction Standards

There are a variety of track construction methods suitable for the special environment of the CBD. For the purposes of this analysis all track within the central area was assumed to be built with girder rail laid directly on a ballast bed, except where special conditions mandate otherwise. A typical downtown track section is shown in Figure 30. This method of track construction has been found to minimize noise and vibration, to be easy to maintain, and is now standard on most European systems.

ERRATA
There is no Page 77
(No content missing)
Joint Development. New Shopping Center over LRT Station.  
(5th and Glisan or on First Avenue)

LRT on One-Way Street with Counter-flow lane.  
(Glisan Street and Glisan Ramp to the Steel Bridge)

LRT in mixed traffic on a minor street  
(5th Avenue, north of Burnside, or on First Avenue)

LRT Station.  
(5th and Glisan, First and Everett)

Figure 28
TYPICAL LRT DESIGN TREATMENTS  
(and potential Portland applications)
LRT Mall, Landscaped Design.  
(Fifth or Sixth Avenues)

LRT Mall, Utilitarian Design.  
(Fifth or Sixth Avenues)

LRT Station in an urban plaza.  
(Oak Street or Pioneer Square)

LRT on a narrow street with one auto lane.  
(Morrison or Yamhill Streets, but with only one, counterflow LRT track)

Figure 29
TYPICAL LRT DESIGN TREATMENTS  
(and potential Portland applications)
Figure 30
TYPICAL TRACK CROSS SECTION

- 2"- A.C. Overlay to Conform
- Web filler (concrete)
- Asphalt seal
- Rock chips packed under rails
- Paving Blocks
- Compacted rock fines
- Compacted ballast
- Rock fines
- 15" x 15" Duct for Traction Power Feeder Cables (where required)

4 feet, 8½ inches
The construction procedure is to first relocate any utilities within the track bed to a sufficient depth or away from the track zone. The pavement is then sawn along both sides of the track trench, and excavated to the bottom of the track base. At this time the ducts for the power feeder cables can also be installed. Track ballast is placed in the trench to form a base layer, and the track assembly of rails and tie bars constructed. Finally, a pavement of pre-cast blocks is constructed around the track and sealed with bitumen.

Where the track is constructed in a vehicular traffic lane, and sufficient width is available, the rails are placed on different centers to the traffic lane, so that rubber-tired vehicles will not drive along the low friction rail heads. This layout is proposed on the Steel Bridge ramps.

The overhead will generally consist of a single contact wire supported by span wires attached to poles or buildings. Wherever permanent buildings are available, attachment to buildings is preferred, being both less obtrusive and less costly. Where poles are needed, the integration of pole functions for lighting, transit power, and traffic signals is an important design goal.

The LRT loading platforms and paving features should be designed to the standard and appearance appropriate to the locality. Thus, sidewalk widenings on the Mall, and platforms at off-mall stations should be constructed of matching brick or other attractive paving material. Other changes to the physical structure of the streets should also be designed to match the existing materials.
This section outlines the impacts on the Downtown of the alternative Banfield transit options discussed in the preceding sections of this report.

- Null, bus
- TSM bus
- Busway bus
- LRT, On-Mall to Oak Street
- LRT, On-Mall to Pioneer Square
- LRT, Cross-Mall to Pioneer Square

Because the selection of a transit plan for the Banfield Corridor cannot be considered without reference to the rest of the system, consideration is also given to the expanded impact of a regional system developed in a manner consistent with the Banfield Corridor, and also to the impact trend for the period beyond the 1990 design year, where appropriate.

**TRAFFIC**

The central fact of traffic conditions in Portland has been the overall decline of traffic in the downtown area resulting from the completion of the freeway around downtown. As a result, most streets in the central area now operate at less than capacity, even in the peak hour.

The Null alternative will lead to very little change in bus traffic in the downtown, and will not of itself have significant impact on traffic. The implications of the null alternative, however, are that substantial traffic increases will occur as a result of the implied transit deficiency, leading to probable congestion and lack of parking. The quantitative extent of this problem was not investigated.
The TSM bus alternative will lead to a doubling of the number of buses on CBD streets, and potential congestion at a few locations. For the Banfield Corridor the bus movements into downtown are well distributed over several streets and no serious problems are anticipated.

The Busway bus alternative will result in the concentration of buses on the route between the Steel Bridge and Transit Mall, requiring parking removal and bus lanes in certain locations, generally as indicated in Figure 13. It is not anticipated that any serious congestion problems will arise north of Burnside although some auto traffic may have to divert to other less heavily used bridges. For both of the bus development alternatives, the establishment of counter-flow bus lanes on Morrison and Yamhill Streets will require the removal of parking from one side of each of these streets and the establishment of signal progressions to favor bus flow.

The development of the all-bus system beyond 1990 will result in bus flow exceeding the capacity of the Mall and the proposed Cross Mall bus lanes, and will require additional bus facilities on other streets. This will require further displacement of traffic and parking lanes, probably on Alder and Washington, or on 4th and Broadway beyond 1990.

The design of the LRT alternatives was developed to minimize impacts on other traffic. On the Steel Bridge, LRT would reduce traffic capacity by less than any of the Bus Alternatives and will not significantly impact traffic flow. The changes to the west end ramps are proposed to facilitate traffic movement in the presently existing pattern, but would reduce the present entry capacity onto Front Avenue from the Steel Bridge in favor of Glisan Street and Third Avenue.

The LRT on-Mall alignment requires the widening of one block of Glisan to avoid restricting traffic flow, and the conversion of Fifth Avenue to two-way traffic between Couch and Glisan Street. The block between Couch and Burnside would be closed to auto traffic.
The LRT cross-Mall alignment would cause changes to the traffic patterns on First Avenue, which would also be blocked as a through route at Ash Street and the Morrison Bridge. This is unlikely to significantly change traffic patterns. Traffic capacity on Morrison and Yamhill Streets will be reduced by the establishment of LRT counter-flow lanes and signal progression to favor LRT.

Any expansion of the LRT system will generally impact traffic flow less than the expansion of the bus system because of the fewer vehicles required, and the tight design of channelization possible with a guided system.

PARKING

The null alternative will have little direct impact on parking, although the implications of this alternative are that there will be a substantial increase in parking demand.

The TSM bus alternative will require the removal of parking at a few locations north of Burnside, primarily during the peak hour, to facilitate bus movements.

The Busway bus alternative will require the removal of parking on Glisan Street between Third and Fifth Avenues, on Everett Street between Sixth and First Avenue, and most of the spaces on the sections of Fifth and Sixth Avenues north of Burnside used by buses, amounting to approximately 150 spaces in all.

The LRT on-Mall alternative to Oak Street will require the removal of approximately 100 spaces, mostly on Fifth Avenue north of Burnside and on Glisan Street.

The LRT on-Mall alignment to Pioneer Square will require the removal of approximately the same number, while the LRT cross-Mall alternative to Pioneer Square would take approximately 235 parking spaces, most of them heavily used spaces south of Burnside.
Commitment to an expanded all bus system will require the development of additional bus facilities on streets other than the transit mall. The creation of bus lanes on Morrison and Yamhill will remove in excess of 100 parking spaces, while various localized improvements at intersection approaches and stops elsewhere in the downtown will probably remove a further 200, giving a total of about 450 spaces.

A regional LRT system using the mall will have the least effect on parking because it will largely use streets already dedicated to transit. Total parking removal would be approximately 300 spaces in the downtown. A regional cross-mall system would displace about 500 spaces (Table 5).

In the period beyond the 1990 design year, further expansion of bus facilities would require additional parking removal, while the LRT system would be able to accommodate substantially expanded patronage without the construction of additional facilities or the taking of more parking.

PROPERTY ACCESS

Access to property frontages, particularly for business involving substantial freight shipments is of primary importance.

The null bus alternative will have little direct effect on property access. The TSM bus system will similarly have little impact on property access so far as the Banfield Corridor is concerned.

The Busway bus alternative will remove some loading zones on Fifth and Sixth Avenues, and on Glisan and Everett Streets, but access to existing driveways will be permitted.

The LRT on-Mall alternative to Oak Street will have little direct effect to property access. The pavement widths on Fifth Avenue north of Burnside would require curb setbacks of approximately two feet in order that existing loading zones be retained. General purpose parking would not be permitted.
The LRT on-Mall alternative to Pioneer Square would have no greater effect on property access than the alternative to Oak Street, except that the conversion of the transit malls to two-way operation would require the removal of auto lanes for the construction of bus or LRT loading areas. While certain auto lanes on the Mall do not serve an access function, others, providing access to the Hilton Hotel and Standard Insurance Parking Garage, will be retained.

The LRT cross-Mall alternative is proposed on a center street alignment on First Avenue expressly to permit continued access to properties on that street. The service entry (non emergency) to the Firehouse on First Avenue would be remain unaffected because this section of the LRT route would be shared with other traffic. On the Morrison/Yamhill Street section of this route, the selection of a counter flow configuration was developed in part to permit continued access to driveways crossing the tracks. This was of particular significance to the parking garage on First and Morrison.

PEDESTRIAN CIRCULATION AND SAFETY

The null alternative is unlikely to have a direct effect on pedestrian circulation or safety in the CBD, except in so far as it encourages attitional auto traffic downtown.

The TSM and Busway bus alternatives will generally not appreciably effect pedestrian circulation either, since conflicts occur only at crosswalks, and here the practice is to set the signal timing to meet pedestrian crossing needs. Exceptions will occur at intersections where there are major bus turning movements. Here there may be conflicts, and in some instances, pedestrian crossing may be prohibited. Even where the pedestrian has right of way, pedestrians are generally intimidated by large numbers of big vehicles. It is a reasonable expectation that replacing auto traffic by fewer, larger and noisier vehicles will generally contribute to pedestrian safety.
The introduction of LRT into the downtown will generally tend to improve the pedestrian environment by replacing some buses with fewer and quieter vehicles. Since the operation of LRT is also controlled by traffic signals and the traffic laws, LRT would have no significant effect on pedestrian circulation. Because the operating rules for LRT normally require the provision of audible warning in certain situations, light rail vehicles are typically equipped with a warning bell in order that this audible warning can be given in an inoffensive manner. Air horns are also used, but primarily at higher speeds, such as in a highway environment where a warning bell is insufficient.

Several common LRT design treatments have been developed to enhance pedestrian safety, including contrast pavement to delineate the vehicle clearance limits, the use of ornamental safety fences, such as bollards and chains at critical locations, and loading from a curb high platforms which always bears a constant relation to the car steps. European experience with LRT Malls suggests that with proper design and operating procedures, high pedestrian safety standards can be attained.

The proposed alignments have been developed in part to minimize changes in direction, because in these places the car clearance requirement is increased and the tracks also come closer to the sidewalks. At no place should the light rail vehicle envelope intrude onto the sidewalk space.

The continued expansion of an all bus system beyond the design year 1990 would add increasing numbers of buses to the CBD streets, but is not anticipated to physically interfere with pedestrian circulation.

NOISE IMPACTS

The null alternative will result in little change in noise on the city streets. Both the TSM and Busway bus alternatives will route substantially increased numbers of buses into downtown Portland. These buses will fill the transit mall to capacity in the peak hour, and will also operate in large numbers on several other streets, in and approaching the CBD.
The noise generated by a bus is dependent primarily on its operating phase. During acceleration, and on grades, high levels of noise are experienced, while when the bus is coasting or slowing down, noise is not generally considered a problem. In wet weather tire noise becomes dominant during the coasting phase. Efforts by the Federal government, by manufacturers and by Tri-Met may lead to some reduction in bus noise in future years.

LRT noise is generated primarily at the rail/wheel interface, and is related to speed rather than operating phase. The universal use of resilient wheels (part rubber, part steel) and non-rigid track on modern LRT systems has resulted in a dramatic reduction in LRT noise since streetcar days, and the total elimination of wheel squeal on curves (provided the usual "Bochum 54" wheel is used).

Figure 31 compares the typical vehicular noise ranges for autos, buses, and light rail on city streets, measured at a distance of 25 feet. As an approximate rule the doubling (halving) of the observer's distance from the source will decrease (increase) the perceived noise by 3-4 dBA. Doubling (halving) the number of vehicles in any time period will increase (decrease) the average noise level ($L_{eq}$, $L_{dn}$, or CNEL) by approximately 3dBA.

As the transit system is expanded, the significance of quieter transit vehicles will become greater.

Review of bus and LRT noise levels in comparison with Federal Highway Administration Standards (FHWA, Federal-Aid Highway Program Manual, Vol. 7, Ch. 7, Sec. 3) indicates that buses operating on a mall or low-traffic street would certainly violate the standards for commercial areas (FHWA Category C) while LRT would probably not.
Diesel Bus Acceleration

Auto (On City Street)

Diesel Bus

Light Rail Vehicle (On City Street)

Source: Field checks by De Leuw, Cather & Company on various transit systems and LRV test data from Boeing Vertol and HTM (The Netherlands).

Figure 31

Vehicular Noise Ranges
VISUAL CONSIDERATIONS

The null bus alternative will have little direct visual impact on city streets.

The TSM and Busway bus alternatives will have a visual impact only insofar as an increased number of vehicles and their exhaust is considered significant. The streets north of Burnside will change somewhat as they are adapted to permit the efficient passage of large numbers of buses, while the construction of counter flow lanes on Morrison and Yamhill will also change the nature and pace of those streets.

The principal visual effect of LRT will be the requirement for an overhead power supply. The care taken in designing this overhead system can significantly influence its visual appearance. So too the location, visual background and observer's position will markedly affect perception of the overhead. Figure 32 shows a scale cross-section of the Transit Mall and illustrates the relationship between the contact wires, typical medium height buildings, trees, and an observer on the sidewalk. Since wires are conspicuous only in silhouette, in many places, such as on much of the mall and on other streets, the wires will be conspicuous only to pedestrians standing close to the curb line and looking upwards. At street intersections, the LRT overhead will be somewhat more noticeable, in the absence of buildings or trees.

At locations where the tracks change direction, additional "pull off" wires are required to keep the contact wire within reach of the pantograph. Since LRT overhead has only single polarity, and no switches, it is only at the changes of direction that significant visual impact is anticipated.

The appearance of LRT overhead is susceptible to good design techniques. Possible methods of mitigation include:

- Integration of visual design into the technical design process for the power supply system.
Figure 32
VISUAL RELATIONSHIPS ON THE TRANSIT MALL
Planting of street trees and other techniques to "manage" wire silhouette in sensitive locations.

Use of eye bolts in buildings rather than poles, where possible, for span wire support.

Integration of poles, where required, with poles needed for street lighting and traffic signals.

Development of system-wide design standards for important design elements such as overhead, which consider both technical and aesthetic requirements.

Use of underground feeder cables, and the avoidance of dual wire catenary on city streets.

TRANSIT OPERATIONS

The null bus alternative can be accommodated entirely within the transit mall, and existing approach routes, and will experience no capacity problems. The increase in other traffic implied by this alternative may seriously impact the ability of the null alternative to function effectively.

The TSM and Busway bus alternatives will result in doubling the number of buses coming downtown. Although the Banfield element will not of itself experience a capacity problem, the systemwide impact will be to fill both the mall and the proposed cross-Mall bus lanes almost to their capacity by the 1990 design year. Thus, the proposed configuration in downtown will require the addition of further transit lanes or other facilities if transit use continues to grow. The expansion of major bus movements to other streets in the period after 1990 will make the system harder to use.

The LRT alternatives for the Banfield corridor are not anticipated to operate at more than about one-quarter of their ultimate capacity. Expanded to a three corridor system, the LRT part of the Tri-Met system
will still operate at approximately one third of its ultimate capacity on the Mall by the 1990 design year. There would thus be very substantial reserve capacity for increased patronage or network expansion after 1990 design year. The concentration of major transit flow on a few clearly identifiable transit routes will retain the simplicity of the system for the user, even at greatly increased patronage levels.

DISPLACEMENT AND RIGHT OF WAY REQUIREMENTS

The proposed bus alternatives can be accommodated entirely within the existing street rights-of-way, and generally within the existing pavement areas. Improvements to operations will require the displacement of some auto traffic or parking lanes, primarily along Fifth and Sixth Avenues, Glisan and Everett Streets, and Morrison and Yamhill Streets.

The long term expansion of an all bus system can similarly be accommodated in the existing right of way,

The reliable operation of large numbers of buses requires the availability of one or more stand-by buses for use in event of equipment failure. At the present time a single bus is normally parked at Third and Main Street for this purpose, but with increasing bus use additional layover space may be required. No difficulty is anticipated in finding such space on city streets.

The three Banfield LRT alternatives are also basically constructed entirely within street right-of-way. However, to improve operation at the west end of the Steel Bridge, it is proposed to construct a connecting street link between Third and Front Avenues on the north side of Glisan across property presently owned by the Portland Traction Company. This land was formally used for railroad purposes, but is now vacant, and the tracks have been removed. The location of this property between the main railroad track and the Glisan Street ramp of the Steel Bridge
gives it little potential for non-transportation purposes. An alternative to the construction of this link would be to omit the connection between the Steel Bridge westbound and Front Avenue southbound, which would prevent direct access from the Steel Bridge to Front Avenue.

The two on-Mall LRT alignments require the purchase of the north half of the block on Glisan between Fifth and Fourth Avenues to provide space for the construction of a station near the Transportation Terminal, and to improve the layout of the curve onto Fifth Avenue. The short block lengths, narrow street rights-of-way, and the requirement to change direction at this point would otherwise prevent the construction of a station within two blocks of the Transportation Terminal. This site could also provide space for a power substation, and possibly a small maintenance store or other transit related facility.

At the present time about half of this parcel is occupied by the Enterprise Building, a three story brick office building that is partly vacant. The remainder of the parcel is used for surface parking.

The LRT cross-Mall alternative will also require space for a turning loop and storage track, proposed for the perimeter of the taxi cab storage yard at First and Everett Streets. This use would be compatible with the taxi cab yard, and would not require its displacement.

Neither the bus nor the LRT alternatives will displace any residential units in the downtown.

The expansion of the all bus transit system beyond the year 1990 is unlikely to require any further property acquisition in the downtown area. Similarly the expansion of the LRT system to a 3 Corridor network, is unlikely to require any additional property.
CONSISTENCY WITH CITY GOALS

The plans and goals of the city are expressed in the Parking and Circulation Policy, the Guidelines for the Downtown Plan, and will be further refined in the Downtown Plan document currently in preparation.

The null bus alternative conflicts with the stated goals in that it does not support increased transit use, and by implication will lead to more traffic.

The TSM and busway bus alternatives are generally consistent with the city's land use and traffic policies, but may conflict with the environmental goals. The long term development of an all bus system, requiring expanded bus activity on a number of other streets may conflict in other areas, by adding buses to streets presently designated as traffic access routes in the CBD, such as Fourth and Broadway.

The LRT options are also generally consistent with the city's land use and traffic policies, and are more compatible with downtown environmental goals. It should be noted that the on-Mall alignments are generally more supportive of the existing development patterns in downtown, while the cross-Mall alignment may stimulate additional development pressures along the First Avenue axis, in conflict with city planning guidelines.

JOINT DEVELOPMENT OPPORTUNITIES

The null bus option is unlikely to result in any direct development stimulus.

The TSM and Busway bus options, while not of themselves generating redevelopment opportunities, might become the catalyst for further extensions to the transit mall, the cross mall, and the redevelopment of buildings along those streets oriented towards transit.

The on-Mall LRT alternatives offer the opportunity to redevelop the north half of the block between Fourth and Fifth at Glisan, acquired for purpose of constructing a station. The station would occupy about half
of the ground level area of this parcel, permitting redevelopment of the remainder, and the air rights above, for a commercial, preferably transit oriented use. The location of this station, together with other supportive developments, could have considerable impact on the redevelopment of the area between the Transportation Terminals and Burnside.

The LRT cross-Mall alternative does not present any significant, direct redevelopment opportunity. Indirectly, it is likely to stimulate redevelopment in the north waterfront area, including the Northwest Natural Gas blocks, and along First Avenue between the Steel Bridge and Morrison and Yamhill Streets. Redevelopment on First Avenue could include use of the street air rights, for instance over the proposed station between Pine and Ash Streets (Figure 28).

In the long term, supported by the appropriate city policies, an LRT system would have considerable potential to shape development and redevelopment in the downtown.

STEEL BRIDGE IMPACT

None of the bus alternatives would directly impact the Steel Bridge fabric. However, inspection of the bridge has revealed extensive corrosion of the main supporting members, and rotting of the deck planks supporting the asphalt road surface. It is clear that extensive renovation work would be required on the Steel Bridge to make good these deficiencies. At the time this renovation work is carried out, limited operational improvements should be made, such as easing the curb at the top of the Glisan ramp, replacing the severely corroded hand railings, and the disintegrating wooden sidewalks, and perhaps repainting the bridge in a manner appropriate to such a monument to early American engineering. No attempt has been made to identify funding sources for this work, but the cost of the repairing the bridge deck should be considered a cost of the bus alternatives.
The LRT alternatives will also require renovation of the bridge, and additionally, the modification or redecking of certain parts of the approach structures that do not need repair under the all-bus alternatives. The costs attributable to this work have been included in the cost of the LRT alternatives.

Once the bridge repairs have been completed, no additional work or costs would be incurred with the expansion of the transit system beyond design year 1990.

The proposed modifications to the Front Avenue ramps to facilitate the metering of the merge of traffic and LRT eastbound do not necessarily represent the long term solution to this location. Continued growth of ridership on an expanded LRT system, and the possible addition of branches to the LRT line using the Steel Bridge may eventually warrant an exclusive LRT lane. In this eventuality, the LRT lanes could be converted to exclusive transit lanes, at the cost of some reduction in automobile capacity, and through the reversion of the Front Avenue ramps to the Steel Bridge to its present function. The existing off ramp would then be closed, and could be removed.

IMPACTS OF THE TRANSIT MALL

The null bus alternative would result in no changes on the Transit Mall. The TSM and Busway bus alternatives would also result in little change in mall conditions. Long before the 1990 design year the Mall will reach its capacity, and thereafter there will be little change, as the residual buses will be displaced onto other streets. While it is possible to increase the bus capacity of the mall, by modification to the entry points, and by operating both malls two ways, the desirability of further increasing mall capacity by these means is environmentally questionable. It would also require the removal of some of the auto lanes, together with sidewalk widening and other modifications, (particularly at Burnside) and is therefore not a proposed alternative.
The LRT on-Mall alternative to Oak Street would involve little change to the transit mall. The installation of tracks for approximately two blocks would have no significant effect on bus capacity, nor on the physical structure of the Mall.

The widening of Fifth Avenue at Burnside would be an operationally desirable improvement for either the Bus or LRT options. The LRT on-Mall option to Pioneer Square would result in several changes to the Mall. Both malls would change from one-way to two-way operation, with buses only on Sixth Avenue and mixed bus and LRT traffic on Fifth Avenue. Several of the auto lanes would be converted to use as transit loading platforms, or as transit lanes. The eventual displacement of auto lanes from the transit mall was foreseen during the design of the mall, and discussed in the 1975 Mall EIS.

It is proposed that the all-bus Mall on Sixth Avenue should not be operated at a greatly increased capacity for environmental reasons, although this option remains open. Access lanes serving the Hilton Hotel and the Standard Insurance Parking Garage would be maintained. The turning loop at Pioneer Square would occupy the west sidewalk of Sixth Avenue, generally avoiding the recently planted trees, but resulting in some displacement of pedestrian flow into the park. This would be not inconsistent with the purpose of constructing the park. The expansion of the LRT line to a 3 Corridor system would displace an additional segment of the auto lane between Main and Madison Streets to provide an LRT stop. The probable removal of buses from Fifth Avenue in this phase would substantially upgrade the environmental conditions on Fifth Avenue, and permit the use of design treatments not possible with bus operation, such as decorative and/or flush paving, and the variation of track location with respect to the curb line from block to block to match the functions of each block.
CONSTRUCTION IMPACTS

The null bus alternative will require no construction other than the redecking of the Steel Bridge. The TSM and Busway bus alternatives will involve extensive curb modifications along Morrison and Yamhill Streets, and at a number of other intersections, and the selective repair of street pavement to improve strength, street crown, and riding qualities, particularly north of Burnside.

No major modifications to the Mall would be required for any of the bus alternatives.

In addition, the Busway bus alternative in particular will require the creation of bus lanes and intersection modifications between Burnside and Steel Bridge. Here it is probable that adjustments to the pavement crown, the strengthening of the pavement, and the resurfacing of the streets will be required to accommodate greatly increased bus traffic.

The principal construction impact of the LRT options is the laying of the tracks. These would be generally constructed to the existing street grades so that a minimum of street pavement change is required outside the trackway. The construction extent and sequence is basically the same for the on-Mall or off-Mall alternatives and is mostly on streets that once had streetcar tracks.

1. Relocate or protect underground utilities. This work consists largely in moving man holes to locations outside, or occasionally, between the tracks. In some places utility lines will need to be lowered or relocated, mostly at locations not on the Mall (where this work has been recently carried out).
2. Make two saw cuts in the pavement to sever a strip along the track alignment, two feet wider than the outermost rails.

3. Excavate and install a feeder cable duct and consolidate the street sub-base. In some locations drainage may be required.

4. Place the ballast track base to within approximately eight inches of the pavement surface.

5. The track assembly is then placed, welded, and aligned on this ballast base.

6. Finally, the pavement is placed around the tracks and sealed with mastic asphalt.

Typically, this operation would be performed about three blocks at a time, and once the utility work has been completed would require approximately three weeks per three-block section.

During construction, pedestrian and cross traffic would be maintained uninterrupted. Parallel traffic could be maintained in the lanes not being reconstructed, or detoured, according to conditions at each location:

The installation of the overhead takes little time, and causes little disruption. Most transit properties presently operating electric transit on the streets perform work on the overhead at night in congested areas to avoid interference with daytime activities.

CAPITAL COST

The cost of the bus alternatives would be much influenced by the need to overhaul and repair the Steel Bridge deck if LRT is not put on the bridge.
Both the bus development alternatives would also include street work, mainly repaving, curb modifications, and traffic signal work.

The Busway Bus alternative would require additional street work between the Steel Bridge and Burnside.

The Banfield LRT costs are divided between Steel Bridge repairs, (only partly required by the LRT system), and track, electrification and street work on city streets.

The order of magnitude costs for each alternative are summarized in Table 8.

Table 8
CAPITAL COST SUMMARY
DOWNTOWN ELEMENTS OF BANFIELD ALTERNATIVES

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Steel Bridge</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null - Bus</td>
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</tr>
<tr>
<td>TSM Bus</td>
<td>2.0</td>
<td>.2</td>
<td>2.2</td>
</tr>
<tr>
<td>Busway Bus</td>
<td>2.2</td>
<td>.4</td>
<td>2.6</td>
</tr>
<tr>
<td>LRT to Oak Street</td>
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<td>2.4</td>
<td>5.9</td>
</tr>
<tr>
<td>LRT On-Mall</td>
<td>3.5</td>
<td>3.1</td>
<td>6.6</td>
</tr>
<tr>
<td>LRT Cross-Mall</td>
<td>4.2</td>
<td>3.2</td>
<td>7.4</td>
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