[redacted]

7-9-75

MICHIGAN BUS RAPID TRANSIT
DEMONSTRATION PROGRAM
PHASE I

FINAL REPORT

Prepared for

The Michigan State Highway Commission

EP-750012

MAY 1975

GM Transportation Systems Division
General Motors Technical Center
Warren, Michigan 48090

GM Transportation Systems

MICHIGAN BUS RAPID TRANSIT
DEMONSTRATION PROGRAM - PHASE I

prepared for:

The Michigan State Highway Commission

by:

GM Transportation Systems Division

Date: May 1975

The preparation of this report was financed by the Michigan State Highway Commission under contract No. 74-1596.

GM Transportation Systems

This study was made possible through the cooperation of the following Municipalities and agencies:

City of Detroit
    Detroit Department of Transportation

Southeastern Michigan Council of Governments

Southeastern Michigan Transportation Authority

City of Flint
    Flint Department of Traffic Engineering
    Flint Mass Transit Authority

Genesee County Metropolitan Planning Commission

City of Grand Rapids
    Grand Rapids Transit Authority

City of Lansing/East Lansing

Tri-County Regional Planning Commission

Capital Area Transportation Authority

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Michigan State Highway Commission.

ACKNOWLEDGEMENTS

MICHIGAN STATE HIGHWAY COMMISSION

E. V. Erickson - Chairman
Charles H. Hewitt - Vice Chairman
Peter B. Fletcher - Commissioner
Carl V. Pellonpaa - Commissioner
John E. Osmer - Secretary to the Commission

MICHIGAN DEPARTMENT OF STATE HIGHWAYS & TRANSPORTATION

J. P. Woodford - Director

BUREAU OF TRANSPORTATION PLANNING

S. F. Cryderman - Deputy Director
J. L. Roach
R. L. Kuehne
E. J. Kazenko

BUREAU OF URBAN AND PUBLIC TRANSPORTATION

J. C. Kellogg - Deputy Director
I. V. Bartha
J. Kazenko

GM TRANSPORTATION SYSTEMS DIVISION

Phase I of the Michigan Bus Rapid Transit Demonstration Project was completed under the direction of Neil H. Triner, Manager, System Design, Advanced Programs Department, and Virgil R. Dahlmann, Project Leader. Robert W. Cowan and Ronald A. Lee, members of the GM TSD staff, were the principal members of the project team during the contract period and contributed most of the planning and analysis effort. L. D. Klement and A. W. Turski also made significant contributions to this project.

TABLE OF CONTENTS

MICHIGAN BUS RAPID TRANSIT DEMONSTRATION PROGRAM - PHASE I

Section Title Page

EXECUTIVE SUMMARY - PHASE I BUS RAPID TRANSIT DEMONSTRATION PROGRAM

TABLE OF CONTENTS

MICHIGAN BUS RAPID TRANSIT DEMONSTRATION PROGRAM - PHASE I

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF TABLES

EXECUTIVE SUMMARY - PHASE I

BUS RAPID TRANSIT DEMONSTRATION PROGRAM

1.0 INTRODUCTION

Phase I effort on this program was initiated in mid-December 1974, and completed in late April 1975. The objectives of the study were to review potential transit corridors within the state and to recommend one or more corridors for further study and possible implementation of a bus rapid transit (BRT) demonstration. The project was limited to consideration of four metropolitan areas: Lansing/East Lansing, Flint, Grand Rapids, and Detroit.

2.0 INITIAL CORRIDOR SCREENING

Based on data supplied by the Michigan Department of State Highways and Transportation and local agencies and on first-hand observations by members of the GM TSD staff, a total of 24 potential corridors were identified in the four metropolitan areas. The corridors were screened with respect to four parameters which were quantified, based on existing data, to measure potential for successful BRT implementation. The four parameters used in the screening process are:

- Daily travel demand in the corridor to selected major destinations
- Traffic congestion as indicated by level of service estimates
- Daily transit ridership in the corridor
- Significant physical characteristics relating to relative ease of implementation

In Table 1, the 24 corridors are identified by the major traffic route in the corridor, and data used for screening are summarized. As a result of the screening process, it was concluded that, although each of the three out-state urban areas includes at least one corridor in which some form of priority bus treatment may be feasible, none of them shares the overall potential of any one of the candidate corridors in the Detroit area. Therefore, after consultation with representatives from the Michigan Department of State Highways and Transportation, Southeastern Michigan Transportation Authority (SEMTA), Southeast Michigan Council of Governments (SEMCOG), and Detroit Department of Transportation (DDOT), the following seven corridors--all in the Detroit area--were selected for further analysis:

- East Jefferson
- Gratiot Avenue
- Lodge
- Michigan/I-94
- I-75/Fort
- Southfield Expressway
- I-94 Crosstown

Table 1 Corridor Screening Characteristic Summary for BRT

Corridor Route	Total Trips To (One-Way) Major Destinations		Level of Service Estimate	Current Transit Ridership in Corridor	Ease of Implementation/Remarks
	Daily	Peak Hr			
Lansing/East Lansing, Michigan					
East Grand River/Oakland	13,443W/11,287E		D	2943 (Michigan)	Park & ride space at Meridian Mall, 2-3 lanes/direction
East Saginaw/Oakland	3761		C	--	Oakland/Saginaw one-way pair through city, 3 lanes
South Cedar	7207		B	873	Row width only 66 ft in places, 2 lanes/direction
South Logan	6821		C	452	At-grade RR crossings, row width = 66 ft, 2 lanes/direction
West Saginaw	4407		D	447	Park & ride space at Lansing Mall, row = 83 ft most areas
Flint, Michigan					
North Saginaw/Detroit	4323		F	2243	Some park & ride possibilities, curb cuts feasible most areas
South Saginaw	3323		E-F	428	Curb cuts feasible most areas
Dort Highway (N/S)	1788N/2067S		D-E	--	Many traffic signals
I-475 (S)	4053		A-B	--	Few access ramps
I-69 (E/W)	1907W/1573E		A-B	439	Park & ride facilities potentially available
Grand Rapids, Michigan					
US-131/Division (S)	495		D-E/D	1158 (Division)	Ramp queue jumpers feasible most areas, freeway flows well
US-131/Plainfield (N)	8378		D-E/D	853 (Plainfield)	Possible park & ride at North Kent Mall
28th Street (E/W)	2220E/409W		E	--	Unsynchronized lights, frequent stops required, L&R turns
I-196 (SW)	3249		B-C	--	Few stops required, park & ride space
I-196 (E)	1724		B-C	--	No major implementation problems
Lake Michigan Drive (W)	3715		C	164	Few stop lights, wide shoulders in outlying areas, 1-1/2 lanes close in
Detroit, Michigan					
Gratiot/I-94	42,641	12,934	D-E/D-E	22,447	Synchonized lights, narrow median on I-94 close in
Mound/Van Dyke	33,913	6,847	D-E/D-E	--	Wide median on Mound, curb cuts tight on Van Dyke
Woodward/I-75	39,143	7,299	D/E	52,848	Synchronized lights on Woodward, ramp queue jumpers feasible on I-75 most areas
Grand River/Jeffries	45,686	12,074	D/C	8,590	Narrow median on Lodge, utilization of Jeffries will allow exclusive lane implementation
Michigan/I-94	22,730	4,747	D/D-E	9,561	Michigan divided by median
I-75/Fort	17,849	4,318	D-E/C-D	11,958	No service drives on I-75, narrow median on I-75
I-696/Lodge	36,989	7,157	D-E/E-F	--	Service drives available some areas
East Jefferson	43,790	10,353	D-E	26,295	Synchronized lights, cross traffic minimized

3.0 EVALUATION OF CANDIDATE CORRIDORS

These seven corridors were then analyzed in greater detail to better assess potential for BRT implementation. Several computer programs were written to facilitate use of the 1965 TALUS survey data for demand estimations. The morning peak period, from 7:00 to 10:00 a.m., was used to estimate corridor demand. The 1965 survey data were adjusted to account for changes in population by multiplying the trip production of each district by the ratio of estimated 1975 population to 1965 population. However, no attempt was made to account for changes in land use. Only trips to major destinations were considered. The selected destinations are among the top 60 attraction zones in Superdistricts 0 through 35. The total demand within each corridor for the selected destinations was screened on the basis of minimum trip length and trip directness via the BRT route to estimate the number of corridor trips which might be suitable for BRT travel. Person trips were eliminated from consideration if they involved travel of less than two miles on the BRT route. In addition, trips were eliminated on the basis of the directness criterion if the corridor access plus egress distance was greater than the straight-line distance between the origin and the destination. A trip matrix and related statistics were generated for each corridor as a result of this screening process.

Three outputs of this demand analysis were used in the corridor evaluation. The total demand in each corridor for the selected destinations was used to provide a comparative measure of potential BRT demand. Each corridor was defined in terms of nodes where passengers are assumed to enter and leave the BRT system. The number of potential trips which would enter the BRT system at each node during the morning peak period--the node load volumes--was tabulated for each corridor. The ratio of the three largest node load volumes to the total trip volume was used in the evaluation to provide a measure of the relative concentration of demand within each corridor. Finally, since the priority bus treatment of the line-haul portion of the trip provides the greatest potential for trip time reduction, a corridor having relatively long trips has a high potential for trip time savings over competitive modes. Therefore, the average trip length on the corridor was used in the evaluation.

Traffic congestion on the main route in each corridor was characterized by a statistic based on volume-to-capacity (V/C) ratios obtained from the 1970 Highway Assignment Network Data File created by SEMCOG and by the average peak-hour velocity based on a limited number of speed runs made by GM TSD staff.

Two measures were used to characterize existing transit in each corridor. Morning peak-period (7:00 to 10:00 a.m.) ridership on DDOT and SEMTA buses entering the CBD on parallel routes within each corridor was tabulated from the Detroit Central Business District Cordon Count prepared by the Traffic Research Division of the Detroit Department of Transportation. Route patronage data prepared by DDOT and SEMTA were used for the Southfield corridor which does not serve the Detroit CBD. Existing transit ridership was used in the evaluation as an indication of the size of the transit patronage base from which BRT passengers could be drawn. The number of existing transit routes which intersect the major BRT route was used as a measure of BRT potential because it indicates the extent of existing feeder service in each corridor.

The ratio of estimated BRT travel time to automobile travel time, based on a number of assumptions concerning corridor access time, line-haul time, and distribution time for both BRT vehicles and automobiles, was used in the evaluation as a first-order comparison of the level of BRT service on each corridor.

Finally, alternative priority bus treatments were considered to assure that at least one potentially feasible implementation scheme exists for each of the corridors.

The measures of BRT potential were arranged in an evaluation matrix and assigned weighting factors to denote the relative importance of each measure. A score for each corridor was computed based on the magnitude of each measure of potential and the weighting factor for that measure. The evaluation was performed using several different sets of weighting factors, and no significant variations in the resulting corridor ranking were observed. The evaluation matrix is shown in Table 2. The following four corridors were selected for further analysis based on the results of this evaluation and on the recommendations of the Michigan Department of State Highways and Transportation:

- East Jefferson
- I-94 Crosstown
- Lodge
- Michigan/I-94

4.0 CORRIDOR SKETCH PLANNING

Corridor sketch plans, a third level of detail, were then prepared for each of the remaining corridors. The sketch planning task included selection and description of the proposed BRT treatment on each corridor, a more detailed analysis of demand, a more refined estimate of BRT trip time, sizing and costing of the BRT and feeder systems, final evaluation and ranking of the corridors, and preparation of a BRT implementation plan.

4.1 BRT Implementation Schemes

The proposed implementation scheme for each of the four candidate corridors was selected from among several alternatives on the basis of providing the highest line-haul speed at reasonable cost and with minimum disruption to existing traffic. The implementation scheme for East Jefferson, an arterial, provides for designation of the center lane as a reversible exclusive bus lane and designation of one lane in the off-peak direction as a left-turn lane. The implementation scheme proposed for the freeway corridors is exclusive bus entrance ramps integrated with the ramp metering and surveillance system planned for Detroit by the Department of State Highways and Transportation. The system, known as SCANDI (Surveillance, Control, and Driver Information), is scheduled for implementation beginning in the spring of 1976 for the Lodge and the Ford expressways.

Table 2 Seven Corridor Evaluation Matrix

Parameter	Total Potential Corridor Demand			Level of Congestion		Existing Transit		Service Estimate	
Weighting Factor	6	3	1	3	3	3	1	3	
Measures / Corridor	Major Destination Total Demand	Ratio of 3 Largest Node Load Volumes to Total Volume	Average Corridor Trip Length	Auto Ave. Speed / Posted Speed	Congested Distance $\sum (N/C)\ D$ where $V/C \geq 1.00$	Ridership Along Corridor	Cross Routes Intersecting BRT Routes	Est. BRT Travel Time / Auto Travel Time	Total Weighted Score
Gratiot	21,322	.443	9.3	.71	18.70	4,525	22	1.36	178.7
Score	5.3	9.6	10	9.3	10	4.7	7.3	9.0	
WF x Score	33.6	28.8	10	27.9	30.0	14.1	7.3	27.0	
E. Jefferson	22,356	.410	9.1	.88	7.45	5,891	11	1.23	156.6
Score	5.6	8.9	9.8	7.5	4.0	6.1	3.7	10	
WF x Score	33.6	26.7	9.8	22.5	12.0	18.3	3.7	30	
I-94 Crosstown	40,156	.291	7.8	.88	17.50	4,525	30	1.43	187.9
Score	10	6.3	8.4	7.5	9.4	4.7	10	8.6	
WF x Score	60.0	18.9	8.4	22.5	28.2	14.1	10	25.8	
Lodge Freeway	36,552	.308	8.3	.74	9.18	9,703	25	1.27	192.4
Score	9.1	6.7	8.9	8.9	4.9	10	8.3	9.7	
WF x Score	54.6	20.1	8.9	26.7	14.7	30.0	8.3	29.1	
Southfield	9,989	.359	6.8	.66	18.62	700	18	1.75	135.7
Score	2.5	7.8	7.3	10.0	10	1.0	6.0	7.0	
WF x Score	15.0	23.4	7.3	30.0	30.0	3.0	6.0	21.0	
Mich Ave/I-94	15,977	.458	9.1	.86	9.30	1,459	14	1.54	134.8
Score	4.0	9.9	9.8	7.7	5.0	1.5	4.7	8.0	
WF x Score	24.0	29.7	9.8	23.1	15.0	4.5	4.7	24.0	
Fisher Freeway	10,253	.463	8.7	.97	0.0	3,030	14	1.90	108.9
Score	2.6	10	9.4	6.8	0	3.1	4.7	6.5	
WF x Score	15.6	30	9.4	20.4	0.0	9.3	4.7	19.5	

BRT freeway access ramps are associated with each collection area to provide unimpeded exclusive access to the freeway for buses and possibly carpools. This is accomplished through bypass ramps shunting the queue of automobiles at the metered auto access ramps. Once the bus accesses the freeway, it proceeds under free-flow conditions with other freeway traffic. The SCANDI system is expected to maintain traffic flow on the freeways in Detroit at an average speed of 40 mph.

The distribution loops at the attraction end of the routes are designed to minimize time of distribution and still serve the required areas. Treatments include contraflow operation on one-way streets where feasible to enhance bus movements.

Conceptual operating characteristics of the bus rapid transit system include a collection function in the near vicinity of each corridor access point. The collection routes are typically 5 to 7 miles in length and are structured to interface with park-and-ride lots, existing transit lines, and supplementary feeder service. The BRT buses operating on the short collection routes are designated for single destinations and proceed on a non-stop basis once access to the line-haul portion of the route is achieved.

4.2 BRT Ridership Estimate

In order to estimate the number of morning peak-period riders which could be expected to use BRT service in each candidate corridor, a transit modal split model was applied to the unscreened corridor trip matrix which was generated in a previous task. Since the scope of the study did not permit the development and calibration of a modal split model, an existing model was used. The Peat, Marwick, Mitchell and Company mode split model which SEMCOG used to estimate transit modal split for the proposed rapid rail transit system was used in this study. The model is an aggregate mode split based on a choice function and consists of 80 diversion curves which relate the following factors to the propensity to use transit:

- Median worker income of the origin zone
- Ratio of door-to-door travel time on public transit to that of the private automobile
- Ratio of excess time on public transit to that of the private automobile
- Ratio of "out-of-pocket" cost of public transit to that of the private automobile

The modal split model was applied to the corridor trip matrix generated previously to obtain a corridor transit trip matrix for selected destinations within each corridor. These trips were screened to eliminate short trips (less than two miles along the corridor) which may not be suitable for BRT service. The resulting BRT trip matrices were used to size the BRT and feeder systems in each corridor. The estimated BRT modal split for the four candidate corridors ranges from 40 to 49 percent. This seems reasonable when compared with the existing transit modal split for trips ending in the CBD of approximately 30 percent and with SEMCOG's projection of a 60 percent mode split for CBD trips on the high-level rail system in 1990.

4.3 BRT Travel Time Estimate

BRT travel time was estimated for trips on each of the corridors and was compared with the estimated travel time by other available modes including private automobile, local bus, and existing express bus. The trips on which the travel times are based are simply examples and are not minimum, maximum, or average trips in their respective corridors. The distance elements of the example trips vary among the four corridors, but are constant for the various modes within each specific corridor.

A computer program was developed to perform the task of calculating portal-to-portal travel times associated with various modes in each corridor. The program also computes the bus-to-automobile travel time ratio for each type of bus transit being examined. The assumed auto speed for freeway travel is based on the presence of a ramp metering system capable of maintaining free-flowing traffic at an average speed of 40 miles per hour. For these conditions, it was assumed that BRT line-haul speeds equal those of automobile traffic.

The results of this analysis in terms of travel time ratios are presented in Table 3.

Table 3 Travel Time Ratios (Examples)

Corridor	Reference Trip Distance (Miles)	Local Bus/Auto (Existing)	Express Bus/Auto (Existing)	BRT/Auto
E. Jefferson	8.7	2.61	2.11	1.36
I-94 Crosstown	14.1	2.44	2.00	1.21
Lodge Freeway	18.3	--	1.87	1.26
Michigan/I-94	14.8	2.46	--	1.24

4.4 BRT System Sizing

The BRT line-haul system and two alternative feeder systems were sized on the basis of estimated BRT demand and area coverage. This effort included consideration of the number of buses required for peak-period and off-peak service, parking facility requirements, and transit shelter needs. The total vehicle operating hours per year were estimated as a first step toward determining labor requirements.

4.4.1 BRT Vehicle Requirements

The number of buses required to provide BRT service from each corridor access point to each major destination during the peak period was determined, based on a simple bus scheduling process. Both demand for each route and the number of round trips per bus during the peak period were considered in determining the number of buses required for each corridor. The total number of trips and buses required to satisfy the demand for each major destination in each of the four corridors are summarized in Table 4. The numbers in parentheses in the last column are the total number of BRT vehicles required for each corridor, including a 7 percent maintenance float to account for buses which may be out of service for one reason or another.

Since no alternate service may be available to a passenger who must return to his origin during the business day or after the evening peak period, limited off-peak service was assumed for all of the corridors except East Jefferson which is adequately served by existing transit during base periods.

The peak hour BRT vehicle headway, expressed in seconds, is tabulated in Table 5 for three locations on each of the four corridors. The minimum headway in the CBD Loop, the New Center Loop, and at the maximum load point of each corridor is presented. The maximum load point occurs on the approach to the CBD and New Center areas. The numbers in parentheses indicate the maximum number of buses per hour which pass through each of the three locations.

In order to provide an indication of the magnitude of the BRT operation on each corridor, Table 6 is presented and gives the number of BRT vehicle operating hours and vehicle miles for each corridor. Driver scheduling was not attempted in this phase, so the number of drivers required to provide service in each corridor was not explicitly determined. However, total vehicle operating hours can be used to give at least a relative measure of labor requirements for the four corridors.

4.4.2 Feeder System Requirements

Two types of feeder service were considered to augment the BRT pick-up loops in the area of each corridor outside the city of Detroit. Both a fixed-route/fixed-schedule (FR-FS) feeder system and a demand responsive Dial-A-Bus (DAB) system were sized. Inside Detroit, the Detroit DOT bus system was assumed to provide feeder service for the BRT system.

The number of fixed-route, fixed-schedule feeder buses required to blanket an area is a function of the average route spacing and the time interval between successive buses on each route, i.e., the headway time. The FR-FS feeder system sizing is based on the following assumptions: the route spacing is 1.0 mile by 1.0 mile, the peak period headway time is 12 minutes, and the average feeder bus velocity is 15 miles per hour. The number of fixed-route, fixed-schedule feeder buses required for each corridor is presented in Table 7.

Table 4 Peak-Period BRT Bus Requirements

Corridor/Destination	BRT Demand	Number of Bus Trips	Number of BRT Buses
Jefferson			
CBD	7,855	183	112
New Center	1,919	52	39
TOTAL	9,774	235	151 (162)
I-94 Crosstown			
CBD	15,631	350	195
New Center	4,291	102	63
Ford Complex	663	20	13
TOTAL	20,585	572	271 (290)
Lodge			
CBD	12,352	282	166
New Center	4,655	109	70
Northland/Southfield	691	20	12
TOTAL	17,698	411	248 (265)
Michigan/I-94			
CBD	5,773	134	77
New Center	1,293	35	22
Ford Complex	2,476	58	36
TOTAL	9,542	227	135 (145)

Table 5 BRT Headway - Peak Hour

Corridor	Peak Hour Headway - Seconds		
	CBD Loop	New Center Loop	Maximum Load Point
E. Jefferson	42.9 (84)	163.6 (22)	34.0 (106)
I-94 Crosstown	22.1 (163)	78.0 (46)	26.5 (136)
Lodge	27.5 (131)	69.2 (52)	21.6 (167)
Michigan/I-94	58.1 (62)	240.0 (15)	51.4 (70)

Table 6 BRT System Operating Characteristics

Corridor	Vehicle Hours Per Day	Vehicle Hours Per Year	Vehicle Miles Per Day	Vehicle Miles Per Year
East Jefferson	346.83	88,442	7,327.5	1,868,513
I-94 Crosstown	624.6	159,273	13,581.4	3,463,257
Lodge	559.5	142,682	12,883.7	3,285,344
Michigan/I-94	321.4	81,952	7,303.3	1,862,342

Table 7 Fixed-Route/Fixed-Schedule Sizing Results

Corridor	Buses/Square Mile	Area (Square Miles)	Buses Required
East Jefferson	1.71	75	128
I-94 Crosstown	1.71	90	154
Lodge	1.71	175	299
Michigan/I-94	1.71	165	282

These buses would also be used to provide off-peak feeder service in the area of the corridor outside Detroit. The off-peak service was assumed to operate on the same routes as in the peak period but at half-hour headways. Eight hours of off-peak operation were assumed each weekday.

The relative magnitude of the fixed-route, fixed-schedule feeder system operation is indicated in Table 8. The number of vehicle operating hours and vehicle miles are listed for peak and off-peak service.

The number of DAB vehicles required to serve a given demand is directly proportional to the number of passengers who request DAB service during the peak hour and the round-trip time of each vehicle, and it is inversely proportional to the average number of passengers who are served by a DAB vehicle during each round trip.

The number of passengers who enter the BRT system during the peak period was determined for each corridor entry point in the demand analysis. The number of passengers who access the system by DAB was assumed to be 40 percent of the BRT passengers who originate outside the city of Detroit.

Table 8 Fixed-Route/Fixed-Schedule Feeder System Operating Characteristics

Corridor	Vehicle Hours Per Day	Vehicle Hours Per Year	Vehicle Miles Per Day	Vehicle Miles Per Year
East Jefferson	1,104	281,520	16,560	4,222,800
I-94 Crosstown	1,334	340,170	20,010	5,102,550
Lodge	2,576	656,880	38,640	9,853,200
Michigan/I-94	2,432	620,160	36,480	9,302,400

The average round-trip time of the DAB vehicles was estimated based on the following assumptions:

- One minute is required to unload passengers at the bus stop.
- The average vehicle speed between passenger pickups is 25 miles per hour.
- The average distance between passenger pickups is one mile.
- The average time required for each passenger who is picked up to board the vehicle is one minute.
- The average number of passengers who are served by a DAB vehicle during one round-trip is 10.

The number of DAB vehicles required for each corridor based on these considerations and assuming a maintenance float of 7 percent, is listed in Table 9.

These buses would also be used to provide off-peak feeder service outside Detroit. The off-peak service was assumed to operate in the same area as the peak service; however, the demand in the off-peak hours was assumed to be five percent of the demand during the peak hour. Eight hours of off-peak operation were assumed each weekday.

The relative magnitude of the DAB feeder operation is shown in Table 10. The number of vehicle operating hours and vehicle miles are listed for peak and off-peak service.

In addition to determining the number of DAB vehicles required, the number of control system components and personnel required to operate the demand-responsive type of feeder system was determined for each corridor. The DAB control system includes reservation, communication, and dispatch equipment and a computer to perform the necessary passenger/bus scheduling determinations.

The elements of the DAB control system were sized on the basis of predicted passenger demand, number of DAB vehicles, and the physical area comprising each DAB zone. Because the BRT system serves mainly recurring, work-related trips, it was assumed that 50 percent of all DAB service is on a subscription basis. Subscription service is highly efficient, allowing prescheduled routes and pickup times, thus eliminating the need for

Table 9 DAB Sizing Results

Corridor	Node Number	No. of Passengers Entering	Peak-Hour DAB Demand	No. of DAB Vehicles
East Jefferson	78	1,176	235	15
	79	840	168	11
	80	1,302	260	16
TOTAL		3,318	663	42
I-94 Crosstown	67	2,185	437	27
	65	1,416	283	18
	64	1,337	267	17
TOTAL		4,938	987	60
Lodge	47	1,236	247	15
	49	2,036	407	25
	51	1,665	333	21
	53	3,808	762	48
TOTAL		8,745	1,749	109
Michigan/I-94	21	981	196	12
	23	2,148	430	27
	24	1,589	318	20
	28	1,466	293	18
TOTAL		6,184	1,237	77

Table 10 DAB Feeder System Operating Characteristics

Corridor	Vehilce Hours Per Day	Vehicle Hours Per Year	Vehicle Miles Per Day	Vehilcle Miles Per Year
East Jefferson	176	44,880	2,640	673,200
I-94 Crosstown	246.4	62,832	3,696	942,480
Lodge	448.8	114,444	6,732	1,716,660
Michigan/I-94	316.8	80,784	4,752	1,211,760

patrons to phone in reservations during the peak period. This results in a substantial reduction in reservation equipment and personnel requirements.

4.4.3 Parking Facility Requirements

Sub-modal split estimates vary widely among existing BRT systems. For example, the sub-modal split for park-and-ride is reported to be about 55 percent for the San Bernardino Busway, but only about 14 percent for express buses operating in the I-35W Corridor in Minneapolis-St. Paul. The traditional auto dependence of Detroit area residents suggests that the park-and-ride sub-modal split for a BRT system in the metropolitan area is likely to be relatively high. Therefore, to obtain a first-order estimate of parking facility requirements, it was assumed that 40 percent of the BRT passengers who originate outside Detroit and 30 percent of those who originate inside Detroit access the system by park-and-ride. The number of park-and-ride spaces required was estimated by applying the assumed sub-modal split to the corridor demand estimate. The average automobile occupancy was assumed to be 1.10.

It is expected that existing parking lots will be used to provide many of these spaces. As an indication of the availability of existing parking facilities in the corridor, a list of parking lots located at retail centers within four miles of each corridor access node was prepared. Although other potential park-and-ride lots such as churches, abandoned service stations, and closed industrial and retail facilities should be considered, the retail center parking facilities that were identified give a relative measure of parking availability in each corridor. In order to estimate parking lot construction needs, it was assumed that the number of parking spaces which would be available at existing facilities is equal to 5 percent of the total identified parking space in the corridor.

Table 11 summarizes the parking requirements and indicates the number of spaces assumed to be provided at existing facilities, as well as the number of spaces to be constructed for each corridor.

Table 11 Park-and-Ride Facilities

Corridor	Spaces Required for Park & Ride	Identified Parking Spaces	Spaces at Existing Facilities	Spaces to Be Constructed
Jefferson	3,047	30,160	1,508	1,539
I-94 Crosstown	6,047	46,405	2,320	3,727
Lodge	5,592	34,950	1,747	3,845
Michigan/I-94	3,215	21,978	1,099	2,116

4.4.4 Bus Shelter Requirements

Bus shelters should be located at high demand locations throughout the corridor. More specifically, they should be located at bus stops along the distribution loops and at each corridor access node. Additional shelters should be located at high demand locations such as park-and-ride lots and apartment houses. Based on these considerations, the number of shelters required for each corridor was estimated.

4.4.5 Cost Estimates

Capital and operating costs were estimated for each of the four proposed BRT corridors. These costs were estimated for the BRT system and for the two types of feeder systems, fixed-route/fixed-schedule and Dial-A-Bus. Cost summaries for the BRT systems and the two feeder systems sized for each corridor are provided in Tables 12 and 13, respectively. An interest rate of 8 percent and amortization periods ranging from 10 to 30 years were assumed for the annualized capital cost calculations. The cost of additional land which may be required for vehicle storage, vehicle maintenance, and park-and-ride facilities was not considered in the cost estimate.

The estimated capital costs of the BRT systems include the cost of exclusive bus ramps for the freeway corridors, signs, traffic signal modifications, shelters, park-and-ride facilities, BRT vehicles, vehicle storage facilities, and vehicle maintenance facilities.

The operating costs of the BRT system as well as the two feeder systems include driver wages, garage expense, and vehicle maintenance expenses. The BRT system operating costs also include restriping costs and shelter maintenance. The DAB feeder system incurs an annual system control cost.

4.5 Corridor Ranking

Three criteria were used consistently throughout the study to evaluate the potential of candidate corridors for successful BRT implementation. The criteria are: 1) high potential for attracting ridership; 2) high potential for improving trip time by implementing a priority treatment, and 3) high potential for economical implementation. Table 14 shows the ranking of the four candidate corridors based on these criteria.

The measures which have been used to quantify the criteria have become more explicit as the corridor analysis has become more detailed. For example, earlier in the study, BRT ridership potential was characterized by a combination of two parameters: the total corridor demand for particular destinations and the magnitude of current transit ridership along the corridor. In the final ranking, the results of the modal split analysis were used to predict BRT ridership in each corridor. Table 14 shows that the I-94 Crosstown and Lodge Corridors clearly have greater BRT ridership potential than the other two corridors.

Table 12 Cost Summary – BRT (Exclusive of Feeder)

Corridor	Capital Cost	Annualized Capital Cost	Annual Operating Cost	Total Annual Cost
East Jefferson	14,742,000	1,923,900	1,807,200	3,731,100
I-94 Crosstown	26,196,800	3,381,700	3,164,900	6,546,600
Lodge	24,578,500	3,147,100	2,897,900	6,045,000
Michigan/I-94	13,331,300	1,713,700	1,660,000	3,373,700

Table 13 Cost Summary – Feeder System

Feeder Type	Corridor	Capital Cost	Annualized Capital Cost	Annual Operating Cost	Total Annual Cost
DAB	East Jefferson	2,341,500	299,800	952,700	1,252,500
	I-94 Crosstown	3,267,900	420,500	1,303,300	1,723,800
	Lodge	5,888,200	759,200	2,317,500	3,076,700
	Michigan/I-94	4,270,700	547,500	1,656,300	2,203,800
FR-FS	East Jefferson	10,819,800	1,352,400	5,025,300	6,377,700
	I-94 Crosstown	12,055,100	1,627,100	6,072,200	7,699,300
	Lodge	23,405,700	3,159,100	11,725,600	14,884,700
	Michigan/I-94	22,075,000	2,979,500	11,070,200	14,049,700

Table 14 Corridor Ranking

Rank	Corridor	Total BRT Demand (a.m. Peak-Period)	Travel Time Ratio BRT/Auto	BRT Cost/ Peak-Period Pass. Trip*	Feeder System (DAB) Cost/Peak-Period Feeder Passenger Trip
1	I-94 Crosstown	20,585	1.21	0.62	1.71
2	Lodge	17,698	1.26	0.67	1.72
3	Michigan/I-94	9,542	1.24	0.69	1.75
4	East Jefferson	9,774	1.36	0.75	1.85

* Not including feeder service

Earlier in the study, average automobile line-haul speed and volume-to-capacity ratios were used to characterize congestion in the various corridors as an indication of travel time reduction potential. In the final ranking, the ratio of estimated BRT trip time to automobile trip time was used as a direct measure of this criterion. The data in Table 14 show that all four corridors offer about the same potential for providing competitive trip time.

Finally, general observations concerning the ease of implementation on each corridor were used earlier in the study to indicate relative implementation costs. Now preliminary capital and operating cost estimates can be used to calculate the total annualized cost per peak-period passenger trip. The values of this parameter calculated for the line-haul BRT system and for the DAB feeder system were used in the final ranking. DAB system costs, rather than FR-FS system costs, were selected for use in the corridor comparisons because they are lower than the costs of the FR-FS systems. The costs used to calculate these ratios include the cost of providing off-peak service, because this is considered to be a necessary part of both the BRT and the feeder systems. However, the feeder system cost ratios do not account for any additional costs which DDOT might incur in providing fixed-route/fixed-schedule feeder service within Detroit. Only peak-period passenger trips were used to calculate the ratios, since off-peak BRT ridership was not estimated. The feeder system cost ratios account only for those BRT patrons outside the city of Detroit who would actually use the DAB feeder service in the peak periods. The number of passengers who access the system via DDOT buses is not included. The data for the line-haul BRT systems indicate that a BRT implementation on the I-94 Crosstown Corridor results in the lowest cost per peak-period passenger trip, while a BRT implementation on East Jefferson results in the highest cost per passenger. The same corridor ranking is indicated by the DAB feeder system cost ratios.

The fact that it is quite expensive to provide a pervasive feeder service should come as no surprise. In the independent study of intermediate- and feeder-level transit conducted by General Motors for SEMTA in late 1974, the annual cost of the recommended feeder system was found to be approximately four times the annual cost of the intermediate-level transit system.

The values of estimated cost per passenger trip listed in Table 14 for the DAB systems are not inconsistent with similar data reported for existing demand-responsive systems. A survey of actual cost-per-ride data for several demand-responsive systems indicates a range in cost of from $0.60 to $3.50 per ride.

In summary, the four candidate corridors are ranked in order of their potential for successful BRT implementation as follows:

1. I-94 Crosstown
2. Lodge
3. Michigan/I-94
4. East Jefferson

4.6 BRT Action Plan

The accomplishment of a logical progression of tasks is quite important to the successful implementation of bus rapid transit service in a selected travel corridor. A description of these tasks and their interrelationships is termed an "action plan." The four candidate BRT corridors all have similar implementation task requirements, with minor exceptions for the non-freeway East Jefferson route. Therefore, a single action plan, common to the four corridors, has been developed. The BRT action plan is diagrammed in Figure 1.

The first task shown in Figure 1, "Preliminary BRT Design," has been completed for each of the four candidate BRT corridors. All other action plan items pertain to the additional analysis, design, and implementation of BRT service in a single corridor (chosen from among the four, or synthesized from elements of two or more candidate corridors).

4.7 Conclusions and Recommendations

Bus rapid transit integrated with a computer controlled ramp metering system is a very efficient means of utilizing an existing freeway facility. The combination possesses the unique feature of enhancing auto travel as well as transit travel without either mode sacrificing appreciable travel time or facilities. Capital implementation costs are relatively low compared to facility expansion costs such as lane additions, right-of-way additions, etc., to accommodate other bus transit treatments. The fact that firm plans currently exist for implementing the SCANDI system in the Detroit area is of significant importance to the Michigan Bus Rapid Transit Demonstration Program (MBRTDP). It is recommended that the SCANDI program schedule be reinforced and possibly expedited to more closely coincide with the MBRTDP schedules.

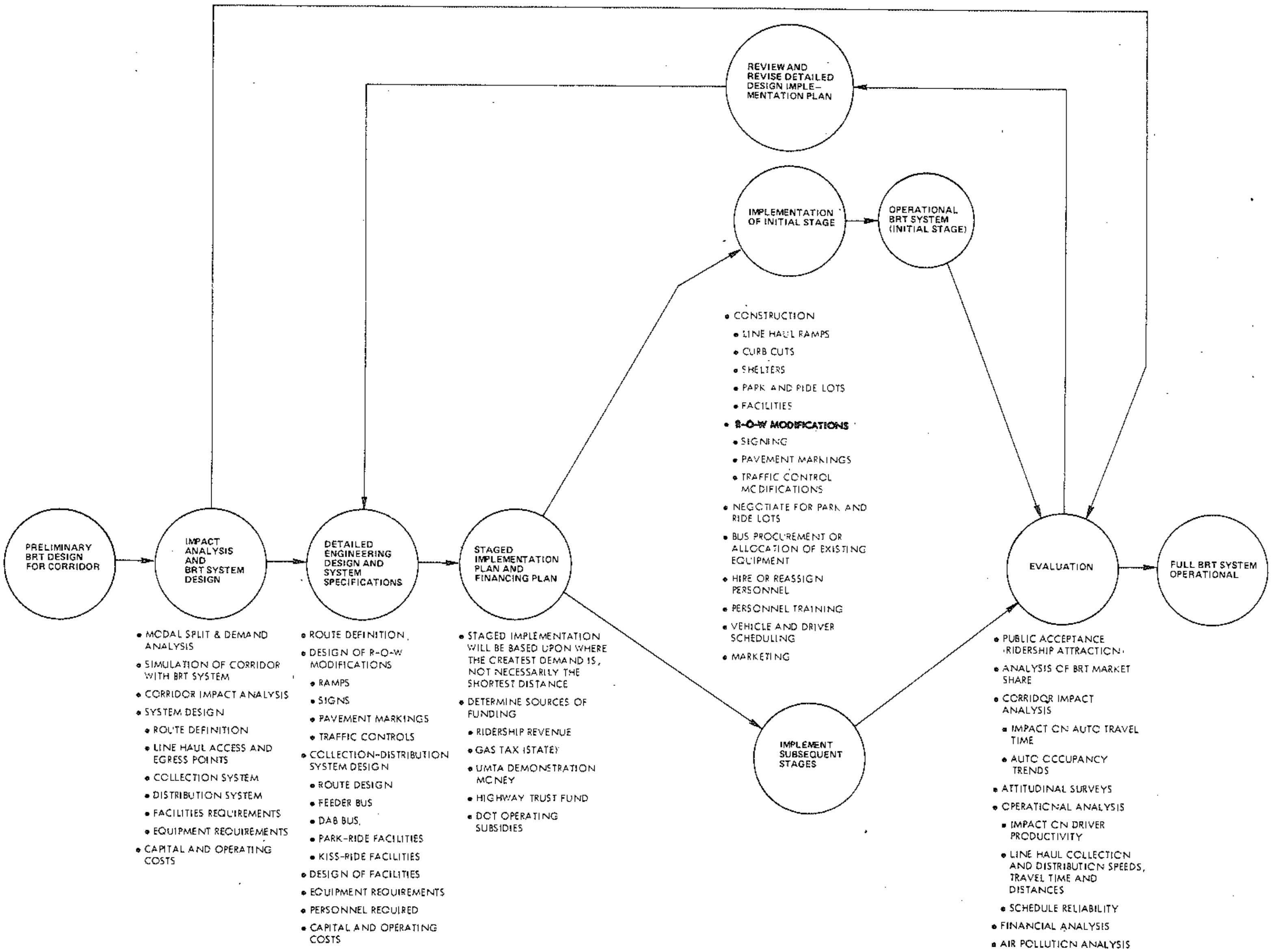


Figure 1 BRT Action Plan

In the event SCANDI is not implemented, alternative BRT treatments, such as exclusive or priority use of freeway lanes by transit and carpool vehicles, appear to be feasible subject to the limitations of safety, public acceptance, and enforcement.

The I-94 Crosstown Corridor was identified as exhibiting the most potential for bus rapid transit based on Phase I studies. A logical extension of this corridor would include service to the Detroit Metropolitan Airport. It may be desirable to consider combining the I-94 Crosstown with the entire Michigan/I-94 Corridor, since an appreciable portion is common to both. If the I-94 Crosstown Corridor is indeed chosen for continued analysis in Phase II, it is recommended that consideration be given to include this extension as part of the overall Phase II analysis effort.

The high costs of the feeder systems associated with BRT implementations are such that additional attention is warranted in this area. Further study is recommended to determine if other incentives such as subscription service or park-and-ride/kiss-and-ride facilities could be established to enhance access to the BRT line and reduce the dependence upon supplemental feeder systems.

1.0 INTRODUCTION

1.0 INTRODUCTION

Ridership declines and operating losses troubling conventional (local, fixed-route/fixed-schedule) bus systems make it apparent that alternative approaches are urgently needed. Bus Rapid Transit (BRT) appears to be among the most promising of the alternatives which can be implemented with today's technology and with only a moderate capital investment.

1.1 Conventional Bus Problems

The shortcomings of conventional bus operations are well-known. The following are among the problems which lead to unattractive service and operational difficulties:

- Average bus speeds during peak times are severely limited by traffic congestion on shared streets.
- Frequent stops to acquire or discharge passengers also contribute to low average speeds.
- The flow of other vehicles is disturbed by buses frequently entering or leaving the traffic system.
- The irregular motions of buses (i.e., frequent stops, starts, and lane changes) provide a source of passenger discomfort.
- A large portion of a bus operating cycle consists of acceleration or braking--increasing noise, mechanical wear, and driver fatigue relative to that experienced with steady operation.

1.2 BRT Benefits

Bus rapid transit systems are potentially capable of surmounting many of the difficulties associated with conventional bus operations. The following benefits are likely to be among those perceived by bus rapid transit patrons:

- The use of priority treatments for BRT vehicles will shorten travel times relative to those attained with conventional buses.
- A reduction in the extent to which traffic congestion influences bus operations will facilitate close adherence to schedules and lead to predictable bus service with regard to pickup times, travel times, and destination/arrival times.
- Riders will experience a more comfortable trip due to fewer intermediate stops and lack of traffic congestion.
- Passenger safety may be enhanced through less exposure of buses to truck and automobile traffic.

It is anticipated that bus rapid transit will also produce operational benefits, including those listed below:

- High average vehicle speeds will result in good vehicle utilization (that is, more round trips per hour than conventional buses).
- Good driver utilization can also be expected as a benefit associated with high average vehicle speeds.
- The more uniform vehicle motion characteristic of bus rapid transit can potentially reduce driver fatigue, mechanical wear in certain vehicle components, fuel consumption, exhaust emissions, and noise.

Since bus rapid transit offers riders a significantly improved level of service (primarily from the standpoint of travel time), the possibility exists that a substantial ridership volume will be developed and maintained. Satisfactory ridership levels have been observed in the limited bus rapid transit operations in Los Angeles, Seattle, New York, and Washington, D.C., even though these systems provide essentially non-stop service with few opportunities for passengers to enter and leave. To further enhance the accessibility of bus rapid transit, it is necessary to provide support facilities (such as park-and-ride and kiss-and-ride) and feeder service in the form of local buses or dial-a-bus operations. Furthermore, the operating efficiencies of bus rapid transit may permit fares to be established at a level which many potential riders find competitive with other modes of transportation available to them.

Each transportation mode has applications to which it is best suited. Bus rapid transit is not intended to compete with high-capacity rail systems in heavily traveled corridors. Nor can it supplant the private automobile in areas with diffused, low-density travel patterns. In applications requiring an intermediate capacity of approximately 2,000 to 10,000 persons per hour, however, bus rapid transit very probably represents an excellent balance between capital investment and the level of passenger service attained. Moreover, it is quite significant that the capital investment in a bus rapid transit system can be adjusted to achieve a desired level of service--ranging from the amount required to implement grade-separated exclusive busways to the minimal investment associated with the shared use of existing traffic lanes.

The potential benefits to be derived from the implementation of bus rapid transit systems in Michigan are considerable. Relatively little operating experience has accrued with bus rapid transit systems of this type, however. It is the opinion of transit planners that the needed experience can best be acquired through a controlled, carefully planned, trial implementation of bus rapid transit in a selected location. An important aspect of this trial implementation is the selection of a test site which will permit meaningful results to be obtained and which will not distort the results due to unusual circumstances in that location. It is also important that the method of implementation be chosen such that express bus operation is provided at a reasonable cost and with a minimum disruption of other traffic and the surrounding neighborhoods. Furthermore, the scheduling and operation of the bus rapid transit system should produce a balance between costs and level of service. Finally, it is necessary to monitor the operation of the test system and analyze its performance.

The following principal results will be among those produced in the course of the bus rapid transit demonstration.

- Bus rapid transit technology will be quantitatively evaluated with regard to its viability as a transportation alternative for Michigan applications. The evaluation will encompass:
    - Implementation costs
    - Operating costs
    - Level of passenger service
    - Public acceptance (ridership attraction)
- A design methodology usable in other Michigan bus rapid transit implementations will be formulated. The BRT design aspects considered will include:
    - Right-of-way modifications (pavement markings, signing, traffic control signals, barriers, curb cuts, etc.)
    - Bus access/egress facilities such as special ramps and lanes
    - Demand analysis and schedule development
    - Operating personnel
    - Support systems (park-and-ride and kiss-and-ride) facilities, feeder bus operations, dial-a-bus service, etc.)

1.3 BRT Program Plan

The bus rapid transit demonstration will be accomplished in five phases, as listed below:

- Phase I - Potential bus rapid transit corridors in four Michigan urban areas will be examined, and a demonstration test site will be recommended.
- Phase II - A travel data base for the selected corridor will be compiled and studied. Existing corridor travel will be simulated, and the simulation will be calibrated through correlation with available data. Bus rapid transit service in the corridor will be simulated, and its performance and impact on other transportation in the corridor will be evaluated. An implementation plan and cost estimate will be prepared. Any necessary support requirements (such as park-and-ride or kiss-and-ride facilities and feeder bus or dial-a-bus service) will also be defined.
- Phase III - Detailed designs, specifications, and cost estimates will be produced for all of the major system elements, including right-of-way modifications, interchanges, access and egress points, pavement markings, lights, signing, and traffic control equipment. Operating personnel requirements will also be determined.
- Phase IV - The implementation and operation of bus rapid transit service in the demonstration corridor will be monitored and coordinated to assure that the demonstration is conducted as planned in earlier phases.

- Phase V - Data will be collected throughout the demonstration, analyzed, and incorporated into a final report detailing the results of the demonstration and outlining recommendations for future applications.

This report summarizes the Phase I effort completed in April 1975.

2.0 IDENTIFICATION OF POTENTIAL BUS RAPID TRANSIT CORRIDORS

2.0 IDENTIFICATION OF POTENTIAL BUS RAPID TRANSIT CORRIDORS

This section summarizes the identification of potential bus rapid transit corridors in selected Michigan cities and describes the corridor screening process utilized to reduce the number of corridors from twenty-four to seven. The number of corridors was reduced to allow a more detailed subsequent analysis to be performed on those corridors exhibiting the most potential for a bus rapid transit demonstration. The total effort included planning and preparation functions, coordination with local transit officials in each of four cities to obtain required basic information, cursory development of existing corridor data to establish a basis for assessment of BRT potential, and, finally, comparison of the contributing factors for each corridor to culminate the judgmental process.

2.1 Areas Visited

The four metropolitan areas examined for potential BRT corridors include Lansing/East Lansing, Flint, Grand Rapids, and Detroit. Each area was visited for the purposes of initial data collection, solicitation of the views of local officials on corridor identities, and general familiarization with the area's traffic patterns. Listed below are organizations and individuals contacted in each locality, along with a general list of data and reports obtained.

- Lansing/East Lansing Area
    - Tri-County Regional Planning Commission, Sam Burns
    - Capital Area Transportation Authority (CATA), Duane Kooyers
    - Michigan Department of State Highways and Transportation, Mike Eberlein, Dave Geiger
    - Data/Reports
        1. "Identification, Delineation, and Classification of Activity Centers," December 1973
        2. "Identification and Delineation of Principal Travel Corridors in the Tri-County Region," January 1974
        3. "Corridor Travel Patterns, Land Use Data, Growth Factors, and Existing Transit System," March 1974
        4. "Annual Report, Fiscal Year 1974, Transportation," September 1974
        5. "Street and Highway Inventory Summary," December 1966
        6. O/D Data for Grand Rapids, Flint, and Lansing/East Lansing

- Grand Rapids Area
    - Grand Rapids Transit Authority (GRTA), David Needham, Robert Lenn
    - Data/Reports

1. "Grand Rapids Transit Improvement," Work Paper No. 5, No. 4, and a portion of No. 3, prepared in 1973 by Barton-Aschman Associates, Inc.
2. Bus Route Maps and Schedules
3. Traffic Flow Map (1972)
4. Population Density Map
5. Tabulation of Traffic Analysis Zone Areas and Population Densities

- Flint Area
    - Genesee County Metropolitan Planning Commission, Thomas Roach, Chapin Cook
    - Flint Mass Transit Authority, Louis Marsack
    - Flint Department of Traffic Engineering, David Henley
    - Data/Reports
        1. "Genesee County 1990 Land Use - Transportation Plan," September 1971
        2. "A Five-Year Mass Transit Development Plan for Flint, Michigan" (Draft Copy Dated November 11, 1974)
        3. "Genesee County Transportation Facilities Inventory Report, Genesee County, Michigan," February 1970
        4. "1973 Annual Report," Flint-Genesee County Comprehensive Land Use - Transportation Planning Study
        5. "Short-Range Multi-Modal Improvement Program," for the Flint-Genesee County Urbanized Area
        6. Genesee County Highway Map
        7. Map of Bus Routes and Activity Centers in Genesee County
        8. Bus Schedules and Route Maps
        9. Ridership Totals (by Route) for the Weeks of November 18 and November 25, 1974
        10. Aggregate Ridership Totals for Each Month in the Years 1972, 1973, and 1974
        11. Ridership Totals for Each Month in the Years 1972, 1973, and 1974
        12. Description of Each Bus in Fleet

- Detroit Area
    - Detroit Department of Transportation, George Basmadjian, Ross Bremmer, George Friend, Bill Morrison, Bob Holliday, Harold Schroeter, Robert Hicks
    - SEMCOG, Jim Thomas
    - SEMTA, Tom Wegerbauer, Dan Morrill
    - Department of State Highway, Herb Crane
    - Data/Reports

1. Tape of Employment Projections by District for 1975
2. 1970 24-Hour Traffic Flow Map
3. Map of Employment Centers by District
4. Map of Retail Centers
5. 1990 Highway Network Map
6. Detroit DOT Bus Line Maps, Schedules, Line Miles, and Collected Revenue by Line
7. Average Weekday 24-Hour and Peak Hour Ramp and Freeway Traffic Counts
8. Detroit CBD Cordon Counts
9. 24-Hour Traffic Counts on Major Arterials
10. "Formation of the Detroit Freeway Operations Unit," TSD-TR-119-69
11. "Improving Eastbound Ford Freeway Traffic Flow by Ramp Metering," Phase I - Analysis of Preliminary Traffic Data, TSD-TR-180-71
12. 1965 TALUS Survey Data

2.2 Corridor List

A total of twenty-four corridors were identified in the four metropolitan areas for consideration in the screening process. The corridors were chosen on the basis of recommendations by local officials as well as characteristics of available data. Major traffic routes are used to identify the corridors in this list. A more detailed account of the area included within each corridor for the screening process is found in subsequent paragraphs.

- Lansing/East Lansing

    - East Grand River Avenue/Oakland Avenue
    - East Saginaw Street/Oakland Avenue
    - South Cedar Street
    - South Logan Street
    - West Saginaw Street

- Flint

    - North Saginaw Street/Detroit Street
    - South Saginaw Street
    - Dort Highway (North/South)
    - I-475 (South)
    - I-69 (East/West)

- Grand Rapids

    - US-131/Division Avenue (South)
    - US-131/Plainfield Avenue (North)

  - 28th Street (East/West)
  - I-196 (Southwest)
  - I-196 (East)
  - Lake Michigan Drive (West)

- Detroit
  - Gratiot/I-94
  - Mound Road/Van Dyke
  - Woodward/I-75
  - Grand River/Jeffries
  - Michigan Avenue/I-94
  - I-75/Fort
  - I-696/Lodge
  - East Jefferson

2.3 Corridor Screening Characteristics

The twenty-four candidate corridors were screened on the basis of four important corridor characteristics. These characteristics include travel demand, peak period level of service estimates, current transit ridership, and significant physical factors relating to the ease of BRT implementation. The objective of the screening process was to provide a timely means for reducing the number of candidate corridors to seven of the most promising in terms of BRT potential. The depth of the effort was limited by constraints of available data as well as the large number of corridors (24) to be screened. The values of the BRT screening characteristics for all 24 of the identified corridors are summarized in Table 2-1.

2.3.1 Corridor Travel Demand

Travel demand for each corridor was estimated, using daily, all-mode origin-destination trip data. Availability and general compatibility of data among the four metropolitan areas were major reasons for representing travel demand in this format. The data for Lansing, Grand Rapids, and Detroit are based on the results of surveys conducted in 1965; the data for Flint are based on the results of a 1966 survey. The origin-destination data for the three outstate areas were provided by the Michigan Department of State Highways and Transportation in Lansing. The Detroit data were obtained from tapes provided by the Southeastern Michigan Council of Governments (SEMCOG).

A minor discrepancy in data exists between outstate and Detroit areas. The O/D tables for the outstate areas list total vehicle trips, while total person trips are reported for the Detroit area. To compensate for this variance and allow direct comparison of travel demand by person trip, average vehicle occupancy factors were obtained and applied to the outstate travel demand numbers. The factors are 1.55, 1.26, and 1.51 for Grand

Table 2-1 Corridor Screening Characteristic Summary for BRT

Corridor Route	Total Trips To (One-Way) Major Destinations Daily	Peak Hr	Level of Service Estimate	Current Transit Ridership in Corridor	Ease of Implementation/Remarks
Lansing/East Lansing, Michigan					
East Grand River/Oakland	13,443W/11,287E		D	2943 (Michigan)	Park & ride space at Meridian Mall, 2-3 lanes/direction
East Saginaw/Oakland	3761		C	--	Oakland/Saginaw one-way pair through city, 3 lanes
South Cedar	7207		B	873	Row width only 66 ft in places, 2 lanes/direction
South Logan	6821		C	452	At-grade RR crossings, row width = 66 ft, 2 lanes/direction
West Saginaw	4407		D	447	Park & ride space at Lansing Mall, row = 83 ft most areas
Flint, Michigan					
North Saginaw/Detroit	4323		F	2243	Some park & ride possibilities, curb cuts feasible most areas
South Saginaw	3323		E-F	428	Curb cuts feasible most areas
Dort Highway (N/S)	1788N/2067S		D-E	--	Many traffic signals
I-475 (S)	4053		A-B	--	Few access ramps
I-69 (E/W)	1907W/1573E		A-B	439	Park & ride facilities potentially available
Grand Rapids, Michigan					
US-131/Division (S)	495		D-E/D	1158 (Division)	Ramp queue jumpers feasible most areas, freeway flows well
US-131/Plainfield (N)	8378		D-E/D	853 (Plainfield)	Possible park & ride at North Kent Mall
28th Street (E/W)	2220E/409W		E	--	Unsynchronized lights, frequent stops required, L&R turns
I-196 (SW)	3249		B-C	--	Few stops required, park & ride space
I-196 (E)	1724		B-C	--	No major implementation problems
Lake Michigan Drive (W)	3715		C	164	Few stop lights, wide shoulders in outlying areas, 1-1/2 lanes close in
Detroit, Michigan					
Gratiot/I-94	42,641	12,934	D-E/D-E	22,447	Synchonized lights, narrow median on I-94 close in
Mound/Van Dyke	33,913	6,847	D-E/D-E	--	Wide median on Mound, curb cuts tight on Van Dyke
Woodward/I-75	39,143	7,299	D/E	52,848	Synchronized lights on Woodward, ramp queue jumpers feasible on I-75 most areas
Grand River/Jeffries	45,686	12,074	D/C	8,590	Narrow median on Lodge, utilization of Jeffries will allow exclusive lane implementation
Michigan/I-94	22,730	4,747	D/D-E	9,561	Michigan divided by median
I-75/Fort	17,849	4,318	D-E/C-D	11,958	No service drives on I-75, narrow median on I-75
I-696/Lodge	36,989	7,157	D-E/E-F	--	Service drives available some areas
East Jefferson	43,790	10,353	D-E	26,295	Synchronized lights, cross traffic minimized

Rapids, Lansing, and Flint, respectively. Travel demand values listed in Table 2-1, therefore, reflect these compensations.

In order to use the O/D data, each corridor was defined in terms of origin and destination zones (traffic analysis zones in the outstate areas and districts in the Detroit area). Only key destinations such as the CBD and other major employment centers were considered for corridor screening purposes. All zones within each corridor, but outside a two-mile radius around the identified employment centers, were considered as origins. That is, although BRT is an express service, it was assumed for the purpose of screening that all trip makers would be served equally. The effect of this assumption is to somewhat overestimate the demand on each corridor from which BRT ridership would be generated. This effect, however, is not considered significantly detrimental to the screening process. The location of each production stop (pickup stop), and the portion of the total trips which have convenient access to that stop, will be estimated for selected corridors as part of the next phase of corridor evaluation.

The two-mile zone without pickup stops surrounding each employment center reflects the assumption that few short trips would be attracted to BRT, and that the bus would, therefore, travel in an express mode for at least two miles before making a destination stop.

The five corridors in Lansing which were considered as candidates are identified in terms of traffic analysis zones in Table 2-2. The corridors in Flint, Grand Rapids, and Detroit are similarly identified in Tables 2-3, 2-4, and 2-5, respectively. Other destinations besides those identified in the tables could have been considered, but areas of the central city were chosen for consistency and simplicity. For the purposes of this analysis, the "central city" is defined as the CBD plus any major employment centers in the downtown area but outside the CBD. For example, the central city includes the state office building in Lansing and the New Center area in Detroit. Radial corridors were evaluated on the basis of the number of trips terminating in the central city where parking may be expensive or inconvenient and congestion is probably greatest. Furthermore, the number of trips destined to other employment centers along the corridor, as defined herein, was usually found to be small compared to the number of trips destined to the central city.

The daily travel demand for each corridor, subject to the limitations described herein, is summarized in Table 2-1. All of the numbers represent unidirectional flows. When two or more destinations combine to produce significant two-way flow along a corridor (e.g., the Grand River-Oakland corridor in Lansing), the flow in each direction is listed separately in the table.

Peak-hour origin-destination data give a better indication of potential BRT demand along a corridor than does the daily data. However, peak-hour data were not available for any of the outstate areas. Morning peak-hour data for the Detroit area were available, however, and are included in Table 2-1. The data indicate, at least for Detroit, that between 20 and 30 percent of the daily travel to the central city occurs during the morning peak hour.

Table 2-2 Definition of BRT Corridors in Lansing

Corridor	Origin Zones	Destination Zones
E. Grand River/Oakland	206-208 212-224 232-238 240-243 251 253-255 258-261 265-270 281 283 285-291 294-311	1-10 Lansing CBD 20 State Offices 260 East Lansing 242, 252, 253 MSU
E. Saginaw/Oakland	217-232 256-257 262-264 271-280 282 284 388-389	1-10 Lansing CBD 20 State Offices
S. Cedar	122-125 128-142 156-166 184-192 316-329	1-10 Lansing CBD 20 State Offices
S. Logan	76-82 126-127 143-155 167-183	1-10 Lansing CBD 20 State Offices
W. Saginaw	35-37 40-61 63-74	1-10 Lansing CBD

Table 2-3 Definition of BRT Corridors in Flint

Corridor	Origin Zones	Destination Zones
N. Saginaw/Detroit	82-85 92-100 102 104 165-168 177-189	3-6 Flint CBD
S. Saginaw	32-34 37 233-241 246-248 251 253-259	3-6 Flint CBD
Dort Highway	19-24 26-30 32 97 100-101 111-117 119-125 164-168 176-181 185-190 196 219-220 232-233 236-238 240-241 246-248 251 254-257	20 Consumers Power 112 AC Spark Plug 237 Fisher Body, Grand Blanc
I-475	33-34 37 233-241 246-261	3-6 Flint CBD

Table 2-3 Definition of BRT Corridors in Flint (Continued)

Corridor	Origin Zones	Destination Zones
I-69 East	5-14 20-26 201-209 212-215	3-6 Flint CBD
I-69 West	38 42-43 278-280 283 286-288 302-307 309	3-6 Flint CBD

Table 2-4 Definition of BRT Corridors in Grand Rapids

Corridor	Origin Zones	Destination Zones
US 131/Division (South)	144 172-179 203-208 216-219 240-246 257-259	96, 101, 102, 108, 109 Grand Rapids CBD
US 131/Plainfield (North)	20-23 35-38 45-50 67-70 72-77 91-94	96, 101, 102, 108, 109 Grand Rapids CBD
28th Street	156 158-162 164 178 181-184 192-203 210-212 221-222 224-234	208 Kent Ind. Center 215 Steel Case 218 Fisher Body
I-196 (Southwest)	139-141 180-186 192-198 221-234	96, 101, 102, 108, 109 Grand Rapids CBD
I-196 (East)	6 16-17 42-43 115-117 153-155	96, 101, 102, 108, 109 Grand Rapids CBD
Lake Michigan Drive	13 27-29 55-58 95 129-138 187	96, 101, 102, 108, 109

Table 2-5 Definition of BRT Corridors in Detroit

Corridor	Origin Districts	Destination Zones
Gratiot/I-94	42-43 61 65 80-85 111-112 305 310-315 320-324 340-341	1-7 Detroit CBD 13, 23, 50 New Center
Mound/Van Dyke	40 42 61-62 64-66 81-82 102 300-305 330-334	1-7 Detroit CBD 13, 23, 50 New Center
Woodward/I-75	62-64 76 100-102 200-207 230-232 234-236 240-241 243 250-255	1-7 Detroit CBD 13, 23, 50 New Center
Grand River/Jeffries	51 53 70-73 92-97 141 143-144 146 214 220-222	1-7 Detroit CBD 13, 23, 50 New Center

Table 2-5 Definition of BRT Corridors in Detroit (Continued)

Corridor	Origin Districts	Destination Zones
Michigan/I-94	34-35 120-123 125-126 133-134 137 139 152-154 180-181	1-7 Detroit CBD 13, 23, 50 New Center
I-75/Fort	30-33 130-136 138 160-164 510-512	1-7 Detroit CBD 13, 23, 50 New Center
I-696/Lodge	53-54 73-75 96 101 203 210-212 214 220-222	1-7 Detroit CBD 13, 23, 50 New Center
E. Jefferson	40-44 85 110-112 310-315 320-324 340-341	1-7 Detroit CBD 13, 23, 50 New Center

2.3.2 Level of Service Estimates

Another requirement, next in importance to travel demand, is the necessity for the priority treatment to attract increased transit ridership and carpool participation. The potential should exist for providing service which is faster than the private automobile. Alternatively, bus travel may be equal to or slightly greater than auto travel time if other incentives to ridership, such as the elimination of unexpected travel delays, can be provided. Both requirements suggest that a potential BRT corridor should be characterized by traffic congestion.

An acceptable measure of congestion, for screening purposes, is the level of service notation (A through F) commonly defined by the Highway Capacity Manual.* To accommodate the urgency of the corridor screening process, local officials were contacted for information pertaining to any previously designed level of service values for the corridors under consideration. Service levels are normally calculated by considering basic elements such as average overall travel speed, volume to capacity ratios, and other related elements in varying proportions for freeways, multi-lane highways, two and three lane highways, urban arterials, and downtown streets. In the absence of available predetermined level of service values, cognizant representatives within the local areas were asked to subjectively estimate levels of service, by corridor, for the peak travel period. To clarify the level of service values utilized for this corridor screening application, the following definitions are supplied:

- Level of Service A: Describes a condition of free flow, with low volumes and high speeds. Traffic density is low, with speeds controlled by driver desires, speed limits, and physical roadway conditions. Little or no restriction in maneuverability due to the presence of other vehicles is encountered.

- Level of Service B: Stable flow, with operating speeds beginning to be restricted somewhat by traffic conditions. Drivers still have reasonable freedom to select their speed and lane of operation. Reduction in speed is not unreasonable, with a low probability of traffic flow being restricted.

- Level of Service C: Flow is still stable, but speeds and maneuverability are more closely controlled by the higher volumes. Most drivers are restricted in freedom to select speed, change lanes, or pass. Relatively satisfactory operating speed still maintained.

- Level of Service D: Approaches unstable flow, with tolerable operating speeds being maintained though considerably affected by changes in operating conditions. Fluctuations in volume and temporary restrictions to flow may cause substantial drops in operating speeds. Drivers have little freedom to maneuver, and comfort and convenience are low.

---

* Highway Capacity Manual, 1965, Highway Research Board, Special Report 87, National Academy of Sciences, National Research Council, Publication 1328.

- Level of Service E: Cannot be described by speed alone, but represents operations at lower operating speeds than in Level D, with volumes at or near capacity of the highway. At capacity, speeds are typically near 30 mph. Flow is unstable with stoppages of momentary duration.

- Level of Service F: Describes forced flow operation at low speeds, where volumes are below capacity resulting from queues of vehicles backing up from restrictions downstream. Highway sections serve as storage areas. Speeds are reduced substantially with stoppages for short or long periods of time. In the extreme, both speed and volume drop to zero.

2.3.3 Current Transit Ridership

Transit ridership data were gathered for the four cities involved in the Michigan BRT study. Ridership data were supplied by the Flint Mass Transportation Authority (FMTA), the Grand Rapids Transit Authority (GRTA), the Capital Area Transit Authority (CATA) in Lansing, the Detroit Department of Transportation (DDOT),and the Southeastern Michigan Transportation Authority (SEMTA). The data supplied are of two types. One type provides the number of passengers for a 24-hour period on individual bus routes in the cities and surrounding areas. The other type indicates the total number of bus passengers during the peak 12-hour travel period. The Detroit CBD Cordon Count, described later, is an example of the latter type. Some of the proposed BRT routes are not presently served by mass transit, and, therefore, the Corridor Screening Characteristic Summary (Table 2-1) includes some blanks in the "Current Transit Ridership" column.

Current transit ridership data are listed by corridor in Table 2-1. For the purpose of this study, corridor transit ridership included not only passengers on buses presently operating on the proposed BRT routes, but also on adjacent routes serving the corridor. It was assumed that the BRT line would draw a portion of the transit riders from parallel routes in the corridor. Therefore, all current transit riders in the corridor were summed to indicate the approximate number of potential BRT riders.

The ridership data tabulated for the Lansing, Flint, and Grand Rapids corridors represent average 24-hour transit ridership obtained within the following time periods. The data for Lansing are indicative of an average day for a period during the summer of 1974. The Flint MTA data represent the average week-day regular service ridership for the week of November 18 through November 22, 1974. The Grand Rapids data provide the total transit ridership for December 2, 1974.

Two sources of data, the 1974 Cordon Count of the Detroit Central Business District, prepared by the Traffic Research Division of the Detroit Department of Transportation, and five-day passenger count averages for SEMTA bus routes were used to determine the current transit ridership for the corridors in Detroit.

The SEMTA data are for 24-hour transit ridership and represent the daily average of a sample five-day week. Similar ridership data by route were not available for DDOT buses operating along the identified corridors in the city of Detroit. Therefore, the number of passengers entering and leaving the Detroit CBD on DDOT buses operating on streets in each corridor was used as an indication of transit ridership. These data were obtained from the 1974 Cordon Count which was conducted between 7:00 a.m. and 7:00 p.m. on April 23, 24, and 25, Tuesday, Wednesday, and Thursday, respectively. The Cordon Count is a classified vehicle and passenger survey of all traffic entering and leaving the Detroit CBD. The boundaries of the cordon area are the John C. Lodge Freeway on the west, the Fisher Freeway on the north, the Chrysler Freeway on the east, and the Detroit River on the south.

The transit ridership estimates for the Detroit corridors obtained from the Cordon Count are 12-hour rather than 24-hour totals. However, the 12 hours not covered by the Cordon Count are off-peak hours with low transit ridership.

2.3.4 Ease of Implementation/Remarks

Subjective remarks relating to physical characteristics of each candidate corridor were formulated to provide insight regarding BRT implementation along corridor routes. These remarks, however, were based upon macroscopic observations made during visits to each of the four metropolitan areas and, as such, were regarded lightly in the corridor screening process.

2.4 Corridor Screening by Urban Area

The corridors in each urban area were evaluated separately on the basis of the screening characteristics. The results of this phase of the screening process are the identification of the most promising corridors in each of the four urban areas.

2.4.1 Lansing/East Lansing

As a result of discussions with regional planning and transit officials and first-hand observation, five corridors were identified in the Lansing/East Lansing area for further consideration in the screening process. Those corridors are identified by traffic analysis zones in Table 2-2 and are listed below for reference:

- East Grand River/Oakland
- East Saginaw/Oakland
- South Cedar
- South Logan
- West Saginaw

The corridor characteristics which were considered in the screening process are summarized in Table 2-1.

According to Table 2-1, the East Grand River/Oakland Corridor is the one which has the largest number of trips destined to major employment centers. The two major employment centers along this corridor which were considered in estimating corridor demand are the Lansing CBD, plus the state offices, and the East Lansing CBD, plus parts of the MSU campus. Since the East Lansing employment center is a major trip attractor, the corridor has significant two-way flow. According to the 1965 O/D data, approximately 13,000 persons initiate trips within the corridor and travel west to the East Lansing and Lansing employment centers. Approximately 11,000 persons travel east along the corridor to the East Lansing employment center. East Grand River appears to be as congested as any arterial under consideration in Lansing, and thus offers as much potential as any other corridor for reducing travel time by implementing a bus priority treatment. The East Grand River/Oakland Corridor also supports the highest transit ridership (approximately 2,900 passengers per day) of all the potential corridors. There appears to be space at Meridian Mall for change-of-mode parking, and the Saginaw-Oakland one-way pair offers good potential for simple BRT implementation.

The four remaining corridors are all oriented radially toward the Lansing employment center. The total number of trips to that destination generated within each of these corridors is less than the corresponding number for the Grand River/Oakland Corridor. Except for West Saginaw Street, traffic on the remaining corridor spines is characterized by stable flow with acceptable operating speeds (Level of Service B to C). Little potential for reducing trip times by priority treatments exists on three out of four of these corridors. Daily transit ridership on these four corridors is much less than the ridership on the Grand River/Oakland Corridor. Without a substantial transit ridership base upon which to build, establishing an acceptable level of BRT ridership would depend heavily on diverting potential riders from automobiles. This diversion is particularly difficult where congestion is lacking.

Considering the total number of trips, comparative levels of congestion, and current transit ridership, the Grand River/Oakland Corridor stands out as the corridor in the Lansing area which offers the highest potential for BRT service.

2.4.2 Flint

As previously discussed, five travel corridors in the Flint area were considered suitable for evaluation. These corridors are listed below:

- Dort Highway (North and South)
- I-69 (East and West)
- I-475 (South)
- South Sagniaw Street
- North Saginaw/Detroit Street

The Dort Highway Corridor has relatively little potential for Bus Rapid Transit. A cursory analysis of 1966 O/D survey data revealed that this corridor generates a base of fewer than 1,800 daily person-trips from which northbound BRT trips could be attracted, while approximately 2,100 daily person-trips are estimated for southbound Dort Highway. The implementation of BRT on Dort Highway could be quite difficult; many traffic signals are located in the vicinity of AC Spark Plug; traffic in the same area is somewhat congested; and an exclusive bus lane does not appear viable. The Flint MTA does not currently provide bus service on the Dort Highway Corridor (with the exception of the Lapeer Road route on South Dort Highway between Lippincott Boulevard and Hemphill Road). It would be necessary, therefore, to attract virtually all BRT riders from among those who presently travel by automobile or who are restricted in their trip making.

The I-69 Corridor, extending from Davison (east of Flint) to Swartz Creek (west of Flint), is also unattractive for BRT implementation. The 1,966 daily person-trips satisfying the appropriate screening criteria total approximately 1,600 and 1,900, respectively, on the east and west segments of the I-69 Corridor. The operation of buses on I-69 could be readily accomplished. Traffic moves freely in both directions, obviating the need for an exclusive bus lane. Furthermore, the location of I-69 provides good access to the Flint CBD from either extremity of the corridor. In addition to the Flint CBD, Swartz Creek, and Davison, I-69 serves GM Parts Division, Genesee Valley Mall, the Chevrolet complex at Bristol Road and I-75, and Eastland Mall. Due to the lack of congestion on I-69, however, BRT could offer no time savings relative to automobile travel, creating a major obstacle to the attraction of ridership. Current ridership on the bus lines paralleling I-69 (Genesee Valley and Richfield Road) is quite low and does not constitute a viable base upon which a substantial BRT ridership could be built.

The I-475 Corridor between a point west of Grand Blanc and the Flint CBD has a slightly higher potential for BRT than the Dort Highway or I-69 Corridors discussed above. A total of approximately 4,100 daily person-trips (in 1966) are judged to be suitable for BRT, more than are associated with the preceding corridors, but still a very small number. I-475 has been open to traffic only since the fall of 1974 and does not yet have significant congestion; buses could move quite well in mixed traffic with no special provisions. The lack of congestion, however, eliminates trip time savings as incentive for travelers to choose BRT rather than automobiles. Also, the small number of I-475 access points restricts opportunities for intermediate feeder connections. Finally, the low ridership on the South Saginaw Street bus line (which parallels much of the I-475 route) does not indicate a substantial group of transit-oriented persons who would be likely to patronize BRT.

The South Saginaw Street Corridor, interconnecting the Flint and Grand Blanc CBD's, was analyzed in a manner similar to that employed for the other Flint corridors. Approximately 3,300 daily person-trips (based upon 1966 O/D survey data) are considered potentially suitable for BRT. BRT service would be more difficult to implement on South Saginaw Street than on either of the freeways discussed above. Through the use of bus-actuated traffic signal pre-emptors, or by other means, BRT travel times comparing favorably with those of automobiles delayed by traffic congestion might be attained. The current South

Saginaw Street bus ridership, however, is not high enough to indicate (by itself) that the corridor is particularly favorable for BRT operation.

The corridor associated with North Saginaw Street and Detroit Street appears to be the most suitable location for BRT in the Flint area. An examination of daily person-trips (using data obtained in a 1966 O/D survey) revealed that a total of approximately 4,300 such trips follow the general pattern of BRT travel. Although this total is greater than those determined for other Flint corridors, it is quite small relative to the capacities obtainable with the BRT systems considered in this study. No major BRT implementation obstacles were observed with regard to North Saginaw Street. Curb cuts for bus loading and unloading seem feasible in all portions of North Saginaw Street, with the exception of the CBD. Parking restrictions could be used to provide bus stops or even bus lanes in the CBD, since parking is currently permitted on both sides of Saginaw Street in that area. (It would be necessary to demonstrate that downtown merchants would experience a net benefit before such parking restrictions would be generally accepted.) In addition to the CBD, Buick Motor Division is a major trip attractor which would be served by a North Saginaw BRT route. If the demand proved sufficient, a portion of the buses could be diverted from North Saginaw Street to travel on Industrial Avenue adjacent to Buick. Furthermore, North Saginaw Street is occasionally quite congested, presenting an opportunity for BRT to compete effectively with automobile travel times. Finally, the current transit ridership along this corridor (computed by adding ridership totals for the Flint MTA lines on both Detroit Street and North Saginaw Street) is higher than was observed for the other Flint corridors studied.

2.4.3 Grand Rapids

The following six candidate BRT corridors in Grand Rapids were evaluated:

- I-196 (Southwest)
- I-196 (East)
- Lake Michigan Drive
- 28th Street
- US-131/Division Avenue
- US-131/Plainfield Avenue

Both segments of I-196 have relatively low potential for successful BRT implementations. In each of these cases, the number of daily vehicle trips (based on 1965 O/D survey data) compatible with BRT characteristics is quite small. Automobile traffic on I-196 moves freely, offering little chance for improved travel times through BRT service. The implementation of BRT on I-196 would not present any major problems and would provide convenient access to the Grand Rapids CBD. There is no well-developed transit ridership in the I-196 Corridor; it would be necessary to attract virtually all of the riders for a BRT system from among automobile users.

Lake Michigan Drive, extending west from the CBD, also does not exhibit a high potential for successful BRT operation. An examination of 1965 daily person-trips in this corridor, for example, indicated approximately 3,700 trips which are suitable for BRT. Furthermore, Lake Michigan Drive is not attractive from an ease-of-implementation standpoint, since portions of the roadway may not permit buses to pass slower vehicles. Current transit ridership in this corridor is quite small (less than 200 passengers per day) and does not provide an incentive to implement BRT service.

The 28th Street Corridor is heavily traveled, but does not include a major trip attractor comparable to the Grand Rapids CBD. While BRT implementation in this corridor could be accomplished, the "many-to-many" nature of the trips to be served does not favor BRT operation. These factors, in conjunction with the lack of an established base of current transit ridership, lead to the conclusion that 28th Street is not an appropriate site for a demonstration of BRT service.

The corridors associated with US-131 and Division Avenue (south of the CBD) and with US-131 and Plainfield Avenue (north of the CBD) are judged to be the most suitable in Grand Rapids for BRT implementation. In an analysis of 1965 travel data, the Division Avenue and Plainfield Avenue Corridors were found to have approximately 10,500 and 8,400 daily person-trips compatible with BRT characteristics, respectively. These travel volumes are higher than determined for other corridors in Grand Rapids, but are not sufficient to justify BRT approaches employing short bus headways or requiring significant capital expenditures. The operation of express buses in mixed traffic on either segment of US-131 would present no special problems, since this freeway does not often become seriously congested. The southern portions of Plainfield Avenue are not particularly attractive for express bus operation; a time savings might result from a longer route south on Plainfield to I-96, west on I-96 to US-131, south on US-131 to I-196, and east on I-196 to the CBD. Division Avenue appears more attractive for express bus service than does Plainfield Avenue; a route on US-131, however, again seems more desirable. Both Plainfield Avenue and Division Avenue are served by GRTA routes, but neither route has a ridership sufficient to indicate a high potential for BRT implementation.

2.4.4 Detroit

Eight corridors in the Detroit area were identified for further evaluation on the basis of daily traffic counts and the location of major employment sites. Since the Detroit CBD is the largest single employment center in the area and since CBD trip makers seem to be more transit-oriented than other trip makers, all of the identified corridors terminate in the CBD or the New Center area. High volume, non-radial travel corridors were identified based on traffic counts (e.g., Eight Mile Road, Southfield, and Telegraph), but they were not considered in the screening process because these corridors lack concentrated centers of employment which can be conveniently served by a BRT implementation. The eight corridors which were considered are defined in terms of analysis districts in Table 2-5 and are listed below for reference:

- Gratiot/I-94
- Mound/Van Dyke
- Woodward/I-75
- Grand River/Jeffries
- Michigan/I-94
- I-75/Fort
- I-696/Lodge
- East Jefferson

As indicated in Table 2-1, all eight of the corridors generate a large number of trips to the CBD and the New Center area. The table lists peak-hour trips as well as the daily total. According to the level of service estimates, the rush-hour traffic flow on all but one of the corridors approaches and sometimes reaches instability, with low operating speeds and occasional stoppages for short duration (Level of Service D to E). The Lodge Expressway periodically enters the forced flow regime where operating speeds are quite low and volumes are below capacity (Level of Service F). Unlike the other corridors, both Grand River and the Jeffries Freeway operate under stable flow conditions with generally satisfactory speeds (Level of Service C to D). With the possible exception of the Grand River/Jeffries Corridor, all of the corridors are relatively congested, and the potential exists for decreasing trip times by implementing a bus priority treatment. All of the corridors except two, Mound/Van Dyke and I-696/Lodge, have a substantial transit ridership base from which BRT ridership can be drawn.

On the basis of these screening characteristics, all eight of the corridors in the Detroit area appear to have potential for a successful BRT demonstration. However, the Southeastern Michigan Transportation Authority (SEMTA) has immediate plans for implementation of an exclusive bus lane on the Jeffries Freeway. The exclusive lane is to be extended as the freeway is completed. Therefore, to avoid duplication, the Grand River/Jeffries corridor has been eliminated from further evaluation for this BRT Demonstration Project.

3.0 CORRIDOR SELECTION

3.0 CORRIDOR SELECTION

Each of the four urban areas has been examined separately, and the corridors within each area having the most potential for attracting BRT ridership have been identified. In Flint, the Detroit Street/North Saginaw Street corridor was judged to be more suitable for BRT than other corridors in the area. In Grand Rapids, the corridors associated with US-131, both north and south of the CBD, show promise. A firm choice between these two corridors in Grand Rapids, however, would require further analysis. The East Grand River/Oakland Avenue corridor in the Lansing/East Lansing area was found to have more potential for successful BRT operation than any other corridor in that area. Finally, all eight corridors in the Detroit area were found to have high potential. The Grand River/ Jeffries Freeway corridor, however, as stated earlier, was eliminated to avoid duplication, since a bus priority project is already planned by SEMTA for the Jeffries Freeway. To complete the screening process, the eleven corridors located in four urban areas were compared on the basis of the screening characteristics. The seven corridors having the highest potential for successful BRT operation were then selected.

According to the level of service estimates which are summarized in Table 2-1, all eleven corridors are comparable in their level of congestion, and all offer roughly the same potential for increasing average velocity during peak hours by implementing some priority treatment. Although the outer terminus of each corridor has not been rigorously defined, it is believed that the corridors in the Detroit area are longer than those in the outside areas due to the greater intensity of suburban development in the Detroit area. Therefore, for a given increase in average velocity, the corridors in the Detroit area offer a greater potential for reducing total trip time than do the corridors in the outstate areas.

Although the estimates of daily person-trips are severely limited in their usefulness for making quantitative BRT ridership estimates, they do serve to indicate the relative magnitude of the demand from which BRT ridership will ultimately be drawn. In nearly all cases, the number of trips that conform to the general pattern of BRT travel which are generated within the Detroit area corridors far exceed the number of such trips generated within the outstate corridors.

Existing transit ridership along the outstate corridors is very small compared to the ridership along the corridors in the Detroit area where transit service is provided.

3.1 Preliminary Recommendations

Based on these considerations, it was concluded that, although each of the three outstate urban areas includes at least one corridor in which some form of priority bus treatment may be feasible, none of these shares the overall potential of any one of the seven candidate corridors in the Detroit area. It was, therefore, recommended that scheduled effort for further analysis be focused on the seven Detroit corridors presented below in non-ranked order:

- Gratiot/I-94
- I-75/Fort
- I-696/Lodge
- East Jefferson
- Michigan/I-94
- Mound/Van Dyke
- Woodward/I-75

3.2 Final Selections

These preliminary recommendations were presented to representatives from cognizant agencies on February 14, 1975. Representatives from the Michigan Department of State Highways and Transportation (MDSHT), Southeastern Michigan Transportation Authority (SEMTA), Southeast Michigan Council of Governments (SEMCOG), and Detroit Department of Transportation (DDOT) were present at the meeting. A discussion of the preliminary recommendations resulted in the final selection of seven corridors for further study.

The original seven corridors identified by the screening process are all CBD oriented. While this characteristic is considered an asset to BRT implementation schemes, it was deemed desirable to consider inclusion of one or two non-CBD oriented corridors for further analysis. The Southfield Corridor and a crosstown corridor were suggested for this purpose.

The Southfield Corridor was suggested on the basis of its high rate of development over the past few years, as well as its continued development rate anticipated for the very near-term, while a viable crosstown link serving the Rouge River area from the east side of Detroit would be a significant service improvement to the community. In order to include these suggested corridors for additional analysis and provide minimum disruption to existing program plans, it was deemed desirable to hold the number of candidate corridors to seven by reviewing and ultimately deleting two others from further consideration.

The discussion which occurred at this meeting resulted in identification of the Woodward/I-75 and Mound/Van Dyke corridors for deletion. The Grand Trunk Line improvements scheduled for the near term within the Woodward/I-75 corridor tend to discount the desirability of adding BRT in that locality. The lack of established transit ridership coupled with relatively low trip demand on the Mound/Van Dyke corridor contributed to its being deleted from further analysis.

In summary, the following seven corridors, identified by tentative routes, were selected to be developed through additional analysis in accordance with the contract.

- East Jefferson
- Gratiot Avenue
- I-696/Lodge Freeway
- Michigan/I-94
- I -75/Fort Street
- Southfield
- Crosstown (possibly I-94)

4.0 DEVELOPMENT OF DATA FOR SEVEN CANDIDATE CORRIDORS

4.0 DEVELOPMENT OF DATA FOR SEVEN CANDIDATE CORRIDORS

4.1 Transportation Demand Data

The basic source of the origin/destination data utilized in this study is the TALUS survey conducted in 1965. In the course of previous work by GM Research Laboratories, a magnetic tape containing the survey data was obtained from SEMCOG. From among the data in each tape record, the following items were extracted:

- Trip type
- Beginning time of trip
- Arrival time
- Trip origin zone
- Trip destination zone
- Expansion factor (i.e., the number of trips represented by the sample reported)

Over 300,000 such condensed survey records are assembled into a disk file to permit convenient future referencing. It is this file which serves as the basis for the demand estimates and travel pattern analyses reported herein.

4.1.1 Demand Analysis Time Interval

The operational characteristics of bus rapid transit are tailored to best serve concentrated, moderately large travel demands. It was decided, therefore, to analyze potential BRT corridors on the basis of peak-period travel to the Detroit CBD. To help choose a specific three-hour peak period, the 1965 TALUS survey file was used to compute the number of trips terminating in the Detroit CBD during half-hour intervals from 5:00 a.m. to 8:00 p.m., and originating in superdistricts 0 through 35. Totals for several different three-hour periods are shown in Table 4-1. It may be seen that the periods from 6:30 to 9:30, 7:00 to 10:00, and 7:30 to 10:30 include more trips than other morning periods. Although the 7:00-to-10:00 period total is not the maximum observed, that period was chosen for the following reasons:

- When only trips to the Detroit CBD are considered, the period from 7:00 to 10:00 has 5.6 percent more trips than the preceding period and only 0.5 percent fewer than the following period.
- It is expected that the 7:00-to-10:00 period includes a higher percentage of work trips than does a slightly later period.
- Analyses related to the SEMTA 1990 Transportation Plan were based upon travel between 7:00 and 10:00 a.m.

Table 4-1 Trip Totals for Various Three-Hour Periods

THREE-HOUR PERIOD	TOTAL TRIPS TO CBD*	THREE-HOUR PERIOD	TOTAL TRIPS TO CBD*
5:30 am - 8:30 am	51,352	11:30 am - 2:30 pm	33,862
6:00 am - 9:00 am	65,041	Noon - 3:00 pm	31,868
6:30 am - 9:30 am	71,661	12:30 pm - 3:30 pm	30,461
7:00 am - 10:00 am	75,649	1:00 pm - 4:00 pm	31,401
7:30 am - 10:30 am	76,021	1:30 pm - 4:30 pm	29,073
8:00 am - 11:00 am	64,171	2:00 pm - 5:00 pm	28,261
8:30 am - 11:30 am	52,682	2:30 pm - 5:30 pm	27,419
9:00 am - Noon	43,888	3:00 pm - 6:00 pm	27,068
9:30 am - 12:30 pm	41,768	3:30 pm - 6:30 pm	25,132
10:00 am - 1:00 pm	39,114	4:00 pm - 7:00 pm	22,379
10:30 am - 1:30 pm	37,550	4:30 pm - 7:30 pm	21,609
11:00 am - 2:00 pm	35,772	5:00 pm - 8:00 pm	21,080

* Number of trips terminating in Detroit CBD from origins within superdistricts 0 through 35 during specified interval, based upon 1965 TALUS survey data.

4.1.2 Corridor Definition

The information utilized to define each candidate BRT corridor includes the following items:

- Origin Traffic Analysis Zone List. These zones constitute the only trip generators to be considered in evaluating a corridor's trip volumes. Rather than specify zones individually, allowable trip origins are listed as entire districts (each containing several zones).
- Destination Zone List. Due to the greater density of trip destinations, these zones are individually specified. Trips terminating at any other locations are not analyzed.
- BRT Route Node List. A series of points, or "nodes," defines the principal route in each corridor. This route may consist of up to 60 nodes, with as many as 20 nodes in a main route and in each of two auxiliary routes.

A list of origin districts and destination zones for each of seven candidate BRT corridors is shown in Table 4-2. All districts and zones in that list are identified according to their TALUS designations. The origin districts in each corridor were chosen on the basis of their proximity to the corridor's primary route in an attempt to define a logical "travel shed." The areas of coverage (from which trips will be attracted) associated with the Gratiot and Michigan/I-94 corridors are illustrated in Figure 4-1. Similar diagrams are presented in Figure 4-2 (for the I-94 Crosstown and Lodge Freeway corridors) and in Figure 4-3 (for the East Jefferson, Southfield Freeway, and Fort/Fisher Freeway corridors).

Destination zones were selected by adding the total number of peak-period trips attracted to each zone in the Detroit area (superdistricts 0 through 35) from all other zones in the same area, and ranking the list to aid in the identification of prominent destinations. Figure 4-4 indicates the zones which were found to be among the top 60 attractors and which are located within the boundaries of one or more candidate BRT corridors. Figure 4-4 also displays the route definition nodes for the composite set of corridor routes. The node identification numbers shown are assigned by a transit network editing program and are used for later references to their associated locations.

4.1.3 1965 Corridor Trip Matrix

After the origin and destination zones in each corridor were selected, trip matrices of 1965 intra-corridor, peak-period travel by all modes were generated. A computer program was implemented to perform this task for each corridor. The program reads the 1965 TALUS survey file and ignores trips ending outside the morning peak period, originating in any zone not specified as a corridor origin, or terminating in any zone which is not among those specified as corridor destinations. The remaining trips are assembled into a peak-period corridor trip matrix. To permit relatively compact trip matrix storage, the program assigns one series of sequential numbers to the corridor's origin zones, and a separate series of numbers to the destination zones. The program

Table 4-2 Definition of Corridor Origins and Destinations

CORRIDOR	ORIGIN DISTRICTS	DESTINATION ZONES
Gratiot	22,24,42,43,61,65, 80-85,111,112,305, 310-315,320,322-324, 340,341	10-72,132,133,500,501, 521,600,1111,1122,3131, 3134,3204
East Jefferson	20,22,40-44,85,110-112, 310-315,320-324,340,341	10-72,132,133,500,501, 521,600,1105,1111,1122, 3131,3134,3204
I-94 Crosstown	11-14,20-24,31,33-35, 42,43,50-52,60,61,65, 80-85,102,111,112, 120-123,126,305,310-315, 320-324,340,341	10-72,132,133,500,501, 521,600,1212,1222,1223, 1260
Lodge Freeway	11-14,50-54,72-76,95-97 101,202-204,210-214, 220-222,240,242,244, 260,262,263	10-72,110,132,133,500, 501,521,600,2110
Southfield	71,72,74,90-97,120-123, 125,126,133,203-206, 210-214,230,240-242	921,962,963,1212,1222, 1223,1231,1260,2110, 2400,2402
Michigan/I-94	10-14,31,34,35,120-123, 125,126,133,134,137, 139,152-154,180-183, 190	10-72,132,133,500,501, 521,600,1212,1222,1223, 1260
Fort/ Fisher Freeway	10,30-33,130-136,138, 160-164,510-512	10-72,132,133,300,500, 501,521,600,1310,1367

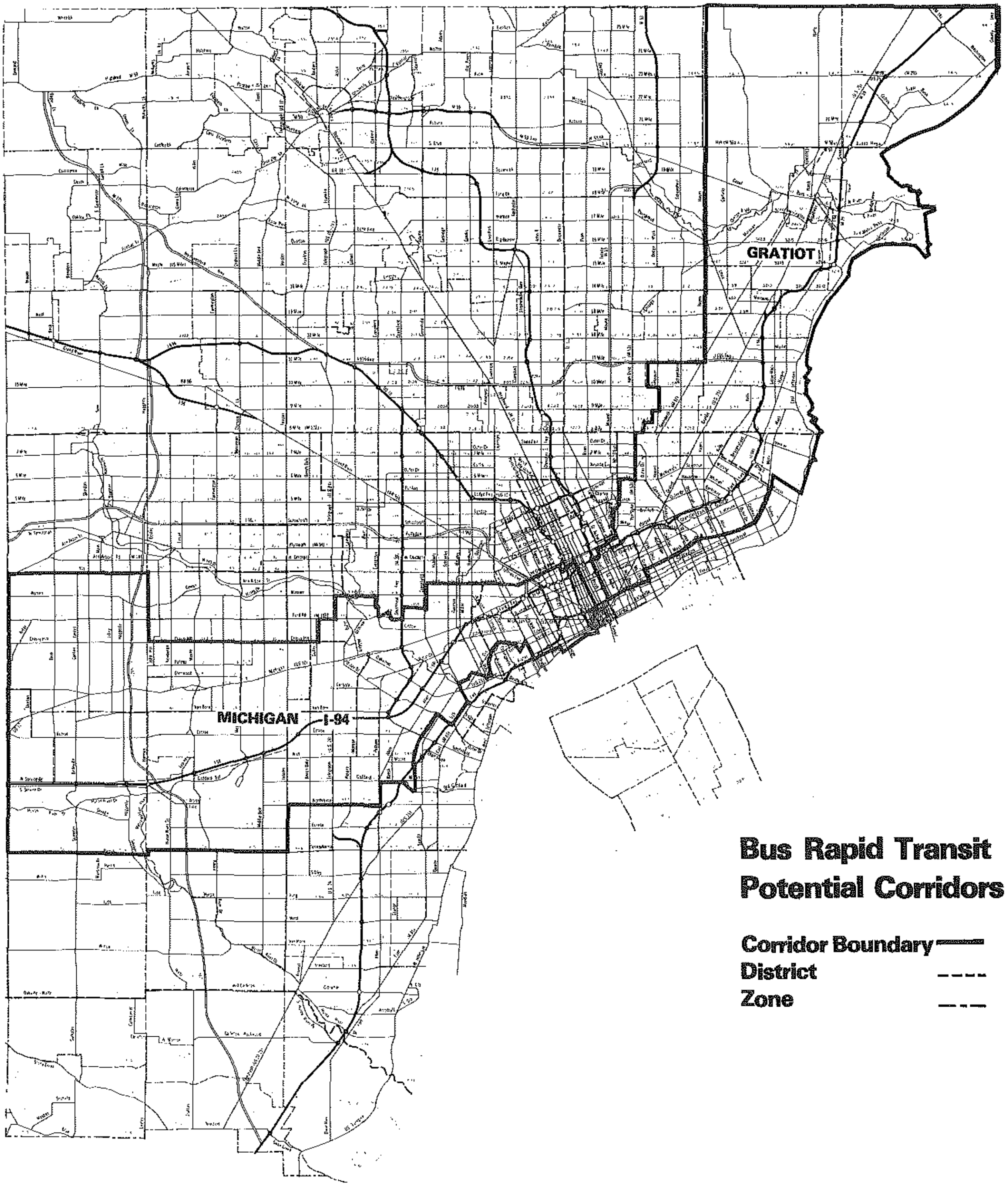


Figure 4-1 Gratiot and Michigan/I-94 Corridors

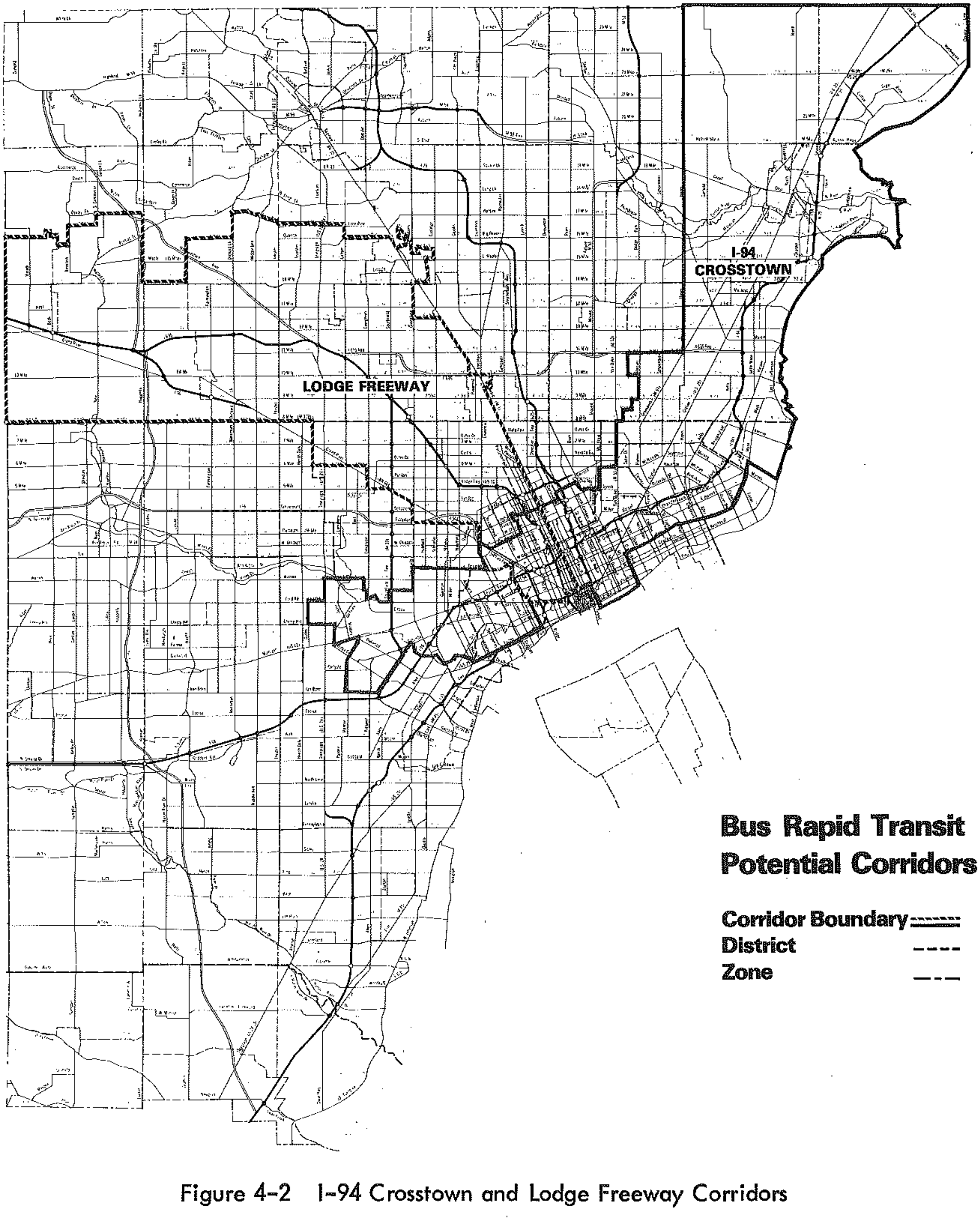


Figure 4-2 I-94 Crosstown and Lodge Freeway Corridors

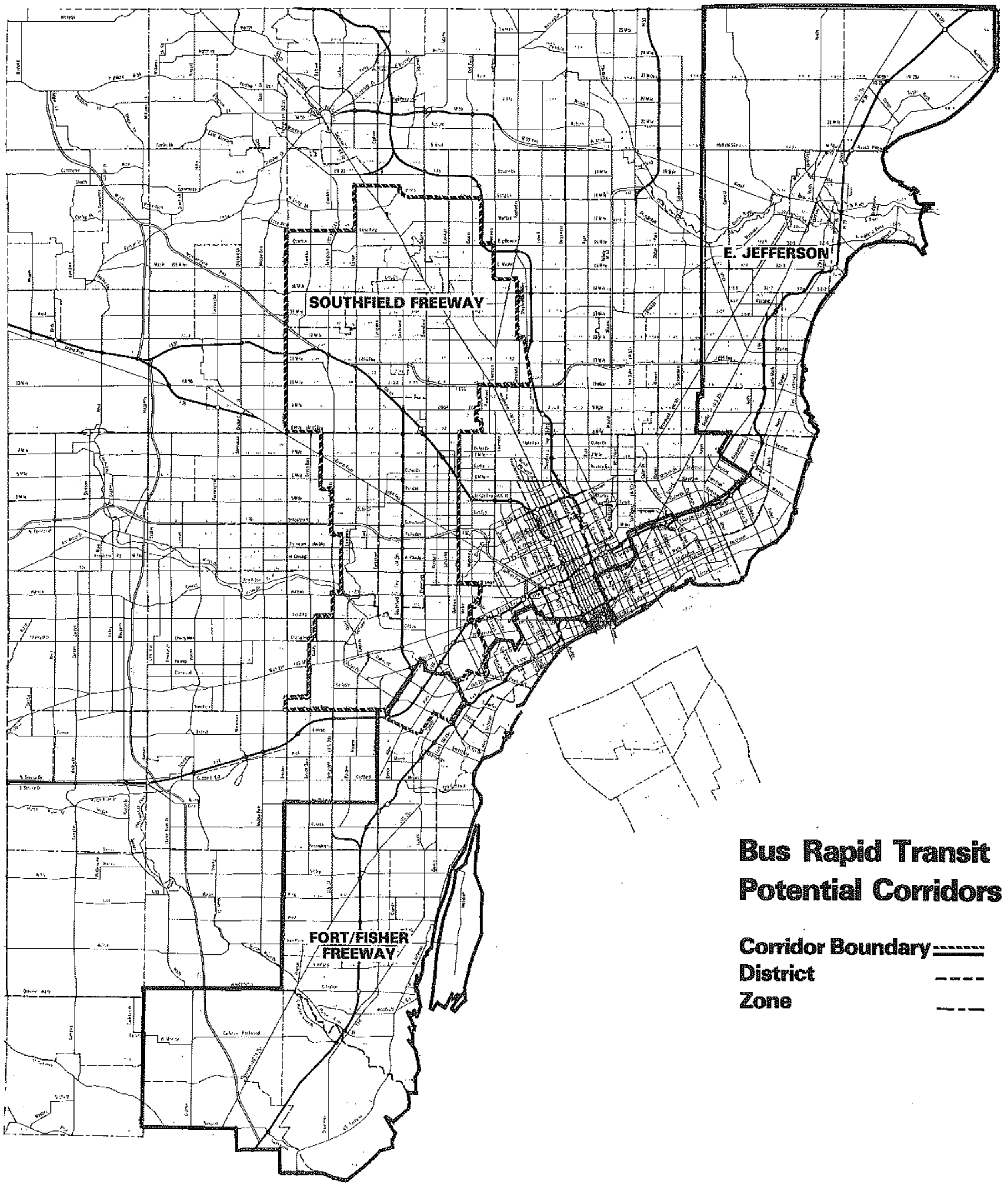


Figure 4-3 East Jefferson, Southfield Freeway, and Fort/Fisher Freeway

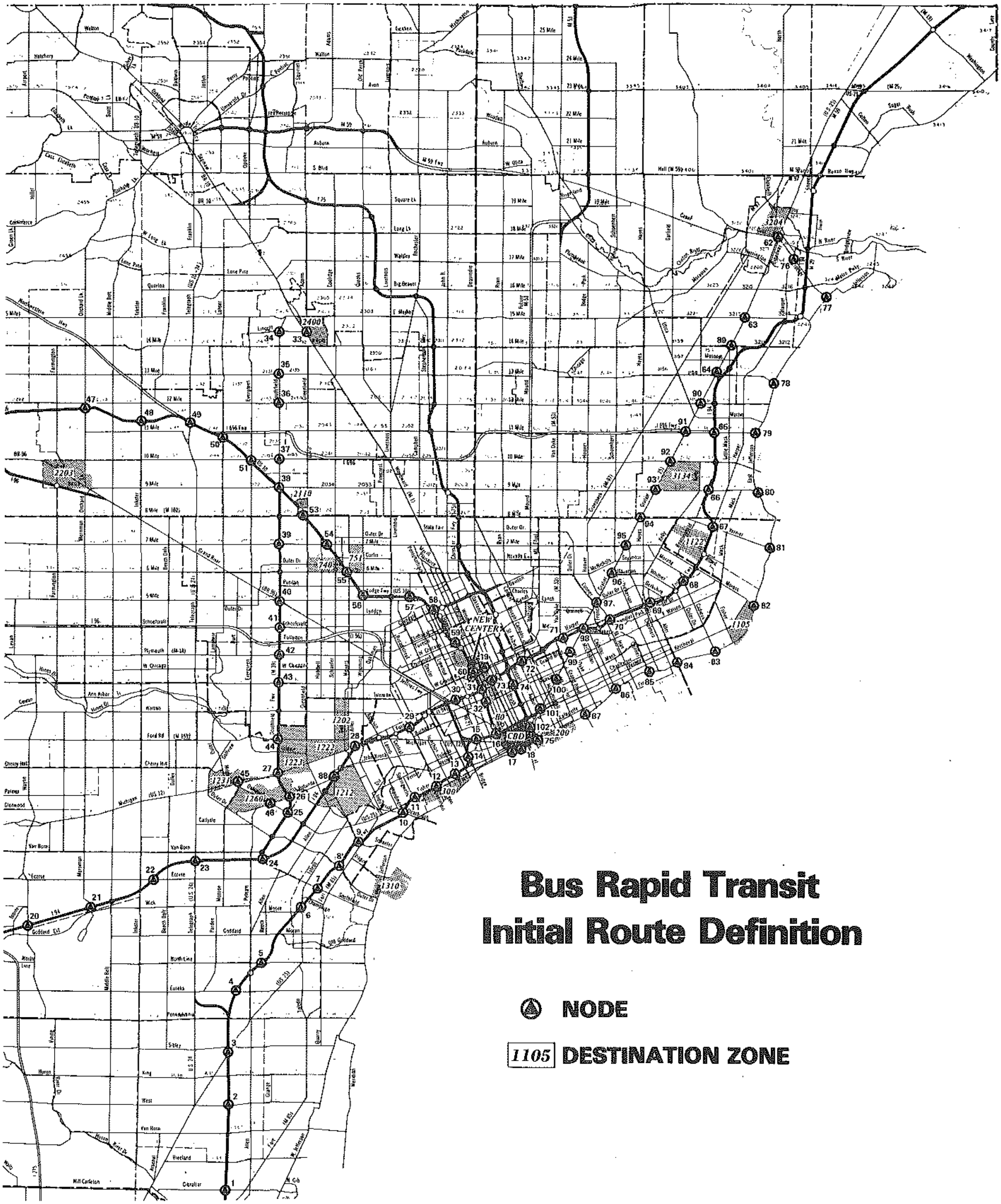


Figure 4-4 Top Attractor Zones and Route Definition Nodes

then produces two computer files--one containing the corridor trip matrix (keyed to "corridor-sequential" zone numbers), and another containing a translation table for converting between "corridor-sequential" and TALUS zone numbers.

4.1.4 1975 Corridor Trip Matrix

Next, an interim computer program was written for the purpose of creating a printout of each corridor's trip matrix, using the zone list and trip matrix files discussed above. This program also generates trip production and attraction totals for each zone. Finally, the program includes the capability to print a trip matrix and zone production/ attraction totals which have been adjusted to reflect population changes which have occurred between 1965 and 1975. Using SEMCOG data, a computer file containing 1965 and estimated 1975 population totals for each district in a study area was assembled. The number of trips in each origin/destination interchange was multiplied by the 1975-to-1965 population ratio of the district containing the origin zone being considered. While it is not claimed that this adjustment procedure accurately models all of the travel pattern changes which have occurred during the past ten years, it is felt that the method does provide a useful indication of internal trip activity for individual corridors. For the total adjusted travel demand in a corridor to be significantly misestimated, a change in the average number of intracorridor trips per corridor resident would be necessary (assuming that most morning, peak-period trips are home-based). Trips from locations outside the corridor to, for example, new trip attractors within the corridor, are not considered in the corridor analysis and need not be estimated.

4.1.5 Corridor Analysis Program

Travel patterns and volumes in each of seven candidate BRT corridors were analyzed through the application of a special-purpose computer program. The program performs two major functions:

- Compiles a list of corridor trips not satisfying the BRT screening criteria specified by the program user. (The corridor trip matrix, as previously discussed, is based upon the 1965 TALUS survey and pertains to trips taken by all modes.)
- Produces various summaries of corridor data and data pertaining to trips which do satisfy the BRT screening criteria.

The corridor analysis program considers the "directness" of each trip it examines. A trip's directness is evaluated by comparing its length as a BRT trip with the straight-line distance between its origin and destination. A BRT trip consists of three segments: access to the mainline route, mainline travel, and travel from the mainline route to the destination. Mainline access distance is measured from the centroid of the origin zone to the nearest node on the mainline route. A mainline egress distance is similarly defined for the trip's destination zone. The mainline travel distance is simply the distance along the mainline route between the trip's access and egress nodes. For each of the corridor's origin/destination pairs, the program multiplies the three BRT trip segment lengths by their associated weighting factors (user-specified numbers ranging from zero to ten) and sums these products to generate a weighted BRT trip length. If this result exceeds the trip's straight-line origin-to-destination distance, the trip is considered unsuitable for BRT. Through weighting factor adjustments, the relative importance of each trip segment may be established for trip screening purposes.

The trip screenings for seven candidate BRT corridors were performed with access, mainline, and egress weighting factors of 1.0, 0.0, and 1.0, respectively. Such a combination of weighting factors emphasizes travel to and from the mainline route and assesses no penalty for travel on the BRT mainline route itself. Trips were eliminated, then, if the extra travel necessary to use the BRT route would exceed the total trip distance directly from origin to destination. A non-zero weighting factor applied to mainline travel would result in the elimination of a greater number of trips, but it is felt that the previously discussed weighting factors are sufficient to produce meaningful results.

The corridor analysis program also screens trips on the basis of mainline travel distance. Any trips in which the mainline travel fails to exceed a particular minimum are considered unsuitable for BRT and are eliminated. This minimum distance is specified by the program user and may range from zero to ten miles. The screening results were found to be relatively insensitive to the value of this parameter (due to the linear nature of the corridors and the manner in which destinations were selected); therefore a minimum distance of 2.0 miles was used throughout the analysis.

The two-stage screening process described above is not intended to replace a modal analysis. Instead, it provides what is felt to be a meaningful indication of the number of trips in each corridor which have characteristics somewhat compatible with bus rapid transit service. These sets of trips serve as the bases for comparing one corridor with another and for evaluating features of individual corridors.

The corridor analysis program generates a variety of outputs to facilitate additional study of each corridor, including the following items:

- Corridor mainline node list
- Corridor mainline travel distance matrix
- Zone-to-node correlation list
- List of trips eliminated
- Trip production for each zone
- Trip attraction for each zone
- Entry/exit trip volumes for each node
- Origin zones and entry nodes for trips to each destination group
- Entry nodes for trips to each destination zone, district, and superdistrict
- Frequency distribution of mainline trip lengths
- Screened corridor trip matrix

The corridor mainline node list is shown in Table 4-3. This output is generated by merging the node number and description list for the corridor with the node coordinate list for the composite BRT study area. The result, as shown, is a node identification

Table 4-3 Corridor Definition Nodes

NODE NUMBER	X	Y	NODE DESCRIPTION
45	434.77	56.09	MICHIGAN & OAKWOOD
27	436.19	56.40	MICHIGAN & SOUTHFIELD
28	438.85	57.47	MICHIGAN & I-94
29	440.71	58.21	I-94 & LIVERNOIS
30	442.29	59.29	I-94 & LINWOOD
31	443.19	59.69	I-94 & LODGE FWY
73	443.55	60.04	I-94 & WOODWARD
72	444.52	60.76	I-94 & CHENE
71	445.98	61.69	I-94 & VAN DYKE
70	447.60	62.41	I-94 & CONNER
69	449.04	63.03	I-94 & ALTER
68	450.15	63.83	I-94 & CADIEUX
67	451.14	65.85	I-94 & VERNIER
66	450.98	67.16	I-94 & 9-MILE
65	451.08	69.23	I-94 & 11-MILE
64	451.07	71.40	I-94 & GRATIOT
63	451.98	73.45	GRATIOT & 15-MILE
62	453.10	76.42	GRATIOT & CROCKER
72	444.52	60.76	CBD SPUR START
74	444.32	59.88	I-75 & E. WARREN
75	445.27	57.97	I-375 & JEFFERSON
18	444.81	57.70	JEFFERSON & WOODWARD
73	443.55	60.04	CBD SPUR END

number, "X" and "Y" coordinates (both in miles), and description of each node in the corridor.

The next corridor analysis program output is the node-to-node travel distance matrix for the mainline BRT routes; a portion of this output is reproduced in Table 4-4. The number in a particular cell of the matrix represents the distance (in miles) between the nodes identifying the cell's row and column. Distances are computed as straight-line segments between successive pairs of nodes along the mainline route. When alternate routes exist between two nodes, the distance for the shortest route is indicated.

Table 4-5 illustrates another of the program's outputs--a listing of all traffic analysis zones in the corridor, the mainline node assigned to each zone, and the distance from the zone centroid to the node (in miles). All zones are identified according to the TALUS numbering system. The assignment of a node to a particular zone is accomplished by computing the straight-line distances between the zone centroid and all nodes and then selecting the node for which that distance is minimized. This node assignment, and the zone-to-node distance, are applicable for the zone as either a trip origin or destination.

Another segment of the program's output is shown in Table 4-6. This output consists of a description of each trip eliminated in the screening process, and an indication of its reason

Table 4-4 Corridor Travel Distance Matrix

NODE	45	27	28	29	30	31	73	72	71	70
45	0.00	1.45	4.32	6.32	8.24	9.22	9.72	10.93	12.66	14.44
27	1.45	0.00	2.87	4.87	6.78	7.77	8.27	9.48	11.21	12.98
28	4.32	2.87	0.00	2.00	3.92	4.90	5.40	6.61	8.34	10.11
29	6.32	4.87	2.00	0.00	1.91	2.90	3.40	4.61	6.34	8.11
30	8.24	6.78	3.92	1.91	0.00	0.99	1.49	2.70	4.43	6.20
31	9.22	7.77	4.90	2.90	0.99	0.00	0.50	1.71	3.44	5.21
73	9.72	8.27	5.40	3.40	1.49	0.50	0.00	1.21	2.94	4.71
72	10.93	9.48	6.61	4.61	2.70	1.71	1.21	0.00	1.73	3.50
71	12.66	11.21	8.34	6.34	4.43	3.44	2.94	1.73	0.00	1.77
70	14.44	12.98	10.11	8.11	6.20	5.21	4.71	3.50	1.77	0.00
69	16.00	14.55	11.68	9.68	7.77	6.78	6.28	5.07	3.34	1.57
68	17.37	15.92	13.05	11.05	9.13	8.15	7.65	6.44	4.71	2.94
67	19.62	18.17	15.30	13.30	11.38	10.40	9.90	8.69	6.96	5.19
66	20.94	19.49	16.62	14.62	12.70	11.72	11.22	10.01	8.28	6.51
65	23.01	21.56	18.69	16.69	14.78	13.79	13.29	12.08	10.35	8.58
64	25.18	23.73	20.86	18.86	16.95	15.96	15.46	14.25	12.52	10.75
63	27.43	25.97	23.11	21.10	19.19	18.20	17.70	16.49	14.76	12.99
62	30.60	29.15	26.28	24.28	22.36	21.38	20.88	19.67	17.94	16.16
72	10.93	9.48	6.61	4.61	2.70	1.71	1.21	0.00	1.73	3.50
74	11.83	10.38	7.51	5.51	3.60	2.61	2.11	0.90	2.63	4.41
75	12.91	11.46	8.59	6.59	4.68	3.65	3.19	3.04	4.77	6.54
76	12.38	10.93	8.06	6.06	4.14	3.16	2.66	3.57	5.30	7.07
73	9.72	8.27	5.40	3.40	1.49	0.50	0.00	1.21	2.94	4.71

(or reasons) for rejection. The first two columns identify each trip as an origin/destination zone pair. The next three columns report the BRT mainline access, mainline egress, and mainline travel distances for the trip. An asterisk printed adjacent to a mainline travel distance identifies a trip with less than the specified minimum distance traveled on the mainline route. The next column contains the straight-line origin-to-destination distance for each trip; an asterisk next to one of these entries denotes a trip with a weighted BRT distance exceeding the straight-line distance. Finally, the number of peak-period person-trips associated with the origin/destination zone pair is shown in the rightmost column.

A listing of the total trip production for each origin zone constitutes the next corridor analysis program output, shown in Table 4-7. The first column identifies origin traffic analysis zones by their TALUS designations. The second column indicates the number of peak-period person-trips originating in each zone and terminating in any of the corridor's destination zones--prior to the trip screening phase of the program. The next column presents the trip production total for each zone after screening, while the fourth column reports the percentage by which entries in the third column differ from those in the second (i.e., the percentage of each zone's trip production eliminated by the screening process). Zones with no initial trip production, and those losing 80 percent or more of their trips during the screening process, are marked with a double asterisk.

In a format similar to that discussed above, the program also generates trip attraction totals, as illustrated in Table 4-8. These totals represented the number of peak-period person-trips (again, before and after screening) which originate anywhere in the corridor

Table 4-5 Corridor Access-Egress Distances

ZONE	NODE	DISTANCE
10	18	0.10
11	18	0.09
12	18	0.23
13	18	0.21
14	18	0.42
20	18	0.36
21	18	0.15
22	18	0.35
23	18	0.14
30	75	0.25
31	75	0.19
32	75	0.40
40	18	0.68
41	18	0.48
42	18	0.29
43	18	0.50
44	18	0.35
50	18	0.37
51	18	0.53
52	18	0.65
60	18	0.63
61	18	0.88
62	18	0.74
63	18	0.57
64	18	0.50
65	18	0.67
66	18	0.83
70	75	0.62
71	18	0.79
72	75	0.79
110	18	1.15
111	18	1.11
112	31	1.04
113	31	0.91
114	31	0.64
120	30	1.06
121	30	1.29
122	18	1.52
123	18	1.22
124	30	0.82
125	30	1.18
126	31	0.79
127	31	0.93
130	31	0.18
131	31	0.26
132	73	0.37
133	73	0.28
140	30	0.78
141	30	0.57

Table 4-6 Trips Not Meeting Bus Rapid Transit Criteria

		A=1.00	B=1.00	C=0.00	TMIN=2.0	
ORIG ZONE	DEST ZONE	ACCESS DISTANCE	EGRESS DISTANCE	CORRIDOR DISTANCE	STRAIGHT DISTANCE	PERSON TRIPS
110	12	1.15	0.23	0.00 *	1.14 *	35
110	13	1.15	0.21	0.00 *	1.00 *	34
110	23	1.15	0.14	0.00 *	1.03 *	32
110	31	1.15	0.19	0.53 *	1.75 *	41
111	13	1.11	0.21	0.00 *	0.93 *	41
111	14	1.11	0.42	0.00 *	0.82 *	41
111	22	1.11	0.35	0.00 *	0.97 *	41
111	63	1.11	0.57	0.00 *	0.57 *	32
112	44	1.04	0.35	3.16	1.19 *	65
112	64	1.04	0.50	3.16	1.06 *	60
112	500	1.04	0.59	0.00 *	1.63 *	27
112	600	1.04	0.99	0.50 *	2.26	33
113	40	0.91	0.68	3.16	1.34 *	32
113	66	0.91	0.83	3.16	0.85 *	41
114	132	0.64	0.37	0.50 *	0.52 *	49
114	600	0.64	0.99	0.50 *	1.87	41
120	132	1.06	0.37	1.49 *	1.91	67
120	521	1.06	1.21	0.99 *	2.47	32
122	13	1.52	0.21	0.00 *	1.44 *	34
122	41	1.52	0.48	0.00 *	1.04 *	30
122	42	1.52	0.29	0.00 *	1.23 *	27
122	63	1.52	0.57	0.00 *	1.03 *	27
122	65	1.52	0.67	0.00 *	1.02 *	27
123	23	1.22	0.14	0.00 *	1.09 *	27
123	41	1.22	0.48	0.00 *	0.77 *	27
123	72	1.22	0.79	0.53 *	1.14 *	32
124	521	0.82	1.21	0.99 *	2.15	32
130	132	0.18	0.37	0.50 *	0.50 *	111
131	132	0.26	0.37	0.50 *	0.22 *	26
132	132	0.37	0.37	0.00 *	0.00 *	121
133	501	0.28	0.82	0.00 *	0.66 *	53
141	521	0.57	1.21	0.99 *	1.90	26
142	133	0.35	0.28	1.49 *	1.34	24
146	132	0.29	0.37	1.49 *	1.41	31
146	500	0.29	0.59	0.99 *	1.01	31
146	521	0.29	1.21	0.99 *	1.19 *	31
146	600	0.29	0.99	1.49 *	1.87	26
147	132	0.63	0.37	1.49 *	1.02	26
200	23	0.67	0.14	0.53 *	1.32	94
200	32	0.67	0.40	0.00 *	0.94 *	94
200	50	0.67	0.37	0.53 *	1.24	105
200	52	0.67	0.65	0.53 *	1.32 *	56
201	14	1.70	0.42	0.53 *	2.04 *	47
202	13	1.83	0.21	0.53 *	2.24	45
202	14	1.83	0.42	0.53 *	2.08 *	37
202	21	1.83	0.15	0.53 *	2.49	37
202	42	1.83	0.29	0.53 *	2.48	37
202	50	1.83	0.37	0.53 *	2.24	45
203	23	0.37	0.14	0.53 *	0.98	94

Table 4-7 Trip Production

TALUS ZONE	INITIAL	FINAL	PCT ELIM.	
110	142	0	100.0	**
111	196	41	79.1	
112	185	0	100.0	**
113	146	73	50.0	
114	212	122	42.5	
120	320	221	30.9	
121	59	59	0.0	
122	145	0	100.0	**
123	86	0	100.0	**
124	32	0	100.0	**
125	0	0	0.0	**
126	32	32	0.0	
127	114	114	0.0	
130	185	74	60.0	
131	53	27	49.1	
132	234	113	51.7	
133	107	54	49.5	
140	116	116	0.0	
141	57	31	45.6	
142	53	29	45.3	
143	52	52	0.0	
144	142	142	0.0	
145	26	26	0.0	
146	258	139	46.1	
147	83	57	31.3	
200	396	47	88.1	**
201	132	85	35.6	
202	201	0	100.0	**
203	376	0	100.0	**
204	56	0	100.0	**
205	371	91	75.5	
206	302	74	75.5	
207	0	0	0.0	**
208	0	0	0.0	**
210	146	0	100.0	**
211	150	101	32.7	
212	80	54	32.5	
213	26	26	0.0	
220	65	28	56.9	
221	94	94	0.0	
222	0	0	0.0	**
223	56	56	0.0	
224	99	99	0.0	
225	172	172	0.0	
226	220	118	46.4	
227	90	90	0.0	
228	62	62	0.0	

Table 4-8 Trip Attraction

TALUS ZONE	INITIAL	FINAL	PCT ELIM.
10	956	911	4.7
11	1546	1499	3.0
12	1088	1006	7.5
13	1110	900	18.9
14	349	168	51.9
20	0	0	0.0 **
21	887	850	4.2
22	495	454	8.3
23	3498	3251	7.1
30	101	101	0.0
31	102	61	40.2
32	1779	1536	13.7
40	167	88	47.3
41	1206	1102	8.6
42	1869	1758	5.9
43	555	555	0.0
44	848	783	7.7
50	4372	4013	8.2
51	435	388	10.8
52	427	371	13.1
60	48	48	0.0
61	0	0	0.0 **
62	562	536	4.6
63	837	731	12.7
64	1264	1157	8.5
65	1108	974	12.1
66	757	716	5.4
70	168	131	22.0
71	343	259	24.5
72	32	0	100.0 **
132	3212	2349	26.9
133	1356	1158	14.2
500	3021	2210	26.8
501	1934	1486	23.2
521	1606	808	49.7
600	1343	648	51.7
1212	1986	1295	34.8
1222	3216	722	77.5
1223	1172	175	85.1 **
1260	2570	771	70.0
TOTAL	48366	36009	25.5

and terminate in each destination zone. Zones with no initial trip attraction, and those with 80 percent or more of their trip attraction eliminated by screening, are denoted by a double asterisk.

A summary of mainline node trip volumes constitutes the next program output. As shown in Table 4-9, the listing of each node is accompanied by a total number of person-trips entering the mainline route at that point, and by the number of person-trips leaving at the same point. The entry volume for a node consists of the sum of the trip production (after screening) of all origin zones to which the node is assigned. Similarly, a node's exit volume is the sum of the trip attraction of all destination zones to which the node is assigned.

The next series of program outputs aid in the recognition of patterns in the generation of trips to specific destination zone groups. An example of such information for trips to the Detroit CBD is shown in Table 4-10. First, a mainline entry node is identified by number and description. Then, the total number of trips to all CBD zones is indicated for each origin zone to which the node is assigned. Finally, the total number of CBD-bound trips entering the mainline route at that node is presented. Similar information is produced for each major destination served by a particular corridor, such as the New Center area, the Ford Complex, and the Northland area.

Another output of the corridor analysis program, partially reproduced in Table 4-11, indicates the number of person-trips going to every destination zone,categorized by mainline entry node. Totals are also displayed for districts and superdistricts--again,separately for each entry node. The totals for districts and superdistricts do not necessarily correspond with the totals which might result if all the zones in those areas were designated as corridor destinations, since the program considers only trips terminating in zones specifically identified as destinations.

As shown in Table 4-12, the program also compiles a trip frequency distribution of mainline route mileage. The first output column lists the mileage intervals for which person-trip totals are accumulated. The designation of "2," for example, identifies the one-mile interval from 1.5 miles to (but not including) 2.5 miles. The second column indicates the number of person-trips having a mainline travel distance within each of the mileage intervals. The third and fourth columns indicate the number of person-trips with mainline mileages below and above each interval, respectively. Finally, a single total representing the number of person-trip miles traveled on the mainline route is produced. This total is obtained by summing the products of mainline mileage and number of person-trips for all origin/destination zone pairs in the corridor.

The last program output is the screened corridor trip matrix (one page of which is presented as Table 4-13). This output is optional and may be suppressed by the program user, if desired. The screened trip matrix simply indicates the number of peak-period person-trips (by all travel modes) for each of the corridor's origin/destination zone pairs, after trips not meeting the user-specified screening criteria have been eliminated. TALUS destination zones are identified at the tops of the trip matrix columns; an origin zone number appears to the left of each row. Trip matrix rows without at least one non-zero entry are not printed. Therefore, the trip matrix printout does not necessarily show all possible interchanges between the corridor's specified origin and destination zones.

Table 4-9 Corridor Node Trip Loadings

NODE	ENTERING	LEAVING
45	1874	771
27	255	175
28	2582	2017
29	3695	0
30	1954	0
31	713	3018
73	1371	5681
72	944	0
71	2437	0
70	2770	0
69	4191	0
68	3412	0
67	2597	0
66	2049	0
65	1578	0
64	675	0
63	986	0
62	627	0
72	0	0
74	961	0
75	297	1829
18	41	22518
73	0	0

Table 4-10 Source Distribution of Trips to the Detroit CBD

NODE	NODE DESCRIPTION	ZONE	TRIPS
64	I-94 & GRATIOT	3120	28
		3121	56
		3122	28
		3147	58
		3150	37
		3153	37
		3154	37
		3158	47
		3159	94
		TOTAL	422
63	GRATIOT & 15-MILE	3123	166
		3213	70
		3215	70
		3221	59
		3241	55
		TOTAL	420
62	GRATIOT & CROCKER	3203	33
		3205	43
		3242	110
		3244	65
		3403	93
		3413	70
		TOTAL	414
74	I-75 & E. WARREN	211	52
		213	26
		220	28
		221	61
		223	28
		224	66
		225	172
		226	62
		231	46
		241	83
		TOTAL	624

Table 4-11 Destination Split of Trips Entering Corridor

DESTINATION / MODE=	45	27	28	29	30	31	73	72
ZONE 10	0	121	0	184	56	0	33	42
ZONE 11	28	0	143	151	80	23	56	152
ZONE 12	28	0	24	135	33	30	0	26
ZONE 13	28	0	26	44	25	27	58	84
ZONE 14	0	0	24	0	25	0	0	42
DISTR 1	84	121	217	514	219	80	147	346
ZONE 21	28	0	26	107	30	0	96	0
ZONE 22	0	0	50	52	27	27	28	0
ZONE 23	0	0	204	289	53	41	137	58
DISTR 2	28	0	280	448	110	68	261	58
ZONE 30	0	0	0	26	0	0	0	28
ZONE 31	34	0	0	0	0	0	0	0
ZONE 32	56	0	35	333	254	122	82	31
DISTR 3	90	0	35	359	254	122	82	59
ZONE 40	28	0	0	0	0	0	33	0
ZONE 41	112	0	29	51	93	25	85	0
ZONE 42	168	0	126	130	83	0	138	23
ZONE 43	28	0	51	54	0	0	53	48
ZONE 44	0	0	122	0	47	23	107	82
DISTR 4	336	0	328	235	223	48	416	153
ZONE 50	206	0	198	703	594	182	116	84
ZONE 51	0	0	0	0	26	0	0	0
ZONE 52	0	0	0	22	55	43	27	0
DISTR 5	206	0	198	725	675	225	143	84
ZONE 60	0	0	24	0	0	0	0	0
ZONE 62	0	0	0	101	0	0	0	0
ZONE 63	28	0	30	57	0	50	0	23
ZONE 64	0	0	136	52	166	0	85	23
ZONE 65	62	0	148	25	0	0	0	27
ZONE 66	0	0	0	53	79	0	78	23
DISTR 6	90	0	338	288	245	50	163	96
ZONE 71	0	0	35	26	0	0	42	25
DISTR 7	0	0	35	26	0	0	42	25
SDISTR 0	834	121	1431	2595	1726	593	1254	861
ZONE 132	68	0	94	180	0	0	0	0

Table 4-12 Frequency Distribution of Corridor Trip Lengths

CORRIDOR MILEAGE	NUMBER OF PEAK-PERIOD PERSON-TRIPS WITHIN INTERVAL	BELOW INTERVAL	ABOVE INTERVAL
0	0	0	36009
1	0	0	36009
2	464	0	35545
3	4101	464	31444
4	3818	4565	27626
5	3411	8383	24215
6	3192	11794	21023
7	2770	14986	18253
8	2951	17756	15302
9	3104	20707	12198
10	2966	23811	9232
11	580	26777	8652
12	3098	27357	5554
13	516	30455	5038
14	1370	30971	3668
15	258	32341	3410
16	1118	32599	2292
17	89	33717	2203
18	949	33806	1254
19	55	34755	1199
20	472	34810	727
21	285	35282	442
22	0	35567	442
23	414	35567	28
24	0	35981	28
25	0	35981	28
26	0	35981	28
27	28	35981	0

TOTAL NUMBER OF PERSON-TRIP-CORRIDOR-MILES.... 301505

Table 4-13 Screened Peak-Period Person-Trips

A=1.00 B=1.00 C=0.00 TMIN=2.00

ORIG	DEST= 10	11	12	13	14	20	21	22	23	30
114	0	0	0	0	0	0	0	0	41	0
120	27	27	0	0	0	0	0	27	27	0
127	0	0	0	0	0	0	0	27	0	0
130	0	23	0	0	0	0	0	0	0	0
131	0	0	0	27	0	0	0	0	0	0
132	0	0	0	27	0	0	0	0	27	0
133	0	0	0	0	0	0	0	0	27	0
142	29	0	0	0	0	0	0	0	0	0
146	0	0	0	0	0	0	0	0	26	0
211	26	26	0	0	0	0	0	0	0	0
224	0	0	33	0	0	0	0	0	0	0
225	0	0	0	0	0	0	36	0	0	0
226	0	34	0	0	0	0	0	28	0	0
227	0	28	0	0	0	0	0	0	28	0
230	0	0	0	0	0	0	0	28	56	0
233	0	0	0	31	0	0	0	0	0	0
241	0	0	0	26	0	0	0	0	0	0
243	0	0	26	0	0	0	0	0	0	0
244	0	28	0	0	0	0	0	0	28	28
245	0	28	0	0	0	0	0	0	0	0
246	0	28	0	0	0	0	0	0	0	0
247	0	0	33	61	0	0	0	28	0	0
310	30	0	60	0	0	0	0	0	28	0
311	0	28	0	0	0	0	0	26	0	0
312	0	0	0	0	0	0	51	26	0	26
313	0	0	26	0	0	0	0	0	26	0
314	26	26	0	0	0	0	0	0	131	0
330	0	24	0	0	0	0	0	0	24	0
332	0	0	0	0	24	0	0	24	24	0
333	62	0	0	0	0	0	0	0	26	0
341	0	0	0	0	0	0	29	0	29	0
342	0	35	0	0	0	0	0	0	29	0
350	22	0	22	0	0	0	27	0	0	0
351	0	0	0	22	0	0	0	0	0	0
352	22	0	0	0	0	0	0	0	0	0
353	0	24	0	0	0	0	0	0	0	0
354	0	0	24	0	0	0	0	0	0	0
355	22	24	0	22	0	0	0	0	0	0
420	0	0	0	0	0	0	21	0	0	21
422	0	0	0	25	0	0	0	0	0	0
423	0	21	0	0	0	0	0	0	21	0
424	21	25	0	0	0	0	0	0	0	0
425	0	0	27	0	0	0	0	0	0	0
432	0	0	0	0	0	0	0	0	26	0
433	0	0	30	0	0	0	0	0	30	0
434	31	0	0	0	0	0	0	0	30	0
501	0	0	0	0	0	0	41	0	0	0

4.2 Traffic Congestion

In order to quantify traffic congestion, peak-hour volume to capacity ratios and travel speeds were obtained for each potential BRT route. The volume to capacity ratios were tabulated from the 1970 Highway Assignment Network Data File created by SEMCOG in 1972. The data were tabulated for each highway link. The links vary in length from a few yards to several miles. Since the volume to capacity ratio varies from one link to another along each BRT route, it was necessary to devise a single measure to characterize the extent to which the highway operates above capacity for comparison purposes. The measure which was chosen is termed the congested distance and is defined as follows:

$$CD = \sum_{i=1}^{n} (V/C)_i \, L_i \qquad \text{where } (V/C) \geq 1.0$$

where $(V/C)_i$ = Volume to capacity ratio of the i^{th} link

L_i = Length in miles of the i^{th} link

n = Number of links which operate at or above capacity in the peak period

A more accurate measure of congestion would be some combination of the volume and operating speed of each link. However, the average peak-hour speed was not generally available for each link but was estimated only for the entire route. Therefore, the overall average operating speed in the peak hour was considered as an independent measure of traffic congestion. At least two timed automobile runs were made on each potential BRT route during the morning peak hour--7:30 to 8:30 a.m.--to give a first-order estimate of travel time. This peak-hour speed information is limited in that it is supported by only two observations on most routes, and it was obtained during a period of unusually high unemployment in the Detroit area.

Table 4-14 lists the calculated values of the congested distance parameter and the average of the observed peak-hour speeds for the potential BRT routes. Table 4-14 also shows that the limited speed run data that were available from the Detroit Department of Transportation agree relatively well with the observed speeds.

4.3 Existing Transit

Two types of data were compiled to describe existing transit service in each corridor. First, peak-period ridership along the corridor was determined. The ridership numbers represent the number of passengers entering the Detroit CBD on the main BRT route plus adjacent streets in the corridor between the hours of 7:00 a.m. and 10:00 a.m. Both Detroit DOT and out-of-town buses (SEMTA) were considered. The source of the ridership data is the 1974 Cordon Count of the Detroit Central Business District prepared by the Traffic Research Division of the Detroit Department of Transportation (DOT). Current transit ridership totals for the I-94 Crosstown and the Gratiot Corridors were assumed to be identical since both corridors serve the same origin zones. Ridership information for the Southfield

Table 4-14 Measures of Congestion

Corridor/Route	Congested Distance Parameter	Observed Peak-Hour Speeds	Detroit DOT Speed Data
Gratiot	18.70	25	25 7:00 a.m. 23 7:30 a.m. 25 8:00 a.m. 35 8:30 a.m. 35 9:00 a.m. 28.6 Average
E. Jefferson	7.45	30.9	
I-94 Crosstown	17.50	48.3	
Lodge Freeway	9.18	40.6	42 7:15 a.m. 23.3 7:30 a.m. 20 7:30 a.m. 49 8:00 a.m. 33.6 Average
Southfield	18.62	36.6	
I-94 West	9.30	47.5	
Fisher Freeway	0.0	53.8	

Corridor was not available, but it was estimated based on Detroit DOT passenger counts for routes similar to the Southfield and Greenfield lines.

In addition to existing transit ridership, the number of existing routes which cross the main BRT route in each corridor was determined. This number gives a relative measure of total transit service and transit orientation in each corridor. In addition, it gives a relative measure of flexibility in choosing locations for intermediate stops which interface with existing feeder service.

Table 4-15 summarizes corridor transit ridership information and the number of transit routes crossing the BRT route for each of the seven corridors.

Table 4-15 Existing Transit Ridership and Routes

Corridor/Route	Existing Peak-Period Ridership	No. of Routes Crossing BRT Route	
		DOT	SEMTA
Gratiot	4525	18	4
E. Jefferson	5891	7	4
I-94 Crosstown	4525	27	3
Lodge	9703	21	4
Southfield	700	15	3
Michigan/I-94	1459	14	0
Fisher Freeway	3030	14	0

4.4 BRT Travel Time Estimates

Preliminary estimates of BRT travel time were made for each corridor and were compared with estimated automobile travel times. The assumptions that were made to estimate BRT travel time are summarized in this section.

The trip for which the travel time is estimated is similar for each corridor. In each case the trip starts at the outer extremity of the corridor and ends in the major activity center served by the corridor (CBD in all cases except Southfield which serves the Ford complex in Dearborn). One intermediate production stop and one intermediate attraction stop is assumed for each corridor trip. The total distance traveled by the bus includes the distance along the principal BRT route, distance on arterials for intermediate stops, and distance within the major activity center for distribution. Operating speeds under line-haul conditions on the principal BRT routes are assumed to be the same as were observed for automobiles on that route. The operating speed on arterials to and from intermediate stop locations is estimated to be 25 mph. CBD distribution speed is estimated to be 12 mph exclusive of passenger stops, and distribution speed in the Ford area is estimated to be 18 mph, also exclusive of stops.

Boarding and deboarding time is assumed to be 3 seconds per passenger. The trip time for the average passenger who rides from one extremity of the corridor to the other is assumed to include time for all passengers to board and time for one-half of the passengers to deboard. It is further assumed that 42 passengers--80 percent of the seating capacity of a 53 passenger coach--board at the origin or outer extremity of the corridor, 11 passengers--20 percent of the seating capacity--deboard at the intermediate attraction stop, and 5 passengers--10 percent of the seating capacity--board the bus at the intermediate production stop. In summary, it is assumed that the trip time for the average passenger includes time for 47 passengers to board and 23 passengers to deboard the bus. This totals 3.5 minutes for boarding and deboarding associated with the average passenger.

Waiting time is usually taken as one-half the average headway time. Headways are a function of demand which varies from corridor to corridor. However, the outer extremity of each corridor was rather arbitrarily selected on the basis of corridor length rather than demand. The potential demand for BRT at the extremity of each corridor is low, so headways are long--on the order of 30-40 minutes. Therefore, it is assumed that passengers know the schedules and arrive about five minutes early for the bus. An average waiting time of 5 minutes is assumed for all of the corridors.

The BRT implementation scheme on the freeways is assumed to be queue jumpers in conjunction with ramp metering. The presence of metering devices at freeway entrance ramps will cause some delay to motorists in gaining access to the freeway. It is reasonable to expect the average delay to be proportional to the demand for use of the freeway. The following relationship is assumed for estimating the average time a motorist spends waiting in an entrance queue at a metered ramp.

$$t_q = 1.0 + 2.0\,((V/C)_w - 1.0)$$

where t_q = Average queue time in minutes

$(V/C)_w$ = Weighted average volume to capacity ratio $\sum L(V/C)\,/\sum L$

(V/C) = Volume to capacity ratio in excess of one

L = Length of highway link corresponding to (V/C)

The estimated queue times range from 1.0 minute for the Fisher Freeway to 1.8 minutes for the Ford Freeway west of the CBD. The Traffic and Safety Division of the Michigan Department of State Highways and Transportation simulated ramp metering on six ramps of the Ford Freeway on the near east side of Detroit in connection with their proposal in 1971 to implement ramp metering. The simulation predicted an average queue time of about 1.0 minute during peak periods.

Another source of delay for motorists is the time required to park near their destination. It is assumed that 4.0 minutes is required for a motorist to park his car in the CBD. Because parking garages and lots in the CBD are relatively small and have few access points, it is assumed that queues develop around CBD parking facilities. No parking time penalty is assumed for the Ford complex because parking lots in this area are larger and probably have better access than CBD parking facilities. Walk time is assumed to be the same for both automobile and bus trips.

Table 4-16 shows estimated BRT and automobile trip times for the seven corridors.

Table 4-16 Estimated Travel Times

Corridor	Distance (miles)	BRT (min)	Auto (min)	Ratio
Gratiot	20.6	74.3	54.6	1.36
Jefferson	24.9	67.2	54.4	1.23
Crosstown	23.5	61.6	43.0	1.43
Lodge	21.8	49.9	39.2	1.27
Southfield	18.9	72.4	41.4	1.75
Michigan/I-94	23.1	57.0	37.1	1.54
Fisher	22.0	59.3	31.2	1.90

4.5 Potential Implementation Schemes

In order to consider potential BRT treatments on the various routes, traffic volume data and highway characteristics were surveyed. The 1970 Highway Assignment Network Data File was used as a source in tabulating pavement width, number of lanes in the peak direction, and average off-peak speed for each route. These data are presented for each potential BRT route in Tables 4-17 to 4-23. The highway links were aggregated into longer sections of relatively homogeneous roadway to simplify presentation of the data. The data show that all of the Detroit area freeways involved in this study have three 12-foot lanes in the peak direction with the exception of the Fisher Freeway which has four 12-foot lanes from Schaefer to the CBD. The arterials which are under consideration vary in width, but most of them have four lanes in the peak direction near the CBD. Parking is restricted on all of them, at least during the peak hours.

Vehicle volume by direction on nearly all of the potential routes for the morning and evening rush hours (7:00 a.m. to 8:00 a.m. and 4:00 p.m. to 5:00 p.m., respectively) were obtained from the Department of Streets and Traffic of the City of Detroit. These volumes are shown in Figure 4-5 to 4-11 for Gratiot, Ford Freeway, Lodge Freeway, Southfield Freeway, and Fisher Freeway, respectively. The data show that only Gratiot Avenue and the Fisher Freeway are unbalanced during both the morning and evening peak hours. The limited amount of data which is available for East Jefferson Avenue indicates that traffic is also unbalanced on this arterial except in the CBD.

In the remainder of this section, a general description of the alternative implementation schemes for each of the seven candidate corridors is given. These alternatives will be considered in more detail for four corridors in the Sketch Planning task.

Table 4-17 Gratiot Avenue

Cross Street	V/C Ratio		Pavement Width (ft)			No. Lanes Peak Dir.			Off-Peak Speed (mph)
	Max	Min	Max	Min	Typical	Max	Min	Typical	
Cass									
	2.55	1.22	96	72	80	3	2	2	30-41
14 Mile									
	1.32	1.01	96	84	96	4	4	4	30
13 Mile									
	2.13	1.38	96	80	80	4	4	4	30
8 Mile									
	1.12	.96	82	82	82	4	4	4	25-30
Harper									
	.96	.57	82	80	80	4	4	4	34-11
Randolph									

Average Speed During Morning Peak Hour: 25 mph

Table 4-18 Jefferson Avenue

Cross Street	V/C Ratio		Pavement Width (ft)			No. Lanes Peak Dir.			Off-Peak Speed (mph)
	Max	Min	Max	Min	Typical	Max	Min	Typical	
Crocker	1.55	.39	44	22	44	2	1	2	33-40
9 Mile	1.72	.53	74	40	54	3	1	2	
Alter	1.18	.53	80	75	80	4	4	4	
Chene	2.30	.85	80	80	80	4	4	4	30
Chrysler Freeway	.80	.56	96	80	96	4	4	4	20
Woodward									

Average Speed During Morning Peak Hour: 30.9 mph

Table 4-19 I-94/Crosstown

Cross Street	V/C Ratio		Pavement Width (ft)			No. Lanes Peak Dir.			Off-Peak Speed (mph)
	Max	Min	Max	Min	Typical	Max	Min	Typical	
N. River Rd.	.55	.37	72	72	72	3	3	3	57
13 Mile	1.25	.91	72	72	72	3	3	3	50-55
Moross	1.11	.62	72	72	72	3	3	3	33-50
Cadillac	1.44	.91	72	72	72	3	3	3	31-36
Grand River	1.33	.58	72	72	72	3	3	3	20-57
Greenfield									

Average Speed During Morning Peak Hour: 48.3 mph

Table 4-20 I-696/Lodge Freeway

Cross Street	V/C Ratio		Pavement Width (ft)			No. Lanes Peak Dir.			Off-Peak Speed (mph)
	Max	Min	Max	Min	Typical	Max	Min	Typical	
Inkster									
	1.73	.43	96	72	72	3	2	3	56-65
8 Mile									
	.79	.70	72	72	72	3	3	3	26-45
Puritan									
	1.41	.67	72	72	72	3	3	3	13-45
Davison Freeway									
	1.63	.67	96	72	72	4	3	3	30
I-94 Fwy									
	1.15	.39	72	72	72	3	3	3	46-50
Griswold									

Average Speed During Morning Peak Hour: 36.6 mph

Table 4-21 Southfield Freeway

Cross Street	V/C Ratio		Pavement Width (ft)			No. Lanes Peak Dir.			Off-Peak Speed (mph)
	Max	Min	Max	Min	Typical	Max	Min	Typical	
14 Mile									
	2.61	1.04	48	48	48	2	2	2	
9 Mile									
	.76	.65	72	72	72	3	3	3	48
8 Mile									
	1.15	1.11	72	72	72	3	3	3	35
7 Mile									
	1.43	1.19	72	72	72	3	3	3	35-52
Ford Road									
	.98	.96	72	72	72	3	3	3	52-56
Rotunda									
	.63	.61	72	72	72	3	3	3	56
I-94 Fwy									

Average Speed During Morning Peak Hour: 36.6 mph

Table 4-22 I-94 Freeway

Cross Street	V/C Ratio		Pavement Width (ft)			No. Lanes Peak Dir.			Off-Peak Speed (mph)
	Max	Min	Max	Min	Typical	Max	Min	Typical	
Wayne									
	1.52	.49	72	48	72	3	2	3	55-62
Greenfield									
	1.26	.71	72	72	72	3	3	3	57
Wyoming									
	1.44	1.28	72	72	72	3	3	3	
W. Grand Boulevard									
	1.44	.58	72	72	72	3	3	3	
Cass									

Average Speed During Morning Peak Hour: 47.5 mph

Table 4-23 Fisher Freeway (I-75)
(Estimated 1970 Data)

Cross Street	V/C Ratio		Pavement Width (ft)			No. Lanes Peak Dir.			Off-Peak Speed (mph)
	Max	Min	Max	Min	Typical	Max	Min	Typical	
Gibralter									
	.73	.38	48	48	48	2	2	2	55
King									
	.94	.27	72	72	72	3	3	3	55
Schaefer									
	.70	.42	96	72	96	4	3	4	55
Trumbull									
	.42	.35	96	96	96	4	4	4	55
Woodward									

Average Speed During Morning Peak Hour: 53.8 mph

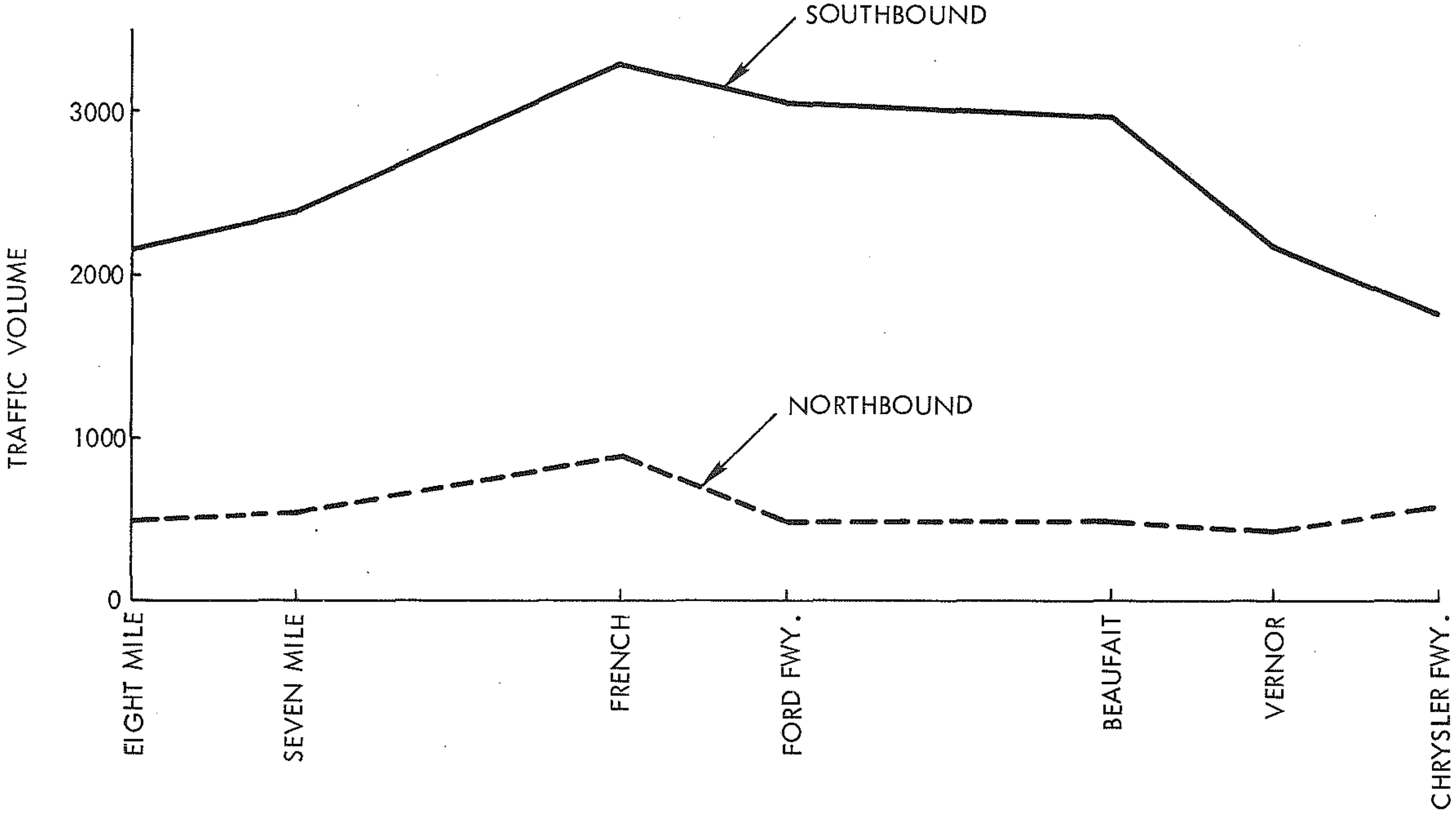


Figure 4-5 Gratiot Avenue Traffic Volumes - Morning Rush Hour

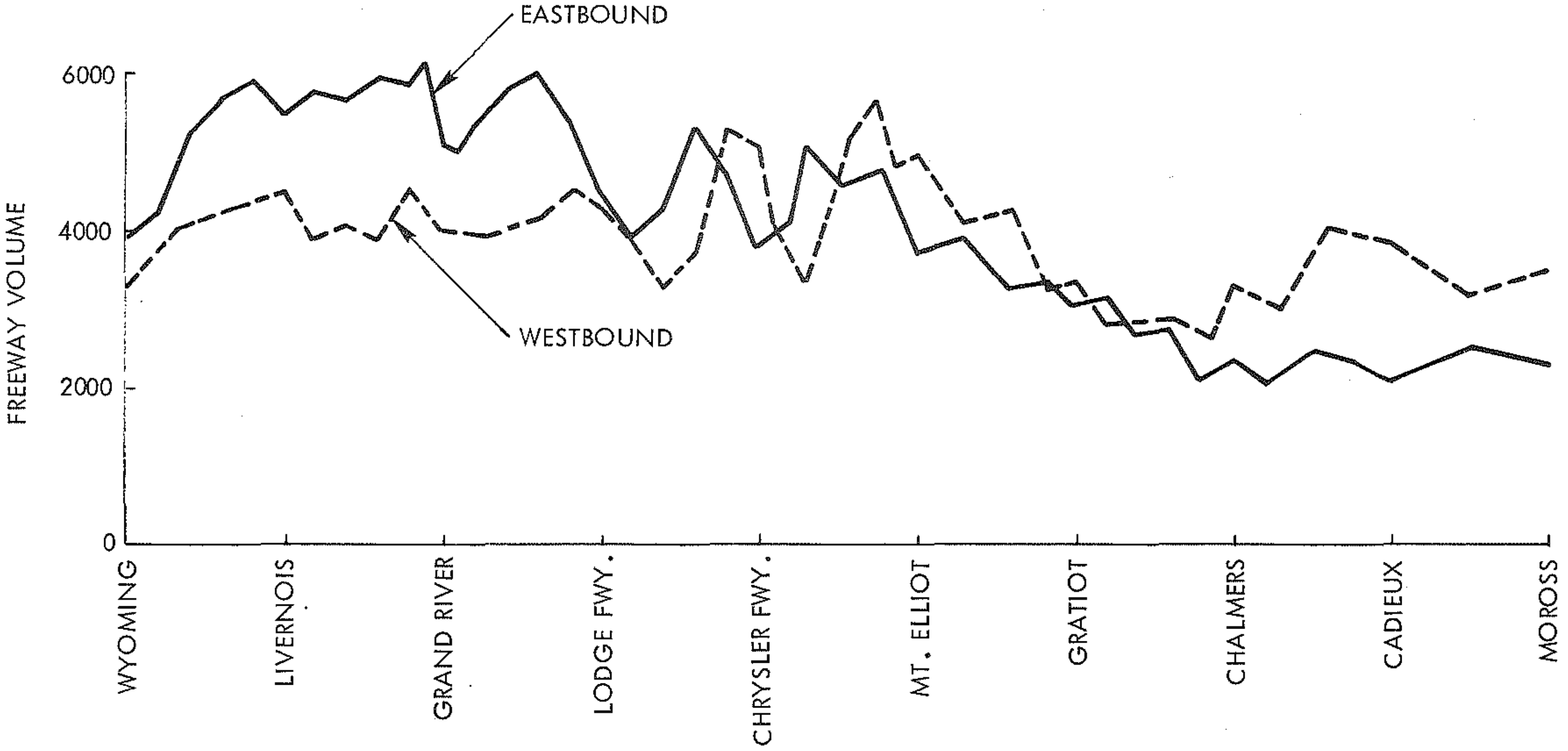


Figure 4-6 Ford Expressway Traffic Volumes - Morning Rush Hour

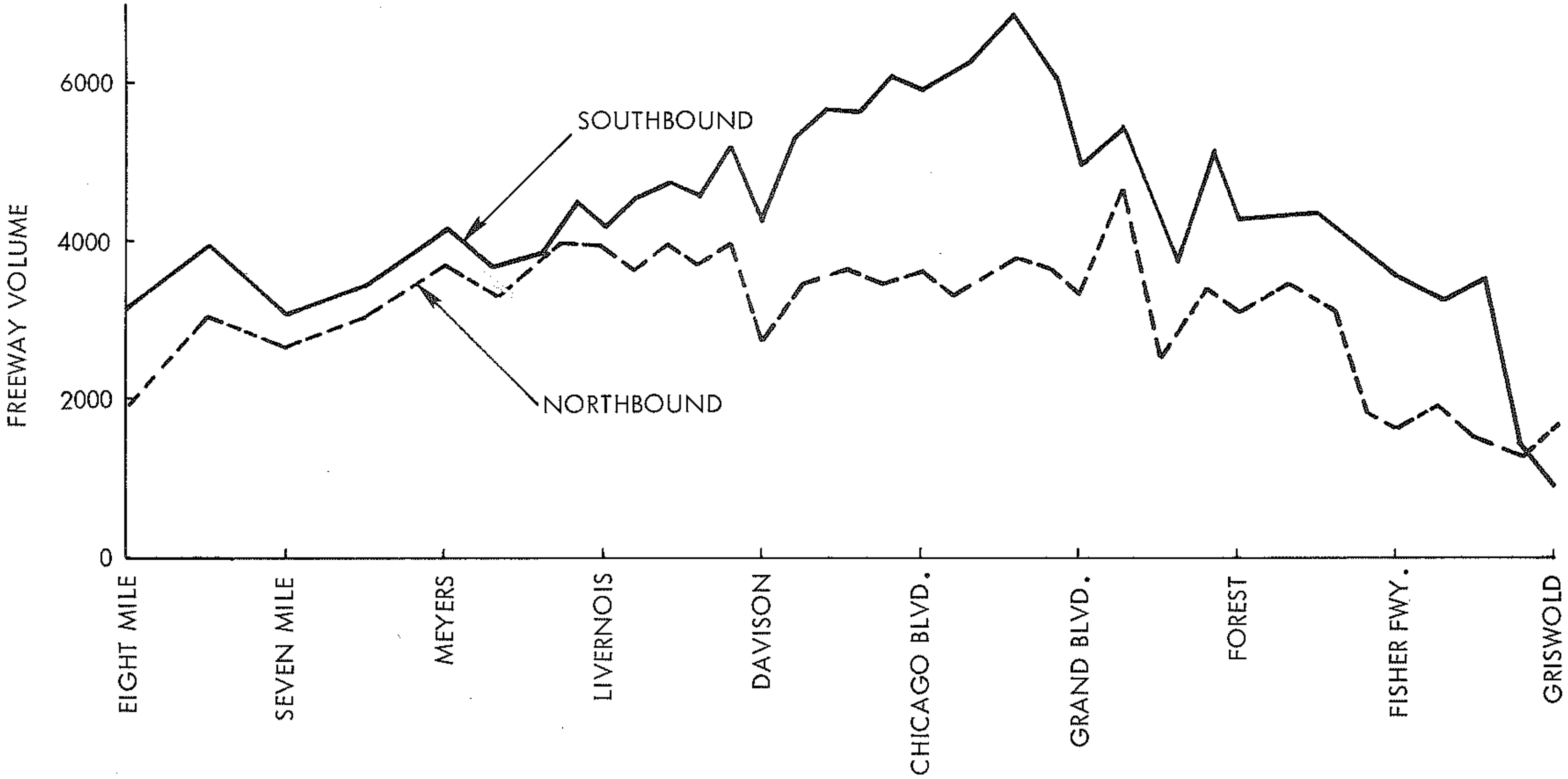


Figure 4-7 Lodge Expressway Traffic Volumes - Morning Rush Hour

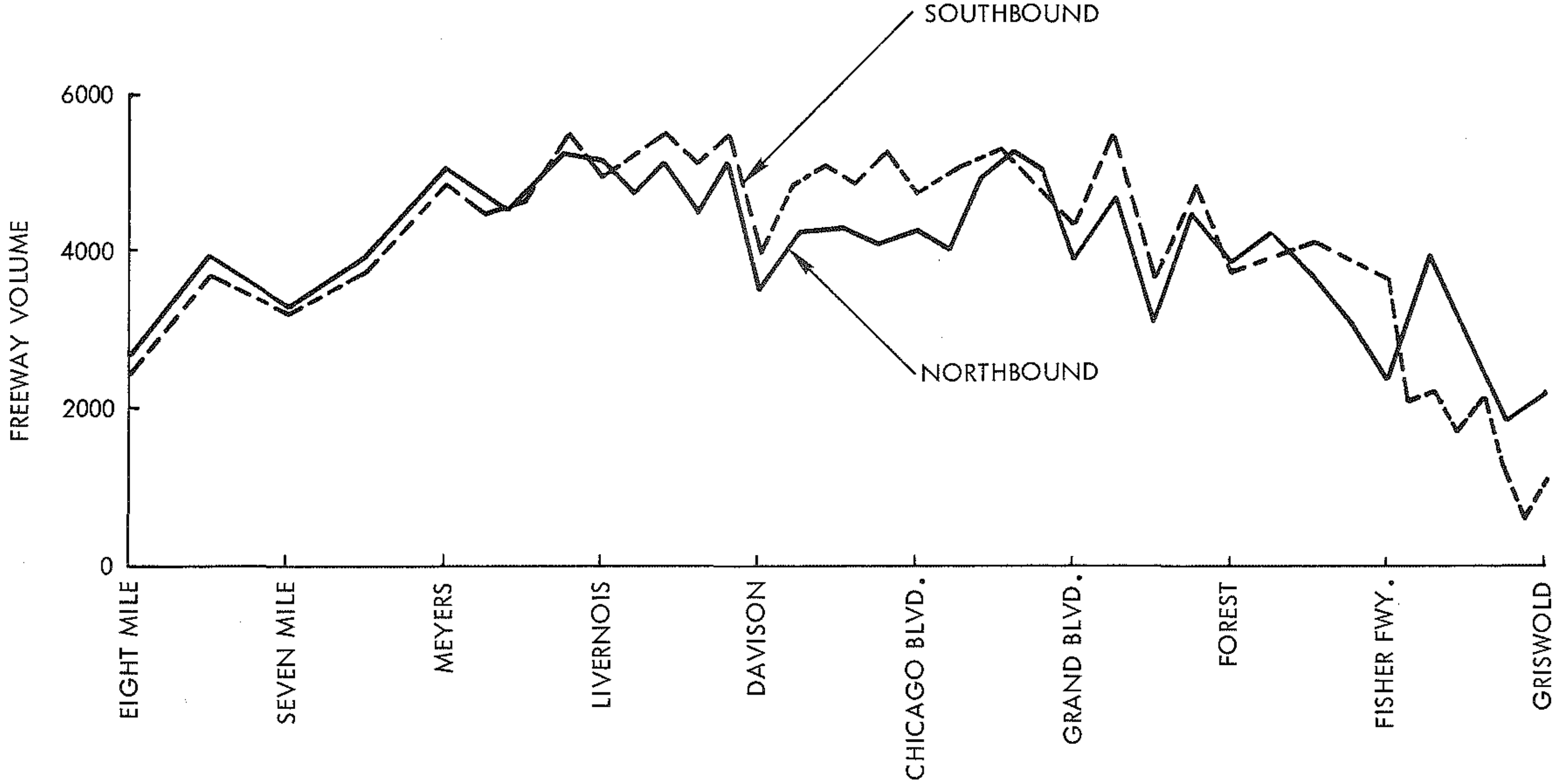


Figure 4-8 Lodge Expressway Traffic Volumes - Evening Rush Hour

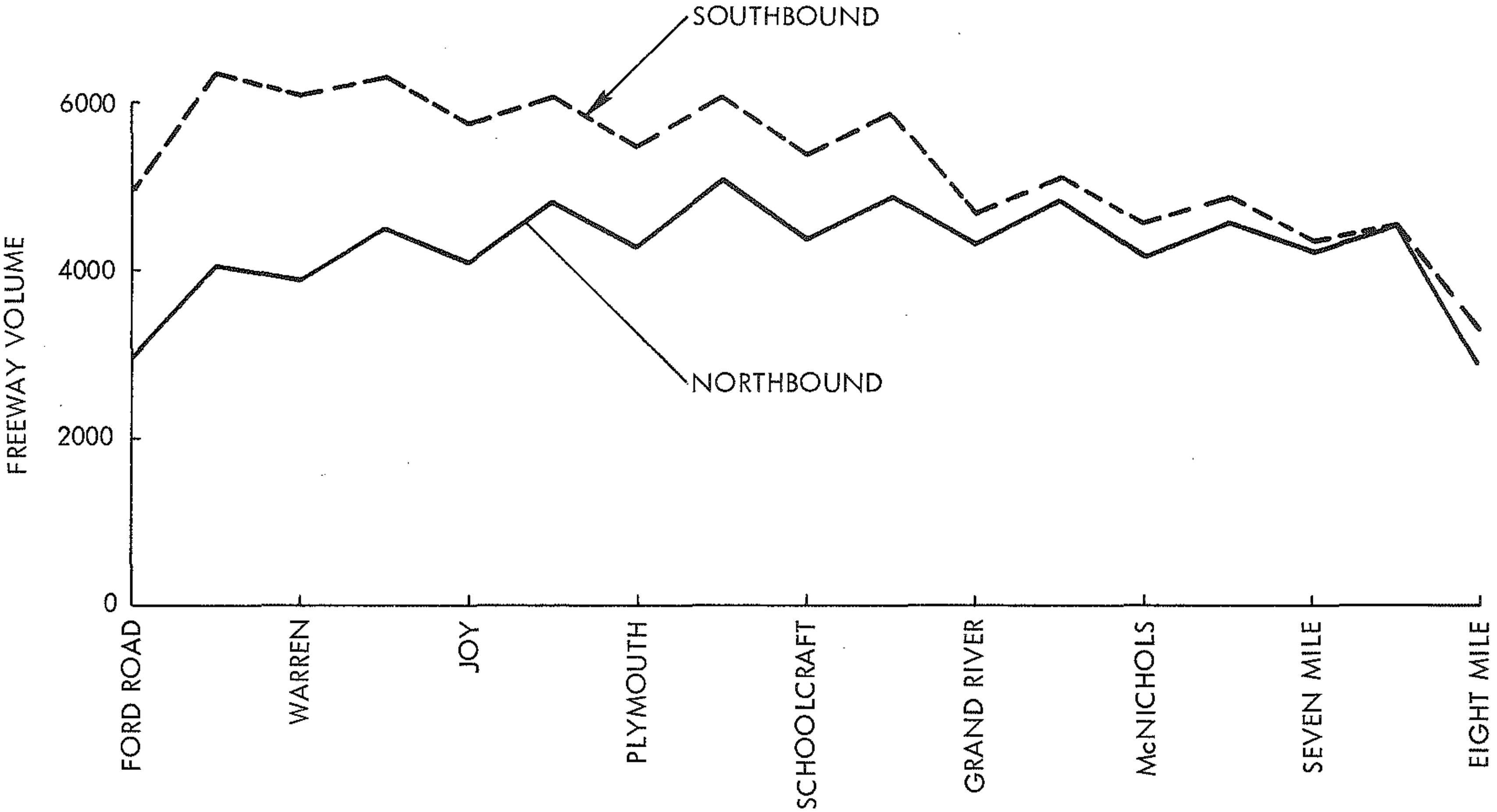


Figure 4-9 Southfield Expressway Traffic Volumes - Morning Rush Hour

Figure 4-10 Fisher Freeway Traffic Volumes – Morning Rush Hour

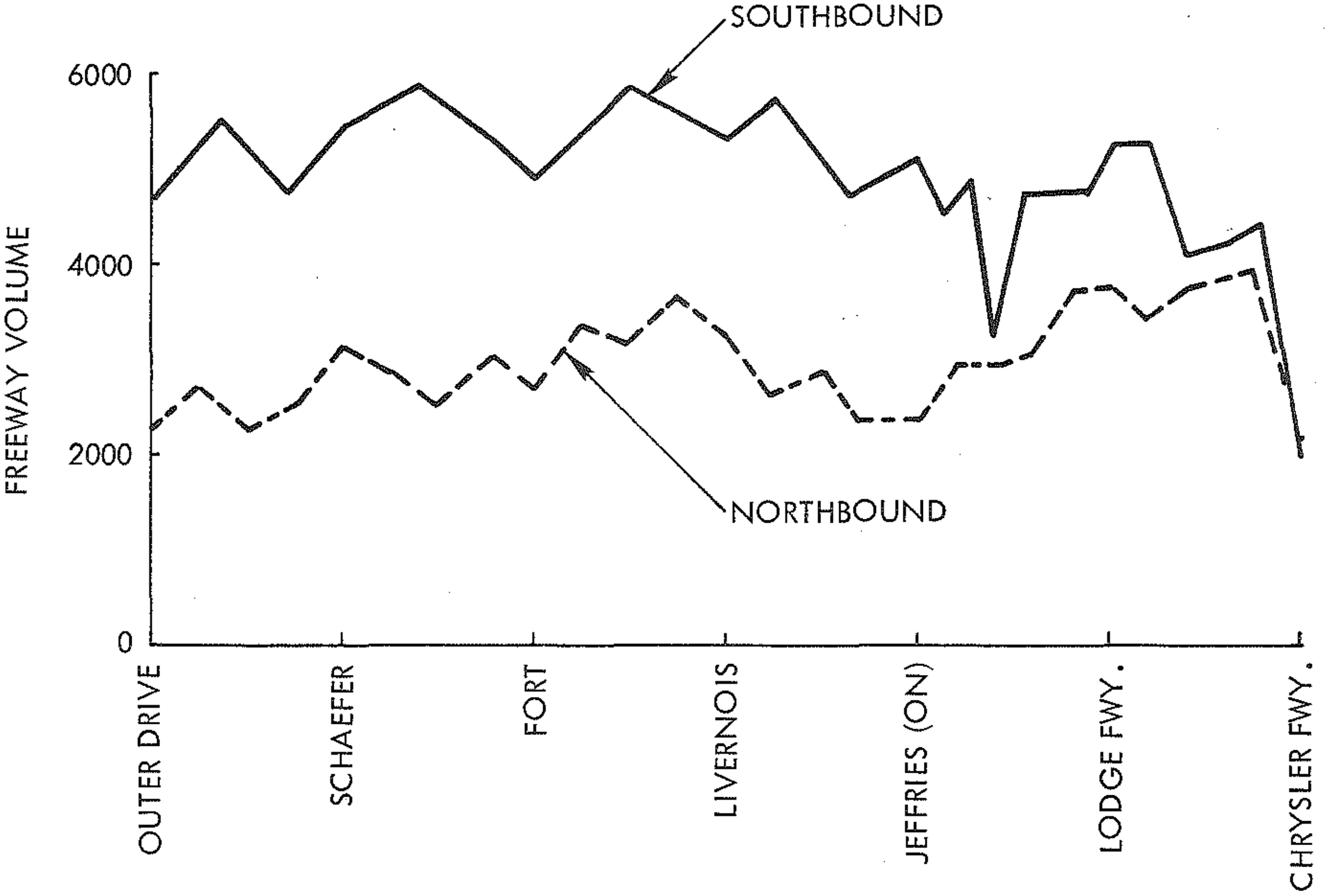


Figure 4-11 Fisher Freeway Traffic Volumes - Evening Rush Hour

4.5.1 Gratiot Avenue

Three BRT implementation schemes appear to be feasible for the Gratiot Corridor. All of them include reserving a lane for the priority use of buses.

The first scheme involves reserving the center lane for exclusive use,or at least for priority use,by buses. Reservation of this lane would result in higher average velocities and reduced trip time variability compared to express buses currently operating on Gratiot. However, left turns would have to be eliminated unless islands were provided at major intersections for looped left turns (right turn followed by a U-turn).

Alternatively, the curb lane could be reserved for priority use by buses. Only right-turning traffic would be permitted to enter the curb lane, and curb cuts at signalized intersections would be provided to prevent the queue of right-turning vehicles from interferring with the bus lane. Right turns would be restricted to the intersections where right-turn lanes are provided. Curb cuts would also be provided at local bus stops to reduce the effects of local buses on BRT operation.

Since the traffic flow is markedly unbalanced during the peak period, as illustrated in Figure 4-5, a third possible BRT implementation scheme for the Gratiot Corridor is a contra-flow lane. Gratiot has a continuous median from Metropolitan Parkway to Eight Mile Road. Intermediate bus stops can be located within the median, thus obviating the need to weave across traffic lanes for passenger pick-up or drop-off. This would also keep the lane clear for through buses.

4.5.2 East Jefferson

There appear to be two feasible BRT implementation schemes along Jefferson Avenue. Since Jefferson exhibits a relatively low level of congestion, except where it merges with the Chrysler Freeway, one viable implementation might be free flow with other traffic. Traffic signal progression or pre-emption by buses outside the city of Detroit should be considered. Within the city of Detroit, East Jefferson is a major arterial with three traffic lanes in the peak direction. In this area it may be possible to reserve one of those lanes for priority use by buses without severely congesting the unreserved lanes. Since the traffic flow is unbalanced, contra-flow bus lanes should be considered.

4.5.3 I-94 Crosstown and Michigan/I-94

The Department of State Highways and Transportation is planning to implement a system which is designed to maintain acceptable speeds on all Detroit area freeways by controlling access with ramp metering and by informing motorists of prevailing freeway conditions. This system--Surveillance, Control, and Driver Information (SCANDI)--offers implementation opportunities for BRT. If SCANDI is implemented and is successful in maintaining acceptable freeway speeds, buses could share the freeway with other traffic after having gained access to the freeway via exclusive bus entrance ramps which bypass the queues at the metered ramps. In addition, the Department of State Highways and Transportation has given some consideration to widening the Ford Freeway from the present three lanes to four lanes. If a fourth lane is added to the freeway, one lane may be reserved for the exclusive use of buses and carpools, i.e., automobiles having three or more occupants. If this is done before the new lane is opened for use, then the magnitude of the problems of unusual congestion during the transition period and enforcement of exclusive use of the lane by buses and carpools will be minimized.

The use of an alternate route such as Warren Avenue is a third alternative which should be considered.

4.5.4 Lodge Freeway

Assuming SCANDI is successfully implemented, BRT vehicles could mix with other traffic in free flow. Exclusive lanes only on entrance ramps would be required to allow BRT vehicles to bypass the queue of vehicles awaiting access to the freeway. A second alternative may include reserving a lane for buses and carpools.

4.5.5 Southfield Freeway

Two alternate BRT implementation schemes for the Southfield Corridor seem feasible. One scheme assumes successful implementation of SCANDI and involves free flow on the freeway with exclusive queue-jumper entrance lanes as suggested for the other freeways. Another scheme which may be appropriate for the Southfield Corridor is implementation of BRT along the service drive using traffic signal pre-emption to minimize delays. Although the freeway itself is relatively congested, the service drive operates close to or below capacity during the peak period. As an illustration, the value of the congested distance parameter, which is defined in Section 4.2, is 18.62 for the freeway, while the value for the service drive is only 8.98.

4.5.6 Fisher Freeway

Three possible BRT implementation schemes should be investigated for the Fisher Freeway. Free flow in mixed traffic after SCANDI has been implemented is one scheme. The peak volume to capacity ratios as reported in SEMCOG's 1970 Highway Assignment Network Data File indicate that the freeway operates below capacity during the peak periods. The average velocities which were observed during the morning peak hour--51.9 mph and 55.6 mph--also indicate a low level of congestion. If the freeway is consistently free-flowing, then a BRT system could be implemented as express buses on the freeway with no priority treatment. Alternatively, this scheme could be used as an interim implementation until SCANDI and the exclusive queue-jumper lanes are operational.

Peak-hour automobile volume data was compiledfor the spring of 1973. These data, which are illustrated in Figures 4-10 and 4-11, indicate two things. First, the volume in the peak direction is relatively high, and the actual level of congestion on the freeway may be understated by the projected 1970 volume to capacity ratios. Second, the flow in the morning and evening peak hours is unbalanced. This suggests the possibility of implementing contra-flow lanes for buses during the peak periods.

5.0 EVALUATION OF SEVEN CANDIDATE CORRIDORS

5.0 EVALUATION OF SEVEN CANDIDATE CORRIDORS

The development of data for each of the seven corridors provided basic information from which an assessment of BRT potential for each corridor was made. Evaluation criteria were established to enhance the comparison process.

5.1 Candidate Corridor Evaluation Criteria

Four major parameters were chosen to characterize each corridor: total potential corridor demand, level of congestion, existing transit, and service estimate (see Table 5-1). The objective was to provide a means by which corridors may be compared for first order evaluation purposes. Each of these parameters was made up of quantified characteristics denoted as "Measures" in Table 5-1. The relative perceived importance of each measure is indicated by the weighting factor. Section 4.0 described the basic process by which data for each measure was obtained. The following definitions describe the significance or purpose for presenting the data in this format.

- Major Destination Total Demand - this provides a measure of potential BRT trips from each corridor to the major destinations.

- Ratio of Three Largest Node Load Volumes to Total Volume - this provides a measure of relative concentration of demand within each corridor.

- Average Corridor Trip Length - a longer average corridor trip length is conducive to a more efficient BRT operation.

- Ratio of Average Auto Speed to Posted Speed - this provides a measure of the relative level of congestion experienced on the corridor during the peak period.

- Congested Distance - this is another measure of the relative level of congestion in the corridor.

- Ridership Along Corridor - this is an indication of the existing transit ridership base from which BRT passengers can be drawn.

- Cross Routes Intersecting BRT Routes - the number of existing transit cross routes intersecting the major BRT route provides insight as to potential feeder operations.

- Ratio of Estimated BRT Travel Time to Auto Travel Time - this first order service estimate provides a means by which corridors may be compared in terms of relative service speed.

Table 5-1 SEVEN CORRIDOR EVALUATION MATRIX

Parameter	Total Potential Corridor Demand			Level of Congestion		Existing Transit		Service Estimate	
Weighting Factor	6	3	1	3	3	3	1	3	
Measures / Corridor	Major Destination / Total Demand	Ratio of 3 Largest Node Load Volumes to Total Volume	Average Corridor Trip Length	Auto Ave. Speed / Posted Speed	Congested Distance $\sum (N/C)\,D$ where $V/C \geq 1.00$	Ridership Along Corridor	Cross Routes Intersecting BRT Routes	Est. BRT Travel Time / Auto Travel Time	Total Weighted Score
Gratiot	21,322	.443	9.3	.71	18.70	4,525	22	1.36	178.7
Score	5.3	9.6	10	9.3	10	4.7	7.3	9.0	
WF x Score	33.6	28.8	10	27.9	30.0	14.1	7.3	27.0	
E. Jefferson	22,356	.410	9.1	.88	7.45	5,891	11	1.23	156.6
Score	5.6	8.9	9.8	7.5	4.0	6.1	3.7	10	
WF x Score	33.6	26.7	9.8	22.5	12.0	18.3	3.7	30	
I-94 Crosstown	40,156	.291	7.8	.88	17.50	4,525	30	1.43	187.9
Score	10	6.3	8.4	7.5	9.4	4.7	10	8.6	
WF x Score	60.0	18.9	8.4	22.5	28.2	14.1	10	25.8	
Lodge Freeway	36,552	.308	8.3	.74	9.18	9,703	25	1.27	192.4
Score	9.1	6.7	8.9	8.9	4.9	10	8.3	9.7	
WF x Score	54.6	20.1	8.9	26.7	14.7	30.0	8.3	29.1	
Southfield	9,989	.359	6.8	.66	18.62	700	18	1.75	135.7
Score	2.5	7.8	7.3	10.0	10	1.0	6.0	7.0	
WF x Score	15.0	23.4	7.3	30.0	30.0	3.0	6.0	21.0	
Mich Ave/I-94	15,977	.458	9.1	.86	9.30	1,459	14	1.54	134.8
Score	4.0	9.9	9.8	7.7	5.0	1.5	4.7	8.0	
WF x Score	24.0	29.7	9.8	23.1	15.0	4.5	4.7	24.0	
Fisher Freeway	10,253	.463	8.7	.97	0.0	3,030	14	1.90	108.9
Score	2.6	10	9.4	6.8	0	3.1	4.7	6.5	
WF x Score	15.6	30	9.4	20.4	0.0	9.3	4.7	19.5	

5.2 Corridor Ranking

All of these measures were determined to provide a methodology for comparing the desirable characteristics of each corridor. A scoring technique was established to allow a quantitative aggregation of corridor characteristics. For each measure, a relative score was calculated based on a maximum of ten. For example, the score for the I-94 Crosstown Corridor is shown to be ten for Major Destination Total Demand because the demand is highest on that corridor. A proportional score was calculated for the demand on each of the other corridors. This method was used for all the remaining measures. The relative importance of the measure is indicated by the weighting factor assigned to each measure. The summation of the products of the calculated score and the weighting factor results in the total weighted score for each corridor. On this basis, the seven corridors were ranked in accordance with the total weighted scores as shown in Table 5-1.

Since the weighting factors were subjectively chosen based on perceived relative importance, an exercise was undertaken to modify the assigned weighting factors and assess any significant changes in corridor ranking. The results indicated slight changes in total weighted scores but no significant changes to overall ranking of corridors.

5.3 Final Corridor Selection

The results of the corridor ranking process were presented and discussed at a meeting held at the SEMTA offices on March 25, 1975. Representatives from SEMCOG, SEMTA, Michigan Department of State Highways and Transportation, and General Motors were in attendance. A summary of the data development tasks as well as the corridor evaluation criteria was presented. The merits of each of the seven corridors were discussed and the following four corridors were selected for additional analysis in accordance with the contract.

- Lodge Freeway
- I-94 Crosstown (East)
- East Jefferson
- Michigan/I-94

The Gratiot Corridor was eliminated from further study on this contract because plans currently exist for establishing a priority bus lane treatment on that corridor in the near future. The Southfield Corridor was eliminated from further study because plans currently exist to include the Southfield Corridor as part of the Jeffries/Southfield Transit Corridor Extension program which will be initiated in the summer of 1975.

6.0 SKETCH PLANNING FOR FOUR CANDIDATE CORRIDORS

6.0 SKETCH PLANNING FOR FOUR CANDIDATE CORRIDORS

The four corridors which emerged from the previous evaluation were analyzed in greater detail and evaluated on the basis of overall BRT potential. The results of that effort and recommendations are reported in this section. The analysis which is described in this section is composed of several tasks. First, several implementation alternatives were considered for each corridor before one was selected for further analysis. Then the basic route structure, including corridor terminal points, corridor access points, and distribution loops, was defined for each corridor. The construction requirements of each candidate implementation were delineated. As an indication of BRT service, BRT travel times were estimated and compared with local bus, express bus, and automobile travel times. The BRT-automobile travel time ratio for each corridor, as well as several other parameters, was used in a limited modal split analysis which was performed in order to predict BRT ridership. BRT ridership information was then used to size the BRT system and two alternative feeder bus systems. Generation of preliminary capital and operating cost estimates for each corridor followed the sizing task. Then the BRT service ridership and cost estimates were used to rank the corridors in order of overall BRT potential. Finally, action plans were formulated to indicate the tasks necessary for final implementation of a BRT system. These analysis tasks are described in detail in the following sections.

6.1 Corridor Treatment Selection

In this section, the general implementation schemes described in Section 4.5 are considered in greater detail, and the treatment for each of the four candidate corridors is selected. Each selection is based on the criterion of providing the highest line-haul speed at reasonable cost and with minimum disruption of existing traffic. These parameters were considered qualitatively in the selection process, as detailed estimates of costs and operating characteristics were not made for each alternative treatment.

6.1.1 East Jefferson Corridor

Outside the city of Detroit, Jefferson Avenue typically has two eleven-foot lanes in each direction. Within the city, Jefferson is a seven-lane arterial with a pavement width of about 80 feet. Since the physical characteristics of these two sections differ so widely, the BRT implementations for them are considered separately.

One alternative implementation for the suburban segment of East Jefferson (east of Alter Road) is a priority bus lane. However, since only one lane would remain for automobile traffic in the peak direction if an existing lane were reserved for buses, this scheme would require the construction of at least one new lane. Traffic volume on this section of East Jefferson is typically below capacity during the peak hours, so the expense and the adverse environmental impact of widening the street to provide a bus lane probably cannot be justified. This section of East Jefferson generally flows at or near the speed limit even during peak periods. Therefore, the criterion of high line-haul speed at reasonable cost can be satisfied with an implementation involving free flow with other traffic. Current speed and delay data for East Jefferson are not available at this time, but the delay due to traffic signals is expected to be small in this section since the signals are spaced relatively far apart. Therefore, traffic signal pre-emption is not warranted for this application. Thus, the recommended BRT implementation scheme for the suburban section of East Jefferson is free flow with other traffic.

Reserving an existing lane for priority use by buses is considered to be a viable alternative for the East Jefferson Corridor inside the city of Detroit. Reserved lane operation can significantly improve BRT line-haul velocity on high volume arterials. For example, Florida DOT reported a 33 percent increase in line-haul speed when the Orange Streaker* changed from mixed mode to reserved lane operation.

Several alternatives must be considered to determine which lane should be reserved for priority use by buses. One alternative is to reserve the curb lane. This lane must be shared with right-turning vehicles and local buses. To minimize the delay which the BRT vehicles will experience as a result of sharing the reserved lane, curb cuts should be provided on the near side of signalized intersections to serve as a queue for right-turning vehicles. Curb cuts should also be provided at local bus stops to help keep the BRT lane clear. Although this alternative would result in higher average velocities for local buses operating on East Jefferson, the improvement on BRT line-haul speed over that expected with free flow is marginal, while the required number of curb cuts is relatively large. Furthermore, this section of East Jefferson operates near capacity during the peak hours, and severe congestion would probably result from taking one of the peak direction lanes.

Another alternative is to reserve the center left turn lane for peak direction buses. Since the center lane is not currently used as a through traffic lane, this alternative would have little effect on existing traffic if satisfactory arrangements were made to accommodate left turns. Detroit Department of Transportation traffic counts indicate that the traffic volume on East Jefferson east of the CBD is quite unbalanced both in the morning and evening peak hours. This suggests the possibility of taking a lane from the off-peak direction and using it as a left turn lane during peak periods. This scheme would provide the speed advantage of reserved lane operation with no reconstruction costs and little effect on existing traffic. However, extensive signing and restriping would be required. Since this treatment -- reserved center lane with one off-peak direction lane being used as a left turn lane -- satisfies the criterion of maximum speed at reasonable cost, it is the recommended implementation scheme for the section of East Jefferson within the city of Detroit. Figure 6-1 illustrates the concept.

6.1.2 I-94 Crosstown Corridor

The BRT implementation alternatives for the Crosstown Corridor include the use of priority entrance ramps on I-94 in conjunction with the Surveillance, Control, and Driver Information System (SCANDI), exclusive bus lane operation on I-94, and the use of an arterial for part of the route.

---

*The Orange Streaker is a BRT project operating with traffic signal pre-emption on a reserved lane on Seventh Avenue in northern Miami.

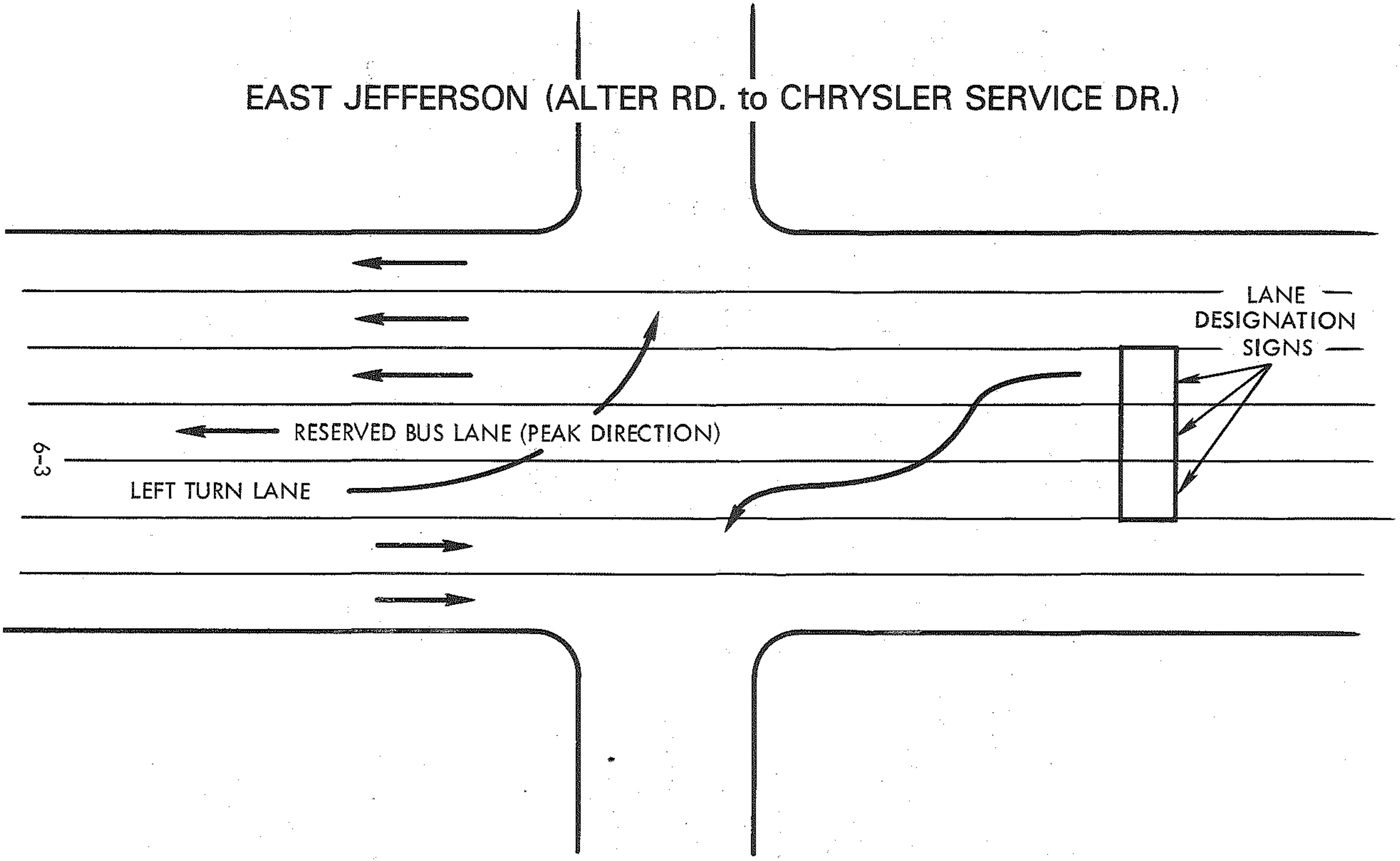


Figure 6-1 BRT Implementation Scheme

The first alternative assumes implementation and successful operation of SCANDI on the Ford Expressway. The SCANDI system is designed to keep Detroit area freeways flowing freely at a speed of at least 40 mph. Several freeway surveillance and control systems are currently operating quite well throughout the country. For example, in the Los Angeles area, 42 miles of the Santa Monica, San Diego, and Harbor Freeways are controlled during peak periods. The system maintains free-flowing traffic on freeways which were previously congested. Average peak-hour speeds typically exceed 50 mph where real-time computer-controlled ramp meters are in operation. Also important, especially for potential BRT operations, is the fact that ramp metering has reduced incident rates by 25 to 50 percent. Lower incident rates mean more reliable BRT trip time.

The I-35W Project in Minneapolis-St. Paul is another example of a successful freeway control system. The final evaluation of this system has not yet been completed, but early results indicate that the goal of maintaining at least 35 mph through bottleneck areas is close to being achieved. The project includes an express bus system which accesses the freeway via exclusive ramps to bypass the automobile queues at metered ramps.

The successful operation of these and other freeway control systems suggest that SCANDI will be able to maintain free flowing freeway conditions and provide more reliable travel times than are currently experienced on freeways in the Detroit area. Assuming the cost of constructing exclusive bus entrance ramps is reasonable, this alternative satisfies the selection criterion.

A second alternative implementation for the Crosstown Corridor is priority use of the left lane of the Ford Expressway by buses and carpools. Since I-94 already operates above capacity in many areas, this is a viable alternative only if the expressway were widened from the present three lanes to four lanes in each direction. This widening is presently being investigated by the Department of State Highways and Transportation.

Buses and carpool vehicles would have to weave across three lanes of traffic to enter the reserved lane unless exclusive ramps were constructed to provide access to the inner-most lane. Reserved-lane access ramps would be difficult to construct in areas where no median exists. Non-priority vehicles would be allowed to use the reserved lane only in areas where left-hand exits and entrances exist. An exclusive lane would isolate the BRT vehicles from congestion in the unreserved lanes; however, enforcement would be difficult.

Although reserved lane operation on the Ford Expressway would be a viable alternative if SCANDI were not to be implemented, the problems of accessing the left lane of a congested freeway in a reasonable distance and of enforcing the priority use of a freeway lane make this scheme less desirable than the previous one.

A third alternative involves the use of an arterial such as Warren or Forest for part of the route. One possible implementation is for buses to operate free flow on Warren Avenue in the morning peak period and on Forest in the evening much like the DOT Crosstown bus does now. The Crosstown Express currently averages 14.8 mph. This speed could be improved somewhat by making the traffic signals progressive or by implementing a signal pre-emption system. However, pre-empting traffic signals at major crossstreets such as

Gratiot and Woodward may not be a reasonable approach. Another possible implementation involves reserving a lane on Warren and Forest. Two possibilities exist. First, a normal flow lane could be reserved on Warren in the morning peak and on Forest in the evening. If the right curb lane were reserved, it would be shared with local buses and right-turning vehicles. This would result in relatively low average speeds for the BRT even if curb cuts were made to accommodate local bus stops and turning vehicles. If the left curb lane were reserved, left-turning vehicles would tend to slow the bus, and the door would be on the traffic side of the vehicle. If either lane were reserved, only two lanes would remain for other traffic in many areas. The other possibility is to reserve a lane for contra-flow on Forest in the morning and a lane for contra-flow on Warren in the evening. In this way a lane is taken from each street only during the off-peak period. As in the case of the East Jefferson Corridor, extensive signing and restriping would be required. The average BRT velocity resulting from this implementation is expected to be considerably lower than the implementation on the metered freeway. In addition, the incident rate is likely to be higher on the arterials than on the freeway, resulting in less reliable trip time. Therefore, the first alternative--free flow on the Ford Expressway in conjunction with SCANDI and exclusive bus entrance ramps--is the recommended implementation scheme for the I-94 Crosstown Corridor.

6.1.3 Lodge Corridor

In general, the alternative BRT implementations for the Lodge Corridor are similar to those considered for the I-94 Crosstown Corridor. The first alternative is free flow on the Lodge Expressway after SCANDI has been implemented. Exclusive entrance ramps for buses to bypass the ramp meters would be required at designated corridor access points. This implementation scheme is recommended for the Lodge Corridor.

A second alternative for this corridor is reserved lane operation on the expressway. Since the Lodge operates above capacity on several segments, the viability of this alternative is questionable unless the expressway were widened to eight lanes. Since available right-of-way adjacent to the expressway is quite limited, the cost of added lanes is expected to be prohibitive.

A third alternative is to use arterials for part of the route. Congestion on the Lodge seems to peak at the Davison interchange, at least in the morning. Therefore, the alternative route should allow this bottleneck to be bypassed. One possible route is east on McNichols to Second Avenue and then south on Second to the CBD. Since Second is one-way north in Detroit, a contra-flow lane would be reserved for buses in the morning. Considerable delay would probably be encountered on McNichols and on Second in Highland Park where it is bi-directional. This alternative does not seem to offer much potential for short BRT trip times.

A fourth alternative for this corridor should be considered further at a later date. This alternative involves implementation on the Southfield Expressway and use of the exclusive bus lanes on the Jeffries Freeway.

6.1.4 Michigan/I-94 Corridor

Considerations for BRT implementation on this corridor are essentially the same as those for the Crosstown Corridor. The recommended implementation is free flow on I-94 with SCANDI and exclusive entrance ramps for buses. Reservation of the center lane for buses and carpools is a viable implementation if the Ford Expressway is widened. However, this treatment suffers from the same disadvantages that were cited in the discussion of I-94 Crosstown implementation schemes (i.e., access to the reserved lane involves weaving across three lanes of traffic; the lane must be shared with non-priority vehicles where left-hand exits exist; and enforcement is likely to be a problem). Michigan Avenue was considered as an alternate route in this corridor; but implementation difficulties and relatively low speeds eliminated this arterial from serious consideration. The number of traffic lanes on Michigan in the peak direction varies, causing bottlenecks and making it difficult to reserve a lane without causing serious congestion.

6.2 Basic BRT Route Structure

Each BRT route is comprised of three segments: collection, line-haul, and distribution. This section discusses the BRT route structure for each of these trip segments. Due to special problems associated with the distribution of passengers to their destinations (e.g., traffic congestion, travel time constraints, and walking distance limitations), the distribution function is emphasized.

6.2.1 Collection Route Structure

The collection of BRT passengers has been approached in two ways. Within the Detroit DOT service area, it has been assumed that a combination of collector service for park-and-ride lots and the existing bus service will be sufficient. Elsewhere in each corridor, it is felt that a feeder service is necessary (in addition to a collection route serving park-and-ride lots).

Two types of feeder service have been considered: Dial-A-Bus and fixed-route/fixed-schedule bus. The Dial-A-Bus feeder system would utilize relatively small buses operating in a demand-responsive mode to pick up passengers and deliver them to collection route transfer points. A computer-aided dispatching system would route each bus in response to telephoned trip requests and/or a set of prearranged (subscription) trips. The alternative feeder service (fixed-route/fixed-schedule) would pick up passengers along major streets and deliver them to collection route transfer points.

So that feeder transfer points and park-and-ride lots may be somewhat dispersed in the vicinity of a BRT mainline route access point, it is proposed that each BRT bus complete a short collection route (stopping at such locations) prior to entering the mainline route.

6.2.2 Mainline Route Structure

The node identification map previously presented as Figure 4-4 shows the mainline nodes initially comprising each candidate BRT corridor's mainline route. The primary function of these nodes was to define the path of each BRT route, since it is not proposed that BRT buses would actually operate to the extremities of the routes or that they would be permitted to enter or leave the mainline routes at any node. For the analysis of BRT travel in each corridor, it was useful to identify two node types: "reference nodes" and "transit nodes." All nodes previously discussed are reference nodes and serve to define the path of each BRT mainline route. Transit nodes are a subset of the reference nodes and designate allowed points of mainline access or egress by BRT vehicles.

Each corridor's transit nodes were selected through an inspection of total corridor travel data. The observed decline of trips entering at mainline extremities permitted the selection of route termini for each corridor. Nodes beyond a route terminus transit node are for reference purposes only. Intermediate transit nodes were chosen to emphasize service to zones exhibiting the most intense trip activity, while keeping the number of such nodes relatively small. The transit nodes selected for each of the four candidate BRT corridors are listed below, with the identification number of each node (as defined in Figure 4-4) shown in parentheses (the nodes listed are those used for demand analysis purposes; differences between analysis routes and proposed actual routes are noted):

- East Jefferson Corridor

- Jefferson and 13 Mile	(78)
- Jefferson and 11 Mile	(79)
- Jefferson and 9 Mile	(80)
- Jefferson and Vernier	(81)
- Jefferson and Moross	(82)
- Jefferson and Cadieux	(83)
- Jefferson and Alter	(84)
- Jefferson and Conner	(85)
- Jefferson and Cadillac	(86)
- Jefferson and Woodward	(18)
- Woodward and Grand Boulevard	(19)

- I-94 Crosstown Corridor

- I-94 and Michigan	(28)
- I-94 and Livernois	(29)
- I-94 and Woodward	(73)
- Woodward and Jefferson	(18)
- I-94 and Van Dyke	(71)
- I-94 and Conner	(70)
- I-94 and Alter	(69)
- I-94 and Cadieux	(68)
- I-94 and Vernier	(67)

  - I-94 and 11 Mile (65)
    (Actual route access proposed at 10 Mile rather than 11 Mile)
  - I-94 and Gratiot (64)

- Lodge Freeway Corridor
  - I-696 and Orchard Lake (47)
    (Actual route terminus proposed at Northwestern Highway rather than I-696)
  - I-696 and Telegraph (49)
  - Lodge and Evergreen (51)
  - Lodge and 8 Mile (53)
  - Lodge and 6 Mile (55)
  - Lodge and Linwood (57)
  - Lodge and West Chicago (59)
  - Lodge and Grand Boulevard (60)
  - Lodge and Jefferson (17)
  - Jefferson and Woodward (18)

- Michigan/I-94 Corridor
  - I-94 and Merriman (21)
  - I-94 and Telegraph (23)
  - I-94 and Southfield (24)
  - Southfield and Rotunda (26)
    (Actual route access proposed at Oakwood rather than Rotunda)
  - I-94 and Michigan (28)
  - I-94 and Livernois (29)
  - I-94 and Woodward (73)
  - Woodward and Jefferson (18)

6.2.3 Distribution Objectives

A common set of objectives was formulated and applied when establishing the distribution routes for the major destinations in the Detroit area, i.e., the CBD, New Center, Ford Complex, and Northland area. Each route would be structured to come within 1000 feet of all major trip attractors in the distribution area. An attempt was made to optimize route length and trip time, consistent with the 1000 feet service criterion. For each distribution area, the major attractors were identified, trial routes were defined and inspected, and a proposed final route, based on the trial routes, was structured.

The major trip attractors were identified using 1975 origin/destination predictions based on the 1965 TALUS data. In addition to this data, an inspection of each major destination was made to locate any new trip attractors which were constructed since the TALUS survey was taken.

Trial routes, based on the attraction data, were laid out for the major destinations. These routes were designed such that buildings which are major attractors are within 1000 feet of the proposed BRT distribution routes. The routes were purposely structured to be short with relatively few turns. In addition, roads wide enough to easily allow an exclusive bus lane were selected. Routes satisfying these criteria provide an acceptible compromise between travel time for the route and ease of access for BRT patrons.

The trial routes were inspected, route distance was measured, and travel times by car were noted. By observing potential points of congestion and delay, some route segments were deemed not viable and were, therefore, eliminated.

Where possible, contra-flow lanes on one-way streets were utilized in the final route. There are several advantages to a contra-flow implementation. Contra-flow lanes are self-enforcing (assuming headways are reasonably short). Traffic congestion and resulting delays do not affect travel in the exclusive contra-flow lane. Finally, when contra-flow lanes on perpendicular one-way streets are arranged such that buses make left turns, assuming the bus entry/exit doors are adjacent to the curb, the bus could, if provided with a priority left-turn signal, complete the turn without delay. Because of the bus length, a right hand turn from one contra-flow lane into another would require encroachment into adjacent lanes in the immediate vicinity of the corner. This problems has not been resolved in detail, but it is no different from the identical situation in conventional bus operations.

To negotiate a left turn from a contra-flow lane, the bus must cross the lane of on-coming, one-way traffic. Traffic signaling is required to stop all traffic at the intersection except the buses in the exclusive lane. Those buses are provided with a left-turn arrow which is illuminated only long enough to allow the bus to turn. The left-turn arrow is illuminated once during every cycle of the traffic signals. If preferred, the buses could be equipped with signaling devices such that the left-turn arrow is illuminated only when a BRT vehicle is waiting to negotiate the turn. Special traffic signaling is necessary only for the intersections at which the buses are required to turn, not at the intersections at which buses merely go straight. However, standard signal heads facing the reverse flow direction on the contra-flow lanes must be added.

The proposed distribution routes for the major destinations in the Detroit metropolitan area represent the implementations which provide service to the majority of transit trip attractors in each area, via the shortest route, as quickly as possible, while minimizing the likelihood of delay. Detailed discussions of the proposed routes follow.

6.2.4 Detroit CBD Distribution

The proposed CBD distribution loop is shown in Figure 6-2. The route, as shown, is two miles long. Buses travel counter-clockwise around the loop, and, for most of the route, the implementation is contra-flow on one-way streets. The proposed route is felt to be the best implementation at present. However, as major trip attractors in the CBD shift, for example, when the Renaissance Center opens, the route can easily be shifted to accommodate the changes in demand concentrations. The circles drawn on Figure 6-3 represent 1000-foot radius circles about each stop showing the coverage area in the CBD.

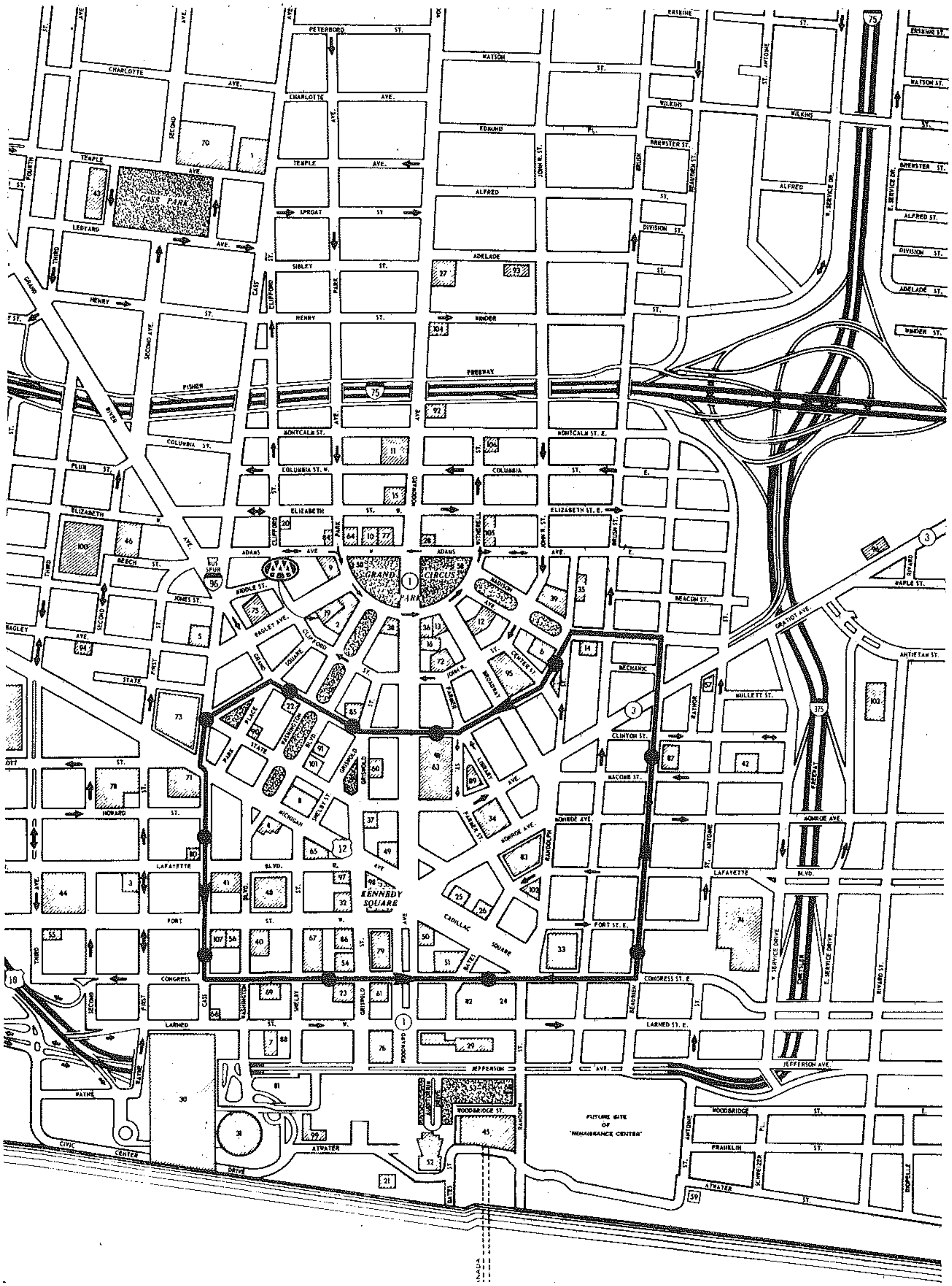


Figure 6–2 CBD Distribution Loop

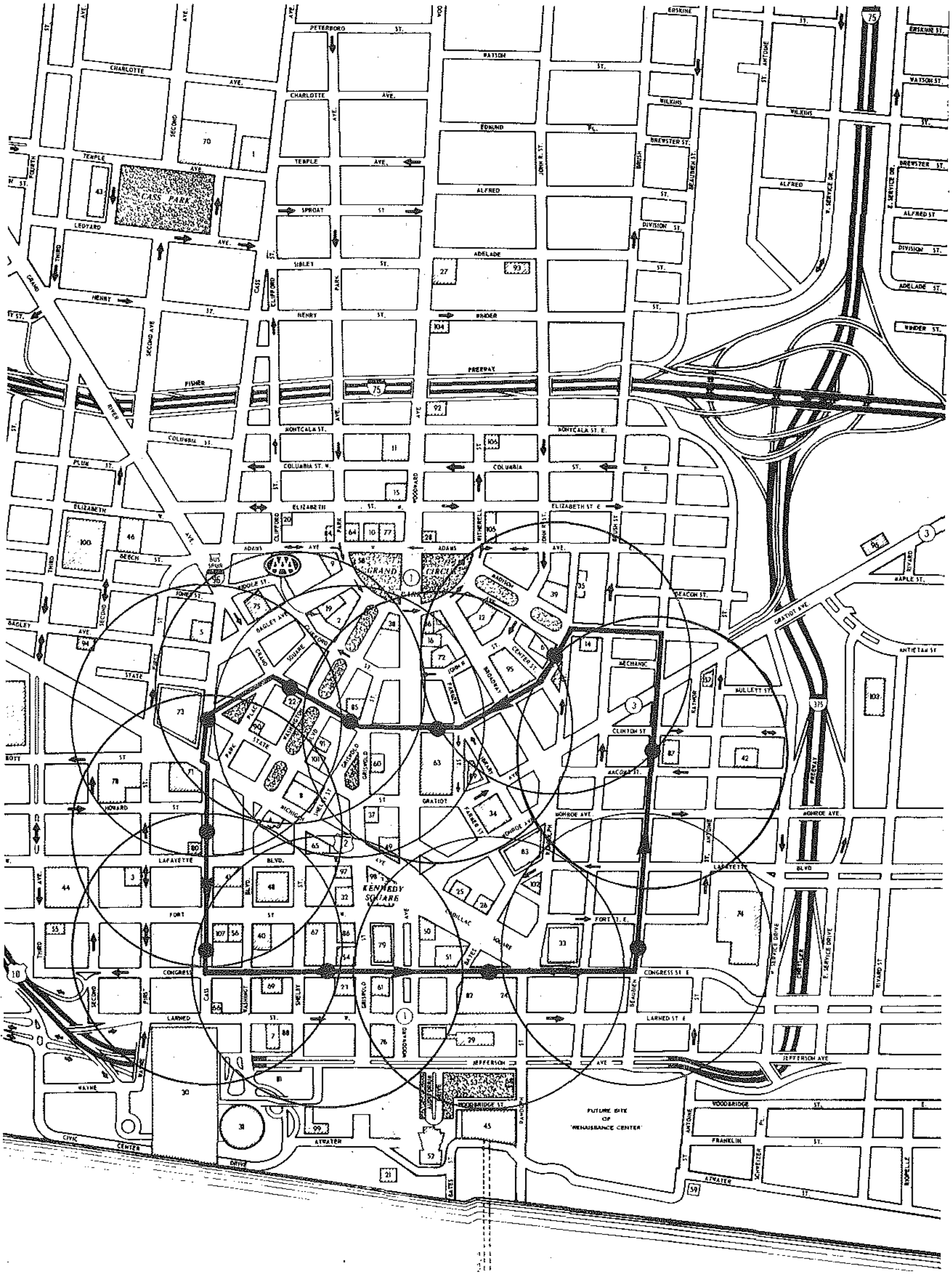


Figure 6-3 Area Coverage of CBD Distribution Loop

Starting in the southwest corner, the BRT route goes east on Congress, contra-flow on the south side of the street from Cass to Beaubien, then north on Beaubien, contra-flow in the east lane, to Madison. The route then proceeds west on Madison for two blocks. Madison in this area is six lanes wide, two-way, with parking on both sides. The curb lane on the north side of the street could be reserved for BRT buses, if necessary. The route then proceeds contra-flow along Grand River to Times Square, along Times Square free flow to Cass, then south on Cass. Cass is adequately wide to run free flow to the Fort Street intersection. South of Fort, Cass is four lanes wide, with parking on both sides, leaving one traffic lane in each direction. Therefore, to minimize delays and to help assure rapid flow of BRT traffic, parking must be eliminated on the west lane, and that lane would then be reserved for buses. Two blocks south of Fort, Cass merges with Congress to complete the CBD loop.

The locations of the access and egress points for the CBD loop are dependent upon the BRT corridor being considered. However, the same CBD distribution loop is proposed for all BRT corridors.

BRT buses from both the Lodge and Michigan/I-94 corridors would enter the CBD distribution loop at the Cass/Congress intersection. Buses traveling south on the Lodge Freeway would exit at the Larned ramp, proceed east on Larned to Cass, turn left onto Cass, proceed north to Congress, and enter the distribution loop by turning east onto Congress. To facilitate departure from the CBD area, a new exclusive bus ramp to the Lodge Expressway near Larned is proposed in conjunction with any of the three freeway corridors. This ramp would connect Larned, at Second Street, to the existing Lodge access ramp and would serve as a queue jumper for BRT buses. The auto ramp would be metered as part of the SCANDI system and to assure buses would not be delayed.

To access the CBD distribution loop from the I-94 Crosstown corridor, BRT vehicles would turn south onto the Chrysler Freeway. The buses would turn onto the West Service Drive at Macomb Street and proceed south to Congress. The buses would then join the CBD distribution loop at the Congress/Beaubien intersection by turning north onto Beaubien. I-94 Crosstown buses would use the exclusive bus entrance ramp to the Lodge Expressway to depart from the CBD.

Access to the CBD loop from the Jefferson Corridor would not require any construction. BRT buses would turn north onto the East Service Drive of the Chrysler Freeway (I-375). From the service drive they would turn west on Congress and would access the CBD loop at the Beaubien/Congress intersection. Exiting the loop would roughly follow the same route; however, the West Service Drive would be utilized.

The time required to complete one complete circuit of the CBD distribution loop is estimated to be 15 minutes, assuming a distribution speed of 8 mph.

6.2.5 New Center Midtown Distribution

The proposed distribution loop for the New Center Midtown area is shown in Figure 6-4. The route shown is 4.7 miles long. Buses travel counter-clockwise around the loop. On Second Street and John R, the BRT buses run contra-flow, south on Second and north on

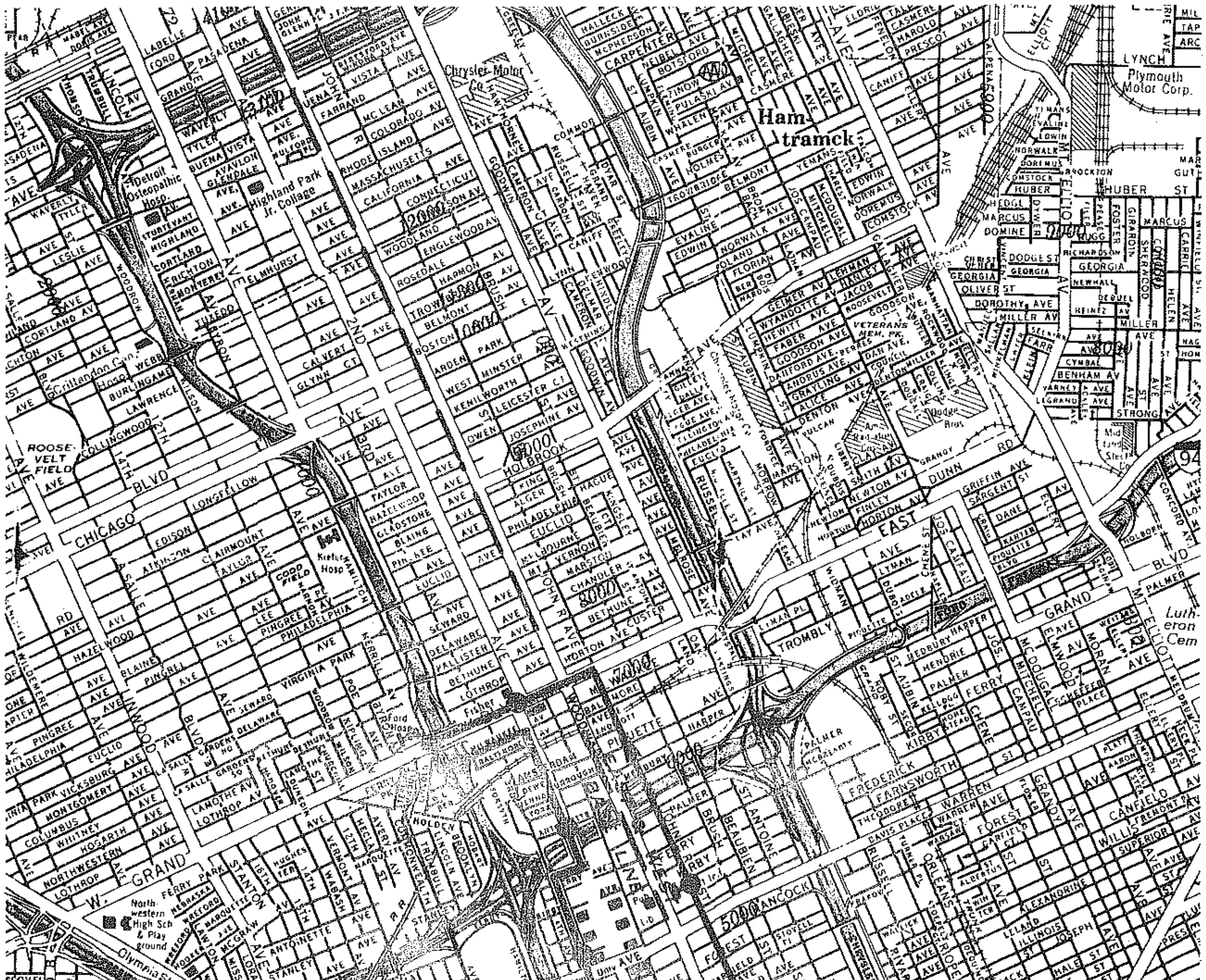


Figure 6-4 New Center Distribution Loop

John R. The distribution loop serves the New Center, Wayne State University, the Medical Center, the Cultural Center, and Ford Hospital.

Starting at the southeast corner, the Medical Center at the intersection of Alexandrine and John R, the New Center distribution loop follows John R north to Grand Boulevard. The buses proceed west on Grand Boulevard to the southbound service drive of the Lodge Expressway at Ford Hospital. The service drive is followed one block south to Milwaukee Avenue. The buses turn east onto Milwaukee and proceed to Second Avenue, then south on Second to Alexandrine and east on Alexandrine to John R, completing the loop.

Access to the New Center distribution loop is readily accomplished from the Lodge and I-94 Freeways. BRT vehicles exiting either of these freeways would travel a minimum distance to access the loop. The Lodge Freeway exit is onto the southbound service drive at Grand Boulevard, and this section of service drive is part of the distribution loop. To access the loop from the Jefferson corridor, the BRT buses would follow the Chrysler Freeway from Jefferson to Warren, exit at Warren, and proceed west on Warren to John R, where the loop would be entered.

The route, as shown, has six proposed stops, serving the major trip attractors in the area. These stops are tentative; changes in demand may dictate adding, deleting, or moving stops.

The estimated time necessary to complete one circuit of the loop is 28 minutes, assuming a distribution speed of 10 mph.

6.2.6 Dearborn-Ford Complex Distribution

The distribution route for the Ford complex is approximately 8.4 miles long and is illustrated in Figure 6-5. The major trip attractors served by the route are the Ford Central Staff Building, the Ford Research and Engineering Center, and the Ford Rouge Plant.

One end of the distribution route is on American Road adjacent to the Ford Central Staff Building. From American Road, the route proceeds west on Michigan Avenue to the Southfield Freeway. The BRT buses then turn south onto the Southfield Freeway service drive. The service drive is followed south to Rotunda Drive. The buses then turn west on Rotunda, proceed to the Ford Research and Engineering Center, turn around, and proceed east on Rotunda to Miller Road. On Miller Road, the Ford Rouge Plant is served. The buses then proceed north on Miller to Michigan Avenue and I-94. The route is not run on exclusive lanes, and therefore, could be run in either direction. The decision as to whether to serve the Rouge Plant or the Ford Central Staff Building first is dependent upon employee starting times.

Approximately 34 minutes are required to complete one circuit on the distribution loop, assuming an average speed of 15 mph.

Figure 6-5 Ford Complex Distribution Route

6.2.7 Northland Distribution

The Northland distribution route is approximately 2.8 miles long and is illustrated in Figure 6-6. The major trip attractors are Providence Hospital, the Northland Shopping Center, and the businesses in the area adjacent to Northland.

The proposed route begins at the Nine Mile Road exit of the southbound Lodge Freeway (US-10). The route then proceeds east on Nine Mile Road to Greenfield Road, where the BRT buses turn south. The route follows Greenfield Road south to Northland Drive, where the buses turn west across US-10 and onto the service drive to return to the southbound Lodge Freeway, ending the route.

Bus stops have been tentatively located on Nine Mile at Rutland, Nine Mile at Providence Hospital, on Greenfield north of J. L. Hudson Drive, on Greenfield at one entrance to Northland Center, and on Northland Drive at another entrance to Northland Center. These five stops would adequately serve the major trip attractors in the area.

No exclusive bus lanes are proposed for the distribution route. Assuming a 10-mile per hour distribution speed, approximately 17 minutes are required to complete one circuit around the loop.

6.3 Construction Requirements

Construction and facility requirements for BRT implementation on the various corridors include lane marking and signs for exclusive bus lanes and exclusive bus ramps for the freeway implementations. The requirements of the CBD and New Center distribution loops are first described. Then the requirements of each corridor are discussed.

6.3.1 Distribution Loops

The CBD and New Center distribution loops are essentially the same, regardless of which corridor is assumed. The basic routes are described in Section 6.2 as exclusive lanes utilizing contra-flow on one-way streets to a great extent. It is proposed that the loops be reserved for exclusive use by buses on a permanent basis throughout the day and that local buses use them during base periods. The exclusive lanes must be clearly identified with signs and pavement marking. A double, solid yellow line on the edge of the lane is suggested. The exclusive lane should further be identified with a standard diamond-shaped marking at appropriate intervals in the center of the lane to indicate transit vehicle priority. The diamond marking which has been approved by AASHO is 12 feet long by 2 1/2 feet wide and consists of 6-inch solid white lines. In addition to the lane marking, two or three double-faced signs per block are required to identify the exclusive

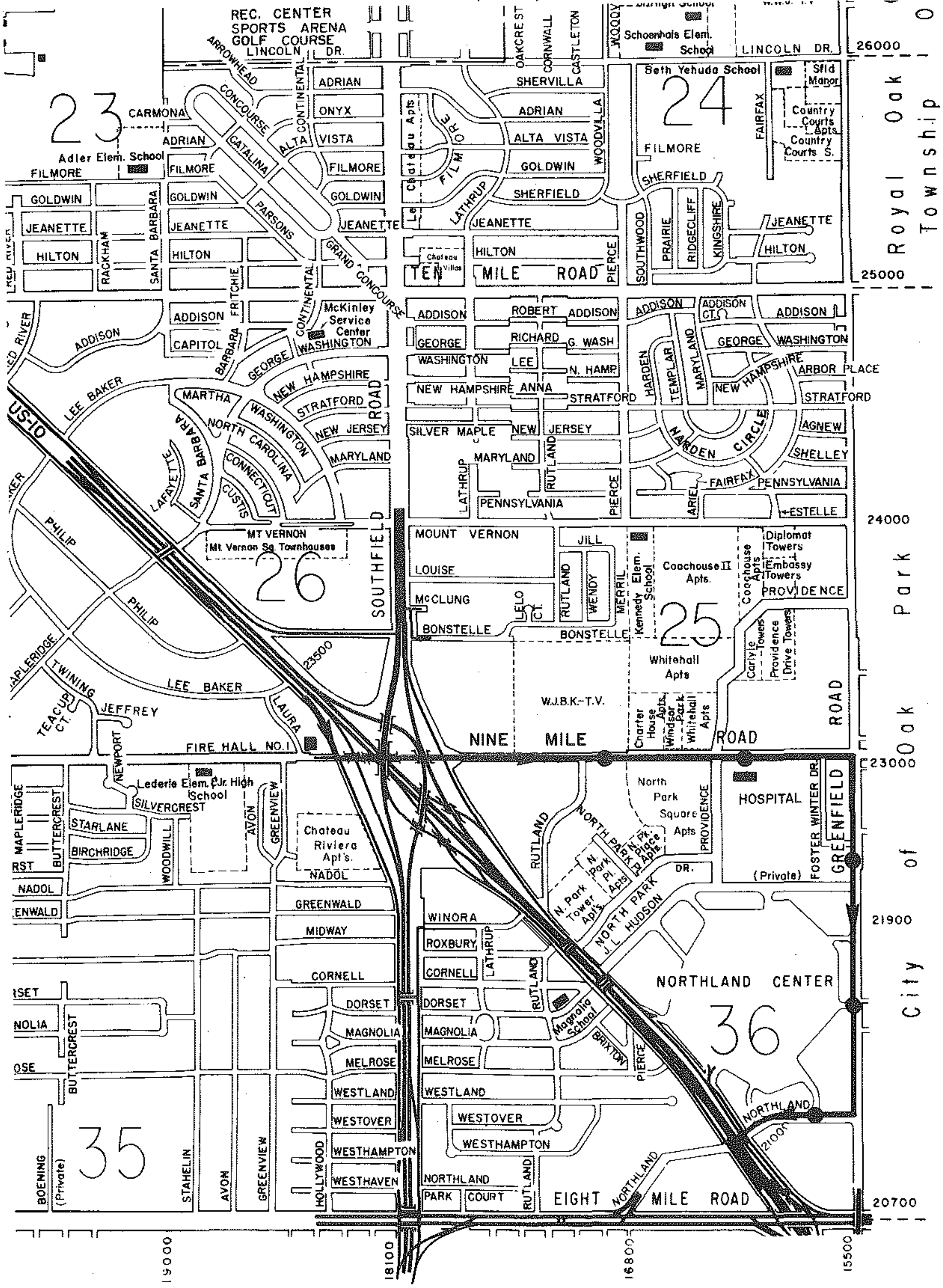


Figure 6-6 Northland Distribution Route

transit lane. A total of 204 signs are required for the CBD loop, and 256 signs are required for the New Center loop. In addition, 17 signs are required for the CBD and New Center loops to identify bus stop locations.

As indicated in Section 6.2, special signals are required at each turn in the CBD and New Center distribution loops to stop other traffic and to allow BRT vehicles to make left turns across traffic lanes. Five such signals are required for the CBD loop, and four signals are required for the New Center loop. In addition, standard signal heads which face the reverse flow direction on one-way streets are required at signalized intersections where BRT vehicles operate in contra-flow lanes. It is estimated that 21 and 14 signal heads are required for the CBD and New Center distribution loops, respectively.

The CBD distribution loop associated with any of the three freeway corridors also includes an exclusive BRT entrance ramp to the Lodge Expressway to facilitate bus departures from the CBD during the evening peak period. The distribution loop is extended one block south on Cass to Larned and then two blocks west on a contra-flow lane on Larned to the Lodge Expressway. The proposed bus only entrance ramp, which is illustrated in Figure 6-7, allows buses to bypass the queue at the metered automobile entrance ramp. The proposed ramp requires no new right-of-way, but a retaining wall may be required to prevent soil erosion.

No priority treatment is proposed for either the Ford Complex Distribution loop or the Northland/Southfield loop. Signs are required, however, to identify bus stop locations. Three are required for the Ford Complex loop and five are required for the Northland loop.

6.3.2 East Jefferson Corridor

The selected BRT implementation for East Jefferson inside the city of Detroit is the center lane reserved for buses with the inside lane in the off-peak direction designated as the left turn lane, as illustrated in Figure 6-1. In this concept, the function of three lanes varies with the time of day. The center lane is a reversible bus-only lane during peak periods and the left turn lane at other times. The left lane on eastbound Jefferson serves as the left turn lane during the morning peak period and as a normal traffic lane at other times. Similarly, the left lane of westbound Jefferson serves as the left turn lane during the evening peak period and as a normal traffic lane at other times. In order to control the use of these lanes as a function of the time of day, variable message signs and lane control signal heads are required at appropriate intervals along the street. It is estimated, based on the experience of Florida DOT with the Orange Streaker, that approximately five sign locations per mile or 30 locations are required. A total of six variable message signs and four lane control signal heads (red X and green arrow) are required for each location. Restriping of these lanes is also required to help identify the multiple use of these lanes. The diamond-shaped pavement marking should not be used in the center lane, since it is not used as an exclusive bus lane during off-peak periods.

In addition to the variable message signs, 189 signs are required to identify bus stop locations in the East Jefferson corridor.

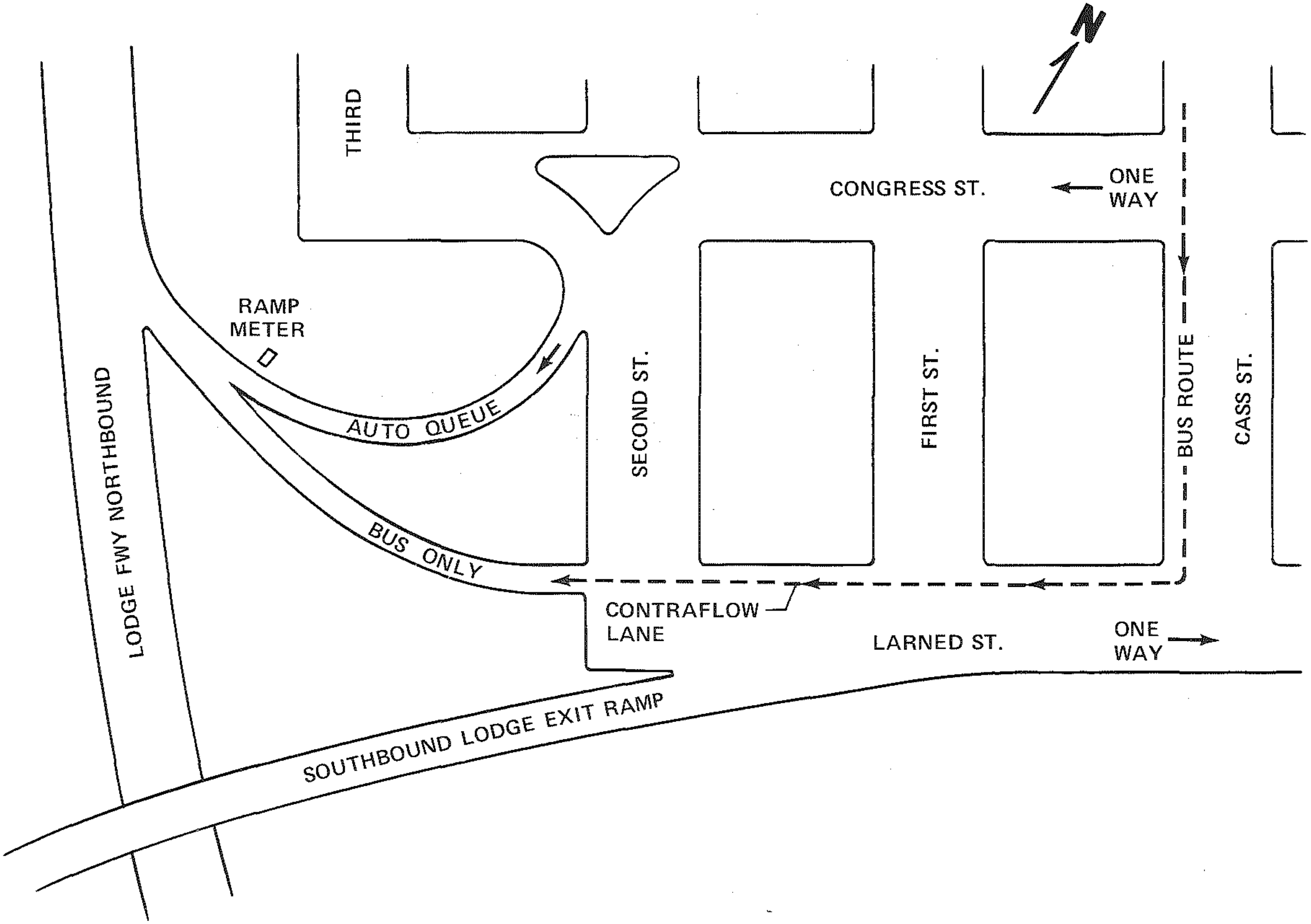


Figure 6-7 Conceptual Sketch of Bus Queue Jumper for Accessing Lodge Freeway Northbound from CBD

6.3.3 I-94 Crosstown Corridor

The major construction requirements for the Crosstown Corridor involve exclusive queue bypass ramps for buses to enter the metered freeway. Thirteen such ramps are proposed for this corridor, including the entrance ramp to the Lodge Expressway from the CBD distribution loop. All of the exclusive bus entrance ramps are similar in design to the typical ramp illustrated in Figure 6-8. All of the ramps provide a separate entrance from the service drive for buses and then merge with the existing automobile ramp upstream from the freeway merge. Inductive loops are placed in the bypass lane at a spacing which allows the presence of a bus to be sensed. The presence of a bus preempts the automobile ramp meter and holds the signal red until the bus has entered the common portion of the ramp. This technique for giving buses priority at metered ramps is operating safely and efficiently in Minneapolis-St. Paul as part of the I-35W Urban Corridor Project. The proposed ramps at Ten Mile, Cadieux, Van Dyke, Livernois, and Michigan will follow the typical design very closely and can probably be constructed on existing right-of-way. Two ramps are required at Livernois--one to the eastbound Ford Expressway to access the CBD and New Center and the other to the westbound Ford to access the Dearborn area. A queue-jumper lane, which is separated from the main ramp by a narrow grass median already exists at the entrance ramp from Livernois to the westbound Ford Expressway. This bypass lane would merely be extended to Livernois to provide exclusive bus access to the ramp. The entrance ramp from Gratiot near Thirteen Mile is a long (0.5 mile), two-lane ramp with considerable queue space to store automobiles when the expressway ramps are metered. Right-of-way appears to be available for widening the ramp to bypass the automobile queue. The bus ramp at Vernier would possibly require a retaining wall to prevent soil erosion, since the slope from the service drive to the expressway is rather steep in this area. Additional right-of-way may be required at both Chalmers and Conner to provide a separate entrance to the ramp for buses. The land which may be required at Chalmers is currently part of a retail store parking lot. The additional right-of-way which may be required for the ramp from southbound Conner is currently vacant. Two ramps are required near Woodward--one to access the Ford Expressway in each direction. The entrance ramp to the eastbound Ford Expressway is a one-lane bridge over the Ford-Chrysler interchange. Exclusive bus access to this ramp can be accomplished relatively inexpensively as illustrated in Figure 6-9. Since the service drive has three lanes in this area, one of them can be designated as a queue for automobiles waiting to be metered onto the expressway. The proposed queue lane is separated from the other lanes by a curb. The curb ends just before the bridge where a sign which reads "No Left Turn Except Buses" is located.

One bus-only sign is required for each exclusive bus ramp for a total of 13 signs. In addition, 210 bus stop signs are required for the corridor.

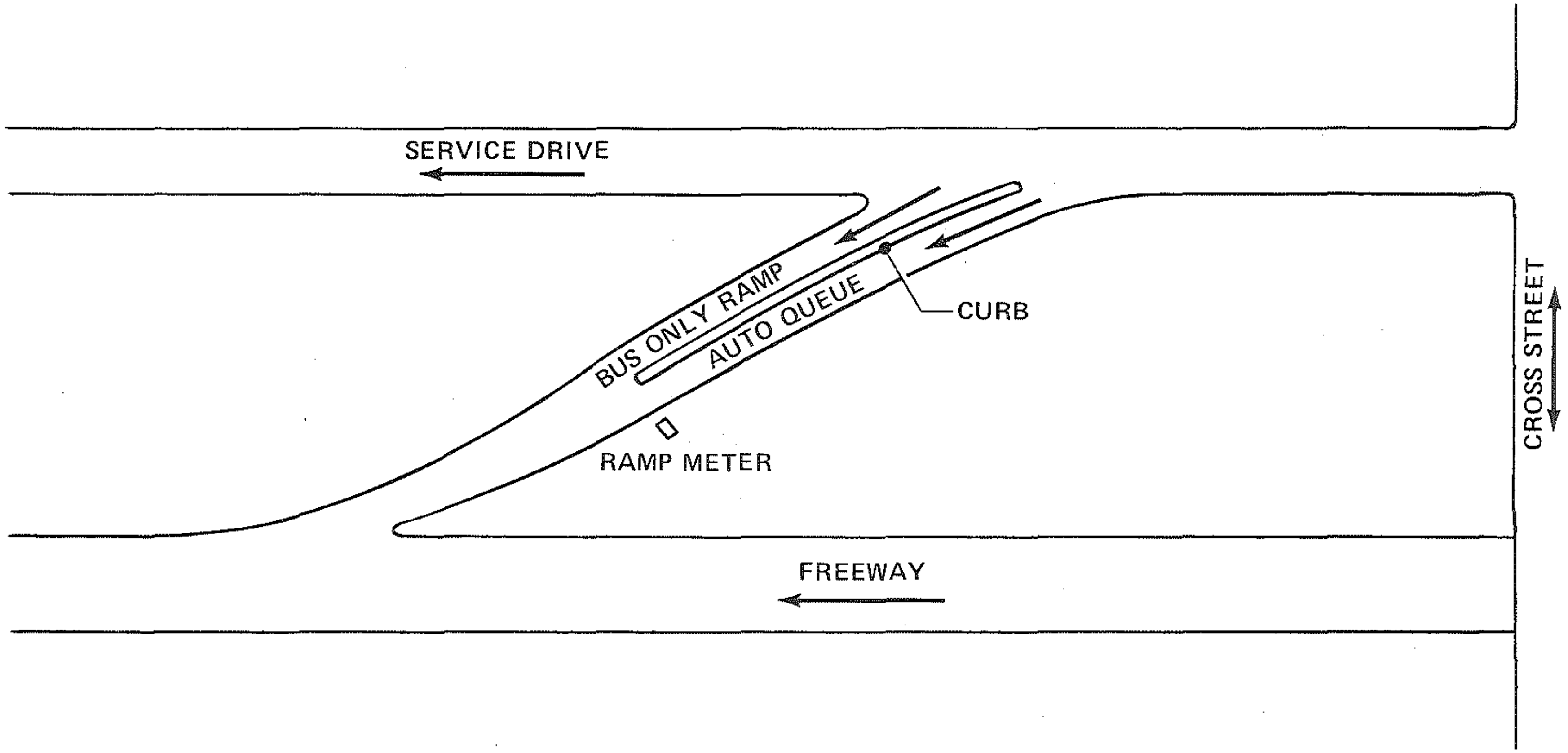


Figure 6-8 Conceptual Sketch of Typical "Bus Only" Access Ramp

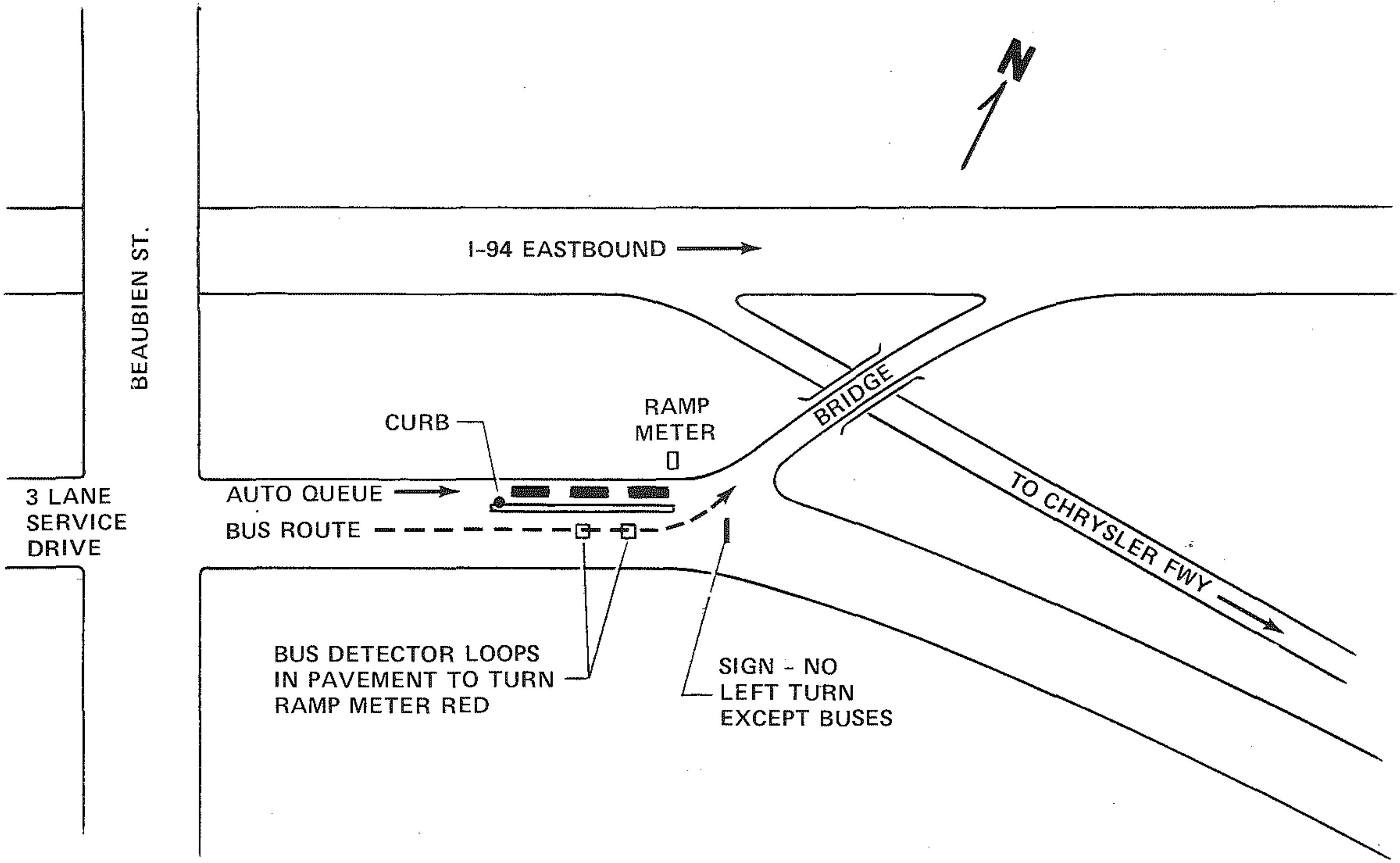


Figure 6-9 Conceptual Sketch of Bus Queue Jumper for Accessing I-94 Near Beaubien St.

6.3.4 Lodge Corridor

Eleven exclusive bus ramps are proposed for the Lodge Corridor, including the entrance ramp to the Lodge Expressway from the CBD distribution loop. The construction of these ramps is hindered in several areas by the existence of extensive retaining walls. The basic design of the ramps, however, is the same as the one described in the previous section. The ramps at Evergreen, Linwood, West Chicago, and West Grand Boulevard are all quite similar to the typical ramp illustrated in Figure 6-8. Two ramps are required at West Grand Boulevard--one to access the CBD via the expressway in the morning and one to enter the northbound Lodge from the New Center loop in the evening. The exclusive bus ramp from southbound Telegraph to the Lodge Expressway is likely to require extensive construction. The existing entrance ramp bridges the I-696 Freeway and begins very close to where the exit ramp from the northbound Lodge merges with southbound Telegraph. When SCANDI is implemented, if the ramp meter is located upstream of the bridge section on this entrance ramp, automobile traffic may queue up onto Telegraph and even block the exit ramp from the northbound Lodge. Therefore, the ramp meter for automobiles must be located on the bridge section, and the bridge must be widened to provide an exclusive entrance for buses. Two ramps are required at both Greenfield and McNichols. Extensive retaining walls line the Lodge Expressway at both of these locations, and the exclusive bus ramps must be cut through them.

A total of 11 bus-only signs are required for the exclusive bus entrance ramps, and 168 bus stop signs are required for the corridor.

6.3.5 Michigan/I-94 Corridor

Nine exclusive bus ramps are proposed for the Michigan/I-94 Corridor, including the bus ramp to the Lodge Expressway from the CBD distribution loop. The ramps at Telegraph, Southfield, Oakwood, and Livernois are all located on relatively flat land with gently sloping ramps. The typical exclusive bus ramp illustrated in Figure 6-8 can be constructed at these locations without significant variation. As in the Crosstown Corridor, two ramps are required at Livernois. The existing entrance ramp at Merriman Road is cut through very hilly terrain, and a considerable amount of grading will be required to construct an exclusive bus entrance ramp at this location. The ramp from eastbound Michigan Avenue to the eastbound Ford Expressway includes a two-lane bridge over the expressway near the end of the ramp. An exclusive entrance for buses can be constructed upstream of the bridge section on existing right-of-way, so no new bridge construction is required. One exclusive bus entrance ramp at Woodward (Woodward to the westbound Ford) is required to serve this corridor.

Nine bus-only signs and 147 bus stop signs are required.

6.4 Travel Time Comparisons

Bus rapid transit is intended to compete effectively with other transportation modes currently available in Metropolitan Detroit. Among the most important attributes of any transportation mode is its portal-to-portal travel time for a particular trip being considered. This measure of service, therefore, was chosen as the basis for a comparison of alternative modes in each of the four candidate BRT corridors.

The following transportation modes, where appropriate, were compared for a particular trip in each corridor:

- Automobile
- Local bus
- "Conventional" express bus
- Bus rapid transit

Local bus travel times were considered only for corridors in which local bus service is currently provided on routes at least partially coincident with, or adjacent to, those proposed for BRT operation. A similar policy was applied with regard to express bus service.

6.4.1 Travel Time Elements

A "typical" trip in each corridor was selected for travel time comparisons. These trips are simply examples and are not minimum, maximum, or average trips in their respective corridors. The distance elements of the example trip vary among the four corridors, but are constant for the various modes within each specific corridor.

The following three explicit distance elements comprise each example trip (it is assumed that an identical path is followed, regardless of travel mode, for a particular origin/destination zone pair):

- Travel from the origin zone centroid to the nearest corridor mainline access point
- Travel along the mainline BRT route
- Travel to the destination zone centroid from the mainline egress point nearest that location

Distances are implied, but not specifically stated, in two additional elements of the bus trips considered. First, time is allowed for a walk from the traveler's residence to a nearby bus stop. Also, a time is identified for a walk from the drop-off bus stop to the traveler's ultimate destination. Auto trips include an implied travel distance in the time allowed for the traveler to locate a parking space, park the car, then complete the trip.

Other travel time elements are not related to trip distances. For bus trips, these elements include a waiting time at the trip's initial bus stop and, for all bus modes except BRT, a bus transfer time (at the intersection of two local bus routes, or at the interface between a local bus and an express bus). For auto trips, times are allowed to start the car and (with the exception of the East Jefferson corridor) wait in queue at a metered freeway ramp.

6.4.2 Travel Time Program

A computer program was developed to perform the task of calculating portal-to-portal travel times associated with various modes in each corridor. The program also computes the bus-to-automobile travel time ratio for each type of bus transit being examined.

The program includes several assumptions regarding travel by each mode. For automobile trips, the following assumptions were applied:

• Start car (minutes)	1.0
• Travel to mainline entry point (miles per hour)	25.0
• Freeway entry ramp queue time, where applicable (minutes)	3.0
• Travel to parking lot from mainline exit point (miles per hour)	15.0
• Park and walk to CBD destination (minutes)	7.0

Local bus, express bus, and BRT trip assumptions are listed below:

• Walk to bus stop (minutes)	5.0
• Wait for bus (minutes)	5.0
• Travel to mainline entry point (miles per hour)	15.0
• Transfer to second bus, except BRT (minutes)	5.0
• Travel to drop-off bus stop from mainline exit point (miles per hour)	8.0

The mainline travel speeds (in miles per hour) assumed for each travel mode are listed by corridor below:

East Jefferson	
- Automobile	31.0
- Local bus	10.9
- Express bus	15.7
- Bus rapid transit	31.0
I-94 Crosstown	
- Automobile	40.0
- Local bus	13.5
- Express bus	18.4
- Bus rapid transit	40.0
Lodge Freeway	
- Automobile	40.0
- Local bus	--
- Express bus	20.5
- Bus rapid transit	40.0
I-94/Michigan	
- Automobile	40.0
- Local bus	13.1
- Express bus	--
- Bus rapid transit	40.0

The automobile travel speed for East Jefferson is based upon a limited number of peak-hour tests by GM TSD personnel. The auto speed for freeway travel assumes the presence of a ramp metering system capable of maintaining free-flowing traffic at an average speed of 40 miles per hour. In all cases, it is assumed that BRT speeds equal those of automobile traffic. Local and express bus speeds for East Jefferson apply to buses presently operating on that arterial. Local and express bus speeds for the I-94 Crosstown Corridor are based upon the Crosstown route on Warren Avenue and the express bus currently operating on Gratiot Avenue, respectively. The average speed of the express bus presently on the Lodge Freeway is indicated for that corridor. Finally, the Michigan/I-94 Corridor local bus speed is based upon that of existing local bus service along Michigan Avenue.

The results of a travel time comparison run for the I-94 Crosstown Corridor, in addition to the trip-specific input data, are shown in Figure 6-10. Travel time ratios associated with example trips in all four candidate BRT corridors are presented in Table 6-1. All ratios in the table represent bus travel times divided by an estimated auto travel time for the same route. As discussed above, BRT and auto travel times assume the existence of ramp metering at access points to any freeway segments of the trip route.

Enter Corridor Access Distance	1.18
Enter Mainline Travel Distance	12.56
Enter Corridor Egress Distance	.37
Enter BRT/Auto Mainline Speed	40.
Enter Local Bus Speed	13.5
Enter Express Bus Speed	18.4

Auto Travel Time	
Start Car	1.00
Mainline Access	2.83
Ramp Queue Time	3.00
Mainline Travel	18.84
Mainline Egress	1.48
Park and Walk to Destination	7.00
TOTAL Auto Travel Time	34.15

Express Bus Travel Time	
Walk to Bus Stop	5.00
Wait for Bus	5.00
Mainline Access	4.72
Transfer to 2nd Bus	5.00
Mainline Travel	40.96
Mainline Egress	2.77
Walk to Destination	5.00
TOTAL Express Bus Travel Time	68.45

Local Bus Travel Time	
Walk to Bus Stop	5.00
Wait for Bus	5.00
Mainline Access	4.72
Transfer to 2nd Bus	5.00
Mainline Travel	55.82
Mainline Egress	2.77
Walk to Destination	5.00
TOTAL Local Bus Travel Time	83.32

BRT Travel Time	
Walk to Bus Stop	5.00
Wait for Bus	5.00
Mainline Access	4.72
Mainline Travel	18.84
Mainline Egress	2.77
Walk to Destination	5.00
TOTAL BRT Travel Time	41.33

Local Bus/Auto Travel Time Ratio	2.44
Express Bus/Auto Travel Time Ratio	2.00
BRT/Auto Travel Time Ratio	1.21

Figure 6-10 I-94 Crosstown Travel Time Comparison

Table 6-1 Travel Time Ratios (Examples)

CORRIDOR	REFERENCE TRIP DISTANCE (MILES)	LOCAL BUS/AUTO (EXISTING)	EXPRESS BUS/AUTO (EXISTING)	BRT/AUTO
E. JEFFERSON	8.7	2.61	2.11	1.36
I-94 CROSSTOWN	14.1	2.44	2.00	1.21
LODGE FREEWAY	18.3	---	1.87	1.26
MICHIGAN/I-94	14.8	2.46	---	1.24

6.5 Limited Modal Split Analysis

A significant part of the sketch planning process was to estimate the number of morning peak-period riders which could be expected to use BRT service in each candidate corridor. This demand estimate is a necessary input to the comparison of corridors, the evaluation of implementation plans, the estimation of capital and operating costs, and the assessment of preliminary routes.

This section discusses the general application of a modal split model, the results obtained, the model itself, the assumptions which were made to formulate input to the model, various computer programs associated with running the model, and a preliminary sensitivity analysis of input parameters. Finally, the modal splits of operational BRT systems elsewhere are discussed.

6.5.1 Modal Split Process

The first step of the modal split analysis was the preparation of a list of total morning peak-period person trips for each corridor, without regard to travel mode or trip purpose. A computer program was employed to read each corridor's 1965 peak-period trip file, adjust the numbers of trips according to 1965-to-1975 population changes, assign the trips to the corridor's mainline route, and produce a file containing the following information for each trip:

- Origin zone number
- Destination zone number
- Mainline access distance by transit
- Mainline travel distance by transit
- Mainline egress distance by transit
- Mainline access distance by automobile
- Mainline travel distance by automobile
- Mainline egress distance by automobile

As discussed in Section 6.2, only a portion of the mainline nodes in each corridor are designated as "transit nodes" at which transit trips may access the mainline route. Automobile access to the mainline route, however, is considered permissible at all nodes. This distinction in node types frequently results in differences between transit and auto trip segment lengths. The trip list generated for the modal split analysis, therefore, separately identifies transit and auto trip distance elements.

The total number of peak-period trips originating within each corridor and terminating in one of the corridor's specified destination zones is listed below:

East Jefferson:	20,193
I-94 Crosstown:	48,366
Lodge Freeway:	39,132
Michigan/I-94	25,340

The next step was to estimate what percentage of these trips would utilize the BRT system, i.e., the BRT modal split. The scope of this study did not permit the development and calibration of a modal split model. Therefore, it was decided to use the Peat, Marwick, Mitchell and Company (PMM and Company) aggregate mode split model which SEMCOG used to develop the transit modal split for the proposed SEMTA rapid rail transit system. Running this model with the operational parameters of the BRT system produced a first-order estimate of BRT ridership. The initial estimate was then screened to eliminate trips having less than two miles of travel on the mainline route.

6.5.2 Modal Split Results

The estimated number of BRT trips in each corridor (after screening) is shown in Figure 6-11. The BRT modal split, expressed as a percentage of total trips, is also indicated for each corridor. Current modal split to the CBD with existing transit is over 30 percent based on 1974 DDOT cordon count data.[1] The modal split estimate for the SEMTA 1990 high-level transit system for trips destined to the CBD is 60 percent.[2] Therefore, the modal split percentages obtained here for BRT appear to be reasonable estimates.

Utilizing screened BRT trip data, major trip production zones in each corridor were identified. Furthermore, the number of trips entering the mainline route at each transit node was totaled for each corridor and for major destination groups within each corridor. Figures 6-12 through 6-30 present the information described above for each of the four candidate BRT corridors. It should be noted that entry loads are not indicated for certain nodes which are planned as exit-only nodes, even though a small number of trips were assigned to enter at those points.

6.5.3 Discussion of Model

The Peat, Marwick, Mitchell and Company mode choice model was used by SEMCOG to develop a zone-to-zone transit trip matrix (1446 x 1446) for the morning peak period. This work is documented in a report by Schultz, "Application of a Modal Split Model to 1990 - Travel Estimates for the Southeast Michigan Region." He explained that the PMM and Company mode choice model was an outgrowth of a mode split technique developed by the National Capitol Transportation Agency in the early 1960's. The development of

---

[1] Detroit Central Business District Cordon Count, April 23-25, 1974, Department of Transportation.

[2] A Preliminary Proposal for High and Intermediate Level Transit in the Detroit Metropolitan Area, SEMTA, March 1974.

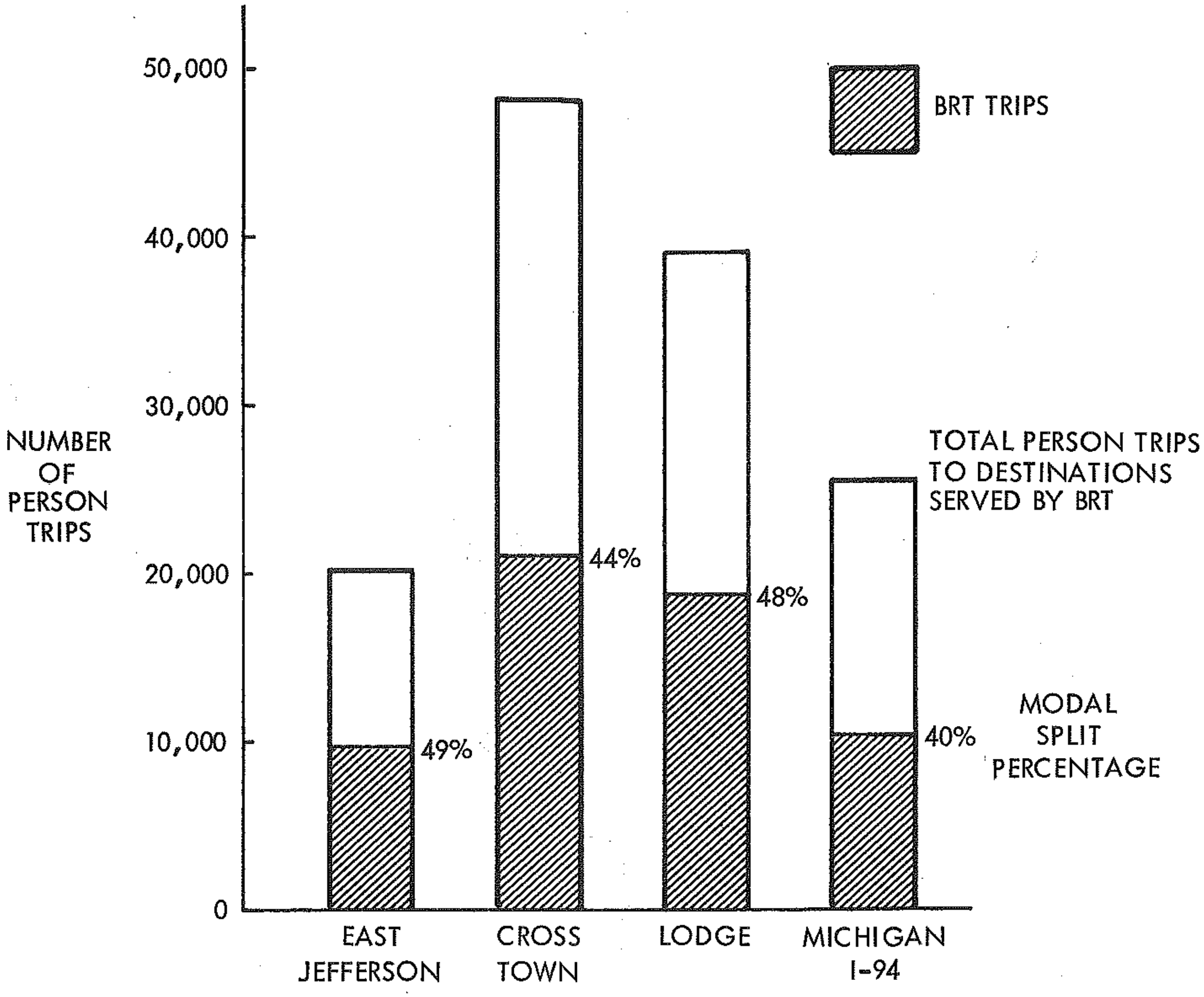


Figure 6-11 Modal Split by Corridor

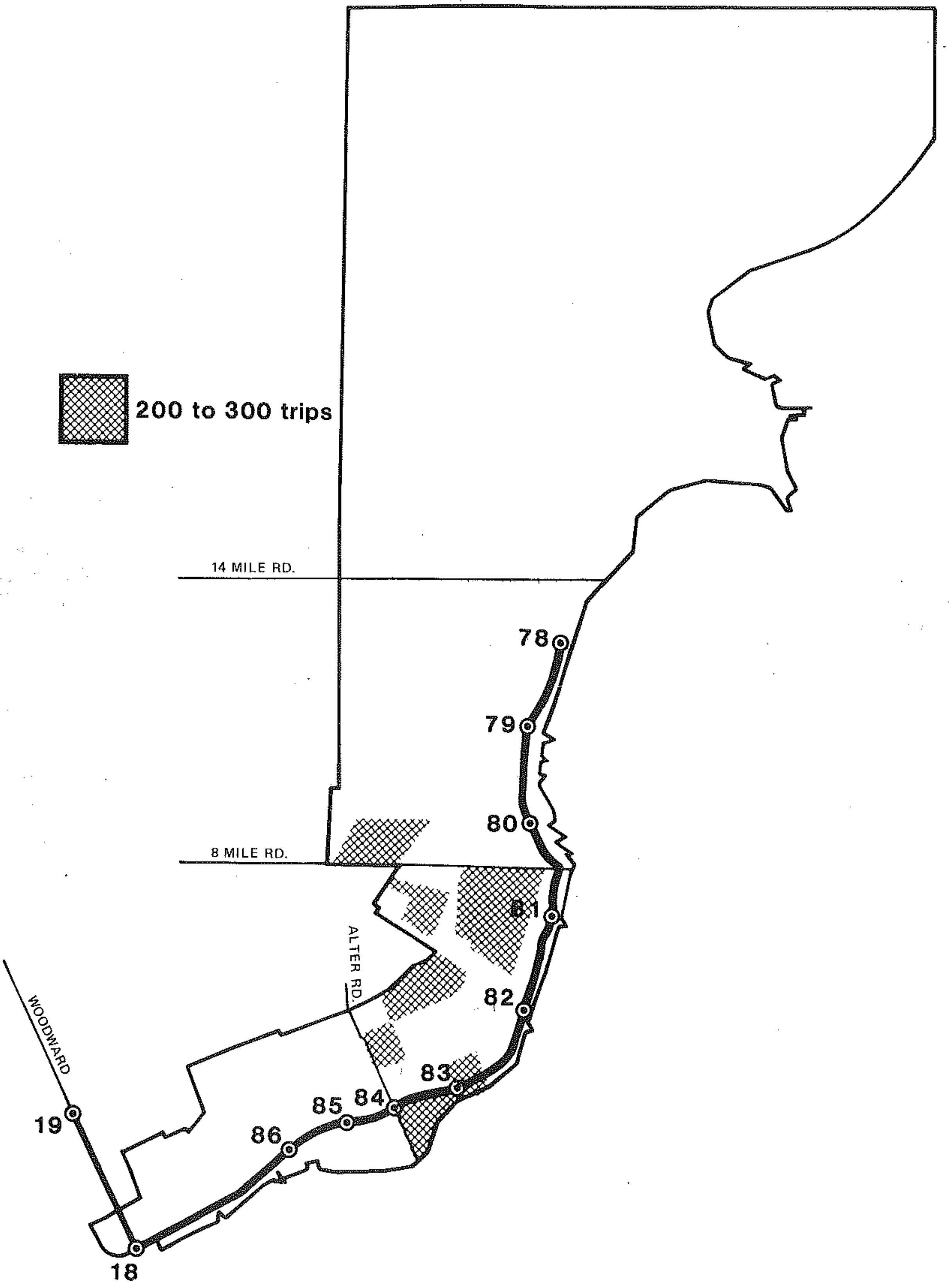


Figure 6-12 East Jefferson Corridor Major Trip Production Zones

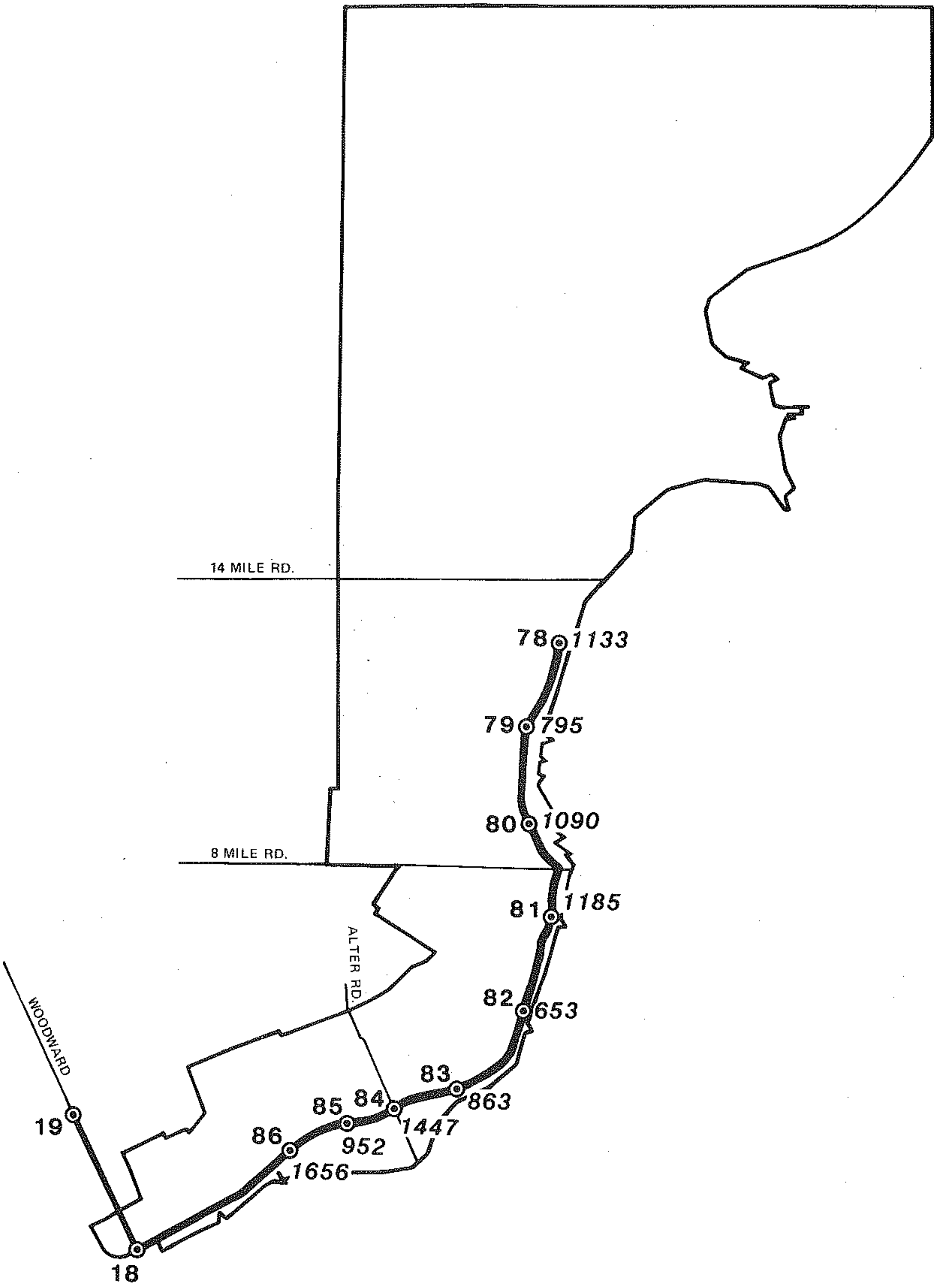


Figure 6-13 East Jefferson Corridor Node Loads - Total Trips

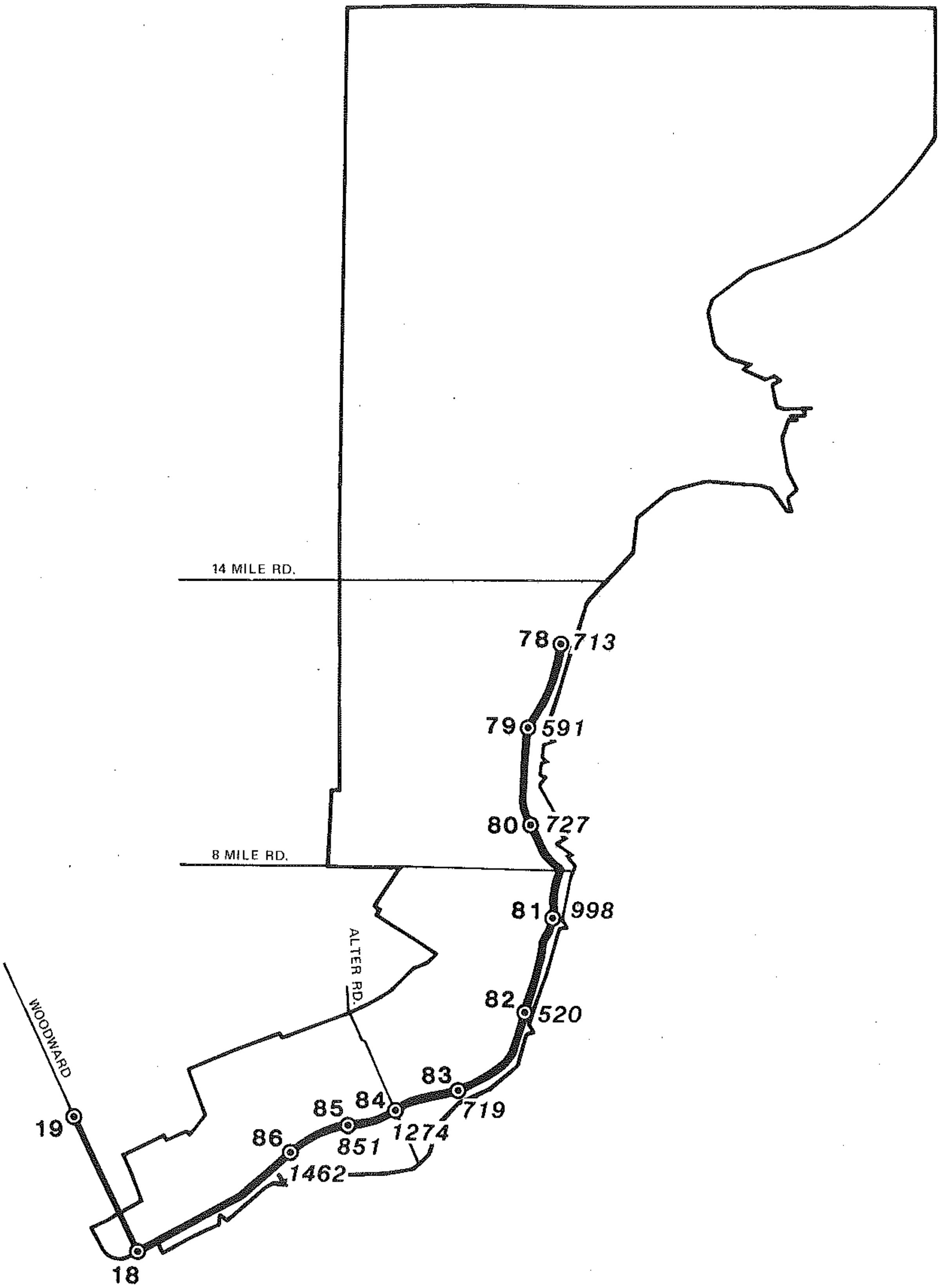


Figure 6-14 East Jefferson Corridor Node Loads - CBD Trips

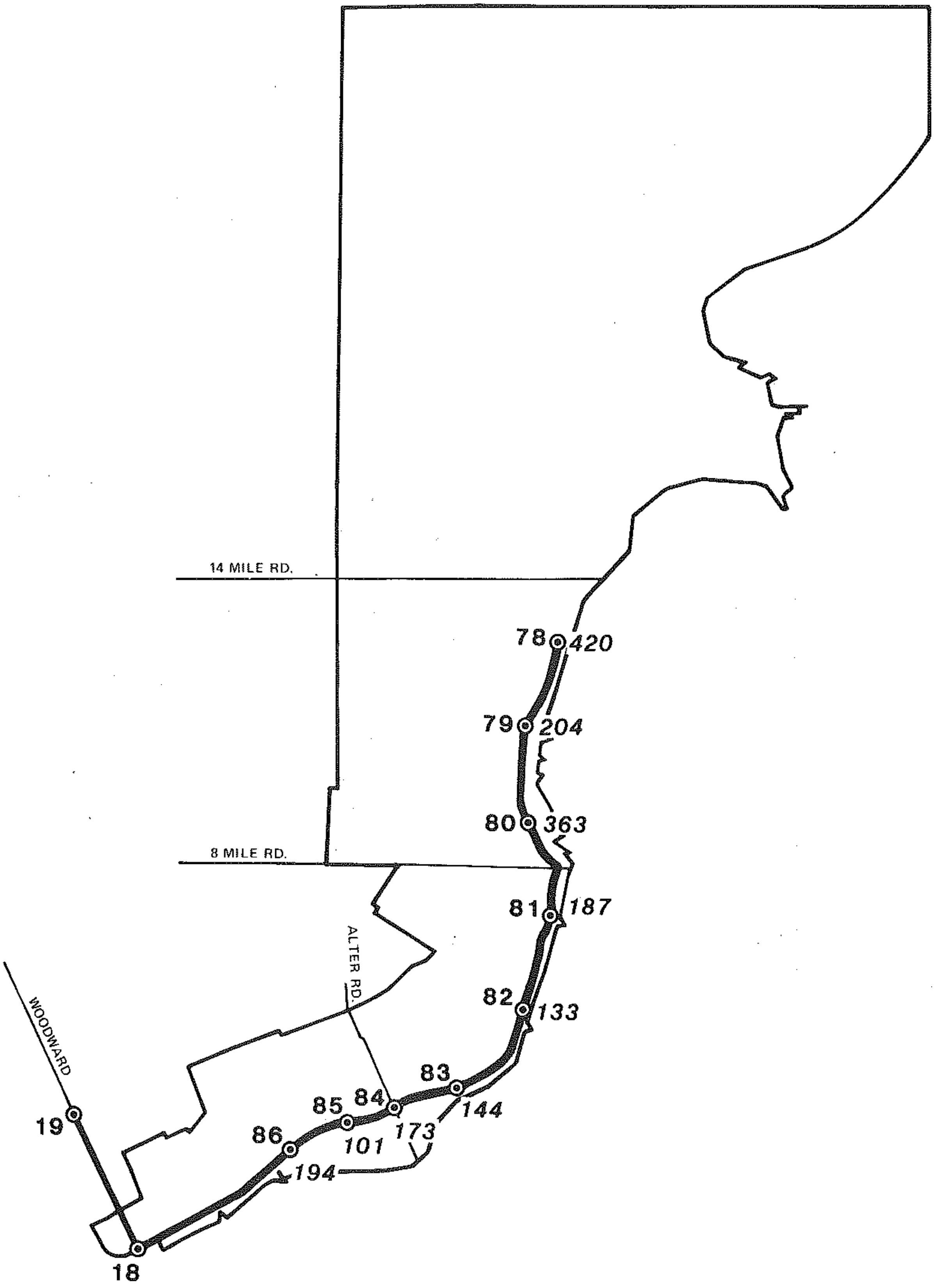


Figure 6-15 East Jefferson Corridor Node Loads - New Center Trips

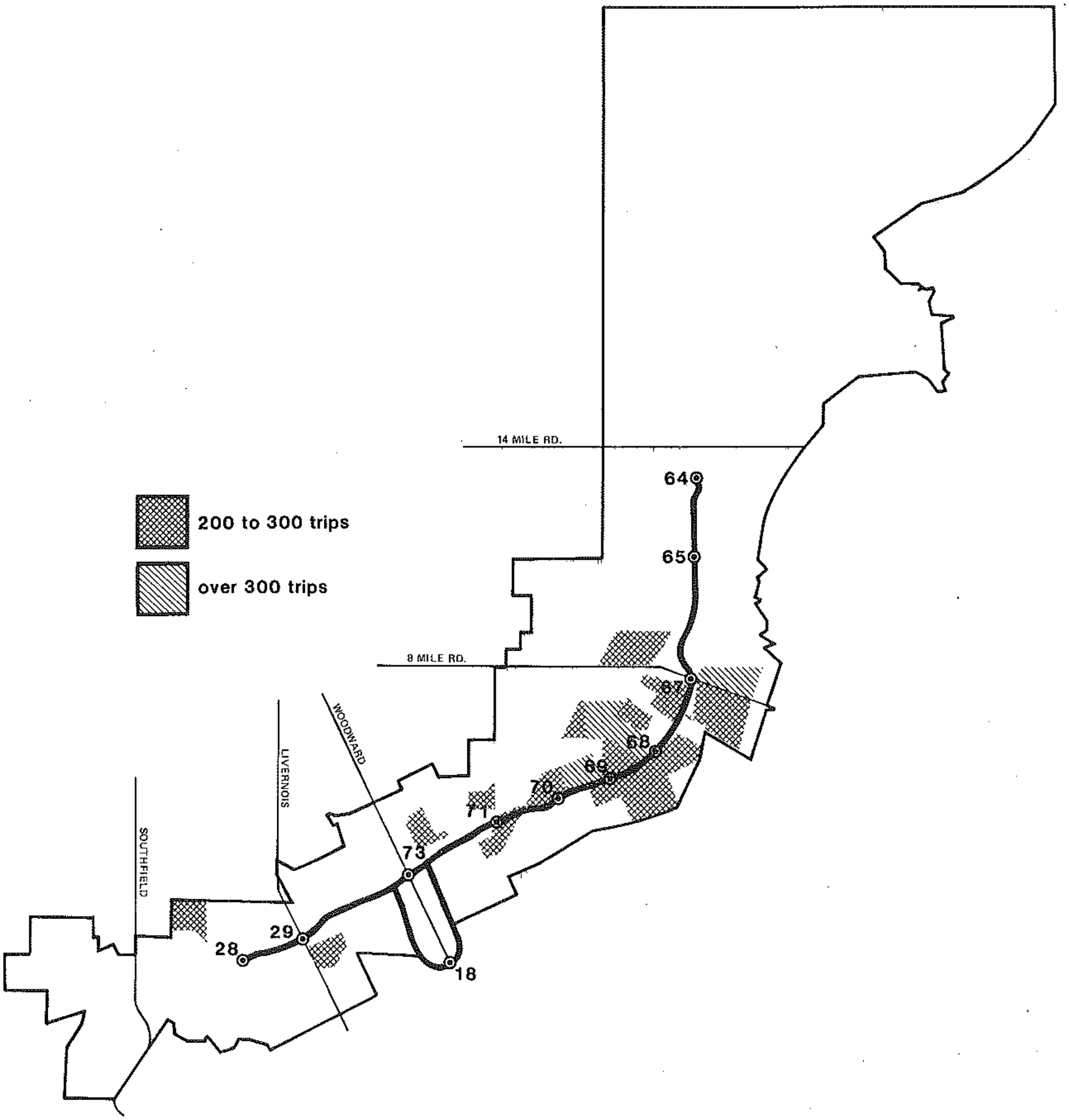


Figure 6-16 I-94 Crosstown Corridor Major Trip Production Zones

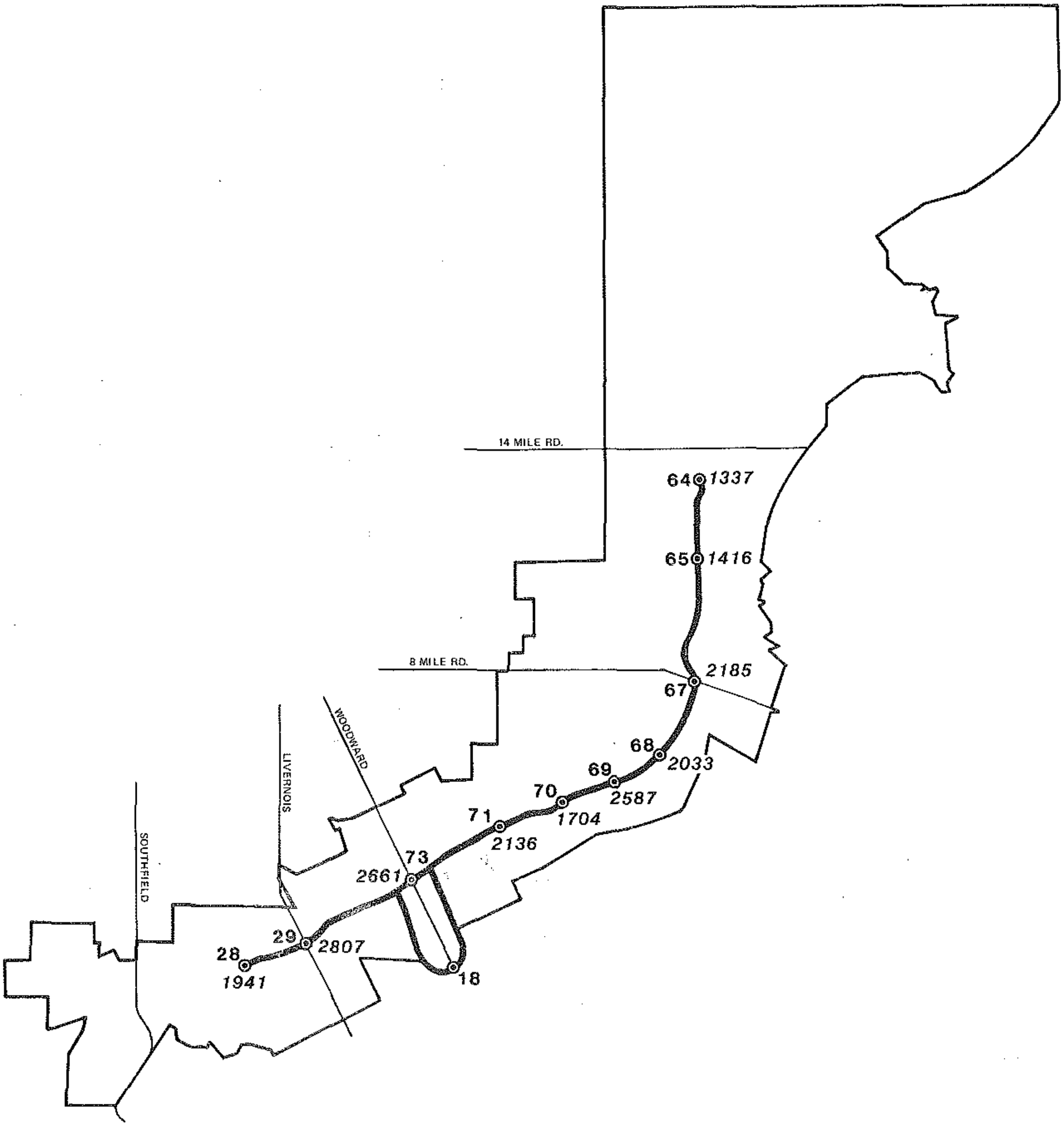


Figure 6-17 I-94 Crosstown Corridor Node Loads - Total Trips

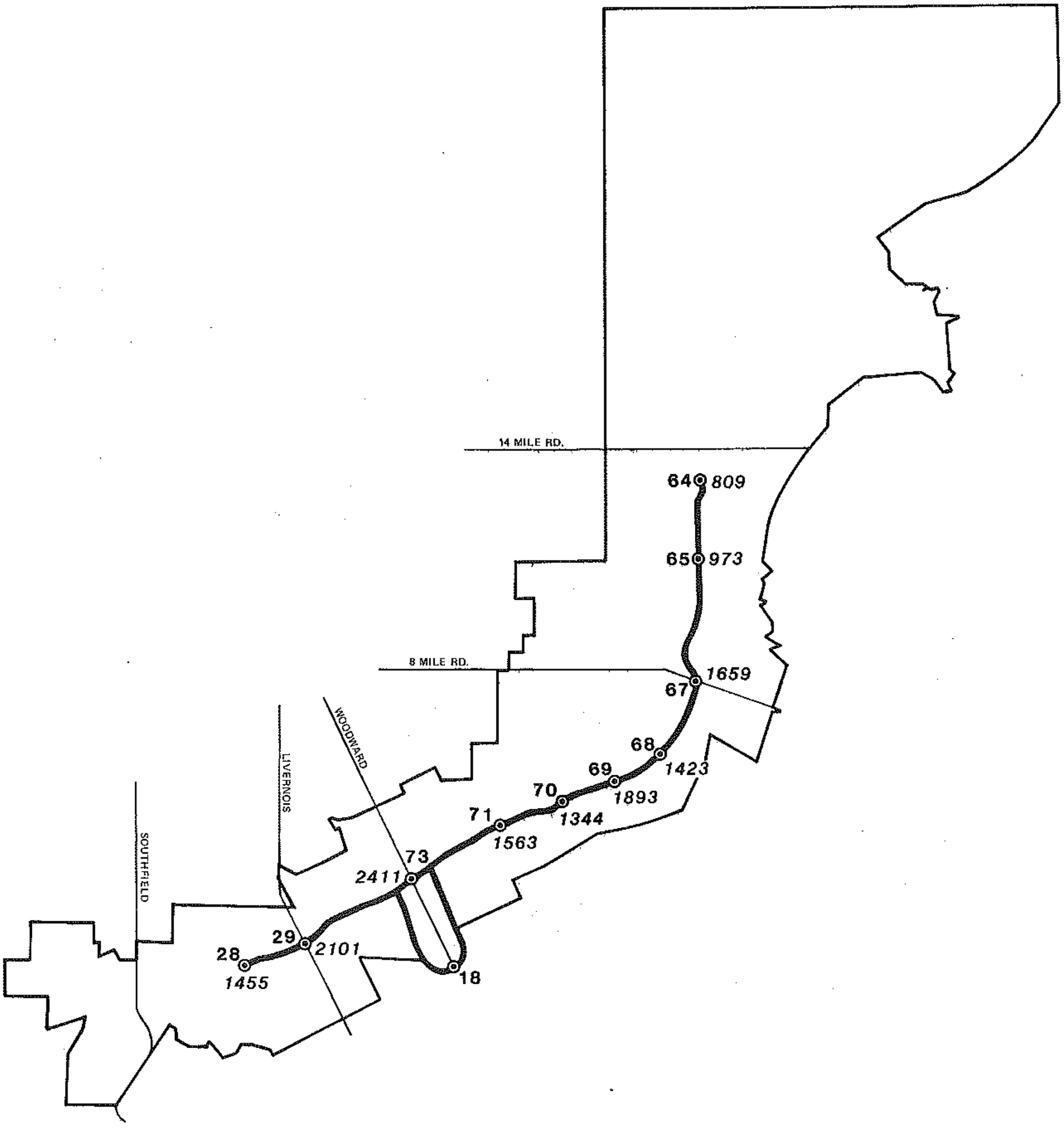


Figure 6-18 I-94 Crosstown Corridor Node Loads - CBD Trips

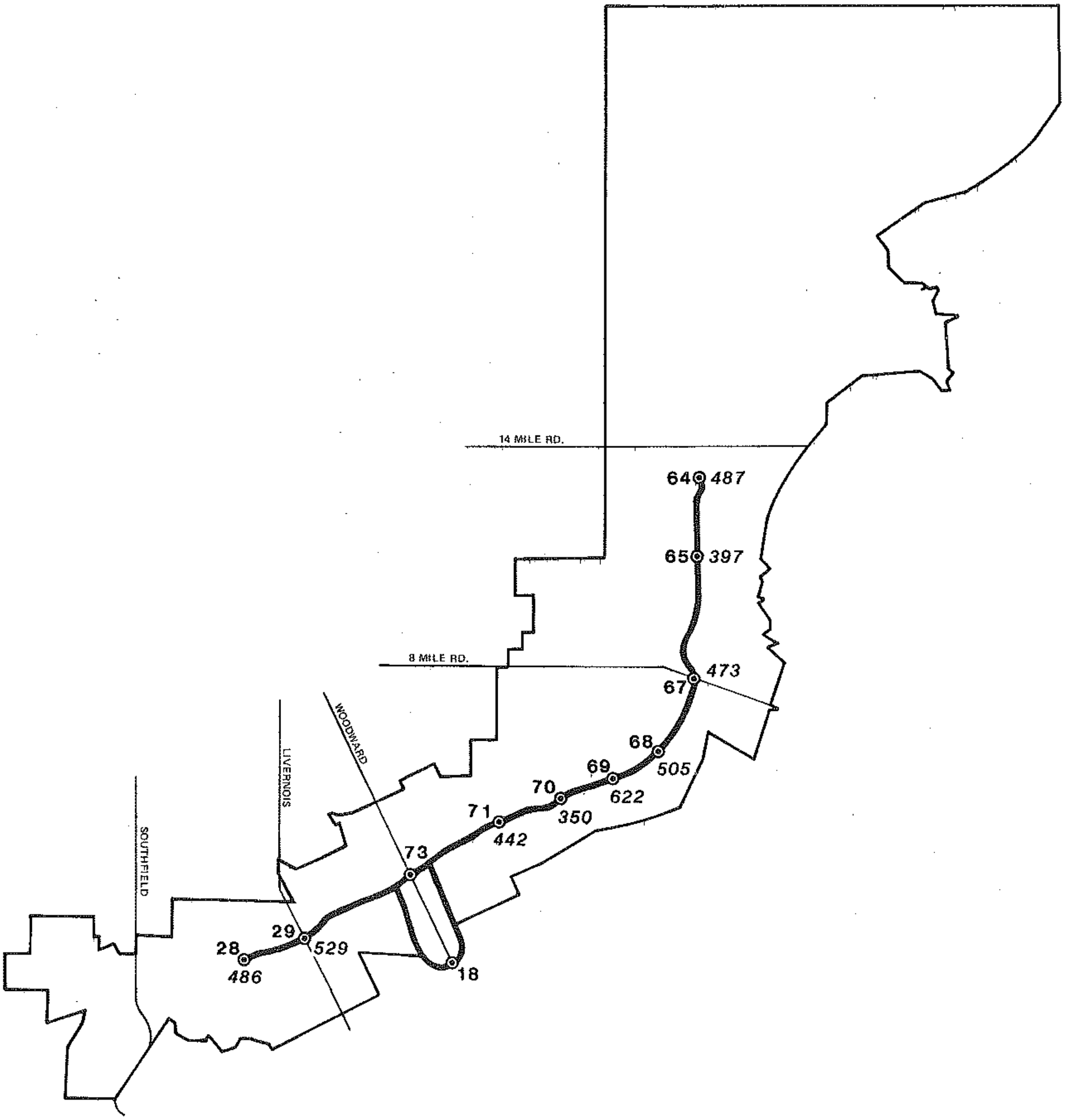


Figure 6-19 I-94 Crosstown Corridor Node Loads - New Center Trips

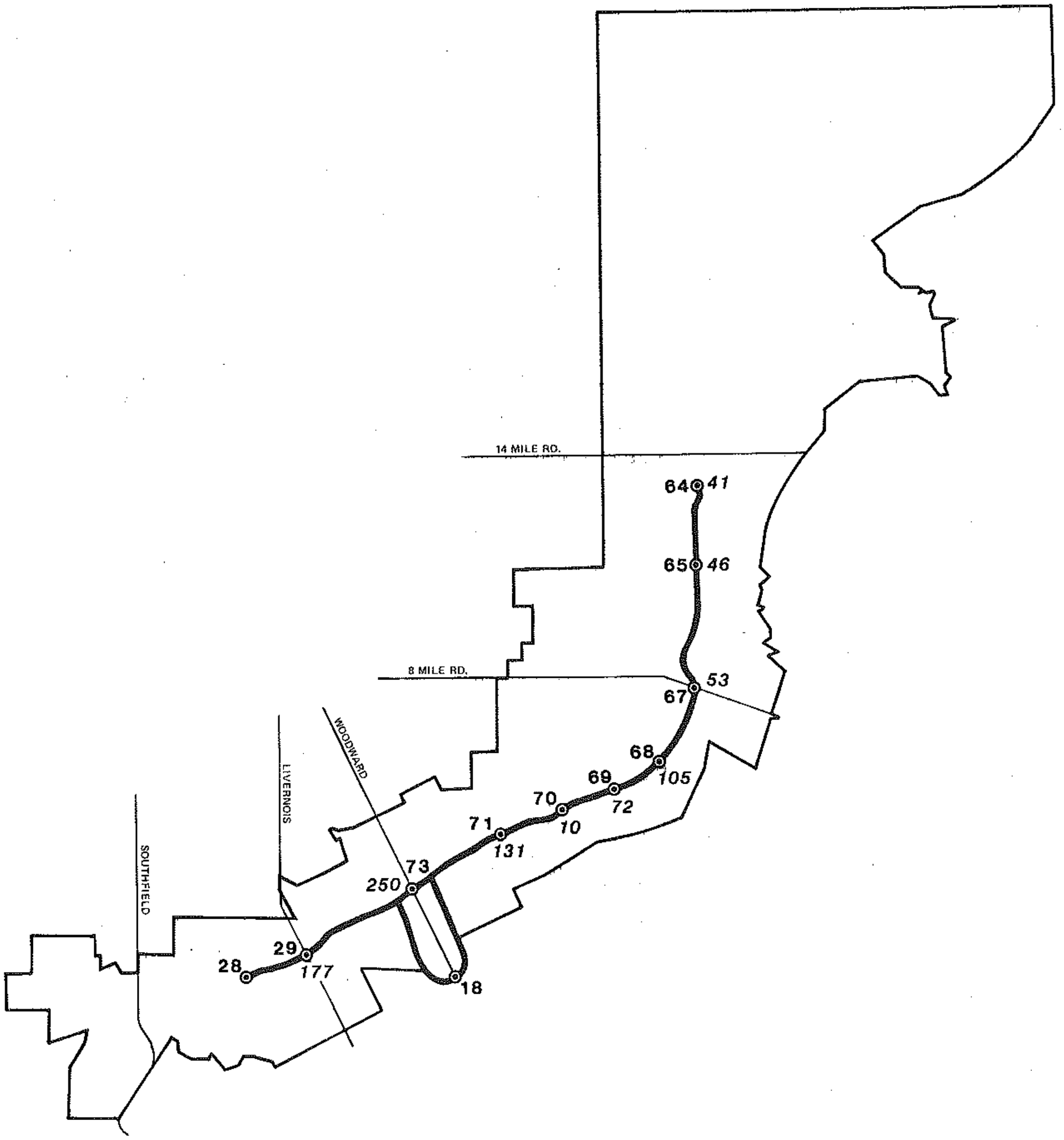


Figure 6-20 I-94 Crosstown Corridor Node Loads - Ford Complex Trips

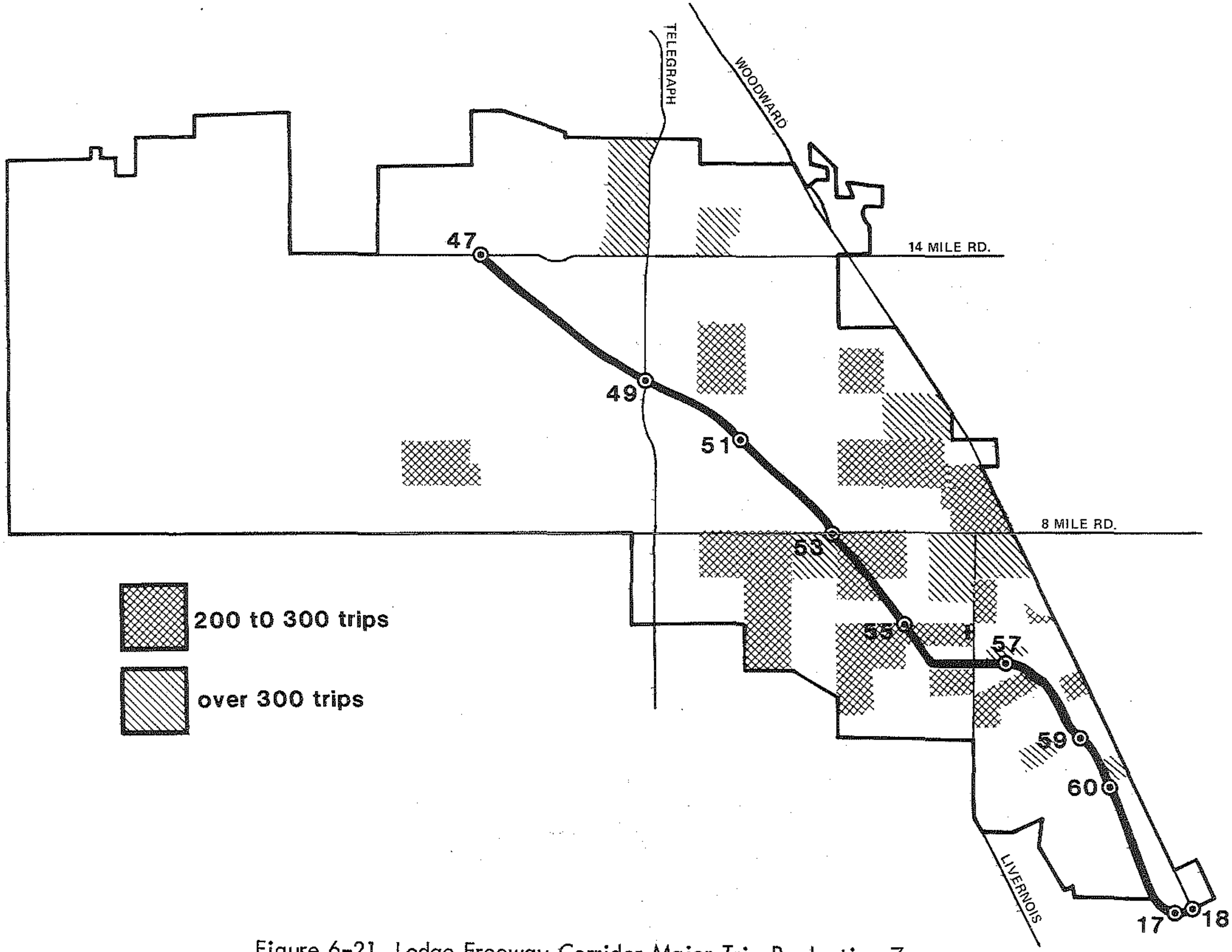


Figure 6-21 Lodge Freeway Corridor Major Trip Production Zones

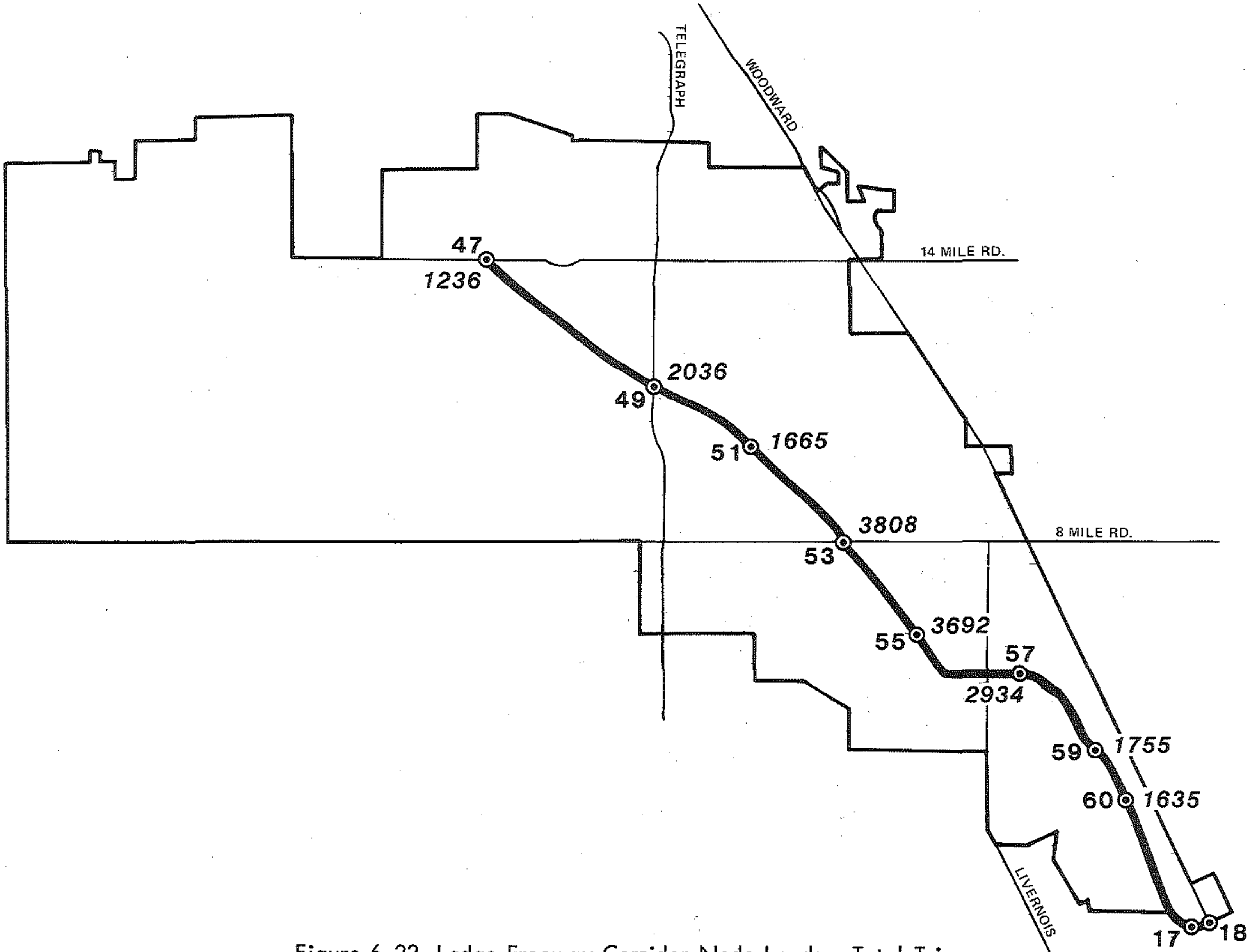


Figure 6-22 Lodge Freeway Corridor Node Loads - Total Trips

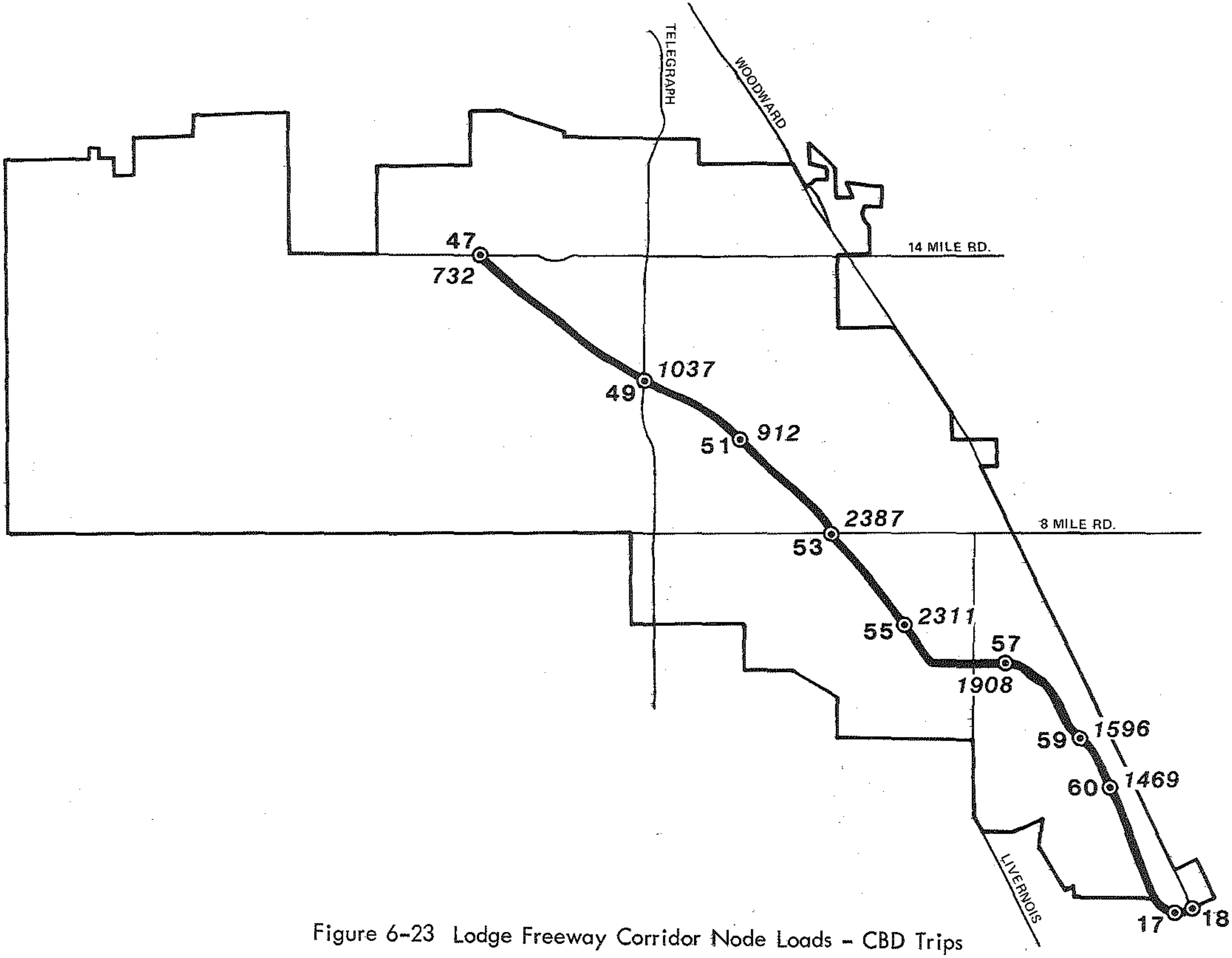


Figure 6-23 Lodge Freeway Corridor Node Loads - CBD Trips

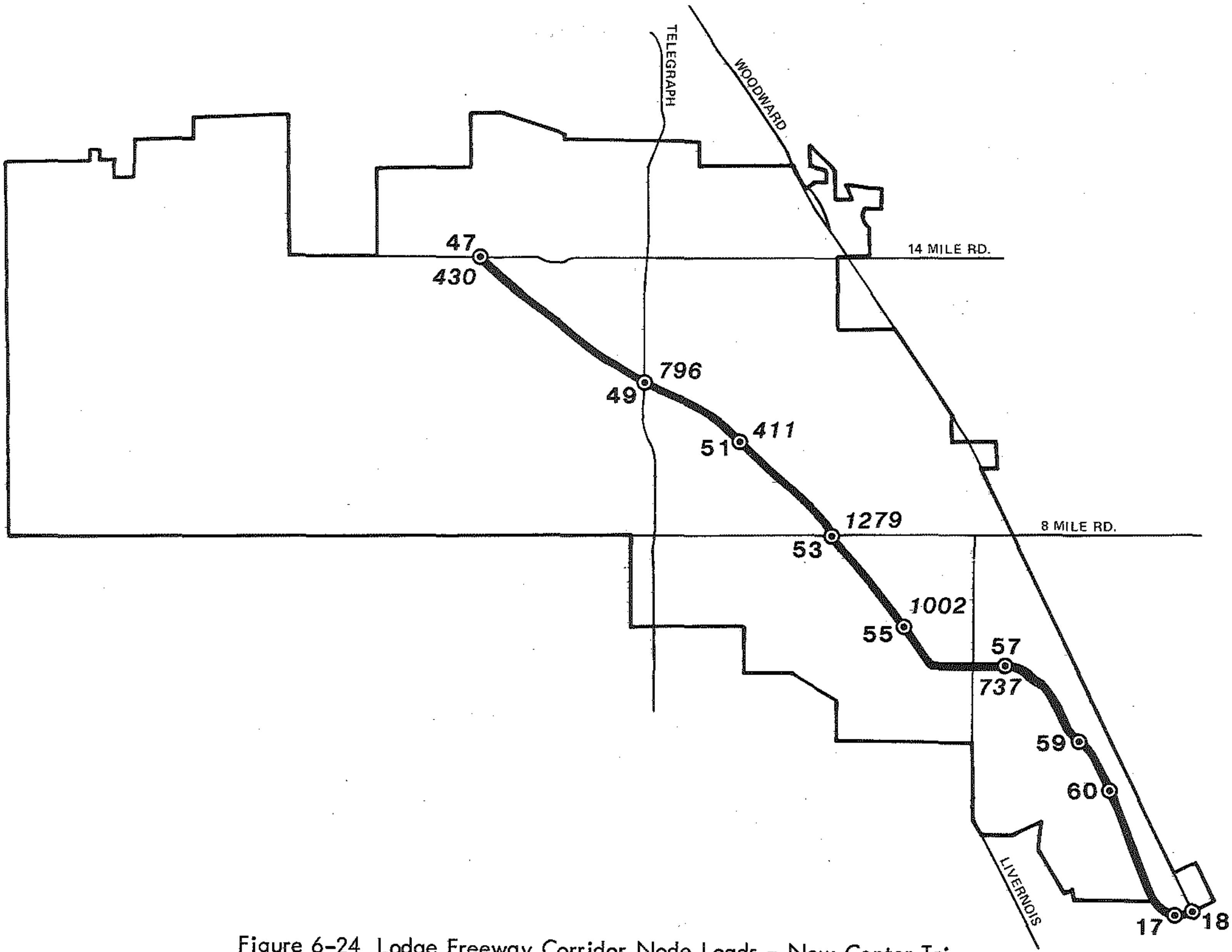


Figure 6-24 Lodge Freeway Corridor Node Loads - New Center Trips

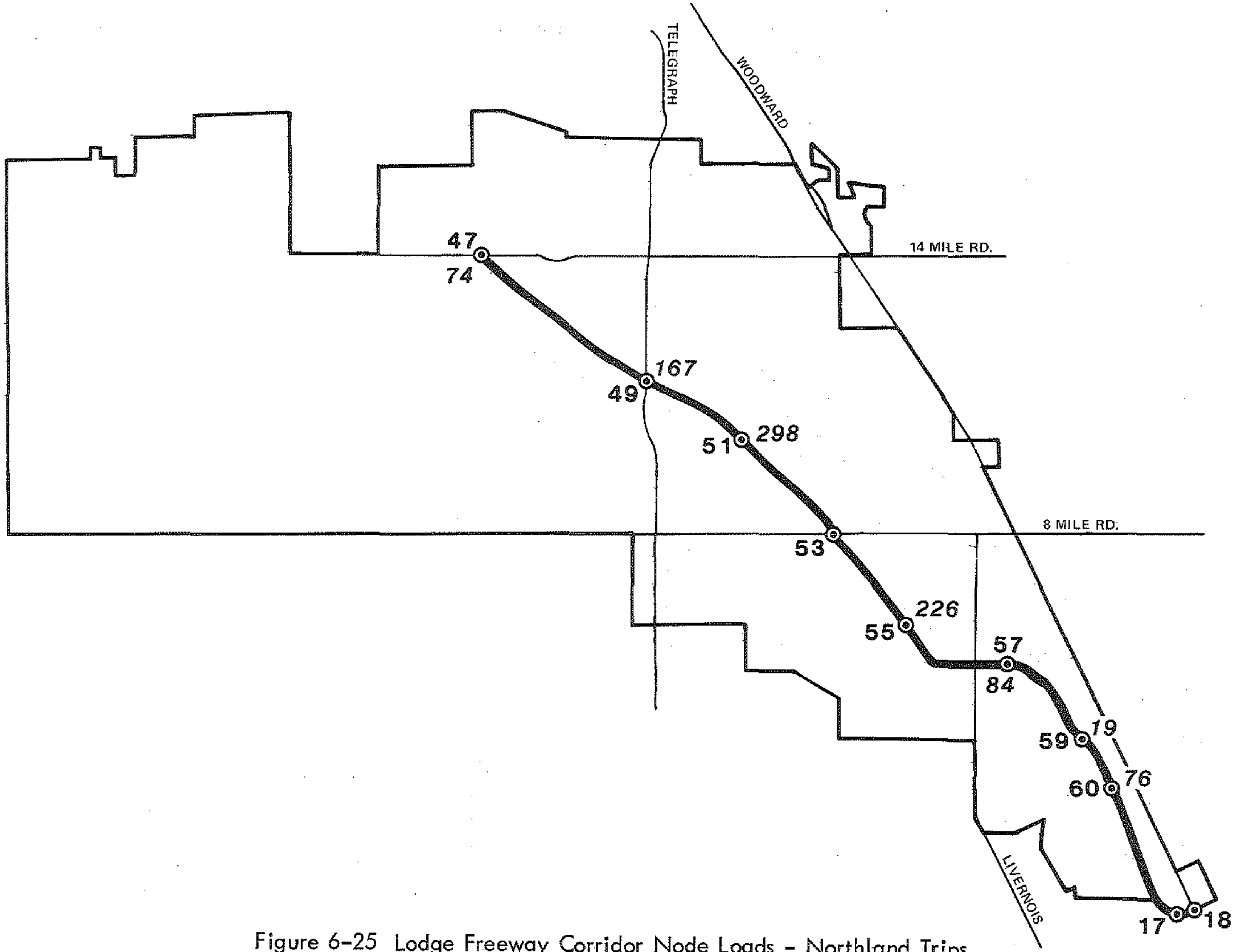


Figure 6-25 Lodge Freeway Corridor Node Loads - Northland Trips

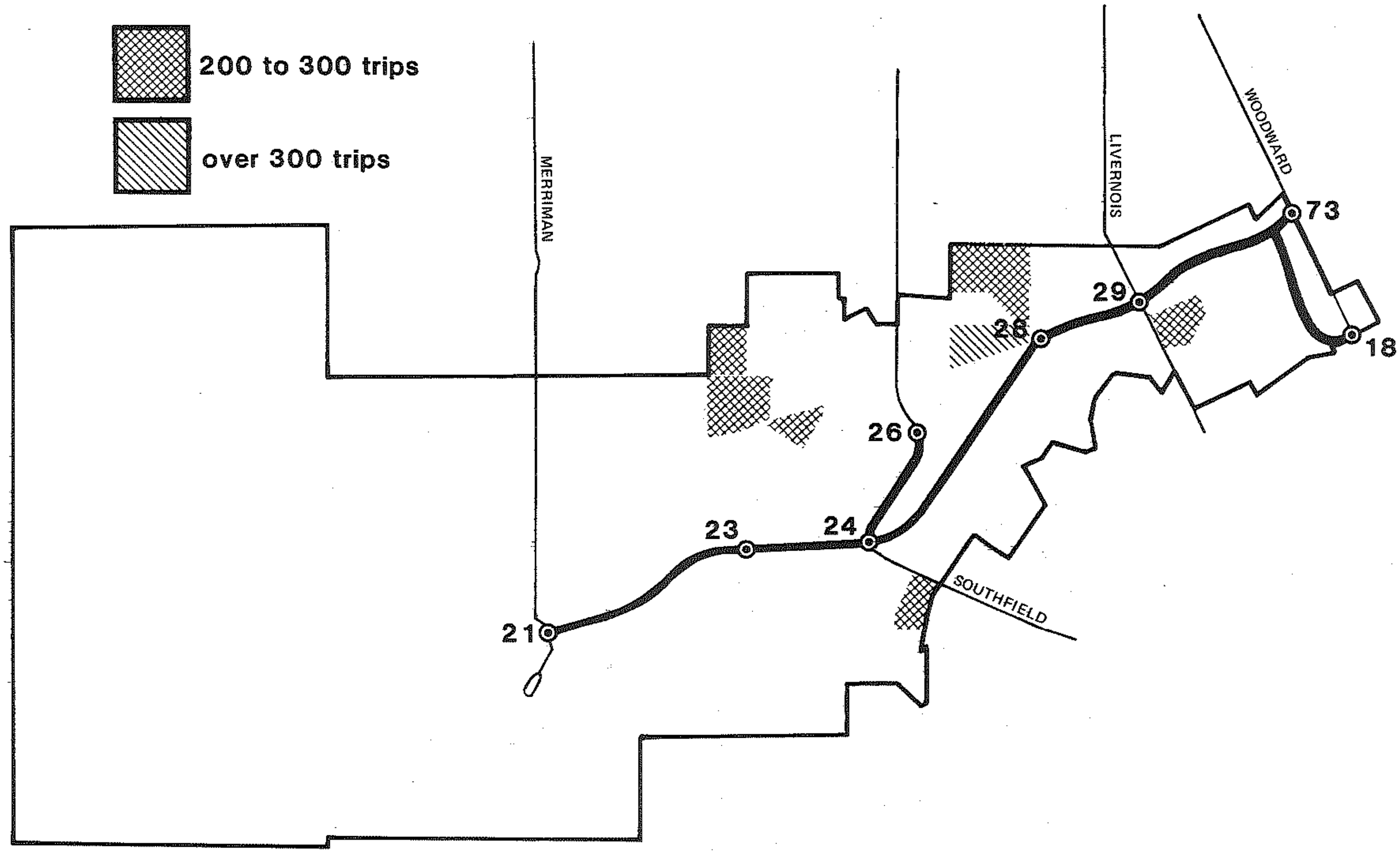


Figure 6-26 Michigan/I-94 Corridor Major Trip Production Zones

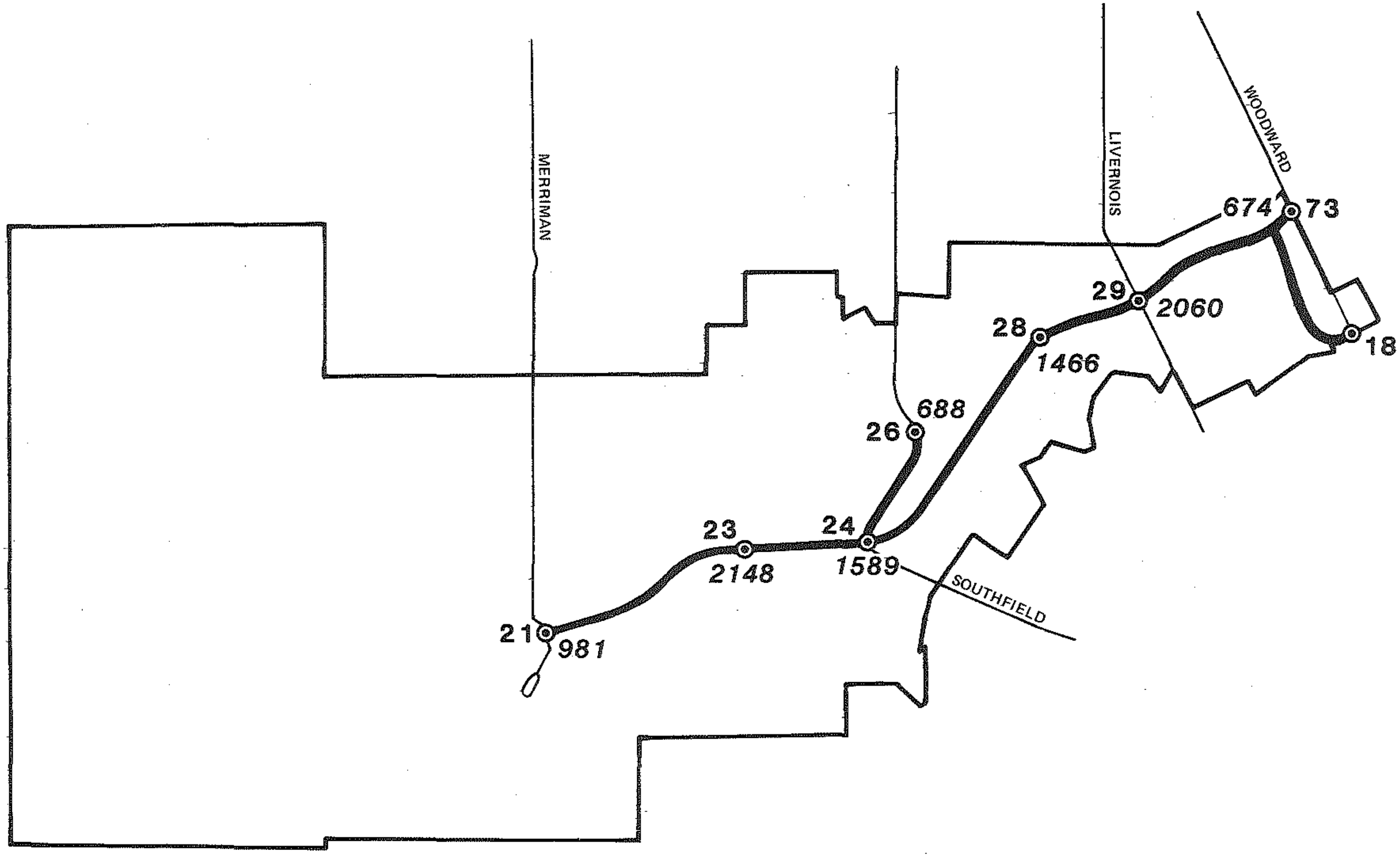


Figure 6-27 Michigan/I-94 Corridor Node Loads - Total Trips

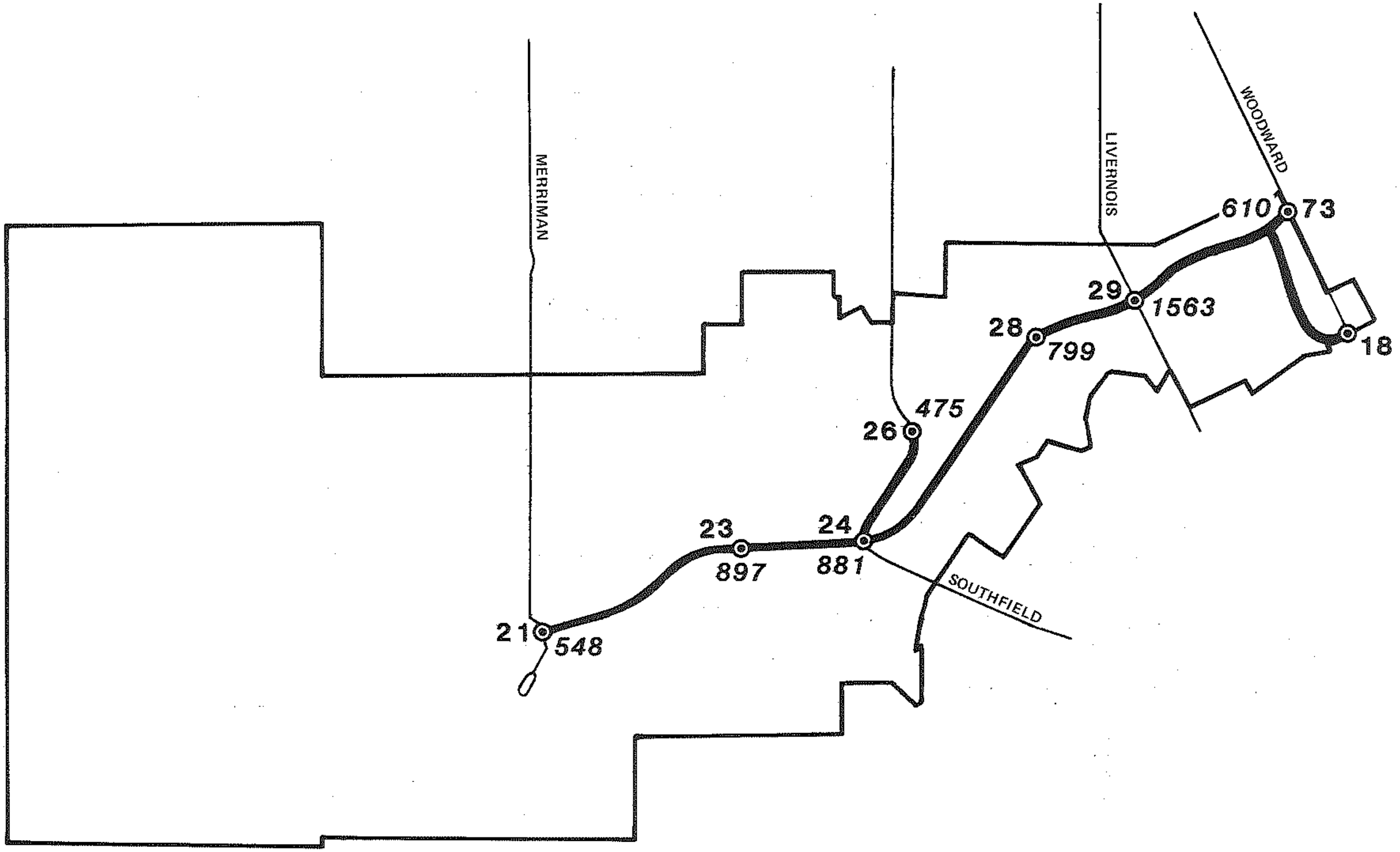


Figure 6-28 Michigan/I-94 Corridor Node Loads - CBD Trips

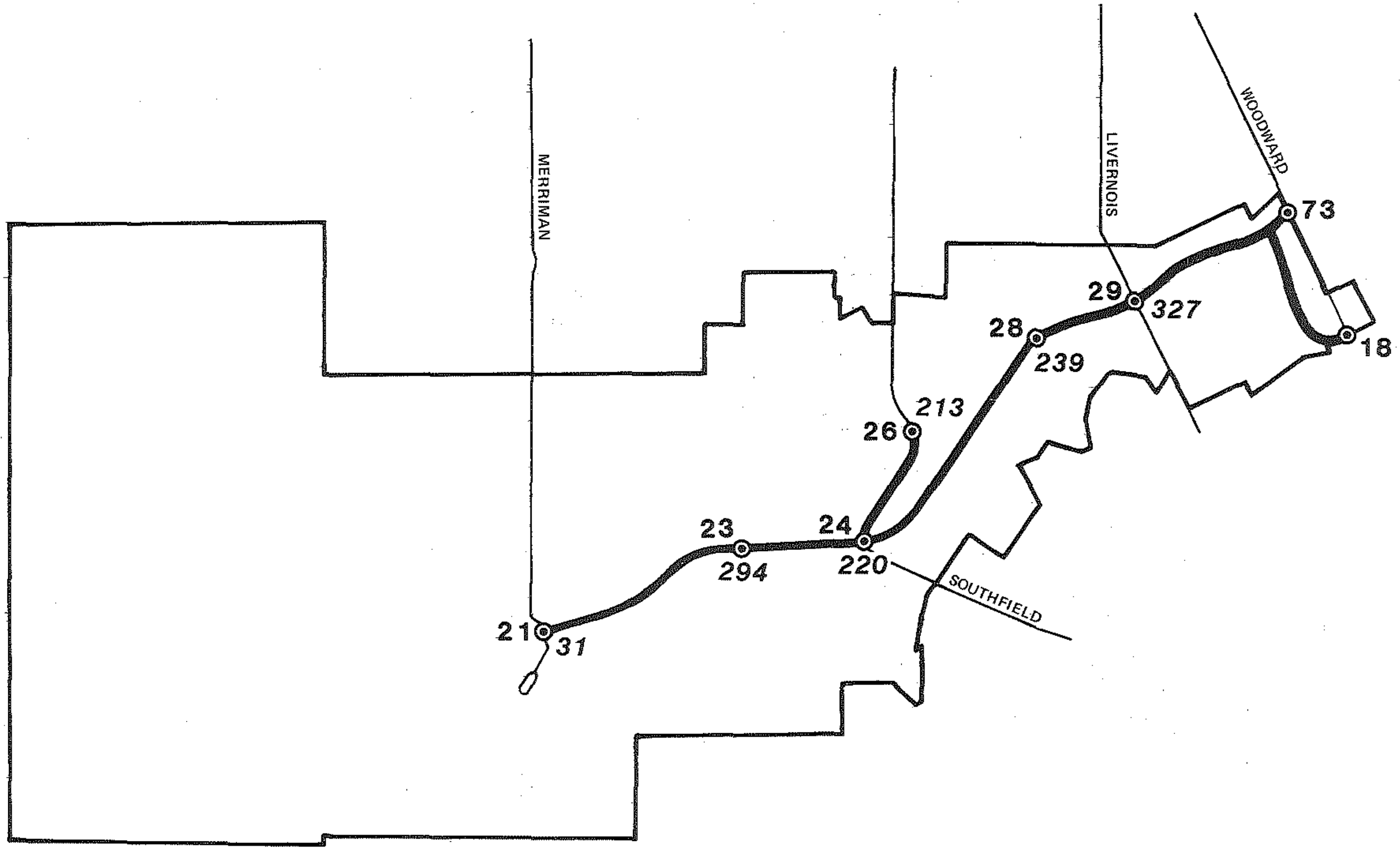


Figure 6-29 Michigan/I-94 Corridor Node Loads - New Center Trips

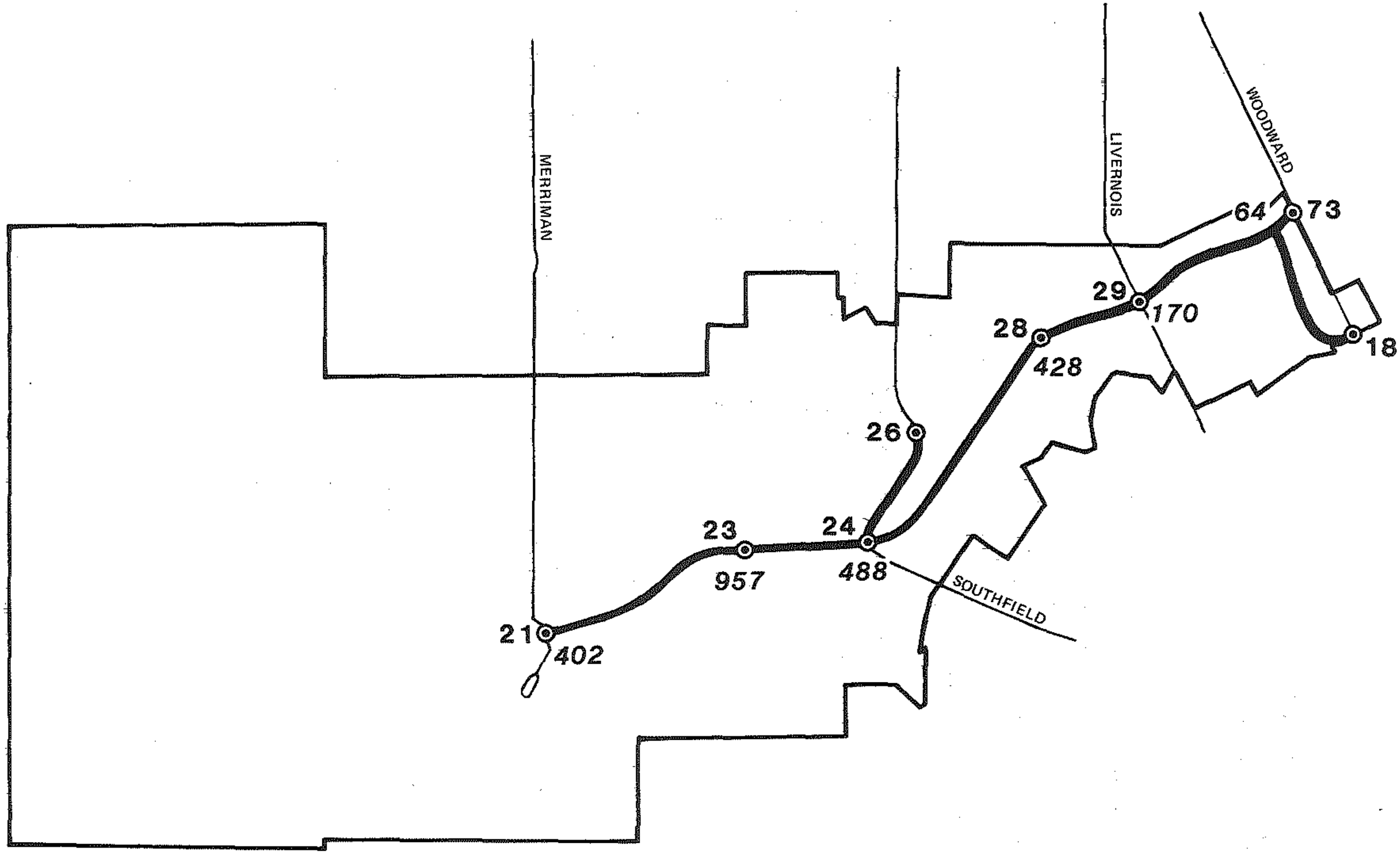


Figure 6-30 Michigan/I-94 Corridor Node Loads - Ford Complex Trips

the model is discussed in two reports.[1,2] The model is an aggregate mode split based upon a choice function. It assumes that the selection of a mode by a trip maker depends on the following factors:

- The economic status of the trip maker
- The purpose of the trip (not used in Detroit)
- The relative level of service provided by the private auto and public transit, expressed in terms of door-to-door (total) travel time
- The relative convenience provided by the private auto
- The relative perceived cost of making the trip by private automobile and public transit modes, expressed in terms of out-of-pocket expenditures

The relationship between the above factors and the percentage of people who will choose to use transit was calculated from analysis of travel data from travelers in Philadelphia, Toronto, and Washington, D.C. The relationships were then verified and further refined with the addition of travel data from the Boston area.

It is recognized that there are more sophisticated disaggregate modal split models based on the behavioral patterns of individuals rather than on the statistically derived correlations used in aggregate models. However, the cost of calibrating and running a disaggregate model is beyond the scope of this study. Therefore, it was decided to use the PMM and Company aggregate model for the first order estimate of modal split.

6.5.4 Application of Model

The PMM and Company modal split model consists of 80 diversion curves which relate the factors discussed above to the propensity to use transit. To apply the model, the following factors need to be determined:

- Median worker income of the origin zone
- Ratio of door-to-door travel time on public transit to that of the private automobile
- Ratio of excess time on public transit to that of the private automobile
- Ratio of "out-of-pocket" cost of public transit to that of the private automobile

The income estimate and ratios developed are not directly inputed into the model, but, rather, classification codes are developed for ranges of variables. The codes and their definitions are shown in Table 6-2. P is the income class code, A is the transit-to-auto

---

[1] T. B. Deen, et al, "Application of a Modal Split Model to Travel Estimates for an Urban Area," Highway Research Record, No. 38, 1963, pp. 97-123.

[2] D. M. Hill and H. G. Von Cube, "Development of a Model for Forecasting Travel Mode Choice in Urban Areas," Highway Research Record, No. 38, 1963, pp. 78-96.

Table 6-2 Modal Split Variable Classes

Class	(P Code) Income ($)	(A Code) Cost Ratio	(R Code) Excess Time Ratio
1	0 - 3585	0 - .31	.00 - .01
2	3585 - 4675	.31 - .44	.01 - 1.19
3	4675 - 6150	.44 - .56	1.19 - 1.56
4	6150 - 7210	.56 - .69	1.56 - 1.94
5	7210+	.69 - .81	1.94 - 2.31
6		.81 - .94	2.31 - 2.75
7		.94 - 1.06	2.75 - 3.25
8		1.06 - 1.19	3.25 - 3.75
9		1.19 - 1.31	3.75 - 4.25
10		1.31 - 1.44	4.25 - 4.69
11		1.44 - 1.56	4.69 - 5.06
12		1.56 - 1.69	5.06 - 5.44
13		1.69+	5.44 - 5.81
14			5.81+

excess time ratio code. Figure 6-31 shows an example of a peak-hour diversion curve for selected values of P, A, and R.

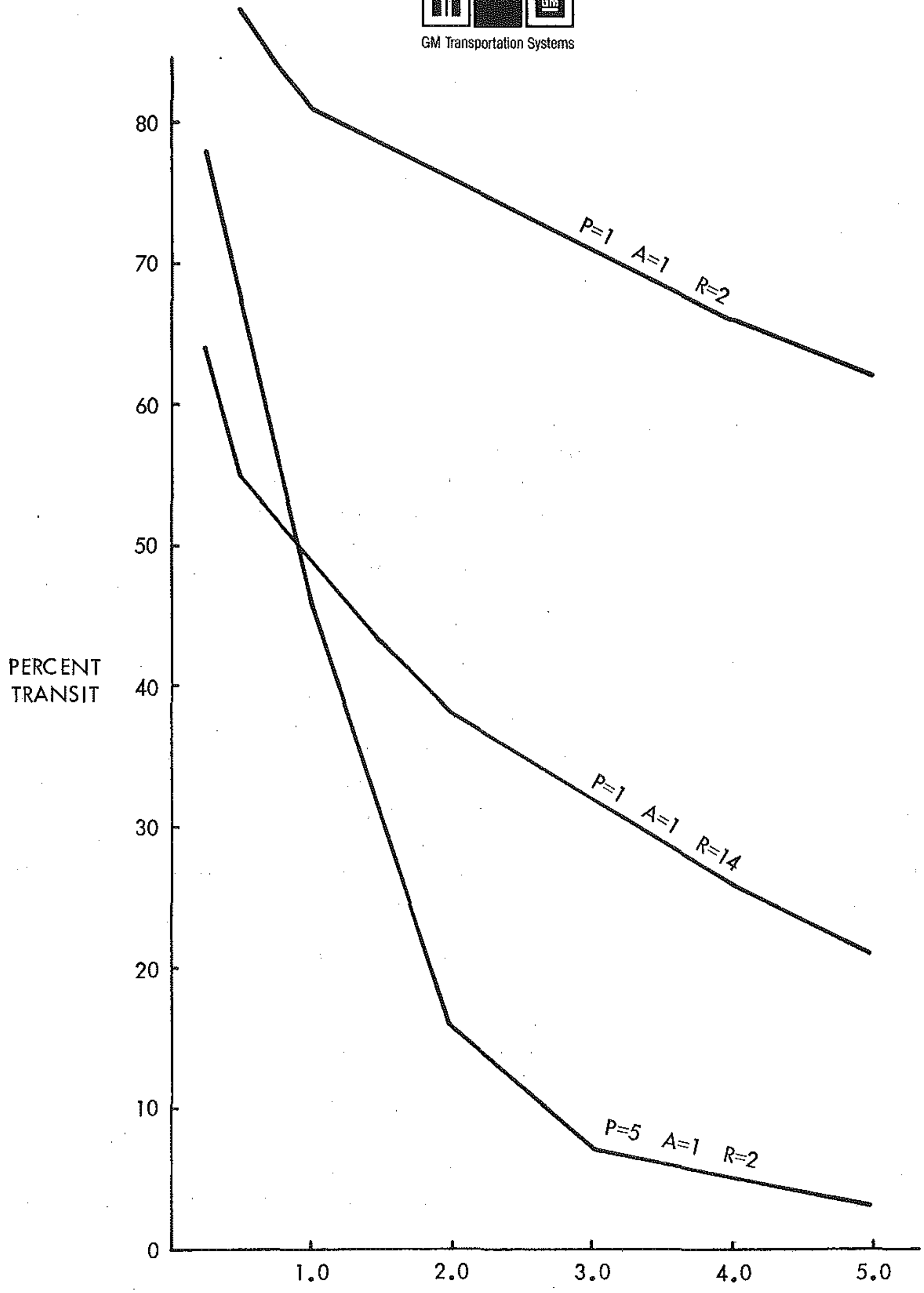
Several assumptions were made in order to estimate the values of P, A, R, and travel time ratio to be used for each trip. The income for each zone was calculated by SEMCOG for 1990 and adjusted to 1965 dollars. The 1990 income for each zone was used rather than 1975 income because it was readily available. The cost of transit is assumed to be 45 cents, the current DDOT bus fare. Out-of-pocket auto costs are estimated to be 5 cents per mile.

The auto excess time has three components: time to start the auto, wait time to enter a metered freeway, and time to park the auto and walk to the destination. It is estimated to take one minute to start the auto. Based upon the operation of the Los Angeles metered freeway, it is assumed that the time in queue would be three minutes. The time to park the auto and walk to the destination is assumed to vary with the destination. It is estimated to take seven minutes to park and walk to a CBD destination, three minutes to park and walk to an activity center other than the CBD, and two minutes to park and walk to a non-activity center destination.

The four components of transit excess time are time to walk to a bus stop, wait time at the bus stop, transfer time, and the time to walk to the destination after deboarding the bus. For initial values, it is assumed to take five minutes to walk to the bus, five minutes to wait for the bus, and five minutes to walk to the destination after deboarding the bus. Transfer time is assumed to be zero because the plan is to have the buses operating on the BRT also be the collector buses. This follows the operation of the Shirley Highway busway. If a person taking the bus were a park-and-ride or kiss-and-ride patron, the five-minute walk to the bus would be eliminated. It is assumed that the transfer time for a park-and-ride person would be equal to the time required to walk to the bus stop.

The travel time is the door-to-door travel time. It includes the excess time discussed above as well as the in-vehicle travel time. The in-vehicle travel time is a function of vehicle collection speed, line-haul speed, and distribution speed. The collection distance is assumed to be the straight line distance from zone centroid to the nearest "transit node" on the corridor's mainline route. The distribution distance, similarly, is assumed to be the distance from the zone centroid of the destination zone to the nearest exit node on the distribution route. Since the speeds vary from corridor to corridor, Tables 6-3 and 6-4, show the vehicle speed assumptions for each corridor for buses and for autos. The line-haul speeds are based upon speed runs conducted by GM TSD, and upon DDOT data.

Figure 6-32 is a flow chart showing the computer programs used to calculate the modal split. The first program calculates the values for P, A, R, and the travel time ratio for each O/D pair in the corridor. The second program uses the values of P, A, R, and the travel time ratio to determine the transit probability value. It then multiplies the total number of trips by the transit probability value to determine the number of transit trips. The third program screens the trips to determine the number of transit trips which will be



SOURCE: PEAT MARWICK & MITCHELL

Figure 6-31 Example Peak-Hour Diversion Curves

Table 6-3 Transit Speeds (mph)

	COLLECTION	LINE-HAUL	DISTRIBUTION
EAST JEFFERSON	10	31	8
I-94/CROSSTOWN	10	40	8
LODGE	10	40	8
MICHIGAN/I-94	10	40	8

Table 6-4 Automobile Speeds (mph)

	COLLECTION	LINE-HAUL	DISTRIBUTION
EAST JEFFERSON	25	31	15
I-94/CROSSTOWN	25	40	15
LODGE	25	40	15
MICHIGAN/I-94	25	40	15

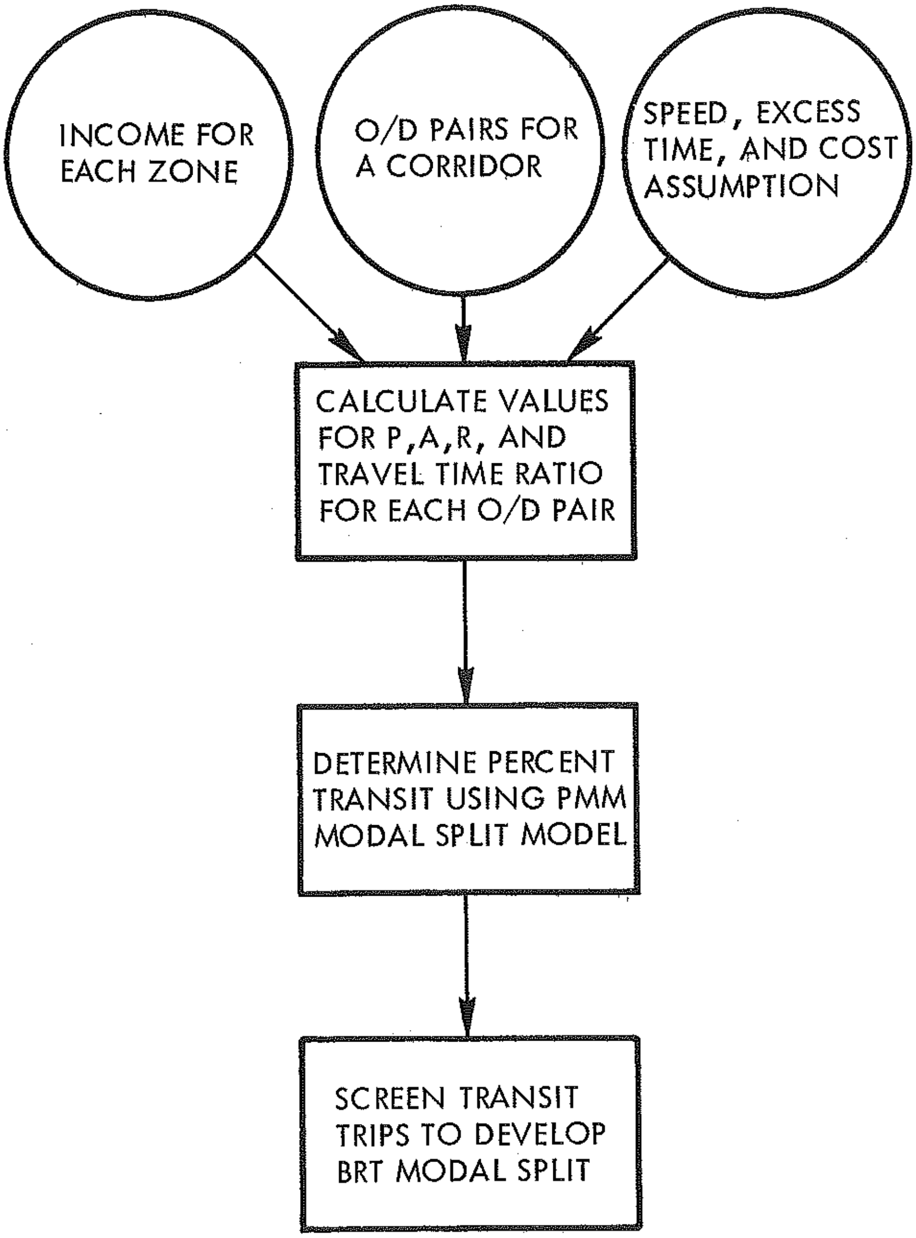


Figure 6-32 Flow Chart of Modal Split Model Computer Processing

assigned to the BRT. The criterion used is that a transit trip must have at least two miles of travel on the corridor. The screening program also produces summaries of corridor travel data in a format similar to that described in Section 4.1 in conjunction with total corridor trips.

6.5.5 Sensitivity Analysis

The travel time ratios for BRT mostly lie in a range between 1.0 and 2.5. In this range, the modal split varies from about 40 to 80 percent. For higher incomes, the modal split does fall below 40 percent. The model is very sensitive to the excess time ratio. One can see this by looking at the curves in Figure 6-31. It was found that a one-minute addition to the transit excess time results in about a 2 percent decrease in propensity to use transit.

6.5.6 Modal Split in Operational BRT Systems

Modal split estimates for the Shirley Highway busway, the San Bernardino busway, and the Minneapolis-St. Paul BRT system were obtained.

The Shirley Highway busway operates on an 11-mile exclusive busway outside of Washington, D.C. There are no stations along the line-haul portion of the route. There are four permanent access points and three temporary access points.

The first portion of the busway opened in 1969. Since then, ridership in the morning peak period has grown from 2,000 trips to 15,000. There are presently 30,000-35,000 trips per day utilizing some portion of the busway. Current estimates indicate that there is a 40 to 45 percent modal split. That is, for the defined corridor (150 square miles), 40 to 45 percent of the trips with origins in the corridor and destinations in the areas served are utilizing the busway. Presently, the system is constrained by lack of equipment. There are not enough buses to service the demand.

The San Bernardino busway in California is 11 miles long. The defined corridor service area is about 100 square miles. There are three on-line stations and two supplementary access ramps along the busway route. At the El Monte Station, the suburban terminal station, there are over 700 parking spaces. The fare on the busway is 25 cents, and parking costs $2 per month.

The first portion was completed early in 1973, and the entire busway was completed in June 1974. Peak period ridership (a.m. and p.m. peak) has grown from 1,200 in 1973 to 9,200. There are 13,500 trips per day utilizing some portion of the busway. It is estimated that there is currently a 20 percent modal split. Of the 6,000 people who recently started using the system, 4,200 are ex-drivers. The recent riders tend to be younger males (average age 35) with an average household income of $15,000 to $18,000. A recent survey has shown that 55 percent of the people park and ride.

In Minneapolis-St. Paul, nine bus bypass ramps have been constructed along the I-35W Interstate highway. Approximately 16 miles of the I-35W freeway are metered, and nine bypass ramps provide priority access for buses. The service area of the defined corridor is about 85 square miles. Presently, there are 8,600 trips per day utilizing the BRT; this is about 12 percent of the trips using the corridor and destined to the CBD. The Minneapolis system has arranged to utilize about 25 small parking lots along collection routes for park-and-ride patrons. Many of these are church parking lots which are used as park-and-ride lots free of charge except for the cost of weekday snow removal.

6.6 BRT System Sizing

In this section, the rationale and assumptions associated with determining the number of buses and other facilities are described. First, the process used to calculate the number of line-haul buses is described. Then the sizing of the two alternative feeder systems is discussed. A discussion of off-peak service is included, and total vehicle operating hours per year are estimated as a first step toward determining labor requirements. Finally, the number of park-and-ride spaces and bus shelters are determined.

6.6.1 BRT Buses

The number of buses required to provide BRT service from each corridor access point to each major destination during the peak period was determined, based on a simple bus scheduling process. Each BRT route is assumed to consist of three parts -- a collection phase, a line-haul phase from a particular corridor access node to a particular destination, and a distribution phase at that destination. In the scheduling process, buses are assigned to particular routes and are not reassigned to other routes during the peak period. Both demand for each route and the number of round trips per bus during the peak period were considered in determining the number of buses required for each corridor.

The time required to complete a round trip on each route was calculated. The time required for the collection phase of each route is assumed to be 30 minutes. The distribution time for the various destinations is listed in Table 6-5.

Table 6-5 BRT Distribution Time

Distribution Loop	Distance Miles	Average Speed MPH	Time Minutes
CBD	2.0	8	15
New Center	4.6	10	28
Northland/Southfield	2.8	10	17
Ford Complex	8.4	15	34

The round trip time for each route also includes an additional 10 minutes for layover and schedule adjustment.

The peak-period BRT demand for each destination associated with each corridor access node was analyzed in the system sizing process. This demand information is summarized in Figures 6-12 through 6-30. The figures show that some nodes produce very little demand for the Northland area and the Ford Complex. In order to avoid the costs of providing BRT service to areas where it is not warranted by sufficient demand, routes which serve fewer than 85 passengers in the peak period were eliminated. This resulted in the elimination of 222 trips from the I-94 Crosstown Corridor demand and 253 trips from the Lodge Corridor demand.

In order to match the required number of bus trips to the BRT demand, the peak period time distribution of demand was determined by analyzing the TALUS Survey data. The time distribution is shown in Table 6-6.

Table 6-6 Time Distribution of Demand in Peak Period

Period	Time Segment	Percent of Peak-Period Demand
Pre-Peak	7:00 - 7:30	10
First Peak	7:30 - 8:30	50
Second Peak	8:30 - 9:30	30
Post-Peak	9:30 - 10:30	10

It is assumed that the demand is uniformly distributed in time during each time segment.

The number of bus trips required to serve the demand for each route during each time segment was determined. The round trip time and bus occupancy assumptions were then used to determine the number of buses required to make those trips, taking into consideration the number of repeat trips possible during the peak period. A 90 percent load factor is assumed for BRT buses operating in the first and second peak hours (from 7:30 to 9:30) and a 70 percent load factor is assumed for the pre-peak and post-peak half hours. The BRT vehicles are assumed to be 53 passenger coaches.

The total number of trips and buses required to satisfy the demand for each major destination in each of the four corridors are summarized in Table 6-7. The numbers in parentheses in the last column are the total number of BRT vehicles required for each corridor, including a 7 percent maintenance float to account for buses which may be out of service for one reason or another.

The peak-hour BRT vehicle headway, expressed in seconds, is tabulated in Table 6-7a for three locations on each of the four corridors. The minimum headway in the CBD Loop, the New Center Loop, and at the maximum load point of each corridor is presented. The maximum load point of each corridor occurs on the approach to the CBD and New

Table 6-7 Peak-Period BRT Bus Requirements

Corridor/Destination	BRT Demand	Number of Bus Trips	Number of BRT Buses
Jefferson			
CBD	7,855	183	112
New Center	1,919	52	39
Total	9,774	235	151 (162)
I-94 Crosstown			
CBD	15,631	350	195
New Center	4,291	102	63
Ford Complex	663	20	13
Total	20,585	572	271 (290)
Lodge			
CBD	12,352	282	166
New Center	4,655	109	70
Northland/Southfield	691	20	12
Total	17,698	411	248 (265)
Michigan/I-94			
CBD	5,773	134	77
New Center	1,293	35	22
Ford Complex	2,476	58	36
Total	9,542	227	135 (145)

Center areas. The numbers in parentheses indicate the maximum number of buses per hour which pass through each of the three locations.

Table 6-7a BRT Headway - Peak Hour

Corridor	Peak-Hour Headway (Seconds)		
	CBD Loop	New Center Loop	Maximum Load Point
E. Jefferson	42.9 (84)	163.6 (22)	34.0 (106)
I-94 Crosstown	22.1 (163)	78.0 (46)	26.5 (136)
Lodge	27.5 (131)	69.2 (52)	21.6 (167)
Michigan/I-94	58.1 (62)	240.0 (15)	51.4 (70)

Since no alternate service may be available to a passenger who must return to his origin during the business day or after the evening peak period, limited off-peak service is recommended. Therefore, limited service between the peak periods (10:00 a.m. to 3:00 p.m.) and after the evening peak for a total of 8 hours is considered as part of the BRT operation on all corridors except East Jefferson. No off-peak service is assumed for the East Jefferson Corridor because the BRT implementation is on an arterial which is adequately served by Detroit DOT and SEMTA buses. Half-hour headways are assumed for off-peak service on the other three corridors. Buses are assumed to travel on the line-haul route and stop at each corridor access node. No off-line collection or distribution is provided by the BRT vehicle, but limited feeder service is also recommended.

In order to provide an indication of the magnitude of the BRT operation on each corridor, Table 6-8 gives the number of BRT vehicle operating hours and vehicle miles for each corridor. The figures were generated by considering each route separately both in the peak and off-peak periods. Driver scheduling was not attempted in this phase, so the number of drivers required to provide service in each corridor was not explicitly determined. However, total vehicle operating hours can be used to give at least a relative measure of labor requirements for the four corridors.

6.6.2 Alternative BRT Feeder Systems

Two types of feeder service were considered to augment the BRT pick-up loops. Both a fixed-route, fixed-schedule feeder (FR-FS) system and a demand-responsive Dial-A-Bus (DAB) system were sized.

Because fixed-route systems generally operate on major streets, large vehicles can be utilized to serve high density areas. Demand-responsive systems are constrained to using small vehicles seating from 10 to 25 passengers in order to reduce on-bus time and to ensure maneuverability on narrow residential streets. The demand-responsive system is thus capacity limited and is economically most competitive with fixed-route systems in areas of relatively low demand density.

Table 6-8 BRT System Operating Characteristics

Corridor	Vehicle Hours Per Day	Vehicle Hours Per Year	Vehicles Miles Per Day	Vehicle Miles Per Year
East Jefferson				
Peak	346.83	88,442	7,327.5	1,868,513
Off-Peak	-	-	-	-
Total	346.83	88,442	7,327.5	1,868,513
I-94 Crosstown				
Peak	596.4	152,082	12,914.2	3,293,121
Off-Peak	28.2	7,191	667.2	170,136
Total	624.6	159,273	13,581.4	3,463,257
Lodge				
Peak	533.4	136,026	12,200.5	3,111,128
Off-Peak	26.1	6,656	683.2	174,216
Total	559.5	142,682	12,883.7	3,285,344
Michigan/I-94				
Peak	300.1	76,520	6,764.1	1,724,846
Off-Peak	21.3	5,432	539.2	137,496
Total	321.4	81,952	7,303.3	1,862,342

Fixed-Route, Fixed-Schedule Feeder System - The number of fixed-route, fixed-schedule feeder buses required to blanket an area is a function of the route spacing and the headway distance, the average distance between successive vehicles on each route. Headway is usually specified as the time interval between vehicles. Headway distance is the product of headway time and average velocity and is given by the following formula:

$$Hd = \frac{Ht}{60} V \qquad (1)$$

where

Hd = Headway distance in miles
Ht = Headway time in minutes
V = Average velocity in mph

The number of fixed-route feeder buses per square mile is given by the following equation:

$$NB = \frac{2Fo}{Hd} \left(\frac{1}{S_1} + \frac{1}{S_2} \right) F_m \qquad (2)$$

where
NB = Number of fixed-route buses per square mile of area served
Fo = Route overlap factor
Hd = Headway distance (miles)
S_1 = Route spacing in the north-south direction (miles)
S_2 = Route spacing in the east-west direction (miles)
F_m = Maintenance float factor

The route overlap factor, Fo, is included to account for the inevitable overlap of routes which results from providing no-transfer service to the BRT collection points. For the purpose of this analysis, that factor is assumed to be 1.20. The maintenance float factor, F_m, is included to account for those vehicles which would be out of service at any one time, for example, for routine service or in the body shop. The maintenance float factor is assumed to be 1.07.

Combining equations (1) and (2) yields:

$$NB = \frac{120Fo}{Ht\ V} \left(\frac{1}{S_1} + \frac{1}{S_2} \right) F_m \qquad (3)$$

The FR-FS feeder system sizing is based on the following assumptions: the route spacing is 1.0 mile by 1.0 mile (S_1 and S_2), the peak period headway time (Ht) is 12 minutes, and the average velocity (V) of the feeder buses is 15 miles per hour. Substituting the known values into equation (3) yields:

$$NB = \frac{120\ (1.20)}{12\ (15)} \left(\frac{1}{1} + \frac{1}{1} \right) 1.07$$

$$NB = 1.71 \text{ buses per square mile}$$

The FR-FS feeder buses are assumed to serve the area of each corridor which is outside the city of Detroit. Inside Detroit, the Detroit DOT bus system is assumed to provide feeder service for the BRT system. Table 6-9 lists the area of feeder coverage and the number of buses required for feeder service in each corridor.

These buses would also be used to provide off-peak feeder service in the area of each corridor outside Detroit. The off-peak service is assumed to operate on the same routes as in the peak period but at half-hour headways. Eight hours of off-peak operation are assumed each weekday.

The relative magnitude of the fixed-route, fixed-schedule feeder system operation in each corridor is indicated in Table 6-10. The number of vehicle operating hours and vehicle miles are listed for each corridor for both peak and off-peak service. The number of vehicle operating hours per day is determined by multiplying the number of buses in operation by the time of operation -- six hours for peak service and eight hours for off-peak service. The number of vehicle miles per day is determined by multiplying the number of vehicle operating hours by the assumed average velocity - 15 mph.

Table 6-9 Fixed-Route, Fixed-Schedule Sizing Results

Corridor	NB Buses Sq. Mi.	Area Sq. Mi.	Buses Required
East Jefferson	1.71	75	128
I-94 Crosstown	1.71	90	154
Lodge	1.71	175	299
Michigan/I-94	1.71	165	282

Table 6-10 Fixed-Route, Fixed-Schedule Feeder System Operating Characteristics

Corridor	Vehicle Hours Per Day	Vehicle Hours Per Year	Vehicle Miles Per Day	Vehicle Miles Per Year
East Jefferson				
Peak	720	183,600	10,800	2,754,000
Off-Peak	384	97,920	5,760	1,468,800
Total	1,104	281,520	16,560	4,222,800
I-94 Crosstown				
Peak	870	221,850	13,050	3,327,750
Off-Peak	464	118,320	6,960	1,774,800
Total	1,334	340,170	20,010	5,102,550
Lodge				
Peak	1,680	428,400	25,200	6,426,000
Off-Peak	896	228,480	13,440	3,427,200
Total	2,576	656,880	38,640	9,853,200
Michigan/I-94				
Peak	1,584	403,920	23,760	6,058,800
Off-Peak	848	216,240	12,720	3,243,600
Total	2,432	620,160	36,480	9,302,400

Dial-A-Bus Feeder System - Several assumptions were made in order to estimate the number of DAB vehicles required to serve a given demand. The DAB vehicle is assumed to be a small, 10-17 passenger vehicle. The average number of passengers who are picked up by a DAB vehicle during one round trip through the zone is assumed to be ten. The number of DAB vehicles is given by the following formula:

$$Nb = \left(\frac{D}{10\, n_t} \right) Fm \qquad (4)$$

where Nb = Number of DAB vehicles required for the peak hour

D = Number of passengers requesting DAB pickup during the peak hour

n_t = Number of vehicle round trips per peak hour

Fm = Maintenance float factor to account for vehicles which may be out of service at any given time (1.07)

The number of vehicle trips per peak hour is the inverse of the round trip time in hours. The following assumptions are made to determine round trip time:

- One minute is required to unload passengers at the bus stop.
- The average vehicle speed between passenger pickups is 25 miles per hour.
- The average distance between passenger pickups is one mile.
- The average time required for each passenger who is picked up to board the vehicle is one minute.
- Each bus picks up 10 passengers.

Using these assumptions, the average round trip time equals 35 minutes. The number of vehicle round trips per hour, n_t, equals 1.71.

The number of passengers entering the BRT system during the peak period is known for each node, or entry point, of each corridor. It is assumed that one DAB zone is associated with each transit node outside the city of Detroit. In Detroit, DOT buses are assumed to provide the BRT feeder service. As indicated in Table 6-6, the peak hour transit demand is assumed to equal 50 percent of the peak period demand. It is further assumed that 40 percent of the BRT passengers access the system via DAB. Using these assumptions, the peak hour DAB demand can be calculated.

Using Equation (4), the number of DAB vehicles was calculated. Table 6-11 provides a summary of the results.

Table 6-11 DAB Sizing Results

Corridor	Node Number	Number of Pass Entering (Np)	Peak-Hr DAB Demand (D)=Np(.5)(.4)	Number of DAB Vehicles (Nb)
East Jefferson	78	1,176	235	15
	79	840	168	11
	80	1,302	260	16
Total		3,318	663	42
I-94 Crosstown	67	2,185	437	27
	65	1,416	283	18
	64	1,337	267	17
Total		4,938	987	60
Lodge	47	1,236	247	15
	49	2,036	407	25
	51	1,665	333	21
	53	3,808	762	48
Total		8,745	1,749	109
Michigan/I-94	21	981	196	12
	23	2,148	430	27
	24	1,589	318	20
	28	1,466	293	18
Total		6,184	1,237	77

These buses would also be used to provide off-peak feeder service in the area of each corridor outside Detroit. The off-peak service is assumed to operate in the same area as the peak service; however, the demand in the off-peak hours is assumed to be five percent of the demand during the peak hour. Eight hours of off-peak operation are assumed each weekday.

The relative magnitude of the DAB feeder operation is shown in Table 6-12. The number of vehicle operating hours and vehicle miles are listed for each corridor for both peak and off-peak service. The number of vehicle operating hours per day is a function of passenger demand. The average number of operating hours per peak hour vehicle is four for the a.m. and p.m. peak periods and 0.4 for the off-peak period. The number of vehicle miles per day is determined by multiplying the number of vehicle operating hours by the assumed average velocity of 15 miles per hour.

Table 6-12 DAB Feeder System Operating Characteristics

Corridor	Vehicle Hours Per Day	Vehicle Hours Per Year	Vehicle Miles Per Day	Vehicle Miles Per Year
East Jefferson				
Peak	160	40,800	2,400	612,000
Off-Peak	16	4,080	240	61,200
Total	176	44,880	2,640	673,200
I-94 Crosstown				
Peak	224	57,120	3,360	856,800
Off-Peak	22.4	5,712	336	85,680
Total	246.4	62,832	3,696	942,480
Lodge				
Peak	408	104,040	6,120	1,560,600
Off-Peak	40.8	10,404	612	156,060
Total	448.8	114,444	6,732	1,716,660
Michigan/I-94				
Peak	288	73,440	4,320	1,101,600
Off-Peak	28.8	7,344	432	110,160
Total	316.8	80,784	4,752	1,211,760

In addition to determining the number of DAB vehicles required, it is also necessary to size the control system required to operate the demand-responsive type of feeder system. The DAB control system includes reservation, communication, and dispatch equipment and a computer to perform the necessary passenger/bus scheduling determinations.

The elements of the DAB control system are sized based on the predicted passenger demand, number of DAB vehicles, and the physical area comprising each DAB zone. It is assumed, because the BRT system serves mainly recurring, work-related trips, that 50 percent of all DAB service is on a subscription basis. Subscription service is highly efficient, allowing pre-scheduled routes and pick-up times, thus eliminating the need for patrons to phone in reservations during the peak period. This results in a substantial reduction in reservation equipment and personnel requirements.

The DAB control equipment includes:

- Message Switching Controller - a device needed to switch from data to voice UHF frequencies depending upon communications needs
- Dispatch Equipment - the devices necessary for a dispatcher to interface with system control and communications equipment
- Satellite UHF Complex - all equipment comprising the UHF Receiver/Transmitter assemblies required to communicate with vehicles in the field
- Reservation Agent Complex - equipment necessary to allow operators to receive reservation requests and input those requests to the system computer for scheduling
- System Management Computer - performs the scheduling tasks for the control system

Tables 6-13 through 6-16 provide a summary of the DAB control equipment needed for each corridor.

The labor requirements of the DAB feeder network include, in addition to the vehicle drivers, reservation agents and vehicle dispatchers. Vehicle driver requirements are a function of the total vehicle hours of operation. One vehicle dispatcher is required to be on duty during the hours of DAB system operation. The DAB system operates 14 hours per day, 6 hours peak and 8 hours off-peak. Therefore, two dispatchers are required per corridor. The number of reservation agents required per corridor is a function of the predicted peak-hour passenger demand for DAB. During the off-peak period, regardless of the corridor, one reservation agent is adequate to handle the reservation requirements. Because there are two peak periods daily, split shifts are assumed for reservation agents. To determine the number of reservation agents required, it is assumed that 50 percent of the peak-hour DAB trips are reserved by telephone during the peak hour. The remaining 50 percent are pre-scheduled, subscription trips. Assuming each reservation transaction requires 30 seconds to complete, the number of agents was calculated. However, a recent report concerning the operation of the Santa Clara DAB system indicates that approximately half of all incoming calls are for information only, not for reservations. Therefore, the calculated number of reservation agents required in the peak hour was doubled such that both information and reservation calls could be adequately answered. The number of telephone lines required for the system is assumed to be 50 percent more than the number of reservation agents required in the peak hour. Table 6-17 shows the total number of reservation agents and dispatchers required for each corridor.

Table 6-13 East Jefferson DAB Control Equipment

Item	Quantity	Remarks
Message Switching Controller	1	One per corridor
Dispatch Equipment	1	One per 85 vehicles
Satellite UHF Complex	35	One per 2.3 square miles
Telephone Equipment	9 (Lines)	
Reservation Agent Complex	6	Each handles 120 calls per hour
DAB Zone Control Assembly	12	Approximately 1 per every 3 Satellite UHF Complexes
System Management Computer	1	One per corridor

Table 6-14 I-94 Crosstown DAB Control Equipment

Item	Quantity	Remarks
Message Switching Controller	1	One per corridor
Dispatch Equipment	1	One per 85 vehicles
Satellite UHF Complex	41	One per 2.3 square miles
Telephone Equipment	12 (Lines)	
Reservation Agent Complex	8	Each handles 120 calls per hour
DAB Zone Control Assembly	14	Approximately 1 per every 3 Satellite UHF Complexes
System Management Computer	1	One per corridor

Table 6-15 Lodge DAB Control Equipment

Item	Quantity	Remarks
Message Switching Controller	1	One per corridor
Dispatch Equipment	2	One per 85 vehicles
Satellite UHF Complex	78	One per 2.3 square miles
Telephone Equipment	21 (Lines)	
Reservation Agent Complex	14	Each handles 120 calls per hour
DAB Zone Control Assembly	26	Approximately 1 per every 3 Satellite UHF Complexes
System Management Computer	1	One per corridor

Table 6-16 Michigan/I-94 DAB Control Equipment

Item	Quantity	Remarks
Message Switching Controller	1	One per corridor
Dispatch Equipment	1	One per 85 vehicles
Satellite UHF Complex	75	One per 2.3 square miles
Telephone Equipment	15 (Lines)	
Reservation Agent Complex	10	Each handles 120 calls per hour
DAB Zone Control Assembly	25	Approximately 1 per every 3 Satellite UHF Complexes
System Management Computer	1	One per corridor

Table 6-17 DAB Control System Labor Requirements

Corridor	Reservation Agents	Dispatchers
East Jefferson	7	2
I-94 Crosstown	9	2
Lodge	15	2
Michigan/I-94	11	2

6.6.3 Park-and-Ride Facilities

Sub-modal split estimates vary widely among existing BRT systems. For example, the sub-modal split for park-and-ride is reported to be about 55 percent for the San Bernardino Busway, but only about 14 percent for express buses operating in the I-35W corridor in Minneapolis-St. Paul. The traditional auto dependence of Detroit area residents suggests that the park-and-ride sub-modal split for a BRT system in the metropolitan area is likely to be relatively high. Therefore, to obtain a first-order estimate of parking facility requirements, it is assumed that 40 percent of the BRT passengers who originate outside Detroit and 30 percent of those who originate inside Detroit access the system by park-and-ride. The number of park-and-ride spaces required for each corridor is estimated by applying the assumed sub-modal split to the corridor demand estimates. Average automobile occupancy is assumed to be 1.10.

The following list summarizes the total number of parking spaces required for each corridor:

• East Jefferson	3047
• I-94 Crosstown	6047
• Lodge	5592
• Michigan/I-94	3215

It is expected that existing parking lots will be used to provide many of these spaces. As an indication of the availability of existing parking facilities in each corridor, a list of parking lots located at retail centers within four miles of each corridor access node was prepared. Tables 6-18 through 6-21 list the location of these parking facilities and give the number of parking spaces at each location for each of the four corridors. The tables are based on a list of major retail centers in Southeast Michigan which was compiled by SEMCOG and the Detroit News.

Although other potential park-and-ride lots such as churches, abandoned service stations, and closed industrial and retail facilities should also be considered, the facilities that are identified in the tables give a relative measure of parking availability in each corridor. In order to estimate parking lot construction needs, it is assumed that the number of parking

Table 6-18 Retail Center Parking Facilities - E. Jefferson Corridor

Facilities	Location	No. of Parking Spaces
Engleside	Gratiot and Wendell	1000
K-Mart	Groesbeck and 15 Mile	800
Korvette	12 Mile and Gratiot	2500
Macomb Mall	Gratiot and Masonic	4500
Macomb Regional Center	Gratiot and 15 Mile	4000
Eastgate	Gratiot and Frazho	3500
Spartan Atlantic	Gratiot and Frazho	700
K-Mart	9 Mile and Harper	800
Eastland	8 Mile and Kelly	7000
Penny's	7 Mile and Mack	1500
Conner Center	Conner and Warren	1410
Federals	Conner and Warren	800
Sparton Atlantic	Mack and Hart	500
Sears	Gratiot and Van Dyke	1150
	Total	30,160

Table 6-19 Retail Center Parking Facilities – I-94 Crosstown Corridor

Facilities	Location	No. of Parking Spaces
Macomb Regional Center	Gratiot and 15 Mile	4000
Macomb Mall	Gratiot and Masonic	4500
K-Mart	Groesbeck and 15 Mile	800
Ingleside	Groesbeck and Wendell	1000
Korvette	Gratiot and 12 Mile	2500
Spartan Atlantic	Gratiot and Frazho	700
Eastgate	Gratiot and Frazho	3500
K-Mart	9 Mile and Harper	800
Penney	7 Mile and Mack	1500
Eastland	8 Mile and Kelly	7000
Shopper's Fair	8 Mile and Gratiot	600
Arlan's Center	8 Mile and Schoenherr	5200
Ward	Gratiot and 7 Mile	470
Federal	Conner and Warren	800
Conner Center	Conner and Warren	1410
Spartan Atlantic	Mack and Hart	500
Sears	Gratiot and Van Dyke	1150
Arlans	E. Grand Blvd. and Concord	400
Sears	Woodward and Sears	1000
Arlan's Center	Warren and Lonyo	2200
Sears	Grand River and Oakman	1700
Atlantic Mills	Bryden and Grand River	1000
Shopper's Fair	Joy and Greenfield	600
Federal, Ward	Michigan and Schaefer	2200
Hudson Budget	Greenfield and Michigan	878
	Total	46,408

Table 6-20 Retail Center Parking Facilities - Lodge Corridor

Facilities	Location	No. of Parking Spaces
Kendallwood	Farmington and 12 Mile	1000
Topps	14 Mile and Orchard Lake	1000
Tel-Twelve Mall	Telegraph and 12 Mile	5000
Southfield Plaza	12 1/2 Mile and Southfield	1800
Green-Eight	Greenfield and 8 Mile	1500
Northland	Northwestern and 8 Mile	10,500
Shopper's Fair	8 Mile and Meyers	1000
K-Mart	8 Mile and Beech Daly	1000
Shopper's Fair	8 Mile and Grand River	750
Seven, Grand	7 Mile and Grand River	800
Livonia Mall	7 Mile and Middlebelt	4500
Federal	Schaefer and McNichols	700
Greenfield, Grand River	Greenfield and Grand River	1200
Spartan Atlantic	Livernois and Lyndon	500
Sears	Grand River and Oakman	1700
Atlantic Mills	Bryden and Grand River	1000
Sears	Woodward and Sears	1000
	Total	34,950

Table 6-21 Retail Center Parking Facilities - Michigan/I-94 Corridor

Facility	Location	No. of Parking Spaces
K-Mart	Telegraph and Goddard	800
Topps	Telegraph and Ecorse	1200
Spartan Atlantic	Michigan and Telegraph	700
Westborn	Michigan and Outer Drive	2200
K-Mart	Van Born and Merrick	1000
Arlans	Southfield and Dix	400
K-Mart	Outer Drive and Dix	800
Lincoln Park Plaza	Fort and New York	2000
Sears, Lincoln Park	Dix and Southfield	3000
Spartan Atlantic	Dix and Champaign	500
Jacobson's	Michigan	800
Hudson Budget	Greenfield and Michigan	878
Michigan, Schaefer	Michigan and Schaefer	2200
Arlan's Center	Warren and Lonyo	2200
Shopper's Fair	Joy and Greenfield	600
Atlantic Mills	Bryden and Grand River	1000
Sears	Grand River and Oakman	1700
	Total	21,978

spaces which would be available at existing facilities is equal to 5 percent of the total identified parking space in each corridor.

Table 6-22 summarizes the parking requirements and indicates the number of spaces assumed to be provided at existing facilities, as well as the number of spaces to be constructed for each corridor.

Table 6-22 Park-and-Ride Facilities

Corridor	Spaces Required for Park & Ride	Identified Parking Spaces	Spaces at Existing Facilities	Spaces to Be Constructed
Jefferson	3,047	30,160	1,508	1,539
I-94 Crosstown	6,047	46,405	2,320	3,727
Lodge	5,592	34,950	1,747	3,845
Michigan/I-94	3,215	21,978	1,099	2,116

6.6.4 Bus Shelters

Bus shelters should be located at high demand locations throughout the corridor. More specifically, they should be located at bus stops along the distribution loops and at each corridor access node. Additional shelters should be located at high demand locations such as park-and-ride lots and apartment houses. Based on these considerations, the number of shelters which may be required for each of the corridors is estimated as shown in the following list:

East Jefferson	35
I-94 Crosstown	50
Lodge	45
Michigan/I-94	35

6.7 Cost Estimates

Capital and operating costs were estimated for each of the four proposed BRT corridors. These costs were estimated for the BRT system and for the two types of feeder systems, fixed-route, fixed-schedule and Dial-A-Bus. Cost summaries for the BRT systems and the two feeder systems sized for each corridor are provided in Tables 6-23 and 6-24, respectively. An 8 percent interest rate was assumed for the annualized capital cost calculations.

Table 6-23 Cost Summary - BRT (Exclusive of Feeder)

Corridor	Capital Cost	Annualized Capital Cost	Annual Operating Cost	Total Annual Cost
East Jefferson	14,742,000	1,923,900	1,807,200	3,731,100
I-94 Crosstown	26,196,800	3,381,700	3,164,900	6,546,600
Lodge	24,578,500	3,147,100	2,897,900	6,045,000
Michigan/I-94	13,331,300	1,713,700	1,660,000	3,373,700

Table 6-24 Cost Summary - Feeder Systems

Feeder Type	Corridor	Capital Cost	Annualized Capital Cost	Annual Operating Cost	Total Annual Cost
DAB	East Jefferson	2,341,500	299,800	952,700	1,252,500
	I-94 Crosstown	3,267,900	420,500	1,303,300	1,723,800
	Lodge	5,888,200	759,200	2,317,500	3,076,700
	Michigan/I-94	4,270,700	547,500	1,656,300	2,203,800
FR-FS	East Jefferson	10,819,800	1,352,400	5,025,300	6,377,700
	I-94 Crosstown	12,055,100	1,627,100	6,072,200	7,699,300
	Lodge	23,405,700	3,159,100	11,725,600	14,884,700
	Michigan/I-94	22,075,000	2,979,500	11,070,200	14,049,700

A summary of the assumptions made and the sources of pertinent costing information used in the formulation of the cost estimates follows.

6.7.1 Capital Costs

Tables 6-25 through 6-32 provide summaries of the capital cost requirements for each corridor. The annualized capital costs are included in these summaries.

Exclusive Bus Ramps

According to very preliminary budgetary cost estimates by the State Highway Department, a typical queue jumper ramp for buses will cost approximately $30,000. This includes some grading and the addition of a 12-foot lane for 400 feet. If a 4-foot high retaining wall were required, the cost of the ramp would approximately double. Extra cost would also be incurred if bridge construction or extensive grading were required.

An average cost for exclusive bus ramp construction was assumed for each of the three freeway corridors based on a subjective assessment of the relative ease of implementing the ramps. The average cost of bus ramps for the I-94 Crosstown Corridor is assumed to be $60,000. As indicated in Section 6.1,some ramps in this corridor may require retaining walls and others may require the acquisition of some right-of-way. The average cost of bus ramps for the Lodge Corridor is likely to be much higher than for the other corridors because extensive retaining wall construction is required, and the bridge over the expressway at the Telegraph ramp will probably have to be widened. An average cost of $100,000 per ramp is assumed for this corridor. Only $40,000 per ramp is assumed for the Michigan/I-94 Corridor because no retaining walls or bridge construction will be required. However, a considerable amount of grading will be required in some areas, especially at the Merriman Road ramp.

An exclusive bus entrance ramp to the Lodge Expressway from the CBD Distribution Loop is recommended for each of the three freeway corridors. This ramp is assumed to cost $60,000,since retaining walls will probably be required.

The assumed amortization period for exclusive bus ramps is 30 years.

Signs

A variety of signs are provided in each corridor to designate priority use of facilities by buses and to identify bus stop locations. Bus stop and bus priority signs are assumed to be standard three foot by four foot steel signs which cost $100 each,including installation. The number and general location of these signs which are required for each corridor are presented in Section 6.1 and are summarized in Table 6-33.

Table 6-25 Capital Cost - BRT System (E. Jefferson Corridor)

Item	Unit Cost	Quantity	Total Cost	Amort. Period	Annual Cost
Signing					
Bus Priority					
Variable Message			837,800	15	97,855
Bus Only	100	460	46,000	15	5,373
Bus Stop	100	206	20,600	15	2,406
SUBTOTAL			904,400		105,634
Traffic Signals					
CBD Loop			20,500	15	2,394
New Center Loop			15,000	15	1,752
SUBTOTAL			35,500		4,146
Shelters	3,000	35	105,000	15	12,264
Park & Ride Facilities	660/space	1,539	1,015,740	30	90,228
BRT Vehicles	60,000	162	9,720,000	10	1,448,572
Vehicle Storage Facility	$25/sq ft	68,040	1,701,000	30	151,100
Maintenance Facilities					
Heavy Maintenance Garage	5,000/bus	162 buses	810,000	30	71,952
Operating Garage	2,780/bus	162 buses	450,360	30	40,005
SUBTOTAL			1,260,360		111,957
TOTAL			14,742,000		1,923,901

Table 6-26 Capital Cost - BRT System (I-94 Crosstown Corridor)

Item	Unit Cost	Quantity	Total Cost	Amort. Period	Annual Cost
Exclusive Bus Ramps					
Corridor Access	60,000	12	720,000	30	63,957
CBD/Lodge	60,000	1	60,000	30	5,330
SUBTOTAL			780,000		69,287
Signing					
Bus Priority	100	473	47,300	15	5,525
Bus Stop	100	230	23,000	15	2,686
SUBTOTAL			70,300		8,211
Traffic Signals					
CBD Loop			20,500	15	2,394
New Center Loop			15,000	15	1,752
SUBTOTAL			35,500		4,146
Shelters	3,000	50	150,000	15	17,520
Park & Ride Facilities	660/space	3,727 spaces	2,459,800	30	218,505
BRT Vehicles	60,000	290	17,400,000	10	2,593,122
Vehicle Storage Facility	$25/sq ft	121,800 sq ft	3,045,000	30	270,487
Maintenance Facility					
Heavy Maintenance Garage	$5,000/bus	290	1,450,000	30	128,803
Operating Garage	$2,780/bus	290	806,200	30	71,615
SUBTOTAL			2,256,200		200,418
TOTAL			26,196,800		3,381,696

Table 6-27 Capital Cost - BRT System (Lodge Corridor)

Item	Unit Cost	Quantity	Total Cost	Amort. Period	Annual Cost
Exclusive Bus Ramps					
Corridor Access	100,000	10	1,000,000	30	88,830
CBD/Lodge	60,000	1	60,000	30	5,330
SUBTOTAL			1,060,000		94,160
Signing					
Bus Priority	100	471	47,100	15	5,501
Bus Stop	100	190	19,000	15	2,219
SUBTOTAL			66,100		7,720
Traffic Signals					
CBD Loop			20,500	15	2,394
New Center Loop			15,000	15	1,752
SUBTOTAL			35,500		4,146
Shelters	3,000	45	135,000	15	15,768
Park & Ride Facilities	660/space	3845 spaces	2,537,700	30	225,424
BRT Vehicles	60,000	265	15,900,000	10	2,369,577
Vehicle Storage Facility	$25/sq ft	111,300	2,782,500	30	247,169
Maintenance Facility					
Heavy Maintenance Garage	$5000/bus	265	1,325,000	30	117,700
Operating Garage	$2780/bus	265	736,700	30	65,441
SUBTOTAL			2,061,700		183,141
TOTAL			24,578,500		3,147,105

Table 6-28 Capital Cost - BRT System (Michigan/I-94 Corridor)

Item	Unit Cost	Quantity	Total Cost	Amort. Period	Annual Cost
Exclusive Bus Ramps					
Corridor Access	40,000	8	320,000	30	28,425
CBD/Lodge	60,000	1	60,000	30	5,330
SUBTOTAL			380,000		33,755
Signing					
Bus Priority	100	469	46,900	15	5,478
Bus Stop	100	167	16,700	15	1,950
SUBTOTAL			63,600		7,428
Traffic Signals					
CBD Loop			20,500	15	2,394
New Center Loop			15,000	15	1,752
SUBTOTAL			35,500		4,146
Shelters	3,000	35	105,000	15	12,264
Park & Ride Facilities	660/space	2116 spaces	1,396,560	30	124,056
BRT Vehicles	60,000	145	8,700,000	10	1,296,561
Vehicle Storage Facility	$25/sq ft	60,900	1,522,500	30	135,244
Maintenance Facility					
Heavy Maintenance Garage	$5,000/bus	145	725,000	30	64,402
Operating Garage	$2,780/bus	145	403,100	30	35,807
SUBTOTAL			1,128,100		100,209
TOTAL			13,331,260		1,713,663

Table 6-29 Capital Cost - Feeder Systems (East Jefferson Corridor)

Feeder Type	Item	Unit Cost	Quantity	Total Cost	Amort. Period	Annual Cost
DAB	Vehicles	35,000	42	1,470,000	10	219,074
	DAB Control			258,078	20	26,285
	Vehicle Storage Facilities	25/sq ft	11,466	286,650	30	25,463
	Maintenance Facilities					
	Heavy Maintenance Garage	5000/bus	42	210,000	30	18,654
	Operating Garage	2780/bus	42	116,760	30	10,372
	SUBTOTAL			326,760		29,026
	TOTAL			2,341,488		299,848
FR-FS	Vehicles	60,000	128	7,680,000	10	1,144,550
	Vehicle Storage Facilities	25/sq ft	53,760	1,344,000	30	119,388
	Maintenance Facilities					
	Heavy Maintenance Garage	5000/bus	128	640,000	30	56,851
	Operating Garage	2780/bus	128	355,840	30	31,609
	SUBTOTAL			995,840		88,460
	TOTAL			10,019,840		1,352,398

Table 6-30 Capital Cost - Feeder Systems (I-94 Crosstown Corridor)

Feeder Type	Item	Unit Cost	Quantity	Total Cost	Amort. Period	Annual Cost
DAB	Vehicles	35,000	60	2,100,000	10	312,963
	DAB Control			291,559	20	29,695
	Vehicle Storage Facilities	25/sq ft	16,380	409,500	30	36,376
	Maintenance Facilities					
	Heavy Maintenance Garage	5000/bus	60	300,000	30	26,649
	Operating Garage	2780/bus	60	166,800	30	14,817
	SUBTOTAL			466,800		41,466
	TOTAL			3,267,859		420,500
FR-FS	Vehicles	60,000	154	9,240,000	10	1,377,037
	Vehicle Storage Facilities	25/sq ft	64,680	1,617,000	30	143,638
	Maintenance Facilities					
	Heavy Maintenance Garage	5000/bus	154	770,000	30	68,399
	Operating Garage	2780/bus	154	428,120	30	38,030
	SUBTOTAL			1,198,120		106,429
	TOTAL			12,055,120		1,627,104

Table 6-31 Capital Cost - Feeder Systems (Lodge Corridor)

Feeder Type	Item	Unit Cost	Quantity	Total Cost	Amort. Period	Annual Cost
DAB	Vehicles	35,000	109	3,815,000	10	568,549
	DAB Control			481,297	20	49,201
	Vehicle Storage Facilities	25/sq ft	29,757	743,925	30	66,083
	Maintenance Facilities					
	Heavy Maintenance Garage	5000/bus	109	545,000	30	48,412
	Operating Garage	2780/bus	109	303,020	30	26,917
	SUBTOTAL			848,020		75,329
	TOTAL			5,888,242		759,162
FR-FS	Vehicles	60,000	299	17,940,000	10	2,673,598
	Vehicle Storage Facilities	25/sq ft	125,580	3,139,500	30	278,882
	Maintenance Facilities					
	Heavy Maintenance Garage	5000/bus	299	1,495,000	30	132,801
	Operating Garage	2780/bus	299	831,220	30	73,837
	SUBTOTAL			2,326,220		206,638
	TOTAL			23,405,720		3,159,118

Table 6-32 Capital Cost - Feeder Systems (Michigan/I-94 Corridor)

Feeder Type	Item	Unit Cost	Quantity	Total Cost	Amort. Period	Annual Cost
DAB	Vehicles	35,000	77	2,695,000	10	401,636
	DAB Control			451,130	20	45,948
	Vehicle Storage Facilities	25/sq ft	21,021	525,525	30	46,682
	Maintenance Facilities					
	Heavy Maintenance Garage	5000/bus	77	385,000	30	34,200
	Operating Garage	2780/bus	77	214,060	30	19,015
	SUBTOTAL			599,060		53,214
	TOTAL			4,270,715		547,480
FR-FS	Vehicles	60,000	282	16,920,000	10	2,521,588
	Vehicle Storage Facilities	25/sq ft	118,440	2,961,000	30	263,026
	Maintenance Facilities					
	Heavy Maintenance Garage	5000/bus	282	1,410,000	30	125,250
	Operating Garage	2780/bus	282	783,960	30	69,639
	SUBTOTAL			2,193,960		194,889
	TOTAL			22,074,960		2,979,503

Table 6-33 BRT Signing Requirements

CORRIDOR	SIGN TYPE	LOCATION						
		BRT Collection Zone	BRT Route	CBD Loop	New Center Loop	Northland Loop	Ford Complex Loop	Total
E. Jefferson	Bus Only			204	256			460
	Bus Stop	189		11	6			206
I-94 Crosstown	Bus Only		13	204	256			473
	Bus Stop	210		11	6		3	230
Lodge	Bus Only		11	204	256			471
	Bus Stop	168		11	6	65		190
Michigan/I-94	Bus Only		9	204	256			469
	Bus Stop	147		11	6		3	167

Variable message signs are required for the East Jefferson Corridor as discussed in Section 6.1. The cost of these signs and associated equipment is estimated based on representative unit costs supplied by the American Sign and Indicator Corporation of Spokane, Washington. The estimated cost of the system required for the East Jefferson Corridor is itemized in Table 6-34.

The capital cost of signs is amortized over a period of 15 years.

Table 6-34 Variable Message Sign Costs for the E. Jefferson Corridor

Item	Unit Cost	Quantity per Location	Number of Locations	Total Quantity	Total Cost
Variable Message Sign	$3,000	6	30	180	$540,000
Lane Control Signal Head	400	4	30	120	48,000
Local Controller	3,000	1	30	30	90,000
Master Controller	5,000			1	5,000
Telephone Lines	600			8	4,800
SUBTOTAL					$687,800
Installation					150,000
TOTAL					$837,800

Traffic Signals

Additional traffic signals are required for the CBD and New Center Distribution Loops. The left turn signals for contra-flow buses require changes in the signal control logic as well as the addition of a signal head. Therefore, the cost of installing each turn signal is estimated to be $2,000. The cost of installing a signal to face the reverse flow direction on one-way streets is estimated to be $500,since no changes in control logic are required. The total cost of signal changes for the CBD Distribution Loop is $20,500 (5 left turn signals @ $2,000 plus 21 contra-flow signal heads @ $500). The traffic signal cost for the New Center Loop is $15,000 (4 left turn signals @ $2,000 plus 14 contra-flow signal heads @ $500). An amortization period of 15 years is assumed for traffic signal equipment.

Shelters

The estimated cost of bus shelters, $3,000 each, is based on typical shelter costs quoted by Columbia Equipment Company plus assumed installation costs. The cost of shelters is amortized over a period of 15 years to obtain estimated annual system costs.

Park-and-Ride Facilities

The cost of constructing park-and-ride facilities is assumed to be $1.65 per square foot including limited grading, base construction, topping, lighting, and drainage, but excluding the cost of land. Parking space requirements vary from 279 to 579 square feet per space depending on the parking angle relative to the aisle and the average size of the vehicles. It is assumed that 400 square feet are required for each space. Thus, the estimated parking facility cost is $660 per space.

A 30-year amortization period is assumed for park and ride lots.

Vehicles

Based on a cursory survey of recent transit coach procurements, as reported in transit industry periodicals, the cost of a 53-passenger vehicle for BRT and Fixed-Route, Fixed-Schedule service is assumed to be $60,000. Dial-A-Bus vehicles, including all on-board communications equipment, are assumed to cost $35,000 each.

Dial-A-Bus Control

Dial-A-Bus control equipment costs are based on previous GM TSD Dual Mode analyses. These values represent the 1974 costs of the equipment. The same basic computer system is used for each corridor. The differences in the computer costs represent those costs,such as core size, which are directly related to corridor demand and size differences.

A twenty-year amortization period is assumed for the DAB control equipment.

Storage Facilities

It is estimated that 420 square feet are required for storing large vehicles and 273 square feet are required for Dial-A-Bus vehicles. Storage building costs are assumed to be $25 per square foot. This does not include cost of land. These capital costs are amortized over a period of 30 years.

Heavy Maintenance Garage and Operating Garage

The heavy maintenance garage capital costs are estimated to be $5,000 for each bus. This is a rough estimate based upon the fact that DDOT spent $5,000,000 for a heavy maintenance garage for their 1000 bus system. The operating garages where vehicles are fueled, cleaned,and serviced are estimated to cost $2,780 per bus. This is based upon analyses done on the cost of operating garages for servicing dual mode vehicles. The heavy maintenance and operating garages capital costs do not include land costs and are amortized over 30 years.

6.7.2 Operating Costs

Tables 6-35 through 6-38 provide summaries of the BRT operating costs for each corridor. Tables 6-39 through 6-42 provide a summary of both FR-FS and DAB feeder system operating costs for each corridor.

The operating costs of the BRT system as well as the two feeder systems include driver wages, garage expense, and vehicle maintenance expenses. The BRT system operating costs also include restriping costs and shelter maintenance. The DAB feeder system incurs an annual system control cost. Driver costs are estimated to be $12.35 per vehicle operating hour. This is based upon the expected driver costs per revenue hour for DDOT in July 1975. The average base salary is $6.36 per hour. However,since the $12.35 is a cost per revenue hour, it includes non-production time such as sign-on time, travel time, dead head, premium pay, waiting time, lost time, vacation and holiday pay, sick leave, and retirement benefit costs. The garage expenses are those costs incurred at the garages. They include fuel costs, lube costs, cleaning materials, and the labor required to clean and service the vehicles. DDOT garage expense from July 1974 to March 1975 was 17.13¢ per vehicle mile. DDOT buses average about 12 mph. Since the BRT buses will average 35-40 mph, they will have greater fuel efficiency. It is expected they will get 6 to 6.5 miles per gallon rather than 4 miles per gallon. Therefore BRT garage expenses are estimated to be 14.13¢ per mile (assuming fuel costs at 29.75¢ per gallon). It is assumed that the Dial-A-Bus costs are also 14.13¢ per mile. The vehicles do not average 35-40 mph, but they are lighter. The garage expense associated with large feeder buses are assumed to be 17.13¢ per mile because these buses operate at speeds similar to DDOT buses.

The maintenance expense is the cost of heavy maintenance. It includes labor, supervision, and material costs. Also included are the costs of maintaining the buildings and grounds. The DDOT cost of 19.54¢ per vehicle mile was used in the calculations.

Lane striping and diamond-shaped markings are required to delineate exclusive transit lanes on public streets. According to Detroit DOT estimates, the cost of striping is $0.03 per linear foot. Two stripes are required along the entire length of the CBD and New Center Distribution Loops to designate the exclusive bus lane. The cost of this striping is estimated to be $634 for the 2.0 mile CBD loop and $1457 for the 4.6 mile New Center Loop. Diamond-shaped pavement markings are also required to identify the exclusive bus lanes in the CBD and New Center areas. Each 12 foot by 2.5 foot diamond consists of 24.5 linear feet.

An average 100-foot spacing is assumed. The cost of these pavement markings, assuming the Detroit DOT estimate of $0.10 per linear foot for hand work, is $260 for the CBD loop and $595 for the New Center loop. The total cost of pavement markings is $894 for the CBD Distribution Loop and $2052 for the New Center loop. Although public streets usually require restriping twice a year, these transit priority pavement markings are assumed to last a full year due to the lower vehicle volumes associated with a reserved bus lane.

Table 6-35 Annual Operating Cost - BRT System (E. Jefferson Corridor)

Item	Unit Cost	Quantity	Total Cost
Shelter Maintenance	300.	35	10,500
Vehicle Expense			
Garage	.1453/mi.	1,868,513	271,495
Maintenance	.1954/mi.	1,868,513	365,107
SUBTOTAL			636,602
Drivers	12.35/V-hr.	88,442	1,092,259
Telephone Line Lease	7200/Line	8	57,600
Pavement Marking			
BRT Line Haul			7,248
CBD Distribution Loop			894
New Center Distribution			2,052
SUBTOTAL			10,194
TOTAL			1,807,155

Table 6-36 Annual Operating Cost - BRT System (I-94 Crosstown Corridor)

Item	Unit Cost	Quantity	Total Cost
Shelter Maintenance	300.	50	15,000
Vehicle Expense			
Garage			
Peak Period	.1453/mi	3,293,121	478,490
Off-Peak Period	.1453/mi	170,136	24,721
Maintenance			
Peak Period	.1954/mi	3,293,121	643,476
Off-Peak Period	.1954/mi	170,136	33,245
SUBTOTAL			1,179,932
Driver Expense			
Peak Period	12.35/V-hr	152,082	1,878,213
Off-Peak Period	12.35/V-hr	7,191	88,809
SUBTOTAL			1,967,022
Pavement Marking			
CBD Loop			894
New Center Loop			2,052
SUBTOTAL			2,946
TOTAL			3,164,900

Table 6-37 Annual Operating Cost - BRT System (Lodge Corridor)

Item	Unit Cost	Quantity	Total Cost
Shelter Maintenance	300	45	13,500
Vehicle Expense			
Garage			
Peak Period	.1453/mi	3,111,128	452,047
Off-Peak Period	.1453/mi	174,216	25,314
Maintenance			
Peak Period	.1954/mi	3,111,128	604,914
Off-Peak Period	.1954/mi	174,216	34,042
SUBTOTAL			1,119,317
Driver Expense			
Peak Period	12.35/V-hr	136,026	1,679,921
Off-Peak Period	12.35/V-hr	6,656	82,202
SUBTOTAL			1,762,123
Pavement Marking			
CBD Loop			894
New Center Loop			2,052
SUBTOTAL			2,946
TOTAL			2,897,886

Table 6-38 Annual Operating Cost - BRT System (Michigan/I-94 Corridor)

Item	Unit Cost	Quantity	Total Cost
Shelter Maintenance	300	35	10,500
Vehicle Expense			
Garage			
Peak Period	.1453/mi	1,724,846	250,620
Off-Peak Period	.1453/mi	137,496	19,978
Maintenance			
Peak Period	.1954/mi	1,724,846	337,035
Off-Peak Period	.1954/mi	137,496	26,867
SUBTOTAL			634,500
Driver Expense			
Peak Period	12.35/V-hr	76,520	945,022
Off-Peak Period	12.35/V-hr	5,432	67,085
SUBTOTAL			1,012,107
Pavement Marking			
CBD Loop			894
New Center Loop			2,052
SUBTOTAL			2,946
TOTAL			1,660,053

Table 6-39 Annual Operating Cost - Feeder Systems (E. Jefferson Corridor)

	Item	Unit Cost	Quantity	Total Cost
DAB	Vehicles			
	Garage	.1453/mi	673,200	97,816
	Maintenance	.1954/mi	673,200	131,543
	SUBTOTAL			229,359
	DAB Control			
	Dispatchers	18,215/yr	2	36,430
	Reservation Agents	18,215/yr	7	127,505
	Equipment Maintenance			5,162
	SUBTOTAL			169,097
	Drivers	12.35/V-hr	44,880	554,268
	TOTAL			952,724
FR-FS	Vehicles			
	Garage	.1713/mi	4,222,800	723,366
	Maintenance	.1954/mi	4,222,800	825,135
	SUBTOTAL			1,548,501
	Drivers	12.35/V-hr	281,520	3,476,772
	TOTAL			5,025,273

Table 6-40 Annual Operating Cost - Feeder Systems (I-94 Crosstown Corridor)

	Item	Unit Cost	Quantity	Total Cost
DAB	Vehicles			
	Garage	.1453/mi	942,480	136,942
	Maintenance	.1954/mi	942,480	184,161
	SUBTOTAL			321,103
	DAB Control			
	Dispatchers	18,215/yr	2	36,430
	Reservation Agents	18,215/yr	9	163,935
	Equipment Maintenance			5,831
	SUBTOTAL			206,196
	Drivers	12.35/V-hr	62,832	775,975
	TOTAL			1,303,274
FR-FS	Vehicles			
	Garage	.1713/mi	5,102,550	874,067
	Maintenance	.1954/mi	5,102,550	997,038
	SUBTOTAL			1,871,105
	Drivers	12/35/V-hr	340,170	4,201,100
	TOTAL			6,072,205

Table 6-41 Annual Operating Cost - Feeder Systems (Lodge Corridor)

	Item	Unit Cost	Quantity	Total Cost
DAB	Vehicles			
	Garage	.1453/mi	1,716,660	249,431
	Maintenance	.1954/mi	1,716,660	335,435
	SUBTOTAL			584,866
	DAB Control			
	Dispatchers	18,215/yr	2	36,430
	Reservation Agents	18,215/yr	15	273,225
	Equipment Maintenance			9,626
	SUBTOTAL			319,281
	Drivers	12.35/V-hr	114,444	1,413,383
	TOTAL			2,317,530
FR-FS	Vehicles			
	Garage	.1713/mi	9,853,200	1,687,853
	Maintenance	.1954/mi	9,853,200	1,925,315
	SUBTOTAL			3,613,168
	Drivers	12.35/V-hr	656,880	8,112,468
	TOTAL			11,725,636

Table 6-42 Annual Operating Cost - Feeder Systems (Michigan/I-94 Corridor)

	Item	Unit Cost	Quantity	Total Cost
DAB	Vehicles			
	Garage	.1453/mi	1,211,760	176,069
	Maintenance	.1954/mi	1,211,760	236,778
	SUBTOTAL			412,847
	DAB Control			
	Dispatchers	18,215/yr	2	36,430
	Reservation Agents	18,215/yr	11	200,365
	Equipment Maintenance			9,025
	SUBTOTAL			245,820
	Drivers	12.35/V-hr	80,784	997,682
	TOTAL			1,656,349
FR-FS	Vehicles			
	Garage	.1713/mi	9,302,400	1,593,501
	Maintenance	.1954/mi	9,302,400	1,817,689
	SUBTOTAL			3,411,190
	Drivers	12.35/V-hr	620,160	7,658,976
	TOTAL			11,070,166

Restriping is also required to delineate the reserved BRT lane on East Jefferson. Since three lanes are involved in the implementation, four stripes are required along the 5.72 mile reserved lane section of this corridor. Assuming semi-annual restriping at $0.03 per linear foot, the annual cost of restriping is $7248 for the East Jefferson corridor. No pavement marking is required along the other BRT routes or for the Northland or Ford Complex Distribution Loops, since no lanes are reserved exclusively for buses.

The annual bus shelter maintenance expense is assumed to be $300 per shelter and includes periodic cleaning and repair.

Dial-A-Bus control operating costs are divided into two categories: personnel costs and maintenance costs. Both dispatchers and reservation agents are assumed to make $18,215 per year, including benefits. This value is based on previous Dual Mode Transit analyses. The maintenance costs for the DAB electronic control equipment is assumed to be two percent of the original purchase price of the equipment per year.

The cost of operating and maintaining park and ride lots was not included in the operating cost estimates. In some cases, parking spaces at large retail centers may be available at no cost. In other cases, a nominal lease or service cost (weekday snow removal, for example) may be incurred. The operating costs associated with system-owned park-and-ride facilities will vary with the size and location of the lots, but, in general, will include lighting, snow removal, maintenance, and security.

6.8 Corridor Ranking

Three criteria have been consistently used throughout the study to evaluate the potential of candidate corridors for successful BRT implementation. The criteria are: 1) high potential for attracting ridership, 2) high potential for improving trip time by implementing a priority treatment, and 3) high potential for economical implementation. Table 6-43 shows the ranking of the four candidate corridors based on these criteria.

Table 6-43 Corridor Ranking

Rank	Corridor	Total BRT Demand (a.m. Peak-Period)	Travel Time Ratio BRT/Auto	BRT Cost/Peak-Period Pass. Trip*	Feeder System (DAB) Cost/Peak-Period Feeder Passenger Trip
1	I-94 Crosstown	20,585	1.21	.62	1.71
2	Lodge	17,698	1.26	.67	1.72
3	Michigan/I-94	9,542	1.24	.69	1.75
4	E. Jefferson	9,774	1.36	.75	1.85

*Not including feeder service

The measures which have been used to quantify the criteria have become more explicit as the corridor analysis has become more detailed. For example, earlier in the study, BRT ridership potential was characterized by a combination of two parameters: the total corridor demand for particular destinations and the magnitude of current transit ridership along the corridor. In the final ranking, the results of the modal split analysis were used to predict BRT ridership in each corridor. Table 6-43 shows that the I-94 Crosstown and Lodge Corridors clearly have greater BRT ridership potential than the other two corridors.

Earlier in the study, average automobile line-haul speed and volume to capacity ratios were used to characterize congestion in the various corridors as an indication of travel time reduction potential. In the final ranking, the ratio of estimated BRT trip time to automobile trip time is used as a direct measure of this criterion. The data in Table 6-43 show that all four corridors offer about the same potential for providing competitive trip time.

Finally, general observations concerning the ease of implementation on each corridor were used earlier in the study to indicate relative implementation costs. Now the preliminary capital and operating cost estimates reported in Section 6.7 can be used to calculate the total annualized cost per peak-period passenger trip. The values of this parameter calculated for the line-haul BRT system and for the DAB feeder system are used in the final ranking. DAB system costs, rather than FR-FS system costs, were selected for use in the corridor comparisons because they are lower than the costs of the FR-FS systems. The costs used to calculate these ratios include the cost of providing off-peak service, because this is considered to be a necessary part of both the BRT and the feeder systems. However, the feeder system cost ratios do not account for any additional costs which DDOT might incur in providing fixed-route, fixed-schedule feeder service within Detroit. Only peak-period passenger trips were used to calculate the ratios, since off-peak BRT ridership was not estimated. The feeder system cost ratios account only for those BRT patrons outside the city of Detroit who actually use the DAB feeder service in the peak periods. The number of passengers who access the system via DDOT buses is not included. The data for the line-haul BRT systems indicate that a BRT implementation on the I-94 Crosstown Corridor results in the lowest cost per peak-period passenger trip, while a BRT implementation on East Jefferson results in the highest cost per passenger. The same corridor ranking is indicated by the DAB feeder system cost ratios.

The fact that it is quite expensive to provide a pervasive feeder service should come as no surprise. In the independent study of intermediate and feeder level transit conducted by General Motors for SEMTA in late 1974, the annual cost of the recommended feeder system was found to be approximately four times the annual cost of the intermediate level transit system.

The values of estimated cost per passenger trip listed in Table 6-43 for the DAB systems are not inconsistent with similar data reported for existing demand-responsive systems. Actual cost per ride data for several demand-responsive systems are indicated in Table 6-44.

Table 6-44 Example DAB System Costs

Location	Cost Per Ride
Ann Arbor	\$1.35[1]
Batavia	.61[2]
Bay Ridges	.60[3]
Haddonfield	3.50[4]
Regina	.70[3]

Source: Dial-A-Ride for the Transit Industry, K. W. Guenther, prepared for ATA meeting August 27, 1972

---

[1] Operating cost only

[2] Includes debt service administration and overhead

[3] Includes depreciation and overhead

[4] Includes capital costs, depreciation, and overhead

Only the value for Haddonfield can be directly compared with the results of this study, since it includes amortized capital costs as well as operating costs. The experimental nature of this system contributed to its high cost.

In summary, the four candidate corridors are ranked in order of their potential for successful BRT implementation as follows:

1. I-94 Crosstown
2. Lodge
3. Michigan/I-94
4. East Jefferson

6.9 BRT Action Plan

The accomplishment of a logical progression of tasks is quite important to the successful implementation of bus rapid transit service in a selected travel corridor. A description of these tasks and their interrelationships is termed an "action plan." The four candidate BRT corridors all have similar implementation task requirements, with minor exceptions for the non-freeway East Jefferson route. Therefore, a single action plan, common to the four corridors, has been developed. The BRT action plan is diagrammed in Figure 6-33, and is discussed in the remainder of this section.

The first task shown in Figure 6-33, "Preliminary BRT Design," has been completed for each of the four candidate BRT corridors. All other action plan items pertain to the additional analysis, design, and implementation of BRT service in a single corridor (chosen from among the four, or synthesized from elements of two or more candidate corridors).

The next task to be performed is a BRT system design and impact analysis. The system design specifies the mainline BRT route, access and egress points along that route, the BRT collection route and feeder system, possible locations of transfer and park-and-ride facilities, and the distribution route for each major destination area. The system design task also generates a refined estimate of BRT capital and operating costs. Interrelated with the system design is a system sizing and impact analysis, including a computer simulation of traffic flow along the corridor's BRT route, with and without BRT operations. Such a corridor simulation permits an assessment of the BRT level of service (primarily BRT travel times relative to those of automobile trips) and the effect of BRT implementation on auto trips. Furthermore, the demand analysis portion of this task produces refined modal split and ridership estimates for system sizing and costing, and for subsequent design, implementation, and evaluation tasks (shown in Figure 6-33).

System specification and detailed engineering design activities constitute the next task to be performed. This task is dependent upon the results of the preceding task and upon the BRT implementation treatment as it applies to the selected BRT corridor. The detailed engineering design task provides for BRT route revisions, based upon an evaluation of initial stages of operation. This task also includes the specification and design of right-

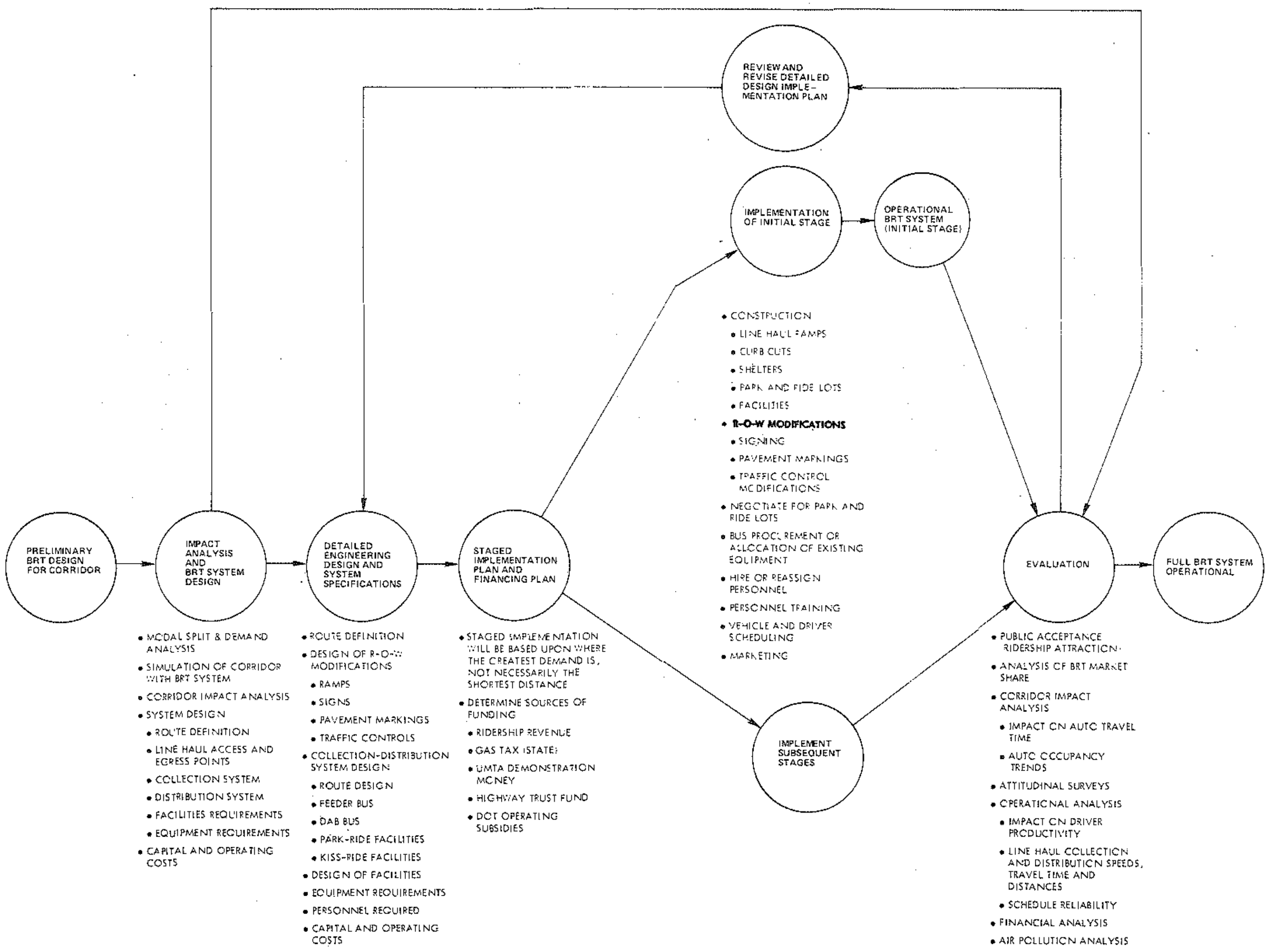


Figure 6-33 BRT Action Plan

of-way modifications, entry and exit ramps, pavement markings, traffic control signals and signs, bus shelters, park-and-ride and transfer facilities, and a feeder bus system (particularly if a Dial-A-Bus feeder system is chosen). Additionally, equipment and personnel requirements are determined and system capital and operating cost estimates are updated.

The next action plan task consists of the detailed staged implementation plan development and the preparation of a financing plan. It is anticipated that BRT operation in the selected corridor will be fully implemented through a succession of service increases. These increases may be configured to emphasize areas of greatest demand, rather than to progressively extend the mainline BRT route. Therefore, an implementation analysis effort, resulting in an implementation plan, is an important segment of the BRT program. Another aspect of this task is the investigation of system financing sources. Various state and federal sources of funds to meet capital and operating expenses are considered, and operating revenues are estimated.

Following the staged implementation and financing planning task, deployment of the initial stage of the BRT system begins. Negotiations to secure park-and-ride space in existing parking lots are conducted and the construction of additional park-and-ride lots is begun. Right-of-way modifications, facilities construction, pavement marking changes, traffic control signal and sign installation, and bus stop shelter placement are all initiated. The required BRT vehicles are either procured or allocated from existing fleets. BRT personnel are hired or reassigned from other duties and their training programs are initiated. Driver and vehicle schedules for the first stage of operation are developed. Also included in this task is a marketing activity to increase public awareness of the BRT service and to attract riders from among the persons who are presently not using transit. All of these subtasks, of course, must be planned such that they interact properly and are congruous with an overall implementation scheduled.

The actual impact of the BRT system is analyzed in the task labeled "Evaluation" in Figure 6-33. The earlier impact analysis task provides a reference with which to compare observed system performance and public acceptance. This task includes attitudinal surveys to quantify the reactions of BRT riders and non-riders. Other analyses gauge changes in auto travel times, auto occupancy levels, energy use, and air quality. An analysis of operational parameters (such as BRT collection, line-haul, and distribution travel times, schedule reliability, vehicle operator productivity, and financial status) is conducted.

As a result of the evaluation task, the system's detailed design and implementation plans are reviewed. Portions of the detailed engineering and system specification tasks are then repeated as necessary. Following this, subsequent stages of the BRT system are implemented and evaluated, leading to full deployment in the selected corridor.

6.10 Conclusions and Recommendations

Bus rapid transit integrated with a computer controlled ramp metering system is one of the most viable means of efficiently utilizing an existing freeway facility. The combination possesses the unique feature of enhancing auto travel as well as transit travel without either mode sacrificing appreciable travel time or facilities. Capital implementation costs are relatively low compared to facility expansion costs such as lane additions, right-of-way additions, etc. to accommodate other types of bus transit treatments. The fact that firm plans currently exist for implementing the SCANDI system in the Detroit area is of significant importance to the Michigan Bus Rapid Transit Demonstration Program (MBRTDP).

Current Schedule for SCANDI System Implementation

Acquisition of Control Building and Computer Equipment	Summer, 1976
Installation of Sensors and Equipment	
• Lodge and Ford Freeways	Summer, 1976
• Chrysler Freeway	Summer, 1977
• Southfield and Fisher Freeways	Summer, 1978
System Refinements	1979

It is recommended that the SCANDI program schedule be reinforced and possibly expedited to more closely coincide with the MBRTDP schedules. If the SCANDI system were not implemented on Detroit's freeways, other alternatives such as exclusive or priority lanes appear feasible within the limitations identified in the text of this report. Also, the results of the analysis effort scheduled for Phase II will further define the traffic characteristics of the corridor and allow final BRT treatment requirements to be established.

The corridor ranking section identified the I-94 Crosstown Corridor as exhibiting the most potential for bus rapid transit based on Phase I studies. A logical extension of this corridor would include service to the Detroit Metropolitan Airport. It may be desirable to consider combining the I-94 Crosstown with the entire Michigan Ave./I-94 Corridor, since an appreciable portion is common to both. If the I-94 Crosstown Corridor is indeed chosen for continued analysis in Phase II, it is recommended that consideration be given to include this extension as part of the overall Phase II analysis effort.

The high costs of the feeder systems associated with BRT implementations are such that additional attention is warranted in this area. Further study is recommended to determine if other incentives such as subscription service, park-and-ride and/or kiss-and-ride facilities could be established to enhance access to the BRT line and reduce the dependency upon supplemental feeder systems.

7.0 BRT PHASE II WORK PROGRAM

7.0 PHASE II WORK PROGRAM

The objective of this program is to develop a preliminary design of the BRT system in the selected corridor and route. This preliminary design will serve as the basis for Phase III detailed design. Phase II preliminary design will cover the following:

System Analysis

- Modal split for BRT ridership, with projections to future dates
- Corridor traffic impact analysis

System Design

- Route definition
- Intermediate stops
- Terminals
- Feeders
- Access
- CBD treatment
- Facilities and equipment for priority treatment

7.1 Tasks

7.1.1 Task 1 - Trial Design

Based upon the output of Phase I work, a trial design for the BRT system along the selected corridor and route will be developed. This trial design will include the following:

- Route Definition - Alignment, access points to main line, rough estimates of headways, interfaces with feeders
- Intermediate Stops - Preliminary selection of major origins and destinations to be served
- Terminals - Locations, functions, rough layouts, and flow arrangements for terminals
- Feeder Service - Preliminary selection and sizing of feeder routes, including both feeders which enter the main line and feeders requiring transfers
- Access - Provisions for walk-in, park-and-ride, and kiss-and-ride facilities, including locations and rough sizing
- CBD Treatment - Preliminary design of special bus flow treatments, if needed, to facilitate BRT movement in the CBD
- Priority Treatment Mechanization - Preliminary engineering design of traffic controls, signing, lane modifications, and other mechanization features

The output of this task will be a preliminary design definition of the BRT system to be used for further analyses and as a reference for design iterations. Preliminary estimates of travel times will be made.

7.1.2 Task 2 - Modal Split Analysis

Additional data required to simulate existing highway and transit use within the selected corridor will be collected, including:

- Transportation Demand Studies: Establishment of zones; interview techniques; classification counts; screen line checks; land use coding; and growth factors
- Highway Use Studies: Average daily traffic; hourly traffic; directional counts; classification and occupancy counts; profile counts; delay studies; capacity; level of service; and peak-hour factor
- Transit Use Studies: Routes and schedules; station location; passenger volume; trip ends; adherence to schedules; fare structure, transit speed, and delays; headways; cost per passenger mile; load checks; modal split

Existing travel will be simulated by mode in the corridor by means of trip distribution and assignment models, and correlated with traffic and transit count data to calibrate the models. Satisfactory correlation will duplicate simulation and calibration for a.m. and p.m. peak periods.

The output of this task is an analysis tool for use in Task 3. Work elements, in addition to the above, include determination of the demographic characteristic distributions of the population within the corridor's service area such as income, car ownership, and residence types.

7.1.3 Task 3 - Estimation of BRT Ridership

Using the modal split model developed in Task 2, the anticipated BRT ridership will be estimated. These estimates will be developed for 1975, 1980, and 1985.

O/D data now in use is really the 1965 O/D data. The following additional information will be used to improve trip distribution estimates:

- 1970 census
- 1975, 1980, 1985 population projections (per SEMCOG)
- Land use plans (per SEMCOG)
- 1990 trip distribution projections (per SEMCOG)

Output of this task will be BRT and auto ridership estimates for the corridor route for 1975, 1980, and 1985. For the BRT, ridership will be daily and peak-hour estimates.

7.1.4 Task 4 - Corridor Traffic Simulation

Using the modal split estimates from Task 3, the impact of BRT implementation on surface traffic in the corridor will be analyzed; that is, the effect on the overall level of transportation service provided in the corridor.

This task requires the development of a model of corridor traffic along the BRT route and available parallel roads for the purpose of predicting, by simulation, traffic volumes and travel times of private automobiles as affected by BRT implementation.

Also required will be the calibration of the model to current traffic conditions; which, in turn, requires the counting of traffic on the potentially affected roads, plus analysis of variation of counts during several time periods.

The output of this task will be a prediction of travel times and volumes for cars resulting from changes to traffic volumes due to the BRT implementation. These travel times will affect modal splits and the iterative analyses of Task 6.

7.1.5 Task 5 - Evaluation of Trial Design

The trial design of Task 1 will be evaluated in the light of ridership estimates and traffic simulation to determine its adequacy to provide the desired service. Evaluation criteria will be developed to measure the adequacy of the BRT design. These will include parameters such as travel time savings, ridership volumes, and traffic congestion.

7.1.6 Task 6 - Iteration of Trial Design

The trial design will be subjected to iteration in order to refine the design based upon the ridership estimates, traffic effects simulation results, and trial design evaluation. The iteration of the trial design will begin as soon as the Task 1 design is postulated; that is, the iteration will be concurrent with the analyses of Tasks 2, 3, and 4. It will continue to permit a final iteration after Task 5.

7.1.7 Task 7 - Preliminary Design and Report

The refined system trial design will be formalized by the specification of characteristics shown in Task 1. This task is, essentially, the preparation of a preliminary design report.

If warranted by the analysis, a program plan will be prepared for implementing the bus rapid transit demonstration. This plan will include:

- An estimate of the equipment required to implement the demonstration and the cost of obtaining the equipment

- A traffic operations plan with particular attention to the problem of providing entrance and egress facilities for the priority treatment at terminal points and stations, and to the problem of merging buses into the normal traffic flow at the end of the priority treatment
- The location and cost of potential bus terminals and support systems which may simultaneously or subsequently be required, such as park-and-ride, kiss-and-ride, feeder bus, or Dial-A-Ride, and their related interface facilities
- A detailed cost estimate of the plan

7.2 Effort Estimate

Task	Task Title	Manpower (Man-Weeks)			
		Manager	Engineer	Planner	Illust.
1	Trial Design	6	12		4
2	Modal Split Analysis	6	12	24	
3	Estimation of BRT Ridership	2	24		
4	Corridor Traffic Simulation	4	16	24	4
5	Evaluation of Trial Design		8		
6	Iteration of Trial Design	6	16		4
7	Preliminary Design & Report	4	6	4	4
	TOTAL	28	94	52	16

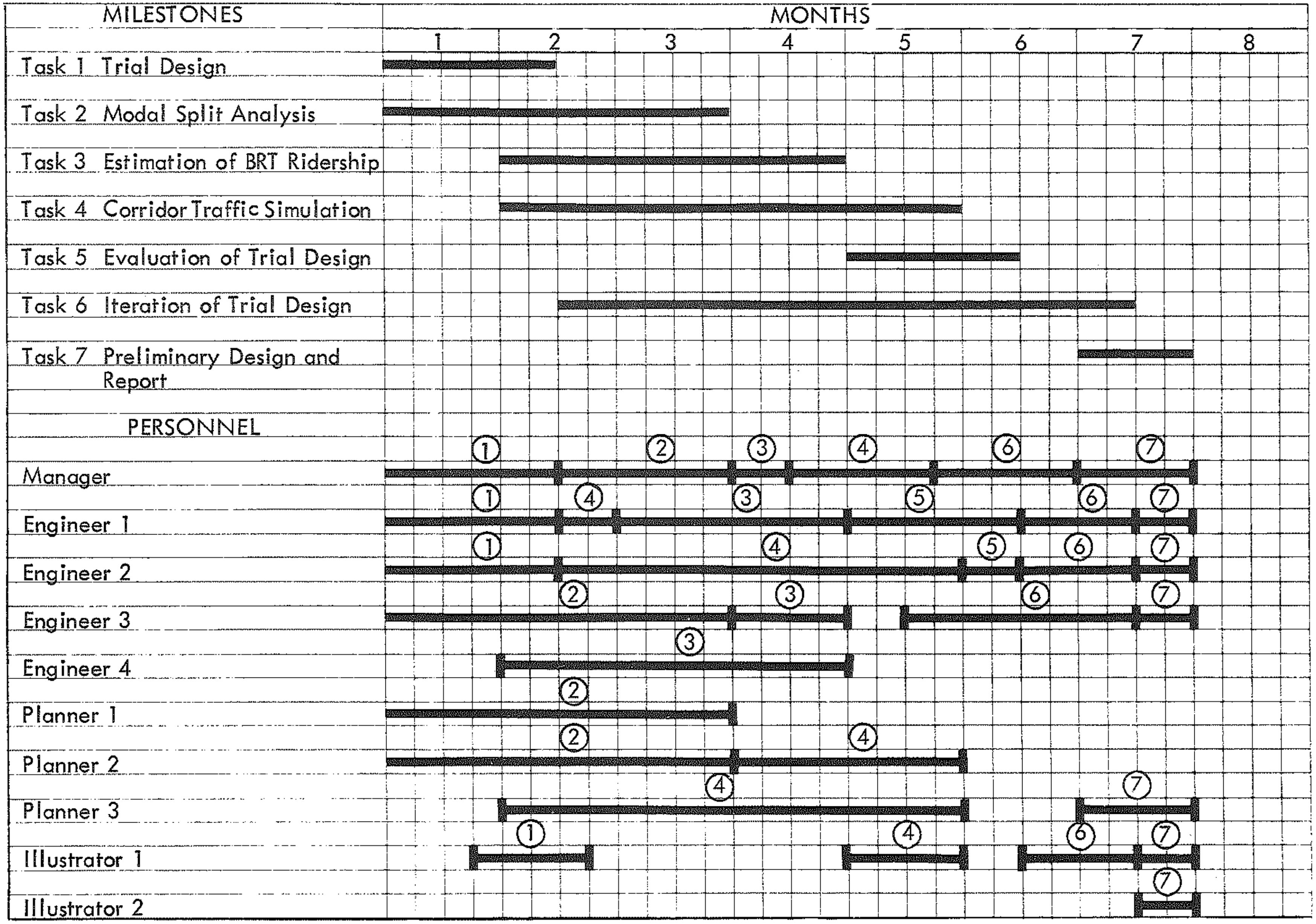


Figure 7-1. BRT Phase II Schedule and Manloading Chart

GM Transportation Systems

APPENDIX

APPENDIX

This appendix contains a collection of ten trip reports prepared by members of the GM TSD staff for the contract effort. The first three reports document information-gathering trips to Lansing, Flint, and Grand Rapids, respectively. The next four reports summarize the results of data-collection meetings with various agencies in Detroit. The next report summarizes the results of the first meeting with Herb Crane of the Traffic and Safety Division, Department of State Highways and Transportation, concerning plans to implement SCANDI on Detroit area expressways. The remaining two trip reports document visits to Los Angeles and Minneapolis-St. Paul, respectively, to investigate the design and performance of existing freeway control and surveillance systems and BRT operations.

Inter-Organization

GM Transportation Systems Division
General Motors Corporation
General Motors Technical Center
Warren, Michigan 48090

Date: December 16, 1974

Subject: BRT Data Collection in Lansing

To: N. H. Triner

We met with Sam Burns of the Tri-County Regional Planning Commission and Duane Kooyers of CATA on Monday, December 16, 1974.

We were given the following Tri-County Regional Planning Commission reports:

1. "Identification, Delineation, and Classification of Activity Centers," December, 1973.
2. "Identification and Delineation of Principal Travel Corridors in the Tri-County Region," January, 1974.
3. "Corridor Travel Patterns, Land Use Data, Growth Factors, and Existing Transit System," March, 1974.
4. "Annual Report, Fiscal Year 1974, Transportation," September, 1974.
5. "Street and Highway Inventory Summary," December, 1966 (on loan, must be returned).

We also received two copies of the CATA route map.

Most of the information we require is already available in our Research and Development Department (Charles Gibson). The CATA route map is accurate, but schedules have been altered somewhat. The existing schedules are available in the R & D Department.

Average velocities for transit vehicles can be obtained from the State Highway Department. The data is probably daily average and does not compare the average velocities for various times during the day. The following people are possible State Highway Department contacts:

Bill Hartwig - UTPS coordinator
Lou Lambert

Ken Opiela - Civil Engineering Department, Wayne State University
667 Merrick, Room 211
577-3789 or 577-3838 (person who actually makes computer runs)

The major corridors which should be considered according to Mr. Burns are illustrated in Figure 2.6, p. II-13 of Reference 3. The eastern part of the area now generates the greatest transit ridership. However, the west and southwest part of the area near Waverly Road is the site of a new Federally subsidized housing development; and this area may generate more transit patronage in the future. A recent temporary extension of the Waverly Road route to serve this housing development resulted in an increase in ridership of only 15 passengers per day.

We drove the following major arterials and recorded notes and travel times:

E. Saginaw
W. Saginaw
E. Grand River
W. Grand River
S. Logan
S. Cedar
Waverly
Michigan
Saginaw Street - west bound starting at Haggardorn

1. E. Saginaw Street - west bound starting at Haggardorn
    No parking at any time
    Haggardorn - apartments, nice suburb
    Route 127 one-way west, 4 lanes
    Apartments and duplexes at Merrill
    Oakland Avenue - 3 lanes, one-way west
    Just before Junction 27, RR underpass
    Just west of Junction 27 at-grade RR, 1 track, becomes 4 lanes one-way
    At about Seymour - 3 lanes
    At Logan 3 lanes, grade school, church
    Bus stop along right lane
    Plant #2, Olds Plant, RR underpass on left
    Plant #3 on right, 5 lanes, 2-way
    Waverly Road, shopping center, 7 lanes, west of Waverly, W. Saginaw Shopping Plaza
    1/4 mi west - 5 lanes
    Dental Plan Building just before Elmwood
    Lansing Mall - parking lot about 75% full, 3:00 p.m. Monday
        Apartments I-96 Hilton Inn, Farm Bureau Building

2. Waverly - south bound from Saginaw
    45 mph, 4 lanes, two-way
    Apartments about 1/2 mile south of Saginaw
    at 496 Woolco Shopping Center, apartments
    Douglas Steel, Adams Tool, just south
    RR track (3 tracks) at grade
    We waited 1 1/4 minutes for train to pass
    Bus stop
    Junction with 27, no left-turn lane
    River, middle-cost housing
    Apartments
    Many apartments at Jolly Road
    Becomes 2-lane road

at Saginaw	2903.4	2:59	
at Miller	2905.4	3:10	
	2 miles	11 minutes	10.9 mph

3. West Grand River to Saginaw to East Grand River

W. Grand River at Airport Road
    45 mph, 4 lanes, two-way
    Apartments at Waverly Road
    More apartments at Airport
    John Deere at Delta River Drive
    Middle income homes
    At-grade RR just before Logan

E. Grand River
    30 mph, east-bound
    4 lanes of traffic
    Parking on both sides of street
    At Pennsylvania - 2 traffic lanes, parking on both sides
    Must go west at Oakland

Saginaw - East bound
    4 lanes, one way
    no parking, 40 mph
    Frandor Shopping Center
    Very nice, large, older homes
    2-way, 4 lanes, 25 mph
    E. Lansing CBD
    6 lanes, 2-way, 30-ft median, no parking

Median ends at Bogue, 5 lanes, 35 mph
Near Meridian Mall - Okemos Road
45 mph, a lot of space for park-and-ride
no curb from Park Lake on

W. Grand River at Airport Road	2934.5	4:17	
E. Grand River at Meridian Mall	2946.3	4:45	
	11.8 mi	28 min	25.3 mph

4. S. Logan, M-99, north-bound at Miller Road 2910.0 3:13
40 mph, 5-lane, 2-way
Apartments north of Jolly
Topps Discount City - empty parking lot just south of Holmes (long red signal)
Logan Center shopping
At-grade RR, 2 tracks
Low-cost homes, Woodline Avenue
Many boarded up on west side of street
At Morris River - Olds Engine Plant
N. of Holmes, 4 lanes, no-turn lane, 30 mph
End at Saginaw (east-bound) 2915.3 3:28
Boarded up houses start at Sparrow and end at Holmes

5.3 miles, 15 minutes, 21.2 mph

5. 27 South (Cedar)
East Bound Saginaw
35 mph, 3 lanes, one-way
bus stops at right-hand curb cut
River on right

Cedar, northbound, starting at 96
5 lanes, 2-way, 30 mph
Apartments just north of 96, south of Miller
Low-cost homes a block off Cedar up to Hodge one block off Cedar
Mt. Hope on - houses up to sidewalk, very close to street
Diamond Reo, RR overpass
Approximately E. Elm Street becomes 4 lanes, one-way north (Larch Street)
35 mph
North of Michigan - 4 lanes with parking in lane on right, 3 traffic lanes

At 96	2924.6	3:54	
About Oakland	2931.0	4:10	
	6.4 miles	16 minutes	24 mph

Cedar, southbound at Saginaw
- 35 mph, 3 lanes, one-way
- At 496 becomes 4 lanes with narrow concrete median, 2-way traffic
- Left turn lane at major cross streets
- Median disappears at Mt. Hope
- Businesses and homes very close to sidewalk (cannot be widened without relocations)
- Continuous left turn lane south of Jolly Road, 5 lanes
- Mobile home park around Holt
- Wide 2 lanes south of Aurelius Road
- Open area for construction of park-and-ride lot
- Meijer Thrifty Acres at Miller Road
- Apartments
- Jolly Cedar Plaza, smaller than Grant City

At Saginaw	2983.5	10:26 a.m.	
South of Decamp	2991.0	10:42 a.m.	
	7.5 miles	16 minutes	28.1 mph

6. Grand River, Oakland 7:31 a.m. 2957.9 (Rush: 7.1 mi; 15 min, 28.4 mph)
   - Start at Okemos Road, 18 people waiting for buses along route
   - Grand River near Saginaw Junction, no more bus patrons
   - At Pine Street, 7:46 2965.0
   - No car pools, 4 or 5 husband/wife teams

Michigan eastbound from Pine
- From freeway east to E. Lansing city limit
- 6 lanes, 30-ft median
- Becomes 4 lanes with median at E. Lansing city limit, then it merges with Grand River
- Michigan runs into State Capital downtown

East Michigan
- 4 traffic lanes, left turn lane, parking both sides

R.A.L.
Ron Lee

vw
cc: R. Cowan
V. Dahlmann

1/2/75

Inter-Organization

GM Transportation Systems Division
General Motors Corporation
General Motors Technical Center
Warren, Michigan 48090

Date: December 18, 1974

Subject: Visit to Flint, Michigan, Regarding BRT Study

To: N.H. Triner

On December 18, 1974, Ron Lee and the undersigned met with Mr. Thomas Roach (Principal Planner) and Mr. Chapin Cook (Senior Planner) of the Genesee County Metropolitan Planning Commission in their Flint, Michigan, office. Also in attendance was Mr. Louis Marsack (Superintendent of Transportation) of Flint's Mass Transportation Authority (MTA).

When asked to identify major travel corridors in the Flint area, Messrs. Roach and Cook suggested the following:

- Dort Highway
- North Saginaw Street
- South Saginaw Street
- I-69 (Chevrolet Freeway)

Other corridors, considered less significant, included the following:

- Miller Road
- Bristol Road
- Clio Road
- Detroit Street
- Flushing Road

The segment of I-475 south of Flint was mentioned as a potentially important corridor, but that highway is now lightly traveled, due in part to the short time it has been open (since fall, 1974). The I-75 corridor, which passes to the west of Flint, is known to be heavily traveled; it was not, however, emphasized in the discussion of major Flint corridors. (It is a distance of approximately three miles from Flint's CBD to the nearest I-75 access point - Miller Road. The junction of I-75 and Corunna Road is slightly more distant from the CBD, while the I-75 connection with Pierson Road is approximately five straight-line miles from the CBD.)

North Saginaw Street and Detroit Street were identified as the most prominent routes in the existing MTA bus system. Mr. Marsack estimated that these routes have a daily total ridership of approximately 1,000 passengers each. (Data subsequently obtained from Mr. Marsack indicate weekday average riderships of 924 and 789 passengers for the North Saginaw Street and Detroit Street routes, respectively, for the week of November 18 through 22, 1974. The Flint MTA operates 13 school routes, in addition to 12 "regular service" routes. The MTA fleet consists of 46 buses, 26 of which carry 45 passengers while 15 accommodate 18 passengers each. On weekdays (i.e., Monday through Friday) six routes operate with 30-minute headways and the other six "regular service" routes have 60-minute headways, with buses beginning their routes from 6:30 a.m. to 6:15 p.m. Service is reduced on Saturdays and no scheduled service is provided on Sundays.

The following items were obtained from the Genesee County Metropolitan Planning Commission:

- Genesee County 1990 Land Use - Transportation Plan, September, 1971
- A Five-Year Mass Transit Development Plan for Flint, Michigan (Draft copy dated November 11, 1974)
- Genesee County Transportation Facilities Inventory Report, Genesee County, Michigan (February, 1970)
- 1973 Annual Report (Flint-Genesee County Comprehensive Land Use - Transportation Planning Study)
- Short-Range Multi-Modal Improvement Program (for the Flint-Genesee County Urbanized Area)
- Genesee County Highway Map
- Map of bus routes and activity centers in Genesee County

Next, Mr. David Henley, of the Flint Department of Traffic Engineering, was visited and consulted with regard to travel speeds on Flint streets. It was learned that speeds are sampled occasionally, but that the results of those samples are not routinely compiled in a form which may be easily reviewed. Mr. Henley offered to search his records for speed data pertaining to streets of interest, if he is requested to do so. The Department of Traffic Engineering maintains a very detailed traffic count map, from which data may be transcribed for specific areas to be studied. Copies of less detailed traffic count maps were obtained for Flint and Genesee County. Street maps were obtained for the City of Flint.

In a separate visit to Mr. Marsack at the offices of the Flint MTA, the following material was obtained:

- Bus schedules and route maps
- Ridership totals (by route) for the weeks of November 18 and November 25, 1975
- Aggregate ridership totals for each day in November, 1974
- Ridership totals for each month in the years 1972, 1973, and 1974
- Description of each bus in fleet

During both days of the visit, major streets and freeways were examined and photographed. No significant traffic congestion was noted in any portion of the Flint metropolitan area.

R. W. Cowan

R. W. Cowan

cc: R. Lee
V. Dahlmann
W. Turski

vw

1/8/75

Inter-Organization

GM Transportation Systems Division
General Motors Corporation
General Motors Technical Center
Warren, Michigan 48090

Date: January 6-7, 1975

Subject: Visit to Grand Rapids, Michigan, Regarding BRT Study

To: N. H. Triner

Grand Rapids was visited by Virgil Dahlmann and the undersigned on January 6 and 7, 1975. Discussions were held with Mr. David Needham (Transportation Planner) and Mr. Robert Lenn (Planning Assistant) of the Grand Rapids Transit Authority (GRTA). The purpose of the visit was to evaluate the potential for bus rapid transit operations in Grand Rapids and to identify any candidate travel corridors.

The US-131 corridor was designated as the most significant for north/south travel in the Grand Rapids area. South of the CBD, Division Avenue is included in this corridor; north of the CBD, US-131 and Plainfield Avenue define the corridor. The most heavily traveled east/west corridors were identified as those associated with 28th Street and I-196. Twenty-eighth Street is slightly over three miles south of the CBD, while I-196 passes immediately north of the CBD and connects to US-131 northwest of the CBD. Other significant routes serving the CBD include Lake Michigan Drive, Bridge Street, Fulton Street, and Michigan Street.

The GRTA operates eleven bus routes with a fleet of 29 buses used for peak-period service. Headways generally range from 30 to 40 minutes, with several headways above and below this range.

The following material was obtained from the GRTA:

- Grand Rapids Transit Improvement Study (Work Paper #5, #4, and a portion of #3, prepared in 1973 by Barton-Aschman Associates, Inc.)
- Bus route maps and schedules
- Traffic flow map (1972)
- Population density map
- Tabulation of traffic analysis zone areas and population densities

The most heavily traveled streets and freeways in the Grand Rapids area were examined and photographed, with particular emphasis placed upon US-131 during peak periods. At no time was any significant traffic congestion encountered.

R. W. Cowan
R. W. Cowan

vw
cc: V. Dahlmann
A. W. Turski
R. Lee

Inter-Organization

GM

GM Transportation Systems Division
General Motors Corporation
General Motors Technical Center
Warren, Michigan 48090

Date: December 20, 1974

Subject: Traffic Counts on Detroit Corridors

To: N.H. Triner

The purpose of this meeting with Mr. Basmadjian (Detroit DOT, Traffic Engineering) was to obtain traffic count data on the major corridors in the city of Detroit. Mr. Basmadjian gave me:

1. Average weekday 24-hour and peak-hour ramp and freeway traffic for the Lodge, Ford, Southfield, Fisher, and Chrysler Freeways. He is going to send the Jeffries counts.

2. Detroit CBD cordon counts. The cordon count is a classified vehicle and passenger survey of all traffic entering and leaving the CBD.

3. 24-hour traffic counts on major corridors in the city taken at key intersections.

Mr. Basmadjian also said we are welcome to use their files if we want further detail. They have traffic counts along corridors taken in 1/2-hour intervals. He also added me to their mailing list so we will receive the reports they publish periodically.

Mr. Basmadjian has been on the SEMTA bus committee for the past few years. They have analyzed the feasibility of exclusive lanes for buses on Gratiot and Woodward. In both cases they could not justify taking the left-turn lane for exclusive use of buses. There was not a significant difference in travel time between express bus service and buses operating on exclusive lanes. Even though they did not recommend implementation, Mayor Young has decided to implement an exclusive lane on Gratiot in the summer of 1975. I received copies of the Gratiot and Woodward exclusive bus lane analysis reports.

In addition, Mr. Basmadjian was involved in the study and implementation plan for the exclusive bus lane on the Jeffries Freeway. He has submitted his part of the project to Julien Wolfe at SEMTA. I am going to contact Wolfe to see if I can get a draft copy of that report.

Mr. Basmadjian commented that in general the streets in the city of Detroit are operating below capacity.

Warren Turski
Warren Turski

vw
cc: R. Lee, R. Cowan, V. Dahlmann

Inter-Organization

GM Transportation Systems Division
General Motors Corporation
General Motors Technical Center
Warren, Michigan 48090

Date: January 3, 1975

Subject: BRT Data Collection - Southeastern Michigan Council of Governments (SEMCOG)

To: N.H. Triner

Meeting Attendees: Jim Thomas, Information Services, SEMCOG
Neil Triner - GM
Warren Turski - GM

Location: 8th Floor Book Building
Detroit, Michigan (961-4266)

Mike Tako, the SEMCOG representative at the kick-off meeting in Lansing, referred us to Jim Thomas.

We asked SEMCOG for demographic information, transit information, and highway use data.

SEMCOG has made employment projections by district for 1975. We have a tape of this information in-house and are arranging to have it printed. In an earlier informal meeting with SEMCOG, we obtained a 1970 24-hour traffic flow map, a map showing employment levels in manufacturing establishments by district, a retail centers map, and a 1990 Highway Network map. We also obtained a copy of their list of publications, and will obtain copies of the ones which are relevant to the BRT project.

For current information on transit questions and highway conditions, he suggested we contact Detroit DOT and the State Highway Department.

Warren Turski

Warren Turski

vw
cc: V. Dahlmann
R. Lee
R. Cowan

1/7/75

Inter-Organization

GM Transportation Systems Division
General Motors Corporation
General Motors Technical Center
Warren, Michigan 48090

Date: January 6, 1975

Subject: BRT Data Collection - Detroit DOT, Bus Operations

To: N.H. Triner

Attendees: George Friend, Superintendent of Scheduling, Marketing, and Planning
Bill Morrison, Transportation Services Coordinator
Bob Holliday, Assistant to Director of Accounting
Harold Schroeter, Scheduling Department
Neil Triner - GM
Warren Turski - GM

Location: Detroit DOT
1301 E. Warren (224-6417)

Mr. John Kanters, the Director of Detroit DOT, referred us to George Friend. Since Mr. Friend was called to a meeting, Mr. Morrison with the cooperation of Mr. Schroeter and Mr. Holliday answered our questions.

We obtained maps, pocket schedules, line miles, and the number of local and express trips for each line operated by Detroit DOT. The average speed of DSR buses is 13.36 mph. We also obtained sample detailed schedules which give travel times over each link of a route at three or four different times during a day. They gave us the line miles and speeds on each express route. The Imperial Express uses the Lodge Freeway between 7 Mile Road and the CBD and the Hamilton and Second Avenue Express runs utilize I-75 between 6 Mile and the CBD. Quite a few years ago they had an express run on the Edsel Ford Expressway. However, due to congestion on the freeway, they took it off and put the run on Michigan Avenue with a resulting time savings of eight minutes.

Detroit DOT no longer keeps passenger counts on a regular basis. However, they are currently in the process of doing ridership counts along their major routes. They are going to ask permission to release this data to us as it becomes available over the next month and a half.

Another indication of ridership is revenue collected from each line. Once a year they break out the revenue by line. However, it is difficult to get accurate ridership levels because all passengers do not pay the same fare, transfer passengers pay on bus of origin, and it is only a one-day sample.

The basic DSR fare is 40¢. The express fare is 45¢, and transfers are 5¢. Senior citizens ride free between 9:00 a.m. and 3:00 p.m. and in the evening, otherwise they pay full fare. Students ride for 25¢.

The major transit corridors are Woodward, Michigan, Gratiot, Grand River, Fort, and East Jefferson.

Warren Turski
Warren Turski

vw

cc: R. Cowan
V. Dahlmann
R. Lee

Inter-Organization

GM Transportation Systems Division
General Motors Corporation
General Motors Technical Center
Warren, Michigan 48090

Date: January 6, 1975

Subject: BRT Data Collection, Detroit DOT, Traffic Engineering and Planning

To: N.H. Triner

Meeting Attendees:
Robert Hicks - Director
Tony Fried - Assistant to Director
George Basmadjian
Neil Triner - GM
Warren Turski - GM

Location:
1502 Water Board Building
735 Randolph
Detroit, Michigan (224-4931)

Detroit DOT, Traffic Engineering and Planning, offered their cooperation. In addition to the material they gave in an earlier informal meeting, they said auto travel times on major corridors were available, recurring areas of congestion could be identified within the city, and maps showing parking areas in the CBD are available. Their library of state highway reports is also available for our use. When we asked about Eight Mile Road, they said it was under the State Highway Department.

We also inquired about the television surveillance of the Lodge Expressway. It was started in 1954, and the experiment ran for 6-7 years with funding from various sources. One of the last studies using the surveillance and metering equipment was done by Texas Transportation Institute. Their final report on the Detroit system was never approved; however, the school published a two-volume report entitled "A System to Facilitate Bus Rapid Transit on Urban Freeways," which includes some work they did on the Detroit system.

Current plans call for electronic surveillance of all Detroit expressways. A $15,000,000 agreement has recently been signed by the Detroit DOT and the Michigan DOT Highway Department. They plan to have detectors every 1/3 of a mile on the expressways and on all ramps. The sensors will report speed, volume, density, and occurrence of incidents to a central computer. The computer can actuate appropriate traffic controls in response to prevailing conditions. Certain ramps will be metered. Provisions for special treatment of bus rapid transit vehicles has been made. Queue jumpers and special access lanes are under consideration.

The report explaining this project is "Formation of the Detroit Freeway Operations Unit." For further information, they suggested we contact:

Don Orne
Michigan DOT
State Highways - Lansing Office

For information on traffic volumes on the state highways in this area, they suggested we contact:

Paul Reilly
District 9 Office
Southfield and 9 Mile Road

Herb Crane
15410 Wyoming
341-7454

The major arterial streets in the city of Detroit with at least 20,000 vehicles per day are:

Eight Mile Road
Woodward
Seven Mile
Six Mile
Greenfield
Grand River
Livernois
E. Warren
E. Jefferson
Van Dyke
W. Grand Boulevard
Gratiot
Dexter
Conner
Ford Road
Fort Street
Michigan

The expressway corridors are:

Fisher Freeway
Chrysler
Lodge
Edsel Ford
Jeffries
Davison

Warren Turski

vw
cc: R. Cowan
V. Dahlmann
R. Lee

Inter-Organization

GM Transportation Systems Division
General Motors Corporation
General Motors Technical Center
Warren, Michigan 48090

Date: 1/14/75

Subject: Surveillance Control and Driver Information (SCANDI) System for the Detroit Area

To: N. H. Triner

On January 9, 1975 N. Triner, F. Caiati, and V. Dahlmann met with Herb Crane of the Traffic and Safety Division, State Highway Department, to discuss planned implementation for the SCANDI system in the Detroit area. It was pointed out that GM's current involvement in the Bus Rapid Transit Study contract with the State Highway Department spawned interest in the SCANDI program and how it might dovetail with any potential BRT implementation. Mr. Crane provided GM with two technical reports summing up earlier work performed by their division to serve as background material:

1. Formation of the Detroit Freeway Operations Unit, TSD-TR-119-69
2. Improving Eastbound Ford Freeway Traffic Flow by Ramp Metering, Phase I - Analysis of Preliminary Traffic Data, TSD-TR-180-71.

A general summary was then given on functional operation of the system.

- Loop detectors will be installed every 1/3 mile in the pavement of all Detroit freeways.
- A single control center will be established to house computers and associated equipment.
- A host computer will provide overall system control with satellite computers providing subordinate functions.
- All freeway access ramps will be controlled to provide metered access.
- A major purpose of the metered access concept is to break up platoons of vehicles entering the freeway.
- Some form of driver information signing will be provided to warn motorists of downstream incidents and suggest alternate routes bypassing congestion.

The subject of bus rapid systems and how they might benefit through integration with SCANDI was then discussed.

- Queue jumpers at metered access ramps for buses and possibly carpools can be implemented conveniently in most cases. Successful operation of this concept has been demonstrated in California cities as well as other locations.

- Advantages of this methodology over exclusive bus or carpool lanes are apparent. Problems are encountered with exclusive lanes on freeways where both left side and right side access and exit ramps are used. The designation of an exclusive lane for buses and carpools requires that sufficient numbers of authorized vehicles are available to use the lane to efficient capacity. This requirement also contributes toward easing enforcement requirements. Queue jumpers at metered ramps provide a convenient means to enhance bus rapid service assuming the metering system can maintain a free flowing freeway.

The time frame of implementation for the SCANDI system covers the next four to five years. Detailed schedules are yet to be formulated. Funding has been approved and is expected to total 12 to 15 million dollars.

Cognizance of the progress of the SCANDI installation will be maintained so as to take advantage of this system for BRT implementation plans in the Detroit area.

V. R. Dahlmann
Transportation Systems Division

cc: F. Caiati
R. Cowan
D. Klement
R. Lee
W. Turski

vw

GM Transportation Systems

Division of General Motors Corporation · General Motors Technical Center · Warren, Michigan 48090

20-I-750028

DATE: 4/11/75

SUBJECT: Trip Report - State of California Department of Transportation (CALTRANS) and Southern California Rapid Transit District (SCRTD)

TO: N. H. Triner

Introduction

Contact was made with the two agencies in Los Angeles on April 3 and 4, 1975. The major purpose of the trip was to discuss the Los Angeles Area Freeway Surveillance and Control Project (LAAFSCP) with CLATRANS and the El Monte-Los Angeles Busway with SCRTD. Operational characteristics of these projects relate directly to implementation considerations for the Michigan Bus Rapid Transit Demonstration contract. The following individuals were contacted:

- Richard H. Green, Senior Engineer, CALTRANS
- C. Gary Bork, Senior Engineer, CALTRANS
- Robert G. B. Goodell, CALTRANS
- Dan Miller, SCRTD
- Gerald L. Squier, SCRTD

Los Angeles Area Freeway Surveillance and Control Project

The project is located in the heart of the Los Angeles urban area on the Santa Monica, San Diego, and Harbor Freeways. The three freeways form a triangle of 42 miles and contain 56 freeway interchanges. The system consists of inductive loop detectors placed in the roadway at approximately 1/2 mile intervals as well as at ramps under ramp control. The detectors provide volume and occupany information which is transmitted over leased telephone lines to a Xerox Sigma 5 computer. Changeable message signs are installed on the Santa Monica Freeway section of the project to communicate downstream freeway conditions to motorists. Thirty-five signs are installed at approximately 2/3 mile spacing.

Two types of ramp metering are in operation. Fixed rate meters operate at fixed rates for specific time periods determined from ramp volume history records. The time periods for particular rates are controlled by a clock thereby allowing some preset metering control in steps over the peak period. Real time ramp control is traffic responsive with metering rates controlled by the computer based upon volume and occupancy information received from the loop detectors. Eight ramps on the southbound Harbor Freeway and thirteen ramps on the northbound San Diego Freeway are currently operating in the real time mode.

The objective of ramp control is to maximize corridor throughput with the least corridor delay by keeping demand and capacity in balance. Real time ramp control allows for adjustments in ramp rates proportional to fluctuations in freeway traffic through the peak period.

Significant points of interest concerning LAAFSCP operational results are listed below:

- Ramp metering control can indeed maintain free-flowing traffic on previously congested freeways.
- Before metering, travel time through a seven-mile section averaged 14 minutes. With real time ramp metering, the travel time averages 7.5 minutes (approximately 54 mph).
- Average auto queue time at a typical metered ramp is 3 to 4 minutes with as much as 12 minutes experienced on occasion. A seven-minute queue time is seldom exceeded.
- Approximately 180 vehicles/hour is the minimum limit of driver patience.
- Metered ramps have reduced incident rates by 25 to 50 %.
- A few metered ramps have by-pass lanes for car pools or buses. A 6% violation rate for use of this lane has been experienced and is considered tolerable. Initial violation rates immediately following implementation were much higher, however.
- 1000 metered ramps are planned for implementation on Los Angeles freeways by 1977.
- CALTRANS officials believe that queue jumpers at metered ramps for buses and carpools is a viable approach to efficient utilization of freeway facilities. This implementation allows free flow of buses and carpools with other traffic on the freeway. However, due primarily to EPA pressures, the inbound lane of the Santa Monica freeway will be designated a priority lane for buses and carpools on June 16, 1975.

El Monte-Los Angeles Busway

The El Monte-Los Angeles Busway is an example of "first class" bus rapid implementation. The eleven-mile line-haul portion of the system includes exclusive elevated bus-only access ramps with two innovative intermediate stops. Over-under type crossover ramps are provided for the buses to facilitate normal right-side loading at two separate platforms at one intermediate stop and right-side loading at a common platform at the other intermediate stop. In both cases, passengers access the system by overhead enclosed walkways and an elevator to platform level. One stop services the Los Angeles County Hospital (500 passengers/day) while the other services California State University Los Angeles (600 passengers/day).

The El Monte Station services the eastern end of the busway including a 500-car park-and-ride lot. Buses enter the station at an elevated level and are assigned a berth on the circular loading platform. Passengers embark to the park-and-ride lot via escalators to ground level. Parking fees at the station are 25 cents/day or $2/month. All bus fares are fixed at 25 cents.

Distribution within the Los Angeles CBD is accomplished primarily without priority treatment. The exception is an exclusive contraflow lane on Spring Street. Spring Street is basically a one-way street with buses free flowing with traffic in the southerly direction (4 lanes). The fifth lane is designated exclusively for buses and operates contraflow in the northerly direction.

Additional points of interest are listed below:

- 9 routes utilize the busway (13,500 daily ridership)
- During peak periods, all routes provide no-transfer service. During off-peak periods, feeders are used from outlying areas to provide transfer service to the busway.
- Buses maintain 55 mph speeds on busway.
- Modal split in the El Monte corridor is currently estimated at 25-30%.

A substantial amount of reports and other miscellaneous information was obtained. Please contact the author for additional information.

V. Dahlmann

vw

cc: F.Caiati, R.Lee, R.Cowan, W.Turski, D.Klement

GM Transportation Systems

Division of General Motors Corporation · General Motors Technical Center · Warren, Michigan 48090

10-1-750044

DATE: May 15, 1975

SUBJECT: Trip Report - Twin Cities Area Metropolitan Transit Commission (MTC) and Minnesota Highway Department

TO: N.H. Triner

Two agencies in Minneapolis-St. Paul were contacted on April 16 and 17, 1975, to discuss the I-35W Urban Corridor Demonstration Project (UCDP). UCDP is a three-phase project, supported in part with UMTA funds, which has resulted in real-time computer control on most of 16.5 miles of Interstate 35W south of Minneapolis, surveillance of traffic conditions including closed circuit television to aid in the early detection of incidents and control equipment failures, and integrated express bus operation utilizing exclusive bus ramps to access the metered freeway and exclusive contra-flow distribution lanes on one-way streets in the CBD. The following individuals were contacted:

- Don Hubert, MTC
- Hugh C. Faville, MTC
- Sam Jacobs, MTC
- Mark R. Wikelius, Minnesota Highway Department

The following documents were obtained:

- Phase II Evaluation Results, I-35W Urban Corridor Deomonstration Project, November, 1974.
- Ovaici, Khosrow; Teal, Roger F.; Ray, James K.; May, Adolf D.; "Developing Freeway Priority Entry Control Strategies," Institute of Transportation and Traffic Engineering, University of California, Berkeley.
- I-35W Urban Corridor Demonstration Project, Bus-Metered Freeway System, Marketing Evaluation, Wave II: October, 1974
- Carlson, G.C.; Benke, R.J.; "Surveillance and Control System Overview, I-35W Urban Control Demonstration Project," Traffic Engineering, Report No. MNHW 5-98073-1, Minnesota Department of Highways.
- Benke, R.J., "Traffic Adjusted Ramp Metering, An isolated Interchange System Evaluation," Traffic Engineering, Report No. MNHW 5-98074-1, Minnesota Department of Highways, March, 1974.

- o Schedules for Express Buses Operating in the I-35W Corridor
- o Miscellaneous Advertising Brochures

I-35W Urban Corridor Demonstration Project

The implementation and evaluation of the I-35W project is being completed in three phases. Phase I is the base condition which existed in the fall of 1972 when only three express bus routes were using Interstate 35W, and two park and ride lots were in operation. No freeway surveillance or control equipment was in operation. In Phase II eleven new expressway routes and several park and ride lots were put into service in the corridor. Still no freeway control equipment was operational. The duration of Phase II was from December, 1972 to the spring of 1974. Phase III began on April 9, 1974, when the freeway surveillance and control system became operational and expressway buses began to use the nine exclusive bus ramps to bypass automobile queues. Several express routes were added during Phase III bringing the total to 22, and all 20 park and ride lots were put into service.

The evaluation of Phases I and II is complete and the results are reported in the first report cited previously. The Phase III evaluation has not been completed. As a result, many of the operating characteristics and patronage estimates of the bus-on-metered-freeway system are not available. However, a copy of the final evaluation report will be forwarded to GM TSD when it becomes available sometime this summer.

Expressway Bus Operation

A total of 104 buses are currently assigned to express service on I-35W in the peak hour. Express service is provided only in the peak periods (from 6:30 to 9:00 a.m. and 3:30 to 6:00 p.m.), and at least two runs are made on each of the 22 express routes during each peak period. Local bus service is provided during off-peak hours in the part of the service area north of the Minnesota River. No off-peak service is provided south of the River. Average bus occupancy on I-35W express buses is about 70 percent. Overloads are corrected by adding more buses when possible since operating with standees on an expressway bus is considered to be unsafe.

The shortest of the 22 routes using I-35W, runs on the expressway for only about 2 miles, while the line-haul portion of the longest express route is about 14 miles. The nearest - in park and ride lots served by I-35W express buses is located about 5 miles from the CBD. All of the express routes include an intermediate stop at exclusive bus pull-outs on both sides of the expressway at the Lake Street overpass. This stop serves Minneapolis Honeywell and permits express bus passengers to transfer to local buses to reach destinations other than the Minneapolis CBD.

The nine exclusive bus entrance ramps to the metered freeway follow one of three typical designs. All of the bus ramps merge with a previously existing automobile ramp downstream from the auto ramp metering signals. Inductive loops in the pavement of the bus ramps generate a signal which holds the auto meter red so that buses can safely merge into the common portion of the ramp and accelerate to freeway speed. The differences in ramp designs occur at the beginning of the ramp. In one case, the Grant Street ramp in the CBD, the bus ramp and the metered automobile ramp begin on different streets but merge with the freeway at a common point. Other ramps have a common entrance and freeway merge, but the two lanes are separated by a narrow median in the middle. This design has proven unsatisfactory because the auto queue often extends beyond the beginning of the exclusive bus ramp thus causing the bus to be delayed. Still other exclusive bus ramps provide a separate entrance for buses from the service drive. The two ramps then merge with the freeway at a common point.

Although the final evaluation of express bus operation on metered freeways has not yet been completed, preliminary results indicate that the average line-haul speed of buses on the freeway has increased from 19 to 20 m.p.h. before metering to about 39 m.p.h. with metering.

Exclusive contra-flow bus lanes on one-way streets were instituted near the end of Phase II (around March, 1974) to expedite CBD distribution in downtown Minneapolis. Buses proceed north on Second Avenue in a contra-flow lane for approximately one mile, making approximately 9 stops, then return in a contra-flow lane on Marquette Avenue, making another ten stops. The exclusive bus lanes are in effect at all times, and are used by local buses, taxis, and emergency vehicles as well as by express buses. The combined peak hour headway in the distribution route is about two to three buses per block.

The average CBD distribution speed prior to the reserved bus lane implementation was 6.2 m.p.h. The average speed is now 7.2 m.p.h. Reserving lanes for buses in the CBD has not only resulted in a 16 percent increase in average speed, but has also drastically reduced variations in travel time. Due to these improvements, the project management is considering replacing the temporary cone lane markers with permanent concrete curbs even though some local businessmen continue to object to the elimination of parking along the bus route.

Ridership on I-35W express buses has increased about 175 percent since the project began in 1972. A summary of daily express bus ridership by phase is presented in the following table:

Table 1 Express Bus Ridership Summary

Phase	Date	Daily Express Bus Ridership	Modal Split-Northbound a.m. Peak Period (CBD Destinations)	
			Express Bus	Express and Local Buses I-35W Corridor
1	12-72	2,400	5%	33%
2	4-74	6,000	12%	35%
3	3-75	8,600	(20%)	40%

Modal split estimates for trips destined to the CBD in the a.m. peak period are also listed in the table for each phase of the project. The modal split for express buses in Phase III was estimated by the author based on the assumptions that the total number of trips in the corridor destined to the CBD has not changed from Phase II to Phase III and that half of the daily passenger trips are made in the a.m. peak period. According to an UCDP Status Report dated 4-3-75, approximately half of the express bus passengers have diverted from the automobile. According to Phase II evaluation results, express transit users have demographic characteristics similar to arterial auto users rather than local bus users, and approximately 74 percent of them have an automobile available.

Freeway Surveillance and Control

Sixteen and one-half miles of I-35W south of the Minneapolis CBD are metered in the peak direction during both the a.m. and p.m. peak periods. A total of 33 ramps are metered, and all but 5 of them are computer-controlled. Ramps in four locations in the controlled section are not currently metered. Two of these are located in the CBD, and are to metered beginning in the fall of 1975. The other two locations are intersections with other interstate freeways, I-94 and I-494. Plans call for the eventual implementation of meters on the two ramps from I-494 to southbound I-35W

The five metered ramps which are not computer-controlled are all located south of the Minnesota River. These ramps are controlled locally by a controller designed and built by Minnesota Highway Department staff. The controller chooses among three possible metering rates based on the magnitude of traffic volume rather than on occupancy. This type of control works well in the absence of congestion. However, when traffic flow breaks down due to congestion, volume decreases, and the controller allows more vehicles to gain access to the freeway, thus causing an unstable condition. The algorithm used by the computer to select the metering rate for each ramp, on the other hand, gives equal weight to three indicators of traffic flow: (1) volume upstream from the ramp, (2) local occupancy in the vicinity of the ramp, and (3) occupancy at the nearest geometric bottleneck downstream from the ramp. Occupancy is the percentage of the time a vehicle is over an inductive loop in the roadway. In order to allow quicker response to impending congestion, the second indicator is soon to be replaced in the algorithm with the occupancy at the second geometric bottleneck downstream from the ramp. The algorithm will assign a lower weight to this indicator. The computer selects from five or six metering rates ranging from one car per five seconds (720 cars/hour) to one car per twenty seconds (180 cars/hour). If necessary, an operator can manually override any metering rate selected by the computer.

Three types of loop detectors are being evaluated in the project. Decatur loops were found to be sensitive to radio waves transmitted through the ground. The detector amplifier would lock on, and erroneous data would be transmitted to the computer. These detectors have been replaced by Sarasota detectors, which do not appear to be sensitive to radio waves. Magnetometers have been installed at 28 locations. These devices are more compact, easier to install, and more sensitive than other detectors. However, they often transmit bad data, especially on humid days. The Department is still evaluating these devices. Regardless of the type, loop detectors are located at half-mile intervals in each lane of the controlled section of the freeway.

A Minneapolis-Honeywell 316 computer in the 1603 configuration is used to control the metering rates on the ramps. The loops are connected to the computer with cable buried specifically for that purpose. Leased telephone lines were not used for economic reasons.

All of the metered ramps north of the Minnesota River are equipped with closed circuit television cameras which can be controlled remotely by an operator at the Traffic Control Center. The cameras are mounted 50 feet above each ramp and can be turned 360°, tilted ± 10°, and are equipped with a 3:1 zoom lens. The operator at the Traffic Control Center has a direct line to the Highway Patrol to coordinate incident detection and removal. He also reports traffic conditions to a local radio station on a direct line.

All of the system components are quite reliable even though they are exposed to extremes of heat and freezing weather. The number one reliability problem seems to be due to corrosion from salt spray. Even the connectors on the television cameras, which are protected and are mounted 50 feet above the freeway, occasionly fail due to corrosion.

Although the final evaluation had not yet been completed, some preliminary results on performance of the system were obtained. The average speed for all days, including those on which incidents occurred, is between 45 and 49 m.p.h. This represents an increase from 20 to 30 percent. If only days without incidents are considered, the average speed exceeds 50 m.p.h. It is estimated that the number of accidents that occur on the freeway during peak hours has been reduced by as much as 50 percent as a result of freeway control. The average of maximum queue times is estimated to be from two to three minutes. Queue times range from zero minutes up to seven minutes. A detector loop located at the beginning of the ramp senses when automobiles are about to queue up into the cross street and transmits a signal which causes the ramp metering rate to be increased.

Two observations concerning public response to the ramp metering system are worth noting. It was reported in a UCDP Status Report dated 5-31-74, that there were very few violations at metered ramps or at exclusive bus ramps even during the first weeks of operation. The report implies that there were numerous complaints about queues at metered ramps during the first week or so of system operation. However, only five complaints were received in the period from Apirl 25 (two weeks after systems turn-on) to May 31 and none were received in the two weeks prior to the report date. The second observation was reported in a Project Review Meeting on 4-22-74. It was reported that many drivers did not pull up close enough to the meter to be detected, and long delays resulted when the meter signal failed to turn green. The problem was alleviated by the addition of painted stop bars on the ramps.

Ron Lee

Ron Lee

cmc

cc: F. Caiati, V. Dahlmann, R. Cowan, W. Turski, D. Klement