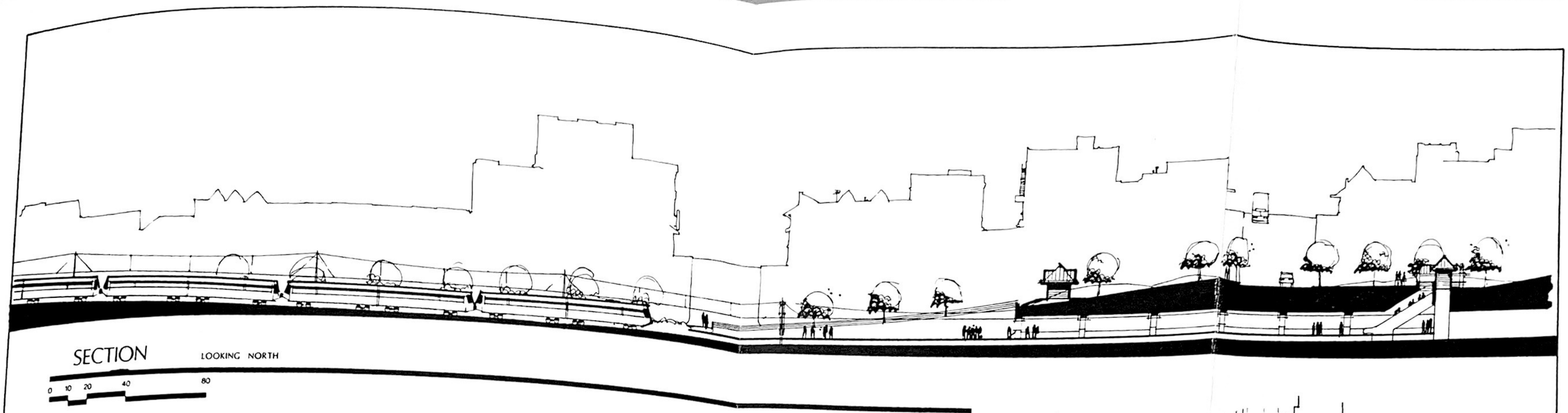
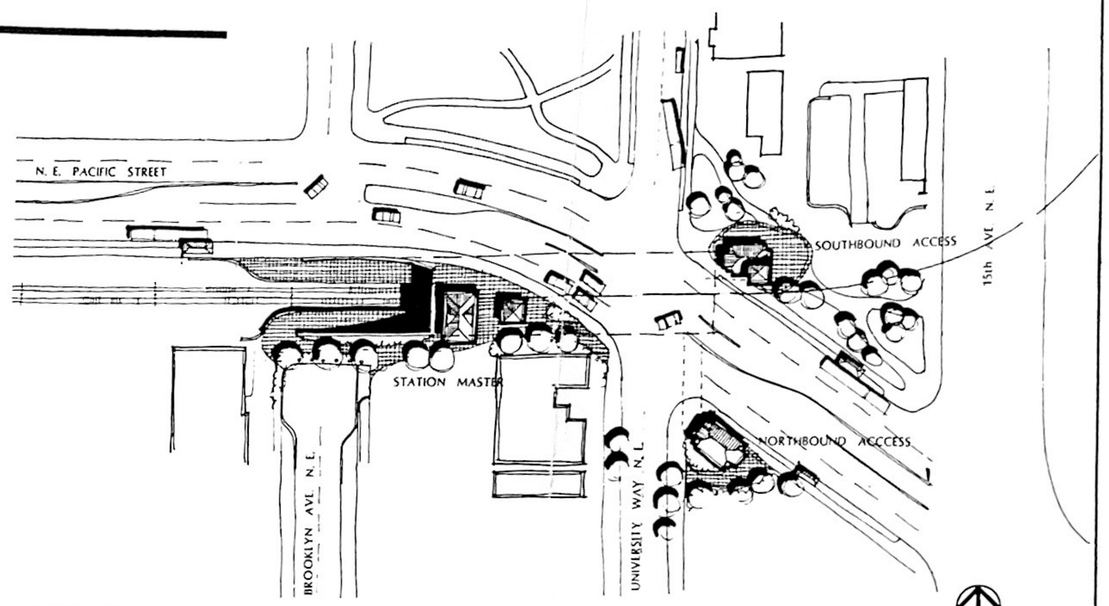


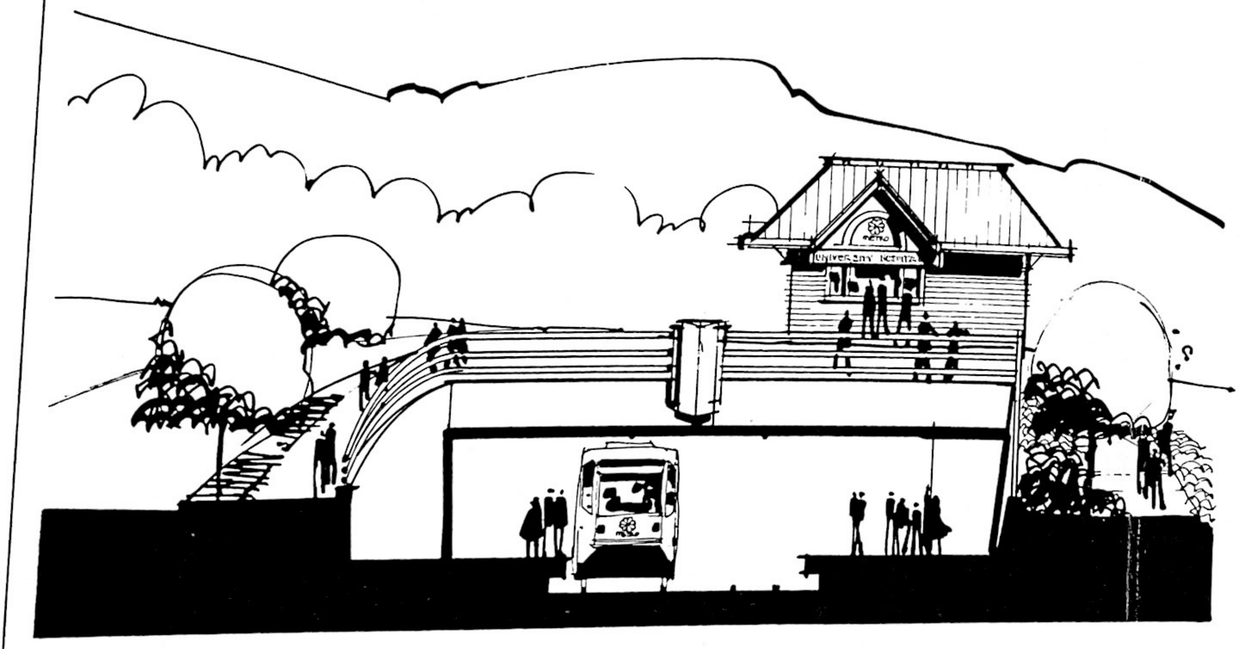
SECTION LOOKING NORTH

0 10 20 40 80



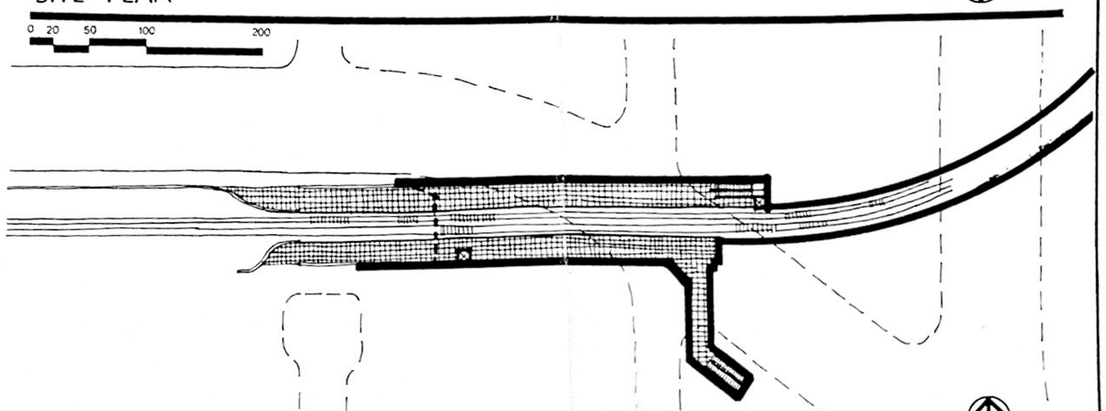
SITE PLAN

0 20 50 100 200



WEST ELEVATION LOOKING EAST

0 3 6 12 24



PLATFORM LEVEL PLAN

UNIVERSITY HOSPITAL STATION

METRO
MUNICIPALITY OF METROPOLITAN SEATTLE

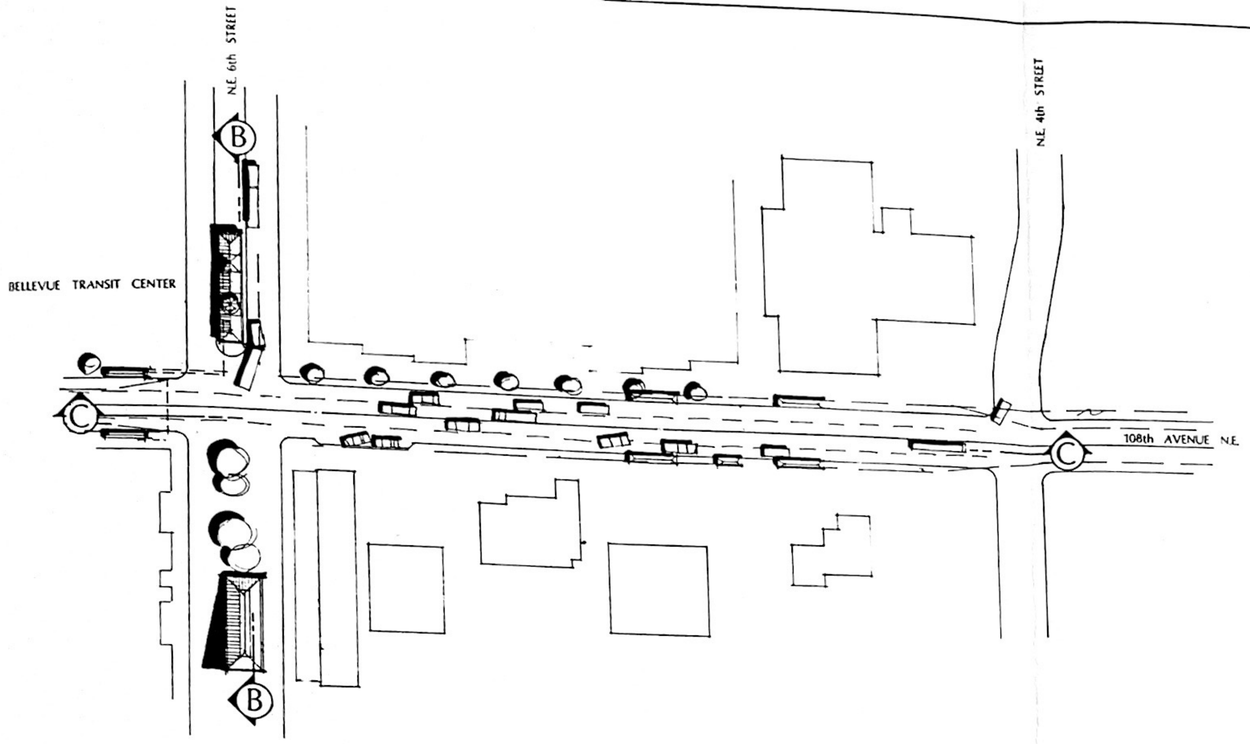
Raymond Kaiser Engineers

MULTI - CORRIDOR PROJECT

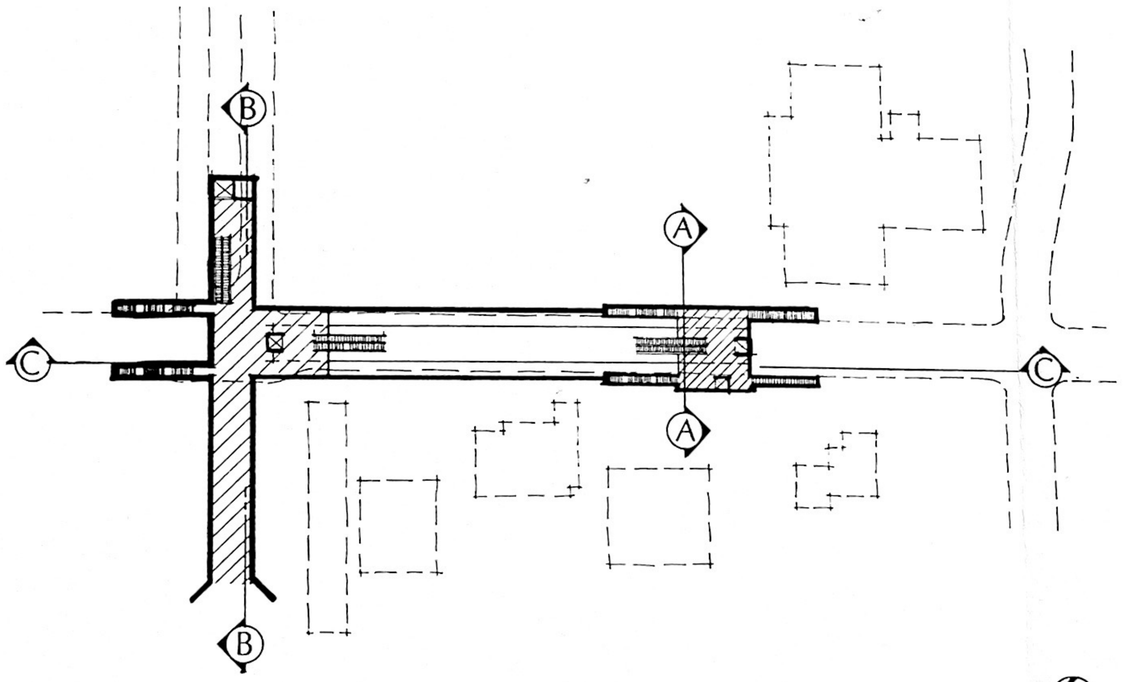
L R T ALTERNATIVE

NORTH CORRIDOR - UNIVERSITY HOSPITAL STATION

DWG. No. R - 201

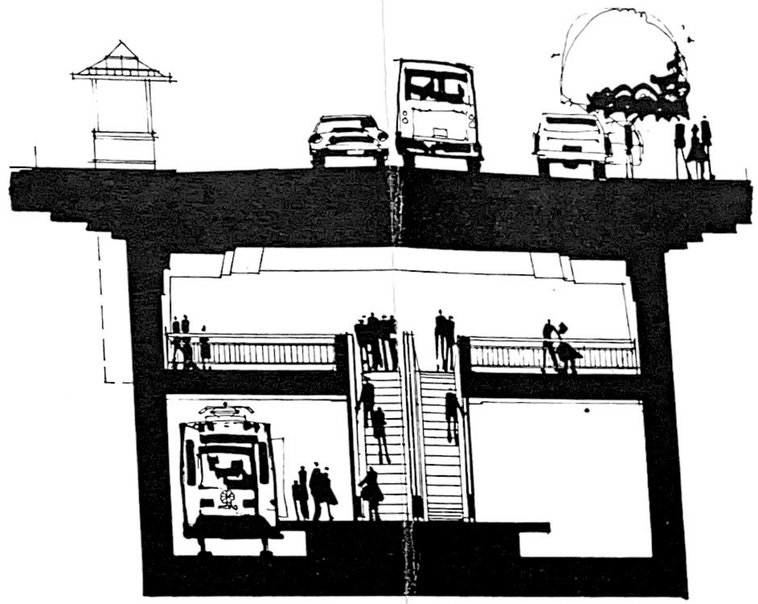


SITE PLAN



PLATFORM LEVEL PLAN

0 20 50 100 200



SECTION A - A LOOKING SOUTH

0 3 6 12 24

BELLEVUE L R T STATION

METRO
MUNICIPALITY OF METROPOLITAN SEATTLE

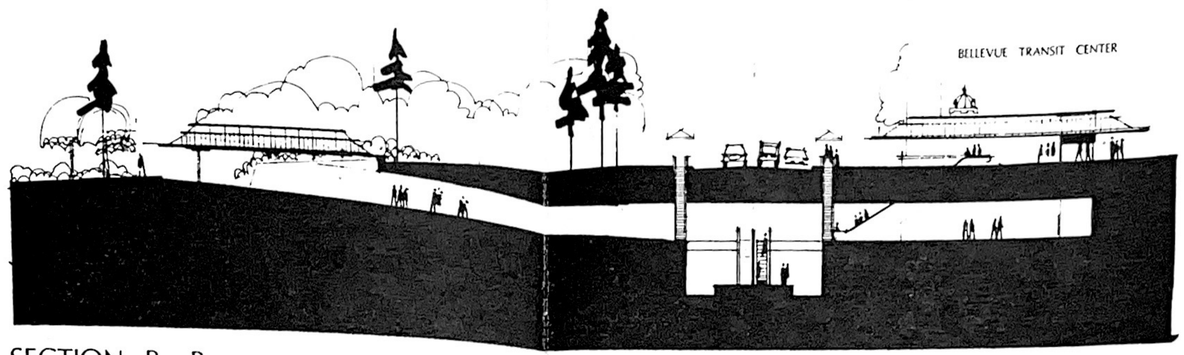
Raymond Kaiser Engineers

MULTI - CORRIDOR PROJECT

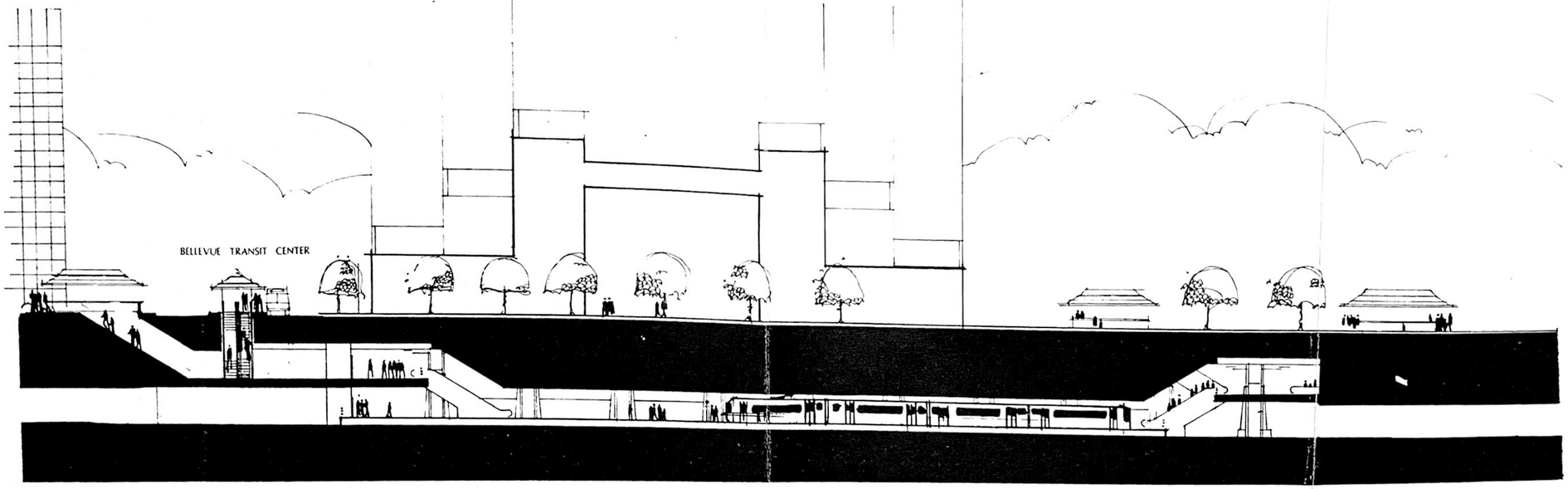
L R T ALTERNATIVE

EAST CORRIDOR BELLEVUE L R T STATION

DWG. No. R - 203



SECTION B - B LOOKING NORTH



SECTION C - C LOOKING EAST

0 10 20 40 80

BELLEVUE L R T STATION

METRO
MUNICIPALITY OF METROPOLITAN SEATTLE

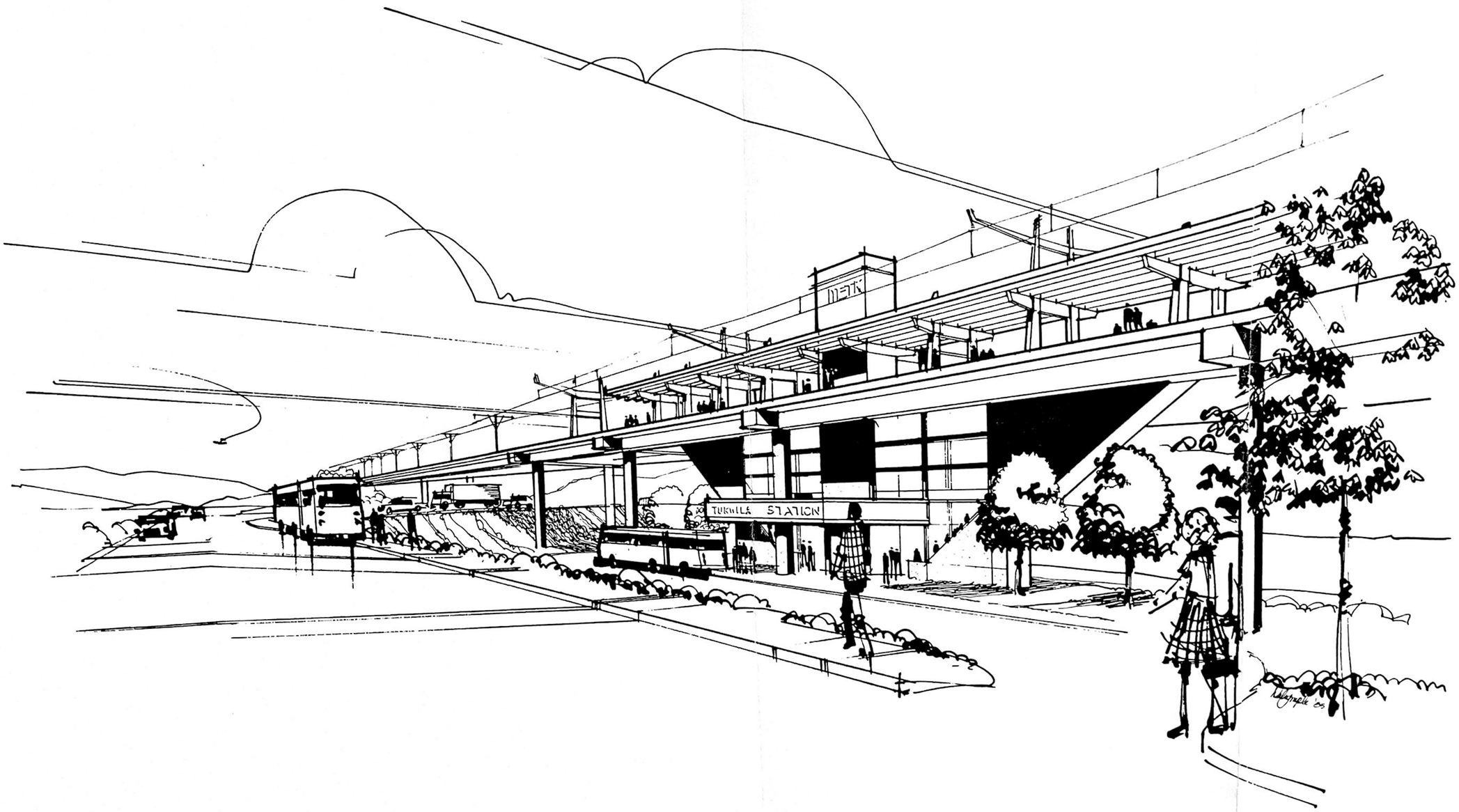
Raymond Kaiser Engineers

MULTI - CORRIDOR PROJECT

L R T ALTERNATIVE

EAST CORRIDOR BELLEVUE L R T STATION

DWG. No. R - 204



TUKWILA L R T STATION

METRO
MUNICIPALITY OF METROPOLITAN SEATTLE

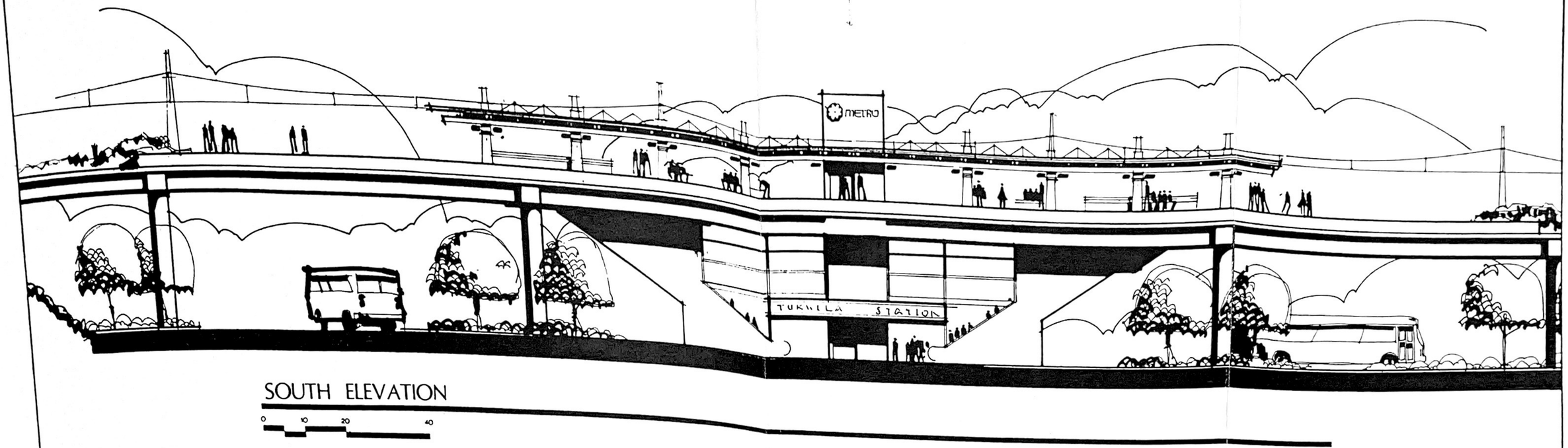
Raymond Kaiser Engineers

MULTI - CORRIDOR PROJECT

L R T ALTERNATIVE

SOUTH CORRIDOR - TUKWILA L R T STATION

DWG. No. R - 212



SOUTH ELEVATION

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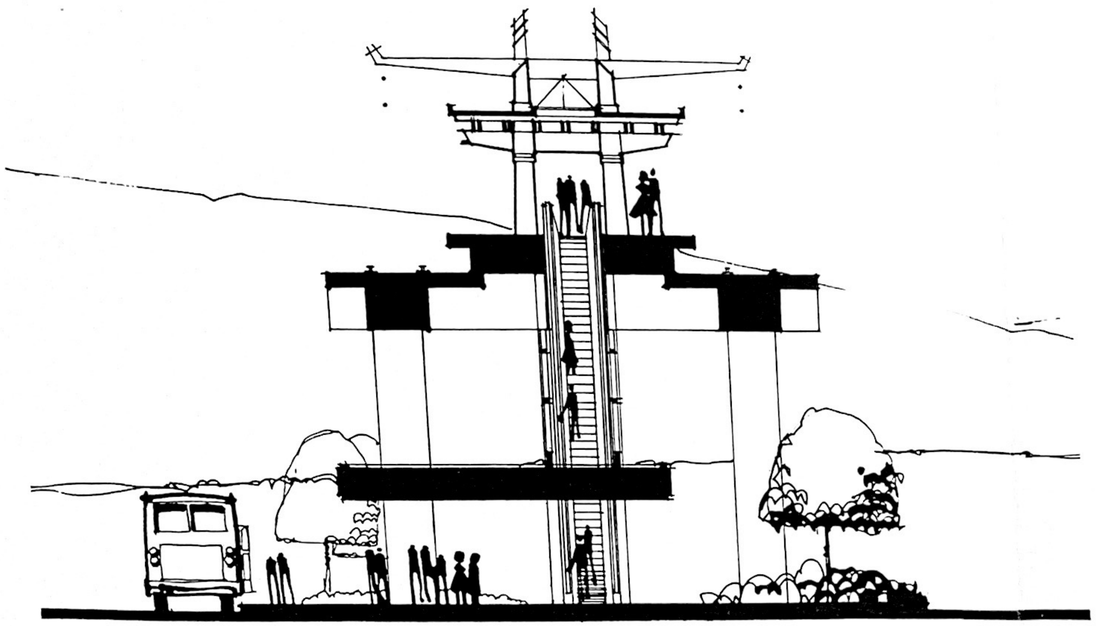
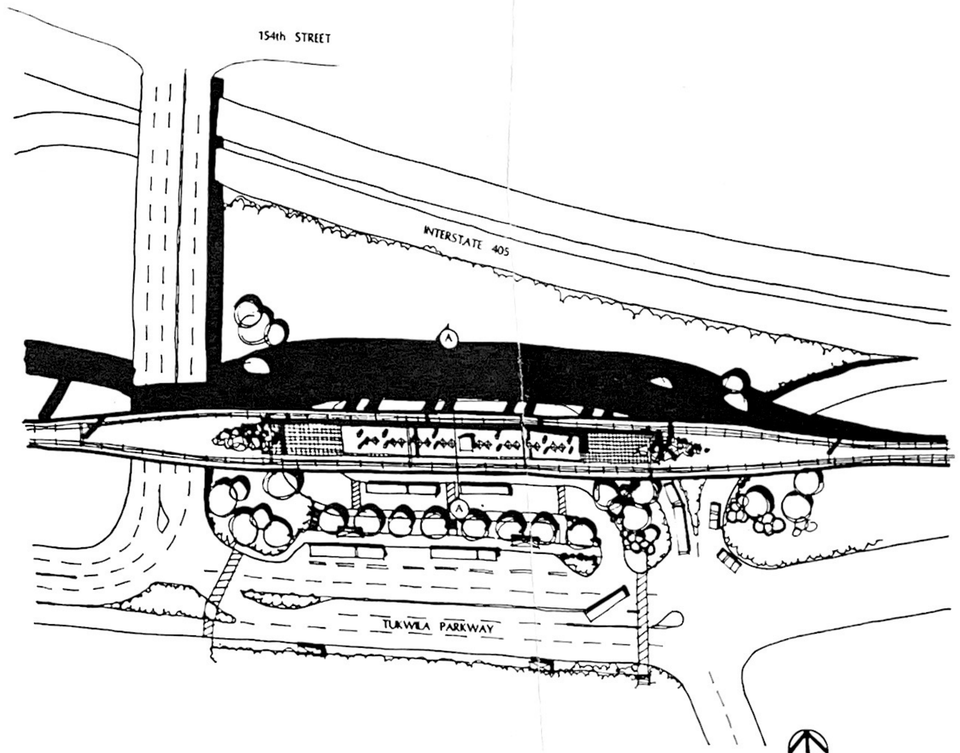


SECTION A - A LOOKING WEST

0 2 5 10 20



SITE PLAN

0 20 50 100 200

TUKWILA L R T STATION

METRO
MUNICIPALITY OF METROPOLITAN SEATTLE

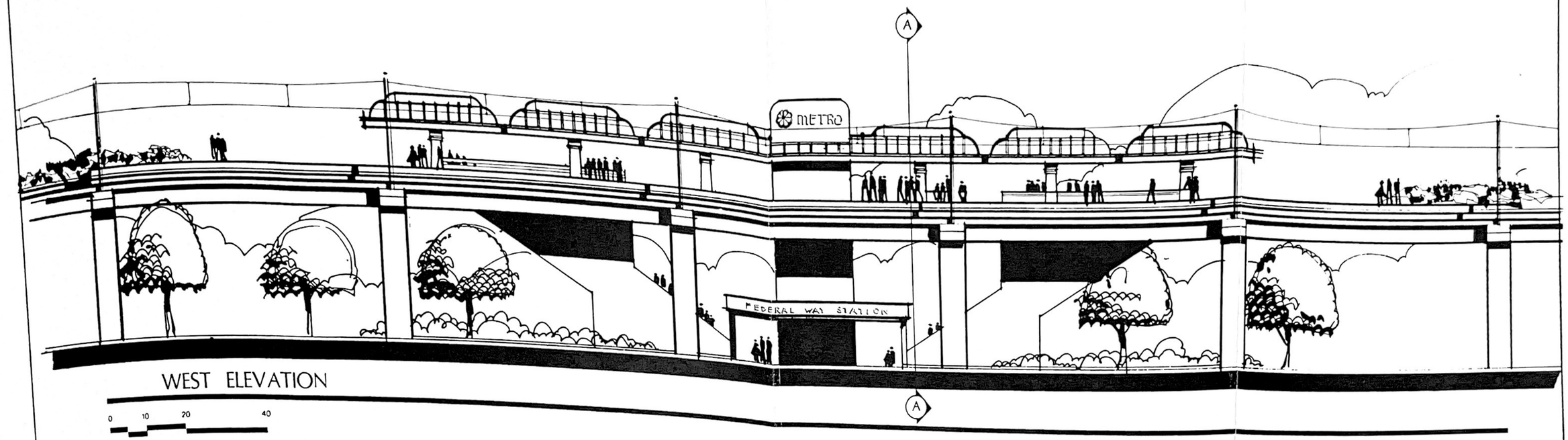
Raymond Kaiser Engineers

MULTI-CORRIDOR PROJECT

L R T ALTERNATIVE

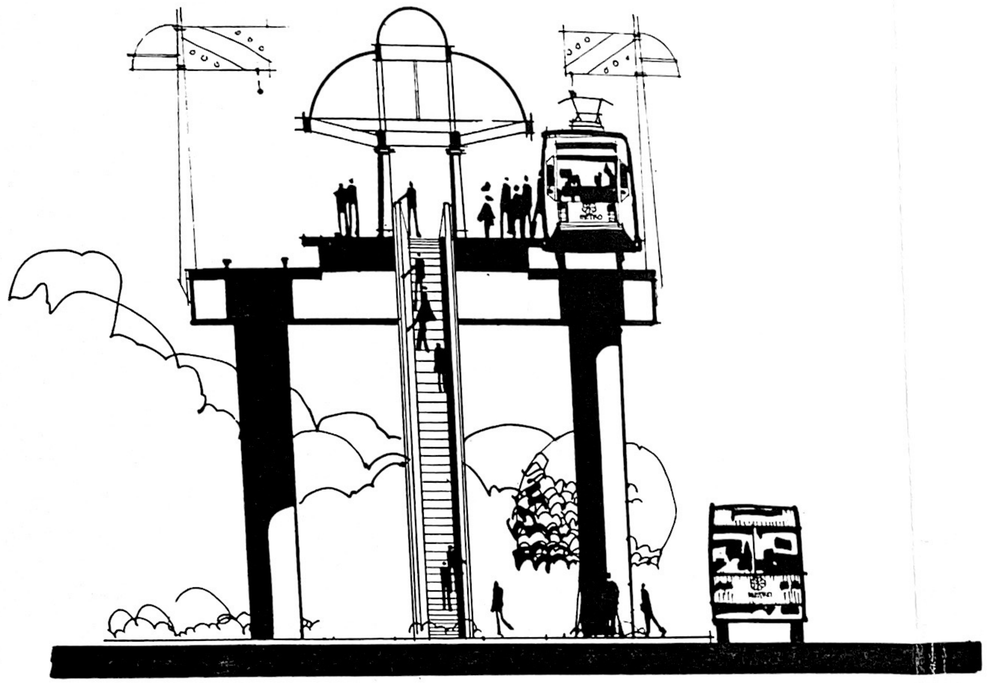
SOUTH CORRIDOR - TUKWILA L R T STATION

DWG. No. R - 206



WEST ELEVATION

0 10 20 40



SECTION A - A LOOKING SOUTH

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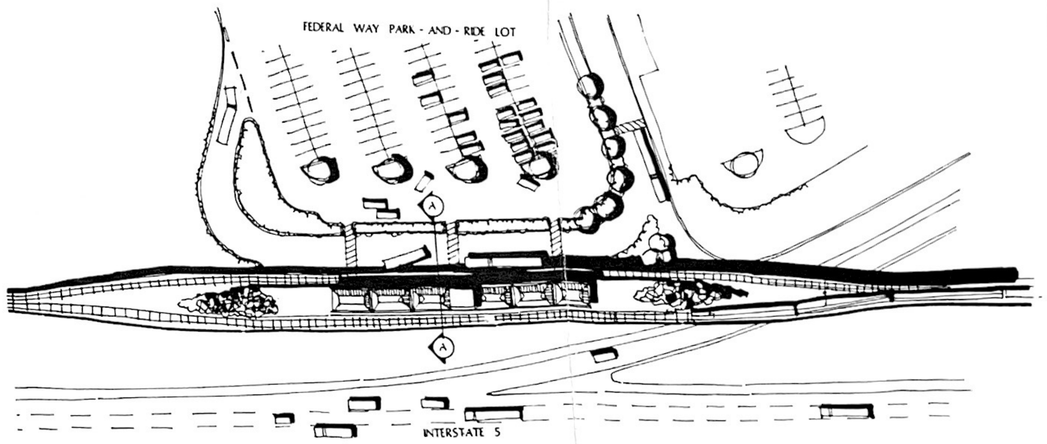


SITE PLAN

0 20 50 100 200

FEDERAL WAY L R T STATION

METRO
MUNICIPALITY OF METROPOLITAN SEATTLE

Raymond Kaiser Engineers

MULTI - CORRIDOR PROJECT

L R T ALTERNATIVE
SOUTH CORRIDOR - FEDERAL WAY L R T STATION

DWG. No. R - 207

FLEET SIZING AND OPERATING PLANS

1. OPERATING ASSUMPTIONS

The basic operational assumptions and criteria are presented below. The travel times were calculated using both manual techniques and computer simulations and are presented in Tables 4 through 14. The roundtrip times include running time, dwell time, and turnback time at one end. The roundtrip distances include the distances between stations and turnback at one end. The scheduled speed is the roundtrip time divided by the roundtrip distance.

The assumptions used are as follows:

(1) Speed limits

- 53 mph in all exclusive segments except as reduced by civil speed restrictions.

- 45 mph, 40 mph, or 35 mph maximum speed in those segments where trains are operating in a semi-exclusive mode in the median of streets.

- 25 mph maximum speed at grade crossings.

(2) Due to lack of patronage values at this time, all station dwell times are assumed to be 15 seconds. This value may be revised for each station to meet patronage demands, if recovery.

(3) Turnback allowance is 3 minutes and 0.2 miles.

(4) Patronage for years 2000 and 2020 is as per METRO preliminary numbers revised on Dec. 6, 1985. NCAA diurnal distribution by hour is used to determine off peak and weekend patronage values for operations planning. Saturday values are assumed to be 42% of weekday with even distribution; Sunday and Holidays 26% of weekday.

(5) Hours of operation are 6 a.m. to 1 a.m. Monday through Saturday; 8 a.m. to midnight on Sundays and Holidays.

(6) Vehicle capacity is assumed at 144 passengers (64 seated, 80 standee) as per NCAA. Off-peak train sizing based on all seated load.

(7) Maximum train length is 4 cars.

(8) Yearly breakdown assumed is 250 weekdays, 52 Saturdays and 63 Sundays/Holidays.

(9) No dead head hours have been included.

(10) Pre-emption of all traffic lights is assumed.

(11) The minimum train headway is 90 seconds and the maximum is 30 minutes except for Saturdays and Sundays when less service may be provided.

2. OPERATING PLANS

This section presents the weekly operating schedules for each LRT alternative for the years 2000 and 2020. The schedules are based on the patronage levels as discussed in item 4 of the operating assumptions. These operating schedules will form the basis of the operations and maintenance cost estimates.

Due to a new revision in the patronage values for all alternatives, the operating schedules are not being presented in this report, and will be presented at a later date.

TABLE 4

TRAVEL TIME CALCULATIONS

Alignment: DT plus N-1, Union Station to Northgate via Univ. Dist. Subway

Station	Dist. (mile)	Avg. Speed (mph)	Time (sec)	Dwell (sec)
Union				
3rd Ave. South	0.36	24	53	
3rd Ave North	0.43	30	52	15
Westlake	0.33	20	58	15
9th & Pine	0.33	26	45	15
Eastlake	1.57	36	155	15
Universtiy Hospital	1.51	36	151	15
University District	0.60	24	88	15
Roosevelt	1.35	29	166	15
Northgate	2.02	46	157	15
TOTAL	8.49		925	135

Turnback Distance	=	0.2	miles
Turnback Time	=	180	seconds
Roundtrip Distance	=	17.17	miles
Roundtrip Time	=	00:38:20	hr:min:sec
Scheduled Speed	=	26.9	mph

TABLE 5

TRAVEL TIME CALCULATIONS

Alignment: DT plus N-2, Union Station to Alderwood Mall via Univ. Dist. Subway

Station	Dist. (mile)	Avg. Speed (mph)	Time (sec)	Dwell (sec)
Union				
3rd Ave. South	0.36	24	53	
3rd Ave. North	0.43	30	52	15
Westlake	0.33	20	58	15
9th & Pine	0.33	26	45	15
Eastlake	1.57	36	155	15
University Hospital	1.51	36	151	15
University District	0.60	24	88	15
Roosevelt	1.35	29	166	15
Northgate	2.02	46	157	15
Jackson Park	2.25	46	175	15
North City	1.62	44	133	15
Mountlake Terrace	2.13	46	166	15
Mountlake Terrace North	0.96	39	89	15
Lynnwood	1.44	41	127	15
Alderwood Mall	1.96	42	167	15
TOTAL	18.85		1782	225

Turnback Distance	=	0.2	miles
Turnback Time	=	180	seconds
Roundtrip Distance	=	37.90	miles
Roundtrip Time	=	01:09:54	hr:min:sec
Scheduled Speed	=	32.5	mph

TABLE 6

TRAVEL TIME CALCULATIONS

Alignment: DT plus N-3, Union Station to Northgate via Univ. Dist. Bypass

Station	Dist. (mile)	Avg. Speed (mph)	Time (sec)	Dwell (sec)
Union				
	0.36	24	53	
3rd Ave. South				15
	0.43	30	52	
3rd Ave. North				15
	0.33	20	58	
Westlake				15
	0.33	26	45	
9th & Pine				15
	3.39	41	296	
University District				15
	0.92	40	84	
Roosevelt				15
	2.02	46	157	
Northgate				15
TOTAL	7.77		745	105

Turnback Distance	=	0.2	miles
Turnback Time	=	180	seconds
Roundtrip Distance	=	15.73	miles
Roundtrip Time	=	00:31:20	hr:min:sec
Scheduled Speed	=	30.1	mph

TABLE 7

TRAVEL TIME CALCULATIONS

Alignment: DT plus N-4, Union Station to Alderwood Mall via Univ. Dist. Bypass

Station	Dist. (mile)	Avg. Speed (mph)	Time (sec)	Dwell (sec)
Union				
	0.36	24	53	
3rd Ave. South				15
	0.43	30	52	
3rd Ave. North				15
	0.33	20	58	
Westlake				15
	0.33	26	45	
9th & Pine				15
	3.39	41	296	
University District				15
	0.92	40	84	
Roosevelt				15
	2.02	46	157	
Northgate				15
	2.25	46	175	
Jackson Park				15
	1.62	44	133	
North City				15
	2.13	46	166	
Mountlake Terrace				15
	0.96	39	89	
Mountlake Terrace North				15
	1.44	41	127	
Lynnwood				15
	1.96	42	167	
Alderwood Mall				15
TOTAL	18.13		1602	195

Turnback Distance	=	0.2	miles
Turnback Time	=	180	seconds
Roundtrip Distance	=	36.46	miles
Roundtrip Time	=	01:02:54	hr:min:sec
Scheduled Speed	=	34.8	mph

TABLE 8

TRAVEL TIME CALCULATIONS

Alignment: E-1, To Bothell via Bellevue Subway

Station	Dist. (mile)	Avg. Speed (mph)	Time (sec)	Dwell (sec)
Union				
	1.46	36	146	
Rainier				15
	3.81	33	409	
Mercer Island				15
	2.86	35	296	
S. Bellevue				15
	1.27	31	148	
Wilburton				15
	1.12	28	144	
Bellevue (CBD)				15
	2.63	35	274	
S. Kirkland				15
	1.73	39	161	
Houghton				15
	0.86	34	92	
Kirkland				15
	2.16	47	167	
Juanita				15
	1.04	41	92	
Kingsgate				15
	1.50	44	122	
Brickyard				15
	1.80	45	143	
Bothell				15
TOTAL	22.23		2194	180

Turnback Distance	=	0.2	miles
Turnback Time	=	180	seconds
Roundtrip Distance	=	44.67	miles
Roundtrip Time	=	01:22:08	hr:min:sec
Scheduled Speed	=	32.6	mph

TABLE 9

TRAVEL TIME CALCULATIONS

Alignment: E-1, To Bothell via Bellevue Subway

Station	Dist. (mile)	Avg. Speed (mph)	Time (sec)	Dwell (sec)
Union				
	1.46	36	146	
Rainier				15
	3.81	33	409	
Mercer Island				15
	2.86	35	296	
S. Bellevue				15
	1.27	31	148	
Wilburton				15
	0.77	42	67	
Bellevue (I-405)				15
	2.38	36	238	
S. Kirkland				15
	1.73	39	161	
Houghton				15
	0.86	34	92	
Kirkland				15
	2.16	47	167	
Juanita				15
	1.04	41	92	
Kingsgate				15
	1.50	44	122	
Brickyard				15
	1.80	45	143	
Bothell				15
TOTAL	21.64		2081	180

Turnback Distance	=	0.2	miles
Turnback Time	=	180	seconds
Roundtrip Distance	=	43.48	miles
Roundtrip Time	=	01:18:22	hr:min:sec
Scheduled Speed	=	33.3	mph

TABLE 10

TRAVEL TIME CALCULATIONS

Alignment: E-3, Redmond via Bellevue Subway

Station	Dist. (mile)	Avg. Speed (mph)	Time (sec)	Dwell (sec)
Union				
Rainier	1.46	36	146	
Mercer Island	3.81	33	409	15
South Bellevue	2.86	35	296	15
Wilburton	1.27	31	148	15
Bellevue (CBD)	1.12	28	144	15
Northup	1.49	29	186	15
Overlake	1.74	39	162	15
Evergreen Highlands	1.28	41	111	15
Redmond	2.38	32	268	15
East Sammamish	1.08	24	160	15
TOTAL	18.48		2030	150

Turnback Distance	=	0.2	miles
Turnback Time	=	180	seconds
Roundtrip Distance	=	37.16	miles
Roundtrip Time	=	01:15:40	hr:min:sec
Scheduled Speed	=	29.5	mph

TABLE 11

TRAVEL TIME CALCULATIONS

Alignment: E-4, To Redmond via Bellevue Bypass

Station	Dist. (mile)	Avg. Speed (mph)	Time (sec)	Dwell (sec)
Union				
	1.46	36	146	
Rainier				15
	3.81	33	409	
Mercer Island				15
	2.86	35	296	
South Bellevue				15
	1.27	31	148	
Wilburton				15
	0.77	38	73	
Bellevue (I-405)				15
	1.24	32	142	
Northup				15
	1.74	39	162	
Overlake				15
	1.28	41	111	
Evergreen Highlands				15
	2.38	32	268	
Redmond				15
	1.08	24	160	
East Sammamish				15
TOTAL	17.89		1915	150

Turnback Distance	=	0.2	miles
Turnback Time	=	180	seconds
Roundtrip Distance	=	35.98	miles
Roundtrip Time	=	01:11:50	hr:min:sec
Scheduled Speed	=	30.0	mph

TABLE 12

TRAVEL TIME CALCULATIONS

Alignment: S-1, To Boeing Field Station

Station	Dist. (mile)	Avg. Speed (mph)	Time (sec)	Dwell (sec)
Union				
Lander	1.23	35	127	
Spokane	0.66	31	77	15
Georgetown	1.70	41	148	15
South Park	1.14	31	130	15
Boeing Field	1.76	33	195	15
TOTAL	6.50		677	75

Turnback Distance	=	0.2	miles
Turnback Time	=	180	seconds
Roundtrip Distance	=	13.19	miles
Roundtrip Time	=	00:28:04	hr:min:sec
Scheduled Speed	=	28:2	mph

TABLE 13

TRAVEL TIME CALCULATIONS

Alignment: S-2, To Sea-Tac Airport Station

Station	Dist. (mile)	Avg. Speed (mph)	Time (sec)	Dwell (sec)
Union				
	1.23	35	127	
Lander				15
	0.66	31	77	
Spokane				15
	1.70	41	148	
Georgetown				15
	1.14	31	130	
South Park				15
	1.76	33	195	
Boeing Field				15
	2.54	37	247	
Interurban				15
	2.12	32	240	
Tukwila				15
	3.03	39	281	
Sea-Tac Airport				15
TOTAL	14.18		1445	120

Turnback Distance	=	0.2	miles
Turnback Time	=	180	seconds
Roundtrip Distance	=	28.56	miles
Roundtrip Time	=	00:55:10	hr:min:sec
Scheduled Speed	=	31.1	mph

TABLE 14

TRAVEL TIME CALCULATIONS

Alignment: S-3, To South Federal Way Station

Station	Dist. (mile)	Avg. Speed (mph)	Time (sec)	Dwell (sec)
Union				
	1.23	35	127	
Lander				15
	0.66	31	77	
Spokane				15
	1.70	41	148	
Georgetown				15
	1.14	31	130	
South Park				15
	1.76	33	195	
Boeing Field				15
	2.54	37	247	
Interurban				15
	2.12	32	240	
Tukwila				15
	3.03	39	281	
Sea-Tac Airport				15
	1.39	43	117	
Angle Lake				15
	2.67	43	223	
Midway				15
	2.18	46	169	
Star Lake				15
	3.24	48	241	
Federal Way				15
	2.54	38	238	
S. Federal Way				15
TOTAL	26.19		2433	195

Turnback Distance	=	0.2	miles
Turnback Time	=	180	seconds
Roundtrip Distance	=	52.59	miles
Roundtrip Time	=	01:30:36	hr:min:sec
Scheduled Speed	=	34.8	mph

SUBSYSTEM DESIGN

1. ELECTRICAL POWER SYSTEM

1.1 Introduction

This section describes the electrification systems that apply to the Multi-Corridor Project's LRT system. The project includes the North Corridor, between Ninth and Pine Street and Alderwood Mall; the South Corridor, between Union Station and South Federal Way; the East Corridor between Union Station and Bothel Station; and between downtown Bellevue and East Sammamish. The Multi-Corridor Project also includes the modification of the Downtown Seattle Transit Project, required to provide for the eventual full light rail vehicle (LRV) operation. Downtown Seattle Transit Project includes Downtown Seattle area, between Union Station and Ninth and Pine Streets.

The Downtown Seattle Transit Project (DSTP-PB Catalog No. C07.01), recommends that the existing traction power nominal voltage of 700 volt DC (750 volts DC maximum) should be used for the project.

Table 15 is a matrix that presents the physical and technical requirements of the substations, including the methods of distributing power to wayside vehicles for each segment. The sizing and supply voltage of the traction power substations are tabulated in Tables 16, 17, 18, and 19 for each segment. The preliminary substation transformer-rectifier capacities for each corridor, as shown in Table 15, are consistent with the substation capacities being proposed for comparable light rail systems in Santa Clara County and Los Angeles County in California. The substation locations for the Multi-Corridor Project are shown in Figure 2. The substation capacities and spacing will be verified during preliminary engineering in order to optimize the overall electrification system.

For the purpose of this work effort, a prefabricated substation design is used as a means of conserving space and minimizing installation costs except for downtown sections of Seattle and Bellevue. For downtown sections of Seattle and Bellevue, a standard underground substation is assumed. The substation design type will be verified during preliminary engineering to optimize the electrification system.

For purpose of this work effort, each traction power substation located in the CBD area has two primary feeders, one normal feeder and another stand-by feeder. Each traction power substation located outside the CBD areas has one primary feeder. The primary power is fed from Seattle City Light, Puget Sound Power and Light Company, or Snohomish County Public Utility District. The primary power voltages are 12.47 kV, 13.8 kV, 26.4 kV, or 34.5 kV as listed in Tables 16 through 19. The primary voltages from the utilities will be verified during preliminary engineering.

1.2 Design Criteria

The traction power system will be designed to meet LRT design requirements stated in DSTP-PB Catalog No. C07.01, April, 1985, for the following headways:

- Downtown Segment (SDT-1) — 90 seconds
- North Corridor Segment — 150 seconds
- South Corridor Segment — 195 seconds
- East Corridor Segment — 240 seconds

The headways will be verified during preliminary engineering in order to optimize the overall electrification system.

1.3 Traction Power

1.3.1 General

The traction power system will provide direct current (DC) electrical power to each vehicle for vehicle propulsion via an overhead contact system (OCS) (see Figure 2), and for operation of all other on-board electrical systems, such as lighting, control, communications, and ventilation. The traction power system will also supply 60-Hertz alternating current (AC) power to operate the various wayside subsystems. Overall, the traction power system will be designed to ensure adequate levels of train performance, operational flexibility, safety, equipment protection, and stray current control. The traction power system will be composed of the following elements:

- Traction power substations
- Wayside power distribution
- Remote control and supervision
- Yard traction power system
- Facilities and auxiliary power.

Each of these elements is described in the following paragraphs.

1.3.1.1 Traction Power Substations

The traction power substations will transform and convert high-voltage AC power, supplied from power utility feeders, into DC power suitable for operation of the system. The substations will also distribute and control traction power for wayside distribution.

The traction power substations will be located at or near most of the passenger stations and at the yard and shops facility (see Figure 3). The spacing of the substations and the capacity of the subsystem elements will be based on the vehicle power requirements during peak traffic periods. Peak period demand will require that the substations be capable of supplying traction power to the maximum number of vehicles that could start simultaneously under the minimum headway operating schedule. For example, enough power would be required during the two-hour peak periods to meet the demand of four-vehicle trains operating at 1.5- to 4-minute headways, with the ability to accelerate two four-vehicle trains simultaneously along adjacent trainways.

If any one of the traction power substations is out of service, the remainder of the substations will be capable of maintaining system operations at a reduced performance level.

Each traction power substation will be composed of the following elements:

- o High-voltage AC switchgear
- o AC to DC conversion assembly
- o DC switchgear
- o Battery and battery charger
- o Substation bus ducts
- o Negative bus box
- o Supervisory control interface terminal cabinet
- o Annunciator panel
- o Power and control cables with associated raceways.

1.3.1.2 Wayside Power Distribution

The wayside power distribution subsystem will be an overhead contact system that collects power from the traction power substations and delivers it to the vehicles. The overhead contact system (OCS) will be composed of the following elements:

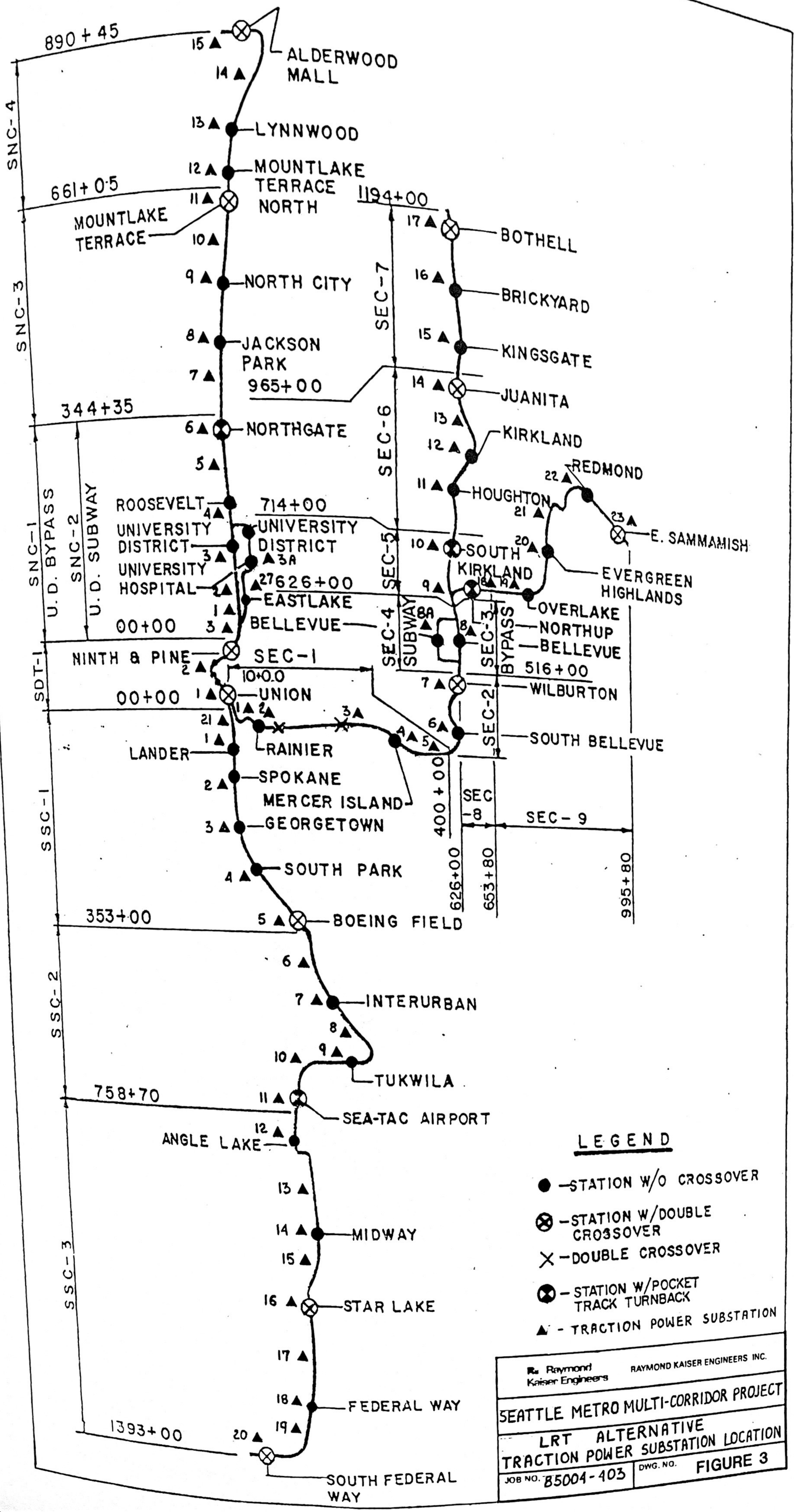
1) Catenary System
2) Galvanized steel poles and foundations
3) DC power feeder cables.

The components of this subsystem are described separately below.

TABLE 15

ELECTRIFICATION SYSTEM MATRIX

	Downtown Update	North Corridor	South Corridor	East Corridor	Maintenance Yard	REMARKS
NO. OF SUBSTATIONS	3	15	20	23	1	For typical substation single-line diagrams, see Dwg. Nos. TP-1, TP-2, and TP-3.
PRIMARY VOLTAGE	26.4 kV, 13.8 kV	26.4 kV, 12.47 kV	26.4 kV, 12.47 kV	26.4 kV, 34.5 kV, 12.47 kV	26.4 kV	
DISTRIBUTION VOLTAGE	650 V DC	650 V DC	650 V DC	650 V DC	650 V DC	
TRANSFORMER-RECTIFIER UNITS						For approximate substation locations, see Figure 1.
Quantity/Substation	1	2	2	2	2 + 1	
Rating	2,000 kW	1,000 kW	1,000 kW	1,000 kW	2,000 kW +2,000 kW	
AC SWITCHGEAR						
Quantity/Substation	2 Circuit Breakers 1 Set of Fuses	1 Circuit Breaker 1 Set of Fuses	1 Circuit Breaker 1 Set of Fuses	1 or 2 Circuit Breakers 1 Set of Fuses	2 Circuit Breakers 1 Set of Fuses	
Rating	1,200 A, 34.5 kV, 1,500 MVA 1,200 A, 15 kV, 1,000 MVA	1,200 A, 34.5 kV, 1,500 MVA 1,200 A, 15 kV, 500 MVA	1,200 A, 34.5 kV, 1,500 MVA 1,200 A, 15 kV, 500 MVA	1,200 A, 34.5 kV, 1,500 MVA 1,200 A, 15 kV, 500 MVA	1,200 A, 34.5 kV, 1,500 MVA	
DC SWITCHGEAR						
CATHODE						
Quantity/Substation	1	2	2	2	3	
Rating	5,000 A, 800 V DC	3,000 A, 800 V DC	3,000 A, 800 V DC	3,500 A, 800 V DC	5,000 A, 800 V DC	
FEEDER						
Quantity/Substation		4	4	4	10 (assumed)	
Rating		3,000 A, 800 V DC	3,000 A, 800 V DC	3,000 A, 800 V DC	3,000 A, 750 V DC	
WAYSIDE DISTRIBUTION						
Feeder Cables	2-750 kCM Copper Cables in 1-4" Ø Conduit/Feeder	4-750 kCM Copper Cables in 2-4" Ø Conduit/Feeder	4-750 kCM Copper Cables in 2-4" Ø Conduit/Feeder	4-750 kCM Copper Cables in 2-4" Ø Conduit/Feeder	4-750 kCM Copper Cables in 2-4" Ø Conduit/Feeder	
Catenary	2-350 kCM Bare Copper	2-350 kCM Bare Copper and 1-4/0 Grooved Copper	2-350 kCM Bare Copper and 1-4/0 Grooved Copper	2-350 kCM Bare Copper and 1-4/0 Grooved Copper	2-350 kCM Bare Copper and 1-4/0 Grooved Copper	
DIMENSIONS OF SUBSTATION (FEET)	25 L x 14 W (1 stn) 20 L x 28 W (2 stn)	66x30x14.5 (12.47 kV) 75x35x14.5 (26.4 kV)	66x30x14.5 (12.47 kV) 75x35x14.5 (26.4 kV)	66x30x14.5 (12.47 kV) 75x35x14.5 (26.4 kV or 34.5 kV)	75x50x14.5 (26.4 kV)	



LEGEND

- ● — STATION W/O CROSSOVER
- ⊗ — STATION W/DOUBLE CROSSOVER
- × — DOUBLE CROSSOVER
- ⊗ — STATION W/POCKET TRACK TURNBACK
- ▲ — TRACTION POWER SUBSTATION

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LRT ALTERNATIVE
TRACTION POWER SUBSTATION LOCATION

JOB NO. 85004-403 | DWG. NO. FIGURE 3