EXHIBIT A

SEC PROJECT LIGHT RAIL TRANSIT (LRT) CROSSING LOCATIONS

The following is a complete listing of the public highways, including on-ramps and off-ramps and pedestrian walkways and bike paths, that will be crossed (hereinafter, an "LRT Crossing") by the proposed Southeast Corridor Project's fully grade-separated LRT element. This listing of LRT Crossings is organized directionally (except where otherwise indicated), as follows: as the SEC Project proceeds south on I-25, starting from the Broadway Station to Lincoln Avenue; and, then north on I-225, from I-25 to Parker Road. Further, this listing of LRT Crossings is also organized such that, where practicable, 2 or more actual crossings have been combined into 1 LRT Crossing (as noted below) when multiple roadways were crossed by a single structure or when, geographically, multiple roadway crossings all had the same clearance evaluation components.

LRT CROSSINGS ALONG WEST SIDE OF I-25

1)	Over Broadway Blvd. & over Kentucky Ave.	City and County of Denver (CCD)
2)	Under Logan St.	CCD
3)	Under SB I –25 off-ramp at Washington St. and under Washington St	CCD
4)	Under Louisiana St.	CCD
5)	Under Emerson St. and under SB I-25 on-ramp at Emerson.	CCD
6)	Under Downing St.	CCD
7)	Under Franklin St.	CCD
8)	Over SB I-25 off-ramp at University Blvd. (SH 177), over University, and over SB I-25 on-ramp at University	CCD
9)	Under Steele/St. Paul	CCD
10)	Under Colorado Blvd. (SH 2) and under Colorado Center Dr.	CCD
11)	Under Birch ST.	CCD
12)	Under SB I-25 off-ramp at Evans Ave., under Evans and	CCD

under SB I-25 on-ramp at Evans	
13) Over SB I-25 off-ramp at Yale Ave., over Yale and over SB I-25 on-ramp at Yale	CCD
14) Over the Highline Canal Service Road	CCD
15) Under SB I-25 off-ramp at Hampden Ave. (SH 30), under Hampden, and under SB I-25 on-ramp at Hampden.	CCD
16) Under Quincy Ave.	CCD
(I-25/I-225 INTERCHANGE - See # 25 below)	
17) Under Union Ave.	CCD
18) Over SB I-25 off-ramp at Belleview Ave. (SH 88), over Belleview, over SB I-25 on-ramp at Belleview	CCD
19) Over SB I-25 off-ramp at Orchard Rd., over Orchard, over SB I-25 on-ramp at Orchard	Greenwood Village (GV)
20) Under Yosemite St.	GV
21) Over SB I-25 off-ramp at Arapahoe Rd. (SH88), over Arapahoe, over SB I-25 on-ramp at Arapahoe	GV
22) Over SB I-25 off-ramp at Dry Creek Rd., over Dry Creek, over SB I-25 on-ramp at Dry Creek	Arapahoe County
23) Over SB I-25 off-ramp at County Line Rd., over County Line, over SB I-25 on-ramp at County Line	Arapahoe County
24) I-25/C-470 INTERCHANGE including:	
• Under SB I-25 off-ramp to WB C-470	Douglas County
• Under NB I-25 off ramp to WB C-470	Douglas County
• Over C-470 Mainline	Douglas County
• Under EB C-470 off ramp to NB I-25	Douglas County
• Under EB C-470 off ramp to SB I-25	Douglas County
25) I-25/I-225 INTERCHANGE including:	
• SB I-25 to NB I-225 structure which goes over:	CCD

- SB I-25 Mainline
- NB I-25 Mainline
- Ramp, SB I-25 to NB I-225
- Ramp, SB I-225 to SB I-25
- Ulster St.

- SB I-225 to NB I-25 structure which goes over: CCD
  - SB I-25 Mainline
  - NB I-25 Mainline
  - Ramp, SB I-25 to NB I-225
  - Ramp, SB I-225 to SB I-25
  - Ulster St.

- SB I-225 to SB I-25 structure which goes over: CCD
  - Ulster St
  - Ramp, SB I-25 to NB I-225
  - Ramp, SB I-225 to SB I-25
  - NB I-25 Mainline
  - SB I-25 Mainline
  - Ramp, SB I-25 to Belleview

- NB I-25 to NB I-225 structure which goes over: CCD
  - Ulster St
  - Ramp, SB I-25 to NB I-225
  - Ramp, SB I-225 to SB I-25
  - NB I-25 Mainline
  - SB I-25 Mainline
  - Ramp, SB I-25 to Belleview

LRT CROSSINGS ALONG I-225 MEDIAN

26) Over DTC Parkway CCD

27) Under Yosemite St.	CCD
28) Under Dayton St. (Undedicated St.)	City of Aurora
29) Over Parker Road (SH 83)	City of Aurora

END

1.2 Basic Configuration

Basic Configuration shall be as defined in Book One, and as follows:

1. The general termini shall be as shown in the Reference Drawings.
2. The LRT alignment shall be grade separated from the highway and cross streets. No at-grade crossings will be allowed.
3. The Highway and Fixed Guideway horizontal and vertical alignments shall be as shown in the Reference Drawings. Additionally, the following shall be allowed without being considered a change to the Basic Configuration.
   A. The vertical alignment for the Highway can be changed up to 2 feet down or 5 feet up, except for the Southmoor area (defined as the area between Hampden Avenue and Quincy Avenue) which can be changed up to 2 feet down or 2 feet up.
   B. The vertical alignment grade for the Fixed Guideway can be changed up to 0.25 percent.
   C. The horizontal alignment for the Highway and Fixed Guideway can be changed up to 10 feet, or within the proposed right-of-way limits as shown in Book 4, whichever is less.
   D. The minimum vertical clearance for the fixed guideway between the top of the rail and overhead structures can be changed up to 2 feet, but shall not be less than minimum criteria.
7. The number of Fixed Guideway tracks, including turnout sizes and special trackwork locations/configurations, shall be as shown in the Reference Drawings. Additionally, the locations of special trackwork can be changed up to 50 feet along the longitudinal axis of the Fixed Guideway alignment.
8. The LRT connection at the I-25/I-225 interchange shall be a wye connection with two (2) tracks on each leg. All track to track crossings shall be grade separated.
9. The LRT connection at the Broadway Station shall be a wye connection with two tracks on the Central to Southeast and Central to Southwest legs. The Southwest to Southeast leg may be one track. A pocket track shall be provided south of the Broadway Station. The number of tracks at the Broadway Station shall be as shown in the Reference Drawings.
10. The location of the stations shall be as shown in the Reference Plans, except as follows:
    A. Design of the station sites shall be as shown in the Contract Drawings.
    B. The station site location can be changed, in its entirety, a distance of up to 100 feet along the longitudinal axis of the fixed guideway alignment.
12. The number and locations of wayside signals and signal box units shall be as shown in the Contract Drawings. Additionally, the locations of wayside signals or signal box units can be changed up to a distance of 50 feet along the longitudinal axis of the fixed guideway alignment, provided that the change does not increase the design headway to greater than 130 seconds and that adequate breaking distance is maintained as given in the Contract.

EXHIBIT
F

3.3 LRT DESIGN

3.3.1 Track Geometry and Trackwork

3.3.1.5 Clearance Requirements

3.3.1.5.1 General

1. The criteria developed in this Section apply to the design of the entire system. All designs shall provide not less than the minimum clearances as specified in this Section.

3.3.1.5.2 Track Spacing

Track spacing will vary, depending on the type of construction used for the particular section.

1. Minimum center-to-center track dimensions for parallel tracks with center catenary poles shall be 14.0 feet.
2. Minimum center-to-center track dimensions for parallel tracks without center catenary poles shall be 13.0 feet.
3. Increased center-to-center dimensions may be required through curved sections.

3.3.1.5.3 Clearance Envelope

The Clearance Envelope (CE) is defined as the space occupied by the vehicle dynamic envelope plus the effects of Other Wayside Factors (OWF) including construction, fabrication, and maintenance tolerances and additional Running Clearance (RC). This relationship can be expressed mathematically as:

CE = VDE + OWF + RC

CE = (5 feet, 9-1/2 inches) + (1.5 inches + 1.0 inches + CW) + (2.0 inches)

CE = 6 feet 2 inches minimum for tangent track

CE = 6 feet 2 inches + CW minimum for outside curves

3.3.1.5.3.1. Vehicle Dynamic Envelope

The dynamic outline of the design vehicle shall be developed in accordance with data as described in RTD's Light Rail Design Criteria, Section 4.2.4.2 - Clearance Envelope.

3.3.1.5.3.2 Other Wayside Factors

Other Wayside Factors is the sum of certain Construction Tolerances (CT) and Maintenance Tolerances (MT), and a chorded wall construction factor (CW)

CT = Allowable deviation from the design position

CT = 0.5 inches for ballasted, paved or direct fixation track plus 1.0 inches for poles, signal equipment or walls

CT = 1.5 inches

MT = Maintenance tolerance (allowable deviation in position from the as constructed position)

MT = 1.0 inches for ballasted track or
0.5 inches for direct fixation or paved track

CW = Additional width for chorded construction of walls, catenary poles, signal poles or other obstructions to be constructed outside of curves

CW = Distance as shown on Figures 4.4 and 4.5 of RTD's LRT Design Criteria

OWF = Other wayside factors

OWF = CT + MT + CW

3.3.1.5.3.3 Running Clearances

Running clearances are the clearance contingency added after the inclusion of all factors which define the vehicle, vehicle tolerances, construction tolerances and maintenance tolerances. Running clearances are specific to the right-of-way condition encountered and shall be as follows:

Condition	RC
Traction power poles	2 inch
Conduit	2 inch
Signals	2 inch.
Other non-structural elements	2 inch
Walkway edge	2 inch
Pantograph electrical clearance	3 inch
Structural members	6 inch
Adjacent LRVs	0 inch

3.3.1.5.3.4. End and Middle Ordinate Displacement

For design purposes, the end overhang and middle ordinate of the vehicle on curved tracks shall be considered. Rounding of car corners shall not be considered.

3.3.1.5.3.5. Effect of Superelevation

1. It is the intent of these criteria to provide facilities which will permit changing the operating speeds of the trains during the life of the system by changing the actual superelevation (E_a). Because some horizontal clearances are a function of superelevation, it is necessary that the facilities be designed for a maximum value of E_a, not to exceed 6 inches, toward the center of the curve, and for a minimum value E_a away from the center of the curve unless physical conditions restrict the operating speed in a given area.
2. A superelevation correction of 2.15 inches per inch of actual superelevation (E_a) at the car mirror, not to exceed 10 inches for outside end overhang, and 1.15 inches per inch of E_a at 5.5 feet above the top of rail shall be applied to the clearance envelope.

3.3.1.5.4 CLEARANCES

3.3.1.5.4.1 Horizontal Clearances

Minimum horizontal clearances measured from centerline of track shall be as follows:

Condition	Horizontal Clearance
Adjacent parallel tracks	See 3.3.1.5.2 Track Spacing
Intermittent columns and point restrictions	7.5 feet minimum (Note 1)
Retaining walls or continuous restrictions	8.5 feet minimum

NOTES:

1. Each such restriction shall be considered independently and submitted to the SEC Representative for prior Approval.
2. In addition to the clearance envelope, an emergency access/maintenance walkway shall be provided adjacent to each track. The walkway shall extend 2 feet, 6 inches from the edge of the clearance envelope and shall extend 6 feet, 6 inches above the top of rail. The walkways shall be provided along the outside edges of the guideway and shall permit unobstructed egress from the guideway. With prior SEC Representative Approval the walkway may be located between the LRT tracks. For walkway clearance calculations only, traction power poles and the LRV mirrors need not be considered.

3.3.1.5.4.2 Vertical Clearances

Minimum vertical clearances, measured from the top of high rail, shall be as follows:

Condition	Required Vertical Clearance
Structure over LRT	17 feet
LRT in long tunnel	15 feet

Prior SEC Representative Approval will be required to use 15 foot clearance.

3.3.1.5.4.3 Chorded Construction

1. When chorded construction is specified, walls and walkways shall be constructed in chords whose lengths shall be measured along the inside face of the wall nearest the curve center. The maximum allowable lengths of chord shall be:
   A. For curves with radii 2500 feet or greater: 50 feet
   B. For curves with radii less than 2500 feet: 25 feet
2. Values to be used for allowances for chorded construction in clearance calculations are shown in Figures 4.4 and 4.5 of RTD's LRT Design Criteria.
3. In chorded construction, the horizontal dimensions from centerline of track to inside face of wall shall be measured normal to the centerline of track between adjacent chorded elements.

3.3.1.5.4.4 Widening on Curves

1. The required increase in width of clearance envelope between a tangent section of track and a curved section of track shall be applied or removed linearly. The transition from tangent width to curved width shall begin at a point 50 feet before the TS (or 50 feet after the ST) and end at a point 25 feet before the TS (or 25 feet after the ST) For horizontal curves without spirals, the PC and PT shall be used in lieu of the TS and ST.
2. The clearance envelope through turnouts shall be determined using the turnout centerline radius.

3.3.1.5.4.5 Structure Width

The minimum structure width shall be determined by the sum of the dynamic total width, required clearances, construction tolerances, allowance for chorded construction, where applicable, allowance for superelevation of the tracks, where applicable, and requirements for safety walks.

3.3.1.5.4.6 Station Clearances

Horizontal clearances at platforms shall be 4 feet, 7 inches from the centerline of the track to the edge of the platform.

3.3.1.5.4.7 Highway

The following vertical clearances (rapid transit structure over highway) shall apply to possible future developments as well as existing conditions.

1. Over roadways under Colorado Department of Transportation jurisdiction:

   Minimum vertical clearance, 16.5 feet

2. The above-listed vertical clearances, vertical clearance requirements in all other jurisdictions, and all horizontal clearance requirements shall be verified with the appropriate authorities. For structures under the jurisdiction of agencies other than those listed above, the design shall be coordinated with the appropriate owner or agency involved.

3.3.1.5.4.8 Undercar Clearance

The minimum vertical clearance envelope under the car shall be 3 inches.

23.3.1.7 LRT Design Variances

3.3.1.7.1 General

The following design variances have been Approved by RTD.

3.3.1.7.2 Curves not meeting 60 mph design speed

Curve No.	Design Speed	Meet Accel/Decel Curves?	Comment
SE1 SB to SW2	40	Yes	

SE1 SB to SW3	55	Yes	
SE1 NB from SW1	55	No	Constrained wye track configuration
SE1 NB from SW2	55	No	Quickly shifting track centers to reuse bridge
Curve No.	**Design Speed**	**Meet Accel/Decel Curves?**	**Comment**
SE1 NB from SW3	55	No	Quickly shifting track centers to reuse bridge
SE1 POCKET1	20	No	Pocket track will not see 60 mph operations
SE1 POCKET2	44	No	Pocket track will not see 60 mph operations
SE1 WYENB1	15	No	Non-revenue track
SE1 WYESB1	20	No	Non-revenue track
SE1 NB1	20	No	Constrained wye track configuration
SE1 SB1	20	No	Constrained wye track configuration
SE1 NB2	25	No	Minimize property impact (Gates building)
SE1 SB2	25	No	Minimize property impact (Gates building)
SE1 NB4	55	Yes	
SE1 SB4	55	No	Minimize ramp structure length
SE1 NB5	50	Yes	
SE1 SB5	50	Yes	
SE1 NB6	50	Yes	
SE1 NB10	45	Yes	
SE1 SB10	45	Yes	
SE1 NB11	45	Yes	
SE1 SB11	45	Yes	
SE1 NB15	40	No	Minimize property impact
SE1SB15	40	No	Minimize property impact
SE1 NB17	35	No	Minimize property impact
SE1 SB17	35	No	Minimize property impact
SE1 NB18	35	No	Minimize property impact
SE1 SB18	35	No	Minimize property impact
SE2 NB2	45	Yes	
SE2 NB3	45	No	Minimize property impact
SE2 SB3	45	Yes	
SE2 NB10	45	Yes	
SE2 NB19	45	Yes	
SE4 NB1	55	Yes	
SE4 NB2	45	Yes	
SE4 SB2	55	Yes	
SE4 NB3	55	No	Compromise between speed and structure cost
SE4 SB3	55	Yes	Compromise between speed and structure cost
SE4 NB4	55	No	Compromise between speed and structure cost
SE4 SB4	55	Yes	Compromise between speed and structure cost
SE4 NB5	55	No	Compromise between speed and structure cost
SE4 SB5	55	No	Compromise between speed and structure cost
SE4 NB7	45	Yes	
SE4 SB7	45	Yes	
SE4 SB8	45	Yes	
SE4 NB13	40	No	Minimize property impact
SE4 SB13	40	No	Minimize property impact
SE4 NB14	40	No	Minimize property impact
SE4 SB14	40	No	Minimize property impact
SE4 SB17	55	No	Minimize property impact
SE4 NB18	45	Yes	

SE2 SB225-NB1	40	No	Constrained wye track configuration
SE2 SB225-NB1	40	No	Constrained wye track configuration
Curve No.	**Design Speed**	**Meet Accel/Decel Curves?**	**Comment**
SE2 NB225-NB1	40	No	Constrained wye track configuration
SE2 SB225-SB1	40	No	Constrained wye track configuration

3.3.1.7.3 Tangent length less than 200' desirable length

Station	Length	Criteria Met	Comment
SE1 SB to SW			
318+01.93	111.88	50'abs min	Constrained wye connection
SE1 NB from SW			
328+90.08	104.22	50' abs min	Constrained wye connection
SE1 POCKET			
418+29.71	134.34	50' abs min	Constrained wye connection
SE1 NB			
23+00.45	179.37	3V min	Constrained wye connection
55+58.84	168.83	3V min	Minimize ramp structure length
68+85.26	128.59	50' abs min	Minimize ramp structure length
168+90.59	180.65	3V min	
183+95.38	118.49	50'abs min	Constrained geometry at Colorado tunnel
206+95.05	113.99	50' abs min	Constrained geometry at Evans tunnel
212+15.98	182.77	3V min	
217+84.45	183.05	3V min	
SE1 SB			
55+65.60	170.16	3V min	Minimize ramp structure length
168+90.61	180.62	3V min	
183+90.70	153.08	50' abs min	Constrained geometry at Colorado tunnel
207+28.12	118.07	50' abs min	Constrained geometry at Evans tunnel
217+85.95	183.05	3V min	
SE2 NB			
264+80.36	103.36	50' abs min	Minimize impact to residences
323+66.41	189.93	3 V min	Minimize impact to residences
330+84.16	147.70	50' abs min	Minimize impact to residences
370+81.92	144.79	50' abs min	Minimize impact to residences
383+66.61	128.18	50' abs min	Constrained interchange geometry
397+14.26	139.53	50' abs min	Constrained interchange geometry
437+78.24	101.20	50' abs min	Minimize property impacts
SE2 SB			
246+83.73	154.33	50' abs min	Minimize property impacts
312+21.50	190.13	3V min	Minimize impact to residences
323+66.02	179.64	50' abs min	Minimize impact to residences
370+82.15	120.10	50' abs min	Constrained interchange geometry

437+77.70	101.75	50' abs min	Minimize property impacts

Station	Length	Criteria Met	Comment
SE4 NB			
543+75.64	173.15	3V min	Minimize property impacts
569+81.97	180.12	3V min	Minimize length of narrow shoulder
650+53.54	112.28	50' abs min	Minimize property impacts

3.3.1.7.4 Tangent length less than 200 feet desirable length

Station	Length	Criteria Met	Comment
SE4 SB			
515+48.79	184.78	3V min	Minimize property impacts
543+77.80	172.75	3V min	Minimize property impacts
569+33.33	189.05	3V min	Minimize property impacts
580+87.97	190.54	3V min	Minimize property impacts
588+65.34	145.04	50' abs min	Minimize property impacts
650+50.75	155.21	50' abs min	Minimize property impacts
732+12.56	184.02	3B min	Constrained by geometry
SE3 NB225			
516+74.92	180.13	3V min	Maximize length of narrow shoulder
520+57.90	186.60	3V min	Maximize length of narrow shoulder

3.3.1.7.5 Curve length less than 3V

Curve No.	Length	Comment
SE1 SB to SW2	107.36	Quickly shifting track centers to reuse bridge
SE1 SB to SW3	117.51	Quickly shifting track centers to reuse bridge
SE1 NB from SW1	129.91	Constrained wye track configuration
SE1 NB from SW2	115.28	Quickly shifting track centers to reuse bridge
SE1 NB from SW3	115.28	Quickly shifting track centers to reuse bridge
SE1 SB10	134.21	Minimize property impacts
SE1 SB11	131.97	Minimize property impacts
SE1 SB19	153.49	
SE2 SB2	169.92	Minimize property impacts
SE2 SB9	105.90	Minimize property impacts
SE2 NB13	143.12	Constrained interchange geometry
SE2 SB13	143.36	Constrained interchange geometry
SE2 NB14	118.42	Constrained interchange geometry
SE2 SB14	118.42	Constrained interchange geometry
SE2 NB15	39.96	Constrained interchange geometry
SE2 NB17	159.16	Constrained interchange geometry

Curve No.	Length	Comment
SE2 SB21	168.98	Minimize property impacts
SE4 NB12	166.32	Minimize property impacts
SE4 SB12	163.64	Minimize property impacts

3.3.1.7.6 Curves with no spirals

Curve No.	Radius	Calculated Spiral Length	Meets Ls/Rc < 1/100 Criteria?	Comment
SE1 POCKET1	2250	95	No	Spirals not needed for storage tracks
SE1 NB16	8750	85	Yes	
SE1 SB16	8764	85	Yes	
SE2 NB1	8014	80	Yes	
SE2 SB1	8000	80	Yes	
SE2 NB6	9014	85	Yes	
SE2 SB6	9000	85	Yes	
SE2 NB11	17500	40	Yes	
SE2 SB11	17500	40	Yes	
SE2 NB12	18000	40	Yes	
SE2 SB12	16500	40	Yes	
SE2 NB13	8200	75	Yes	
SE2 SB13	8214	75	Yes	
SE2 NB18	8000	80	Yes	
SE2 SB18	8000	80	Yes	
SE2 NB19	5500	55	Yes	
SE4 NB1	12950	45	Yes	
SE4 SB1	8000	80	Yes	
SE4 NB2	5500	55	Yes	
SE4 SB2	7500	75	Yes	
SE4 NB6	8000	80	yes	
SE4 SB6	8000	80	Yes	
SE4 NB7	5500	55	Yes	
SE4 SB7	5500	55	Yes	
SE4 SB8	5500	55	Yes	
SE2 NB225-NB2	5000	40	Yes	
SE2 SB225-NB2	5000	40	Yes	
SE3 NB1	16250	40	Yes	
SE3 NB2	16250	40	Yes	
SE3 NB3	16250	40	Yes	
SE3 NB4	16250	40	Yes	
SE3 SB1	10000	70	Yes	
SE3 SB2	8000	80	Yes	

3.3.1.7.7 Reverse curves with no tangent track between them

Curve No.	Comment
SE2 SB3 SE2 SB4	Minimize impacts to residences

3.3.1.7.8 Vertical grades exceeding the desirable maximum

Mainline Track (desirable maximum grade = 3.5 percent maximum grade = 6 percent

Begin Station	End Station	Grade	Meets Max Grade Criteria	Comments
SE1 WYE				
220+47.50	224+66.79	5.00%	Yes	Over Broadway, minimize structure length
SE1 NB				
20+45.00	24+75.00	5.00%	Yes	Over Broadway, minimize structure length
120+50.00	123+00.00	5.00%	Yes	Over Broadway, minimize structure length
132+50.00	134+75.00	4.00%	Yes	Over Broadway, minimize structure length
213+50.00	216+17.50	4.96%	Yes	Minimize retained cut length
SE2 NB				
327+25.00 New interchange	329+75.00	4.60%	Yes	Minimize retained cut length
SE4 NB				
584+85.00	588+00.00	6.00%	No	Over Arapahoe, minimize structure length Does not meet Gc=Gt-230/Rc criteria
609+75.00	611+50.00	4.41%	Yes	Over Arapahoe, minimize structure length
620+00.00	629+40.00	3.71%	Yes	Match existing grade, minimize earthwork
693+50.00	695+60.00	6.00%	No	Over County Line, minimize structure length Does not meet Gc=Gt-230/Rc criteria
706+60.00	708+77.50	4.33%	Yes	Over County Line, minimize structure length
747+50.00	750+00.00	3.60%	Yes	Weave through C-470 interchange
757+00.00	765+00.00	4.48%	Yes	Minimize retained cut length
SE3 NB				
637+65.00	640+75.00	5.00%	Yes	Minimize retained fill length

3.3.1.7.9 Vertical grades exceeding the desirable maximum

Special Trackwork (desirable maximum grade = 1.0 percent maximum grade = 4.5 percent

Begin Station	End Station	Grade	Meets Max Grade Criteria	Comment
SE1 NB				
23+00	24+79.82	5.00%	No	5.00% Grade needed to match grade at Broadway Station and get over Broadway
228+76.55	243+06.50	1.01%	Yes	
SE2 NB				
341+80.00 New interchange	350+48.88	1.25%	Yes	Match existing grade to minimize earthwork
SE4 NB				
508+70.31	513+30.82	2.27%	Yes	Minimize retained fill length
783+26.17	786+92.69	1.50%	Yes	Match existing grade to minimize earthwork
791+92.69	795+59.22	1.50%	Yes	Match existing grade to minimize earthwork

Begin Station	End Station	Grade	Meets Max Grade Criteria	Comment
SE3 NB				
631+93.39	633+98.54	3.01%	Yes	Match existing grade to minimize earthwork

Station Platform (desirable maximum grade = 0.5 percent, maximum grade = 1.5 percent)

Station Name	Grade	Meets Max Grade Criteria	Comment
Louisiana	0.87%	Yes	
Colorado	0.97%	Yes	
Southmoor	1.25%	Yes	
Belleview	1.50%	Yes	
Orchard	1.50%	Yes	
Lincoln	1.50%	Yes	

Storage Track (desirable maximum grade = 0.0 percent, maximum grade = 0.25 percent)

Location	Grade	Meets Max Grade Criteria	Comments
SE1 POCKET	0.21%	Yes	Match existing grade to minimize earthwork
SE2 POCKET	1.25%	No	Match existing grade to minimize earthwork
SE4 END OF LINE	0.87%	No	Match existing grade to minimize earthwork
SE3 END OF LINE	1.50%	No	Match existing grade to minimize earthwork

3.3.1.7.10 Length of constant profile grade less than 3V

Begin Station	End Station	Length	Comment
New intersection			
SE4 NB			
609+75.00	611+50.00	175.00	Minimize retained cut length

3.3.1.7.11 Minimum tangent prior to PS less than desirable (45 feet)

Station	Criteria Met	Comment
SE1 NB		
SE2 NB		
New interchange		

3.3.1.7.12 Vertical clearance less than desirable (17 feet)

Begin Station	End Station	Length	Comment
SE4 739+35	740+65	130'	Meets 15 foot minimum clearance criteria

RTD LIGHT RAIL

DESIGN CRITERIA

Regional Transportation District
October 2000

PREFACE

4.2.4 Clearances

4.2.4.1 General

The criteria developed in this section apply to the design of the entire system. All designs shall provide not less than the minimum clearances as specified in this section.

Assurance of adequate and appropriate clearance for the passage of light rail vehicles throughout the mainline trackage, switches and special trackwork, stations, storage yards and operations facilities is one of the most fundamental concerns inherent in the design process and must be rigorously monitored during the construction phase. Design criteria for clearances are complex and are based on numerous assumptions and interfaces.

It is in the development of clearance requirements that the build-up of concurrent, multiple tolerances must be scrutinized and balanced with the practicality of available space and other functional requirements. The clearance requirements in this section seek to make that balance.

4.2.4.2 Clearance Envelope

The Clearance Envelope (CE) is defined as the space occupied by the Vehicle Dynamic Envelope (VDE) plus the effects of Other Wayside Factors (OWF) including construction, fabrication, and maintenance tolerances for certain track and facilities plus Running Clearances (RC). Simplistically this relationship can be expressed as follows:

CE = VDE + OWF + RC
= (5 feet-9-1/2 inches) + (1.5 inches + 1.0 inch + CW) + (2.0 inch)
= 6 feet-2 inch minimum (centerline track to pole face, tangent track)

Add CW correction from Figure 4.4 for outside curves (6 feet-2 inches + CW).

Generally speaking, the clearance envelope represents the space in or into which, other than the light rail vehicle, no physical part of the system may be placed or constructed or may protrude. The clearance envelope is normally referenced from, or represented by its relationship to, the theoretical centerline of track at Top of Rail (TOR).

a) Vehicle Dynamic Envelope

In addition to the LRV static dimensions, the vehicle dynamic envelope (VDE) includes all possible vehicle movements from vehicle tolerances and from certain closely-related rail/track tolerances. More specifically, the VDE is based upon the following assumptions:

- Static geometry of the vehicle
- Roll angle of ± 4°
- Suspension lateral travel (per side) of 1.340 inch
- Wheel gauge construction tolerance (per side) of 0.031 inch
- Lateral wheel wear (per side) of 0.300 inch
- Radial wheel wear of 1.000 inch
- Rail gauge construction tolerance (per side) of 0.125 inch
- Lateral rail wear (per side) of 0.500 inch
- Wheel-to-rail sideplay (per side) of 0.375 inch

b) Other Wayside Factors

The clearance envelope (CE) can be determined by adding other wayside factors (OWF) for certain construction and maintenance tolerances plus running clearance to the vehicle dynamic envelope. Other Wayside Factors is the sum of certain construction tolerances (CT) plus certain maintenance tolerances (MT) plus a corded wall construction factor (CW) to account for the effects of certain wall construction, all where applicable.

OWF = CT + MT + CW

The following defines the Other Wayside Factors and are applicable to and included in the horizontal component of the CE:

CT = Construction tolerances (allowable deviation from design position)

Track = 0.5 in open, paved, and direct fixation

Plus:

poles or signals equipment = 1.0 in, or
walls = 1.0 in, or

MT = Maintenance tolerances (allowable deviation from as constructed condition)

Track = 1.0 in open track (each track), or
= 0.5 in paved and Direct Fixation track

CW = Additional width for chorded construction of walls, catenary poles, signal poles, other obstructions to be constructed outside of curves. (See Figure 4.4 and 4.5)

c) Running Clearances

In addition to the vehicle dynamic envelope and the other wayside factors, the clearance envelope includes an allowance for running clearances (RC). Running

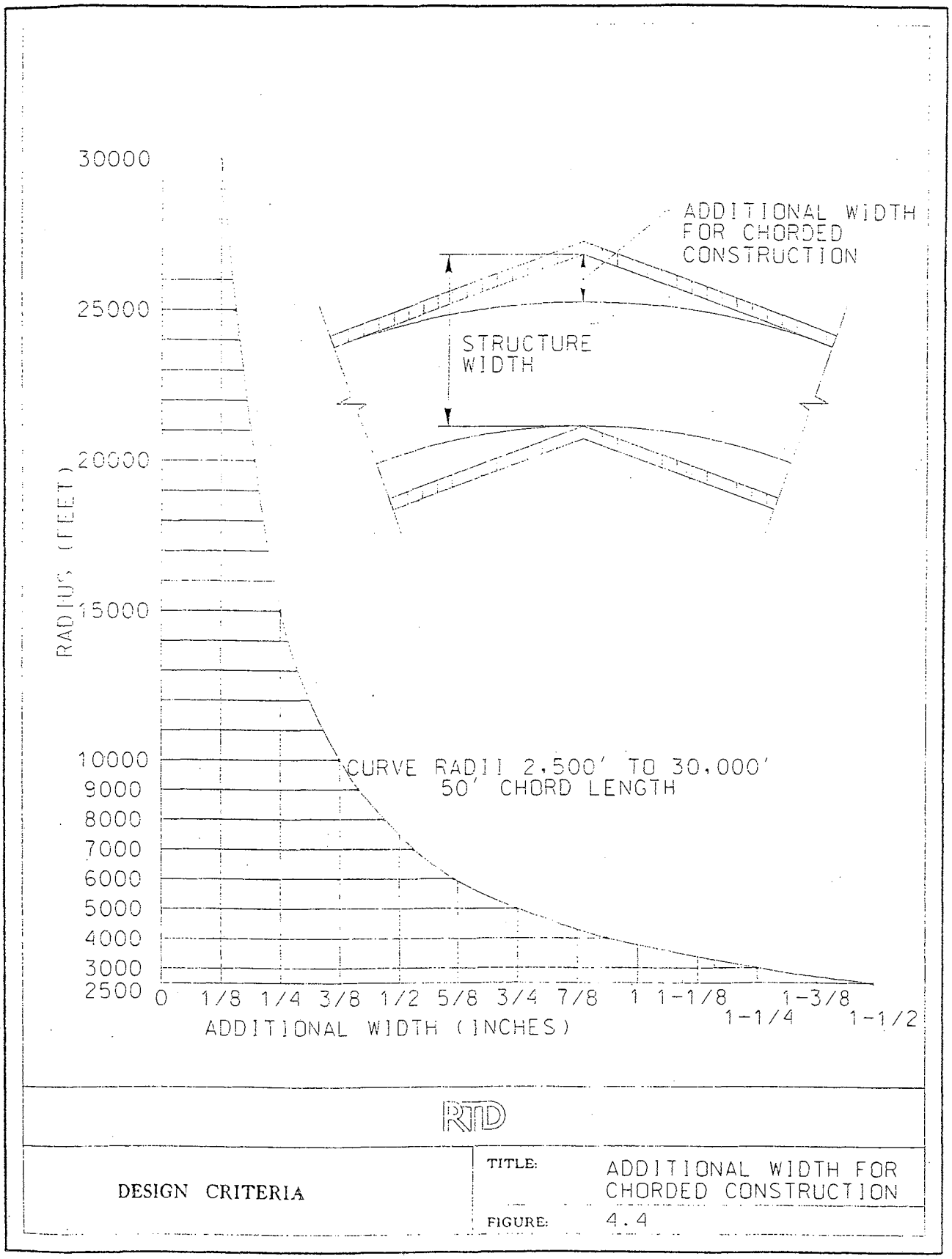
clearances can be considered as the RTD clearance contingency after the inclusion of all factors purporting to define the vehicle, the vehicle tolerances, the construction tolerances, and the maintenance tolerances.

Running clearances are specific to the ROW conditions encountered and shall include one of the following in any direction:

2 inch	For traction power poles, conduit, signals, signs, and other non-structural members, or
2 inch	For walkway edge, or
3 inch	For pantograph electrical clearance, or
6 inch	For structural members, or
0 inch	For adjacent LRV.

For horizontal curves with spirals, the tangent clearance envelope shall end 50 feet before the point of Tangent-to-Spiral (TS) and 50 feet after the point of Spiral-to-Tangent (ST). The full curvature clearance envelope shall begin 25 feet prior to the point of Spiral-to-Curve (SC) and end 25 feet beyond the point of curve-to-spiral (CS). The horizontal component of the vehicle dynamic envelope between these two offset points (i.e., 50 feet before TS and 25 feet before SC) shall be considered to vary linearly with distance between the two points. Horizontal offsets at intermediate locations shall be calculated with straight line interpolation. For horizontal curves that do not include spiral transition curves, the full curvature clearance envelope shall begin 50 feet prior to the Point of Curvature (PC) and extend to 50 feet beyond the Point of Tangency (PT). More detailed computer simulations with more precise geometry may be used, subject to RTD approval, to define the clearance envelope in place of these 25 foot and 50 foot locations and straight line interpolations. The clearance envelope through turnouts shall be calculated based on the turnout centerline radius.

Superelevation correction (e) = 2.15 inches per inch of actual Superelevation (Ea) at car mirror, but not to exceed 10 inches for outside end overhang, 1.15 inches per inch of Ea at 5.5 feet above TOR.



RTD

DESIGN CRITERIA	TITLE:	ADDITIONAL WIDTH FOR CHORDED CONSTRUCTION
	FIGURE:	4.4

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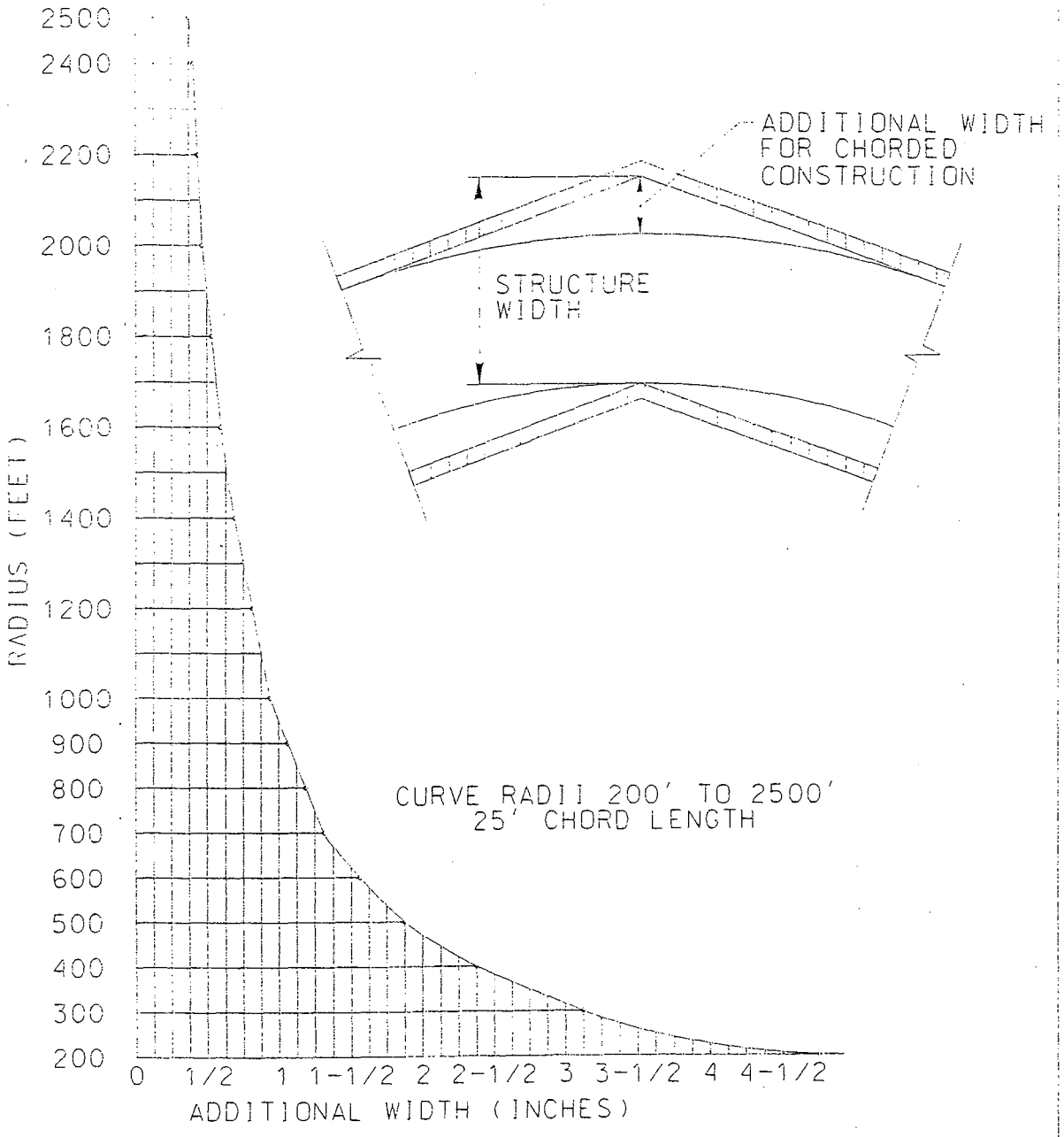
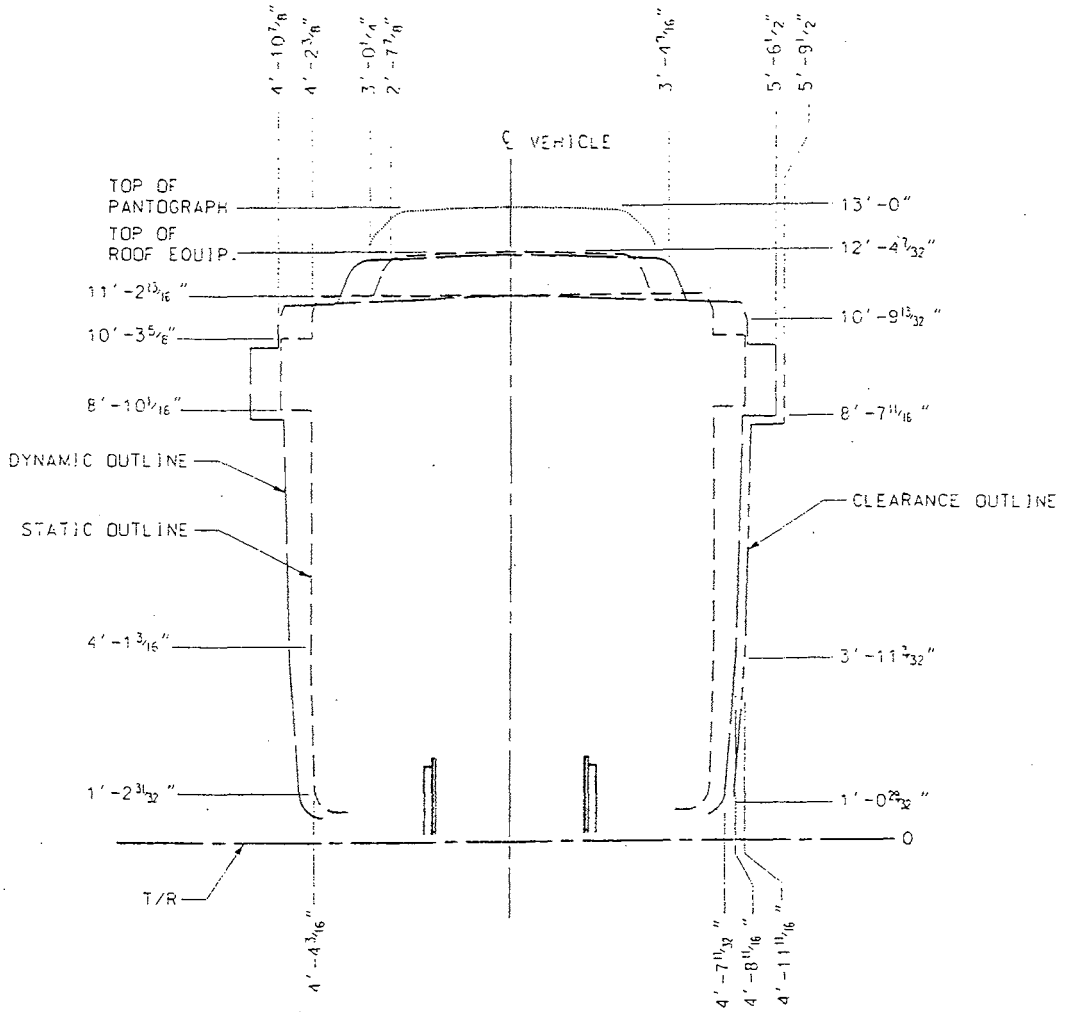


RTD

DESIGN CRITERIA

TITLE: ADDITIONAL WIDTH FOR CHORDED CONSTRUCTION

FIGURE: 4.5



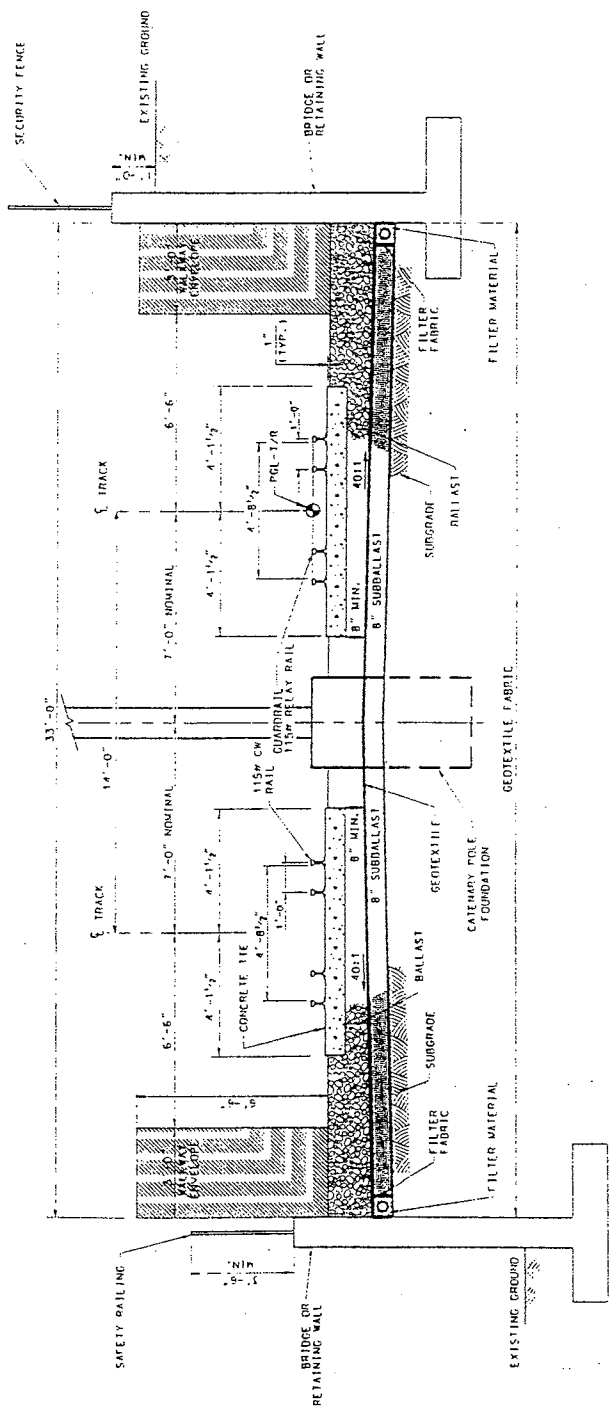
NOTE: CLEARANCE OUTLINE = DYNAMIC OUTLINE + 2" (SAFETY ZONE) + 1" (WHEEL/TRACK WEAR)

RTD

DESIGN CRITERIA

TITLE: LRV DYNAMIC ENVELOPE

FIGURE: 4.6



RTD

DESIGN CRITERIA

TITLE: TYPICAL RETAINED TRACK – TANGENT

FIGURE: 4.10