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SECTION 3 - CIVIL ENGINEERING

3.1.0 GENERAL

The Design Criteria establish the minimum standards to be used in the design of RTD's LRT system.

The criteria presented herein were developed considering safety, accepted engineering practices, passenger comfort, ride quality and protection for the LRT system.

3.2.0 CONTROL SURVEY

3.2.1 Horizontal Control

The Horizontal Control for all alignments shall be coordinated with and approved by RTD. All projects shall use a "Project Coordinate Base" for field stationing. Minimum accuracy of survey work based on the control network shall be one part in 20,000 for linear measurements and 5 seconds per transit station for angular measurements. Legal descriptions of transit right-of-way (ROW) shall be tied into the established property lines of adjacent properties and on established section monumentation. The coordinate system will be approved by RTD at the beginning of the project.

3.2.2 Vertical Control

The Vertical Control for all projects shall be based on the North American Vertical Datum of 1988 (NAVD 88).

Where proposed work is to be in a certain relationship to an existing structure or facility, elevations of the existing structure or facility shall be established by field survey and tied to existing benchmarks.

The error of closure in feet for establishment of vertical elevations shall not exceed $0.05\sqrt{M}$, where M is the distance in miles.

3.3.0 CLEARANCES

3.3.1 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 (LRV) 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 Design Criteria seek to make that balance.

3.3.2 Public Utilities Commission (PUC) Approvals for LRT Crossings

The construction, operation and maintenance of the LRT, as it crosses at, above, or below any "public highway" (which term shall be interpreted to include pedestrian walkways, bicycle paths, equestrian trails, and roadways for motor vehicles, as well as overcrossings and undercrossings of the same), are subject to approval by the PUC pursuant to Section 40-4-106, Colorado Revised Statutes (C.R.S.). In order to expedite the issuance of such approval a General Concept Application shall be prepared of those anticipated LRT/public highway crossings and submitted to the PUC for approval. LRT crossing analysis for PUC approval shall include but not limited to the following:

- Gated crossings
- Track signalization implementation and supporting data
- Cross-sections
- Warning devices
- Submittal chain
- Traffic study/analysis

In addition the General Concept Application shall include but not be limited to the following:

- Plan Drawing showing the public crossing of the LRT alignment
- Property owners and their legal addresses on all four corners affected by the public/LRT crossing
- An elevation drawing showing the proposed horizontal and vertical clearances of the LRT envelope with the public crossing for both at-grade and grade-separated crossings, which includes, but is not limited to, street crossings, cross sections and clearance envelopes.
- If the crossing includes any structures, details of the type of structure shall be included in both the plan view and elevation views

3.3.3 Clearance Envelope

See Section 4 - Trackwork, General Track Alignment and Clearances.

3.4.0 STREET DESIGN

3.4.1 General, Horizontal & Vertical Geometry and Public Streets

Unless otherwise specified, all road and street design including horizontal and vertical geometry and public street roadway sections, shall be in accordance with the current specifications and design guidelines of the involved local jurisdictions (or CDOT in the case of State Highways). For those cases where the local jurisdictions have no design guidelines, the most current versions of the Colorado Department of Transportation (CDOT) Design Guide and/or the Policy on Geometric Design of Highways and Streets by the American Association of State Highway and Transportation Officials (AASHTO) shall be used.

3.4.2 Clearance to LRT Facilities

Where the LRT corridor is located adjacent and parallel to roadway facilities, then the standards presented in the System Safety and System Security Sections 14.7, 14.8 and 14.9 of this Design Criteria shall apply.

Clearance height shall be in accordance with RR, CDOT and local jurisdictional requirements.

3.4.3 Signs, Bollards and Markers

Where ROW permits, signs, bollards and markers shall conform to the clearance requirements listed in Section 4. Breakaway units shall be used where the installation is in a location exposed to traffic, except where the purpose is protection of passengers (e.g., at platform ends).

3.4.4 Pavement

All pavements in public streets shall be in conformance with the current specifications and practices of the involved local jurisdictions (or CDOT in the case of State Highways). In a case where the local jurisdictions have no codes or standards, the CDOT Pavement Design Manual or the Metropolitan Government Pavement Engineers Council (MGPEC) criteria shall be followed. Pavement on RTD owned property shall be in conformance with the standards and specifications presented in the RTD Design Guidelines and Criteria for Bus Transit Facilities.

3.4.5 Traffic Signals

3.4.5.1 Codes and Standards

All relocations, temporary or permanent, and restoration of traffic signal facilities shall be in accordance with the practices of the involved local jurisdictions (or CDOT in the case of State Highways). In the case where the local jurisdictions have no

standards, the Manual on Uniform Traffic Control Devices (MUTCD), as modified by the State of Colorado, shall be followed.

3.4.5.2 New and Existing Signal Installations

New traffic signal installations shall provide for all required auto and pedestrian movements in addition to signal preemption that may be required for LRVs. All existing signals shall be modified to accommodate any revisions to auto and pedestrian movements and signal preemption for LRVs where required. All revisions shall be compatible with the involved local jurisdiction's traffic signal control program (or CDOT in the case of State Highways).

3.4.6 Signs and Striping

All signs and striping in public streets shall be in conformance with the current specifications and practices of the involved local jurisdictions. In a case where the local jurisdictions have no standards, the MUTCD, as modified by the State of Colorado, shall be followed.

3.4.7 Curb Ramps and Curb Cuts

The Design Engineer shall obtain approval from the local jurisdiction or proper authority for the geometry and locations of curb cuts.

The design of curb cuts and curb ramps shall be in strict accordance with the applicable provisions of the Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG).

Curb cuts are to be included when curbs in public space are constructed or restored as part of the LRT Project.

Walkway, highblock and structural access ramps shall not exceed 4.75%.

3.4.8 Roadway/LRT At-Grade Crossings

The Design Engineer shall coordinate with the local jurisdiction and with the Colorado PUC during the design of at-grade roadway crossings.

3.5.0 DRAINAGE

3.5.1 General

This section provides standards for the design of drainage facilities associated with the LRT infrastructure and systems impacted by development of new LRT systems. Drainage facilities may include storm sewer, cross-culverts, detention ponds, water quality ponds and open channels that may serve the LRT, adjacent properties or may be a part of a regional drainage system.

The purpose of drainage facilities associated with LRT and the goal of the LRT drainage Design Engineer is to protect the LRT infrastructure, protect public safety, and to protect other public and private property from damage caused by flooding. All signal, OCS equipment, TES equipment and communication equipment shall be protected from major storm events. Such protection shall be provided in accordance with locally and regionally accepted engineering standards and practices, as modified for LRT by the standards presented in this Design Criteria Manual.

Facilities shall be designed according to the criteria of the agency in whose jurisdiction each project or section of project is located. For work located within or adjacent to CDOT ROW, CDOT standards as specified in the CDOT Drainage Design Manual shall be followed. If local jurisdictions do not have applicable criteria or standards, the designer shall use the design standards and technical criteria presented in the Urban Drainage and Flood Control District's Urban Storm Drainage Criteria Manual (UDFCD USDCM) Volumes 1, 2 and 3, and the CDOT Drainage Design Manual. Facilities shall be designed in cooperation with local jurisdictions.

3.5.2 Hydrologic Criteria

Unless otherwise noted, hydrologic criteria used in design of LRT facilities shall be in accordance with the Urban Drainage and Flood Control District's Urban Storm Drainage Criteria Manual (UDFCD USDCM).

3.5.2.1 Minor and Major Storm Drainage Facilities

The minor storm drainage system transports runoff from minor frequency storm events with minimum disruption to the urban environment. The minor storm may be conveyed in curb and gutter, ditches and storm sewer. The 5-year event shall be the minor design storm for LRT facilities.

The major storm drainage system shall be designed to convey runoff from the 100-year frequency storm event to minimize health and life hazards, damage to structures and interruption of services.

LRT and appurtenant facilities shall be designed for both recurrence intervals with the following criteria:

- LRT drainage facilities shall be designed to protect the LRT system, all parts of LRT trackway and LRT stations from flooding due to the major storm. LRT trackway and station platforms shall not be located in a 100-year floodplain, and conveyance systems adjacent to LRT trackway shall be designed so that the ballast shall not be inundated during a 100-year event. The LRT trackway (including paved and

ballasted sections) shall not be used for conveyance of stormwater. Where located within roadways, LRT trackway drainage shall be coordinated with the roadway drainage system.

- For facilities appurtenant to the LRT, including roadways and parking lots, the minor storm drainage system shall be designed for the 5-year recurrence interval storm. The major storm system shall be designed for the 100-year recurrence interval storm. Park-n-Ride facilities are addressed in the RTD Design Guidelines and Criteria for Bus Transit Facilities.

3.5.2.2 Runoff

Design peak runoff rates shall be determined using methods specified by the criteria of the local jurisdiction. If a method is not specified by the local jurisdiction, the Rational Method or the Colorado Urban Hydrograph Procedure (CUHP) and Storm Water Management Model (SWMM) as presented in the USDCM shall be used, as applicable.

3.5.2.3 Federal Emergency Management Association (FEMA) Regulatory Floodplains

Facilities that cross or are adjacent to a FEMA-regulated flood zone shall use FEMA jurisdictional flows in facility design. Facilities shall be designed in accordance with the floodplain ordinance of the local drainage authority. The design shall include preparation of the documentation required for submittal of CLOMR application, and preparation of LOMR documents, if required.

3.5.3 Hydraulic Criteria

All storm sewer, hydraulic structures and appurtenances shall be designed in accordance with the design standards and technical criteria of the local jurisdiction, as modified in this section.

Drainage design shall consider areas adjacent to the tracks where elements such as streets, parking facilities, roads, landscaping, walls, etc. may have an impact on the drainage of the trackway area.

Special attention shall be directed to providing drainage in all track areas. Ditches, grated inlets, curb and gutter, storm sewers and/or underdrains shall be provided along the track alignment to prevent water from ponding or covering any part of the track structure, or contributing to subgrade instability. Trackside ditches shall be provided wherever possible. Minimum ditch grades shall be 0.3%.

3.5.3.1 Design Storms

Facilities shall be designed for the design storm frequencies discussed in Section 3.5.2.

3.5.3.2 Replacement of Existing Facilities

Necessary replacement of existing storm drainage facilities shall, at a minimum, provide services equivalent to the existing facilities. New facilities shall be designed in accordance with the current design standards of the jurisdictional authority. Services to adjoining properties shall be maintained at all times during construction.

3.5.3.3 LRT Trackway

Standard trackway drainage is shown in Figure 3-1 and 3-2. Ditches shall be located parallel to the trackway to convey trackway drainage and to intercept runoff entering the ROW.

Stormwater runoff from off-site areas shall be intercepted and conveyed out of the ROW in ditches and storm sewer, and shall not be conveyed in trackway underdrains.

The design hydraulic grade line (HGL) in ditches adjacent to the trackway for the 100-year event shall not be above the top of subgrade during the peak 100-year runoff.

3.5.3.4 Storm Sewer

All storm sewer or culverts crossing under the LRT ROW shall be constructed with Class V Reinforced Concrete Pipe (RCP). The minimum pipe diameter shall be 15 inches.

Plastic and metal pipe shall not be used without RTD approval. Variances shall be based, in part, upon the ability of the material to withstand light rail loading and to resist corrosion due to stray current.

Storm sewer constructed outside of the LRT trackway shall be constructed with Class III or better RCP.

Storm sewer shall be placed with a minimum clearance of 5 feet from top of rail to top of pipe unless otherwise approved by RTD. The 100-year energy grade line (EGL) in the storm sewer system shall be below the top of subgrade. The Design Engineer shall include EGLs/HGLs on all storm sewer and ditch profiles.

Cross-culverts under the LRT trackway shall have a maximum headwater to depth ratio of 1.5. The EGL in cross-culverts shall be below the top of subgrade for all areas adjacent to the trackway.

Any structures that vary from agency standards, including manholes, junction boxes, inlets, vaults or other structures shall be subject to acceptance by RTD for maintenance. For storm sewer construction through contaminated subsurface materials, consideration shall be given to pipe design features, such as a pipe lining system, to eliminate infiltration of contaminated groundwater into the storm pipe.

Storm drainage facilities for the LRT shall be designed for an expected functional life of 50 years as a minimum.

3.5.3.5 Inlets

Inlet boxes and grates within the LRT trackway shall be designed for LRT loading. Inlets shall not be placed in paved trackway adjacent to station platforms. Flangeway drains or trench drains shall not be used within paved trackway unless approved by RTD.

Inlet grates located within the LRT trackway shall be designed to prevent ballast rock from passing into the storm sewer system. Inlets located directly adjacent to the trackway shall be designed with a ballast retaining wall between the inlet and the track, or shall be constructed with ballast-proof grates.

Inlet grates in pedestrian areas shall be heel-proof and non-slip. Bicycle-safe grates are required where bicycle traffic will occur.

Inlets shall be located in sumps rather than on grade wherever possible. Inlets shall be located at the low points of the profile. The design 100-year ponding depth over inlets in parking areas, driveways and roadways shall not exceed 9 inches.

3.5.3.6 Underdrains

Where ROW constraints do not allow use of the standard ditch section, underdrains may be used. Underdrains shall be sized based on a hydraulic analysis of local drainage. Underdrains shall consist of perforated concrete or perforated plastic pipe. Underdrain pipes shall be a minimum of 6 inches in diameter for lengths less than 500 feet, and a minimum of 8 inches in diameter for lengths greater or equal to 500 feet. The perforated pipe shall be surrounded by a minimum 4 inches of crushed rock or gravel drainage material. The underdrain systems shall be wrapped with

a filter fabric (minimum weight 4 ounces per square yard) by placing the fabric between the gravel drain material and the subgrade. Underdrain depth and cover shall be in accordance with RTD Standard Drawings. Underdrain clean outs, pipes and culverts shall be designed and located to facilitate maintenance and to reduce the possibility of becoming clogged. The distance between cleanouts shall not exceed 200 feet or as required by local code. See Figure 3-1.

The designer shall check the HGL of the system where the underdrain outfalls to confirm that the 100-year HGL of the downstream system will not allow the introduction of stormwater into the trackway subgrade through the underdrain system. Flap gates shall not be used in underdrain systems.

Underdrain systems constructed for the purpose of intercepting groundwater shall not be connected to the storm sewer system unless approved by RTD.

3.5.3.7 Station Platforms

The designer shall minimize the amount of offsite runoff entering trackway in station areas and avoid placing inlets within station platforms. Inlets that are located within platform areas shall be constructed for HS-20 loading and shall be installed with pedestrian friendly, heel-proof grates.

3.5.3.8 Park-n-Rides

See the RTD Design Guidelines and Criteria for Bus Transit Facilities for Park-n-ride drainage design criteria.

3.5.3.9 Rail Embankment Edge Treatment

Underdrains shall be provided adjacent to track in areas where more than 50 feet of trackbed width contributes runoff to a fill slope. Concentrated flow from underdrains and storm sewer shall be conveyed down the slope in pipe or rundowns to prevent erosion of the embankment.

3.5.4 Bridges/Structures

3.5.4.1 Retaining Walls

Retaining wall drainage shall be coordinated with the retaining wall structural designer. Concentrated flows shall not be allowed to discharge behind any retaining wall. Such flows shall be intercepted and conveyed down to grade before reaching the wall.

Underdrains shall be provided adjacent to track supported on MSE walls.

3.5.4.2 Bridges

Bridge deck drainage shall be in accordance with the criteria presented in the CDOT Bridge Design Manual, Subsection 16.1, and the FHWA publication HEC-21, Design of Bridge Deck Drainage.

Drainage of elevated LRT bridges from the deck down to the local system shall be conveyed to an approved point of discharge, which may include storm sewer, ditch, roadway, channels or other approved conveyance system.

Bridge deck drainage systems for LRT bridges are required to meet the following criteria:

- The flow across expansion joints in a 5-year event shall not exceed 0.2 cfs. Where track is directly fixed to the bridge deck surface, the depth of bridge deck surface flow in a 100-year event shall not exceed the elevation of the bottom of the rail at any location on the bridge deck surface. All gutter flow at both ends of bridges shall be intercepted in a 100-year event. Storm water flowing toward or leaving the bridge shall be intercepted prior to the approach slab.

All deck drain inlets shall be grated. Inlets shall be sized to intercept the design storm runoff and allow no bypass. The drainage system shall be compatible with the structural reinforcement components and aesthetics of the bridge. Outfalls shall be positioned to avoid corrosion of structural members, erosion of embankments, and splash on moving traffic (vehicular, train, and sidewalk) areas below the bridge. Downspouts shall be galvanized steel pipe 10-inch minimum diameter for bridge drains and shall meet the requirements of ASTM A53; they shall be standard weight (Sch. 40). Downspout pipe shall be hot dipped galvanized after fabrication. Galvanizing shall meet the requirements of AASHTO M111. Gray iron castings shall conform to the requirements of AASHTO M105, class 30. Ductile iron castings shall conform to the requirements of ASTM A536. Grade shall be optional unless otherwise designated. Structural steel shall conform to the requirements of AASHTO M183. Cleanouts shall be provided for downspout systems in a manner as to provide access to all parts of the deck drainage system.

The Design Engineer shall consider the use of trench drains at the ends of all direct-fixation bridges. The use of trench drains at the

ends of direct-fixation bridges shall be evaluated on a case by case basis and approved by RTD.

All drainage components located in the trackbed and on grade separation structures (i.e. bridges, tunnels, cut and cover structures, etc.) shall be designed and installed following the guidelines pertaining to stray current stated in this Design Criteria.

Bridge deck drainage shall be intercepted and conveyed to ground in downspout systems. Wherever possible, bridge deck drainage systems shall discharge directly to existing drainage systems, rather that discharging directly onto the ground surface.

3.5.4.3 Bridges over Drainageways

Bridge abutments and piers located within the floodplain shall be designed to withstand scour during a 100-year storm event. The potential for scour shall be evaluated in accordance with the FHWA publications HEC-18 and 21.

Bridges and structures across FEMA regulated floodplains shall be designed so that impacts to the floodplain are within allowable limits in accordance with the criteria of FEMA and the local floodplain ordinance. Bridges and structures across floodways that are not FEMA regulated shall be designed so that the improvements shall not adversely impact upstream or downstream properties.

3.5.5 Detention Facilities

Detention facilities shall be provided in accordance with local criteria. If the local jurisdiction does not have detention facility design criteria, the UDFCD USDCM criteria shall be used. Underground detention shall not be used unless approved by RTD in writing. If the LRT facilities are located within an area served by regional detention facilities, detention shall be provided under the terms associated with those facilities.

3.5.6 Water Quality

Structural water quality facilities shall be provided for stations to meet the requirements of the local jurisdiction. Water quality facilities shall be combined with stormwater detention facilities, unless required otherwise by the appropriate jurisdiction, and shall be designed with consideration for aesthetics and ease of long-term maintenance. Underground facilities (such as water quality vaults and inlets) shall not be used unless approved by RTD.

3.5.7 Pump Stations

The use of pumping stations shall not be permitted unless approved by RTD, and shall be used only where storm water removal by other means is not feasible. Pump stations shall be designed to protect LRT facilities in accordance with the criteria presented in Section 3.5.2 of this Design Criteria. The FHWA publication Highway Stormwater Pump Station Design (Hydraulic Engineering Circular 24) shall be used for pump station design. The extent of the 100-year storm shall be determined and safeguards against flooding shall be provided.

A storage reservoir shall be incorporated with the pump station design. The maximum water level in storage shall be more than 2 feet below the lowest grate elevation in the tributary system. The configuration shall provide for screening out debris and a minimum of 3 pumps. Pump equipment and controls shall be explosion proof, corrosion resistant and appropriate for the application. Backup systems for power, control and pumping shall be provided.

The design shall include access for ordinary maintenance, including provisions for replacing pumps. The pump house shall have locked doors, fence and gate for security and an adequate ventilation system. The design shall eliminate the need for confined space entry as defined by OSHA and NIOSH where possible. The site layout shall address mitigation of aesthetics and noise. The installed equipment shall be certified and tested prior to acceptance. Operation and maintenance manuals for the facility shall be provided by the Contractor.

Pump station equipment shall be connected to RTD's SCADA system.

3.5.8 Erosion Control

A Stormwater Management Plan (SWMP) for erosion control Best Management Practices (BMP) during construction is required for all projects. If the local jurisdiction does not require prepared plans, SWMPs will be the responsibility of the LRT construction Contractor.

SWMPs will be prepared in accordance with the standards and criteria of the local jurisdiction and with the State of Colorado Department of Public Health and Environment (CDPHE) requirements. The LRT construction Contractor shall be responsible for obtaining local permits and coverage under the CDPHE Stormwater General Permit for Construction Activities.

All erosion control activities shall comply with the conditions of RTD's Light Rail Corridor Stormwater Management Program.

3.5.9 Easements

All storm sewers crossing the LRT ROW that serve upstream properties shall become the ownership of the local jurisdiction. Where such storm sewer facilities are located outside of public ROW, license agreements shall be prepared for the conduit crossing.

The Design Engineer shall identify any temporary or permanent easements required to construct and maintain storm water drainage facilities. The Design Engineer shall coordinate easements with RTD's Property Management Division.

3.5.10 Permits

404 Permit - Acquisition of an individual or nationwide permit required for construction of the LRT corridor and appurtenant facilities shall be the responsibility of the Design Engineer, unless otherwise excluded in the Contract Requirements.

Erosion Control Permits - The Design Engineer shall prepare materials as necessary for inclusion of the LRT corridor in RTD's Municipal Separate Storm Sewer permit. Acquisition of state and local stormwater discharge permits required for construction shall be the responsibility of the construction Contractor, unless otherwise specified in the Contract Requirements.

3.6.0 UTILITIES

3.6.1 General

This section establishes design standards for the relocation, adjustment, and abandonment of existing utilities, and the construction of new utilities, within the LRT ROW. In general, such work will be designed by the utility owners. Some utilities, such as water and sanitary sewer utilities required for new LRT construction will be designed by RTD's Design Engineer in coordination with the utility owner. Water service shall be provided to the station platforms. Consideration shall be given to the need to provide electrical power to the traction power substations. No new or existing utilities shall be located within the trackway or within the limits of track pavement, except for the purpose of crossing the tracks. The utility design engineer shall provide corrosion protection in the design and construction of new utilities that cross the LRT trackway. Refer to Section 10 - Stray Current/Corrosion Control for design criteria.

3.6.2 General Design Guidelines

The following general design guidelines shall be followed for all utility work.

- Depth of cover under the LRT envelope shall be a minimum of 5 feet from the top of rail to the top of all utilities (top of encasements, if encased), unless otherwise approved by RTD.
- Utilities encountered or located close enough to be affected by transit construction shall be:
    - Protected in place;
    - Temporarily relocated; or
    - Permanently relocated
- Maintain utility service continuity to abutting property or subject said property to the least interruption practicable. Utility relocations shall be designed to provide service equal to that offered by the existing facility. No betterments shall be included, unless approved by RTD.
- All pressurized pipelines crossing the LRT and pipes carrying flammable or volatile substances shall be encased. The length of the casing pipe shall extend across the width of the ROW. Casing pipes shall be designed to withstand LRT loadings, and shall be coated with a suitable material to provide cathodic protection. See Figure 3.3 for LRT loadings. See Figures 6.1 through 6.6 for typical cross-sections and Figure 6.7 for the zone of influence. The Design Engineer shall coordinate with RTD's Utility Engineer for casing pipe specifications.
- No encasements are required for pipelines greater than 10' below LRT track ties.
- All crossing utilities shall cross beneath the LRT ROW at 90˚ to the LRT centerline unless approved by RTD. Manholes, valves, and other utility-related appurtenances requiring periodic maintenance or operation should not be placed within the LRT ROW. Such features shall be relocated outside of a zone 10 feet either side of centerline of track during new LRT construction.
- All new or relocated utilities shall be placed so that the edge of excavation is no less than 10 feet to the centerline of track. See Figures 6.1 through 6.6 for typical cross-sections and Figure 6.7 for the zone of influence.
- All non-metallic buried utilities shall have detection aids or tone wires within LRT ROW for field-locating buried pipes.
- All abandoned pipes beneath the trackbed shall be plugged and filled with flow-fill or other suitable material approved by RTD.
- All relocation, restoration and construction of utility improvements shall be in conformance with the current standards and specifications of the responsible local and state jurisdiction or utility agency and shall comply with other applicable codes.
- All utility work shall be coordinated through RTD with the appropriate city, county or utility agency.

- Utilities located over the LRT ROW will not be allowed unless specifically requested and approved by RTD. Design of approved utilities located over LRT ROW shall be approved in writing by RTD.

During new LRT construction, all water service lines that cross the LRT ROW shall be placed in a sleeve with a minimum diameter 2 inches larger than the service line. Sleeves shall be constructed without vertical or horizontal bends or curves, shall be capable of withstanding LRT loading, and shall be constructed to allow for future replacement of the service line within the sleeve.

During new LRT construction, utility agencies may elect to encase utilities crossing the LRT ROW that may otherwise not require encasement. Pursuant to license agreements and easements, such construction shall be done at the expense of the affected agency, as required, and shall conform to these criteria. Each end of the encasement shall terminate outside the LRT ROW and shall have sufficient additional length that future excavation of either end of the encasement will not extend into LRT ROW.

3.6.3 Coordination

RTD will coordinate design of installation of new or the relocation of existing utilities between RTD and all impacted utility agencies. Utilities designed by the utility agency will be submitted to RTD for review and approval. Generally, a design review and utility coordination process will be as follows:

1. A preliminary drawing of the utility owner's preferred new or relocation alignments and requirements will be prepared by the utility owner and submitted to RTD for review.
2. RTD will review the utility design requirements and preferred alignment and issue a draft composite utility map showing proposed utility alignments and orientations from various utility agencies.
3. Each utility will respond to RTD with either acceptance of proposed alignments and orientations or submittal of a request for further alteration.
4. RTD will issue a final composite utility plan showing utility orientations. The final design of each utility will then be developed on this basis by the utility owner.

Utilities designed by RTD will be submitted to the utility agency for approval and coordination. Construction plans for utility relocations will be approved by the utility agency that owns the affected utility.

3.6.4 License Agreements and Easements

The placement of any utility within RTD owned ROW requires an Easement, Permit or License Agreement for that utility from RTD, depending upon the

circumstances. Easements, Permits and License Agreements are issued through RTD's Property Management Division. Each Easement, Permit or License Agreement shall require the grantee to provide RTD as-built drawings in CADD format for the utility and grantee emergency contact information. As-built drawings shall be in conformance with RTD's CADD Standards.

The replacement or modification of an existing utility shall be considered a new utility installation, and the utility owner shall conform to the standards and criteria for new utilities as presented in this Design Criteria. The Easement, Permit or License Agreement must be renewed per above.

3.6.5 Relocation of Utilities

In the event RTD's construction requires the relocation of a utility located within RTD's ROW, the relocation will be evaluated on an individual, case by case basis considering at a minimum the following factors:

- the right by which the utility is located in RTD ROW prior to construction;
- the ability of RTD to provide an alternate location within RTD ROW;
- the responsibility of who performs actual relocation; and
- who pays for the relocation.

3.6.6 LRT Utilities

3.6.6.1 Codes and Standards

All utilities specifically designed for the LRT shall conform to the standards, codes, and requirements of the local jurisdiction within which the LRT utilities are located.

3.6.6.2 General Design Guidelines

Final design of the LRT utilities shall be done by RTD's Design Engineer. Design approvals from the local jurisdictions and public utility agencies shall be coordinated through RTD.

The design of the LRT utilities shall conform to the appropriate design guidelines indicated in Sections 3.6.1 through 3.6.6 of these criteria.

3.7.0 CONCRETE

For reinforced concrete, precast concrete, and prestressed concrete structures other than structures subjected to LRT, railroad or highway loading, the "Building Code Requirements for Reinforced Concrete (ACI 318)", hereinafter referred to as the ACI Code, shall be followed.

For mildly reinforced concrete structures, the "Building Code Requirements for Structural Concrete (ACI 318)" shall be followed.

Portland Cement Concrete Pavement shall conform to the requirements for Class P concrete as specified in Section 601 of CDOT – Standard Specifications for Road and Bridge Construction.

3.8.0 STRUCTURAL STEEL

For structural steel structures other than structures subjected to LRT, railroad or highway loading, the Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings of the American Institute of Steel Construction, hereinafter referred to as the AISC Code, shall be followed.

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FIGURE 3.1 .....TYPICAL UNDERDRAIN

FIGURE 3.2 .....TYPICAL DITCH

FIGURE 3.3 .....LRV LOADING DIAGRAM

FIGURE 3.4 .....LOADING GROUPS

DESIGN CRITERIA

RTD

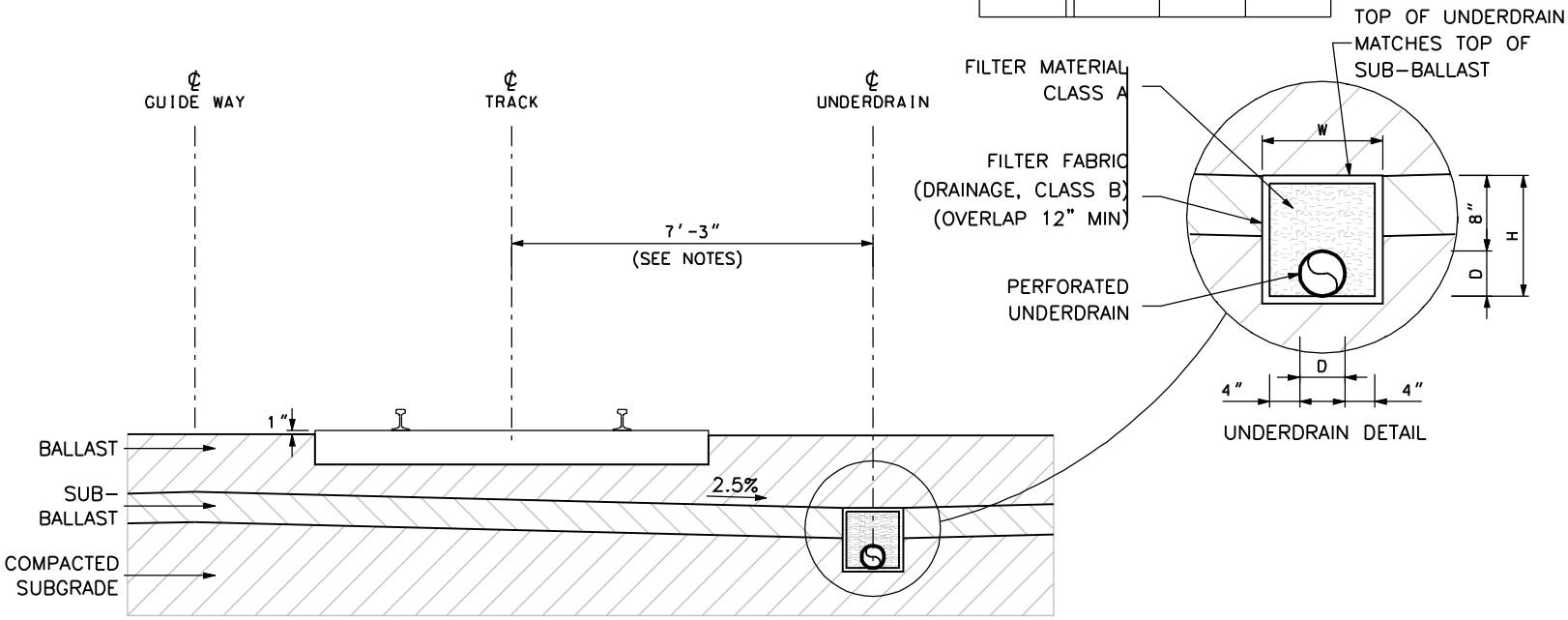
TITLE: TYPICAL UNDERDRAIN

FIGURE: 3.1

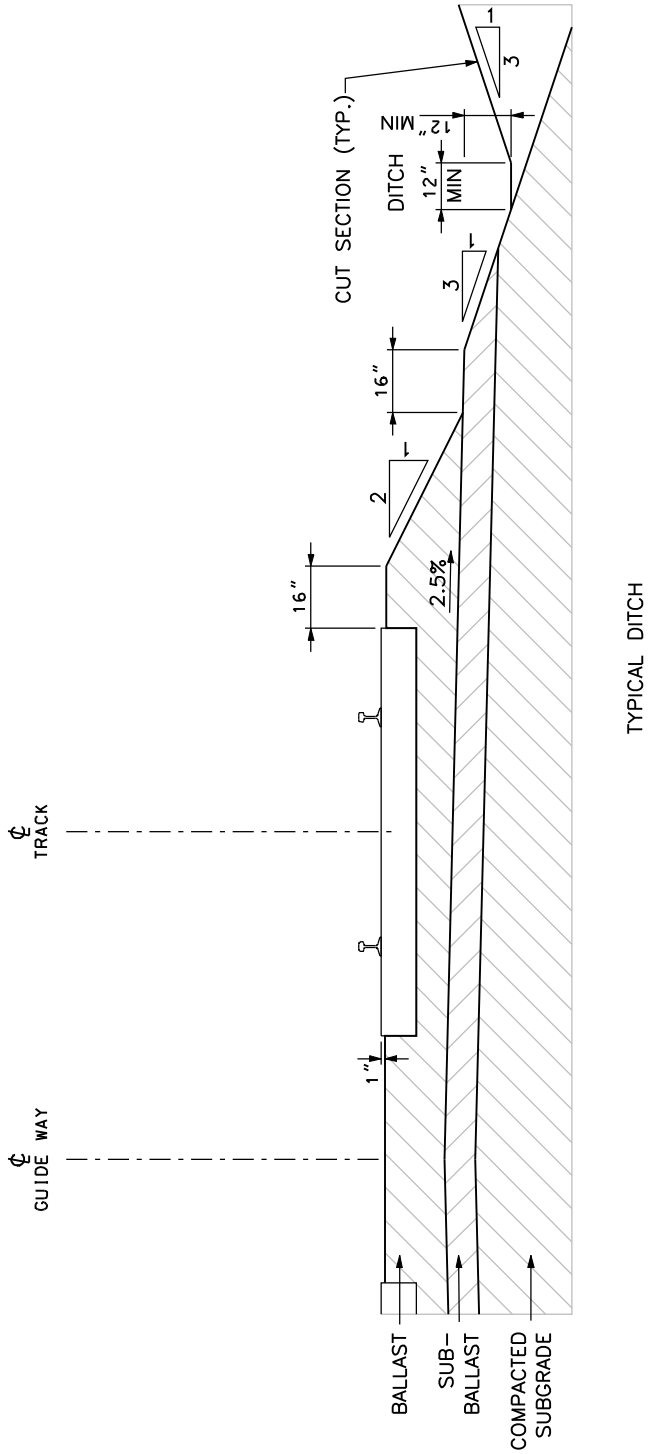
NOTES:

1. SUB-BALLAST TO SLOPE TOWARD SIDE DRAIN AT 2.5%
2. FOR UNDERDRAIN IN MSE FILL SECTIONS, SEE MSE DETAIL SHEETS.
3. DESIGNER MUST CALCULATE Y IF DISTANCE IS DIFFERENT THAN 7'-3"

UNDERDRAIN TABLE			
PIPE SIZE D	6"	8"	10"
W	1.17'	1.33'	1.5'
H	1.17'	1.33'	1.5'
Y	3.37'	3.53'	3.70'



TYPICAL UNDERDRAIN



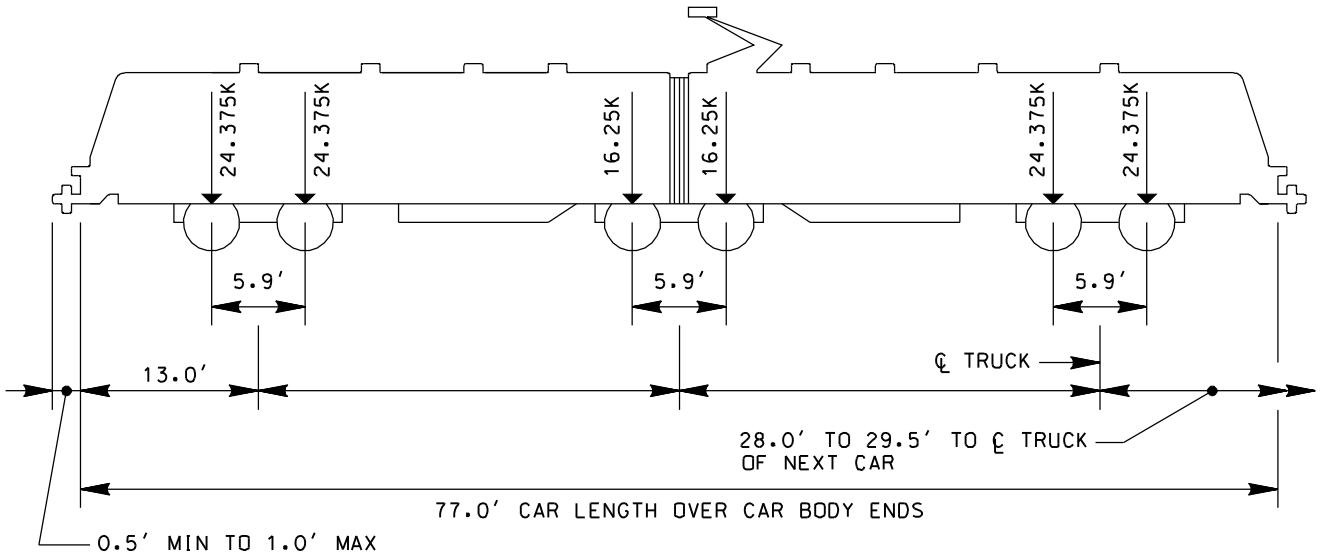
TYPICAL DITCH

RTD

DESIGN CRITERIA

TITLE: TYPICAL DITCH

FIGURE: 3.2



NOTE:

1. TOTAL CRUSH LOAD 130 KIPS/CAR
2. MAXIMUM LOADING WILL OCCUR WHEN (2) THREE-CAR TRAINS PASS EACH OTHER ON ADJACENT TRACKS

RTD

DESIGN CRITERIA	TITLE: LRV LOADING DIAGRAM
	FIGURE: 3.3

GROUP	GAMMA FACTOR	BETA FACTORS																	
		D	(L+I)				(L)RT	CF	E	B	SF	W	WL	NF	LF	PS	R+S+T	EQ	ICE
			H	P	RT	DR													
1H	1.30	D	1.67	0	1	0	0	1	E	1	1	0	0	0	0	0.77	0	0	0
1PC	1.30	D	0	1	1	0	0	1	E	1	1	0	0	0	0	0.77	0	0	0
1PW	1.30	D	1	1.15	1	0	0	1	E	1	1	0	0	0	0	0.77	0	0	0
1RT	1.30	D	0	0	1	0	0	0	E	1	1	0	0	1	0	0.77	0	0	0
II	1.30	D	0	0	0	0	0	0	E	1	1	1	0	0	0	0.77	0	0	0
III	1.30	D	1	0	1	0	0	1	E	1	1	1.3	1	1	1	0.77	0	0	0
IV	1.30	D	1	0	1	0	0	1	E	1	1	0	0	0	0	0.77	1	0	0
V	1.25	D	0	0	1	0	0	0	E	1	1	1	0	0	0	0.80	1	0	0
VI	1.25	D	1	0	1	0	0	1	E	1	1	1.3	1	1	1	0.80	1	0	0
VII	1.00	1.0	0	0	0	0	0	0	E	1	1	0	0	0	0	1.00	0	1	0
VIII	1.30	D	1	0	1	0	0	1	E	1	1	0	0	0	0	0.77	0	0	1
IX	1.20	D	0	0	0	0	0	0	E	1	1	1	0	0	0	0.83	0	0	1
X	1.30	D	1.67	0	1	0	0	0	E	0	0	0	0	0	0	0.77	0	0	0
XI	1.30	D	0	0	0	1	1	1	E	1	1	0	0	0	0	0.77	0	0	0

RTD

DESIGN CRITERIA

TITLE: LOADING GROUPS

FIGURE: 3.4