SYSTEM DESIGN CRITERIA

COLORADO FRONT RANGE PASSENGER RAIL SYSTEM

VERSION 0.1 – MARCH 2022

0. CONTENTS

0.1 AUTHORITY

These FRPR System Design Criteria and Engineering Standards present general guidelines and specific criteria to be used in the planning, design, and construction of passenger rail corridors for the Front Range Passenger Rail system. These System Design Criteria comply with safety and security requirements and are compatible with the intended future systems that FRPR will construct. The Engineering Standards reference and require the use of the most current accepted industry practices and applicable codes.

These Design Criteria and Engineering Standards are as adopted by the Board of Directors of the Front Range Passenger Rail District, pursuant to C.R.S. 32-22-106.

This manual establishes guidelines, criteria, and standards to be used in the planning, design, and construction process. Any deviation from these accepted criteria must be approved by FRPR Engineering as specified herein. Coordination with local agencies and jurisdictions is required to determine and approve fire protection, life safety and security measures that will be implemented as part of the planning, design, and construction of the FRPR system. Conflicting information or directives within the criteria set forth in this Manual shall be brought to the attention of FRPR and will be addressed and resolved between FRPR and the local agencies and/or jurisdictions.

This initial version of the FRPR Design Criteria was published in summer of 2021. This version represents the first version of the Criteria, and any updates or modifications to the Criteria shall take precedence over previous versions or sections.

Version No.	**Date of Revision**	**Revision By:**	**Change Summary**
0.0	06/01/2021	Enright, Chris	Original Document
0.1	03/07/2022	Enright, Chris	Traction power chapter, added more detail throughout

Approved by:

1. GENERAL

1.1 PURPOSE

The Design Criteria (this document) establishes uniform and minimum standards for the planning, design, construction and maintenance of the Front Range Passenger Rail system and its facilities. This document is developed using industry best practices and standards from commuter and Class 1 railroads, with the intent to meet or exceed all regulatory requirements both from the State and Federal levels.

The Design Criteria is intended to cover the majority of FRPR's current and future design and construction needs. Subsequent major projects (such as system electrification) shall develop their own standards and criteria. Other local transit and rail agencies exist in parallel with the FRPR system, and integration (as possible) is intended with these agencies, to maximize the potential for the transit systems of the greater Front Range.

1.2 PROJECT GOALS

As established by Colorado Senate Bill 21-238, the purpose of the Front Range Passenger Rail District is to research, develop, construct, operate, and maintain an interconnected passenger rail system within the front range that is competitive in terms of travel time for comparable trips with other modes of surface transportation. (CRS 32-22-103 (2)).

Vision: Developing passenger rail that serves Front Range communities from Fort Collins to Pueblo is a critical component of Colorado's future. FRPR will provide a safe, efficient, and reliable transportation option for travel between major population centers and destinations along the Front Range and create a backbone for connecting and expanding rail and transit options in the state and region.

The project would provide sustainable and reliable travel options to meet the growing needs of the state, supporting multiple transportation, economic, and environmental goals.

The Front Range Passenger Rail team is committed to a transparent and fully collaborative approach with the public, interest groups, and local jurisdictions. This effort is aimed at moving Front Range Passenger Rail from vision to implementation in support of sustainable, alternative mobility options for the growing Front Range.

1.3 DESIGN CRITERIA OVERVIEW

This document stands alongside with the Standard Drawings to collectively form the Engineering Standards of the Front Range Passenger Rail system. These are intended to be supplemented with more specific guidance and design standards in areas such as structures, shoring, and drafting/detailing as the project advances.

Design is to be directed toward minimum feasible costs for design, construction, capital facilities and operation, minimum energy consumption and minimum disruption of local businesses and communities. It should be consistent with system reliability, passenger comfort, mode of operation, type of rolling stock to be used and maintained. Safety for passengers, workers and the public is of primary importance.

1.3.1 ORDER OF PRECEDENCE

In the event of conflict between the Design Criteria, Standard Drawings, and regulations or industry standards, the most stringent requirements shall take precedence. In questions of generalized design where no specific regulation or industry standard applies, engineering judgement shall be applied, with the rationale and conflict presented to FRPR engineering leadership for approval.

Specific attention should be given to the Americans with Disabilities Act (ADA), the ADA Accessibility Guidelines for Building and Facilities (ADAAG), the ADA Accessibility Guidelines for Transportation Vehicles and to any succeeding modifications that may be issued. The applicability of those documents is noted in several sections of this manual where it appears to be particularly appropriate. However, the regulations must be adhered to in all areas, whether or not mentioned herein

1.3.2 DESIGN CODES AND MANUALS

In addition to this Design Criteria, the Engineer must comply with all other applicable engineering codes and standards, including those of the various Federal, State, and local jurisdictions.

If codes and/or manuals are specified herein for the design of an element of the FRPR system, then the most recent edition(s) shall be used. Responsibility for design remains with the Engineer in accordance with the terms and conditions of their contract with FRPR.

Where design codes conflict with each other, the Engineer shall notify FRPR in writing and recommend a solution. The Design Engineer shall also investigate those codes and manuals that have precedence.

Specific codes and standards include, but are not limited to, the following (latest editions):

- Americans with Disabilities Act
- Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)
- Americans with Disabilities Act Accessibility Guidelines for Transportation Vehicles
- Colorado Department of Transportation (CDOT) - Standard Specifications for Road and Bridge Construction
- CDOT M & S Standard Plans
- CDOT Roadway Design Guide
- FHWA Manual on Uniform Traffic Control Devices (MUTCD)

- Colorado Public Utilities Commission (PUC) Rules and Regulations
- International Fire Code
- International Building Code
- National Fire Protection Association (NFPA) Standard 130
- NFPA Standard 101
- American Association of State Highway and Transportation Officials (AASHTO) - Standard Specifications for Highway Bridges
- AASHTO - Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals
- Regional Transportation District (RTD) Commuter Rail Design Criteria Manual
- National Railroad Passenger Corporation (Amtrak) Design Standards
- Union Pacific Railroad (UPRR) Design Standards
- BNSF Railway Design Standards

1.3.3 DESIGN STANDARD CLASSIFICATIONS

Recommended – Standard to be equaled or exceeded where there are no major physical, cost or schedule constraints. Designers should use 'Recommended' values to the extent practical.

Minimum/Maximum – Represent limits. Designers shall make every effort to avoid the use of minimum/maximum values. These values are acceptable where constraints make the use of 'Recommended' values impracticable.

Shall - Indicates mandatory requirement that must be strictly implemented. Waiver is permissible only under approval of design variance.

Should – Indicates preferred course of action. Design variance is not required if it is not exercised.

May - Indicates permissible course of action within the limits of the standards. Design variance is not required if it is not exercised.

It shall be noted that variances or deviations are not for convenience. They shall be very rare, and only as a last resort after exhaustive analysis. Designers and other project personnel should not request a variance based on precedence. To request a variance, designers shall prepare written justifications documenting the rationale and potential impacts of the variance. If approved, the variance shall only be valid for the specific location included in the request for a variance. Variances shall not be used to justify a future variance request. Any design variances shall never be less than regulatory standard, and shall not introduce unacceptable safety risks or diminish the function of the system.

1.3.4 ROLE AND RESPONSIBILITY OF THE DESIGNER

The Criteria contained in this document and in the Standard Plans is intended to provide the designer with flexibility while ensuring that the functionality, goals, and objectives of the FRPR system are met. The Design Criteria shall be used in conjunction with sound engineering judgement, experience, and industry best practices. The Engineering Standards in no way replace the individual designer's adherence to their professional standard of care in system design and development.

Design and construction drawings shall be produced under the responsible charge of a Professional Engineer licensed to practice in the state of Colorado who is appropriately qualified in civil infrastructure design. Final drawings issued for construction or permit review or contracts with outside organizations shall bear the seal and signature of the engineer in responsible charge, pursuant to the rules promulgated by the Colorado Architecture and Engineering Board for sealing. Drawings bound in a set (digitally or physically) may use seals on a title page only as allowed by Board Rules.

1.4 BASIS OF DESIGN

The Colorado Front Range Passenger Rail (FRPR) System is a diesel-electric (or dual mode), steel wheel on steel rail system with standard gauge tracks that shall meet the following physical and functional requirements.

The principal objectives of this design are:

A. Safe, reliable, and cost-effective passenger service
B. Use existing rail corridors to ease implementation and design
C. Use existing, commercial off-the-shelf or minimally custom components, including infrastructure and rolling stock elements
D. Build operational infrastructure that can later be upgraded to higher speed or traction modes.

1.4.1 INFRASTRUCTURE

The long term intended infrastructure of the FRPR system consist of:

- Dual-track mainline, with sidings to serve secondary stations
- Minimum at-grade crossings of roadways, with quiet zones in populated areas.
- Independent capacity, operating with minimized interaction between freight or other commuter and light rail systems

1.4.2 DESIGN SPEED

A design speed of 110 MPH or greater shall be used where cost effective, and conditions allow. As of 2022, maximum passenger rail speed on BNSF tracks is 90 mph. A design speed of 125 MPH is permitted when greater than 150 feet away from freight main tracks; per standard drawing D-04. When allowed, the design shall allow for a cruising speed of 90 MPH, with an absolute minimum of 65 MPH when not within yard limits or approaching primary stations.

1.4.3 PROVEN HARDWARE

The system shall be designed using subsystems consisting of proven equipment and design concepts. Subsystems and spare parts are to have a documented operating history of previous and current usage and be available off the shelf, so far as practical. The same requirements shall apply to spare parts. Waiver of these requirements shall be considered only where the alternative subsystem offers substantial technical and cost advantages, is in an advanced stage of development, and has accumulated substantial test data under near-revenue conditions.

Designs and specifications shall be prepared in such a way as to encourage competitive bidding by established manufacturers of transportation equipment. Industry guidelines from recognized and established organizations such as the AREMA, partner railroads, Amtrak, RTD and Colorado Department of Transportation shall be used.

1.4.4 CONCEPT OF FUTURE EVOLUTION

This operational system is intended as the first step of an evolving system, and design at this stage should be reflective of a potential future improvement of the system. Designers should make choices with the intention of the system being upgraded and evolving in the future, particularly focusing on potential electrification, speed increases, or secondary station addition.

1.4.5 ROLLING STOCK AND TRACTION

The FRPR system is designed to use conventional, commercial off-the-shelf rolling stock (or as close as is technically possible with rolling stock).

Rolling stock shall be capable of serving both level (51 inches ATOR) *and* low (8 inches ATOR) platforms, preferably at the same doorways. Rolling stock shall meet FRA Tier 1 requirements for passenger equipment operating in concert with freight systems and at speeds up to 125 MPH.

The rolling stock intended in the first stage of implementation is diesel-electric locomotives, functioning in push-pull configuration with non-powered control unit or cab car, and two or more passenger coaches midtrain. For train performance calculations in ridership estimation, refer to the appropriate memorandum or other documents as relevant. Dual-mode propulsion technologies are preferred, to allow for electric operation in areas with traction power available overhead. Refer to Section 6. Traction Power for additional details.

This rolling stock will presumably be upgraded as the corridor is improved and technology matures in US implementation, and as the corridor and system is built out to ultimate configuration, would be an electric fixed trainset.

1.4.6 CLIMATIC CONDITIONS FOR SYSTEM DESIGN

The Denver metropolitan area, within which FRPR operates, is situated at the foot of the eastern slope of the Rocky Mountains in central Colorado. The area has a semiarid climate that is somewhat characteristic of the High Plains but is modified by the Rocky Mountains to the west. Because of this, Denver lies in a belt where there is a rapid change in climate from the foothills to the plains. This change is largely caused by the increase in elevation as you travel west to the foothills. Denver has an elevation of 5,280 feet.

The average annual temperature is about 50°F at this elevation, though this varies a few degrees as elevation changes. The wide average range in daily temperature of 25° to 30°F in the Denver metropolitan area and a wide average range in annual temperature are typical for the High Plains. Variations in temperature are wide from day to day; extremely hot weather in summer and extremely cold weather in the winter normally do not last long and are followed by much more moderate temperatures.

System equipment including vehicles, signal system and fare collection/validation equipment along with trackwork, stations and other civil features shall be capable of maintaining operation within the following conditions:

Table 1-1: Climatic Conditions

Ambient Temperature	-30°F - +110°F
Relative Humidity	8 – 100%
Maximum Rainfall in 24 Hours	1.88 inches
Maximum Snowfall in 24 Hours	10.1 inches
Maximum Wind Speed	54 MPH
Average Elevation	5,280 feet AMSL

Data for long periods indicate that the average annual precipitation ranges from 13.5 to 14.5 inches, with the highest precipitation occurring at the western edge of the metropolitan area. Particularly in summer and spring, precipitation may vary from year to year and in different areas in the same year. Precipitation in the winter is more in the western part of the Denver metropolitan area than it is in other parts. These differences are small but consistent from October to May. The annual snowfall is about 59 inches. The eastern part of the metropolitan area, however, usually receives more rainfall in summer than the west, but local rainfall varies widely from year to year. The relative humidity averages 39% during the day and 62% at night, but these averages are slightly higher in winter than in summer. In an average year, the percentage of sunshine is about 69%.

Hailstorms cause some local damage almost every year. The hail usually falls in strips 1-mile-wide and 6 miles long. These storms are more common in the eastern part of the Denver metropolitan area than the western part and they generally occur from about May 15 to September 1 but are most common in June and July.

Requirements for climatic conditions defined in other sections of these Design Criteria take precedence.

1.5 CORRIDOR CONVENTION

Northbound and southbound are defined relative to compass directions for the originating and destination terminal stations, i.e., a train from Denver to Fort Collins is northbound.

Tracks are referenced by number. The track toward the bottom of the drawing is the northbound track and is numbered Track 1. The track toward the top of the drawing is southbound, and numbered Track 2, with additional track numbers proceeding in this manner.

Stationing starts from the southernmost and westernmost point of a given alignment, increasing toward the north and east (like Cartesian coordinates). Stationing shall reset to 0+00 at each division boundary, and station equations at division boundaries shall be clearly annotated and signed on the wayside.

1.6 REFERENCE CRITERIA AND EXAMPLES USED

This document references the following design criteria and engineering standards:

Peninsula Corridor Joint Powers Board – Caltrain: *Design Criteria*, Second Ed. September 30, 2011.

Utah Transit Authority: *Commuter Rail Design Criteria.* Revision 3, March 2015

California High-Speed Rail Authority, Request for Proposals for Design-Build Services for Construction Package 4: *Book III, Part A.1: Design Criteria Manual*, Revision 3, February 2016

Engineering Division, Regional Transportation District: *RTD Commuter Rail Design Criteria*. Revision 01, April 2009.

American Railway Engineering and Maintenance-of-Way Association. *Manual for Railway Engineering*. 2019

2. DESIGN GUIDELINES

2.1 PLANNING AND DESIGN INTEGRATION

For successful implementation and operation of the Front Range Rail system, especially in the early design stages, designers must partner with the planning teams to develop a good understanding of the future needs of the system, and the key design parameters that has an impact on both design and operation of the system over time.

In the planning phase, inputs from operations planning are essential. Inputs may include:

1. Capacity (present and future)
2. Electrification (partial or full)
3. Performance improvements possible with infrastructure changes
4. Train levels of service
5. Safe and timely interchange of passengers between local and regional transportation modes.

It is imperative that during the design phase, construction phasing or staging is considered in the design so that project impact on rail operations is minimized.

2.2 DESIGN LIFE

The FRPR system's structures, such as bridges, tunnels or culverts shall be designed for a minimum functional life of 75 years. Other fixed facilities (track structure, buildings) shall be designed for continuous operation over a minimum of 50 years before complete refurbishment and renovations are needed due to wear. Signaling systems shall have a design life of 25 years, with signal computer equipment having a design life of 10 years. Train control communication systems shall have a design life of 20 years.

Where possible, functional life and capacity of the system shall be designed to match a design life of a project element or be sufficiently scalable to accommodate future expansion.

2.3 CLEARANCES

FRPR System shall use a nominal horizontal clearance of 9 feet (per Standard Drawing D-03). Minimum structure vertical clearance shall be 23'-6", with greater clearance required for overhead utility crossings.

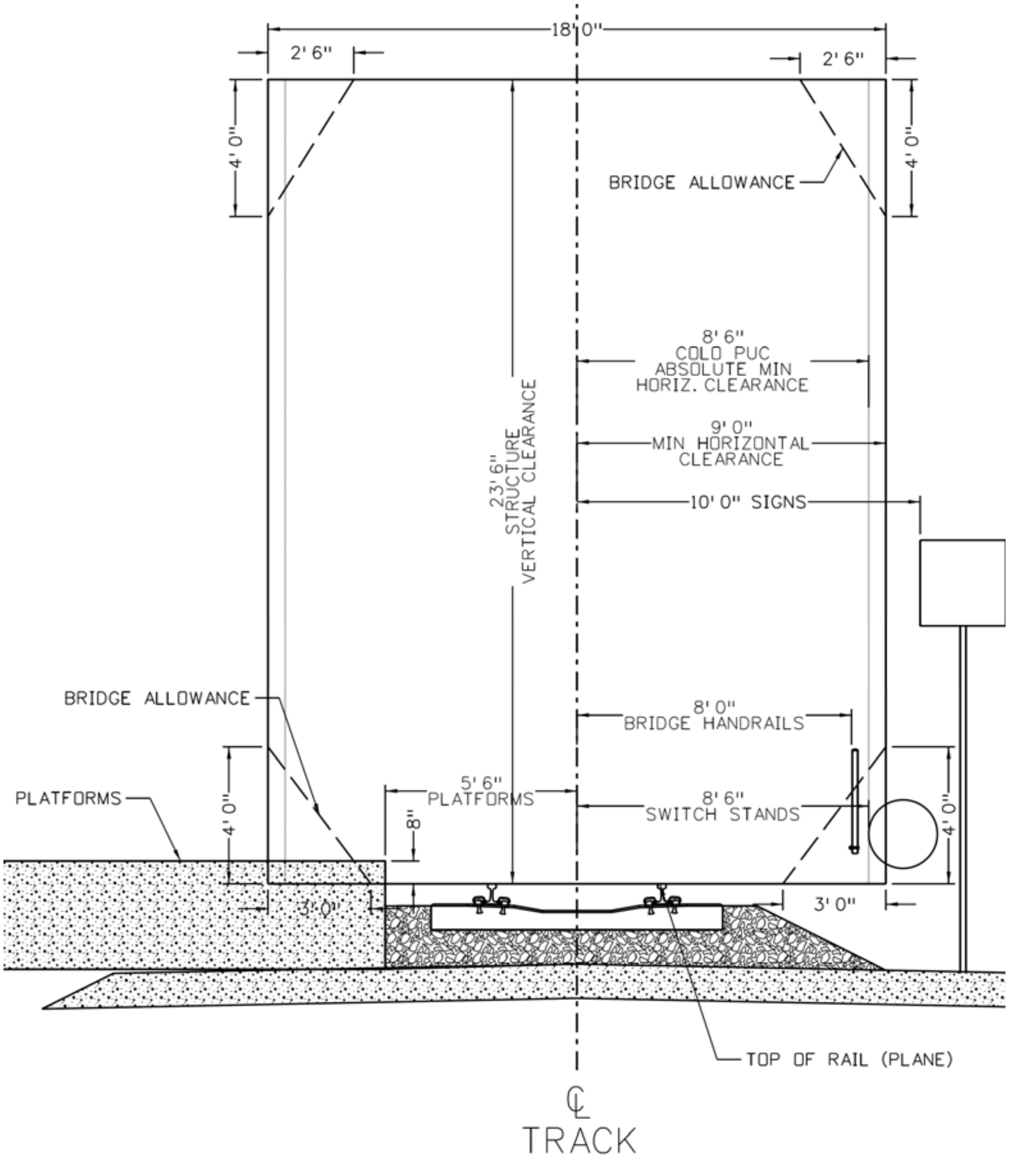

Figure 1: Clearance Diagram. Ref. Std Dwg D-03

2.4 SYSTEM SAFETY AND SECURITY

Reserved.

3. TRACK

3.1 GENERAL

The primary considerations of track design are safety, economy, ease of maintenance, ride comfort, and constructability. Factors that affect the track system such as safety, ride comfort, design speed, noise and vibration, and other factors, such as constructability, maintainability, reliability, and track component standardization which have major impacts to capital and maintenance costs, must be recognized and implemented in the early phase of planning and design. It shall be the objective and responsibility of the designer to design a functional track system that meets FRPR's current and future needs with a high degree of reliability, minimal maintenance requirements, and construction of which with minimal impact to normal revenue operations.

3.1.1 TOLERANCES AND CLASS OF TRACK

Track construction and maintenance tolerance shall be within FRA Class 7 as prescribed by 49 CFR Part 213. Deviation to Class 5 may be permitted at the discretion of FRPR Engineering only as track condition and design speeds allow.

3.2 TRACK STRUCTURE

3.2.1 TRACK GAUGE

The FRPR system shall use Standard Gauge, defined as 4'-8.5" between heads of rails.

3.2.2 TYPICAL SECTION

Typical track section shall consist of two parallel (or concentrically curving) tracks with spacing defined in Section 3.3.2.1 General Alignment and Configuration of Track. The typical section of each track shall consist of two rails, spaced at standard gauge, atop concrete ties, ballast, subballast and a compacted grade. Typical section over structures and through tunnels may omit ballast and subballast as appropriate, instead using low vibration ballastless track; reference Section 3.2.11: Ballastless Track.

Typical sections and standards are provided in Standard Drawing D-02.

Total mainline corridor width for purposes of Right-of-Way planning shall be 75 feet, widening to 100 feet in anticipated areas of special trackwork or stations.

3.2.3 EXCAVATION AND SUBGRADE

The Contractor shall load, haul, spread, place and compact suitable materials in embankments and shall finish the embankments to the grade, slope and alignment as shown in the plans. Suitable materials shall consist of mineral soils free from organics, debris, and frozen materials. Embankment slopes shall be compacted and dressed to provide a uniform and dense slope. Embankments shall be built with approved materials from excavation of cuts or from borrow unless otherwise shown on the plans.

If materials unsuitable for embankments (organics, debris, brush, and trees, etc.) are encountered within the areas to be excavated, or material existing below the designated subgrade in cuts or within areas on which embankments are to be placed are of such nature that stability of the roadbed will be impaired, such material shall be removed and wasted or stockpiled for other use. Topsoil removed from embankment areas shall be spread uniformly over the embankment slopes.

Unsuitable material removed from embankment foundations or below subgrade elevation in excavation areas shall be replaced to grade with suitable material compacted as specified for embankments in these specifications.

Wherever an embankment is to be placed on or against an existing slope steeper than four horizontal to one vertical (4:1), such slope shall be cut into steps as the construction of the new embankment progresses. Such steps shall each have a horizontal dimension of not less than three feet and a vertical rise of one foot.

At all times, the Contractor shall operate sufficient equipment to compact the embankment at the rate at which it is being placed. Compaction shall be accomplished by sheep's foot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Use construction procedures and drainage design that will provide a stable roadbed.

Each layer in embankments made up primarily of materials other than rock shall not exceed 6" in loose depth and shall be compacted to the dry density as specified hereinafter before additional layers are placed.

The subgrade 14 feet both sides of track centerline shall be compacted to at least 95% of maximum dry density, and not more than +4 percent above optimum moisture content as determined by the current revision of ASTM Specification, D1557, Modified Proctor. If laboratory results indicate that existing material is unsuitable (insufficient bearing capacity, poor drainage characteristics, etc.) the material must be removed and replaced with clean, sound and properly compacted material, per ASTM standards.

The compacted subgrade shall be sloped at 2.0% downward and away from the center point located midway between the two tracks in double track territory. In single track areas, the compacted subgrade shall slope away from the centerline at 2.0%.

3.2.4 SUBBALLAST

Subballast is the transition zone between the subgrade and the ballast. The subballast acts as a barrier filter separating the ballast section from the subgrade material and plays an integral role in the track structure. The quality of the subballast has a direct relationship to the overall performance of the track structure. This layer acts as a drainage medium for the track bed.

Subballast shall conform to the requirements for Class 6 Aggregate Base Course, as dictated by CDOT Standard Specification 703.03.

Subballast shall be placed in two six-inch lifts to achieve a minimum depth of 12 inches. When vibratory or other approved types of special compacting equipment are used, the compacted depth of a single layer may be increased to 8 inches upon request, provided that specified density is achieved, and written approval is given.

Compaction of each layer shall continue until a density of at least 95 percent of the maximum density has been achieved as determined in accordance with AASHTO T 180 as modified by CP 23. The moisture content shall be at ± 2 percent of optimum moisture content. The surface of each layer shall be maintained during the compaction operations so that a uniform texture is produced, and the aggregates are firmly keyed. Moisture conditioning shall be performed uniformly during compaction.

The surface of the base course will be tested with a 10-foot straightedge, or other approved device. The surface shall be tested prior to the application of any ballast or construction of track structure. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall not exceed ¼ inch.

3.2.5 BALLAST

No. 4 (1-1/2 inches to 3/4 inches) ballast conforming to AREMA specifications shall be used on all main tracks except for those in streets and yards, where No. 5 (1 inch to 3/8 inch) ballast shall be used. All ballast is to be thoroughly washed prior to placement. Minimum ballast depth shall be 12.0 inches, at a maximum of 18 inches depth.

3.2.6 GEOTEXTILE FABRICS

Reserved.

3.2.7 TIES

New mainline track shall use concrete crossties, approximately 8'-6" on length and 8 ¾" x 11" in cross section. Ties shall be spaced 24 inches center-to-center, reduced to 20 inches in curves with a degree of curvature less than 5°30".

Hardwood timber ties in compliance with freight railroad standards may be used or retained in shared corridors.

Ties through special trackwork may be timber, concrete, or steel. Reference Standard Drawing D-05 – Turnouts, and Section 3.4 - Special Trackwork.

3.2.8 RAIL

The standard rail section shall be 141RE. Rail shall be continuously welded on mainline tracks, with jointed rail only permitted on nonrevenue low speed trackage.

Heat-treated or alloy rails shall be used in all special trackwork and on all curves with Dc=5°30' or greater and extending into the spiral until the point of degree of curve on spiral exceeds Dc=5°30'. Heat-treated or alloy rails are not required to be installed on seldom used emergency or storage tracks, even though they may satisfy the above criteria. Heat-treated or alloy rails may be used, with FRPR approval, in other locations where excessive rail wear is anticipated.

3.2.9 EMERGENCY GUARD RAIL

Emergency guard rails shall be used as a safety measure to capture the inside of the wheel in the event of a derailment and keep the trainset on or near the track. Gard rail shall be installed adjacent to the inside running rail on all tracks on bridges, track on a fill with a vertical drop greater than three feet, and otherwise as directed by FRPR Engineering at critical points. Guard rails shall extend for the length of the structure and for 50 feet on the inbound direction and 10 feet on the outbound. Guard rail shall not be installed through special trackwork.

Guard rails shall be designed to retain the wheels of a derailed vehicle moving at the design speed of the track. The striking face of the rail shall be uniformly located approximately 1 foot from the gauge line of the running rail. Guard rail shall be fastened to every second tie in ballasted track.

3.2.10 RAIL SEATS AND FASTENING

Concrete and wooden cross ties shall use spring clips isolated from the tie using plastic insulators and placed on an insulating pad.

Rail anchors may be required or retained on existing timber tie freight alignments near tight curves and or at grade road crossings. Rail anchors placement shall follow the design criteria of the freight railroad.

Rail fasteners for use in direct fixation special trackwork shall be of a design compatible with the standard fastener used in conventional direct fixation track.

Rail clips or other devices used in direct fixation fasteners shall produce the required longitudinal rail restraint after repeated load testing in accordance with AREMA Chapter 10, except load application angle in that test shall be 27 degrees.

3.2.11 BALLASTLESS TRACK

Ballastless track designs may be required in tunnels, bridges, or other structural applications. Designs shall be reviewed by FRPR Engineering prior to acceptance in overall design.

Ballastless track (including direct fixation) rail fasteners shall provide the required lateral and longitudinal restraint for continuous welded rail and the electrical insulation required for the negative return current and the proper operation of 60 Hz track signal circuits. Ballastless track fasteners or concrete ties shall provide a 40:1 cant of the rail.

Ballastless track fasteners shall incorporate, or be placed on, a suitable elastomeric pad for reducing transmission of high frequency (i.e., greater than 30 Hz) loads to the support structure.

Engineered transition zones shall be placed at the transition between ballastless and ballasted track sections to mitigate undesirable effect from the change in track modulus.

3.2.12 RAIL WELDING AND JOINTS

Rail shall be welded into Continuous Welded Rail (CWR) strings of site-specific length by the electric flash-butt or aluminothermic welding processes in accordance with AREMA specifications. The ends of welded rail strings shall be field welded together by thermite welding or flash-butt welding according to AREMA specifications.

Insulated and standard rail joints shall be placed only at locations where required to accommodate track signal circuits and connections to special trackwork. The insulated joints for signal operations shall be prefabricated and welded onto ends of CWR. Insulated plugs shall be trimmed to 14 feet. Kits may be used with approval of FRPR Engineering.

3.2.13 RAIL AND SWITCH HEATERS

Switch heaters shall be installed at all power operated turnouts on both mainline and yard tracks. In areas with commercial electrical service, electric switch heaters should be used. For areas without electrical service, designers should consider propane switch heaters.

3.2.14 YARD TRACK

Yard track shall conform to the same standards as mainline track with the following exceptions:

3.2.14.1 SUBBALLAST

Subballast placement may be omitted when no geotechnical need is present.

3.2.14.2 BALLAST

Number 5 ballast conforming to AREMA specifications shall be used on yard tracks.

A minimum depth of 12 inches of ballast shall be used between the bottom of tie and top of subgrade. The top of ballast elevation shall be at least 1 inch below the base of rail and the ballast shoulder shall extend level 1 foot 6 inches to the field side, beyond the ends of the ties to form a suitable walking surface. Crushed slag ballast will not be permitted.

3.2.14.3 TIES

Yard tracks shall use timber cross ties, spaced at 24 inches center-to-center, except at braced and guarded track, where spacing shall be 22 inches center-to-center. Ties shall be 9 feet in length, 7 inches by 9 inches in cross section, and in conformance with AREMA specifications. Switch ties shall be of the lengths and dimensions required for the selected turnout.

3.2.14.4 RAIL

Yard tracks shall be constructed with 136RE new rail and shall be continuously welded.

3.2.14.5 GUARD RAIL

Emergency guardrail shall be installed where tracks are adjacent to major structures or where a derailment may cause extensive damage to cars or structures.

3.2.14.6 CROSSINGS

At-grade crossings for yard operations may be constructed of asphalt with flangeway liners. Crosswalks may be constructed of asphalt with flangeway liners and may be located in curves.

3.2.14.7 ILLUMINATION

Yards shall be lighted sufficiently to provide adequate working light for 24-hour operations.

3.3 GEOMETRY

The primary goals of geometric criteria for FRPR are to provide a safe, cost effective, efficient, and comfortable ride, while maintaining adequate factors of safety with respect to overall operations, maintenance, and vehicle stability.

The geometric design should strive to balance among the following competing principles:

A. Consideration of overall system safety
B. Optimization of passenger comfort
C. Maximization of speed
D. Effectiveness of implementation costs
E. Ease and efficiency of maintenance

3.3.1 GENERAL GEOMETRIC DESIGN REQUIREMENTS

3.3.1.1 SELECTION OF SPECIFIC DESIGN SPEED

Alignments should be designed to minimize the use of curves and to maximize the potential operating speed of the system.

Table 3-1: System Design Speeds

Recommended Design Speed	110 MPH*	**or greater if conditions permit.* This will maximize future capability of expansion and upgrading to high speed.
Cruising Speed	90 MPH	Target minimum speed to ensure effective system operation
Minimum Mainline Design Speed	65 MPH	Absolute minimum for mainline tracks – will adversely impact system operation
Yard or Station Limits	30 MPH	Or otherwise as determined appropriate for acceleration out of stations or similar.

3.3.1.2 GENERAL GUIDELINES

Designers should consider minimizing the number of horizontal curves to the degree possible by context and other design needs. This is best achieved using longer curves at larger radii in place of a more ‘broken back’ arrangement of sequential curves and tangents in the same general direction.

Vertical curves should as well be minimized, and longer, continuous grades are more easily managed by locomotive engineers. Undulating grades (produced by a desire to balance earthwork) should be avoided. Trains should be only on a single increasing/decreasing grade pair at a time. Vertical design should additionally consider the location of control points and turnouts, factoring in the difficulty in starting on a upgrade or in stopping on a downgrade.

Designs should avoid the placement of a horizontal curve immediately following a significant downgrade on tangent.

Design should not assume helper or distributed power operations for FRPR trains.

Horizontal compound curves may be utilized by designers as appropriate with spiral transition curves as required. Reverse curves should be avoided to the extent possible. See 3.3.2.2 Tangents for minimum tangent length requirements.

3.3.2 HORIZONTAL ALIGNMENT

The horizontal alignment of track consists of a series of tangents joined to circular curves and spiral transition curves as measured along the centerline of track. Track superelevation in curves is used to maximize train operating speeds wherever practicable. In yards and other non-revenue tracks, spiral transition curves are rarely required.

Curvature and superelevation of track alignment are related to design speed and to the acceleration and deceleration characteristics of the rail cars and locomotives for that location. The design criteria for tangent, curve, design speed, superelevation, and spiral transition curve are described in the next few sections.

3.3.2.1 GENERAL ALIGNMENT AND CONFIGURATION OF TRACK

Horizontal alignments for FRPR mainline tracks shall be stationed along track centerlines from south to north and west to east.

3.3.2.1.1 TRACK CENTERS

When possible, double track alignment shall be designed with a constant distance between track centerlines. Segments along straight tracks should be parallel, and curvature should be concentric maintaining a parallel nature at the entry and exit to curves.

Mainline tracks are recommended at 25.0 feet, with a minimum acceptable spacing at 16.5 feet. Absolute minimum spacing (speeds less than 90MPH only) shall not be less than 15.0 feet. Yard or other nonrevenue tracks shall have a minimum spacing of 15.0 feet.

Track centers through curves do not need to be increased if they are greater than 16.5 feet, and if less than 16.5 feet, shall be widened according to:

Equation 3-1: Curve Widening of Track Centers

$$Track\ Centers\ (feet) = 14.7 + \frac{1{,}100}{R\ (feet)}$$

In case of curves under 3,000 feet radius and the inside track is superelevated to a lower extent than the outside track, track centers shall be widened to twice the difference in superelevation (inches).

3.3.2.1.2 CLEARANCE OR FOULING POINT

The clearance (fouling) point shall be located at the point that track centers are less than 14.0 feet as diverging.

3.3.2.2 TANGENTS

Horizontal tangents shall be designed based on the longest rail car length for the rail corridor and ride comfort for the passengers. A formula for tangent length in feet (L=3V) where V is the design speed (MPH) for ride comfort is based on the rail car traveling at least three (3) seconds on tangent track between two curves. Tangent shall extend at least 100 feet beyond both ends of the limits of the station platforms, and of at-grade crossings.

3.3.2.3 HORIZONTAL CURVES

Maximum speeds permitted in curves are governed by 49 CFR §213.57, where

Equation 3-2: Vmax (FRA Speed Limit)

$$V_{\max} = \sqrt{\frac{E_a + E_u}{0.0007D}}$$

Where E_a is the superelevation of the outside rail (inches), E_u is the maximum allowable cant deficiency of the vehicle, and D is the degree of curvature (chord-definition).

Track shall use circular curves with spiral transitions as described in Section 3.3.2.4.

3.3.2.4 SPIRALS

Spirals (transition or easement curves) are defined as transition curves with a constantly decreasing or increasing radius proportional between either a tangent and a curve (simple spiral) or between two curves with different radii (compound/intermediate spiral). More specifically, the spiral is a curve whose degree-of-curve increases directly as the distance along the curve from the point of spiral.

Spirals provide a gradual change of curve and ride comfort from the tangent to full curvature. Spirals are a means of introducing a superelevation at a rate corresponding to the rate of increase in curvature, which permits a gradual increase to full lateral acceleration at a comfortable, and non-destructive rate.

The spiral transition curves shall be provided between circular curves and horizontal tangents. The spiral transition curve shall be the “ten-chord spiral” as defined by the AREMA Manual for Railway engineering or the “clothoid spiral”. Clothoid spirals provide a constant rate of change in curvature between the tangent and the connecting circular curve. Clothoid spirals shall be used on tracks having design speed lower than 110 mph. Clothoid spirals may be used on large radius curves that require small amounts or no superelevation and small unbalanced superelevation.

Spiral transitions may be omitted for curves less than 30 minutes (Radius > 11,459 feet), or when a curve is a part of a turnout (but these curves must have a length greater than 100 feet).

The length of spiral shall be longest as determined from formulas (Recommended Values):

1. $L_s = 1.63\ E_u\ V$ – Unbalance determined
2. $L_s = 1.47\ E_a\ V$ – Superelevation determined
3. $L_s = 90\ E_a$ – Vehicle twist
4. $L_s = \ 2.64\ V$ – Minimum segment

The *minimum* spiral lengths shall be the longest determined from:

A. $L_s = 1.22\ E_u\ V$ – Unbalance determined
B. $L_s = 1.17\ E_a\ V$ – Superelevation determined
C. $L_s = 75\ E_a$ – Vehicle twist
D. $L_s = \ 2.20\ V$ – Minimum segment

Where L_s = Length of spiral, E_a is the superelevation of the outside rail (inches), E_u is the maximum allowable cant deficiency of the vehicle, and V is the design speed (miles/hour)

3.3.2.5 SUPERELEVATION

Superelevation is the height difference in inches between the high (outside) and low (inside) rail. Superelevation is used to counteract, or partially counteract the centrifugal force acting radially outward on a train when it is traveling along the curve. A state of equilibrium is reached when the centrifugal force acting on a train is equal to the counteracting force pulling on a train by gravity along the superelevated plane of the track. The superelevated track results in improved ride quality, and reduced wear on rail and rolling stock.

Actual superelevation shall be accomplished by maintaining the top of the inside (or low) rail at the "top of rail profile" while raising the outside (or high) rail by an amount of the actual superelevation. The inside rail is designated as the "grade rail" (or profile rail) and the outside rail is designated as the "line rail".

Equilibrium superelevation shall be determined by the following equation:

$$e = 0.0007\ D\ V^2$$

Where e = total superelevation (inches), D = degree of curvature (chord definition), V=maximum design speed (miles/hour).

The total superelevation is expressed as:

$$e = E_a + E_u$$

Where E_a is the superelevation of the outside rail (inches), E_u is the maximum allowable cant deficiency of the vehicle.

The actual superelevation shall be rounded to the nearest 1/4 inch. A superelevation of ½ shall be required for all curves. Curves in slower speed track (such as yard or other nonrevenue track), and curves in special trackwork shall not be superelevated. Curves within stations and at-grade crossings should be avoided to the maximum extent practical.

The FRPR system shall be designed with a maximum allowable cant deficiency (maximum unbalance) of **5 inches**.

3.3.3 VERTICAL ALIGNMENT

The vertical alignment shall be defined by the profile grade represented by the top of rail (TOR) elevation of the low rail. This low rail is the grade rail. When TOR profile is given for one track only, the TOR elevations of the other tracks are to be equal to the profile track at points radially and perpendicularly opposite.

Gradients and lengths of vertical curves shall vary accordingly, (slightly), to accommodate the differences in lengths through horizontal curves. All main tracks and sidings shall be designed to the same vertical profile. In multi-track territories where there are more than two tracks, the profile of the outside tracks may be lowered based on the cross slope of the roadbed to minimize the need of increasing ballast depth.

Designers are encouraged to consider vertical alignment design simultaneously with the horizontal alignment. Considering track grade and other vertical features early can create a more efficient and effective design while minimizing redesign or decreases in train performance.

3.3.3.1 GRADES

The maximum continuous main line grade on the FRPR system is 1.25%. Grades of 1.25% to 1.5% shall be permissible for lengths not to exceed 2,500 feet. Grades greater than 1.5% shall be permissible only with engineering review and approval, and grades shall not exceed 2.25% under any circumstance.

Station track shall have a maximum grade of 0.35%, with an absolute maximum of 0.50%. Yard and storage tracks shall have a maximum grade of 0.10%, with an absolute maximum of 0.30%.

3.3.3.2 VERTICAL CURVES

Vertical tangents shall be connected with parabolic vertical curves to transition between differing grades. Length of vertical curves should be rounded up to the nearest 100 feet as practical. The minimum distance between vertical curves shall be 100 feet.

The minimum length of vertical curves shall be determined by:

Equation 3-3: Length of Vertical Curves

$$L_{VC} = \frac{2.15 \times V^2 \times D}{A}$$

Where V=design speed of the curve, D is the absolute value of the difference in grades (decimal feet/feet), and A is the allowable vertical acceleration (ft/sec^2).

Maximum allowable vertical acceleration (A) shall be 0.60 ft/sec^2 (per AREMA §3.6. g).

3.3.3.3 COMPENSATED GRADIENT

Maximum gradient where there are horizontal curves shall be compensated to equate total resistance of a train on a horizontal curve on a gradient to that of a train on a tangent gradient. Gradient compensation is determined using a compensation factor of 0.04%/Dc, as recommended by AREMA Section 3.7.1.

Compensated maximum gradient shall be determined by:

Equation 3-4: Grade Compensation

$$G_c = G - 0.04\, D$$

Where G_c = compensated gradient (percent), D = degree of curve (decimal, chord definition), and G = gradient before compensation.

3.4 SPECIAL TRACKWORK

Special trackwork refers to track components that are used for the convergence, divergence or crossing of track. Special trackwork includes turnouts (switches), crossovers, derails, and crossings.

All special trackwork design should be based on FRPR Standard Drawings, and if no standard exists on AREMA Drawings. Other design standards from Class 1 Railroads in the operating area may be used with approval of FRPR Engineering. Use of substandard or alternative turnout designs and configuration shall be permitted only when no practicable alternative exists and with approval of FRPR Engineering.

3.4.1 TURNOUTS

Turnouts are used for tracks to diverge or converge from one track to another. Turnouts are classified by types and sizes (numerical). Each unit consists of points, frog, straight and curved stock rails, and the mechanical means to move the points (and occasionally frog) into alignment for the direction of movement.

The frog is the component of the turnout or crossing where wheels move from one track to another. Turnout size is denoted by a frog number, which is the arctangent of the frog angle.

3.4.2 CROSSOVERS

Reserved.

3.4.3 DERAILS

Derails are mechanical and/or electrical safety devices intentionally used to derail or divert uncontrolled movement of train, rail vehicles, or on-track equipment away from adjacent or connecting tracks without fouling the tracks. See FRPR Standard Drawings for layouts and details. The designer shall closely coordinate with the signal designer for design and layout requirements.

Derails shall be installed on the connections of lead tracks or yards to the main line if cars are moved or stored on said track. Derails may be needed in other areas at the direction of FRPR Engineering to mitigate risk of errant cars or locomotives causing to injury passengers or personnel or that may damage equipment or infrastructure.

Derails shall be located such that they derail equipment away from the main track. Derails shall be located past the clearance point. Derails shall be connected to the signal system to indicate alignment for movement or derail protection.

Derails with blue flag signals are required to protect workers at service facility areas as per 49 CFR 218.

3.4.4 RAILROAD CROSSINGS

At-grade intersections of tracks where they cross over one another (railroad crossings or diamond crossings) shall require approval from the FRPR Engineering team and shall only be permitted when there is no other economical or feasible option. If installed, crossings may only be located on tangent track at the skew angles recommended by AREMA.

3.5 OTHER TRACK CONSIDERATIONS

3.5.1 MAINTENANCE ACCESS

Access points for maintenance personnel and equipment shall be provided everywhere possible. Areas shall be provided at or near wayside equipment for the parking of maintenance vehicles to prevent infringing on roadway travel lanes or pedestrian areas.

Areas of special trackwork shall be accessible via road (at a minimum) meeting AASHTO SU-40 turning radius criteria. Appropriate turnaround space shall be provided for maintenance vehicles at each turnout pad or other area of special trackwork. Additional maintenance access routes shall be planned for defect detectors or other specialty signal components.

High-rail access points shall be provided at least every 4 miles when possible and if deemed necessary. They shall be located on tangent track and be constructed of grade crossing materials durable enough to withstand maintenance vehicles. Highrail access points shall be adequately secured to prevent unauthorized entry.

Maintenance access points shall be equipped with fire department access keys (Knox™ or similar as approved by the Fire AHJ) or other provisions shall be made for emergency access along the right of way.

4. GRADE CROSSINGS

At-grade crossings are intersections where vehicles, pedestrians, bicycles, and other mobility platforms cross train tracks at the same elevation. At these locations the train always has the right of way. By definition an intersection is an area of potential conflict, i.e., two (2) users cannot occupy the same space at the same time. The term motorized users or motorists, denotes all types of vehicular drivers (automobiles, buses, trucks, motorcycles, etc.). The term non-motorized users or non-motorists refers to all pedestrians, which includes mobility impaired persons, wheelchair occupants, and bicyclists.

The at-grade crossing design consists of three (3) essential elements: safety, accessibility, and functionality. To achieve these, the at-grade crossing requires a clearly defined and readily traversable crossing surface for both the motorist and pedestrian. In addition to the defined crossing surface, the at-grade crossing limits need to be clearly delineated. That is, those areas where a pedestrian or motorist can safely wait for a train to pass, or where a pedestrian or motorist has passed beyond the area of potential conflict must be readily apparent. Additionally, the design of at-grade crossings should make correct, lawful, and safe behavior intuitive for users of all modes.

4.1 POLICY

At-grade crossings shall be permitted in the design and construction, but the number of crossings shall be limited to the greatest degree possible. FRPR intends to implement quiet zones in urban or residential areas.

Intersections of the FRPR system and any State Highway (Interstate, US Highway or State Highway) shall be grade separated. If the State Highway intersection is not classified as a freeway or Interstate, at-grade intersections may be permitted with the approval of FRPR Management and the appropriate CDOT Regional Management Team.

Intersections of roadways classified as arterials by the local municipality or county shall be considered for grade separation. Grade separation may be warranted based on interest of the municipality, traffic volume on the intersected road, and/or other design needs and engineering judgments.

At-grade crossings near residential or urbanized areas (as determined by FRPR Engineering) shall be designed with the intention of quiet zone implementation, as dictated by Section 4.4.

Closure of minor street crossings or private crossings shall be considered when nearby major facilities provide crossings.

4.2 PRINCIPLES

Because design is site specific, each at-grade crossing is unique and complex. Each of the three different types of user groups (trains, vehicles, pedestrians) has distinct characteristics in crossing behavior and limitations. Moreover, among users of the same group these differences vary widely. The system design needs to address the needs and capabilities of each of these user groups.

The underlying principle of at-grade crossing safety is to provide a defined path for safe passage across the tracks in an expeditious and efficient manner. Safety is enhanced by credible warning devices which are appropriate to the different target users.

All the at-grade crossings of public roadways shall be equipped with an active crossing warning system to provide notice that a train is approaching sufficient warning time for the motorist and pedestrian to stop short of the crossing, or if they have already entered the crossing, to safely continue past the area of potential conflict.

All at-grade crossings shall be equipped with an Emergency Notification Sign (I-13), which clearly delineates the emergency contact phone number and crossing number.

At-grade crossings for roadways with sidewalks shall provide an integrated design that factors in the needs of motorized and nonmotorized users. This design for nonmotorized users shall follow ADA and the requirements in the following sections. The design shall be clear of obstructions and provide adequate maneuvering space in a consistent manner for wheelchairs, strollers, and bicycles. If sidewalk is absent, efforts should be made to deter pedestrians from using that crossing.

Any modifications to the existing at-grade crossings, whether rehabilitation or improvement require an integrated effort among the civil, and signal disciplines, as well as roadway traffic signaling.

4.3 GENERAL REQUIREMENTS

4.3.1.1 GEOMETRY

The geometric characteristics of an at-grade crossing directly impact the sight distance for the users. The sight distance is characterized by the horizontal and vertical alignment, transition from track to the roadway, and crossing surface. Vertical curves should be of sufficient length to ensure an adequate view of the crossing.

The grade through the crossing shall follow the track profile and grade. At-grade crossings should not be placed on curved track without advance approval from FRPR Engineering. At grade crossing shall not be placed in areas of special trackwork.

Ideally, the roadway should intersect the tracks at a right angle and with no nearby intersections or driveways. When the right angle is not possible, the skew of the roadway should be reduced as much as possible to facilitate ease of crossing. For the motorists, this layout enhances the view of the crossing and tracks and reduces conflicting vehicular movements from crossroads and driveways. To the extent practical, crossings should not be located on either roadway curves.

Skewed crossings are hazards for pedestrians. They lengthen the crossing, and because of the rail flangeway, increase the hazards to pedestrians, especially people on wheelchairs and strollers, as well as to the visually impaired persons, bicyclists, or persons using other micromobility platforms. Where possible, right-angled crossings for pedestrians should be provided with a local realignment of the sidewalk to mitigate the hazard presented.

4.3.1.2 VISIBILITY

Approaching crossings (within 150 feet), fences other than the center fence at stations higher than four (4) feet, signs not part of the passive traffic control devices, cases, cabinets, or any equipment or structures or other physical sight obstructions which interfere the view of the warning devices should be removed. Vegetation within 150 feet or within the sight triangles (whichever is larger) of crossings should be removed.

4.3.1.3 ILLUMINATION

A well-lighted crossing will assist the motorists, pedestrian, and bicyclists to assess the conditions of the crossings, the crossing warning devices, and roadway conditions.

Designers shall consider the installation of roadway or pedestrian path lighting in urban areas or where expected volumes of traffic are high. Illumination should be considered when roadway geometry makes illumination of the crossing via the headlights of the vehicle inadequate.

4.3.1.4 MATERIALS

Mainline at-grade crossings shall be prefabricated and made of durable, long-lasting materials. Grade crossing panels shall be constructed with due regard to removability for track maintenance, electrical isolation, to non-interference with electrical track circuits or rail fastenings, tire adhesion, and slip resistance for vehicles and pedestrians.

Cross tie type, size and spacing through at-grade crossings shall be in accordance with the grade crossing manufacturer's recommendations. If the grade crossing requires cross ties that differ it type from the mainline track, then transition zones shall be designed to accommodate for the change in track modulus.

4.3.1.5 CROSSING SURFACE

Reserved.

4.4 QUIET ZONE DESIGN REQUIREMENTS

Crossings at locations intended for quiet zone designation shall include the installation of engineered Supplementary Safety Measures (SSMs) as needed to reduce the Quiet Zone Risk Index (QZRI) below the Nationwide Significant Risk Threshold (NSRT).

Designers should consult FRA Part 222 for specific guidance and the regulatory procedures that shall prevail over these design criteria if more stringent or in conflict.

4.4.1.1 SUPPLEMENTARY SAFETY MEASURES (SSM)

The following SSMs are approved for implementation for quiet zone compliant design on the FRPR System. Use of other SSMs shall be only with approval by FRPR Engineering in advance of design progressing. Alternative Safety Measures (ASMs) shall not be used in quiet zone design.

4.4.1.1.1 FOUR-QUADRANT GATES

A four-quadrant gate system consists of two gates in each direction: one at the entrance, and one at the exit. Four-quadrant gates provide a visual indication across the entire roadway that a train is approaching and that drivers should stop; with entrance gates providing visual notification of the approaching train and exit gates providing additional visual notification for preventing drivers from circumnavigating the crossing.

Four-quadrant gates should be supplemented with radar-based presence detection, such that exit gates remain raised if traffic is occupying crossing area.

Four-quadrant gate systems shall conform to the standards for four-quadrant gates contained in the MUTCD and shall comply with the following:

A. When a train is approaching, all highway approach and exit lanes on both sides of the highway-rail crossing must be spanned by gates, thus denying to the highway user the option of circumventing the conventional approach lane gates by switching into the opposing (oncoming) traffic lane to enter the crossing and cross the tracks.
B. Crossing warning systems must be activated by use of constant warning time devices unless existing conditions at the crossing would prevent the proper operation of the constant warning time devices.
C. Crossing warning systems must be equipped with power-out indicators.
D. The gap between the ends of the entrance and exit gates (on the same side of the railroad tracks) when both are in the fully lowered, or down, position must be less than two feet if no median is present. If the highway approach is equipped with a median or a channelization device between the approach and exit lanes, the lowered gates must reach to within one foot of the median or channelization device, measured horizontally across the road from the end of the lowered gate to the median or channelization device or to a point over the edge of the median or channelization device. The gate and the median top or channelization device do not have to be at the same elevation.
E. ‘‘Break-away’’ channelization devices must be frequently monitored to replace broken elements.

Design of four-quadrant gates should consider:

A. Gate timing should be established by a qualified traffic engineer based on site specific determinations. Such determination should consider the need for and timing of a delay in the descent of the exit gates (following descent of the conventional entrance gates). Factors to be considered may include available storage space between the gates that is outside the fouling limits of the track(s) and the possibility that traffic flows may be interrupted because of nearby intersections.

B. Vehicle presence detectors (VPDs) to open or keep open the exit gates until all vehicles are clear of the crossing shall be considered at each crossing. VPD should be installed on one or both sides of the crossing and/or in the surface between the rails closest to the field. Among the factors that should be considered are the presence of intersecting roadways near the crossing, the priority that the traffic crossing the railroad is given at such intersections, the types of traffic control devices at those intersections, and the presence and timing of traffic signal preemption. Radar-based VPD is preferred. Consideration should be given to the detection of bicycles and pedestrians.
C. Highway approaches on one or both sides of the highway-rail crossing may be provided with medians or channelization devices between the opposing lanes. Medians should be defined by a non-traversable curb or traversable curb, or by reflectorized channelization devices, or by both – see section 4.4.1.1.2.
D. Remote monitoring (in addition to power-out indicators, which are required) of the status of these crossing systems is preferable.

4.4.1.1.2 CHANNELIZATION DEVICES AND MEDIANS

Channelization and median installation may be used as a design option to deny the highway user the option of circumventing the approach lane gates by switching to the opposing (oncoming) traffic lane to drive around the lowered gates to cross the tracks.

Design of this SSM shall be such that:

A. Opposing traffic lanes on both highway approaches to the crossing must be separated by either: (1) medians bounded by non-traversable curbs or (2) channelization devices.
B. Medians or channelization devices must extend at least 100 feet from the gate arm, or if there is an intersection within 100 feet of the gate, the median or channelization device must extend at least 60 feet from the gate arm.
C. Intersections of two or more streets, or a street and an alley, that are within 60 feet of the gate arm must be closed or relocated. Driveways for private, residential properties (up to four units) within 60 feet of the gate arm are not considered to be intersections under this part and need not be closed. However, consideration should be given to taking steps to ensure that motorists exiting the driveways are not able to move against the flow of traffic to circumvent the purpose of the median and drive around lowered gates. This may be accomplished by the posting of ‘‘no left turn’’ signs or other means of notification. For this part, driveways accessing commercial properties are considered to be intersections and are not allowed. Crossing warning systems must be activated by use of constant warning time devices unless existing conditions at the crossing would prevent the proper operation of the constant warning time devices.
D. Crossing warning systems must be equipped with power-out indicators.
E. The gap between the lowered gate and the curb or channelization device must be one foot or less, measured horizontally across the road from the end of the lowered gate to the curb or channelization device or to a point over the curb edge or channelization

device. The gate and the curb top or channelization device do not have to be at the same elevation.

F. ‘‘Break-away’’ channelization devices must be frequently monitored to replace broken elements and should be avoided as a standalone channelization option.

4.4.1.2 WAYSIDE HORNS

Wayside horns provide a one-for-one substitution for train horns, and typically provide a smaller sound footprint that is targeted toward motorists. Wayside horns may be installed in areas where sound from locomotive horns is a nuisance, but the configuration of the area does not warrant the installation of a full quiet zone, or as a component of a quiet zone.

A wayside horn conforming to the requirements of Appendix E of FRA Part 222 may be used in lieu of a locomotive horn at any highway-rail at-grade crossing equipped with an active warning system consisting of, at a minimum, flashing lights and gates.

4.5 SIGNALING

Reserved.

4.6 TRAFFIC CONTROL DEVICES

4.6.1 ACTIVE TRAFFIC CONTROL DEVICES

Reserved.

4.6.2 PASSIVE TRAFFIC CONTROL DEVICES

Reserved.

4.6.3 PEDESTRIAN TREATMENTS

Reserved.

4.6.4 TRAFFIC SIGNAL PREEMPTION

Reserved.

4.7 VEHICULAR CROSSING DESIGN

4.7.1 DESIGN WARNING TIME

4.8 PEDESTRIAN CROSSING DESIGN

Unlike the vehicular crossings, there are no nationally or state recognized standards for the design of pedestrian crossing warning systems on railroads. These practices utilize active warning devices similar to those at vehicular crossings: signal equipment modified from that of vehicular crossing, crossing gate arm, and a crossing configuration which channels pedestrians. There is an increasing awareness of the need to enhance the safety of pedestrians at crossings.

This section leverages the criteria and standards developed by Caltrain in their Design Criteria Manual.

4.8.1 CONCEPT OF OPERATIONS

Normal operation is for the bells to activate, lights to flash, and three (3) seconds later, the gates to descend. The bells will continue to sound until the train has cleared the signal island circuit and the gates begin their ascent. At that time, the bells will cease to ring. Bells are considered pedestrian warning devices, and a at-grade crossing shall have enough bells so that the bell can be heard in every quadrant. Soft Tone Bells are preferred except in an environment with high ambient noise levels. The bells shall all be electronic.

4.8.1.1 WARNING

The ADAAG walking rate of 1.5 feet per second (FPS) for a mobility impaired person, shall be used as the basis for calculating pedestrian warning times. Since one cannot rely on a locomotive engineer seeing a person in the crossing and being able to brake in sufficient time, the individual is relying on the warning devices to provide sufficient warning time. The 1.5 FPS walking rate allows sufficient time for a mobility-impaired person to safely travel across the crossing.

Nominal warning time shall be set at 25 seconds. The warning time is defined as the time from when the warning devices begin operating, i.e., when the bells ring and the lights flash and after a delay, automatic gate arms begin their decent. There are special circumstances where the warning times are lengthened, depending on site conditions and/or the circumstances of train operations. The public is accustomed to this standard warning time, as well as to a slightly longer time caused by decelerating trains.

Since the flashing lights for pedestrians are aimed across the tracks and the bells are primarily a pedestrian warning device, walking times are calculated for the mobility impaired person (at 1.5 FPS) from the clear point on the start point to the clear point across the tracks. A warning time of 25 seconds allows a mobility impaired individual to safely traverse 37 feet and 6 inches, so any longer of a crossing warrants additional warning time.

4.8.1.2 FENCING

Track centers at stations with outboard platforms are widened to 18 feet minimum to accommodate a center track fence which must be at 8 feet 6 inches clear from each track center.

The center fence will extend the length of the platform and beyond the crossing and will channel the passengers to crossings at the end of the platforms. ADA compliant ramps will be provided as a transition from platform height to rail crossing height.

Fencing or railing will encompass the ramp through the gate arm and swing gate to the crossing clear point.

4.8.1.3 WARNING DEVICES

4.8.1.3.1 GATE ARMS AND FLASHING LIGHTS

Pedestrian warning devices shall be standard AREMA compliant railroad gates and flashing lights that are commercially available. These devices are immediately recognizable to the public as train approach warning system. A separate gate mechanism for sidewalks should be provided in lieu of a supplemental or auxiliary gate arm installed as a part of the same mechanism to prevent a pedestrian from raising the vehicular gate at a highway-rail at-grade crossing.

4.8.1.3.2 SWING GATES

At a crossing with pedestrian gate arms, a person may have begun crossing the tracks when an approaching train activates the crossing. For this person not to perceive that he is trapped by the gate arms, a swing gate is provided adjacent to the pedestrian gate arm. This gate only swings away from the crossing and is marked "EXIT". The back side of the swing gate is marked "STOP, $ FINE" as a reminder to the pedestrians that the swing gate is only for one-way use.

4.8.1.4 BUFFER ZONE

A pedestrian safety buffer zone is created on the level area between the clear point and the gate arms and swing gate. This will allow a person to recognize the gate arms with adequate space for a group to stand in safety, or a wheel chair to maneuver. The perpendicular alignment of the gate to the tracks allows a maximum safety buffer zone. This is the preferred arrangement, although where available space prohibits it a parallel alignment may be used.

A safety buffer zone also provides accommodation for the slower moving individual to turn back and take refuge if he has passed the gate arms and sees and hears the crossing activation. The presumption is the mobility impaired person will not attempt to beat the train.

4.8.1.5 WARNING ASSEMBLIES

Pedestrian warning assemblies at stations will consist of lights arranged in a vertical configuration rather than in a horizontal arrangement. One (1) pair of the lights will be aimed down the platform and the other pair across the tracks. The lights aimed across the tracks are similar to the pedestrian walk light across a street at a standard pedestrian roadway crossing. If auxiliary lights are needed due to station entries perpendicular to the tracks or parallel to the tracks, they will be provided as needed.

4.8.1.6 GATE RECOVERY

After a train stops at the station, the gate arms should recover, and passengers should be able to safely cross from one platform to the other while the train dwells at the station. If a second train approaches on the opposite track, the gates will reactivate or remain down as required.

4.8.2 PEDESTRIAN CROSSINGS AT STATIONS

Pedestrian crossings at stations are for pedestrians accessing the platforms or for the public to cross the tracks in that location.

Pedestrian crossings at stations shall be located at the ends of platforms. Consult standard drawing P-XX.

4.8.3 CROSSINGS AT STATIONS WITH ROADWAYS

Some of the stations are adjacent to a street. In this case, the station has a dedicated pedestrian crossing at one end of the platform, and the other crossing shares the street sidewalk. Automatic pedestrian gate arms will be required at the pedestrian sidewalk, and provided with full treatments including swing gates, pavement striping, markings, and texturing. If the station parking is located on the street side, or if there are other considerations such as schools or other foot traffic generators near the station, then the treatment shall be evaluated based on risk for pedestrian gates on both sides of the street.

4.8.4 PEDESTRIAN CROSSINGS NOT AT STATIONS

Pedestrian crossings that are separate from a roadway or station shall be grade separated.

5. CIVIL DESIGN

5.1 GENERAL

Reserved.

5.2 SURVEY AND GEODETIC CONTROL

5.2.1 GENERAL

Locating, preserving, referencing, installing and restoring land monuments such as Primary Control monuments from which the Right of way or any land boundary will be calculated, described or monumented, Public Land Survey System (PLSS) monuments, General Land Office (GLO) monuments, Bureau of Land Management (BLM) monuments, Mineral Survey (MS) monuments, Right of way (ROW) monuments, property boundary monuments, easement monuments, and other monuments that are required by law or regulation to be established by a PLS, and the determination of any land boundary, shall be done in accordance with Section 629 of the CDOT Standard Specifications, under the supervision of a Professional Land Surveyor (PLS) who is experienced and competent in Right of way and boundary surveying and licensed in the State of Colorado.

The PLS or PE shall be available to review work, resolve problems, and make decisions in a timely manner.

Unless specified otherwise in the Contract, all survey procedures shall be in conformance with the CDOT Survey Manual.

5.2.2 CONTROL

5.2.2.1 HORIZONTAL CONTROL

The Horizontal Control for all system-level alignment design shall be based on the Colorado State Plane system, Central Zone, and the North American Datum of 1983 (NAD83).

Specific coordinate transformations may be done for final design of segments, and the surveyor shall develop a Project Control Diagram detailing the control monuments, latitude and longitudes and State Plane Coordinates for monuments, and the transformation needed to ground coordinates for construction.

Design and survey shall use the U.S. Survey Foot.

The 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 R.O.W. shall be tied into the established property lines of adjacent properties and on established section monumentation

5.2.2.2 VERTICAL CONTROL

The Vertical Control for all projects shall be based on the North American Vertical Datum of 1988 (NAVD 88). Where the proposed work is to be in a certain relationship to an existing structure or facility, elevations of the existing structure or facility must be established by field survey and tied to existing benchmarks. Where the proposed project is to be coordinated with other work, the relationship between the project datum and other working datums shall be established by field survey and tied to existing benchmarks.

5.2.2.3 PROJECT-SPECIFIC CONTROL

Individual construction projects may establish a project-specific coordinate system at the discretion and direction of the PLS in responsible charge. This shall be done in accordance with the CDOT Survey Manual, latest edition.

5.3 RIGHT OF WAY

5.3.1 GENERAL

5.3.1.1 WIDTH

The nominal right of way required for FRPR system construction is 74 feet. This includes access routes on both sides of two main tracks spaced at 25 feet. Reference Standard Drawing D-02 for details. Additional permanent easements or width of right of way may be required for cut and fill areas. In areas of special trackwork (turnouts, crossovers) and near stations, nominal right of way shall be 100 feet (minimum).

Consideration of additional width for future expansion or stations should be made in areas where future expansion of freight or passenger rail operations may be challenging due to future development or other constraints. Additional width for future stations should be considered in populated areas that meet criteria for secondary stations. (See 8.3.2, Secondary Stations).

5.3.1.2 MAINTENANCE ACCESS

Consideration for maintenance access shall be made for all new right of way and alignment construction. Design of improvements within existing ROW should be considered to the extent possible. The design vehicle for maintenance access shall be the AASHTO SU-40.

Access for rubber tired/motorized equipment along the trackside is preferred. Hammerhead turnarounds or other provisions for turning maintenance vehicles should be provided at (minimum) 1000-foot intervals. Access roads shall be constructed of compacted aggregate base course, meeting the standards of subballast (see Section 3.2.4 Subballast).

Access via only high-rail or rail-based maintenance equipment should be limited to areas where right of way is highly constrained or otherwise the design necessitates this limitation. Access for high-rail vehicles should be provided at (minimum) 5,000 foot intervals or to the best extent practicable. Aerial or fill structures, depressed or tunneled sections are exempt from this requirement. High-rail access points shall be compatible with SU-40 design vehicle.

5.3.1.3 TRACK CLEAR ZONE

Clear visibility up and down the right of way, both for train crews and maintenance personnel working on the ground, is essential for personnel and operational safety and shall be considered by designers.

No obstructions of any kind (including but not limited to vegetation, structures, switch stands, fences) shall be permissible within the clearance envelope (Std. Drawing D-02). Deviation to the CO-PUC horizontal clearance shall only be with authorization of FRPR engineering. Deviation below those absolute minimum vertical clearance will not be permitted by FRPR engineering.

A 25-foot wide clear zone should be designed in new right of way construction.

5.3.2 SECONDARY USAGE

Secondary usage of FRPR Right of Way, i.e., any usage other than for the operation of the Front Range Passenger Rail and other associated heavy rail systems, shall be by explicit approval of FRPR Engineering only. FRPR reserves the right to refuse access for secondary usage for any reason.

Utility crossing requirements are outlined in Section: 5.6 Utilities.

5.3.3 FENCING

Boundaries of FRPR Right of Way should be fenced. Type and height of fencing shall be selected based on the area that the ROW passes through but may require upgrading if experience shows a trespassing problem in a specific area.

Fencing shall be design such that a person who may become behind the fence will not be trapped within the clearance envelope of the adjoining track.

Fencing shall be grounded and bonded in areas of electrified track. Grounding and bonding shall follow National Electric Code requirements.

5.3.3.1 RURAL AREAS

Fencing should be installed where there is a likelihood of train-human or train-livestock interaction in rural areas. This includes areas near roads, manufacturing or agricultural structures, pastures, and other areas where engineering judgment determines fencing is warranted.

Fencing in rural areas, where determined needed, shall consist of a four-wire partial barbed and partial smooth wire fence standing at 42 inches. See FRPR Standard Drawing No. R-03. In areas of livestock grazing or as appropriate based on engineering judgment and neighboring property owner needs, a Combination Wire Fence (per CDOT Standard Plan M-607-1) should be used.

5.3.3.2 URBAN AREAS

Right of way in urban areas shall be fenced. Fencing shall be chain link fence with barbed wire, 72" tall, and in compliance with CDOT Standard Plan No. M-607-2. Barbed wire may be omitted if a low frequency of interactions (such as suburban or low-traffic areas) is likely.

Station areas shall be fenced according to the details in Section 7: Stations.

5.3.3.3 YARDS AND SUPPORT FACILITIES

Support facilities and yards shall be fenced using high security, 96-inch tall, flattened expanded metal fence, in compliance with UPRR Standard Drawing 0077.

5.3.3.4 SNOW FENCING

Design in open, rural areas may require the installation of snow drift fencing. Designers may reference CDOT Standard Plan M-607-10, Picket Snow Fence, for a suggested option for mitigating drifting snow. Snow fencing should be located approximately 100-150 feet from the alignment centerline, aligned orthogonally to the prevailing wind direction.

Alternative snow drift protection (including vegetative barriers) may be considered based on local conditions and what provides the best operational protection for the right of way.

5.3.4 VEGETATION AND LANDSCAPING

Vegetation along rights of way and track shall be maintained to ensure an effective clear zone as prescribed by Section 5.3.1.3: Track Clear Zone.

Track and structures shall be clear of vegetation. Trees or shrubs shall be maintained to ensure adequate line of sight to signals, wayside signs, turnouts and control points, and other critical appurtenances to the track structure.

Grasses and other ground cover foliage should be permitted outside of the ballast prism to the extent practicable and feasible for maintenance. Species selected should be such that maintenance (mowing) is minimized. Maintenance access roads and access areas should be kept clear.

Landscaping along the right of way should be permitted to the extent that the clear zone is maintained, operation and safety are not impacted, and maintenance is not significantly increased. Landscaping at areas such as overpasses, stations, and other areas of public visibility should be planned with consideration of local context, aesthetics, and ease of maintenance, while enhancing the visual appeal and diminishing impact of the rail corridor.

5.4 STREET DESIGN

5.4.1 GENERAL

Necessary repair or replacement of existing roadways shall, at a minimum, provide services equivalent to the existing facilities. The costs associated with betterments to roadways shall be the responsibility of the facility owner.

Unless otherwise specified, all road and street design for at-grade crossings, grade-separated crossings, and for other associated facilities should be in accordance with the current specifications and design guidelines of the local jurisdictions. Where the local jurisdictions have no design guidelines, the most current versions of the Colorado Department of Transportation (CDOT) Design Guide, and/or A Policy on Geometric Design of Highways and Streets (Green Book) by the American Association of State Highway and Transportation Officials (AASHTO) should be used.

5.4.2 CLEARANCE TO TRACK FACILITIES

Where possible, the design of public streets adjacent to track facilities shall not preclude the construction of future stations.

5.4.3 CLEAR ZONE

Wherever practicable, all posts, pipes, warning signs and other small obstructions should be given a side clearance of at least 10 feet measured from track centerline and meet standards of local jurisdiction, AASHTO and MUTCD. 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).

5.4.4 PAVEMENT

Necessary repair or replacement of existing pavements shall, at a minimum, provide services equivalent to the existing facilities. The costs associated with betterments to roadways shall be the responsibility of the facility owner.

All new pavements in public streets shall be in conformance with the current specifications and practices of the local jurisdictions. In a case where the local jurisdictions have no codes or standards, the CDOT Pavement Design Manual (latest edition) shall be followed.

5.4.5 TRAFFIC SIGNALS

Reserved.

5.5 DRAINAGE

Reserved.

5.6 UTILITIES

Reserved.

6. TRACTION POWER

6.1 GENERAL

Portions of the Front Range Passenger Rail corridor are to be electrified at the direction of FRPR Engineering based on their investigation and coordination with local stakeholders following the principles outlined in this section. Electrification shall be 25kV (nominal), 60 Hz, single-phase alternating current, unless otherwise approved by FRPR Engineering. FRPR-owned traction power substations shall receive primary supply from electric power utility company ("Utility") feeders or taps and supply 25kV electrical power to the commuter trains' pantographs via an overhead contact system. Return current from the trains shall reach the substation via the wheels and the traction power return system.

Unless defined within this document, traction electrification system terms are defined in the American Railway Engineering and Maintenance-of-Way Association Manual for Railway Engineering (the "AREMA Manual"), Chapter 33.

6.1.1 AREAS TO BE ELECTRIFIED – DESIGN INTENT

The intent of the traction electrification system's design is to provide the ability for trainsets to run off supplied electric power in lieu of a diesel prime mover.

Design of the system should consider traction electrification (and installation of overhead contact system infrastructure) in the following cases:

A. Locations subject to potential extended idling of locomotives, such as terminal stations or staging tracks
B. Urbanized areas with significant air quality and emissions concern
C. Urbanized or other areas with local interest (and financial support) to electrify
D. Other areas where local interest, conditions, and infrastructure favors electric traction over the diesel prime mover.

6.1.2 TRACTION ELECTRIFICATION SYSTEM

The Traction Electrification System (TES) shall be comprised of three major electrical systems- Traction Power System (TPS), the Traction Power Distribution System (TPDS), and the corridor-wide Traction Power Return System (TPRS).

The design of the 25kV traction electrification system depends on the type of traction power distribution system actually used. The variations possible for the 25kV power distribution system shall include direct feed system or "1x25kV system", and autotransformer system or "2x25kV system".

These design criteria address both systems but assumes that the autotransformer system will be used for the major part of the route, with extremities and yard facilities supplied by direct feed systems. For the purposes of this design criteria section, track running rails, impedance bonds and rail bonds are considered part of the TPRS, while covered under the signaling system and trackwork design criteria sections.

6.1.3 TRACTION POWER SUPPLY SYSTEM

The Traction Power Supply System shall include Traction Power Substations (TPSS), Autotransformer/Paralleling Stations (APS), and Switching Stations (SWS), and their connections to the Traction Power Distribution System (TPDS) and the Traction Power Return System (TPRS).

The traction power substations shall receive primary power from Utility feeders or taps at transmission levels (115kV or 230kV) and shall include the equipment necessary to step-down the levels to the traction system distribution voltage of 25kV, and the necessary ancillaries and protective systems. Traction power shall be supplied to the traction power distribution system by underground cables or aerial conductors terminated on trackside disconnect switches. Current shall return to substations via permanently connected cables from the running rails.

The autotransformer/paralleling stations shall have switchgear to parallel the Overhead Contact System (OCS) and feeders of multiple tracks, autotransformers (if used), sectionalizing switchgear if the station is located at interlockings, the necessary ancillaries, and protective systems.

The switching stations shall separate the traction power supplies of different phases by phase breaks in the OCS. Switching stations shall have provisions for extending the 25kV supply from one side to the other in the event that supply on one side is not available, such as occurring from a substation failure. The switching station shall have equipment to parallel the OCS of two tracks, autotransformers (if used), and the necessary ancillary and protective systems.

6.1.4 TRACTION POWER DISTRIBUTION SYSTEM

The Traction Power Distribution System (TPDS) shall include the OCS and the Autotransformer Feeder System (AFS).

6.1.4.1 OVERHEAD CONTACT SYSTEM

The OCS shall consist of an arrangement of steel poles, cantilever assemblies and conductors installed over the rail tracks that deliver the 25kV single phase power supplied by the Traction Power Supply System to the pantographs of the trains.

6.1.4.2 AUTOTRANSFORMER FEEDER SYSTEM

The AFS shall comprise bare aerial conductors installed on the OCS poles to supply power to the autotransformers at paralleling stations.

6.1.4.3 STATIC WIRE

Although part of Traction Power Return System (TPRS), static wires shall be considered part of the TPDS for the purpose of designing structures and assemblies.

6.1.5 TRACTION POWER RETURN SYSTEM

The TPRS shall comprise the track running rails, the rail bonds, the impedance bonds, and the static wires. There shall be no direct connection between OCS poles and track rails except in the areas without track circuits.

Static wires, one for each track, shall be provided from end-to-end to connect all OCS poles, except those installed on passenger station platforms. Only one static wire is required in areas where center poles are used. Static wire shall be electrically connected to the OCS poles by a flexible bond of compatible material. Static wires of the two tracks shall be electrically paralleled at intervals determined by the Grounding and Bonding Study.

Impedance bonds shall be installed at insulated rail joints to allow traction current to flow while blocking signaling currents. Track rails shall be periodically grounded by connection to the static wires at selected impedance bond locations (also known as A-points). Return cables shall connect the running rails to the TPSS return bus at substations and autotransformer/paralleling stations. Where yard and shop tracks are isolated from mainline tracks, impedance bonds shall be provided at the rail joints for passage of traction return currents.

6.2 STANDARDS AND CODES

All design work and material selection shall conform to or exceed the requirements of the latest editions of the following standards or codes:

A. National Electric Code (NEC)
B. American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering

6.3 FUNCTIONAL REQUIREMENTS

6.3.1 TRACTION POWER

The TES shall be designed to maintain the voltage at the pantographs and the OCS conductor temperatures within limits specified in AREMA Manual or by the conductor manufacturer. The number, location, and rating of the paralleling stations shall be determined by a computerized traction power load flow analysis which shall also determine the territorial limits of the direct feed (25kV) system and, if selected, autotransformer feeder (2x25kV) system.

The TPS shall supply 25kV power to the OCS and to the Autotransformer Feeder System (AFS) via disconnect switches installed at trackside gantries with separate feeds for inbound and outbound tracks. The TPS shall be designed for full redundancy, such that the loss of any one major item of equipment or feeder will not result in degradation of train schedules in any corridor. There shall be at a minimum, two traction power substations (TPSS), each supplied by different Utility substations such that a complete loss of a TPSS or Utility substation shall not preclude train operations at the specified reduced level of performance in any corridor.

For a 2x25kV system, APS shall each have at least one autotransformer and Switching Station at least two, one for each side of the phase break.

The TES shall be designed for a minimum functional life expectancy of forty (40) years.

6.3.2 POWER DISTRIBUTION

The OCS shall be designed to ensure spark-free current collection by multiple-unit train consists with each train having multiple pantographs in use at any one time.

Train consists considered in designs shall include both initial maximum train length and any future maximum train length specified by FRPR for the route.

There shall be no high-voltage interconnection between the pantographs.

The design of phase breaks shall permit operation of randomly marshaled train consists with various pantograph separations.

AFS conductors shall be located adjacent and parallel to the OCS to optimize mitigation of their electromagnetic fields and reduce inductive interference in communications lines. Electrical clearance suitable for 50 kV shall be provided between the OCS and feeder.

6.3.3 OCS SECTIONING

The system sectioning shall be designed to allow isolation and de-energization of parts of the TPDS to permit planned maintenance, to isolate faulted sections, and to permit flexible operation during system emergencies.

Where they are installed, OCS conductors and each autotransformer feeder circuit shall form part of a single circuit and shall be sectionalized together by 2-pole circuit breakers and 2-pole disconnect switches.

Schematic Sectioning Diagrams shall show diagrammatically the relative location of all tracks, interlockings, fixed signals, passenger stations, substations, and switching and paralleling stations. For each track with OCS, a single line shall be shown with its phase breaks and sectioning points. Unwired turnouts shall also be shown and identified as such.

Normal position of the circuit breakers and disconnect switches, open or closed, shall be shown. The normal method of operation of each motorized or hand-operated disconnect switch shall be indicated. All circuit breakers and disconnect switches shall be identified for operating purposes by a serial number unique within the FRPR system.

For isolated and independent areas of OCS less than 1,000 feet in length, no sectioning is required.

6.3.3.1 MAINLINE

OCS sectioning on the mainline shall utilize insulated overlaps suitable for 25kV.

6.3.3.2 CROSSOVERS, TURNOUTS, YARDS

Bridging section insulators shall be used for:

A. Crossovers and turnouts that are not used during normal revenue service
B. Main lines when the maximum operating speed is limited to 30 mph
C. In yard areas

6.3.3.3 PHASE BREAKS

A design shall be produced that integrates OCS, vehicle, and track details to permit trains to routinely operate through each phase break without impacting train service. Phase breaks are required at substations, switching stations and locations where adjacent sections of the traction power distribution system are supplied by different electrical phases.

Phase breaks shall not be located:

A. Where trains require high current draw or regeneration capabilities
B. in braking or stationary zones on the approach side of signals at interlockings
C. on sharp curves and steep gradients

Phase breaks may be accomplished with extended gaps in overhead contact system where a diesel prime mover can provide traction power for the duration of interruption of overhead traction power.

6.3.3.4 INTERLOCKED SWITCHING

Yards and shops shall be provided with interlocked arrangements of disconnect switches to protect or warn maintenance staff from approaching or touching ungrounded wiring above rail vehicles. Such design shall be site specific and support the safety procedures, equipment and features developed and approved for such operations.

Typically, interlocked switching equipment may include safety mechanisms preventing access to the OCS unless it has been de-energized and providing audible and visible warning before being energized.

6.3.4 REMOTE OPERATION

Substations, switching and paralleling stations, circuit breakers, and motor-operated disconnect switches, shall be designed for remote operation from the Commuter Rail Operations Control Center. Local operation of individual equipment shall be possible via control switches.

6.4 TES DESIGN REQUIREMENTS

For reasons of practical support dimensioning and strength rating, aerial feeder wires, static wires, and pole-mounted disconnect switches shall be considered to be part of the OCS design, specification, and construction. Impedance bonds and rail bonds shall be considered part of signaling systems and trackwork design and specifications, respectively.

6.4.1 TRACTION POWER SYSTEM

Reserved.

6.4.2 TRACTION POWER FEEDERS AND RETURN CABLES

Reserved.

6.4.3 OVERHEAD CONTACT SYSTEM

Reserved,

6.4.4 OCS ROUTE DESIGN

A route design shall be prepared to show at a low level of detail, the arrangement of each tension length of OCS to be built or altered. The route design shall take into consideration fixed locations for phase breaks, insulated overlaps, station crossovers, low clearance buildings and bridges, and any infrastructure features preventing the placement of wiring terminations.

Live conductors shall not be installed above passenger platforms or buildings.

To improve operational options following wiring damage incidents, the OCS wires of individual mainline tracks should be routed to service only one track of that route. Tension lengths servicing crossover tracks or yard leads should be independent of mainline wiring.

6.4.5 OCS WIRING ARRANGEMENTS AT OVERLAPS, SPECIAL TRACKWORK AND PHASE BREAKS

Reserved,

6.4.6 OCS CLEARANCE

Reserved,

6.4.7 CONTACT WIRE DIMENSIONING

6.4.7.1 CONTACT WIRE HEIGHT

6.4.7.2 CONTACT WIRE GRADIENT

The pantograph shall track smoothly under the contact wire at all times. Where the contact wire height needs to be changed, the change shall not cause bouncing and arcing of the pantograph.

Table 9-2 provides recommendations from the AREMA Manual for Railway Engineering for the maximum wire gradient versus train speed ranges. Contact wire gradient values are to be applied relative to the track plane.

6.4.7.3 CONTACT WIRE STAGGER

Reserved.

6.4.8 FOUNDATIONS

Reserved.

6.4.9 POLES AND PORTALS

Reserved.

6.4.10 OCS SUPPORT REQUIREMENTS

Reserved.

6.4.11 CONTACT WIRE REGISTRATIONS

Reserved.

6.4.12 INSULATION

Reserved.

6.4.13 DOCUMENTATION

Reserved.

6.5 GROUNDING

Reserved.

6.6 EQUIPMENT REQUIREMENTS

Reserved.

7. STRUCTURES

The design and construction of passenger rail bridges and associated structures shall be in accordance with AREMA Manual for Railway Engineering and CDOT Bridge Design Manual. If FRPR is operating on the ROW, or partially on the ROW, of either the BNSF Railway (BNSF) or Union Pacific Railroad (UPRR), the design and construction shall also be in accordance with BNSF/UPRR Guidelines for Railroad Grade Separation Projects.

The design and construction of freight rail bridges and associated structures shall be in accordance with AREMA Manual for Railway Engineering, BNSF/UPRR Guidelines for Railroad Grade Separation Projects, and CDOT Bridge Design Manual.

The design and construction of highway bridges, pedestrian bridges and associated structures shall be in accordance with AASHTO LRFD Bridge Design Specifications, CDOT Bridge Design Manual, and the BNSF/UPRR Guidelines for Railroad Grade Separation Projects. The vibration criteria for pedestrian bridges shall be in accordance with AASHTO Guide Specifications for Design of Pedestrian Bridges.

Where the requirements of the design documents are in conflict, the stricter shall apply unless otherwise approved by FRPR Engineering.

7.1 STANDARDS, CODES AND GUIDELINES

Reserved.

7.2 DESIGN METHODOLOGY

Structure types will be restricted to those historically used by local railroads or those that have been accepted for general use by other transportation authorities and can be demonstrated that the design of the structure types and components will perform well for the intent of the project and under the project's environmental conditions, including frequent freeze-thaw cycles. Experimental structure types, timber bridges, masonry bridges and structural plate arches are not permitted. FRPR reserves the right to reject the use of non-historic structure types proposed.

7.2.1 RAIL STRUCTURES

The following structural design methodologies shall be used for rail structures as given below:

A. Concrete Structures – Load Factor Design Method
B. Prestressed Concrete Structures – Service Load Design Method with check for Ultimate Strength
C. Steel Structures – Service Load Design Method
D. Abutments and Piers – Load Factor Design Method
E. Foundations – Service Load Design Method

7.2.2 HIGHWAY AND PEDESTRIAN STRUCTURES

Load and Resistance Factor Design Method shall be used for highway and pedestrian structures.

7.3 GENERAL DESIGN GUIDELINES

Reserved

7.4 LOADING

7.4.1 DESIGN LOADS

Bridge structures shall be designed for all loads specified in the AREMA Manual or AASHTO Specifications and as modified by the appropriate FRPR and railroad guidelines.

7.4.1.1 DEAD LOAD

Table 2: Dead Loads

Track, rails, inside guard rails, fastenings	200 lbs per linear foot
Ballast, including ties	120 lbs per cubic foot
Timber	5 lbs per board foot measure
Reinforced concrete	150 lbs per cubic foot
Earthen materials (fills)	120 lbs per cubic foot
Waterproofing or protective covering materials	Estimated weight
Catenary system*	Per catenary design
Future utilities	5 lbs per square foot of deck

*Design of all FRPR system structures to factor in future construction of overhead contact system and catenary wire.

7.4.1.2 LIVE LOADS

7.4.1.2.1 COOPER E80

Reserved

7.4.1.2.2 AMTRAK CONSIST

Reserved

7.5 SEISMIC DESIGN CONSIDERATIONS

Reserved

7.6 STRUCTURE TYPE SELECTION

Reserved

7.7 CONCRETE STRUCTURES

Reserved

7.8 STEEL STRUCTURES

Reserved

7.9 BRIDGE BEARINGS

Reserved

7.10 WATERPROOFING

Reserved

7.11 CULVERTS

Reserved

7.12 PERMANENT RETAINING WALLS

Reserved

7.13 LOAD RATING

8. STATIONS

8.1 GENERAL

This section establishes specific guidelines and standards for the design of stations. The stations will be at-grade (except in special cases), standardized and cost effective in design. Elements discussed in this section include the design of platforms or platform access.

These criteria intend to enhance the safety and quality of the system, which has a fundamental impact on the ability to attract and sustain patronage.

A rail station consists of site access, multimodal access, transition plaza, platform, tracks, and all appurtenances necessary to provide for the public safety, protection from the elements, and public information. The station also serves as a gateway in and out of a community as the origin/destination source of passenger traffic.

The general design of the stations shall be standardized. Equipment, shelters, platform features, structural elements, and signage used shall be the same system-wide and compatible with FRPR's identity. Deviations from standard design elements may be required for specific sites but must be approved by FRPR before design proceeds.

FRPR and community planners should explore potential opportunities to develop transit-oriented development (TOD) adjacent to FRPR station locations. TOD, however, needs to occur with a balance toward providing a convenient and pleasant experience for FRPR passengers and providing opportunities for mixed use development.

8.1.1 GOALS

The basic goals for these criteria are to provide the design professionals with the information necessary to maximize the design effort in providing a safe functional station. The station area must provide a safe and efficient transition from multi-modal arrival areas through a space that provides ticketing, schedule, and community/regional information; to a station platform (concourse) that provides a safe area from which to board trains. All station areas must consider the safety and comfort of the patron through appropriate lighting and protection from the elements. These criteria cover that portion of station design from the bus boarding/alighting location to the train platform. For criteria on park and Ride design, reference the standards of the local transit agency.

8.2 STANDARDS, CODES AND GUIDANCE

The nature of rail causes its alignment to travel through numerous districts, cities, and counties. Each of these legally defined areas has different land use and development regulations and legislative procedures directly affecting station site planning and design. Each individual jurisdiction may have special amendments or supplements to codes and standards that apply on a statewide and national basis.

Designer shall identify governing jurisdiction for each site after reviewing local jurisdictional boundaries and adopted master plans and municipal codes.

Designs (in general) shall comply with the latest edition of the following:

A. International Building Code
B. NFPA 130
C. NFPA 101
D. State of Colorado "Building Regulations for Protection from Fire and Panic
E. U.S. Department of Transportation's Transportation for Individuals with Disabilities; Final Rule, including 49 CFR Parts 27, 37 and 38 with Appendix A "Standards for Accessible Transportation Facilities,"
F. ANSI A17-1
G. ADAAG
H. AREMA Manual for Railway Engineering
I. Colorado PUC Rules
J. Title 49 of the Code of Federal Regulations
K. Manual on Uniform Traffic Control Devices
L. RTD, Amtrak, and host railroad design standards
M. CDOT Mobility Hub Design Guide

8.3 STATION CLASSIFICATION

Station locations are broken down into two classifications, each with requirements for the class and specific design criteria. For the purpose of station classification, the population of a municipality and general catchment area is defined as either the boundaries of the jurisdiction or the population surrounding the station location within a five-mile radius.

8.3.1 PRIMARY STATIONS

Primary stations are the principal stations that serve major communities with large capture areas, large anticipated ridership, and that would receive service from all FRPR trains.

8.3.1.1 REQUIREMENTS OF PRIMARY STATIONS

Primary Stations must:

1. Be located within a municipality (or within close proximity to a municipality) with a population greater than 55,000,
2. Be located within the general corridor of the FRPR system,
3. Not be within eight (8) miles of another primary station, and
4. Provide connectivity to a regional or local transit system.

8.3.2 SECONDARY STATIONS

Secondary stations are those that do not serve major metropolitan areas, but that provide significant additional ridership and connectivity, and may serve special events or non-municipal station locations. Secondary stations would be served by local service trains but would not be served by express service.

8.3.2.1 REQUIREMENTS OF SECONDARY STATIONS

Secondary stations must:

1. Serve a population exceeding 10,000 persons or anticipated ridership from special events or otherwise exceeding 10,000 persons,
2. Be adequately located within the FRPR system (not requiring a realignment of the system corridor to serve the station),
3. Be sufficiently located to provide connectivity to transit-oriented development or transit system connectivity, and
4. Not be within three (3) miles of another primary or secondary station.

8.4 STATION CONFIGURATION

Consideration shall be given to possible track additions and possible extensions in the future, for longer train consists. The station designers shall seek input from FRPR in determining requirements for possible future station expansion and provision for future electrification of the system.

The station layout shall include provisions for roadway maintenance trucks to access the tracks on both sides of the station. If this access is to be provided from the public parking or driveway areas, a locked gate shall be installed to keep unauthorized vehicles from entering the right-of-way.

Stations shall be designed for through movement without reversing, either in current or planned future layout. Terminal stations shall be designed not to preclude future expansion and through movements.

8.4.1 TRACK

Areas with tangent track are preferred, and curved track should be avoided if possible. If placement on a curved track is unavoidable, the curve shall be no more than 1 degree and 30 minutes and be located at either end of the platform. Platforms located on a curve shall be approved in advance from FRPR Engineering.

Station track shall have a maximum grade of 0.35%, with an absolute maximum of 0.50%. (Ref. 3.3.3.1 Grades)

Track centers shall be a minimum of 18 feet through station areas, to ensure that central fencing is a minimum of 8’-6” from track centerline.

Primary stations (as defined in 8.3 Station Classification) may be located on the main track with no provisions for passing. Secondary stations shall be located on a siding, such that express trains serving all stations would be able to pass the local service train at a passing siding. Passing sidings for stations shall be a minimum of 1000 feet in length, with 1500 feet or longer preferred.

Terminal stations should be sized larger or have other provisions to accommodate four trains (two stored, two on platforms) at any point in time.

8.4.2 BOARDING PLATFORMS

The two preferred alternatives for FRPR station platforms are as follows:

A. Outboard Platforms: Outboard platforms are side platforms located directly opposite one another, each servicing one mainline track.
B. Center Island Platform: Center island platform is a single platform that services tracks located on each side of the platform. The center island platform arrangement is considered to offer the most efficient use of platform space and furnishings.

The staggered platforms are outboard platforms where the platforms do not align or are staggered either around or not around an adjacent street. These platforms are neither efficient nor convenient for passengers and may be used on a temporary basis such as temporary station during construction. See Figure 2: General Station Layouts for typical platform arrangements. See FRPR Standard Drawings (P series) for further details.

Platforms, including potential extensions, should be located at least 100 feet from the nearest road crossing to prevent the locomotive of a stopped train from obstructing the crossing.

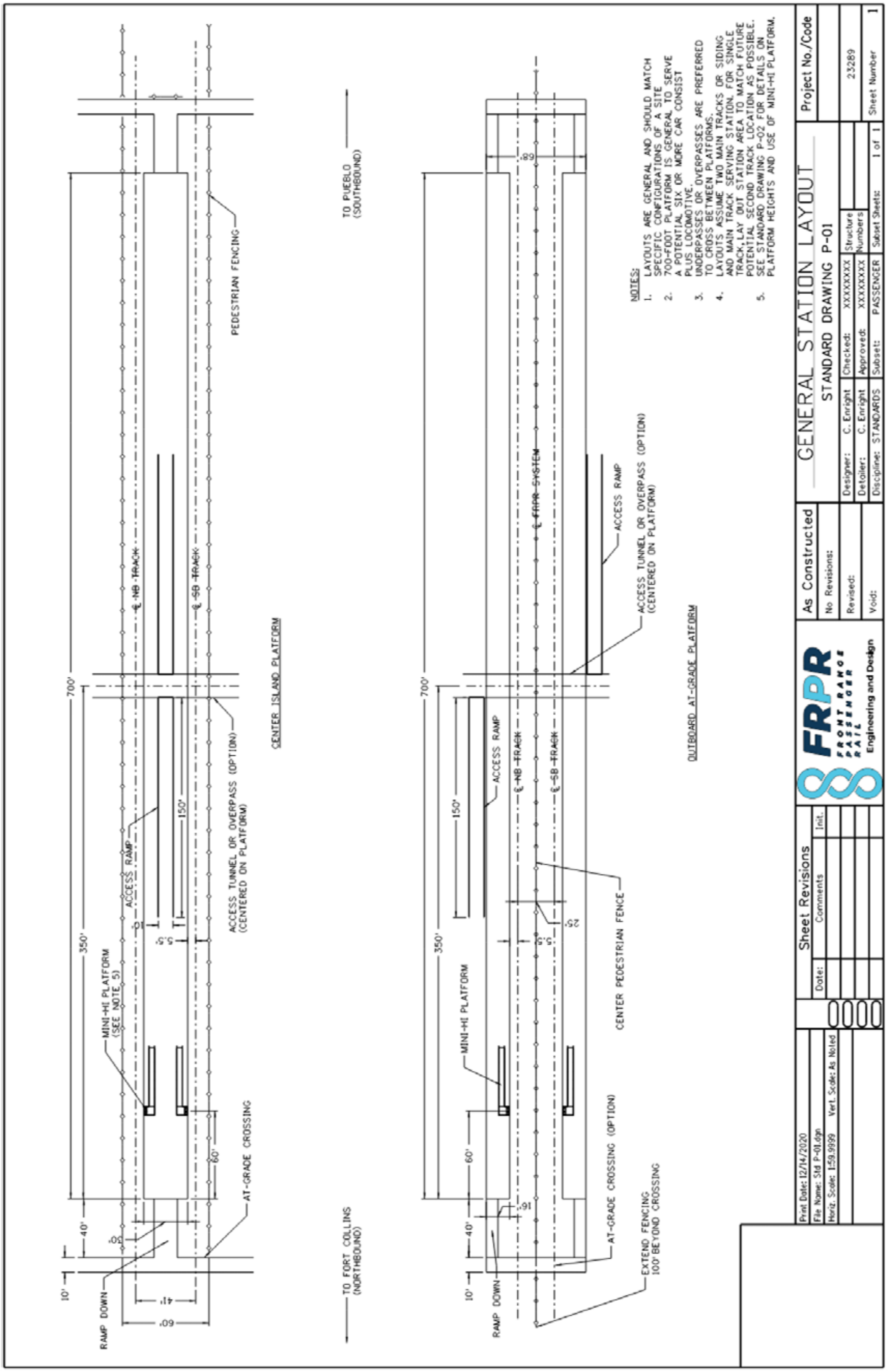

Figure 2: General Station Layouts

8.4.2.1 PLATFORM DIMENSIONS

8.4.2.1.1 PLATFORM HEIGHT

Platforms may be low-boarding or level boarding based on the intended service and compatibility needs of the station.

Level boarding or high platforms should be used wherever possible to allow for passengers to board and alight without requiring the use of stairs, in compliance with latest USDOT ADA guidance. High platforms shall be used at all stations where interoperation with RTD Commuter system is intended. High platforms shall be at an elevation of 48 inches above the top of rail. The platform edge shall be 5 feet 9 inches (5'-9") from the centerline of the nearest track. A minimum clear space of 8'-6" shall be provided opposite any high boarding platform as required by BNSF Railway. A 2-foot-wide clear space shall be provided under the platform to provide emergency refuge in the event of a fall into the track area.

Low platforms shall be used where interoperation with Amtrak long-distance equipment is expected or possible and may be required where dictated by freight operations in the area. Low platforms shall be at an elevation eight (8) inches above the top of rail. The platform edge shall be 5 feet 6 inches (5'-6") from the centerline of nearest track.

Low platforms shall be supplemented with a mini-hi platform to provide an area of level boarding for passengers with disabilities. Mini-hi platforms shall be four (4) feet above the top of rail, and a minimum of six (6) feet wide at that elevation. Ramps shall be provided down at a slope in accordance with ADA Guidelines.

Platforms shall be cast-in-place concrete over a compacted fill and subgrade. Platforms shall be reinforced with steel as needed. Designer shall seek inputs from FRPR on the final profile and alignment for the tracks through the station area to establish the platform elevation.

8.4.2.1.2 PLATFORM LENGTH

The standard platform length shall be 700 feet to allow for six car consists. Platform and station design shall consider and not preclude a possible expansion of platform length to 1000 feet (for eight car consists).

8.4.2.1.3 PLATFORM WIDTH

Outboard platforms shall be a minimum of 16 feet wide, with 20 feet preferred. Center platforms shall be a minimum of 30 feet wide, with 32 feet preferred. This added width is to accommodate access stairs, ramps, elevators, shelters and for passenger access and circulation.

A minimum walking space of seven (7) feet shall be required from the safety stripe to any obstruction for the entire length of the platform.

Designers should consider increasing platform widths to accommodate surge loading for peak hour based on forecast ridership for that station.

8.4.2.1.4 SLOPE

All side platforms should slope away from the track a minimum of 1 percent and no more than 2.0 percent in accordance with ADA guidelines. At center platforms, the slope shall be to a centerline swale with area drains for discharge to the municipal storm drain system. Drain the entire station site and contiguous track ROW.

8.4.2.2 PLATFORM MARKING

8.4.2.2.1 TACTILE WARNING

A truncated dome tactile warning panel shall be placed along the platform edge. This panel shall be 24 inches wide, yellow in color, and in compliance with the latest ADAAG standards. Mini-high platforms shall be treated with similar 2-foot-wide tactile panels.

8.4.2.2.2 SAFETY STRIPE

A 6-inch-wide yellow stripe (Federal yellow) shall be painted behind the tactile that the far side of the stripe marks a distance of 9 feet from the center of the track. Six (6) inch high letters "WAIT BEHIND YELLOW LINE" shall be painted behind the stripe to indicate where passengers are to stand. The marking shall line up with the car door.

For areas where an obstruction or feature (such as a mini-high platform) create a space that is between the obstruction and tracks and that is within the clearance envelope (9 feet), additional striping shall be added to indicate the unsafe/prohibited area. This striping shall be red, 8 inches (or wider), and angled at 45 degrees relative to the track and platform.

8.4.2.3 SIGNAGE

Reserved.

8.4.3 PLATFORM ACCESS

The preferred means of pedestrian crossing and access is tunnel or bridge structures (grade-separated). Where bridges or tunnels are not practicable or cost-effective, access shall be provided via at-grade crossings.

8.4.3.1 GRADE-SEPARATED CROSSINGS

Grade separated crossings either above or below ground shall be designed with stairs/ramps and elevators to be open, well lit, safe, and secure. Overpasses are preferred to underpasses for these safety and comfort reasons. Grade separated crossings shall be barrier free and equipped with CCTV and emergency phones.

Overpasses shall have a minimum clearance of 30 feet ATOR and shall a 12-foot minimum width and 8-foot internal clearance. Overpasses shall have a protective canopy or roof, and appropriate railing, barriers, or side fencing.

Underpasses should only be considered when requirements for safety, security, and control can be met. Underpasses shall be a minimum of 20 feet wide, and the access point should be visible from adjacent streets or the station. Design should eliminate curves or corners to the degree that permits daylight to enter from at least one end.

8.4.3.2 AT-GRADE CROSSINGS

Track crossings should provide pedestrians with the quickest and safest route across tracks from one platform to another. At-grade crossings shall be located at the ends of platforms. If an adjacent roadway crossing is equipped with automatic warning devices, it may be an acceptable at-grade passenger/pedestrian crossing. It is preferable to use existing crossings prior to adding new crossings.

Crossings shall be 20 feet wide, with a 2-foot tactile warning strip along the trackside. At-grade crossings shall meet all requirements of ADAAG, the MUTCD, and the Colorado PUC.

At-grade crossings shall include warning bells, signage, flashing lights, and gates. A combination of manual pedestrian swing gates and automatic gates shall be permissible. Consult Section 4.8 - Pedestrian Crossing Design for additional details and design requirements.

8.5 GENERAL STATION REQUIREMENTS

8.5.1 CONTEXT-SENSITIVE DESIGN

Station designs should not only consider functional and operational efficiencies, but also integrate humanistic and community spirit into station design. FRPR Stations will inherently become a centering point for urban landscapes that surround them, and the design, layout, and features of stations shall be planned with this community context in mind. Community involvement is necessary to create a sense of place for the station, and to integrate that place into the broader local context that exists. FRPR recognizes that enhancing the character of the station areas improves the quality and function of the broader system and community.

Designs should create a commuter rail civic architecture that is permanent, functional and pleasant, and contributes to its context -- one that is not entirely a derivative of the transit system, but of the neighborhoods and community of which it is a part yet maintains an overall line recognition and system identity.

Design and planning should identify and maintain community characteristics and values already established. Design and general layout of the transition plaza and pedestrian circulating elements in such a way that compliments the character of the area. Consider integrating art or interpretive displays where possible in platforms, shelters, plazas, or station structures. Consider retention or reuse of existing former passenger rail facilities (historic station structures).

As much as possible or permissible, integrate local planning organizations to help facilitate Transit-Oriented Development (TOD) for station areas. It is the policy of FRPR to support TOD to the extent possible to ensure safe and efficient system function.

8.5.2 ADA REQUIREMENTS

Reserved.

8.5.3 FENCING

Reserved.

8.5.4 SIGNAGE

Reserved.

8.5.5 UTILITIES

Reserved.

8.5.6 DRAINAGE

Reserved.

8.6 AMENITIES

Reserved.

8.7 ACCESS AND CIRCULATION

Stations, platforms, and supporting infrastructure shall be designed in such a way that maximizes connectivity and safety for passengers and operations, while ensuring effective context-sensitive design that integrates with the local community. Underlying site requirements that support transit, such as parking, furnishings, operating equipment, shelters, and landscaping provide convenience, comfort, accessibility, and an enhanced transportation experience for all users.

8.7.1 MULTIMODAL ACCESS

FRPR Stations shall be designed with the intent to serve multiple modes of transportation; notably rail (FRPR or other passenger rail systems), bus, pedestrian, TNC, bicycle, and automobile. Each mode of transportation presents specific circulation and operational requirements, and all modes must respect and enhance the operation and access of other modes in and around the rail facilities.

FRPR Station Designs shall include a multimodal access plan, documenting how each planned mode of access is accommodated, including specific paths from arterial facilities or other major transportation corridors.

8.7.1.1 PASSENGER RAIL / LIGHT RAIL

Station layouts for passenger circulation should facilitate simple, readily apparent, and efficient transfers between FRPR trains and passenger or light rail service.

8.7.1.2 BUS

Designers and planners shall anticipate integration of local and regional bus service into FRPR stations as a connecting mode. Where applicable, the hierarchy of vehicular access modes shall give priority to bus traffic. In designing for bus system integration, designers shall consider the following:

A. Minimize the situations where buses would cross FRPR or other tracks.
B. Provisions to provide bus service in the event of FRPR system outage.
C. Separate access for buses and privately-owned automobiles
D. Minimize conflicts between buses, trains, automobiles, bicycles, and pedestrians

Ensure compliance with the design criteria of the local transit operator that would likely provide bus service to the station. Coordinate with the local transit operator in the design and planning process for station areas.

8.7.1.3 PEDESTRIAN

Good pedestrian circulation to, from, and across train stations is essential for the smooth and safe operation of stations. Circulation patterns should be as simple, obvious, and comfortable as possible.

Provide the shortest travel path from station entrance to platforms. All access paths shall be ADA compliant, and distinctly not interfered with by other modes.

Additional discussion and criteria for pedestrian circulation inside the station is provided in Section 8.7.2 - Station Circulation.

8.7.1.4 BICYCLE

Passengers arriving and departing from stations via bicycle shall be accommodated in the safest and most inviting manner possible. Smooth transitions between roadway and station areas should be provided. Designs may include designated dismounting areas or similar location for cyclists to dismount prior to accessing station platforms.

Station area access plans should include added signage and improvements for wayfinding from bicycle facilities to locate and access FRPR stations.

Bike racks and lockers shall be located at park and ride facilities in accordance with Section 12. - System Safety and Security. Bike lockers and racks shall not be located on the platform or within 250 feet of a station area or passenger gathering area.

8.7.1.5 AUTOMOBILE

FRPR Stations shall accommodate auto access for passenger drop off (kiss-and-ride) as well as parking (park-and-ride). Exceptions to automobile access requirements shall be via variance with FRPR engineering and are anticipated where station locations are inconsistent with inclusion of park-and-ride facilities.

Automobile access shall be provided in a manner that meets state and local design guidelines and does not interfere or degrade access modes of higher priority.

Motorcycle parking shall be considered, and separate provisions shall be made in the layout for secure and economic motorcycle parking close to platforms where car parking may not be possible.

The required number of parking spaces shall be based on forecast ridership for both FRPR and connecting transit modes and be provided by FRPR. Parking structures may be considered to accommodate the parking need.

8.7.1.5.1 ELECTRIC VEHICLE CHARGING

All FRPR stations shall include charging stations for electric vehicles. Charging stations shall be Level 2 chargers, and Fast Chargers may be installed as supplementary to these requirements.

Level 2 charging stations shall comply with SAE J1772 standards for AC 208/240 volt, 30 amps. Charging stations shall be outdoor, commercial grade, wall, or pedestal mounted equipment with robust weatherproof construction, and shall comply with NEMA 3-R for indoor/outdoor use.

A minimum of 20% of parking spaces shall be equipped with EV Charging. Designers should consider future installation of additional charging infrastructure to 50% or more of spaces in the layout of parking lots, such as including spare conduits in median spaces and oversizing electrical equipment that supplies the infrastructure.

EV Charging spaces shall be marked and signed in accordance with the latest CDOT Standards.

FRPR stations that do not accommodate parking (by variance) will not be required to include EV Charging.

8.7.1.6 EMERGING TRANSPORTATION MODES

Designers of station access shall consider emerging transportation modes in the development and layout of station accesses. These modes may include (but are not limited to):

- Transportation Network Companies (TNC) – such as ridesharing services

- Micromobility
- Dockless or docked bikes and scooters
- Connected and autonomous vehicles

Specific design and layout needs for those modes may be dynamic, so a flexible space (with the potential for electric service) may be considered as a mitigation technique.

8.7.2 STATION CIRCULATION

Effective pedestrian circulation at stations improves the efficiency and overall function of the FRPR system. Passenger walkways and movement areas shall be in compliance with ADAAG and ANSI A17-1.

Designers of station areas should consider the following in efforts to achieve effective passenger orientation and circulation:

A. Pedestrian access from bus, drop-off/pick-up lanes, and park-and-ride areas shall be as clear and simple as possible
B. Circulation elements shall use color, texture, and pattern and sight distances to increase visual pleasure, guidance, patron safety and security.
C. Generally, provide right-hand circulation.
D. Circulation shall be designed to provide ample waiting space adjacent to, but out of the mainstream of, pedestrian flow.
E. Surge and queuing spaces shall be provided ahead of every barrier and change in circulation, direction, or mode.
F. Cross flows, dead ends, and turns greater than 90 degrees are undesirable for both patron security and circulation.
G. Avoid cross-circulation at fare collection and decision points.
H. Provide well-lit pedestrian walkways.
I. Locate passageways, shelters, stairways, etc., to encourage balanced train loading and unloading. Passengers tend to board at such connection points on the platform.
J. Minimize grade changes. Design grade changes in compliance with Section 8.7.2.3 - Vertical Circulation.

8.7.2.1 EGRESS

All platforms shall have a minimum of two access and egress locations that meet the requirements of NFPA 130.

8.7.2.2 WALKWAYS

Walkways shall be 8 feet wide to allow for passage between pedestrians and bicyclists, except at crossing, the walkways shall be 10 feet wide. Provide adequate sight distance and visibility along pedestrian routes. Pedestrian walkways shall be well lit.

8.7.2.3 VERTICAL CIRCULATION

Provide stairs and ramps if required. Elevators and escalators are not preferred. Site selection, however, should serve to eliminate the need for vertical circulation. All vertical circulation elements shall conform to all building code requirements and accessibility standards per American with Disabilities Act Accessibility Guidelines (ADAAG).

8.7.2.3.1 STAIRS AND RAMPS

Stairs and ramps shall be provided where changes in grade make vertical access to platforms a necessity. At locations where grade changes of 10 feet or more occur, for example at pedestrian overpass, elevators may be considered. Exterior stairs at FRPR stations are cast-in-place concrete. Use of precast concrete or steel stairs is discouraged.

8.7.2.3.2 ELEVATORS

Elevators may be considered for platform access only where vertical distance makes ramps impractical, which is generally defined as greater than 12 feet. Installation of elevators only with approval of FRPR Engineering. Elevators should be located adjacent to the main access point of platforms.

Elevators are typically prone to maintenance for functional and general upkeep; therefore they are generally economically prohibitive. The machinery requires mandatory regular safety inspections as part of permitting by the state.

8.7.2.3.3 ESCALATORS

Escalators may be considered for platform access where stair rise exceeds 24 feet in height and were justified by passenger volume, and only with approval of FRPR Engineering. Escalators serving platforms shall be fully enclosed in weather-tight structures and enclosed landings shall be provided at platform level

9. AESTHETIC AND CONTEXT SENSITIVE DESIGN

Reserved.

10. COMMUNICATIONS AND CONTROL

10.1 FARE COLLECTION

Reserved.

10.2 COMMUNICATIONS

Reserved.

10.3 SCADA

Reserved.

11. SIGNAL SYSTEM

Reserved.

12. SYSTEM SAFETY AND SECURITY

Reserved.

13. SUPPORT FACILITIES

13.1 MAINTENANCE FACILITIES

13.1.1 CONCEPT OF OPERATIONS

The layout of the general FRPR corridor suggests the need for at least one maintenance facility that provides service to rolling stock and motive power, and that can provide storage for trainsets when not in operation. Phased implementation suggests that this facility is likely located north of Denver, with a future satellite facility located near Pueblo to reduce deadhead moves for light maintenance and inspection. This primary maintenance facility may be combined with an operations base with dispatching and train control, as well as administrative functions, and the criteria for these facilities are in Section 13.2 - Operations Facilities. Centralized maintenance of way (MOW) facility design needs will be included in the criteria, but it is anticipated that satellite MOW facilities will be needed as the line expands.

13.1.2 CENTRAL MAINTENANCE FACILITY

The proposed central maintenance facility is intended to serve:

- Routine operational service, such as:
  - Passenger coach cleaning, resupply, and waste discharge
  - Locomotive fueling, sand replenishment
  - Washing of trainsets
- Running Repair Track (RIP Track)
  - For minor repairs of trainsets without uncoupling
- Diesel Locomotive repair, both light and medium duty, including:
  - Change out of locomotive wheel sets and traction motors,
  - Change out of trucks
  - Change out locomotive power units or perform service on traction motors
  - Structural repairs following wrecks
  - Lubrication and cooling water replacements
  - Brake component changes
  - Operational testing
  - And other minor adjustments and repairs
- Passenger fleet repair; both light and medium duty
- Coach and locomotive storage, including space for complete trainsets
- MOW Fleet Base and Repair Facility
  - Storage and medium-duty of MOW on-track equipment
  - Storage of MOW rubber-tired equipment
- Central storage of:
  - Mechanical and electrical equipment for locomotives and coaches

    - Fuel
    - Lubricating oils
    - On-track equipment and signaling equipment
    - Track materials

13.1.3 SATELLITE FACILITIES

The satellite fleet maintenance facilities are intended to provide:

- Routine operational service, such as:
    - Passenger coach cleaning, resupply, and waste discharge
    - Locomotive fueling, sand replenishment
    - Washing of trainsets
- Running Repair Track (RIP Track)
    - For minor repairs of trainsets without uncoupling
- Storage of 2-3 trainsets
- Storage of immediate need repair parts in concert with RIP track scope of work

The satellite MOW facilities are intended to provide:

- Storage for rubber-tired MOW equipment
- Limited storage of rail-based MOW equipment
- Storage of immediate-need maintenance items, such as signaling components, switch parts
- Office and MOW crew base space

13.1.4 SITE CONSIDERATIONS

For planning and initial concept evaluation purposes, sites for maintenance facilities should:

1. Be located on or have a short (<1 mile) rail connection to the FRPR main line
2. Have an area of 30-40 acres, generally 3:1 length-to-width (Central Facility only)
3. Have relatively flat and level ground
4. Be supplied with domestic water, electricity, and natural gas
5. Have easy access to the highway system for both delivery and departing maintenance vehicles

13.2 OPERATIONS FACILITIES

Reserved.