

# **SANDAG** *Design Criteria*



## *LOSSAN Corridor in San Diego County*





## Approvals page for Design Criteria

*Prepared by:*

The San Diego Association of Governments (SANDAG)

This Manual is published as a set of general guidelines for the planning and design of LOSSAN Rail Projects. While this Manual is comprehensive, it is not meant to replace the standard design process. Project design is still the responsibility of the designer.

The intent of the Manual is to establish general criteria for the project design. However, deviations are anticipated from time to time. The Director of Rail must approve any such changes or deviations.

This Design Criteria comes into effect for projects where the design starts on a date after this page of the design criteria has been agreed and approved by both SANDAG and NCTD.

Prepared by Bruce Smith PE et al  
SANDAG Senior Engineer *BS*

Recommended by Jennifer Ryan *JR*  
NCTD Senior Rail Engineer

Approved by:



Don Filippi  
NCTD Chief Operations Officer

Date *8-22-2017*

Approved by:



John Haggerty  
SANDAG Director of Rail

Date *9/16/2017*

**REVISION RECORD**

<b>Rev. No</b>	<b>Author</b>	<b>Date</b>	<b>Section(s) affected</b>	<b>Description</b>
Draft 1	Bruce Smith etal	10/2014	1, 2, 3, 4, 6, 7, 8, 9, 10 & 11	Revised numbering of Plans and Chapters
Draft 2	Bruce Smith etal	5/27/2015	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 17 & 18	Minor edits to Chapters 1, 3, 4, 6, 7, 8, 9 & 10. Added Signals and Grade Crossing Warning Systems Ch. 17 & 18
Draft 3	Bruce Smith etal	6/30/2016	All	Added Ch. 5, 12, 13, 14, 15, 19 & 20
Draft 4	Bruce Smith etal	5/19/2017	1, 2, 3, 4, 6, 7, 9 & 10	Edits requested by NCTD Chiefs and SANDAG Director of Engineering

## Contents

Chapter	Subject	Date Agreed
1	General	April 2017
2	Survey and Right-of-Way	July 2017
3	Environmental Guidance	May 2017
4	Clearance and Rolling Stock	February 2017
5	Geology	June 2016
6	Track	May 2017
7	Stations and Signage	May 2017
8	Drainage and Grading	June 2016
9	Utilities and Pipelines	April 2017
10	Railway Structures	July 2017
11	Bridge Load Ratings	June 2016
12	Seismic	June 2016
13	Mechanical	June 2016
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15	Electrical	June 2016
16	Aesthetic Considerations	June 2016
17	Train Control Signals	June 2016
18	Grade Crossing Warning Systems	June 2016
19	Grade Crossing Roadway Traffic Systems	June 2016
20	Service and Layover Facilities	June 2016

<b>Appendices</b>	
Appendix A	Terms and Definitions
Appendix B	Acronyms
Appendix C	Request to Deviate from Baseline Document
<b>Reference Documents</b>	
SANDAG CADD Manual	March 2012
SANDAG Infrastructure Development Plan for the LOSSAN Rail Corridor in San Diego County	August 2013
SANDAG San Diego Region Coastal Sea Level Rise Analysis	September 2013
SANDAG Service Life Design Guide for Corrosion Prevention of Concrete Structures on LOSSAN Rail Corridor in San Diego County	October 2015
NCTD Landscape Design and Maintenance Plan	June 2015
NCTD Integrated Pest Management Plan	June 2015



## LOSSAN Corridor, Draft Design Criteria Acknowledgments

The following table denotes the responsible consultant personnel who have lead the effort of completing the various chapters of this Design Criteria Manual.

Chapter	Title	Firm	Lead
1	General	RailPros	Chris Coffman
2	Survey & Row	PDC & RailPros	Gary Hus & Chip Willett
3	Environmental Guidelines	Dudek, SCM & SANDAG	Sherr Miller, Shaun Flater & Cheryle Hodge
4	Clearance & Rolling Stock	RailPros	Chris Coffman
5	Geology	Lieghton & Associates	Sean Colorado
6	Track	HDR	Ray Gigear Russ McNaught
7	Stations and Signage	RailPros & SKA	Chris Coffman Joseph Stoddard
8	Drainage And Grading	Rick Eng	Roberta Cronquist Dennis Bowling
9	Utilities and Pipelines	Metrolink	Engineering & Construction
10	Railway Structures	HDR	Eric Johnson Michael Boraks
11	Bridge Load Ratings	Metrolink	Engineering & Construction
12	Seismic	HDR, HNTB & RailPros	Eric Johnson, Pat Pence & Bob Matthews
13	Mechanical	Metrolink	Engineering & Construction
14	Corrosion Control	Tourney Consulting	Neal Berke & Paul Tourney
15	Electrical	Metrolink	Engineering & Construction
16	Aesthetics	SANDAG	Danny Veeh
17	Train Control Signals	PRE	Raul Martinez
18	Grade Crossing Warning System	PRE	Raul Martinez
19	Grade Crossing Roadway Traffic Systems	STC	Jason Stack
20	Service and Layover Facilities	RailPros	Johnny Johnson

We wish to acknowledge the assistance of Naresh Patel and Arturo Carlos at Metrolink for their assistance in sharing their design criteria and associated engineering standard plan set.

The Metrolink, Engineering and Construction Department's, Design Criteria was used as the base document for developing the LOSSAN San Diego Design Criteria. However due to the unique features of the LOSSAN Corridor in San Diego County many chapters have been revised to meet the needs of the Rail Agencies in San Diego County.

The Metrolink Engineering Standard Plans were used and modified to meet the needs of the Rail Agencies in San Diego County by RailPros.



## Chapter 1

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## **1.0 GENERAL INFORMATION**

### **1.1 PURPOSE**

This manual provides design criteria to be used in the design of projects on the mainline, Los Angeles to San Diego (LOSSAN), rail corridor in San Diego County. The LOSSAN corridor comprises approximately 60 route-miles of mainline track from the Orange County Line at MP 207.4 near San Mateo Creek to Santa Fe Depot at MP 267.5. This Design Criteria is Part III of the San Diego Association of Governments (SANDAG) Transit Design Criteria and is also used by NCTD.

The design for the LOSSAN shared use Corridor should consider safety, travel times, passenger comfort, and maintenance costs, based on accepted railroad industry engineering practice and the experience of conventional mixed freight and passenger train operations.

### **1.2 TERMS, DEFINITIONS AND ACRONYMS**

Technical terms, definitions and acronyms used in this document are provided in Appendix A and B, respectively.

### **1.3 LOSSAN ROLES AND RESPONSIBILITIES**

#### **1.3.1 INTRODUCTION**

SANDAG in accordance with Senate Bill 1703 is responsible for the planning, design and construction of new capacity enhancing capital projects. SANDAG has final approval of items relating to capital project design. NCTD maintains the rail infrastructure and operates the Coaster Commuter trains and stations. NCTD has final approval of items affecting rail operations, maintenance and safety. NCTD also maintains and operates transit systems that interconnect with the LOSSAN Corridor, such as the Sprinter light rail system and the Breeze bus system.

#### **1.3.2 HISTORY**

In 1992 the railroad corridor was purchased by: NCTD from MP 207.4 (county line) to MP 245.7 (Del Mar) in north county and MTS from MP 245.7 to MP 267.5 (Santa Fe Depot) in the City of San Diego. In 1993 the Escondido subdivision was purchased. The railway was purchased from the Atchison, Topeka, and Santa Fe Railway to preserve and expand the passenger services on the lines. A provision of the purchase is that the freight operations of the railway and its successor (the BNSF) are to be continued in conjunction with passenger operations. Also, the rights and obligations of the holders of transverse and longitudinal real estate agreements, (including utility franchise and easement agreements) were continued under NCTD/MTS ownership.

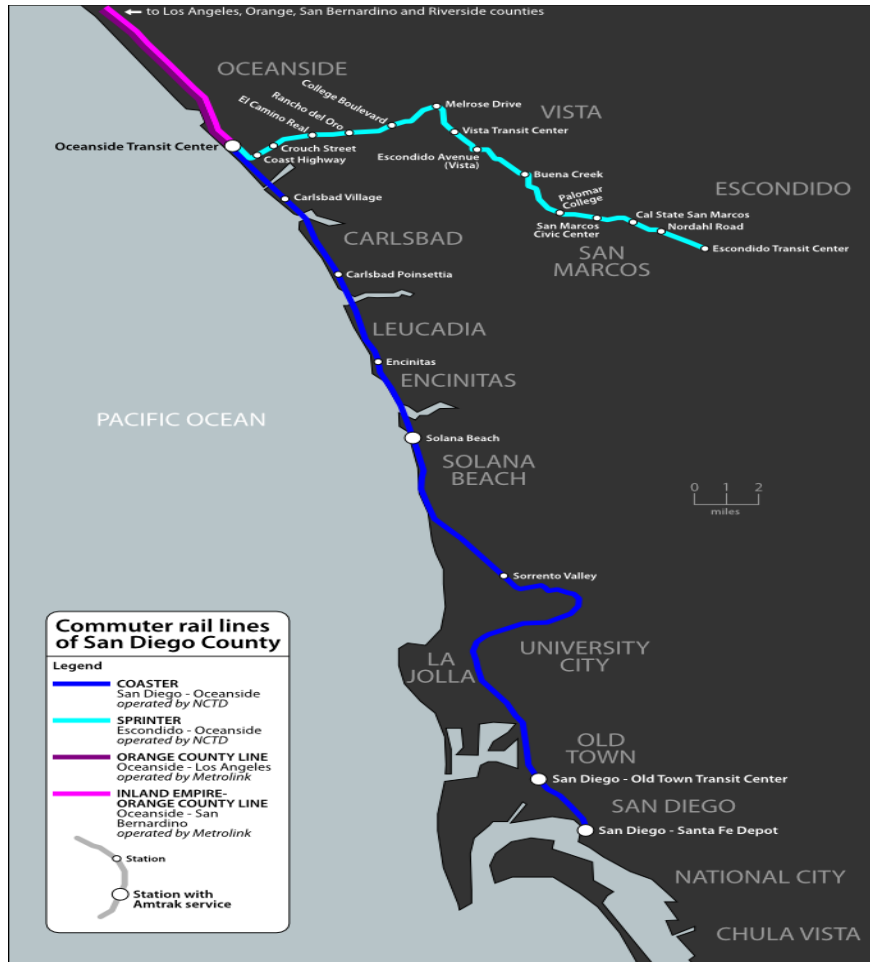
A shared use agreement exists to support Burlington Northern and Santa Fe Railroad (BNSF) freight (“goods movement”), AMTRAK Intercity Surfliner, and Southern California Regional Rail Authority (SCRRA) “Metrolink” passenger rail services.

On January 1, 2003, a new state law (SB 1703) consolidated the roles and responsibilities of SANDAG, NCTD and MTS. The consolidation mandated that SANDAG to assume transit planning, funding allocation, project development, and construction of regional transportation projects in the San Diego region. The consolidation left the transit operations, maintenance, security, safety, Right of Way (ROW) and minor capital projects with the Metropolitan Transit Development Board and the North San Diego County Transit Development Board. The roles and responsibilities are further defined in Memorandum of Understandings and Addendums.

### **1.3.3 SANDAG**

SANDAG is governed by a Board of Directors composed of mayors, council members, and county supervisors from each of the region's 19 local governments. Supplementing these voting members are advisory representatives from Imperial County, the U.S. Department of Defense, Caltrans, San Diego Unified Port District, Metropolitan Transit System, North County Transit District, San Diego County Water Authority, Southern California Tribal Chairmen's Association, and Mexico. The Board of Directors is assisted by a professional staff of planners, engineers, and research specialists.

SANDAG secures funding for LOSSAN capacity enhancing projects and is responsible for the planning, design engineering and construction for these projects. When completed SANDAG turns the facilities over to NCTD to operate and maintain. SANDAG receives funding from Local, State, and Federal sources. Figure 1-1 below shows the LOSSAN and related commuter rail lines in North San Diego County; NCTD Coaster System including stations and connecting Sprinter and Metrolink rail transit systems.



**FIGURE 1-1 Commuter Rail and LOSSAN**

**1.3.4 NORTH COUNTY TRANSIT DISTRICT - NCTD**

NCTD (Formerly North San Diego County Transit Development Board or NSDCTDB) owns the portion of the LOSSAN rail corridor in San Diego County in the Cities of Oceanside, Carlsbad, Encinitas, Solana Beach and Del Mar and maintains the rail infrastructure and operates the Coaster Commuter trains and stations in the joint NCTD/MTS Corridor. NCTD also maintains and operates Transit Systems that interconnect with the LOSSAN Corridor, such as the Sprinter Light Rail system and the Breeze bus system.

The COASTER train carries passenger on a 41-mile route between Oceanside and San Diego with an average of 6,000 passengers on weekdays. Refer <http://www.gonctd.com> for the current schedule.

**1.3.5 SAN DIEGO METROPOLITAN TRANSIT SYSTEM - MTS**

MTS owns the City of San Diego portion of the LOSSAN rail corridor in San Diego County. MTS also maintains and operates transit systems, that interconnect with the LOSSAN Corridor trains, such as the San Diego Trolley Light Rail system and the MTS bus system.

### 1.3.6 METROLINK COMMUTER OPERATIONS

SCRRA operates METROLINK service on the LOSSAN Corridor in San Diego County between the Orange County Line and the City of Oceanside. Refer to <http://www.metrolinktrains.com> for current schedule.

### 1.3.7 AMTRAK PACIFIC SURFLINER

Amtrak operates regional passenger service between San Diego and Los Angeles, (the "LOSSAN Corridor") on the MTS/NCTD rail infrastructure. Hours of operation vary by day. Scheduled passenger services are shown on the most recently issued passenger schedule, which may be obtained from the Official AMTRAK Website at <http://www.amtrak.com>. Additional special event trains may be operated on some weekends.

### 1.3.8 BNSF FREIGHT SERVICE

BNSF operates freight rail services per the Shared use Agreement with NCTD. BNSF allows access to the freight tracks and sidings in downtown San Diego, south of the Santa Fe Depot for storing Coaster trains during off peak times of the day. Catellus merged with Prologis oversees the depot.

### 1.3.9 HOLIDAY OPERATIONS

Metrolink and NCTD Coaster have no operations on the following holidays: New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, and Christmas Day. BNSF may operate any day of the year on the LOSSAN Corridor. For BNSF schedules contact NCTD operations. Refer to AMTRAK/NCTD websites for current Holiday schedule.

### 1.3.10 FACILITIES & INFRASTRUCTURE

LOSSAN Corridor trains operate on North County Transit Coaster (NCTC) track and right of way, which are owned either by NCTD or MTS. Or on an easement on Camp Pendleton.

- NCTD has an easement across Camp Pendleton from MP 207.4 (county line) to near MP 225.1 (Eastbrook) the north border of Oceanside.
- NCTD owns from near MP 225.1 (Eastbrook) the north border of Oceanside to MP 245.7 (the south side of Del Mar) in north county.
- MTS owns from MP 245.7 to MP 267.5 (Santa Fe Depot) in the City of San Diego.
- BNSF owns from MP 267.5 at (Santa Fe Depot) in the City of San Diego to National City as listed in table below.

Real Property	Owner
MP 207.4 to MP 225.1	Easement to NCTD from Camp Pendleton
MP 225.1 to MP 245.7	NCTD

<b>Real Property</b>	<b>Owner</b>
MP 245.7 to MP 267.5	MTS
MP 267.5 to National City	BNSF

NCTD owns a fleet of locomotives and coaches that are stored and maintained at the Coaster Maintenance Facility located at Stuart Mesa on the grounds of Camp Pendleton Marine Corps Base. Coasters are also stored at the BNSF yard south of the Santa Fe Depot.

### **1.3.11 TRAIN DISPATCHING**

The dispatching functions for LOSSAN and Sprinter in San Diego County are performed from the NCTD Sprinter Operations Facility at Escondido.

## **1.4 DESIGN STANDARDS**

### **1.4.1 SCOPE**

The requirement for railroad geometric design is to provide a track structure that is; safe, regulatory compliant, economical and provides for efficient train operations and maintenance. NCTD, SCRRA, and Amtrak, as commuter operations, place a high priority on passenger safety and on minimum travel times. The design, maintenance, and operation of the corridor must also support BNSF freight operations as a part of goods movements throughout the nation and to/from Mexico.

All designs for alterations of the corridor must include staging plans to maintain passenger and freight train services to the public during construction except for occasional and limited pre-approved suspensions of train operations, or Absolute Work Windows, for some week-ends when no other method of accomplishing the work is practicable.

The criteria presented herein follow accepted engineering practices used on operating Class 1 railroads, including but not limited to the requirements of FRA, CPUC, BNSF, SCRRA, and Amtrak as appropriate.

The design criteria will take precedence over all other standards referred to herein with the exception of those criteria mandated by legislation or existing agreements. On LOSSAN passenger trains operates on right-of-way shared with freight trains, in this regard the design requirements of BNSF shall also be considered according to the Shared Use Agreement.

In addition to this Design Criteria Manual, the Design Engineer must be familiar and 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 LOSSAN system, then the most recent edition(s) shall be used. Responsibility for design remains

with the Design Engineer in accordance with the terms and conditions of their design contract.

Individual chapters of these criteria may also define additional code requirements. Where any conflict in criteria exists, the stricter criteria shall govern unless stated otherwise in this document, or approved in writing by SANDAG and or NCTD. Where design codes conflict with each other, the Design Engineer shall notify the lead agency in writing and recommend a solution. The Design Engineer shall also investigate those codes and manuals that have precedence.

The railroad design, maintenance, and operation shall comply with all applicable parts of the State of California general laws, CPUC requirements, FRA safety requirements, and the specific project requirements.

Where Mainline track is adjacent to the MTS Trolley operations. The MTS/SANDAG Trolley Design Criteria should be referenced.

Specific codes and standards include, but are not limited to, the following:

**A. Federal and National;**

- American Railway Engineering and Maintenance-of-Way Association (AREMA) Recommended Practice
- American Concrete Institute (ACI)
- American Welding Society (AWS)
- American Society for the Testing of Materials (ASTM)
- Americans with Disabilities Act (ADA)
- Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)
- American Association of State Highway and Transportation Officials (AASHTO)
  - AASHTO – Guide Specifications for Design of Pedestrian Bridges
  - AASHTO – Highway Signs, Luminaries, and Traffic Signals
  - AASHTO – Roadside Design Guide
  - AASHTO – Standard Specifications for Highway Bridges
  - AASHTO - Standard Specifications for Structural Supports for Highway Signs
- American Institute of Steel Construction (AISC)
- American National Standards Institute (ANSI)
- CFR Part 195 - Transportation of Hazardous Liquids by Pipeline
- FRA safety standards, including but not limited to Parts 213, 214, 234 and 236
- Local jurisdictional codes, requirements and ordinances, as applicable
- National Electric Code (NEC)
- National Electric Safety Code (NESC)
- National Fire Protection Association (NFPA) including NFPA 130 and 101
- International Building Code (IBC)
- Uniform Fire Code
- USDOT MUTCD Manual (CA MUTCD)



## B. State of California;

- Government Code of the State of California
- Cal OSHA - Safety Orders
- CPUC general orders as follows:
  - CPUC GO No. 26 - Clearances
  - CPUC GO No. 33 - Interlocking Plants
  - CPUC GO No. 36 - Abolition of Services
  - CPUC GO No. 72 - At-Grade Crossings
  - CPUC GO No. 75 - Protection of Crossings
  - CPUC GO No. 88 - Rules for Altering Public Grade Crossings
  - CPUC GO No. 95 - Rules Governing Overhead Electric Line Construction
  - CPUC GO No. 112 - Utility Construction
  - CPUC GO No. 118 - Walkways Maintenance and Construction
  - CPUC GO No. 128 - Rules for Underground Electric Construction
- Caltrans Highway Design Manual
- SWQCB's NPDES Construction General Permit (CGP) order 2010-0014-DWQ and in particular section XIII.A.4, hydro-modification management.

## C. Regional:

- LOSSAN Corridor standards and specifications;
  - LOSSAN San Diego Design Criteria Manual (this document)
  - LOSSAN Design Procedures Manual
  - SANDAG CADD Manual
  - LOSSAN Corridor, San Diego Subdivision, Engineering Standard Drawings
  - NCTD Standard Specifications
  - NCTD Track Maintenance and Engineering Instructions
  - NCTD CWR Plan
  - NCTD Stormwater Management Plan (Includes SWPPP Templates)
- "Greenbook" Standard specification for Public Works Construction (SSPWC), ["Greenbook" Committee of Public Works Standards, Inc.](#)
- San Diego Area Regional Standard Drawings <http://www.regional-stds.com>
- The SANDAG LRT Design Criteria for MTS Trolley for trolley projects.
- Local:
  - Standards of the Cities of San Diego, Del Mar, Solana Beach, Encinitas, Carlsbad and Oceanside (where applicable to work outside the Railway ROW)
    - Standard Drawings
    - Traffic Control Plans
    - Local Fire Marshal requirements for facilities

### 1.4.2 DESIGN LIFE

The LOSSAN Corridor is an Intercity Rail Corridor and as such the design life will be 100 years for civil and structural design for new projects along the main line and for multi-story

parking garages. The design life will be 50 years for stations, parking lots and roadway access to match local standards.

### **1.4.3 DESIGN CRITERIA DEVIATIONS AND EXCEPTIONS**

Deviations may be made within the framework of the Design Criteria to meet the requirements of a particular issue. However, any deviation, discrepancy or unusual solution must be approved by SANDAG before it can be included in the design. It is the responsibility of the Design Engineer to identify, explain, and justify any deviation from the established criteria and to secure the necessary approvals from SANDAG. Any variation from these Design Criteria must be submitted on a request to deviate from baseline documents and be approved in advance by SANDAG's Director of Rail. NCTD and/or MTS the operating Agencies will need to review and approve design exceptions that may affect operations, safety or maintenance on the LOSSAN Corridor. The Request to Deviate from Baseline Criteria or Standard Form is provided in Appendix C. Should a design deviation affect the NCTD Shared use Agreement with BNSF then BNSF should be consulted via NCTD.

### **1.4.4 DESIGN CODES AND MANUALS**

Additional manuals are available from SANDAG and will be used for the design development of projects.

- A. *SANDAG Configuration Management Plan*
- B. *SANDAG Design Procedures Manual*
- C. *SANDAG CADD standards*

### **1.4.5 UPDATING THE CRITERIA**

This is a control document and as such shall be updated on a periodic and as needed basis. SANDAG's Director of Rail will be responsible for periodically issuing revisions to this document. NCTD will forward any suggested revisions to SANDAG's Director of Rail or LOSSAN Corridor Director for incorporation into this manual.

## CHAPTER 2

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## 2.0 SURVEY AND RIGHT-OF-WAY

### 2.1 SURVEY

#### 2.1.1 SCOPE

This chapter establishes survey design criteria for horizontal and vertical control of facilities within and along the LOSSAN Corridor right-of-way (ROW). All survey work to be performed by or under the direct supervision of a California Licensed Surveyor (LS).

#### 2.1.2 STANDARDS, CODES AND GUIDELINES

The latest edition of the following standards, codes and guidelines shall be used for guidance on mapping, surveying or right-of-way work:

- Caltrans Orders of Survey Accuracy per the Caltrans Surveys Manual  
[http://www.dot.ca.gov/hq/row/landsurveys/SurveysManual/05\\_Surveys.pdf](http://www.dot.ca.gov/hq/row/landsurveys/SurveysManual/05_Surveys.pdf)
- Caltrans Control surveys per the Caltrans Surveys Manual  
[http://www.dot.ca.gov/hq/row/landsurveys/SurveysManual/09\\_Surveys.pdf](http://www.dot.ca.gov/hq/row/landsurveys/SurveysManual/09_Surveys.pdf)
- Caltrans Right of Way Specifications per the Caltrans Surveys Manual  
[http://www.dot.ca.gov/hq/row/landsurveys/SurveysManual/10\\_Surveys.pdf](http://www.dot.ca.gov/hq/row/landsurveys/SurveysManual/10_Surveys.pdf)
- GPS Survey Control Points for North County Transit District, prepared by Project Design Consultants (PDC) 2007 and available upon request.

#### 2.1.3 CALIFORNIA STATE PLANE COORDINATES

The LOSSAN survey control network and its railroad design criteria are based on the California Coordinate System. Unless otherwise directed all surveys performed for NCTD and SANDAG shall be on the California Coordinate System, the North American Datum of 1983 (NAD83) horizontal datum (CCS83) in conformance with the California Public Resources Code Section 8802 and 8813.1. Surveyors working on the LOSSAN corridor shall be familiar with these codes because they define the CCS and provide for its use. Products, deliverables, and calculations having to do with ROW engineering shall be also on said CCS83. These datum specifications are described and discussed in detail in the section on Survey Control and Geodetic Surveying, below.

The State of California is comprised of six zones, all utilizing the Lambert Conformal Conic Projection. The San Diego Subdivision of the LOSSAN corridor lies within one zone. Zone VI covers four counties, which include Orange, Riverside, Imperial and San Diego. Survey work performed for NCTD and SANDAG shall be based on this zone.

## **2.1.4 SURVEY CONTROL AND GEODETIC SURVEYING**

Survey control establishes a common, consistent network of physical points that are the basis for controlling the horizontal and vertical positions of rail transportation improvement projects and facilities. The survey control network ensures that adjacent projects have compatible control. Furthermore, a precise control network provides consistent and accurate horizontal and vertical control for all subsequent project surveys, including photogrammetric, mapping, planning, design, construction, and ROW boundary surveys.

The following policies, standards, and procedures shall be applicable for any survey control work for any capital improvement project unless otherwise agreed upon. This includes surveys performed by consultants, local agencies, private developers, and others.

All survey work shall be based on the California Coordinate System per the State of California Public Resource Code Section 8802 and 8813.1 Any new GPS Control Network shall employ the principals of geodesy. Surveys employing the principals of geodesy are of high precision and generally extend over large areas, such as the rail corridor, which runs north to south from the San Diego/Orange County Line to Sante Fe Railroad Depot at Broadway in downtown San Diego for a total of approximately 60 miles. It is important to understand the elements that comprise geodetic surveys in order to understand requirements for geodetic surveys along the LOSSAN corridor.

Any new GPS Control Network also should be established to replace or supplement an existing or aging corridor control network. Any control network along this corridor could be by nature linear and therefore presents problems associated with its geometric shape. Any survey network in a corridor shall be planned and performed with this important consideration in mind.

In addition to concerns with the geometry of the network, further planning shall be conducted to accommodate various levels of surveying expertise and instrumentation that may be employed along the corridor. This network can accommodate theodolite, total stations, static global positioning system (GPS), real-time kinematic (RTK) GPS, long-range RTK GPS, laser scanner systems, and traditional and digital differential levels. It is important to understand the elements that comprise a geodetic survey in order to understand a control network.

Please refer to the current State of California Department of Transportation (CALTRANS), Division of Right of Way and Land Surveys, Surveys Manual chapters 5 and 9 for general control information and accuracy specifications. A control network of a mile or more length will have geodetic considerations and will need to be designed to be at a precision level of First-Order or better. Said control network will need to be field surveyed, constrained and adjusted to published high-order geodetic control stations being either ground stations or Continually Operating Reference Stations (CORS).

At a minimum the following data needs to be cited:

- a. Datum, epoch, geoid and source of high-order control
- b. Control station description, sketch, photograph, vicinity map and other pertinent information all on a consistent form.

- c. Control procedure, existing control stations utilized, equipment employed, processing software and final adjustment report all contained in a concise but complete report.

### **A. Horizontal Datums**

The GPS Control Network is based upon NAD 83, and all geodetic surveying work performed for NCTD and SANDAG shall adhere to this datum. This is partly because California State Code presently requires surveyors to use NAD 83 as the reference frame for geodetic surveys.

Relative positioning data collected by surveyors can be tied to the NAD 83 datum using a State HARN (High Accuracy Reference Network) or the national CORS (Continuously Operating Reference Stations) network, or calculated from either a HARN or CORS. HARNs and CORS are from different adjustments and should not be used together in the same survey.

The National Geodetic Survey (NGS) has put all control under a national control system known as the NAD 83 National Spatial Reference System (NSRS). The NGS has combined all control points, including both HARN and CORS points, under one system. NCTD and SANDAG surveyor consultants shall use this system in conjunction with the California Spatial Reference System (CSRS).

### **B. Epochs**

An epoch can be calculated for any given moment in time and is a “snapshot” in time of all the horizontal positions of the included monumentation. The project lead agency shall specify which epoch is to be used as the basis for all geodetic survey performed on its ROW when required by a project or survey. The epoch of any geodetic survey conducted should be referenced. This is necessary to account for tectonic plate movement.

In San Diego most of the traditional standard geodetic ground monuments that are shown on recorded surveys are from the first comprehensive GPS/geodetic survey in the county which is dated 1991.35. This is the epoch used for the LOSSAN corridor network that was prepared in 2007 using numerous high precision monuments that we recovered and based that survey on.

The science community updates the epoch there are referencing to be as close to real time as they can and thus they have many epoch updates. The National Geodetic Survey (NGS) periodically updates a new official epoch with the current epoch being 2010.

Many surveyors today utilize either the County or private vendor GNSS (GPS) “Real Time Network” (RTN) positioning service. This allows them to have NAD-83 coordinates live in a GPS rover unit as they go without setting up a base station to get differential corrections. The epoch of the RTN system is not critical as they can localize to whatever control they like by surveying ground stations with established coordinates. This means that they can be on a different epoch as specified by the project needs.

### **C. The Geoid**

The most current Geoid published by NGS shall be used in the processing and adjusting of geodetic survey data while performing geodetic surveys along ROW corridors. The geoid is available to users via download on the NGS website.

## D. Vertical Datums

Vertical project control surveys shall be based on a single, common vertical datum to ensure that various phases of a particular project are consistent. The vertical datum for SANDAG or NCTD projects may be National Vertical Datum 1988 (NAVD 88) or National Geodetic Vertical Datum 1929 (NGVD 29) as originally established by NGS. The majority of historic road and railway information is in NGVD 29 and all current SANDAG LOSSAN double track projects are being designed using this datum. All scopes of services developed for SANDAG and NCTD shall specify which vertical datum the project will utilize. Various organizations use datums that best serve their needs and these different datums can cause confusion when trying to compare vertical data between projects performed by different agencies or private entities.

The origin of the datum of NGVD 29 is different than the origin of the NAVD 88 datum. However when incorporated into a geodetic control net the vertical values are reported as orthometric elevations. The following table provides a comparison of commonly used tidal datums.

Description	Elevation	Elevation	Elevation	Elevation
	(ft., MLLW)	(ft., NGVD29)	(ft., MSL)	(ft., NAVD88)
<b>Extreme High Water (11/13/1997)</b>	7.65	5.36	4.92	7.47
<b>Mean Higher High Water (MHHW)</b>	5.33	3.04	2.60	5.15
<b>Mean High Water (MHW)</b>	4.60	2.31	1.87	4.42
<b>Mean Tidal Level (MTL)</b>	2.75	0.46	0.02	2.57
<b>Mean Sea Level (MSL)</b>	2.73	0.44	0.00	2.55
<b>National Geodetic Vertical Datum 1929 (NGVD)</b>	2.29	0.00	-0.44	2.11
<b>Mean Low Water (MLW)</b>	0.90	-1.39	-1.83	0.72
<b>North America Vertical Datum 1988 (NAVD)</b>	0.18	-2.11	-2.55	0.00
<b>Mean Lower Low Water (MLLW)</b>	0.00	-2.29	-2.73	-0.18

Local cities or agencies may still use different vertical datums that are of some variation of mean sea level or differ from that of the NGVD 29 or NAVD 88 vertical datums and these differences will have to be taken into consideration when trying to use as-built plans on work performed by others on adjacent projects or on projects that are dated.

All vertical project control shall be accurate to within third-order accuracy or higher specifications per the current Caltrans Survey Manual (CSM), Chapter that details vertical control accuracies and standards.

## E. Control Station Monumentation



Control Station Monuments shall be located along rail transportation corridors in secure locations. The monument site shall be selected with the highest safety considerations in mind for the surveyor. If possible, monuments shall be accessible to the public, preferably in the railroad ROW or easement.

Benchmarks shall be of a stable and permanent nature. Monument types for benchmarks shall be chosen to suit the local conditions. Acceptable benchmarks are as follows:

- Concrete monument with metal disk
- Galvanized steel pipe with brass disk
- Steel rod or rebar with cap
- Metal disk epoxied in rock mass or bridge abutment
- Existing stable monuments

Control point monuments shall be set at locations where the base will be very stable such as concrete bridge abutments, concrete wing walls, tops of concrete channel walls, concrete platforms, etc. and outside the rail corridor so as to avoid disturbance or obliteration due to construction projects taking place along the corridor.

### **2.1.5 PRELIMINARY RIGHT-OF-WAY ASSESSMENT**

A Preliminary ROW Assessment is an in-house SANDAG tool or process for assessing property issues during the conceptual stage of proposed improvements. A Preliminary ROW Assessment process is not a boundary survey, nor is it designed to be used in replacement of, or in conflict with, state law and local law regarding boundary surveying. It is a process of examining available property record information in the area of a proposed improvement project. It is designed to produce an early assessment of the potential for property conflicts and the need for property acquisition in order to accommodate the needs of the proposed improvements. A Preliminary ROW Assessment, if requested by NCTD or SANDAG, shall be performed at the preliminary engineering stage of all projects to identify ROW impacts.

The preliminary ROW assessment shall include the following tasks:

- A. The ROW ownership and easements of records (if any) in the area of the proposed improvement project, shall be determined by utilizing the title and deed information made available from the ROW Owner on the subject property. For the LOSSAN Corridor, franchise rights only apply where a roadway crosses the railroad that existed prior to the original railroad grant, and that the roadway owner had prior rights.
- B. Request copies of any agreements (licenses, leases, etc.) within the project area that were inherited by ROW Owner as part of the purchase and sale agreement with A.T. & S.F. and request copies all new agreements issued by ROW Owner in the project area that were negotiated subsequent to purchase of the ROW from the BNSF Railway (formerly AT&SF).
- C. Research public records at the County of the subject property for recorded parcel maps, subdivision maps, records of survey, monumentation maps, ROW mapping and any other pertinent survey mapping records that may have been prepared in and around the

subject property.

- D. Request historic A.T. & S.F. ROW and track mapping, valuation maps, and station maps available in ROW Owners in-house mapping records for original track alignment and parcel configuration information.
- E. Request any ROW Owner records for ROW work previously performed in the area of the subject property.
- F. Prepare a CADD base map compiled from the record information and available topographic information which must be correlated. This process may require a sufficient number of boundary corner monuments to be field located and/or a verification of common coordinate system and epoch for both the topography source and the record map compilation.
- G. Provide NCTD with a comprehensive list of all agreements/rights in Excell format, highlighting discrepancies.

### **2.1.6 RIGHT-OF-WAY BOUNDARY RESOLUTION**

A ROW boundary resolution will be performed at either 10% or 30% design stage as this is a critical design element and may affect final engineering. The ROW boundary resolution shall be performed and/or supervised by a California Licensed Land Surveyor and at a minimum shall include the following:

- A. The ROW survey will be based upon a field survey to recover available evidence in the form of survey monuments and other physical features that may indicate lines of possession.
- B. Ideally the records research described in the preliminary ROW assessment will provide the basis to begin the field survey. The recovery of field evidence may lead to the need for additional records research.
- C. As part of the gathering of field evidence, existing railroad tracks shall be located. At a minimum the geometry of the main track needs to be resolved for a number of reasons. The track rails may be the best evidence of an offset to the ROW, It may be needed to reconcile any calls in the Railroad legal description to “centerline of track” and finally it provides documentation as to where the rails were at the date of the survey.
- D. At the conclusion of the ROW analysis process a comprehensive CADD electronic file will be delivered to the design engineer and ROW base maps may be prepared if requested.
- E. Per the State of California Land Surveyor’s Act Section 8762 - If the section of ROW being surveyed has not been previously retraced with a filed public record in the form of a Record of Survey (ROS) then a one must be prepared. The following is a list of minimum requirements for said ROS:
  - 1. The basis of bearings/coordinates will be NAD-83 as tied locally to a high order geodetic survey that is appropriate for the section of railroad they are working on

unless there is a specific control network designated for the project.

2. If there is an adjoining ROS on a section of ROW prepared for NCTD or MTS than it needs to be tied into the current survey to provide relationship from one survey to the next.
3. Sufficient boundary evidence must be recovered to prove the ROW on both sides. If there are long tangents they must be established along the entire tangent length and not just a small segment in front of the project. For much of the ROW corridor the original railroad grant was for a specific width. If possible this width should be held. There exists the possibility that due to a number of reasons such as long-accepted monuments on both sides of the ROW and/or occupation a variable width may exist on the ground. This should be considered exceptional and evaluated on a case-by-case basis and discussed with the agency and project manager.
4. Sufficient narrative regarding boundary procedure must be developed to readily explain the procedures used, evidence held and reasoning applied to establish the ROW. This narrative should be a part of and shown on an ROS if a ROS is deemed a requirement.
5. Sufficient reference to record maps and deeds need to be shown as it relates to the establishment of the ROW. If historic Valuation maps (VALMAP) indicate survey field ties to PLS section corners and/or Pueblo lot corners, an effort shall be made to determine the relationship of a current survey to the historic corner location.
6. As part of the survey historic VALMAP railroad stationing and mileposts, if possible need to be shown on the points of centerline geometry and a relationship to current mile posting and/or stationing if different. This is a critical ROW retracement parameter needed to determine the original railroad grant location and provide continuity along the corridor.
7. Significant conflicts and encroachments with and into the ROW need to be identified. Significant material discrepancies must be identified and clearly displayed on the ROS. Additional service and fees may be required if it is deemed necessary to provide a comprehensive survey and mapping of said encroachments.
8. The relationship of the existing centerline of track needs to be shown at key points of geometry as a record of track location. If the track itself is used as best evidence of the ROW location, historic railroad structures, such as bridges (where possible) must be surveyed to help prove the track location as a monument.
9. The relationship of the railway to any dedicated streets/roads that cross the railway must be established by survey for both the centerline and right-of-way width. This is to be included on any required ROS and as part of the CADD file deliverable to the project team and agency.
10. If the project meets the requirement of needing an ROS then unless otherwise agreed upon the ROW will be monumented on both sides at all points of

geometry change and in long tangents at an interval of approximately 1,000 feet or other logical points. Typical survey monuments to be set would be a 2" iron pipe with a 31/2" brass or aluminum cap indicating NCTD/MTS ROW and the LS number of the surveyor with the year set. Other suitable monument types may be necessary to fit the situation of each monument position. It is preferable to set the actual ROW position and offsets are to be set at a last resort only.

### **2.1.7 ADJOINING PROPERTIES TO ROW - BOUNDARY RESOLUTION**

Boundary Determination – The boundary of any adjoining property shall be established on the same coordinate system as discussed above (California Coordinate System) for existing property ownership or any proposed acquisition parcels: In addition:

- A. Ownership boundaries of adjoining properties shall be at least in-part located from field survey data and record information in accordance with established legal principles, California state law and local accepted standards of practice. The decision on whether a particular adjoining parcel needs to have a full and complete boundary survey is project specific and needs to be coordinated with and agreed upon by the responsible agency, project manager and the contract LS.
  - The underlying fee in an abutting public road will be mapped as part of an ownership as defined above only when it is specifically included in the record description of the property. However there shall be a standard note regarding the potential existence of reversion rights and that it is not the intent of this ROW action to sever said rights, if any.

### **2.1.8 MILEPOSTS**

Surveys and mapping will include the milepost location in addition to stationing on all project drawings, ROW (ROS) mapping. Milepost locations will be used to update track charts, which are accurate to 0.01 mile. Milepost sign markers are frequently moved or relocated, so they are not to be used as precise reference marks.

### **2.1.9 LEGAL DESCRIPTIONS**

Prior to the preparation of legal descriptions and accompanying plat maps, all proposed parcels for ROW takes shall be coordinated closely with the project team and clearly identified in the ROW exhibit maps for the approval by the ROW Owner. The following documents are typically included with or within said maps:

- ROW base maps of a final resolved ROW boundary
- ROW exhibits that clearly define areas of ROW "takes"
- ROW appraisal maps and record maps

A complete legal description shall consist of two parts, the legal description in writing and the plat map showing the area being described. A legal description submitted without both parts will be considered incomplete unless otherwise agreed upon by ROW owners.

## A. Written Legal Descriptions

There are many ways to describe land, but the type of legal description that is typically used for the ROW is of the metes and bounds type. This is a description that uses both written instructions for measurements and direction of travel along with a call for a map. This type of legal description allows for the calculation of a precise area for purposes of real estate valuation. The other type of legal description used for the ROW is a combination of bounds and strip descriptions. Written Legal Descriptions will be prepared by a California Licensed Land Surveyor who in coordination with ROW owner will make the decision on the appropriate type of legal description. The various types of descriptions are defined as follows;

- **Metes descriptions** are perimeter descriptions described by measurement and direction of travel only, and they have no bounds calls or calls to an adjoiner.
- **Bounds descriptions** are perimeter descriptions based on bounds calls only, and they have no measurement or direction of travel calls included.
- **Metes and bounds descriptions** are perimeter descriptions that are described by measurements, direction of travel, and calls to adjoiners.
- **Strip descriptions** are descriptions of property whose perimeter is described by widths from a given base line or centerline, say the centerline of a track, such as “30 feet on each side of the following described centerline.”
- **Descriptions by reference** are descriptions of property by reference to some map or plat, such as “Lot 1, Block 49 of University Subdivision.”
- **Descriptions by exception** are descriptions of property that except out certain areas as a reservation from the conveyance, such as “Lot 1, Block 49 of the University Subdivision, except the northerly 50 feet.”

## B. Plat Maps

A plat map is a map or drawing of the land being described in the legal description. The plat map is attached to, and made a part of, the legal description. A plat map prepared for the ROW owner shall be drawn to scale and shall include, at a minimum, the following information;

- North arrow
- Legend
- Point of beginning
- Point of commencement, if applicable
- Thicker line indicating the land being described
- Adjoiner record deed or map information
- Relevant record deed or map data on the subject parcel of land
- Adjacent street names, ROW lines, and ROW widths
- Distances and bearings of all lines along the land being described
- Relevant bearings or distances to adjoiners
- Area of described land
- Stamp and signature of the licensed California land surveyor responsible for the map

- Title block
- Date
- Scale
- Title or name of the land being described
- Assigned Parcel Number
- Plat Map prepared on an 8.5" x 11" or 8.5" x 14" sheet of paper.
- Space for recorder to be allotted per local jurisdiction.

### **2.1.10 TOPOGRAPHIC SURVEYING**

Topographic surveys are used to determine the configuration of the surface of the project site and the locations of readily visible natural and manmade objects and features. The deliverables of topographic surveys, including topographic maps and DTMs, are the basis for planning studies and engineering designs.

Aerial Mapping is the preferred methodology for large area corridor mapping requirements with the width being typically at least 100 feet beyond the railway ROW on either side. The desired corridor width is project specific and not to be assumed. The specific width shall be agreed upon in coordination with the project manager.

Many if not most topographic surveys utilize a combination of both aerial mapping and direct survey data collection. At a minimum the topographic survey shall include the following items along the railroad corridor:

- Track centerline and profile of all existing rails, which shall include at least 500 feet beyond project limits or as agreed upon in coordination with the Project Manager.
- Survey on grade crossing roadways, which shall include a minimum of 200 feet in either direction of the intersection or as directed by the Project Manager.
- Items such as switch points, point of frogs, joints at project limits, joints at control points, signal facilities, and communication line locations.
- All readily visible significant planimetric features within the railway ROW shall be shown along with any other specific requests from the project manager as mutually agreed upon.

### **2.1.11 SUPPLEMENTAL TOPOGRAPHIC SURVEYING**

Supplemental topographic surveys shall be provided for planning and engineering of detailed topographic features which are not available through aerial maps. Conventional (on the ground) surveying methods or other appropriate methods shall be used to gather data for supplemental surveys. Typically the supplemental survey data is in a digital topographic format that can and/or should be incorporated into an existing digital terrain model (DTMs) developed for the aerial mapping. This will increase both the precision and the accuracy of said DTM.

Surveyors need to carefully select methods and procedures for conducting the survey work to obtain accurate data. Below is a table that gives approximate precision figures as a guide for different survey methodologies and technologies, if applied properly. The required precision affects cost/fees and shall be selected by a combination of what are commonly accepted

practices and specific precision requirements as agreed upon with the project manager.

TABLE 2-2 - Survey Method Precision	
Survey methodology/technology	Precision
GPS – Real-Time Network (RTN) Solution	+/- 0.10'-0.20'
GPS – Real-Time Kinematic (RTK) Solution	+/- 0.05'
Survey Total Station Instrument	+/-0.02'
Differential leveling Instruments	+/-0.01'

## 2.1.12 AERIAL MAPPING AND PHOTOGRAMMETRY

### A. Aerial Mapping and Photography

Accuracy standards vary in complexity and usability, and it is best that a discussion with the photogrammetrist take place regarding accuracy specification that would best suit the needs and budget of the project. The concept of map standards and the statistics behind them can cause much confusion for contracting agencies. It should be understood that while some of these standards complement each other, mixing them within the same statement is counterproductive.

The most common used data accuracy standards for county and municipal mapping applications are the American Society of Photogrammetry and Remote Sensing (ASPRS) Class I and II. A number a counties and municipalities are requesting that their mapping projects be compliant with NMAS for large-scale mapping. At a minimum aerial mapping must meet or exceed be what are considered National Mapping Accuracy Standards. NCTD and SANDAG may require a report of the checks that were made to verify that the mapping is in compliance with these standards, and this report may be requested at any time, including as part of deliverables.

### B. Horizontal Accuracy

For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, as measured on the publication scale. As an example, a map with a published scale of 1"=100' or (1:1,200), 90 percent of the measured checkpoints or mapped features should have a residual of no more than 100.0/30 feet or 3.33 feet.

For maps on publication scales of 1:20,000 or smaller, not more than 10 percent of the points tested shall be in error by more than 1/50 inch, as measured on the publication scale. As an example, a map such as the USGS quarter quads published with a scale of 1:24,000 or (1"=2,000'), 90 percent of the measured checkpoints or mapped features should have a residual of no more than 2,000.0/50 ft. or 40.0 ft.

These limits of accuracy shall apply in all cases to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers, such as benchmarks and property boundary monuments; intersections of road, railroads, etc.; and the corners of large buildings or structures (or center points of small buildings. In general, a point that is well defined is plottable on the scale of the map within 1/100 inch.

### C. Vertical Accuracy

Vertical accuracy as applied to contour maps on all publication scales shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. Published maps meeting these accuracy requirements shall note this fact in their legends, as follows: The map complies with National Map Accuracy Standards.”

### D. Aerial Mapping and Photography

Accuracy standards vary in complexity and usability, and it is best that a discussion with the photogrammetrist take place regarding accuracy specification that would best suit the needs and budget of the project. The concept of map standards and the statistics behind them can cause much confusion for contracting agencies. It should be understood that while some of these standards complement each other, mixing them within the same statement is counterproductive.

The most common used data accuracy standards for county and municipal mapping applications are the American Society of Photogrammetry and Remote Sensing (ASPRS) Class I and II. A number a counties and municipalities are requesting that their mapping projects be compliant with NMAS for large-scale mapping.

### E. Mapping Scale and Application

Table 2-3 depicts various mapping scales and their applications:

<b>TABLE 2-3 Mapping Scale Applications</b>		
<b>Map Scale</b>	<b>Contour Interval</b>	<b>Mapping Application</b>
1"=20'	1 foot	Grade Crossing, Bridge, and Station Sites for Final Design
1"=40'	1 to 2 foot	Standard Maps for Engineering Design (PE and PS&E)
1"=100'	5 foot	Standard Maps for Environmental Studies, Feasibility Studies, Planning, and Conceptual Engineering
1"=200'	10 foot	Corridor Studies

### F. Orthophotography

In digital orthophotography, pixel resolution correlates with map scale. The Table below gives a general idea of the pixel resolution as it correlates with various map scales. These correlations are typical, and the needs of the project may dictate a higher or lower level of output pixel resolution.



**TABLE 2-4 Map Scale Pixel Resolution**

Target Map Scale		Orthophoto
1 in = x ft.	Ratio, ft./ft.	Pixel Res. (ft.)
40	1:480	0.20
50	1:600	0.25
100	1:1,200	0.5
200	1:2,400	1.0
400	1:4,800	2.0

### 2.1.13 UTILITY SURVEYS

Utility surveys are used to locate existing utilities for the following purposes:

- Basis for planning and design
- Relocations of impacted utilities
- Acquisition for utility easements and/or ROW
- Information for coordination and negotiation with utility companies

Survey limits and types of utilities to be located should be shown on the project manager's survey request and/or its attachments. If available, utility maps and drawings may be provided to aid in the location of utility features.

It is important to locate all significant utility facilities. It is recognized that all utility features may not be readily visible and in fact may require coordination with the Project Manager. The following are facilities and critical points to be located for various utilities; potholing shall be considered to verify locations of critical utilities:

- Oil, Gas and Jet Fuel Pipelines;
  - Intersection point with centerlines of track and/or ROW lines
  - For lines parallel to ROW, location ties necessary to show relationship to the ROW lines
  - Vents
  - Angle points
  - Meter Vaults, valve pits, etc.
  - Depth below base of rail(s) shall be calculated via inlet and outlet surveyed locations if available.
- Water, Sewer and Storm Drain Lines;
  - Intersection point with centerlines of track and/or ROW lines.
  - For lines parallel to ROW, location ties necessary to show relationship to the ROW lines

- Manholes, valve boxes, meter pits, crosses, tees, bends, etc.
  - Elevation on, sewer inverts, and manhole rims, storm drain inverts and other pertinent drainage structures as required
  - Fire hydrants
  - Curb stops
  - Depth below base of rail(s) shall be calculated via inlet and outlet surveyed locations if available.
- Overhead Lines;
    - Supporting structures on each side of railway with elevation of neutral or lowest conductor at each centerline of track crossing point. This data requires the noting of the temperature, date and time of day.
    - On lines parallel to railway, supporting structures that may require relocation, including overhead guys, stubs, and anchors
    - Height above top of rail(s)

It is important to note that any live electrical lines should be surveyed without direct contact with said lines.

- Underground Lines;
  - Cables/lines (denote direct burial or conduit, if known), etc.
  - Manholes, pull boxes, and transformer pads
  - Crossing at centerline or ROW lines
  - Depth below base of rail(s)
  - For lines parallel to ROW, location ties as necessary to show relationship to the ROW lines

As part of any final deliverable to NCTD and or SANDAG for any survey and/or ROW task the State of California Land Surveyor of record must submit a written statement signed and stamped indicating that his or her work product has been through an internal QA/QC process that can be articulated or described upon request. At a minimum this requires an independent review of another qualified land surveyor for any work product that has been signed and stamped. The QA/QC signoff form should be included in the report and must clearly show the names of the staff who prepared and reviewed the work.

## **2.2 RIGHT OF WAY**

### **2.2.1 OWNERSHIP**

Ownership of the ROW is vested in North County Transit District from the Orange County Line (MP 207.4) to the City of San Diego (MP 245.6), including the Cities of Oceanside, Carlsbad, Encinitas, Solana Beach and Del Mar (“NCTD Property”), and in Metropolitan Transit System in the City of San Diego from MP 245.6 to MP 267.5 (“MTS Property”).

### **2.2.2 ACCESS**

Access to the ROW is controlled by the owner (NCTD and or MTS). A right-of-entry permit (“ROE”) must be obtained from the owner prior to entry onto the ROW. Obtaining these permits can take 6 to 8 weeks so plan ahead. When accessing the ROW, an active right-of-entry permit agreement must be in place, staff must have gone through Road Worker Protection (RWP) training, and must be accompanied by a flagger.

On NCTD Property, contact the NCTD ROW Coordinator, who serves as the point of contact for permitting activity. Contact information is NCTD, 810 Mission Avenue, Oceanside, CA 92054, Telephone No. (760) 967-2851. Permitting information is available on the web at (<http://www.gonctd.com/working-around-the-rails>).

On MTS Property, initially contact MTS ROW Department, 1225 Imperial Ave, San Diego, CA 92101. Tel 619 557 4501. Information can also be found on the MTS website (<http://www.sdmts.com/Business/Permits.asp>). A joint ROE permit will typically be required with MTS and NCTD.

The costs associated with obtaining and complying with the ROE include, but are not limited to, obtaining railroad protective insurance, a permit fee, safety training, flagging costs, and inspection fees.

### **2.2.3 ACQUISITION**

Right of Way to be acquired for any project within the LOSSAN Corridor shall be acquired pursuant to the adopted real estate policy of the acquiring agency, and the policies and provisions embodied in Title III of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 and the Uniform Relocation Act Amendments of 1987, as such will be amended from time to time. Generally, these policies encourage and expedite acquisition by agreement, to avoid litigation, to assure consistent treatment for owners, and to promote public confidence. Property acquisition by NCTD shall conform to NCTD Board Policy 11, which addresses NCTD real estate policies. Property acquisitions by SANDAG should conform to SANDAG Board Policy 21, Acquisition of Real Property Interests and Relocation Assistance. Copies of these board policies are available at [WWW.gonctd.com](http://WWW.gonctd.com) and [http://sandag.org/organization/about/pubs/policy\\_021.pdf](http://sandag.org/organization/about/pubs/policy_021.pdf)

### **2.2.4 ROW ACQUISITION DRAWINGS**

ROW acquisition drawings shall show the limits and types of acquisition required, ownership information, encroachments, and easements of record within the area to be acquired.

The legal description of permanent ROW to be acquired shall use simple curves and tangents. All spiral curves shall be reduced to circular curves at the limits of the ROW. Circular curves are the only types of curves acceptable for recording purposes.

### **2.2.5 TRACK CHARTS AND MILEPOSTS**

The current track chart for the LOSSAN Corridor is located in Appendix D. Existing track charts are only accurate to 0.1 of a mile. Construction drawings will include existing milepost locations in addition to stationing for reference. If possible, stationing will be in the same direction as the mileposts.

As-built drawings will be used to update track charts.

### **2.2.6 FENCING**

The minimum safety setback shall be twenty-five (25) feet from the centerline of the closest track to support consistency with NCTD's Roadway Worker Protection Program.

Fencing at the ROW Boundaries shall be chain link fencing 6 feet high (Per Engineering Standard Drawing ESD 5106). Vehicle service, maintenance and storage areas shall be secured by perimeter fencing. All construction staging areas shall be secured by temporary fences or barricades.

Fencing shall be parallel to the track, forming an open-ended envelope and allowing unrestricted movement by maintenance of way crews. Fence height shall be reduced to 4 feet for 150 feet either side of the road crossings to provide adequate sight distances for approaching vehicle drivers.

Gates for MOW access shall be provided where ROW access is available across neighboring properties. At locations where NCTD has parallel access, gates shall be installed at approximately 500 feet intervals. MOW access gates shall be pairs of eight feet wide chain link double swing gates. Gate swings shall swing away from the track where possible. If that is not possible in-swinging gates shall not encroach on the construction clearance envelope of 12 feet from center of track.

### **2.2.7 VEGETATION CONTROL**

Embankment and drainage swales, immediately adjacent to the roadbed, (that is within approximately 10 feet of the tracks), must have vegetation controlled per FRA regulation CFR 49 Part 213.37 Vegetation which states that;

*“Vegetation on railroad property which is on or immediately adjacent to roadbed shall be controlled so that it does not—*

- (a) Become a fire hazard to track-carrying structures;*
- (b) Obstruct visibility of railroad signs and signals:*
  - (1) Along the right-of-way, and*
  - (2) At highway-rail crossings; (This paragraph (b)(2) is applicable September 21, 1999.)*
- (c) Interfere with railroad employees performing normal trackside duties;*
- (d) Prevent proper functioning of signal and communication lines; or*

*(e) Prevent railroad employees from visually inspecting moving equipment from their normal duty stations.”*

### **Clean Water Act**

Construction permits issued under the Clean Water Act require that disturbed areas of ground are revegetated, including drainage swales, and the permitting agencies require at least 70% vegetation cover to close out the permits.

### **2.2.8 PLANNING AND THIRD PARTY PROJECTS**

Designers must be familiar with the overall LOSSAN Prioritization and long-term development plan for the right of way, including potential facilities such as additional tracks, stations, parking garages, grade separations, etc., that are necessary for light rail transit, high speed rail, or expanded freight operation. The current design, evaluation of placement of facilities within the ROW, and evaluation of ROW requirements, must consider future plans and ancillary third party projects.

## Chapter 3

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### **NCTD Reference Documents**

- NCTD Landscape Design and Maintenance Plan
- NCTD Integrated Pest Management Plan

### 3.0 ENVIRONMENTAL GUIDANCE

This chapter gives the designer general information and guidance regarding environmental compliance requirements for NCTD and SANDAG LOSSAN projects. Environmental compliance and permitting for all projects are subject to review, approval and where applicable signature of the Principal Planner of the lead agency for environmental notices, permits, and transmittal letters to regulatory resource agencies. (The Principal Planner for SANDAG is the SANDAG Principal Regional Planner.)

Projects are subject to applicable federal, state, and local environmental regulations and guidelines. Local (TransNet) and State-funded projects are subject to the California Environmental Quality Act (CEQA). Federally funded projects are subject to the National Environmental Policy Act (NEPA) and Federal Transit Administration (FTA) and the Federal Railroad Administration (FRA) regulations. Each project shall be evaluated to determine the applicable environmental regulations.

Construction of projects and facilities within existing interstate railway rights-of-way (ROWs) already in use are generally exempt from CEQA requirements pursuant to CEQA Statute Section 21080(b) (10). Additionally, as a part of the national railroad system, maintenance and operations are generally exempt from local ordinances and state environmental regulations.

The LOSSAN Corridor is subject to the jurisdiction of the Federal Surface Transportation Board (STB). State and local environmental regulations have been found to be pre-empted by federal statute (49 U.S.C. 10501(b)) in those cases where the STB has licensing authority over railroad activities (i.e., LOSSAN Corridor and Sprinter Corridor). An example of STB's ruling on the matter of pre-emption (NCTD's Encinitas Passing Track) is provided in Appendix D (August 19, 2002), The STB Ruling is applicable for railroad projects constructed when the tracks are used for interstate freight transport and/or intercity passenger service (i.e., freight (BNSF) and Amtrak). The STB Ruling is based on the premise that projects that improve railroad reliability and capacity on tracks used for interstate commerce are not subject to regulatory compliance with state and local regulations due to the interstate commerce clause in the United States Constitution. San Diego Trolley projects operating for the sole use of light-rail commuter services do not fall under the STB Ruling.

### 3.1 STANDARDS, CODES, AND GUIDELINES

The latest edition of the following standards, codes, and guidelines shall be used during design as determined applicable to the projects:

- SANDAG 2050 Regional Transportation Plan (RTP) and associated Environmental Impact Report (EIR)
- NEPA (42 USC 4321–4370f; 40 CFR 1500–1508)
- Federal Highway Administration (FHWA), “Environmental Impact and Related Procedures” (23 CFR 771) <http://ceres.ca.gov/ceqa/>
- CEQA (California Public Resources Code, Section 21000–21189.3) and CEQA Guidelines (14 C.C.R. 15000–15387)
- Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended (16 USC 470; 36 CFR 800)



- Section 4(f) of the Department of Transportation (DOT) Act (49 USC 303 or 23 USC 138; 23 CFR 771.135; 23 CFR 771 and 774; FHWA Section 4(f) Policy Paper, March 2005)
- Sections 401, 402, and 404 of the Clean Water Act of 1977 and 1987 (33 USC 1251–1376)
- Sections 9 and 10 of the Rivers and Harbors Act (33 USC 401 et seq.)
- Section 7 of the federal Endangered Species Act (FESA) of 1973 (16 USC 1531–1543)
- Sections 2080.1, 2081, and 1602 of the California Fish and Wildlife Code
- Coastal Zone Management Act of 1972 (16 USC 1451–1464)
- California Coastal Act of 1976 (California Public Resources Code, Division 20)
- FTA, “Transit Noise and Vibration Impact Assessment,” Publication FTA-VA-90-1003-06, May 2006
- United States Department of Agriculture, Soil Conservation Service, “Urban Hydrology for Small Watersheds,” Technical Release 55, June 1986
- Federal Railroad Administration, “High-Speed Ground Transportation Noise and Vibration Impact Assessment,” Final Report, October 2005, Report No. 293630-4.
- State of California SWRCB Construction General Permit Order No. 2009-0009-DWQ.
- State of California SWRCB General Industrial Permit Order No. 97-03-DWQ.
- California Stormwater Quality Association BMP Handbook Construction November 2009.
- Caltrans Stormwater Pollution Prevention Plan (SWPPP) and Water pollution Control Plan (WPCP) preparation Manual March 2011.
- NCTD Stormwater Management Plan.
- NCTD Landscape Design and Maintenance Plan
- NCTD Integrated Pest Management Plan

There are also Executive Orders providing protection or directing special consideration to preservation of wetlands, floodplains, environmental justice, children’s safety, and prevention of invasion by toxic plant species.

## **3.2 CONSTRUCTION ACTIVITIES AND ASSOCIATED PERMITTING**

Construction activities and associated permitting is required for new projects and emergency projects. For each of these work categories, special permit and notification processes apply.

### **3.2.1 NEW PROJECT PERMITTING**

New projects include the construction of new buildings, bridges, and railways that are either within or outside the existing ROW or that would result in substantial improvements or changes to existing facilities. New projects shall not begin until the appropriate levels of environmental evaluation have been completed to determine the potential for impacts on sensitive resources, to identify means to avoid or minimize adverse impacts, and to determine which agencies have jurisdiction over the activity or project location. Designers shall consult with the Principal Planner to determine the appropriate environmental

compliance documentation and facilitate the completion of the environmental documentation and obtain applicable permits and approvals as described below.

### **3.2.2 EMERGENCY CONSTRUCTION PERMITTING**

Emergency construction is associated with specific events such as fires, floods, landslides, earthquakes, and resulting damage to the railway. Emergency construction is the immediate work required to restore the railway operations and to protect lives and property. These are projects that must be conducted immediately to protect or replace existing infrastructure (for example, culverts, rails, or bridges) or to repair damaged facilities (for example, bridge abutments or footings) to allow their continued safe use. These projects are generally performed within the footprints of existing facilities and do not result in major changes to existing facilities. Emergency construction may include minor upgrades or improvements, provided they do not result in a major change in the original footprint or operations of the facility prior to the emergency.

Emergency construction may include work to repair flood damage, replace burnt structures, remove debris from culverts and bridges, repair landslide damage, respond to derailments, or make repairs due to vandalism. Although these projects can generally be performed under special regulatory provisions that allow for emergency response, environmental considerations must be identified and evaluated, and notice must be provided to regulatory agencies during and after the emergency construction. In the case of emergency wetlands impacts, the U.S. Army Corps of Engineers (USACE), Regional Water Quality Control Board (RWQCB), and for projects in the Coastal Zone the California Coastal Commission (CCC) shall be informed immediately, preferably prior to the impact.

During emergency construction, more substantial retrofitting or improvement of an existing structure/facility may be identified. Construction that would substantially alter the original design, operation, or function of the infrastructure would be considered maintenance activities or program work, as discussed below.

## **3.3 ENVIRONMENTAL COMPLIANCE PROCESSES**

The environmental compliance process differs in emergency versus non-emergency situations. The first step in environmental compliance is to determine whether the proposed work has the potential to affect an environmentally sensitive resource (for example, cultural resources, wetlands, lakes, streams, drainages, coastal areas, and special-status plants or animals). If environmentally sensitive resources **are not** present, then the work can proceed after applicable environmental approvals have been obtained if required.

### **3.3.1 NEW PROJECT PROCESS**

This type of work includes new projects, retrofits, and upgrades. The process typically consists of preparing an Alternatives Analysis and Permit Handbook when impacts are associated with sensitive environmentally resources.

### 3.3.1.1 Alternatives Analysis

Alternative Analysis is required per CEQA and NEPA regulations when the Project is subject to an EIR under CEQA and an EA or EIS under NEPA.

Project Development Team's (PDT) shall confirm through alternatives analysis, the initial environmental review approach proposed in the Project Study Report (PSR). The alternatives analysis review will include an environmental constraints and opportunities report for the proposed work. This environmental review shall be conducted in consultation with the Principal Planner of the lead Agency or their designated senior environmental planner.

The environmental review may identify issues that require the PDT to evaluate the significance of those issues relative to project schedule, budget, and rail operations. For example, if a new project is planned for an area supporting habitat for an endangered or threatened species or wetlands, the Project Manager will direct the PDT to design the project to avoid or minimize environmental impacts wherever practicable. This alternatives analysis stage in the project is the time to identify environmental constraints and make project adjustments to avoid or minimize impacts where practicable.

### 3.3.1.2 Permitting Handbook

Once the appropriate clearance process and regulatory agencies have been identified then a Permit Handbook shall be prepared providing a list of relevant permits and agency contacts.

### 3.3.1.3 Preparation of Conceptual Mitigation Plans

If impacts that require mitigation are identified during project development then conceptual mitigation plans need to be developed by the design consultant. These mitigation plans shall be developed during the environmental clearance phase to facilitate permitting.

### 3.3.1.4 Pre-Application Permitting Meeting

A pre-application meeting with the Regulatory Resource Agencies shall be held for projects located within and/or nearby sensitive environmental areas. The PDT will prepare a presentation summarizing the alternatives considered and the impacts associated with the proposed project. In addition provide the project description information, site photographs, and sensitive species/habitat information and survey data. The permitting agencies will be asked to review the project and provide comments regarding jurisdiction and permit requirements.

### 3.3.1.5 Pre-Application Permit Submittal to ROW Owner

NCTD requests that all permit packages submitted to natural resources agencies for mitigation measures proposed on NCTD-owned ROW be submitted to NCTD for review and comments, prior to final permit package submittal to the respective natural resource agencies by SANDAG.

### 3.4 EMERGENCY CONSTRUCTION PROCESS

If the proposed work will be done immediately in order to protect lives and property and will be limited in extent, then the work may qualify as emergency construction. Under CEQA, an emergency is defined as “a sudden, unexpected occurrence, involving a clear and imminent danger, demanding immediate action to prevent or mitigate loss of, or damage to, life, health, property, or essential public services. ‘Emergency’ includes such occurrences as fire, flood, earthquake, or other soil or geologic movements, as well as such occurrences as riot, accident, or sabotage” (California Public Resources Code, Section 21060.3). Other agencies such as the USACE, RWQCB, and CCC have definitions for an “emergency” that shall be reviewed to determine application to the construction activity proposed.

#### 3.4.1.1 Initial Agency Contact

The Principal Planner shall be person to contact the appropriate agencies with jurisdiction over environmental resources. The government agency(s) to be contacted depends on the environmental resource (for example, wetlands, streams, or coastal areas) affected by the emergency. If the emergency construction will affect a sensitive habitat (i.e. uplands, wetlands, stream, lagoon, or marsh); then USACE, USFWS, CCC, and RWQCB shall be contacted immediately. Other agencies to be contacted may include the CDFW, the county and local municipal agencies. When a permitting or regulatory agency is contacted, the following information shall be provided:

- A. The contact person responsible for the emergency repair
- B. The contact phone number
- C. What the emergency involved
- D. Why it is an emergency
- E. The type and extent of work to be done
- F. Exact location of the emergency.

#### 3.4.1.2 Work Plan

After contacting the agencies, a work plan and site map shall be prepared. These three items shall be prepared and submitted to the agencies by the Principal Planner as soon as possible. If photographs of the emergency are available, they shall be sent to the agencies.

#### 3.4.1.3 Issuance of Emergency Permits

The applicable agencies having jurisdiction over resources shall issue emergency authorization/permits (i.e. Letter of Authorization from USACOE for scour protection in a wetland area) within 24 to 48 hours of the project leads submittal of a work plan and site map. The emergency authorization/permits shall be kept on site during emergency construction. Emergency repairs in sensitive areas typically require a construction monitor (biologist) to avoid or minimize encroachment into sensitive areas. Generally, the project lead will be responsible for compensatory mitigation at reduced ratios (unless damage is determined to be caused by others). All emergency permits and agency conversations where directions were given or decisions were made shall be documented and entered into the project file.

## 3.5 ENVIRONMENTAL DOCUMENTS

The following describes the requirements set forth by the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA).

### 3.5.1 CALIFORNIA ENVIRONMENTAL QUALITY ACT

The California Environmental Quality Act (CEQA) was enacted in 1970. The Designer shall consult with the Principal Planner or their designated Environmental Manager for the project to verify the applicable environmental requirements for the project and if those requirements have been completed. The completed and Board approved CEQA document (if CEQA is applicable to the project) shall be provided by the SANDAG Environmental Manager to the designer to integrate the environmental requirements into the project design. Ongoing coordination between the designer and Lead Agency will be required to ensure the project maintains consistency with the approved environmental document. The Principal Planner of the lead Agency is responsible for making the environmental determination if the project requires any additional CEQA documentation and/or the appropriate type of CEQA documentation and scope of environmental studies that may be required in compliance with state law.

The railroad right-of-way (ROW) is subject to the jurisdiction of the federal Surface Transportation Board (STB). The STB has issued numerous rulings nationwide that stipulate that State and Local environmental regulation has been found to be preempted by federal statute (49 U.S.C. 10501(b)) for railroad projects when the tracks are used for interstate commerce (freight) transport and/or intercity passenger service (i.e. Amtrak). Therefore, the project is not subject to CEQA. The STB rulings are based on the premise that projects that improve railroad reliability and capacity on tracks used for interstate commerce are not subject to regulatory compliance with state and local regulations due to the interstate commerce clause in the United States Constitution. In 2002, the STB ruled in favor of the North County Transit District (NCTD) that the Encinitas Passing Track Project was not subject to regulatory compliance with state and local regulations due to the interstate commerce clause in the United States Constitution (see the 2002 STB Ruling in Appendix D).

For projects that may not be federally preempted, the project may be exempt under CEQA. There are two types of exemptions under CEQA: Statutory and Categorical.

- Statutory exemption is projects specifically excluded from CEQA consideration as defined by the state legislature. These exemptions are delineated in Public Resource Code (PRC) 21080 et seq. statutory exemptions apply to any given project that falls under its definition disregarding the project's potential environmental impacts.
- Categorical exemptions are made up of classes of projects that generally are considered not to have potential impacts on the environment. Categorical exemptions are identified by the State Resource Agency and in CEQA Guidelines, California Code of Regulations (CCR section 15300- 15331). Categorical exemptions are not allowed to be used for projects that may cause a significant impact to the environment.

Upon determining whether the project falls under an exemption from CEQA, a Notice of Exemption (NOE) shall be prepared and filed with the County Clerk's office and the State Clearinghouse, Office of Planning and Research (OPR). This determination shall be made by the Principal Planner of Environmental/Public Facilities Section and the NOE. The NOE requires approval and signature of the Principal Planner of the Lead Agency. The NOE is also subject to Board approval prior to filing the notice with the County Clerk and OPR. Filing a notice of exemption with the County Clerk's office starts a 35-day statute of limitations for any potential legal challenges. Inversely, a 180-day statute of limitations will apply if a notice is not filed.

The CEQA requirements and CEQA guidelines are updated annually and are accessible online at <http://ceres.ca.gov/ceqa/>.

If a project does not fall under the STB Ruling, a CEQA statutory exemption or categorical exemption, to satisfy CEQA requirements, further environmental review would need to be conducted. In compliance with CEQA requirements, it may be determined that the appropriate environmental documentation may be a Negative Declaration, Mitigated Negative Declaration or an Environmental Impact Report. All projects should be reviewed in consultation with the Lead Agencies Principal Planner once the initial planning/design has commenced to determine the appropriate environmental compliance and permitting applicable to the specific project.

### **3.5.2 NATIONAL ENVIRONMENTAL POLICY ACT**

Under NEPA (42 USC 4321; 40 CFR 1500.1), a process was established by which federal agencies must study the environmental effects of their actions "significantly affecting the quality of the human environment." Projects that involve a federal agency, either through direct participation, funding, or authorization of a discretionary permit (for example, a Section 404 Clean Water Act permit) may be subject to NEPA evaluation.

The process for complying with NEPA and federal surface transportation statutes is defined in the joint FHWA/FTA "Environmental Impact and Related Procedures" ([23 CFR 771](#)) and the Federal Railroad Administration (FRA) *Procedures for Considering Environmental Impacts*. The regulation sets forth the agencies' policy of combining all environmental analyses and reviews into a single process. It defines the roles and responsibilities of the federal agency and its grant (project) applicants in preparing environmental documents and in managing the environmental process within the various project development phases. The following briefly describes the types of environmental compliance documents under NEPA:

#### **3.5.2.1 Categorical Exclusion (CE)**

Categorical Exclusions (CE) are granted for actions that do not individually or cumulatively involve significant social, economic, or environmental impacts. These projects require little or no construction and involve minimal or no effects off site. The regulation gives a list of the types of projects that are categorically excluded. Once FTA or FRA has determined that a Categorical Exclusion applies, it may act on the application for financial assistance.

### 3.5.2.2 Environmental Assessment (EA)

An Environmental Assessment (EA) shall be prepared when the federal agency has determined that the project does not fall within a Categorical Exclusion (CE) determination. The EA addressing the project would be followed by a Finding of No Significant Impact (FONSI) or it may be determined by the federal agency that the EA has identified the need for preparation of an Environmental Impact Statement (EIS).

### 3.5.2.3 Environmental Impact Statement (EIS)

Environmental Impact Statement (Key sections to be addressed in an environmental impact statement include, but are not limited to, biological resources, cultural resources (including historic, archaeological, and cultural resources), cumulative projects, alternatives, social impacts, environmental justice, and visual impacts.

## **3.5.3 DOT ORDER 5650.2 FLOODPLAIN REQUIREMENTS**

The placement of new facilities that are within floodplains or that encourage future development within floodplains are subject to Executive Order 11988, as amended by Executive Order 12148 (DOT Order 5650.2; 23 CFR 650, Subpart A; and 23 CFR 771). These Executive Orders apply to construction of all federal or federally aided facilities that encroach upon or affect the base floodplain, as defined by FEMA. An assessment of floodplain hazards with discussion of impacts in the context of preservation of natural and beneficial floodplain values is required during the preliminary engineering and environmental review phase of the project, and **a specific finding must be reported in the final environmental document**. Coordination may be with FEMA and state and local agencies, such as the RWQCB, CCC, local coastal zone management agencies, and flood control districts, as appropriate.

The design of the project shall demonstrate compliance with Order No. DOT 5650.2 dated April 23, 1979, issued by the DOT. Order No. 5650.2 requires specific findings if a project involves a significant encroachment on the base floodplain.

An individual 5650.2 report will be prepared for each impacted creek or river. This report shall include the following information:

- The effective Federal Emergency Management Agency (FEMA) floodplain identification
- An exhibit showing the limits of the project that will remain in the FEMA floodplain following construction.
- A finding that construction within the floodplain is the only practicable alternative must be made with the following supporting information:
  - A discussion of why the project must be located in the floodplain
  - A description of alternatives investigated to remove the project from the FEMA floodplain
  - Verification that the project conforms to applicable state and/or local floodplain protection standards
  - A description of public involvement and the environmental review process in accordance with Order No. 5650.2

Note also that DOT Order 5650.2; 23 CFR 650, Subpart A; and 23 CFR 771 apply to all construction of federal or federally aided buildings, structures, roads, or facilities that encroach upon or affect the base floodplain. The general procedure is to prepare an assessment of floodplain hazards. Then prepare a report with a specific finding required in the final NEPA environmental document for significant encroachments. The finding shall be made in the initial design phase of the project, and it shall be in the environmental impact statement or a subsequent addendum or environmental assessment.

### **3.5.4 ENVIRONMENTAL JUSTICE**

Pursuant to Executive Order 12898, Environmental Justice (Federal Register, Vol. 62, No. 72 pp. 18377–18381), procedures set forth in the DOT Final Environmental Justice Order of April 15, 1997, all LOSSAN projects and facilities will be planned and designed insofar as feasible to avoid causing disproportionately high and adverse impacts on minority and low-income populations with respect to human health and the environment. For projects that require preparation of NEPA documentation (i.e. EA, EIS), an environmental justice (EJ) analysis will be prepared in compliance with the U.S. Department of Transportation (DOT) Title VI regulations (49 CFR part 21) and expressed in the DOT's Order on Environmental Justice (Order 5610.2) that includes following components in compliance with DOT's requirements:

- A description of the low-income and minority population within the study area affected by the project, and a discussion of the method used to identify this population (e.g., analysis of Census data, minority business directories, direct observation, or a public involvement process).
- A discussion of all adverse effects of the project both during and after construction that would affect the identified minority and low-income population.
- A discussion of all positive effects that would affect the identified minority and low-income population, such as an improvement in transit service, mobility, or accessibility.
- A description of all mitigation and environmental enhancement actions incorporated into the project to address the adverse effects, including, but not limited to, any special features of the relocation program that go beyond the requirements of the Uniform Relocation Act and address adverse community effects such as separation or cohesion issues; and the replacement of the community resources destroyed by the project.
- A discussion of the remaining effects, if any, and why further mitigation is not proposed.
- For projects that traverse predominantly minority and low-income and predominantly non-minority and non-low-income areas, a comparison of mitigation and environmental enhancement actions that affect predominantly low-income and minority areas with mitigation implemented in predominantly non-minority or non-low-income areas. If it is determined there is no basis for such a comparison describe why that is so.



### 3.6 FEDERAL PERMITS AND APPROVALS

The following are federal permits presented in Table 3-1 that may be required for LOSSAN projects. Projects that are determined to be subject to state environmental regulations (project is preempted by federal law) would be subject to applicable state permitting requirements (see Section 3.7, Table 3-2).

**TABLE 3-1 Federal Permit Summary**

Permit or Approval	Responsible Agency	Applicable Work Activity
Section 4(f) Evaluation	United States Department of Transportation	Section 4(f) applies to projects affecting land from publicly owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites.
Section 7 and 10a (FESA)	United States Fish and Wildlife Service	The FESA applies to activities affecting federally listed threatened and endangered plants and animals and the habitats in which they are found. The Section 7 permit process occurs when a federal agency is involved, and the Section 10 permit process occurs when no other federal agency is involved.
Section 9 Rivers and Harbors Act	United States Coast Guard	Section 9 regulates construction, reconstruction, or modification of bridges or causeways across navigable waters of the United States.
Section 10 Rivers and Harbors Act	United States Army Corps of Engineers	Section 10 regulates all navigable waters of the United States, which are defined as "those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible to use to transport interstate or foreign commerce."
Section 106 State Historic Preservation Act	Federal lead agency	Section 106 applies to projects with federal agency involvement that may affect historic properties such as building sites, districts, structures, and objects.
Section 404 Clean Water Act	United States Army Corps of Engineers	A Section 404 permit may be required where an activity affects a jurisdictional wetland or water of the United States. Nationwide Permits 3, 14, and 33 are also used for railway activities.
Section 408 Federal Levee and Dams	United States Army Corps of Engineers	Section 14 of the Rivers and Harbors Act of 1899 ( <a href="#">33 U.S.C. 408</a> , referred to as "Section 408") for projects that propose to alter federally designated levees or dams built by the US.

Permit or Approval	Responsible Agency	Applicable Work Activity
Coastal Zone Management Act	California Coastal Commission (San Francisco)	Projects located within a coastal zone are subject to either a Federal Coastal Consistency Certification or a Coastal Development Permit (CDP). Projects that are found to be preempted under federal law (i.e. interstate commerce (freight) and/or intercity passenger service (Amtrak)) would be subject to a Federal Coastal Consistency Certification.

### 3.6.1 SECTION 4(F)

The DOT Act of 1966 included a special provision—Section 4(f)—which stipulated that FHWA and other DOT agencies (i.e. FTA and FRA) cannot approve the use of land from publicly owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites unless the following conditions apply:

- There is no feasible and prudent alternative to the use of land.
- The action includes all possible planning to minimize harm to the property resulting from use.

When a project uses land protected by Section 4(f), a Section 4(f) evaluation must be prepared (23 CFR 771 and 774; 49 CFR 662; FHWA Section 4(f) Policy Paper, March 2005). The Section 4(f) is subject to approval by the DOT agency and concurrence with the 4(f) determination is required from the entity with ownership over the 4(f) resource property.

### 3.6.2 FEDERAL ENDANGERED SPECIES ACT, SECTION 7

The FESA (16 USC 1531–1543) provides a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found. The United States Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) administer the program and maintain a worldwide list of threatened and endangered species.

The law requires federal agencies to consult with USFWS and/or NMFS if there is a potential for the discretionary federal action to affect a listed species, and to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat of such species. The law also prohibits any action that causes a "taking" of any listed species of endangered fish or wildlife, other than taking that is "incidental" to an otherwise lawful activity. Likewise, import, export, interstate, and foreign commerce of listed species are all generally prohibited.

Under Section 7, a biological assessment (BA) is submitted by the federal lead agency to USFWS and/or NMFS for a formal consultation or an informal consultation for any activity that may affect a federally listed threatened or endangered species, or habitat that has been designated as critical habitat for a listed species. The BA includes information regarding the federally listed species that will be impacted by the proposed project. One should note that surveys for these biological resources often have seasonal and/or special protocol requirements. Focused surveys for special-status plants are typically tied to blooming periods, which can fall between February and September.

In the event that an informal consultation is determined to be appropriate, the USFWS and/or NMFS will issue conditions of work (conservations measures) to avoid any take of the federally listed species. Typically this means that no work will be conducted during the breeding period for the species and impacts to the species will be avoided; this can also result in construction delays. In the event that a formal consultation is determined to be appropriate, the USFWS and/or NMFS will issue a biological opinion (BO) describing the incidental take allowed, as well as avoidance, minimization, and mitigation measures to offset the impacts. These evaluative steps are typically completed during the environmental review and permitting phases of the project and the mitigation measures are identified in the BA and BO. All such mitigation measures and permit conditions shall be incorporated into the final design. A formal consultation has a 180-day time frame. An informal consultation does not have a specific time frame but is much less than that of a formal consultation.

If a plant or animal species is found in the project area that has been added to the list(s) since completion of the environmental review and permitting phases of a project, additional field survey and consultation will be required.

### **3.6.3 FEDERAL RIVERS AND HARBORS ACT, SECTION 9**

Federal law prohibits construction or repairs that alter clearances of any bridges, dams, dikes, or any other obstruction across navigable waters of the United States unless first authorized by the United States Coast Guard (USCG) (33 CFR 114–115). USCG approves the location and clearances of bridges through the issuance of bridge permits or permit amendments under the authority of Section 9 of the Rivers and Harbors Act of 1899, the General Bridge Act of 1946, and other statutes. This permit is required for new construction, reconstruction, or modification of a bridge or causeway over waters of the United States.<sup>1</sup>

### **3.6.4 FEDERAL RIVERS AND HARBORS ACT, SECTION 10**

The Rivers and Harbors Acts of 1890 (superseded) and 1899 (33 USC 401 et seq.) are administered through the USACE regulatory program. Various sections establish permit requirements to prevent unauthorized obstruction or alteration of any navigable water of the United States. Section 10 (33 USC 403) of the Rivers and Harbors Act covers construction, excavation, or deposition of materials in, over, or under such waters, or any work that would affect the course, location, condition, or capacity of those waters. Activities requiring Section 10 permits include structures (for example, piers, wharfs, breakwaters, bulkheads, jetties, weirs, and transmission lines) and work such as dredging or disposal of dredged material, or excavation, filling, or other modifications to the navigable waters of the United States.

The geographic jurisdiction of the Rivers and Harbors Act includes all navigable waters of the United States, which are defined as “those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible to use to transport interstate or foreign commerce” (33 CFR 329). This jurisdiction extends seaward to include all ocean waters within a zone 3 nautical miles from the coastline (the “territorial seas”). Limited authorities extend across the outer continental shelf for artificial islands, installations, and other devices (see 43 USC 333 (e)).

USACE permits are required to authorize certain structures or work in, or affecting, navigable waters of the United States pursuant to Section 10 of the Rivers and Harbors Act. Certain

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<sup>1</sup> <http://www.spl.usace.army.mil/regulatory/>

activities may fall under an authorized NWP or RGP. If this is not the case, an individual Section 10 permit is required.

### **3.6.5 NATIONAL HISTORIC PRESERVATION ACT, SECTION 106**

Significant architectural and archaeological resources are protected by Sections 106 and 110 of the NHPA and Section 4(f) of the DOT Act of 1966. The NHPA (16 USC 470) is the primary federal law governing the preservation of cultural and historic resources in the United States. It created the implementing procedures of the Advisory Council on Historic Preservation (ACHP) to evaluate all federal actions that will have an effect on properties listed on or eligible for listing on the National Register of Historic Places (“historic properties”). Specifically, Section 106 of the NHPA (16 USC 470(f)) requires that a federal agency involved in a proposed project or activity is responsible for initiating and completing the review process. Section 110 of the NHPA sets out the broad historic preservation responsibilities of federal agencies and is intended to ensure that historic preservation is fully integrated into the ongoing programs of all federal agencies.

Section 4(f) of the DOT Act (23 CFR 774.3) also stipulates that the FHWA and other DOT agencies cannot approve the use of land from publicly owned parks, recreational areas, wildlife and waterfowl refuges, or public and private historical sites unless (1) there is no feasible and prudent alternative to the use of land; and (2) the action includes all possible planning to minimize harm to the property resulting from use. The use of such a property is allowed if the project description includes any measure(s) to minimize harm to the resource (such as avoidance, minimization, mitigation, or enhancement), resulting in a *de minimis* impact.

Federal actions subject to NHPA review include, but are not limited to, construction, rehabilitation, and repair projects; demolition; licenses; permits (for example, Clean Water Act Section 404 permits); loans; loan guarantees; grants; and federal property transfer. The agency sponsoring one of these activities is required to seek ACHP comments.

Section 106 applies to historic properties such as building sites, districts, structures, and objects. For example, LOSSAN structures that are over 50 years old and significantly retain their original design and form and are relatively unique may qualify as a historic property. The Section 106 process requires agencies to identify such properties in advance of actions that may affect the integrity of the structure or site.

NHPA Section 101(d) (6) (A) and (B) also requires that agencies must make a reasonable and good faith effort to identify federally recognized Native American tribes who may consider that a historic property (i.e., a prehistoric archaeological site) has religious and cultural significance. The agency is required to consult with each concerned federally recognized Native American tribe to identify historic properties that may be of religious and cultural significance, and to work to minimize any adverse project effects on those resources through project redesign.

A determination of eligibility and identification of potential effects is completed during the Section 106 review process, the results of which are incorporated in appropriate NEPA and CEQA environmental documents. The agency considers the possible effects of the action on the property and resolves any adverse effects through consultation with concerned parties such as the State Historic Preservation Office (SHPO). Federal Clean Water Act, Section 404

The Federal Water Pollution Control Act (Clean Water Act) Amendments of 1972 established the Section 404 Regulatory Program. Under this act, it is unlawful to discharge dredged or fill material into waters of the United States without first receiving authorization (usually a permit) from United States Army Corps of Engineers (USACE). The term “waters of the United States” defines the extent of geographic jurisdiction of the Section 404 program. The term includes such waters as rivers, lakes, streams, tidal waters, and most wetlands. A discharge of dredged or fill material involves the physical placement of soil, sand, gravel, dredged material, or other such materials into the waters of the United States. Section 404 regulated activities that have received judicial attention include land clearing; stream channelization; the placing of pilings for bridges and piers; and discharges for converting waters to dry land, for raising bottom elevations, from road construction, and for loss or modification of aquatic habitat.

Avoidance and minimization of impacts on identified wetlands shall be considered carefully during the preliminary engineering and environmental review phase of any proposed project improvements. Delineation of wetlands and other waters of the United States in the project vicinity and a jurisdictional determination from USACE may be required. Based on the results of the preliminary engineering environmental review phase, a conceptual wetland mitigation report and design may be required. Mitigation, in the form of enhancement of existing wetlands or construction of replacement wetlands to replace specific wetland functions and values lost due to project-related disturbances, will be determined during permit approval.

Section 404 permitting is required for projects involving jurisdictional waters of the United States or wetlands. The three primary types of Section 404 permits addressing SANDAG actions are Nationwide Permits, Individual Permits, and Regional General Permits.

#### 3.6.5.1 Nationwide Permits

Nationwide Permits (NWP) are preauthorized permits for certain types of activities that are substantially similar in nature and cause only minimal individual and cumulative environmental impacts or would result in avoiding unnecessary duplication of regulatory control exercised by another federal, state, or local agency provided that it has been determined that the environmental consequences of the action are individually and cumulatively minimal. For NWPs, NEPA evaluation has already been completed by the USACE as part of the preauthorization process for the nationwide program. Therefore, no additional NEPA documentation is required. There are two types of NWPs, those that require a preconstruction notification and those that do not require notification (non-notifying).

NWPs requiring a preconstruction notification are generally required for impacts less than half an acre of jurisdictional wetlands and waters of the US. The typical NWP takes 6 to 9 months to process, longer if a formal Section 7 consultation with U.S. Fish and Wildlife Service (USFWS) is required in relation to threatened or endangered species.

#### 3.6.5.2 Individual Permits

The basic form of authorization is the Standard Individual Permit (IP). Activities that do not qualify for authorization under the NWP program, discussed above (typically impacts over half an acre of jurisdictional wetlands and waters of the US), may require authorization under an IP. Authorization under an IP may be obtained only through application with USACE. These permits are issued for activities that have more than minimal adverse impacts on waters of the United States. The IP process can be lengthy and requires evaluation of

alternatives to the proposed discharge, including conducting the project in an upland area. Each permit application involves a thorough NEPA evaluation and review of the potential environmental and socioeconomic effects of the proposed activity, public review, and potential benefits of the discharge. The IP process also requires that the project undergo an alternatives analysis under Section 404(b)(1) to identify the least environmentally damaging practical alternative (LEDPA).

### 3.6.5.3 Regional General Permits

Regional General Permits (RGPs) are preauthorized permits for certain types of activities that are substantially similar in nature and cause only minimal individual and cumulative environmental impacts. RGPs are authorized through notice and comment and may be conditioned with requirements for case-by-case reporting or notification. RGPs are available by contacting the local USACE district and requesting the applicable RGPs, if any are in effect. The typical RGP takes 6 to 9 months to process, longer if a formal Section 7 consultation is required.

### 3.6.6 SECTION 408 FEDERAL LEVEE AND DAMS

U.S. Army Corps of Engineers shall be consulted pursuant to Section 14 of the Rivers and Harbors Act of 1899 (33 U.S.C. 408, referred to as “Section 408”) for projects that propose to alter federally designated levees or dams built by the US.

## 3.7 STATE AND LOCAL PERMITS AND APPROVALS

In addition to the federal regulations discussed above, LOSSAN projects may require working with state and local agencies. Table 3-2 provides a summary of State and Local Permits that may be required.

**TABLE 3-2 State Permit Summary**

Permit or Approval	Responsible Agency	Applicable Work Activity
Coastal Development Permit	California Coastal Commission or local agency with certified local coastal program	Construction proposed within the coastal zone (i.e., 3 miles seaward and 1,000 yards inland) may be regulated by the Coastal Zone Management Act administered by the CCC.
Coastal Consistency Certification	California Coastal Commission (San Francisco)	For projects located within the coastal zone along the LOSSAN Corridor in the existing ROW, which benefits interstate commerce (i.e., freight goods movement).
Section 401 - RWQCB Administered Federal Clean Water Act	Regional Water Quality Control Board	A Section 401 Water Quality Certification is required for any permit or license issued by a federal agency (USCG Section 10 permits and USACE Section 404 permits) for any activity that may result in a discharge into waters of the state.
Section 402 – NPDES General Industrial Storm Water Permit	State Water Resources Control Board	The General Industrial Storm Water Permit regulates storm water runoff from eligible transportation facilities.

Permit or Approval	Responsible Agency	Applicable Work Activity
Section 402 – NPDES General Construction Activity Storm Water Permit	State Water Resources Control Board	The General Construction Activity Storm Water Permit regulates storm water discharges associated with any construction activity including clearing, grading, excavation reconstruction, and dredge and fill activities that result in the disturbance of at least 1 acre of total land area.
Section 1600 – Stream Bed alteration Agreement	California Department of Fish and Wildlife	Section 1600 regulates the alteration of streams and other water bodies. Streambed Alteration Agreements are generally not required for LOSSAN projects in existing ROW
CESA – Incidental Take Permit	California Department of Fish and Wildlife	A permit or approval from CDFW is required whenever an activity may affect state-listed threatened or endangered plant or animal species.
Rail Crossings	California Public Utilities Commission	SANDAG/NCTD will need to file applications with CPUC for new rail crossings or “GO 88-B authorization” requests for alterations of existing rail crossings.
New Transit Stations	State or City Fire Marshal	State Fire Marshal shall review and approve transit stations for occupancy higher than 50 people, fire alarms devices, equipment and systems. City Fire Marshal shall also review.

### 3.7.1 CALIFORNIA COASTAL ACT

In 2002 the STB ruled that rail projects benefiting interstate commerce are preempted from local and state permitting and environmental regulations including state review (see an example of an STB Ruling in Appendix D).

For projects located within the coastal zone that are subject to state environmental and permitting regulations, a Coastal Development Permit (CDP) will be required. Many coastal communities have developed local coastal plans (LCPs) that have been certified by the California Coastal Commission. A project located within the coastal zone that is subject to a certified LCP allows the local agency (i.e. City or Port) the authority to issue a CDP; otherwise, if there is no LCP, a coastal development permit will be required from CCC.

For projects located in the coastal zone that are preempted (i.e. improvements benefiting Freight and/or Amtrak) fall under the federal Coastal Zone Management Act of 1972 (16 USC 1451–1464), federal or federally assisted projects must be, to the maximum extent possible, consistent with the approved state coastal zone management program. A certification of consistency with the approved coastal zone management program is required from the federal consistency office of the California Coastal Commission located in San Francisco. This consistency certification is ordinarily obtained after the preliminary engineering/environmental review phase of a project.

### 3.7.2 RWQCB ADMINISTERED FEDERAL CLEAN WATER ACT, SECTION

## 401

Under the Clean Water Act, Section 401 water quality certification is required for any permit or license issued by a federal agency (USCG Section 9 permits, USACE Section 10 permits, and USACE Section 404 permits) for any activity that may result in a discharge into waters of the state to ensure that the proposed project will not violate state water quality standards. For example, if someone proposes to discharge dredge or fill material into navigable waters of the United States, including wetlands, they must obtain a Section 404 permit from the USACE and a Section 401 water quality certification from the RWQCB. The USACE Section 404 permit is by far the most common federal permit issued in California that requires a Section 401 determination from the RWQCB. This water quality certification is part of the 1974 Clean Water Act, which allows each state to have input into projects that may affect its waters (rivers, streams, lakes, and wetlands). RWQCBs are responsible for issuing Section 401 certifications in California. The typical water quality certification takes 3 to 9 months to process.

The California EPA SWRCB has issued guidance on Section 401 certification waivers that apply to all RWQCBs. The SWRCB lists the Section 404 NHPs that are exempt from Section 401 certification. An updated listing of NHPs with Section 401 certification waived in California is available from the appropriate RWQCB office.<sup>2</sup>

### **3.7.3 RWQCB ADMINISTERS FEDERAL CLEAN WATER ACT, SECTION 402**

Any facility that is currently discharging, or proposing to discharge, waste into any surface water of the state either directly, or indirectly through municipal separate storm sewers, must comply with waste discharge requirements. For discharges to surface waters, the requirements are to obtain a federal NPDES permit from the RWQCB in the project area.

Facilities that discharge waste into a municipal sanitary sewer system do not need to obtain an NPDES permit. The United States Environmental Protection Agency (USEPA), the State Water Resources Control Board (SWRCB), and the respective RWQCB or local wastewater management agency may require some industries to treat industrial hazardous wastes before such wastes are discharged to a municipal sanitary sewer system. These requirements are available from the local wastewater management agency.

General Industrial Storm Water Permit and Construction General Permit (CGP) are discussed in depth in section 3.10 of this chapter.

### **3.7.4 CA DEPARTMENT OF FISH AND WILDLIFE, SECTION 1600**

In 2002, the STB ruled that rail projects benefiting interstate commerce are exempt from state and local regulations (see the STB Ruling in Appendix D). If the project benefit interstate commerce (i.e. BNSF freight) and/or intercity rail passenger service (Amtrak) a California Fish and Wildlife Code (CDFW) streambed alteration agreement is not required.

Under Section 1600 of the Fish and Wildlife Code, CDFW regulates the alteration of streams, lakes, and other waterbodies. Any person, government agency, or public utility proposing any

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<sup>2</sup> <http://www.waterboards.ca.gov/sandiego/>



activity that will substantially divert or obstruct the natural flow or substantially change the bed, channel, or bank of any river, stream, or lake, or proposing to use any material from a streambed must notify CDFW of such activity before beginning the project.

Generally, the notification applies to any work undertaken within the normal high-water mark of a wash, stream, or lake that contains or once contained fish and wildlife or supports or once supported riparian vegetation.

CDFW provides regular permitting through the processing of a streambed alteration agreement. The lead agency would file a “Notification of Lake or Streambed alteration” form (FG 2023) and “Project Questionnaire” form (FG 2024) with the local CDFW office. The typical time frame for a streambed alteration agreement is 3 to 9 months.

For permitting of emergency construction, CDFW has established a process for emergency notification. Section 1610 of the Fish and Wildlife Code exempts certain types of emergency work from the notification requirements. Notification is not required before beginning emergency work necessary to protect life and property and/or repair public service facilities necessary to maintain service as a result of a disaster.

All CDFW regions request that applicants notify the applicable regional office within 14 days of beginning emergency construction. Region 5 (South Coast Region) requests that applicants complete and submit its “Notification of Emergency Work <http://www.dfg.ca.gov/habcon/1600/> as well.

### **3.7.5 CALIFORNIA ENDANGERED SPECIES ACT**

In 2002 the STB ruled that rail projects benefiting interstate commerce occurring within existing ROW are exempt from state and local regulations (see the Ruling in Appendix D). If the project benefits interstate commerce then a CESA permit is not required.

CDFW administers the California Endangered Species Act (CESA) under Fish and Wildlife Code Sections 2080 through 2085. A permit or approval from CDFW is required whenever an activity may affect state-listed threatened or endangered plant or animal species. The CESA allows for “take” incidental to otherwise lawful development projects. Fish and Wildlife Code Section 2081 (b) and (c) describes the Incidental Take Permit process. In addition to the 2081 Incidental Take Permit, a 2080.1 Consistency Determination may be an option if Section 7 consultation under the FESA has resulted in a BO.

The CESA emphasizes early consultation to avoid potential impacts on rare, endangered, and threatened species, and to develop appropriate mitigation planning to offset project-caused losses of listed species. Complete requirements and procedures for CESA Incidental Take Permits are found in 14 C.C.R. 783.0–783.8.

The CESA has no provisions for emergency construction that may affect threatened or endangered species; therefore, it is necessary to begin immediate consultation with CDFW whenever an emergency activity may affect such species. However, for the LOSSAN Corridor (tracks used by freight and Amtrak) any emergency incident that may affect a threatened or endangered species would require consultation with the appropriate federal regulatory resource agencies (USFWS, ACOE, and CCC (Federal Consistency Office, San Francisco)).

Multiple Species Conservation Plans (MSCPs) and Natural Community Conservation Plans (NCCPs) have been developed by various entities such as cities, counties, and utilities in a number of areas that include provisions for permitting pursuant to the FESA and CESA. Because MSCPs and NCCPs provide for protection and preservation of existing listed species as well as species that may be listed in the future, these MSCPs and NCCPs have the potential opportunity to streamline the permitting process (for projects that would be subject to applicable local and state environmental regulations) while providing an adequate level of protection. Projects that meet the terms and conditions of these MSCPs and NCCPs and are in the MSCP and NCCP areas can use the MSCP or NCCP to authorize a project if the project proponent becomes a signatory to the MSCP or NCCP and agrees to its terms and conditions. SANDAG, NCTD and MTS are not signatories to any MSCPs and/or NCCPs.

### **3.7.6 CALIFORNIA PUBLIC UTILITIES COMMISSION**

The California Public Utilities Commission (CPUC) Rail Crossings and Engineering Branch ensures that railroad–highway grade crossings are designed, constructed, and properly maintained to ensure public safety. The CPUC Rail Crossings and Engineering Branch engineers investigate and evaluate requests to construct new or modify existing rail crossings. They also investigate train-related incidents that occur at rail crossings and complaints regarding rail crossings safety or conditions. Rail Crossings and Engineering Branch engineers are assigned to territories by county and are responsible for rail crossing matters in those territories.

SANDAG, NCTD will need to file applications with CPUC for new rail crossings or “GO 88-B authorization” requests for alterations of existing rail crossings. GO-88-b authorization requests from NCTD would require concurrence from the owner of the road being crossed. If concurrence cannot be obtained, a formal application can be submitted to the CPUC Docket Office. There is a formal process to resolve disputes, typically through mediation or hearings under an Administrative Law Judge. The process results in an Order from the CPUC. For more details see the CPUC Rules of Practice and Procedure. Details are on the website in the section “Construction or modification of a rail crossing” <http://www.cpuc.ca.gov/crossings/>.

#### Overview of GO88-B Authorization Request Process

- A. Contact interested parties at the rail crossing, including the rail organization, roadway authority, and CPUC staff.
- B. Conduct on-site diagnostic team meeting with the interested parties to review the proposed changes.
- C. Update plans based on feedback from the interested parties.
- D. Obtain written concurrence of the rail organization and/ or roadway authority with jurisdiction at the crossing.
- E. Submit the GO-88-B authorization request form to the CPUC.

### **3.8 LOCAL PERMITS AND APPROVALS**

In addition to the federal and state regulations discussed above, LOSSAN projects will usually require working with local (city, county and municipal) agencies, particularly for work

outside established rail corridors. Cities and counties prepare planning documents (General Plans, Zoning and various adopted ordinances) that provide guidance for development in a specific area and include relevant land use and zoning regulations. SANDAG and the City of San Diego have entered into a Cooperative Agreement for Project Review Procedures (SANDAG Document #5001195, August 17, 2009). The Cooperative Agreement describes the project review procedures between SANDAG and the City of San Diego. SANDAG is exempt from City zoning and building regulations pursuant to Public Utilities Code section 132354.4 and Government Code sections 53090 and 53091. Except as specified in the Agreement, SANDAG will not be required to obtain City permits or other approvals including but not limited to bond estimates, building permits, community plan amendments, conditional use permits, construction permits, discretionary permits, encroachment removal agreements, engineering permits, grading permits, neighborhood use permits, public right-of-way permits, site development permits, and zoning variances.

Table 3-3 provides a summary of Local Permits that may be required depending on project activity and location.

**TABLE 3-3 Local Permit Summary**

Permit or Approval	Responsible Agency	Permit or Approval
Flood Control Permit	Flood Control District	A flood control permit may be required for projects affecting county flood control structures.
Special Use Permits	Cities, Counties, Special Districts	For projects occurring outside existing transit or rail ROWs, additional city, county, or special district permitting may be required.
Building Permits	Municipal and Fire Department	For projects occurring outside of existing ROWs, additional municipal permitting may be required for the project(example habitable structures). Local Fire Marshal will need to review and approve plans prior to construction.
Building Occupancy	Local Fire Marshal	Prior to occupancy of a building, the local Fire Marshal will need to inspect and issue an occupancy permit.

### **3.8.1 COUNTY AND CITY FLOOD CONTROL DISTRICTS**

County and City flood control districts have jurisdiction over many flood control structures that may cross rail corridors. LOSSAN projects that cross but do not affect a flood control structure would receive a Letter of No Objection from the local district; projects that adversely impact a flood control structure may require a flood control district permit.

### **3.8.2 SPECIAL USE PERMITS**

For projects occurring outside existing transit or rail ROWs, additional city, county, or special district permitting may be required as determined by SANDAG/NCTD and in consultation with the local jurisdiction.

### **3.8.3 BUILDING PERMITS AND OCCUPANCY**

For projects occurring outside of existing ROWs or that are determined by SANDAG to be subject to local and/or state permitting requirements, additional municipal permitting may be required for the project. Local Fire Marshal will need to review and approve plans prior to construction and building occupancy.

## **3.9 PERMIT CONDITIONS**

Agencies granting a permit to SANDAG, NCTD, or their agents, may grant the application as filed; deny the application as filed; or most likely, grant it subject to terms, conditions, limitations, or modifications of the regulated activity. Such terms may include any reasonable measure that would mitigate the impacts of the regulated activity and that would:

1. Prevent or minimize pollution or other environmental damage
2. Maintain or enhance existing environmental quality
3. In the following order of priority, restore, enhance, and create productive wetland or watercourse resources.

SANDAG, NCTD and PDT Staff shall comply with permit conditions. SANDAG and NCTD may be required to implement structural engineering changes to project plans, conduct construction monitoring, and provide environmental mitigation (i.e. on and off-site biological mitigation) or pay in-lieu mitigation fees to an approved mitigation bank that has restored, enhanced, or created similar habitat through a restoration program.

## **3.10 MITIGATION, MONITORING, AND REPORTING**

SANDAG or NCTD may choose to modify the proposed project in response to permitting agency comments to avoid or minimize environmental impacts. Mitigation measures generally involve on-site or off-site environmental compensation in the form of habitat creation, dedication, or restoration/enhancement or purchase of credits in appropriate mitigation areas. Where sensitive habitats are being affected or where construction occurs in proximity to a sensitive environmental resource, such as wetlands, least Bell's vireo, California gnatcatcher, or significant archaeological site; a construction mitigation monitoring program will be required. The mitigation monitoring program and reporting requirements will be established in conjunction with permit conditions as required by the applicable jurisdictional agency.

The environmental requirements (permit conditions) are documented in the project permits. The environmental mitigation requirements shall be summarized in a project mitigation plan. The draft mitigation plan shall be prepared at the 60% design phase along with the permit applications. The final mitigation plan needs to be developed upon issuance of all applicable permits. The mitigation plan shall identify the permit condition, timing of performance and responsible party. The mitigation plan needs to be updated quarterly.

These requirements where applicable need to be communicated to contractors via project specifications and plans. The information conveyed to contractors shall include the limitations and conditions of the environmental permits and approvals.

### **3.11 MS4 GENERAL PERMIT**

In 2013 the SWRCB designated NCTD a Non Traditional Phase 2 MS4 Permittee with Water Quality Order No. 2013-0001-DWQ. This permit requires NCTD to comply with storm water pollution prevention provisions including; industrial, construction, and MOW activities. This permit requires new construction (initiated after July 1, 2015) on NCTD owned ROW to implement the San Diego County Standard Urban Stormwater Mitigation Plan (SUSMP) requirements for site design measures and Low impact Design (LID) to mitigate pollutants in stormwater runoff.

For Projects on NCTD owned ROW, all designs should comply with the NCTD Storm Water Management Plan available at <http://www.gonctd.com/storm-water-management-plan>.

#### **3.11.1 INDUSTRIAL GENERAL PERMIT**

Industrial facilities whose discharges are composed entirely of industrial storm water runoff may be eligible to be regulated under the General Industrial Storm Water Permit, Order No. 97-03-DWQ, issued by the SWRCB rather than an individual NPDES permit issued by the RWQCB. The General Industrial Storm Water Permit regulates storm water runoff from eligible transportation facilities (see Attachment 1 of permit). In order to obtain permit coverage under the General Industrial Permit, facility operators must submit a Notice of Intent (NOI), site map, and a check with the appropriate fee to the SWRCB. It is advised that the NOI be submitted 30 days prior to the anticipated project start date to ensure adequate processing time. Project Managers and design consultants can find additional information on the [General Industrial Permit Website](#).

In 2014, the State Water Board adopted IGP (14-0057-DWQ) which went into effect July 1, 2015. Each of the four NCTD maintenance facilities are covered under this permit. Project Managers and design consultants can find the latest permit requirements on the water board at the [Industrial Storm Water Program Website](#).

A facility Storm Water Pollution Prevention Plan (SWPPP) is required to be prepared in accordance with the Industrial General Permit, which must be kept onsite and appropriately implemented. Site monitoring, sampling, and reporting of stormwater discharges and authorized non-storm water discharges must be conducted as outlined in the permit and SWPPP. Annual reports are required to be submitted to the Executive Officer of the RWQCB by July 1st of each year. Storm Water Multi-Application Reporting and Tracking System (SMARTS) allows an individual discharger to file and submit their Annual Report electronically to the Regional Water Board. Currently SMARTS is not a mandatory reporting method, but the SWRCB encourages all dischargers to register and use SMARTS. Permittees are required to submit annual renewal fees to the SWRCB.

#### **3.11.2 EROSION SEDIMENT CONTROL PLANS**

For construction projects disturbing less than one acre of soil on NCTD ROW from the Orange County line near San Mateo Creek at MP 207.4 to Downtown San Diego at MP 264.2 (Santa Fe Station). NCTD requires an Erosion Sediment Control Plan, or ESCP, to be

developed, approved and implemented. The ESCP needs to be approved by NCTD. The ESCP needs to have consistent sediment control practices to meet the minimum requirements defined in Table 2 on NCTD's Stormwater Management Plan available on the web at <http://www.gonctd.com/storm-water-management-plan>.

### **3.11.3 CONSTRUCTION GENERAL PERMIT**

Project Managers and design consultants can find additional information on the [Construction General Permit Website](#).

For General Construction Activity the SWRCB has adopted an NPDES General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities, (Order No. 2009-0009-DWQ) which was amended by Order No. 2010-0014-DWQ and became effective on February 14, 2011. This permit is generically termed the Construction General Permit (CGP) and is required for storm water discharges associated with any construction or demolition activity including, but not limited to, clearing, grading, grubbing, excavation, reconstruction, or any other activity that results in a land disturbance of **equal to or greater than 1 acre**. Storm water discharges from dredge spoil placement that occur outside of USACE jurisdiction (upland areas) and that disturb 1 or more acre of land surface from construction activity are included under this permit.

For LOSSAN construction projects that result in a land disturbance of 1 acre or more, the lead agency must apply for coverage under the CGP, which requires electronically filing Permit Registration Documents (PRDs). PRDs include a NOI, SWPPP, Site Map, Risk Assessment, annual fee, and certification prior to commencement of construction activities. The appropriate fee must be sent to the SWRCB at least 2 weeks prior to initiating ground-disturbing activities. Beginning September 2011, the SWRCB requires that a Qualified SWPPP Developer (QSD) prepare, sign, and certify all SWPPPs and that SWPPP implementation work be performed by a Qualified SWPPP Practitioner (QSP). QSD and QSP definitions are included in the CGP (Fact Sheet p. 21 Item H, and p. 45 Item M and Order pp. 33–34). For projects requiring RWQCB Clean Water Act 401 certifications the draft SWPP must be submitted with the 60% plan set to SANDAG and NCTD for review. NCTD requires review and approval of SWPPP's for projects on NCTD owned ROW prior to uploading to SMARTS.

SWPPP monitoring, maintenance, sampling, and reporting is required to be performed based on each project's determined Risk Level as outlined in the CGP (Order Attachments C through E). SWPPP plans are required to be kept on site or in the QSP's vehicle during construction work. Annual reports must be digitally submitted to the Storm Water Multiple Application and Tracking System (SMARTS) no later than September 1st of each year. For Projects on NCTD owned ROW NCTD requires access to all completed SWPPP inspection reports. Non compliances should be noticed immediately. NCTD requires a copy of the annual report for review by August 15<sup>th</sup> of each year

Upon completion of construction work and final stabilization of the site, a Notice of Termination must be digitally submitted to the SWRCB's SMARTS.

For LOSSAN Corridor projects, the Legally Responsible Person (LRP) is provided by the agency owning the project ROW.

For the NCTD ROW the Legally Responsible Person (LRP) is the NCTD Senior Legal Council. The Authorized Signatory (AS) is a NCTD Senior Environmental Planner designated by the LRP. Consultants to check with NCTD for current responsible persons.

For projects on MTS ROW, the Legally Responsible Person (LRP) is Karen Landers the MTS Attorney. The Authorized Signatory (AS) for the LRP is Tim Allison the Real Estate Manager.

The Data Submitter (DS) for the project will be designated by the Project Manager, and may be either the Qualified SWPPP Developer (QSD) or the Qualified SWPPP Practitioner (QSP) or both. The LRP must obtain coverage under this General Permit. To obtain coverage, the LRP or the LRP's Approved Signatory must file Permit Registration Documents (PRDs) prior to the commencement of construction activity. LRP's must electronically file the PRDs, which include a Notice of Intent (NOI), Storm Water Pollution Prevention Plan (SWPPP), and other documents required by this General Permit, and mail the appropriate permit fee to the State Water Board.

The LRP, Project Managers and design consultants can find additional information on the [LRP Amendment Order No. 2010-0014-DWQ Website](#).

### **3.11.4 STORMWATER PERMIT COVERAGE CONDITIONS**

Conditions for permit coverage include the following:

- A. Construction activity, including demolition, clearing, grading, and excavation, and other land disturbance activities (except operations that result in disturbance of less than one acre of total land area and which are not part of a larger common plan of development or sale).
- B. Construction activity that results in land surface disturbances of less than one acre if the construction activity is part of a larger common plan of development or the sale of one or more acres of disturbed land surface.
- C. Construction activity related to residential, commercial, or industrial development on lands currently used for agriculture including, but not limited to, the construction of buildings related to agriculture that are considered industrial pursuant to U.S. EPA regulations, such as dairy barns or food processing facilities.
- D. Construction activity associated with Linear Underground/Overhead Utility Projects (LUPs) including, but not limited to, those activities necessary for the installation of underground and overhead linear facilities (e.g., conduits, substructures, pipelines, towers, poles, cables, wires, connectors, switching, regulating and transforming equipment and associated ancillary facilities) and include, but are not limited to, underground utility mark-out, potholing, concrete and asphalt cutting and removal, trenching, excavation, boring and drilling, access road and pole/tower pad and cable/wire pull station, substation construction, substructure installation, construction of tower footings and/or foundations, pole and tower installations, pipeline installations, welding, concrete and/or pavement repair or replacement, and stockpile/borrow locations.
- E. Discharges of sediment from construction activities associated with oil and gas exploration, production, processing, or treatment operations or transmission facilities. Storm water discharges from dredge spoil placement that occur outside of U.S. Army Corps of Engineers jurisdiction (upland sites) and that disturb one or more acres of land surface from construction activity are covered by the CGP. Construction sites

that intend to disturb one or more acres of land within the jurisdictional boundaries of a CWA § 404 permit shall contact the appropriate Regional Water Board to determine whether this permit applies to the site.

The Construction General Permit (CGP) requires all permittees to electronically file all Permit Registration Documents (PRDs), Notices of Termination (NOT), changes of information, annual reporting, and other compliance documents through the State Water Board's Storm water Multi-Application and Report Tracking System (SMARTS) website. Project Managers and design consultants can find additional information on the [SMARTS Website](#).

The Permit Registration Documents shall consist of the following items:

- Notice of Intent (NOI),
- Risk Assessment (found in Section VIII of the CGP),
- Site Map,
- Storm Water Pollution Prevention Plan,
- Annual Fee, and
- The Signed Certification Statement.

LOSSAN consultants shall follow the Construction General Permit requirements to assess the risk level of a site based on both sediment transport and receiving water risk. The CGP contains specific requirements for each Risk Levels 1, 2, and 3, and Linear Underground Projects (LUP) Risk Type 1, 2, and 3. Risk levels are established by determining two factors: first, calculating the site's sediment risk; and second, evaluating the site's receiving water risk - the risk sediment discharges pose to the receiving waters. Both factors are used to determine the site-specific Risk Level(s).

#### 3.11.4.1 StormWater Monitoring and Reporting

Monitoring and reporting requirements differ per risk level. The permit requirements, visual inspections, sample collections and reporting requirements are summarized in the following table for each risk level.

**Table 3-4 Construction General Permit 2009-0009-DWQ  
Project Requirement Matrix**

<b>Permit Requirements</b>	<b>Risk Level 1</b>	<b>Risk Level 2</b>	<b>Risk Level 3</b>
Notice of Intent – SMARTS	✓	✓	✓
Annual Report – SMARTS	✓	✓	✓
Change of Information – SMARTS	✓	✓	✓
Notice of Termination - SMARTS	✓	✓	✓
<b>Visual Inspections</b>	<b>Risk Level 1</b>	<b>Risk Level 2</b>	<b>Risk Level 3</b>
Weekly Visual Inspections	✓	✓	✓
Quarterly Visual Inspections (Jan-Mar, Apr-June, July-Sept, Oct-Dec)	✓	✓	✓
Rain Event Action Plans		✓	✓
Pre-Storm Inspections	✓	✓	✓



During-Storm Inspections (each 24hrs. extended events)	✓	✓	✓
Post-Storm Inspections	✓	✓	✓
<b>Sample Collections and Reporting Requirements</b>	<b>Risk Level 1</b>	<b>Risk Level 2</b>	<b>Risk Level 3</b>
Breach or spill that would discharge pollutants to surface waters	✓	✓	✓
Any additional parameters for which monitoring is required by the Regional Water Board	✓	✓	✓
Sampling for pH and Turbidity		✓	✓
NAL Exceedance (shall electronically submit all storm event sampling results to the State Water Board no later than 10 days after the conclusion of the storm event)		✓	✓
Risk Level 3 sampling data (shall electronically submit all storm event sampling results to the State Water Board no later than 5 days after the conclusion of the storm event)			✓
NEL Exceedance Report (shall submit an NEL Violation Report to the State Water Board within 24 hours after the NEL exceedance has been identified)			✓

All permittees are required to appoint two positions - the Qualified SWPPP Developer (QSD) and the Qualified SWPPP Practitioner (QSP) - who must obtain appropriate registrations or certifications and experience.

The CGP requires the development of a site-specific SWPPP. The SWPPP must include the information needed to demonstrate compliance with all requirements of this General Permit. The permittee shall ensure that a QSD develops the SWPPP. To ensure proper site oversight, a Qualified SWPPP Practitioner is required to oversee implementation of the Best Management Practices (BMPs) required to comply with this General Permit.

#### 3.11.4.2 StormWater Annual Reports

All permittees are required to prepare and electronically submit an Annual Report no later than September 1 of each year through the SMARTS database. The Annual Report is an electronic form within SMARTS and contains multiple questions consisting of: a summary and evaluation of all sampling and analysis results, including copies of laboratory reports; the analytical method(s), method reporting unit(s), and method detection limit(s) of each analytical parameter (analytical results that are less than the method detection limit shall be reported as "less than the method detection limit"); a summary of all corrective actions taken during the compliance year; identification of any compliance activities or corrective actions that were not implemented; a summary of all violations of the General Permit; the names of individual(s) who performed the facility inspections, sampling, visual observation (inspections), and/or measurements; the date, place, time of facility inspections, sampling,

visual observation (inspections), and/or measurements, including precipitation (rain gauge); and the visual observation and sample collection exception records and reports specified for the project's risk or type level; documentation of all training for individuals responsible for all activities associated with compliance with this General Permit; documentation of all training for individuals responsible for BMP installation, inspection, maintenance, and repair; and documentation of all training for individuals responsible for overseeing, revising, and amending the SWPPP.

Within 90 days of when construction is complete or ownership has been transferred, the permittee shall electronically file a Notice of Termination (NOT), a final site map, and photos through the State Water Boards SMARTS database. Filing a NOT certifies that all General Permit requirements have been met. The Regional Water Board will consider a construction site complete only when all portions of the site have been transferred to a new owner, or all of the permit conditions have been met.

LOSSAN consultants shall comply with the CGP post construction standards to match pre-project hydrology.

#### 3.11.4.3 StormWater BMP Design Standards

Designers and Project Managers shall reference the following Stormwater Design Standards when developing all Erosion Control Plans and Best Management Practice (BMP) designs/details. Some projects or construction activities may require site specific BMP designs, details, and/or specifications. The latest edition of the following standards and guidelines shall be used during project design:

1. Caltrans Stormwater Pollution Prevention Plan (SWPPP) and Water pollution Control Plan (WPCP) preparation Manual March 2011.
2. California Stormwater Quality Association (CASQA) BMP Handbook Construction November 2009.

Caltrans design specification fact sheets can be found at the [Caltrans Specification Fact Sheets Website](#). Caltrans BMP Details and Drawings can be found at the [Caltrans Details and Drawings Website](#). The CASQA design specification fact sheets can be found at the [CASQA Specification Fact Sheets Website](#).

Sediment Control BMPs are installed on the perimeter and interior of disturbed areas. The BMPs are designed to reduce, prevent or eliminate sheet and rill erosion.

Erosion Control BMPs are applied in a manner that covers disturbed soil and prevents rain drops or wind from direct contact with the soil particles. The BMPs are designed to reduce, prevent or eliminate the process of erosion from occurring.

Tracking Control BMPs prevent sediment from leaving a disturbed area.

Non-Stormwater Management Control BMPs minimize, contain, and dispose prohibited discharges or minimize adverse impacts of authorized discharges from the project into the storm drain system or waterway.

Waste Management and Materials Pollution Control BMPs consists of implementing procedural and structural BMPs for collecting, handling, storing and disposing of wastes generated by a construction project to prevent the release of waste materials into stormwater discharges. The latest edition of the following standards, codes and guidelines shall be used during design of these projects.

### **3.11.5 STORM WATER POLLUTION PREVENTION**

#### **3.11.5.1 Water Contamination**

Temporary construction impacts on water quality, such as increased turbidity in adjacent streams, can be controlled through implementation of proper erosion and sedimentation control practices. Conditions and time constraints affecting construction activities may be set forth in mitigation measures required by USFWS, NMFS (Section 7, FESA), the USACE (Section 404, Clean Water Act), RWQCB (Section 401, Clean Water Act), or CDFW (Section 1602, California Fish and Wildlife Code), as applicable. All LOSSAN projects shall adhere to the terms and conditions specified in such mitigation commitments, permits, and agreements.

#### **3.11.5.2 Hydromodification**

In general, local and state regulations now require that the maximum rate of storm water runoff after development be no greater than the rate of storm water runoff before development. This requirement may be met by constructing storm water detention facilities to control the rate of runoff, or by designing the project such that the relationship of impervious surfaces and travel time does not cause the maximum rate of storm water runoff to increase. Guidelines for storm water management can be found in United States Department of Agriculture, Soil Conservation Service, Technical Release 55, "Urban Hydrology for Small Watersheds," dated June 1986.

Catch basins, curbing, culverts, gutters, and storm sewers shall be constructed as necessary for the permanent control of water runoff during the operation phase of the project. Specific drainage design criteria are provided in this Design Criteria Manual in Chapter 4.0, Drainage and Grading.

Storm water discharges associated with industrial wastes or activities, including construction sites larger than 1 acre, require an NPDES permit from USEPA or the RWQCB under the federal Water Pollution Control Act (1972), as amended by the Clean Water Act.

Water quality certification or waiver may be required under Section 401 of the Clean Water Act from the RWQCB.

All projects shall be consistent with the State Non-Point Source Pollution Management Program and the SWPPP.

Projects are required to comply with the RWQCB's Construction General Permit (CGP) section XIII.A.4, which is applicable to hydro-modification management and states that: "For sites whose disturbed area exceeds two acres, the discharger shall preserve the pre-construction drainage density (miles of stream length per square mile of drainage area) for all drainage areas within the area serving a first order stream or larger stream and ensure that

post project time of runoff concentration is equal or greater than pre-project time of concentration“

## 3.12 OTHER ENVIRONMENTAL CONSIDERATIONS

### 3.12.1 FLOODPLAINS

The placement or removal of earth fill material into floodplains may alter flooding characteristics along the river or creek. LOSSAN facilities that are evaluated for protection from flooding hazards will be designed in compliance with the appropriate agency and FEMA regulations, and these agencies will be afforded an opportunity to review and comment on the design plans for such facilities.

All new bridges and their associated abutments will be designed to maintain or enhance stream flow capacity. During the preliminary engineering phase, hydrologic and hydraulic studies will be undertaken to ensure that design of the improvements will not adversely impact floodways and floodplains.

#### 3.12.1.1 No rise certifications

All Consultants shall endeavor to design projects to ensure no rise in water surface elevations upstream or downstream of the project.

#### 3.12.1.2 Conditional Letter of Map Revisions (CLOMR)

If no rise certification is unobtainable, then a CLOMR will need to be obtained from FEMA prior to construction bidding.

#### 3.12.1.3 Letter of Map Revisions (LOMR)

Following receipt of the As-built drawings, a Letter of Map Revisions shall be prepared and submitted to FEMA via the Flood Plain Manager by the engineer of record.

### 3.12.2 CLIMATE CHANGE

Measures to address climate change fall into two categories: mitigation and adaptation. Mitigation measures work to reduce greenhouse gas (GHG) emissions. Primary sources of GHGs come from transportation fuel use and energy use in buildings; other sources include emissions from solid waste decomposition and wastewater treatment. Adaptation measures address impacts that are expected to occur due to climatic changes in the San Diego region; such as sea level rise, increased temperatures, changes in weather patterns, and heightened wildfire risk. Climate adaptation addresses GHGs already in the earth's atmosphere. Guidelines for addressing both climate change mitigation and adaptation are described in the following sections.

Project Managers and design consultants shall use the most recently adopted Regional Transportation Plan (RTP) and Environmental Impact Report (EIR) as reference during project design:

1. SANDAG 2050 RTP, adopted by SANDAG on October 28, 2011. In particular,

Chapter 3-Forging a Path Toward More Sustainable Living: A Sustainable Communities Strategy.

2. SANDAG 2050 RTP/SCS EIR, certified by SANDAG on October 28, 2011.

In addition, Project Managers and design consultants should use relevant local climate plans as reference during project design.

### 3.12.2.1 Mitigation

GHG emissions associated with passenger vehicles account for the largest portion of the total GHG emissions in the San Diego region (SANDAG 2050 RTP). Generally, LOSSAN projects are expected to reduce GHG emissions by reducing vehicle miles traveled (VMT). Other efforts described in this report to address energy and air quality (Sections 3.11.6 and 3.11.11, respectively) also reduce GHG emissions through reductions in energy use, VMT, and use of transportation fuels.

The SANDAG 2050 RTP/SCS EIR identifies the following mitigation measures to reduce GHG emissions during the construction and operation of projects (Section 4.8.5 Mitigation Measures, GHG-C.):

- GHG-C SANDAG shall and implementing agencies can and should require Best Available Control Technology (BACT) during construction and operation of projects, including:
- a) Solicit bids that include use of energy and fuel efficient fleets;
  - b) Solicit preference construction bids that use BACT;
  - c) Employ use of alternative fueled vehicles;
  - d) Use lighting systems that are energy efficient, such as LED technology;
  - e) Use CEQA guidelines Appendix F, Energy Conservation, to create an energy conservation plan;
  - f) Streamline permitting process to infill, redevelopment, and energy-efficient project;
  - g) Use an adopted emissions calculator to estimate construction-related emissions;
  - h) Use the minimum feasible amount of GHG-emitting construction materials that is feasible;
  - i) Use of cement blended with the maximum feasible amount of flash or other materials that reduce GHG emissions from cement production;
  - j) Use of lighter-colored pavement where feasible;
  - k) Recycle construction debris to maximum extent feasible; and
  - l) Plant shade trees in or near construction projects where feasible.

### 3.12.2.2 Adaptation

The 2050 RTP Sustainable Communities Strategy (Chapter 3) identifies the following action to address climate change adaptation:

26. To the extent possible, address climate adaptation issues in the design of new projects, and when improvements are made to existing infrastructure.

There are various impacts of climate change that are likely to occur regardless of efforts to reduce GHG emissions. The most relevant impact for LOSSAN projects is sea level rise. Sea level rise is driven by increased temperatures and the resulting impacts of thermal expansion and the melting of land-based ice. LOSSAN projects near the coastline must account for a rising sea level.

Guidance for addressing sea level rise has been developed on both a federal and state level. These data combined with results of local sea level rise studies can provide a range of scenarios for any given location. The current requirement is for projects to consider the full range of sea level rise predictions in the design of projects. Consultants should also refer to the San Diego Coastal Sea Level Rise Analysis prepared in 2013 by SANDAG & Caltrans by Moffatt & Nichol and Everest Consultants.

The table below summarizes current Sea Level Rise predictions based on different plausible scenarios and guidance documents.

<b>Table 3-5 Sea Level Rise predictions</b>				
<b>Year</b>	<b>2000</b>	<b>2030</b>	<b>2050</b>	<b>2100</b>
Lower Rate	0.0 ft.	0.3 ft.	0.4 ft.	1.4 ft.
Likely High	0.0 ft.	0.5 ft.	0.8 ft.	2.0 ft.
High Rate	0.0 ft.	1.0 ft.	2.0 ft.	5.5 ft.

**For the purpose of preparing the alternative analysis for a new project**, LOSSAN corridor consultants shall consider a range of sea level rise from 1.4 to 5.5 feet, or the latest guidance from State or Federal regulations, to determine project impacts associated with predicted sea level rise. These impacts shall then be considered; along with flooding, environmental habitat loss, wetlands loss, view impacts, and cost to establish two alternatives to advance to the next design stage.

**During design development**, the project development team will advance the Least Environmentally Damaging Practicable Alternative or LEDPA which will need to be agreed with the Permitting Agencies.

**Consultants are encouraged to use adaptation strategies** to facilitate the higher predictions for sea level rise should impacts to wetlands, views and project budgets make complying with the highest prediction impractical.

In addition local project specific information such as local tide gauges, plate tectonics, erosion, and the requirements of funding agencies also need to be considered to make a final determination on forecasted sea-level rise rates.

The Tide Gauge data illustrated below for the last 100 years would support the lower range of values in the table above. The mean sea level trend is 2.06 millimeters/year with a 95%

confidence interval of +/- 0.20 mm/yr. based on monthly mean sea level data from 1906 to 2006 which is equivalent to a change of 0.68 feet in 100 years.

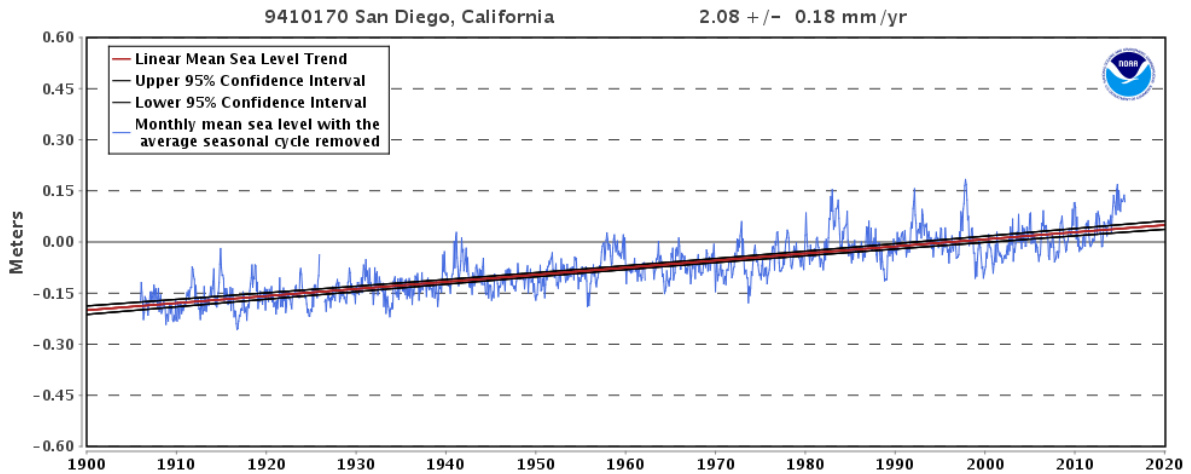


Figure 3-2 - Mean Sea Level Trend San Diego Bay, California

Over the last 25 years the sea has risen at less than half the lowest scientific prediction made in the 1980's. The following graph shows the rise in sea level from 1875 to 1975 (by Gornitz etal as reported by Robin G. deQ in Scope 29, 1986, p327) and the predicted sea level rise over the next century from 1975 to 2075 (Hoffman as reported by Barth and Titus etal 1984:97)

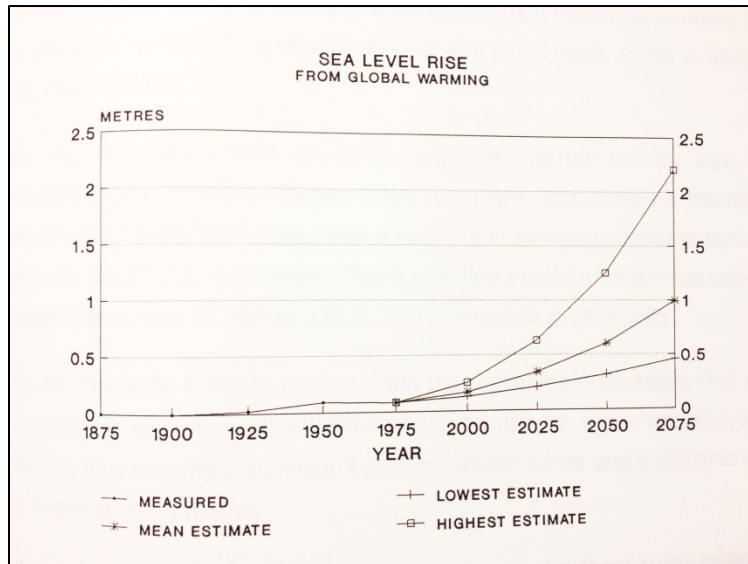


Figure 3.3- Mean Global Sea level rise 1875 to 1975 and future prediction to 2075

To place the above figures in context consider the following. During the last ice age, which ended 10,000 years ago, the sea level was approximately 325 feet lower than today. During

the middle of the last interglacial period, the West Antarctic ice sheet melted and the sea level rose slowly to approximately 20 feet above its present level (Bath and Titus etal 1984:7-8)

### **3.12.3 CONTAMINATION AND REMEDIATION**

LOSSAN projects may encounter contaminated soil and/or water that will require removal and/or remediation. Evaluation of hazardous materials impacts in the project area shall be conducted prior to construction. Initial evaluation can include a Phase I Environmental Site Assessment (ESA) or Hazardous Materials Assessment Report, which include a computerized database search of regulatory agency records to see if there are currently, or were previously, any reports of hazardous materials contamination or usage at the site or contamination at other sites within the search radius. The initial evaluation could also include a review of historical aerial photographs and topographic maps to assist in identification of historical land uses that could impact the environmental condition of the subject property. For Phase I ESAs conducted for stations or maintenance facilities, the evaluation would also include a site inspection and interview with current site owners/occupants.

Phase I ESAs shall be conducted in accordance with the American Society for Testing and Materials (ASTM) Standard E 1527-05 and under the supervision of an environmental professional, as defined in the ASTM Standard.

Based on the findings of the Phase I ESA or Hazardous Materials Assessment, further investigation may be conducted to evaluate potential environmental concerns. Further review could include soil, soil vapor, or groundwater sampling or site surveys included in a Phase II ESA.

If contaminated soil or groundwater is identified, mitigation measures or remediation would be implemented. Such measures could include soil management plans, soil excavation, or engineering controls such as gas membranes and passive vents. Shallow contaminated water may need to be managed if dewatering is necessary. Dewatering permits, which detail sampling, treatment, and disposal, would be required.

In addition to site evaluations to identify potential existing contamination, site reporting could also include Spill Prevention, Control, and Countermeasure Plans as well as Hazardous Materials Business Plans for maintenance facilities that store hazardous materials or fuel.

### **3.12.4 TOPOGRAPHY, SOILS, AND GEOLOGY**

#### **3.12.4.1 General**

Any subsurface testing program for LOSSAN must include sufficient test borings to characterize the soils and potential fill materials, including composition and extent. Of primary importance is the identification of unsuitable material or waste in the soil (for example, hydrocarbons). If adverse environmental impacts could result from disturbance of subsurface materials during construction, the subsurface investigation must be adequately comprehensive to determine that no significant adverse impacts would result or must provide the data required to develop mitigation measures.



During the investigation, if a test boring encounters an aquifer that could be contaminated by materials falling into the boring; the boring will be backfilled with grout slurry upon completion of boring operations, unless otherwise defined by local regulations.

#### 3.12.4.2 Soil and Geology

LOSSAN is located in a seismically active area. A moderate to major earthquake on any of the major faults in the area during the operational lifetime of the proposed project would subject the project to strong ground shaking. Such ground shaking could result in the failure of structures along the proposed corridor and could disrupt service along the corridor. Actual displacement or fault movement is less likely, but could occur. Refer to Chapter 5 of this Design Criteria for further information on Geotechnical requirements.

The likelihood of a severe earthquake occurring during the construction period is low. However, the possibility does exist and shall not be discounted. If the area is subject to a substantial seismic event and associated severe ground shaking during the construction period, the effects of the shaking can be minimized through appropriate construction techniques. All available construction techniques for the safety of workers, pedestrians, motorists, and nearby residents shall be implemented. These measures include shoring and falsework. Refer to Chapter 12 of this Design Criteria for further information on Siesmic requirements.

#### 3.12.4.3 Construction over Inactive Landfills

During the preliminary engineering phase, a study will be undertaken to determine if any active or inactive disposal areas or mine dumps fall within the proposed construction areas. If LOSSAN improvements are to be constructed on, or close to, an inactive landfill, then the density of the filled area and the presence of methane gas or other potentially harmful gas in the vicinity of the work must be determined. If an inactive landfill is discovered in proximity to new construction, alternative sites shall be considered. If alternative sites are not feasible, mitigation measures to prevent such proximate areas from affecting the LOSSAN improvements shall be implemented.

### **3.12.5 REVEGETATION, LANDSCAPING, AND IRRIGATION**

LOSSAN improvements may require removal of some existing vegetation. In these locations, replacement planting will be provided where feasible and appropriate. The placement and types of vegetation and timing for planting, watering, and monitoring will be specified as part of preliminary engineering in a landscaping plan and as required per applicable project permits conditions. The landscaping plan will include a master plant list of new vegetation that conforms to the surrounding environment and enhances visual appeal without hindering operation and maintenance of the system. Such landscaping plans shall be consistent with the terms and conditions of any mitigation commitments adopted during environmental review, as set forth in any environmental permits obtained, and as required by the LCP or other applicable local planning documents. Station Requirements must meet local requirements as well as SANDAG, NCTD (and, where applicable, Metropolitan Transit System (MTS) requirements). NCTD has implemented a "Landscape Design and Maintenance Plan" pursuant to the Phase II MS4 permit requirement for landscape maintenance on NCTD owned ROW to mitigate pollutants in stormwater discharges. The plan shall be used by Consultants and Contractors as applicable.

The RWQCB General Construction Permit requires a minimum of 70% vegetative cover for all cuts and fills to demonstrate effective erosion control. Cover may be vegetative and/or derived from erosion control geotextiles. Vegetative cover shall be derived from a seed mix containing nurse crop (pioneer and annual) species and perennial woody species.

Plant materials introduced through seed and container plants shall be drought-tolerant species that are appropriate for the anticipated final site conditions including soil types, slope, solar aspect, adjacent vegetation and species composition, etc. If native vegetation/habitat is anticipated to be required by permits, appropriate native vegetation shall be established through a plant palette prepared by a qualified restoration ecologist and approved by the relevant permitting agency.

All planted landscaped areas shall be irrigated (if determined necessary and/or as required per applicable project permits), when possible, to establish vegetation cover. Water use shall emphasize the use of recycled water and low precipitation rate delivery components such as drip and rotor heads, when practicable. Station irrigation controllers shall have rain gauge or a similar rain interruption device, and seasonal adjustments for evapotranspiration. Irrigation shall be temporary, used only for initial vegetation survival and establishment, except around stations where long term irrigation is permitted. Irrigation system components shall comply with public health and safety standards. Irrigation system components shall be installed above grade for temporary systems and below grade for permanent systems at stations. Non irrigated hydroseed shall be permitted on areas impacted by construction along the right of way where it is not feasible to provide irrigation.

In general, landscape plans shall include sections on pre-plant site preparation that incorporate activities such as soil decompaction, soil testing (agricultural suitability) and soil amendment (if needed), and pre-plant weed control procedures. The design shall consider the most efficient irrigation system design that provides 100% coverage to planted areas.

### **3.12.6 ENERGY**

Project Managers and design consultants shall use the the adopted Regional Transportation Plan (RTP) and Environmental Impact Report (EIR) as reference for energy saving and GHG reduction measures to consider during project design:

1. SANDAG 2050 RTP, adopted by SANDAG on October 28, 2011. In particular, Chapter 3-Forging a Path Toward More Sustainable Living: A Sustainable Communities Strategy.
2. SANDAG 2050 RTP EIR, adopted by SANDAG on October 28, 2011.

Energy conservation features and operating procedures should be evaluated and incorporated into project design where found to be practical and cost effective on a lifecycle cost basis. Relevant energy actions identified in Chapter 3 of the 2050 RTP include:

20. Support the increased use of clean, alternative fuels in SANDAG and local jurisdiction-owned vehicle fleets, and the vehicle and equipment fleets of contractors and funding recipients, such as the vehicle fleet for the SANDAG Vanpool Program or for local jurisdiction waste haulers.
21. Support planning and infrastructure development for alternative fueling stations and plug-in electric vehicle (EV) chargers.

24. Integrate alternative fuel considerations into the development of the regional transportation network by, for example, integrating infrastructure for electric vehicle charging into regional park-and-ride lots and transit stations.

### 3.12.6.1 ENERGY EFFICIENCY DESIGN CRITERIA

Savings By Design (SBD) is California's nonresidential new construction energy efficiency program, administered statewide and funded by Utility customers through the Public Purpose Programs surcharge applied to gas and electric services. New construction projects should participate in the SBD program, managed by the local utility San Diego Gas & Electric (SDG&E). Project managers and design consultants should contact the SDG&E Savings By Design program at 858-503-5142 for more information.

Projects participating in SBD receive services including design assistance, Owners Incentives, Design Team Incentives, and Energy Design Resources. Services begin in the project design phase and continue through construction completion. To be eligible for SBD, projects must be:

- 1) At a point where design changes are feasible, preferably in the conceptual or schematic design phase;
- 2) Located in the service territory of a participating Utility and subject to payment of Public Goods Charge (PGC) for electric service and/or the gas surcharge for gas service; and
- 3) Within the definition of new construction.

### 3.12.6.2 PLUG-IN ELECTRIC VEHICLE CHARGING INFRASTRUCTURE

If plug-in electric vehicle chargers, also known as electric vehicle supply equipment (EVSE), are to be included in a project, the electrical load switchgear and/or panel board must be sized to account for the increased electrical load. The electrical load will be dependent on the number of chargers installed and the level of each charger (e.g., Level 1, Level 2, or DC fast charge). EVSE should have a dedicated electric meter. The EVSE and all associated components shall be designed, manufactured and tested in accordance with the latest version of the approved year of the following standards:

Society of Automotive Engineers (SAE) J1772, J2836, J2847 and J2931

National Electric Code Article 625

UL 2231, 2594, 1998

The design and integration of EVSE shall be coordinated with San Diego Gas & Electric's (SDG&E) Project Management Team for EVSE siting and installation at 877-789-9866.

### **3.12.7 NOISE AND VIBRATION**

Noise and vibration assessments are needed for new projects. For projects where existing in-service alignments are to be used, the standards for changes in noise and vibration levels before and after the project apply.

### 3.12.7.1 Construction Noise and Vibration

The control of noise and vibration during the construction of projects is important because in some locations the railroad may be in close proximity to residential and commercial areas.

Most local county and city jurisdictions have specific noise criteria for construction activities. Typically, these criteria specify limits for construction noise levels that are close to sensitive areas and also the allowable construction hours. Specific noise control requirements in the construction specifications help reduce noise. Effort shall be made to reduce nighttime noise impacts as local noise ordinances in most circumstances discourage or prohibit nighttime construction activities within noise-sensitive areas. Noise considerations for individual projects shall verify if there are any agreements with local jurisdictions that may apply. Some jurisdictions may also have vibration criteria.

The FTA and FRA have identified various construction noise level limit guidelines. These noise level limits vary depending on the construction time period and level of assessment detail. For general assessments, the FTA and FRA identify a maximum 1-hour daytime Leq limit of 90 dBA for construction noise and an 80 dBA hourly Leq for nighttime construction noise for noise-sensitive receptors (i.e., residences, schools). For all non-sensitive land uses, such as commercial and industrial uses, FTA and FRA procedures utilize a 100 dBA hourly Leq during day or nighttime construction noise. For detailed assessments, the FTA and FRA identify a maximum 8-hour Leq of 80 dBA during the day and an 8-hour Leq 70 dBA at night. Vibration limits that are specified for operations will also apply to the construction activities.

### 3.12.7.2 Noise Design Criteria

Noise design criteria are provided for maximum train pass-bys and average noise for a given period of the time. The maximum levels are not dependent on the number of operations or the existing background noise levels; however, average noise levels are directly related to the existing background noise levels. Design noise limits are normally higher for areas with existing high background noise levels compared to areas with low background noise levels.

FTA and FRA guidelines indicate that noise impacts are generally less than significant if there are no noise-sensitive sites located in the project area. The significance of increasing existing noise levels at noise-sensitive areas would be evaluated by following FTA and FRA procedures to compare the project noise and the existing background noise.

Specific guidelines for preparing noise and vibration impact assessments for rail transit project environmental documents are provided in the FTA publication "Transit Noise and Vibration Impact Assessment," dated May 2006, and the FRA document "High-Speed Ground Transportation Noise and Vibration Impact Assessment," dated October 2005. These documents set forth methods and procedures for determining the level of noise and vibration impact from transit projects and for determining what can be done to mitigate such impact.

## **3.12.8 COMMUNITY SERVICES**

### 3.12.8.1 Emergency Vehicle Access

It is possible that new project construction or operations may temporarily and/or permanently obstruct certain at-grade crossings along the route, thereby increasing the response time of emergency vehicles. To the extent that signalization improvements, temporary detours, or

other traffic management strategies can minimize this problem, such improvements shall be considered and implemented where feasible. In addition, the contractor shall be required to provide advance notification of the location, timing, and duration of such construction activities and/or permanent changes to roadway crossings and routes to local emergency service providers. Alternative access routes shall also be identified for concurrence and use by emergency vehicles.

#### 3.12.8.2 Safety/Security

As with all public facilities, users of the system could be subject to crimes against persons and property in vehicles, stations, parking areas, and other public areas created by the system. To minimize this potential, public areas associated with the transit system shall be designed to promote maximum safety and security for patrons. Specific design measures for security shall be employed, including adequate lighting, good visibility, and good pedestrian and vehicle circulation.

#### 3.12.8.3 Accessibility to Community Services

The placement of ROW fencing for safety may restrict access to some community service facilities, resulting in increased walking distances. To facilitate access to these facilities, existing legal track crossings may be closed or relocated where safety and traffic considerations warrant. In addition, the contractor shall be required to provide advance notification of such access restrictions and shall consult with local community service providers to identify and address their needs.

### **3.12.9 VISUAL QUALITY**

In general, new projects involve refurbishment or expansion of existing facilities and are not expected to result in visual incompatibilities. Nevertheless, visual quality shall be considered in preliminary and final engineering design to blend facilities with surrounding land uses. Architectural principles and local municipal regulations must also be considered during final design activities. When required by CEQA, a formal visual analysis shall be prepared by a licensed landscape architect in accordance with local government (lead agency) guidelines to determine potential visual effects and identify potential remedies to site-specific issues that will reduce potential impacts to a level below significant.

The effects of projects on visual quality shall take into account public viewpoints of the proposed facility. Visual assessment shall consider the visual setting and context of the facility as viewed from public viewpoints. Engineering design shall incorporate design elements and treatments that maximize visual compatibility with adjacent land use and visual context using color, texture, line, form, and mass. Facilities design shall be sensitive to indirect visual impacts from lighting on adjacent land uses where sensitive receptors are present, such as highways, residential areas, public gathering places, and open space habitat areas.

#### 3.12.9.1 Track and Track Support Systems

As part of preliminary engineering design, materials and surface textures for replacement of any aerial structures or elevated track sections will be selected in accordance with generally accepted architectural principles to achieve an effective visual integration between the track

structure and its surrounding environment. Particular attention shall be paid to background colors and textures.

Area and track lighting fixtures and standards shall incorporate directional shielding where needed to avoid the intrusion of unwanted light and glare into adjacent sensitive land uses, such as residential areas and native open space/habitat.

### 3.12.9.2 Stations

LOSSAN projects may involve replacement or refurbishment of existing facilities, such as station platforms, waiting areas, ticketing areas, access walkways, or other facilities, or the construction of new stations. As part of preliminary engineering and final design, all materials, surfaces, fixtures, furnishings, and other elements will be selected in accordance with generally accepted architectural principles to integrate NCTD facilities with the surrounding environment.

### 3.12.9.3 Parking Lots

Surface lots shall incorporate elements that visually “scale” the parking area to be compatible with the surrounding site context as viewed from public locations including viewpoints from station platforms and trains. Site design shall use screening vegetation, walls, and other design elements to divide view images and/or screen portions of parking facilities from public viewpoints. Screening elements shall consider public safety issues and preserve lines of sight. Landscape trees shall be incorporated into parking areas to provide shaded areas and planted islands that visually break up large paved areas.

Light fixtures shall be shielded to avoid the intrusion of unwanted light and glare into adjacent roadways, residential areas, and open space/habitat. Walls over 3 feet in height shall have textured and/or colored vertical surfaces to reduce the visual mass of the wall face. Signage shall be consistent with thematic LOSSAN sign standards. Signage shall be sized to be compatible with the surrounding site context.

## **3.12.10 TRAFFIC AND TRANSPORTATION**

Every effort shall be made to maintain existing local street capacities and cross vehicle traffic movements. If necessary, revised traffic signalization, the provision of adequate circulation to serve new facilities, and the reconstruction of certain intersections to maintain through and left-turn lanes may be required. Temporary impacts, including those to pedestrians and bicyclists using the existing sidewalks, bike lanes or trails affected by construction projects should be mitigated with clear signage to users of the routes.

Increases in local traffic congestion could also occur in areas around LOSSAN stations. To alleviate this, additional or revised traffic signals or other intersection improvements may be required, as deemed necessary by traffic studies and consultations with local jurisdictions. The project may cause increases in traffic and some traffic delays at grade crossings. Coordination of crossing protection with traffic signal operations, turn restrictions, and changes to roadway cross section or geometry will be evaluated in coordination with the local jurisdictions to reduce this delay.

Changes in traffic signal timing or railroad preemption operation may impact safety at the crossing. The potential for vehicles to be stopped or queued on the tracks should be

carefully considered as part of the traffic analysis near rail crossings. A queueing study should be done to help determine how to clear vehicles from the tracks. (Refer Chapter 19 of this Design Criteria for Grade Crossing Traffic Requirements.)

It is anticipated that these needs, along with needs for expanded station parking areas, if any, will be identified with appropriate mitigation measures in the project environmental document(s). Construction activities for such projects shall be subject to the noise, air quality, water quality, and visual/aesthetic guidelines set forth in other sections of this Design Criteria Manual.

### **3.12.11 AIR QUALITY**

Pursuant to the Clean Air Act Transportation Conformity Rule (40 CFR 93, Subpart A), transportation projects in non-attainment and maintenance areas must conform with State Implementation Plans (SIPs) that provide for attainment of National Ambient Air Quality Standards (adopted pursuant to the federal Clean Air Act of 1970, as amended). The California Air Resources Board also establishes state ambient air quality standards that are generally more stringent than the national standards. Project conformity with the Clean Air Act is typically determined during the environmental review. All activities are subject to the regulations of USEPA, California Air Resources Board, and San Diego Air Pollution Control District.

Generally, LOSSAN projects are expected to enhance regional air quality by reducing vehicle miles of travel. Changes to cross roadway geometry or signalization as described above, as well as system facilities for the movement of automobiles (Park-and-Ride, Kiss-and-Ride, etc.), shall be designed to minimize delays and vehicle idling, thereby minimizing contributions to local carbon monoxide, nitrogen oxide, and ozone levels. It is anticipated that if any violations of air quality standards are anticipated from LOSSAN projects, the project modifications needed to address them will be identified as appropriate mitigation measures in the project environmental document(s). These project modifications and mitigation measures shall be incorporated into the final design of the project(s).

Construction activities for LOSSAN projects may produce temporary air quality impacts that could contribute to violations of national and state standards. Carbon monoxide or ozone precursor emissions from construction equipment or particulate emissions from ground-disturbing activities are of particular concern. The contractor shall be required to be knowledgeable of and shall be required to implement the best management practices and other mitigation measures identified in the project(s) environmental document(s) to reduce such emissions during construction activities.

In addition, all construction contracts shall ensure that compliance with San Diego Air Pollution Control District Rules 55 (Fugitive Dust Control) and 67.0 (Architectural Coatings) and applicable programs for portable and mobile equipment will be achieved throughout the construction phase. Specifically, the following measures shall be incorporated into construction contracts:

- No visible dust emissions into the atmosphere shall travel beyond the property line for a period or periods aggregating more than 3 minutes in any 60-minute period.
- Visible roadway dust as a result of active operations, spillage from transport trucks, erosion, or track-out/carry-out shall be minimized by the use of any of the following or equally effective track-out/carry-out and erosion control measures that apply to the project or operation:

- Track-out grates or gravel beds at each egress point, wheel-washing at each egress during muddy conditions, soil binders, chemical soil stabilizers, geotextiles, mulching, or seeding
- Outbound transport trucks shall use secured tarps or cargo covering, watering, or treatment of transported material.
- All coatings, adhesives, and related materials shall comply with the limits for volatile organic compounds in San Diego Air Pollution Control District Rule 67.0.
- All portable equipment shall be registered by one of the following methods:
  - Registered in accordance with San Diego Air Pollution Control District Rule 12.1 or
  - Registered in accordance with the Statewide Portable Equipment Registration Program adopted pursuant to California Health and Safety Code Section 41750 et seq., except in circumstances specified in that program (13 C.C.R. 2451 and 2457).
- All off-road diesel-fueled construction vehicles with engines rated at 25 horsepower or greater shall meet the applicable fleet standards in 13 C.C.R., Article 4.8,

### 3.12.12 *Federal Communications Commission (FCC)*

The FCC's goal is to make high-quality affordable communications services available to all Americans. The FCC requires agencies erecting Communications Antennas to file documentation with the FCC prior to installing the Antennas. The Commission also provides for online registration of a new antenna structure in the **Antenna Structure Registration (ASR)** system. Refer

<http://wireless.fcc.gov/antenna/index.htm?job=home>

The Commission also provides for online updating of antenna structure registrations. Refer [www.fcc.gov](http://www.fcc.gov). Another useful link is <http://www.fcc.gov/encyclopedia/tower-and-antenna-siting>.

The environmental process to comply with the FCC regulations includes;

- New/relocated PTC and ATCS antennas will require completion of Form 620 by a Principal Investigator who satisfies the Secretary of the Interior's Professional Qualification Standards (not just archeologist) for approval by NCTD and uploaded to the FCC server. Tribal and SHPO letters are generated by FCC's server/software. There will be a 30-day SHPO review (and Native American review). If comments are generated through this process, we would have to address them.
- Projects with EAs will not have to do a separate FCC NEPA document for the antenna, provided the antenna is reasonably covered by the EA as determined by FCC.
- Projects with a CE will have to complete the FCC NEPA Checklist. Draft Checklists will be reviewed by SANDAG Environmental Planning staff. The idea will be to provide evidence that there are no significant impacts in the checklist discussion, if such evidence is available. NCTD will provide review and be the final arbiter on the CE checklist findings.



- No approval is needed to remove antenna, only for constructing new and relocated antenna.
- The process may take six months, depending on how long it takes to complete the Form 620 and NEPA Checklist.
- FCC will only get involved if issues are raised by others. The FCC places the burden of NEPA and National Historic Preservation Act compliance on the license owner (NCTD).

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## **4.0 CLEARANCES AND ROLLING STOCK**

### **4.1 SCOPE**

The design criteria for critical horizontal and vertical clearance dimensions between rolling stock and fixed facilities are provided in this chapter. While minimum CPUC clearances must always be met, NCTD also has additional clearance requirements established in the “shared use agreement” with BNSF as described in this chapter.

### **4.2 CLEARANCE REGULATIONS AND GUIDELINES**

Required minimum SANDAG/NCTD guidelines for clearance to new facilities on new mainline tracks, secondary tracks, and yard tracks are shown on ESD2101. Any deviation from these guidelines requires approval from the Director of Rail.

Minimum legal CPUC clearance standards are described in CPUC GO No. 26-D and shown on ESD2102. No design variances can be granted that do not meet these legal minimums. Minimum/maximum standard clearance of structures are illustrated on LOSSAN Standard Plans:

ESD 2101 –Clearance Requirements for New Construction

ESD 2102 – CPUC Minimum Clearance Requirements

ESD 2207 – Track Spacing (Track Centers on tangent & curved track)

ESD 3200 – Standard Clearance of Station Platforms

#### **4.2.1 CPUC STANDARDS**

Clearances shall meet or exceed the requirements of the California Public Utilities Commission (CPUC) clearance standards as detailed in the current revision of CPUC General Order 26-D. The CPUC standard clearance of structures is illustrated on LOSSAN Standard Plan ESD2102.

#### **4.2.2 NCTD/BNSF SHARED USE AGREEMENT**

The clearance envelope required for new construction under the NCTD/BNSF Shared use agreement is shown on LOSSAN Standard Plan ESD2101.

Preferred vertical clearance is 26 feet to structures. Vertical clearances less than 26 feet but not less than 24 feet must be approved by the SANDAG LOSSAN Director of Rail and must also be submitted through NCTD to BNSF per the Shared Use Agreement for approval. Vertical clearances less than 24 feet are not allowed. The clearances are larger than the CPUC limits to accommodate future electrification per the NCTD/BNSF Shared Use Agreement.

For construction staging 21 feet is the minimum vertical clearance above top of rail. And 12 foot horizontal clearance per LOSSAN Standard Plan ESD2101.

The minimum horizontal clearance is 12 feet from centerline of track, except platforms, which are 5 feet 4 inches from centerline.

Any variation must be submitted to BNSF per the Shared Use Agreement for approval and approved by NCTD and the SANDAG Director of Rail.

At all times, minimum CPUC, SANDAG/NCTD, and BNSF shared-use agreement clearances shall be maintained. If the facility is on another railroad, meet or exceed the clearances specified by the specific railroad at that location, in addition to the required clearance standards stated above. At clearance locations where superelevation is present, vertical clearances shall be measured from the high rail.

### **4.2.3 ROAD UNDERPASSES**

Vertical Clearances should be in accordance with the Caltrans Highway Design Manual for Major Structures like railway bridges above roads.

(a) Freeways and Expressways, All construction except overlay projects – 16 feet 6 inches shall be the minimum vertical clearance over the roadbed of the State facility (e.g., main lanes, shoulders, ramps, collector-distributor roads, etc.).

(b) Freeways and Expressways, Overlay Projects – 16 feet shall be the minimum vertical clearance over the roadbed of the State facility.

(c) Conventional Highways, Parkways, and Local Facilities, All Projects – 15 feet shall be the minimum vertical clearance over the traveled way and 14 feet 6 inches shall be the minimum vertical clearance over the shoulders of all portions of the roadbed.

### **4.2.4 PEDESTRIAN UNDERPASSES**

The inside clear dimensions of the pedestrian underpass structure varies depending on location and utilization;

- In Stations pedestrian undercrossings refer to chapter 7
- Non-station undercrossings shall not be less than 16 feet wide by 9 feet high for combined pedestrian and bicycle access.
- Non-station undercrossings for pedestrians only shall not be less than 10 feet wide by 8 feet high.

## **4.3 TRACK CLEARANCES**

### Clearance to Other Facilities

The LOSSAN minimum standard clearance envelope is shown in ESD2101 and ESD 2102. All permanent construction must comply with these clearance requirements. During construction, temporary clearances shown in ESD2101 may be used for formwork or other temporary construction, which will be removed prior to final completion. The CPUC minimum legal clearances are shown in ESD2102. No design exceptions will be considered if they do not meet the requirements to comply with

CPUC GO No. 26-D.

Clearance design must also comply with the requirements detailed in the Grade Separation Guidelines, for any proposed rail/highway or rail/rail grade-separated crossings. For curved track, the minimum horizontal clearance shall be the minimum horizontal clearances listed above increased by 1 inch per degree of curvature.

At all times, minimum approved clearances shall be maintained. If the facility is on another railroad, the clearances specified by the specific railroad at that location shall be followed. At clearance locations where superelevation is present, horizontal clearance shall be measured perpendicular to the plane across the top of both rails and vertical clearance shall be measured from the high rail.

### **4.3.1 TRACK SPACING**

Preferred mainline track spacing, measured from centerline of track to centerline of adjacent track, is 25 feet as this allows unencumbered train operations on an adjacent track during maintenance operations. However in San Diego's urban environment, that spacing is seldom possible and the LOSSAN minimum mainline track spacing of 15 feet, centerline to centerline, is required for new trackwork on tangent track. Centerlines of curved mainline tracks shall be spaced as defined in ESD2207 which adds two inches of track spacing per degree of track curvature.

Some areas of the existing mainline may have existing track centers of 14 feet per CPUC 26D section 5.1. Designer will increase track centers to the minimum of 15 feet within the project limits except where required to transition to existing undisturbed track. Where possible, the designer should review the relevant strategic plans for the track segment such that the current design is consistent with future plans.

The LOSSAN minimum spacing between a mainline track and an adjacent yard track is 25 feet, centerline to centerline. Any required track spacing between mainline and adjacent yard tracks that is less than 25 feet requires an approved design exception. Other safety improvements, like fences or barriers, to compensate for less than 25-foot track centers may be required, but in no case will less than 15-foot track centers be allowed.

If movement of servicing equipment is not required between or adjacent to two tracks, the minimum track spacing for newly constructed yard tracks is 15 feet. For existing yards, where interior tracks have been constructed at 14-foot track centers, a design exception may be granted if it is not possible for tracks to be reconstructed at 15-foot track centers.

Alternatively, if movement of servicing equipment is required between or adjacent to two tracks, the minimum track spacing may be 25 to 35 feet, depending on the dimensions of the service equipment to be used. Verification of anticipated service equipment dimensions and turning radii is required to ensure that there is adequate clearance between and adjacent to yard tracks. Additional information is provided in Chapter 4, General Clearances and Rolling Stock.

Piers, abutments, and columns as they affect track spacing must comply with the requirements in the SCRRA current Grade Separation Guidance and the AREMA Manual for

Railway Engineering, Chapter 8. New piers, abutments, and columns shall not be permitted on the ROW without permission from SANDAG and or NCTD.

### 4.3.2 SHARED CORRIDORS

Clearances for light rail transit, or bicycle/pedestrian paths within the LOSSAN corridor require compliance with and adherence to the guidelines in the Table 4-1 below and the typical sections. Shared-corridor clearances shall allow for future trackage.

**TABLE 4-1**

Center to Center Spacing	Light Rail Transit (LRT)	Bicycle/Pedestrian Paths
18ft to 25ft	Fence may separate track corridors where ROW has sufficient width. Fence to be a minimum of 9ft for tangent and 10 feet from track for curved track. An 6-foot chain link fence may separate LOSSAN Mainline track from LRT track where sufficient ROW exists.	Trespass control fence must be placed a minimum of 25 feet from track.
> 25ft	No restrictions. Normal ROW fencing required. Fence to be a minimum of 25 feet from track.	Trespass control fence must be placed a minimum of 25 feet from track.
Crossing Tracks	Light Rail Transit (LRT)	Bicycle/Pedestrian Paths
At grade	Not permitted if transit has catenaries, third rail, and/or three or more tracks.	Must be signalized to warn pedestrian/ bicycle traffic.
Grade separated	Permitted; must comply with grade separation guidance.	Permitted; must comply with grade separation guidance.

## 4.4 ROLLING STOCK VEHICLES

### 4.4.1 CARS

Coaster and Metrolink coach cars are bi-level commuter cars manufactured by Bombardier. Coaster and Metrolink Coaches generally are 85 ft. long over coupler faces and 9 ft. 10 in. wide over side sheets. Refer to appendix for cut sheets.

Amtrak and privately-owned passenger cars (all of which are similar in overall dimensions to the Coaster and Metrolink cars) will operate over all LOSSAN Corridor lines.

Freight cars, weighing up to 286,000 lbs. on four axles, in general interchange service operate over the LOSSAN Corridor in San Diego County. Shipments of oversized cargo (up to 13'-0" wide) or unusually heavy loads is generally permitted with prior review and approval of NCTD.

#### 4.4.2 LOCOMOTIVES

NCTD utilizes three different locomotives, all manufactured by General Motors: model F40PH, model F59PH and model F59PHI. All locomotives have four axles and weight about 286,000 lbs. The maximum dimensions for the locomotives are as follows:

<u>Model</u>	<u>Width</u>	<u>Length</u>
F40PHM-2C	10 ft. 3.5 in Cab width	56 ft. 2 in. total length
F59PH	10 ft. 6 in over handrails	58 ft. 2 in. over coupler faces
F59PHI	10 ft. 6 ½ in. over handrails	58 ft. 2 in. over coupler faces

Complete specifications of each model may be found in the F40PHM-2C, F59PH, and F59PHI Owner's Manuals. These manuals should be consulted for locomotive data. One locomotive is used to either push or pull a five or six-car train set which includes a cab control car at the opposite end.

Amtrak and BNSF locomotives operate over all main tracks and sidings of LOSSAN Corridor tracks. Many BNSF locomotives have six axles, weigh approximately 410,000 lbs., exert 120,000 lbs. of tractive effort, and operate in multiple unit consists.

**All track structures will be designed to meet the COOPER E-80 LOADING** as described in the Railway Structures chapter of this design criteria manual and the AREMA manual.

#### 4.4.3 TRAIN SETS

The current 5 car COASTER consist with locomotive is 485 feet long. For a brief period 6 car consists were used in 2008 when ridership peaked. A 7 car consist is the longest that can be used with one locomotive and is 655 feet long. A 700 foot long platform is adequate for current and near term Coaster operations. However in planning for the long term NCTD now requires new stations to have 1000 ft platforms. (Refer chapter 7 of this design criteria)

AMTRAK operates special event SURFLINER trains during the summer and to facilitate these trains 1,000 foot long platform are required at stations where AMTRAK special event trains stop.

BNSF currently operates 4 to 6 trains a week which are 4,400 feet long. Freight Train lengths may increase to a mile once the TCIF double track projects are completed.



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## 5.0 GEOTECHNICAL CRITERIA

### 5.1 GENERAL

The intent of this section is to provide the minimum requirements for characterizing the subsurface geotechnical conditions and for geotechnical design. Roadbed construction and maintenance costs can be reduced by using an effective exploration and testing program. It is also important to have adequate geotechnical information to reduce risk and the likelihood of encountering differing site conditions.

Geotechnical design for all railway improvements shall be consistent with standard railway practice. All geotechnical designs shall follow these criteria. Improvements shall be designed to remain serviceable under service loading conditions and the appropriate service level earthquakes.

#### 5.1.1 SCOPE

This chapter provides criteria for geotechnical studies for and design of all railroad improvements within the LOSSAN corridor. Where special cases are encountered that are not specifically covered in these criteria, a project-specific basis of design report shall be submitted by the design consultant to SANDAG and NCTD for approval.

#### 5.1.2 STANDARDS/CODES & GUIDELINES

The geotechnical design and construction of railroad improvements shall be in accordance with the current edition of the AREMA Manual for Railway Engineering.

The Basis of Design Report for the railroad project should outline the applicable codes and guidelines that will be considered in the geotechnical design of the project. Relevant documents include the current edition of the following:

- AREMA Manual for Railway Engineering
- CALTRANS Geotechnical Manual
- AASHTO LRFD Bridge Design Specifications
- California Amendments to the AASHTO LRFD Bridge Design Specifications
- Caltrans Trenching and Shoring Manual
- AASHTO LRFD Bridge Construction Specifications
- Caltrans Construction Manual
- Caltrans Soil and Rock Logging, Classification and Presentation Manual

The geotechnical professional may also incorporate documents from other sources that are deemed relevant to the project design.

### **5.1.3 DESIGN METHODOLOGY**

Geotechnical design for railroad structures, roadbed and track structure shall be performed using Allowable Stress Design (ASD) procedures. For ancillary improvements, design shall follow the design methodology of the agency having jurisdiction or the applicable design code.

## **5.2 GEOLOGY IN SAN DIEGO COUNTY**

Geologic maps for the San Diego Region have been prepared by the California Geological Survey (CGS). Regional geologic maps prepared at 1:100,000 scale are available at: [http://www.conservation.ca.gov/cgs/information/geologic\\_mapping/Pages/googlemaps.aspx#regionalseries](http://www.conservation.ca.gov/cgs/information/geologic_mapping/Pages/googlemaps.aspx#regionalseries). The United States Geological Survey (USGS) maintains a database of geologic maps and topographic maps available at: [http://ngmdb.usgs.gov/ngmdb/ngmdb\\_home.html](http://ngmdb.usgs.gov/ngmdb/ngmdb_home.html). In addition to those items published by the CGS and USGS, local government, universities and professional societies have prepared maps and studies that are available to supplement regional mapping publications.

### **5.2.1 GEOLOGIC AND SEISMIC HAZARDS**

San Diego County is within a seismically active region with active faults located both offshore and onshore. Geologic and seismic hazards have been mapped throughout the county. The California Geological Survey and local governments have prepared maps and publications that summarize these hazards based on geologic and seismic hazards. The incorporated cities and the County of San Diego formed a Joint Powers Agreement which established the Office of Emergency Services (OES) and the Unified Disaster Council (UDC). The OES and UDC commissioned and maintain a Multi-jurisdictional Hazard Mitigation Plan that can be found at: [http://www.sandiegocounty.gov/content/sdc/oes/emergency\\_management/oes\\_jl\\_mitplan.html](http://www.sandiegocounty.gov/content/sdc/oes/emergency_management/oes_jl_mitplan.html). In summary, that plan includes maps that covers seismicity, dam inundation areas, flooding, liquefaction, landsliding, and tsunami. GIS data for these maps can be obtained from the SANGIS Data Warehouse. Corridor specific studies have also been commissioned by SANDAG that also address sea level rise and associated design considerations. Local general plans can often provide smaller scale maps to improve hazard assessment prior to field exploration activities.

## **5.3 GEOTECHNICAL EXPLORATION AND TESTING**

Exploration and testing for fills and cuts are outlined in AREMA Chapter 1, Part 1. Subsurface exploration for structures is covered in AREMA Chapter 8, Part 22. Geotechnical site investigation is usually performed in two phases:

- Preliminary Site Investigation
- Detailed Site Investigation

### 5.3.1 PRELIMINARY SITE INVESTIGATION

Preliminary studies are typically performed as part of the planning-level or 10% design effort. Studies for the railroad roadbed are often separate from those prepared for bridge structures. Preliminary studies generally rely on existing data and serve, in part, as a basis to plan for detailed studies. Preliminary studies should also provide the designer with geotechnical assessment of the geologic site conditions and geotechnical considerations that will affect the design. Available information and low impact site characterization techniques that are useful in preliminary site investigation are discussed in the following topics.

- A. **SITE RECONNAISSANCE** – A thorough reconnaissance of the site should be performed to observe the geologic setting, vegetation, drainage patterns and evidence of erosion, seepage or instability.
- B. **EXISTING DATA COLLECTION** – Existing data can be collected from historical topography, geologic maps, climate and seismic information. As-built plans from previous projects along the alignment can be requested from NCTD or the local highway/streets department. As-built structure plans often contain Log of Test Borings (LOTBs) that provide subsurface information. NCTD maintains track charts that schematically summarize the existing improvements along the railroad corridor.
- C. **AERIAL PHOTOGRAPHS** – Historical aerial photographs should be reviewed for evaluation of previous site usage. Stereoscopic aerial photos are useful for interpretation of land forms for identification of landslides, faulting and erosional features. USGS, web search maps, and various interest group and commercial website are sources of aerial photos. There are several local commercial companies along with the County of San Diego that also maintain collections of aerial photographs.
- D. **GENERALIZED SOIL INFORMATION** – Generalized soil information may be obtained from CGS publications, local experience, and the United States Department of Agriculture (USDA). The USDA maintains an interactive website at: [www.websoilsurvey.nrcs.usda.gov](http://www.websoilsurvey.nrcs.usda.gov). The USDA web application provides a broad range of generalized interpretations for surficial soil conditions.
- E. **GENERALIZED GROUNDWATER INFORMATION** – Characterization of groundwater is necessary to plan for subsurface construction, evaluation of liquefaction and slope stability, load induced consolidation, and for hydrostatic design loading. During the preliminary stages, as-built data and explorations from nearby studies can be useful in evaluation of groundwater levels, including historical fluctuations. Several online resources also exist that can be sources of groundwater information. Some of those are:
  - California Department of Water Resources:

<http://www.water.ca.gov/waterdatalibrary/index.cfm>

- State Water Resource Board  
<http://geotracker.waterboards.ca.gov/>
- USGS Water Data  
<http://maps.waterdata.usgs.gov/mapper/>

It is noted that the datum from collected data that shows elevations may differ from those used for the project. The VERTCON tool by NOAA can provide datum corrections on a site specific basis.

F. GEOPHYSICAL STUDIES – There are many geophysical techniques that do not require advancement of drills, penetrometers or other excavation equipment into the subsurface. As a result, these techniques tend to be easier to complete during preliminary stages of a design from environmental and railroad operations perspectives. Additionally, to characterize subsurface profiles and preliminary evaluation of seismic site class, geophysical surveys can be useful tools for improving preliminary geotechnical site assessment and seismic site response.

G. PRELIMINARY REPORTS - As a general guide, the Caltrans Guidelines for Preparing District Preliminary Geotechnical Reports provides a good overview of the content that should be addressed in a Preliminary Geotechnical Report. That document can be found at:

[http://www.dot.ca.gov/hq/esc/geotech/geo\\_manual/District%20Preliminary%20Geotechnical%20Reports\\_May%202013.pdf](http://www.dot.ca.gov/hq/esc/geotech/geo_manual/District%20Preliminary%20Geotechnical%20Reports_May%202013.pdf)

For bridges, the Caltrans Foundation Reports for Bridges provides an overview of content for preliminary foundation reports and that document can be found at:

[http://www.dot.ca.gov/hq/esc/geotech/geo\\_manual/page/FR\\_for\\_Bridges\\_December2009.v3.pdf](http://www.dot.ca.gov/hq/esc/geotech/geo_manual/page/FR_for_Bridges_December2009.v3.pdf)

It is recognized that Caltrans design approach does not fully agree with that prescribed in the AREMA Manual for Railway Engineering, but the designer should be aware of these differences and adapt reporting guidelines to be in line with the project design criteria. An example of one of these differences is the continued use of Allowable Stress Design (ASD) in the AREMA Manual for Railway Engineering and on LOSSAN projects. (Note that Caltrans uses Load and Resistance Factor Design (LRFD)). AREMA guidelines also prescribe performance for different levels for design earthquakes with different design earthquakes being considered for roadbed design and for bridges. (Note that the general Caltrans approach to seismic design on the other hand is typically based on a single design earthquake.)

H. SCOPE FOR DESIGN LEVEL EXPLORATION – Based on the findings of the preliminary site investigation, the recommendation for the detailed investigation should be included in the narrative or exhibits of the preliminary report.

### 5.3.2 DETAILED SITE INVESTIGATION

The AREMA Manual for Railway Engineering, the Caltrans Geotechnical Manual, and AASHTO LRFD BDS provide discussion and guidance on subsurface exploration. Additionally, a number of publications are available from the Federal Highway Administration and can be found at: [http://www.fhwa.dot.gov/engineering/geotech/library\\_sub.cfm?keyword=017](http://www.fhwa.dot.gov/engineering/geotech/library_sub.cfm?keyword=017).

- A. Subsurface Explorations – The following table provides guidelines for planning the detailed geotechnical investigation along the existing LOSSAN rail corridor. Exploration techniques, logging and presentation should generally follow ASTM procedures. The Caltrans Soil and Rock Logging, Classification and Presentation Manual provides further guidance.

<b>Application</b>	<b>Explorations</b>	<b>Depth of Exploration</b>
Retaining Walls	A minimum of one exploration point for each retaining wall. For retaining walls more than 100 ft in length, exploration points spaced every 250 ft (highly variable conditions) to 500 ft (uniform conditions) with locations alternating from in front of the wall to behind the wall. For anchored walls, additional exploration points in the anchorage zone spaced at 250 to 500 ft. For soil-nailed walls, additional exploration points at a distance of 1.0 to 1.5 times the height of the wall behind the wall spaced at 250 to 500 ft.	Investigate to a depth below bottom of wall at least to a depth where stress increase due to estimated foundation load is less than ten percent of the existing effective overburden stress at that depth and between one and two times the wall height. Exploration depth should be great enough to fully penetrate soft highly compressible soils, e.g., peat, organic silt, or soft fine grained soils, into competent material of suitable bearing capacity, e.g., stiff to hard cohesive soil, compact dense cohesionless soil, or competent bedrock.
Shallow Foundations	For substructure, e.g., piers or abutments, a minimum of one exploration point per 100 ft of substructure and each abutment. Additional exploration points should be provided if erratic subsurface conditions are encountered.	Depth of exploration should be: <ul style="list-style-type: none"> <li>• great enough to fully penetrate unsuitable foundation soils, e.g., peat, organic silt, soft fine grained soils, or loose sand, into competent material of suitable bearing resistance, e.g., stiff to hard cohesive soil, or compact to dense cohesionless soil or bedrock;</li> <li>• at least to a depth where stress increase due to estimated foundation load is less than ten percent of the existing effective overburden stress at that depth;</li> </ul>

<b>Application</b>	<b>Explorations</b>	<b>Depth of Exploration</b>
Shallow Foundations continued		<p>and</p> <ul style="list-style-type: none"> <li>if bedrock is encountered before the depth required by the second criterion above is achieved, exploration depth should be great enough to penetrate a minimum of 10 ft into the bedrock, but rock exploration should be sufficient to characterize compressibility of infill material of near-horizontal to horizontal discontinuities.</li> </ul> <p>Note that for variable bedrock conditions, or in areas where boulders are likely, more than 10 ft or rock core may be required to verify that adequate quality bedrock is present.</p>
Deep Foundations	<p>For substructure, e.g., bridge piers or abutments, a minimum of one exploration point per abutment and per 100 ft length of structure. Additional exploration points should be provided if erratic subsurface conditions are encountered, especially for the case of shafts socketed into bedrock.</p>	<p>In soil, depth of exploration should extend below the anticipated pile or shaft tip elevation a minimum of 10 ft, or a minimum of one times the minimum pile group dimension, whichever is deeper. All borings should extend through unsuitable strata such as unconsolidated fill, peat, highly organic materials, soft fine-grained soils, and loose coarse-grained soils to reach hard or dense materials.</p> <p>For piles bearing on rock, a minimum of 10 ft of rock core should be obtained at each exploration point location to verify that the boring has not terminated on a boulder.</p> <p>For shafts supported on or extending into rock, a minimum of 10 ft of rock core, or a length of rock core equal to at least three times the shaft diameter for isolated shafts or one times the minimum shaft group dimension, whichever is greater, should be extended below the anticipated shaft tip elevation to determine the physical characteristics of rock within the zone of foundation influence. Note that for variable bedrock conditions, or in areas where boulders are likely, more than 10 ft or rock core may be required to verify that adequate quality bedrock is present. The investigation should include provisions to verify bedrock contact</p>



**TABLE 5-1 Minimum Requirements for Geotechnical Explorations**

Application	Explorations	Depth of Exploration
Embankment Foundations and Culverts	<p>A minimum of one investigation point every 250 ft (highly variable conditions) to 500 ft (uniform conditions) of embankment length along the centerline of the embankment.</p> <p>At critical locations, (e.g., maximum embankment heights, maximum depths of soft strata) a minimum of two investigation points in the transverse direction to define the existing subsurface conditions for stability analyses.</p> <p>For bridge approach embankments, at least one investigation point at abutment locations.</p>	<p>Investigation depth should be, at a minimum, equal to twice the embankment height unless a hard stratum is encountered above this depth. If soft strata is encountered extending to a depth greater than twice the embankment height, investigation depth should be great enough to fully penetrate the soft or loose strata into competent material (e.g., stiff to hard cohesive soil, compact to dense cohesionless soil, or competent bedrock).</p>
Cut Slopes	<p>A minimum of one investigation point every 400 ft (highly variable conditions) to 800 ft (uniform conditions) of slope length.</p> <p>At critical locations (e.g., maximum cut depths, maximum depths of soft strata) a minimum of two investigation points in the transverse direction to define the existing subsurface conditions for stability analyses.</p> <p>For cut slopes in rock, perform geologic mapping along the length of the cut slope.</p>	<p>Investigation depth should be, at a minimum, 15 ft below the minimum elevation of the cut unless a hard stratum is encountered below the minimum elevation of the cut. Investigation depth should be great enough to fully penetrate through soft strata into competent material (e.g., stiff to hard cohesive soil, compact to dense cohesionless soil, or bedrock). In locations where the base of cut is below groundwater level, increase depth of investigation as needed to determine the depth of underlying pervious strata.</p>
Landslides / Landslide Prone Geology	<p>Minimum of 3 borings along a line perpendicular to centerline or planned slope face to establish geologic cross-section for analysis. Number of sections depends on extent of instability.</p> <p>For active slide, place at least one boring above and below slide area.</p> <p>Downhole logging by an engineering geologist should be performed where viable.</p>	<p>Extend borings to an elevation below active or potential failure surface and into hard stratum or to a depth for which failure is unlikely because of geometry of cross-section.</p>

**TABLE 5-1 Minimum Requirements for Geotechnical Explorations**

Application	Explorations	Depth of Exploration
Track Roadbed (Subgrade)	The minimum data needed to evaluate the subgrade soils should be classification (which requires Atterberg limits and gradation as appropriate) and strength (lowest expected). Exploration should be performed every 500 ft in variable conditions and every 1000 ft in uniform conditions	The depths and thicknesses of the lower strength layers to a depth of at least 3 feet should be examined.
Channel Crossing / Scour	Streambed material samples should be collected upstream and downstream of proposed structures for use in streambed scour analysis. Samples shall be collected at each abutment borehole and at the center span pier.	At least one sample should be collected upstream and downstream from the bed of the channel. Samples from boreholes shall be collected for grain size distribution at 5 ft depth intervals below high water level down to the anticipated scour depth at each abutment borehole and at the center span pier for input into the scour model. The need for additional samples and anticipated scour depth should be coordinated with the project hydrologist.

To reduce design and construction risk due to subsurface condition variability and the potential for construction claims, additional explorations may be proposed by the design team. Boreholes shall be permitted and backfilled according to County of San Diego requirements. All core samples shall be stored by the geotechnical consultant, for review by contractors and until construction is completed and all claims resolved.

B. Field investigation should be performed according to accepted geotechnical techniques. Guidance on a broad range of geotechnical investigation techniques can be found in:

- NHI Course No. 132031 Subsurface Investigations (Geotechnical Site Characterization)  
<http://isddc.dot.gov/OLPFiles/FHWA/012546.pdf>
- FHWA Geotechnical Engineering Circular No. 5 – Evaluation of Soil and Rock Properties  
<http://isddc.dot.gov/OLPFiles/FHWA/010549.pdf>
- FHWA Soils and Foundations Reference Manual – Volumes I and II  
<http://www.fhwa.dot.gov/engineering/geotech/pubs/nhi06088.pdf>  
<http://www.fhwa.dot.gov/engineering/geotech/pubs/nhi06089.pdf>
- Caltrans Geotechnical Manual  
[http://www.dot.ca.gov/hq/esc/geotech/geo\\_manual/manual.html](http://www.dot.ca.gov/hq/esc/geotech/geo_manual/manual.html)
- AASHTO LRFD Bridge Design Specifications

- ASCE/SCEC Recommended Procedures for Implementation of Special Publication 117 Guidelines  
<http://www.scec.org/resources/catalog/hazardmitigation.html#land>
- C. Split-spoon, extruded samples and core samples should be photographed.
- D. In-situ tests may be performed to obtain deformation and strength parameters of foundation soils or rock for the purposes of design and/or analysis. In-situ tests should be conducted in soils that do not lend themselves to undisturbed sampling as a means to estimate soil design parameters. When performed, in-situ tests shall be conducted in accordance with the appropriate ASTM or AASHTO standards. Where in-situ test results are used to estimate design properties through correlations, such correlations should be well established through long-term widespread use or through detailed measurements that illustrate the accuracy of the correlation.
- E. Laboratory Testing – Laboratory testing of disturbed and undisturbed samples should generally follow ASTM, AASHTO and Caltrans test methods. Corrosivity testing should be performed to facilitate corrosion mitigation design in the design structures and culverts that are in contact with the soil. Typical corrosion tests include chloride content, soluble sulfate content, pH, and minimum resistivity. At least one water sample should be taken at each bridge or culvert where water is present and analyzed for soluble chloride and sulfate.

**5.3.3. DESIGN REPORTS** - As a general guide, Caltrans Guidelines provide a good overview of the content that should be addressed in a Geotechnical Design Report. Those documents include:

- Guidelines for Preparing Geotechnical Design Reports:  
[http://www.dot.ca.gov/hq/esc/geotech/geo\\_manual/page/Geotechnical\\_Design\\_Reports\\_2006.pdf](http://www.dot.ca.gov/hq/esc/geotech/geo_manual/page/Geotechnical_Design_Reports_2006.pdf)
- Foundation Reports for Earth Retaining Structures  
[http://www.dot.ca.gov/hq/esc/geotech/geo\\_manual/page/FR\\_ERS\\_August2015.pdf](http://www.dot.ca.gov/hq/esc/geotech/geo_manual/page/FR_ERS_August2015.pdf)
- For bridges, the Caltrans Foundation Reports for Bridges provides an overview of content for foundation reports and that document can be found at:  
[http://www.dot.ca.gov/hq/esc/geotech/geo\\_manual/page/FR\\_for\\_Bridges\\_Dember2009.v3.pdf](http://www.dot.ca.gov/hq/esc/geotech/geo_manual/page/FR_for_Bridges_Dember2009.v3.pdf)

**5.3.4 Log of Test Borings** – As part of the 90 percent design effort, Log of Test Boring sheets shall be included in the project plan set for each bridge and include

subsurface logs for each exploration performed for the structure. It should be noted that subsurface information shown on the profile between test pits or borings has been interpolated and may not reflect actual field conditions.

## 5.4 GEOTECHNICAL DESIGN CRITERIA

In the geotechnical design of soil and rock supporting railroad improvements, both factor of safety and serviceability needs need to be satisfied.

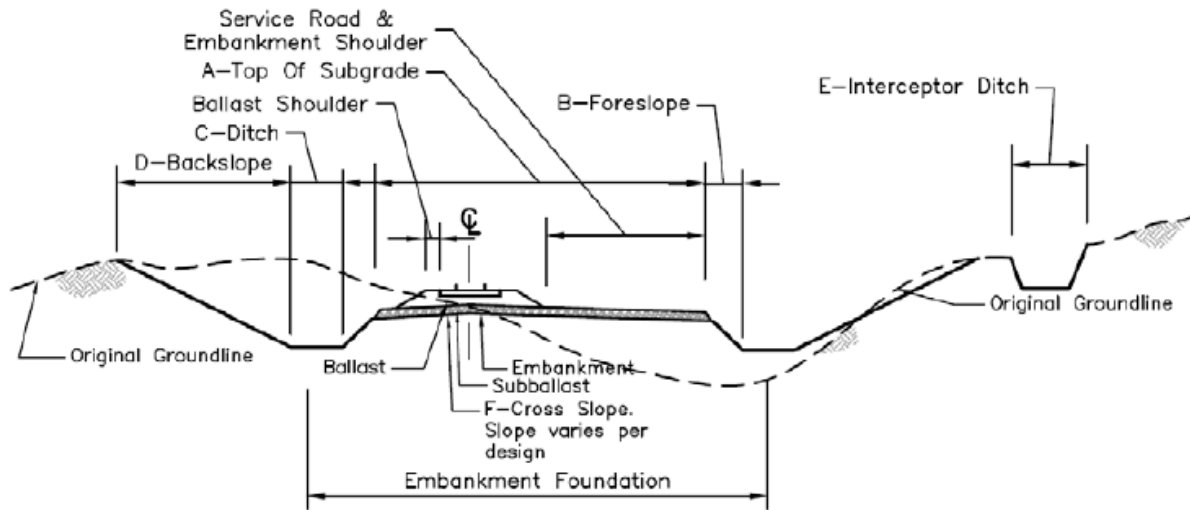
### 5.4.1 GEOTECHNICAL FACTOR OF SAFETY

The following table summarizes the minimum geotechnical design factor of safety for support of railroad improvements:

<b>TABLE 5-2 Minimum Geotechnical Factors of Safety</b>	
<b>Feature</b>	<b>Factor of Safety</b>
Roadbed Embankment Slope and Retaining Walls (Foreslope – see Exhibit 5-1)	Global Stability – 1.5 (static); 1.1 @ $k_h=1/3$ PGA (seismic) Surficial Slope Stability- 1.5 at 3 ft saturation. Ref: AREMA Chapter 1, Part 1, Article 1.2.3.2c Soil Embankment slopes shall be 2(H):1(V), or flatter. Hard Rock Fill Embankment Slopes up to 50 feet in height may be 1.5(H):1(V), or flatter. Ref: AREMA Chapter 1, Part 1, Articles 1.2.3.3 and 1.2.3.4
Graded Trackside Slopes and Retaining Walls (Backslope – see Exhibit 5-1)	Global Stability – 1.33 (static within railroad right-of-way where slope or wall does not support structures, roadways or pipelines); 1.5 (static for all other cases); 1.1 @ $k_h=1/3$ PGA (seismic) Surficial Slope Stability- 1.5 at 3 ft saturation.
Shallow Foundation	Bearing Capacity – 3.0 (primary loads); 2.0 (primary and secondary loads) Ref: AREMA Chapter 8, Part 3, Article 3.4.2
Piles - Downward	When pile foundations are designed for AREMA primary and secondary loads in combination as defined in Part 2, the allowable loads may be increased 25% for Load Cases A, B, and C. The number of piles shall not be less than is required for primary forces alone with no increases in allowable stress for Case A. The minimum factor of safety shall be 2.0 for Cases B and C. For group friction piles, the factor of safety for Case C shall not fall below 2.0 for primary and secondary load combinations. If the pile design capacity is not determined by geotechnical investigations, known positive contact with bedrock, or field testing of the pile, the Factor of Safety shall be increased to at least 2.5 times the required design load, and the Engineer shall be notified.

**TABLE 5-2 Minimum Geotechnical Factors of Safety**

Feature	Factor of Safety
	<p>Ref: AREMA Chapter 8, Part 4, Article 4.2.3</p> <p>For driven piles, the Geotechnical consultant will perform a drivability analysis and recommend a pile wall thickness suitable for the expected driving stresses.</p> <p>Per AREMA CH. 8 Part 4 Article 4.4.2.6, for steel piles driving stresses shall be limited to 0.8 yield strength of the pile steel. Drivability of concrete pile shall be evaluated according to provisions in Section 10.7.8 of the AASHTO LRFD BDS.</p>
Piles - Uplift	<p>The pile foundation shall be designed for uplift considering load capacity Cases A, B, and C of Article 4.2.3 in Chapter 8 of the AREMA Railway Engineering Manual. The factor of safety for Cases B and C shall be a minimum of 2.0 for combinations of primary and secondary loads and forces, and a minimum of 3.0 for combinations of secondary loads and forces with dead load alone. The maximum capacity of a tension pile group shall be considered to be the smaller of (1) the capacity of a single pile multiplied by the number of piles in the group, or (2) the weight of the block of soil contained within the perimeter of the groups and frictional resistance of the block, each with a minimum safety factor of 2.0, except as previously noted.</p> <p>Ref: AREMA Chapter 8, Part 4, Article 4.2.3.2</p>
Drilled Shafts	<p>For drilled shafts in soil or socketed in rock, a minimum design factor of safety of 2.5 shall be used against bearing capacity failure and when designing for conditions which produce uplift.</p> <p>Ref: AREMA Chapter 8, Part 24, Article 24.3.2.5</p>
Subgrade	<p>The railroad substructure must be designed so that the subgrade, sub-ballast and track ballast provide uniform support and distribution of superstructure loadings. The level of stress in the subgrade should not exceed an allowable bearing pressure that includes a safety factor. A minimum factor safety of 2 should be provided to prevent bearing capacity failure or undue creep under the loaded area. When subgrade support is marginal and/or where the liquid limit of the subgrade soil exceeds a value of 30 or the plasticity index exceeds 12, special attention should be given to that soil. A change of subgrade soil or stabilization of the subgrade material may be considered to obtain a more reliable support for the subballast.</p> <p>Ref: AREMA Chapter 1, Part 2, Article 2.11.2.1</p>



**EXHIBIT 5-1 Cut and Fill Section Components**

#### 5.4.2 GEOTECHNICAL SERVICEABILITY

Settlement of embankments and structures shall be evaluated to ensure that the anticipated settlement is within the serviceability limits that will allow normal operations of the railroad and within the tolerances of the structure. Seismic induced deformations shall be evaluated for applicable Ground Motion Levels covered in Chapter 12 of this Design Criteria Manual. For trackbed, culverts, trackside slopes within the right-of-way and retaining walls not part of a bridge structure, earthquake levels consistent with the NCTD Train Dispatchers Manual guidelines shall be considered as summarized in Tables 5-3 and 5.4

**From MP 244.0 to MP 246.0 on the Del Mar Bluffs follow Table 5.3:**

TABLE 5-3 NCTD Operations Response to Earthquakes on Del Mar Bluffs		
Magnitude	Radius	Response
<3.0	Any	No inspection required
3.0-3.9	30 Miles	Trains must proceed at Restricted speed until tracks, bridges and structures have been inspected.
4.0-4.9	50 Miles	Trains must STOP until instructed to proceed after
5.0 and Above	100 Miles	Trains must STOP until instructed to proceed after

From MP 207 to MP 244 and from MP246 to MP 269 follow instructions on Table 5.4;

<b>TABLE 5-4 NCTD Operations Response to Earthquakes on all other track</b>		
<b>Magnitude Range</b>	<b>Criteria for Response</b>	<b>Radius</b>
Less than 5.0	No inspection required	Any
5.0 to 5.49	Trains proceed at restricted speed until signals have been inspected	30 miles
5.5 to 5.99	Trains proceed at restricted speed until signals, track and bridges have been inspected	30 miles
6.0 to 6.49	Trains stop until signals, track and bridges have been inspected	50 miles
6.5 to 6.99		70 miles
7.0 to 7.49		100 miles
7.5 and above	Trains stop until instructed to proceed after inspection of signals, track and bridges completed	As Directed

## 5.5 STORM WATER INFILTRATION

Geotechnical evaluation of the suitability of a site to accommodate low impact development infiltration shall follow guidelines provided in the County of San Diego Low Impact Development Handbook. <http://www.sandiegocounty.gov/content/sdc/dpw/watersheds/susmp/lid.html>

## 5.6 DRAINAGE AND SUBDRAINAGE

For using in channel design, the Geotechnical Report shall provide a characterization of the onsite soils according to Table 862.2 of the Caltrans Highway Design Manual.

Necessary subdrainage provisions shall be identified in the Geotechnical Report and conform to AREMA guidance (Ref: Chapter 1, Part 1, Articles 1.2.4.3.2 and 1.2.4.3.3).

## 5.7 TEMPORARY EXCAVATIONS AND SHORING

All temporary excavations and shoring shall comply with the latest edition of the SCRRA Excavation Support Guidelines. The guidelines can be found at the following link:

[http://www.metrolinktrains.com/agency/page/title/engineering\\_construction](http://www.metrolinktrains.com/agency/page/title/engineering_construction)

The Railroad Zone of Influence is defined on Figure 2-1 of the SCRRA Excavation Support Guidelines. Where reference is made to review or approval of SCRRA in the manual, NCTD shall be the reviewing and approval authority.

## **5.8 INDICATOR TEST PILE**

Where driven piles are planned, the designer shall specify installation of an indicator piles to be installed and tested to confirm contractor's piling means and methods are suitable. This pile may be used as part of the permanent structure provided it meets the design requirements. Dynamic pile load testing shall be performed during indicator pile driving and restrike. The geotechnical engineer shall specify the anticipated set-up timeframe for performing restrike. Additional discussion is provided in AREMA Chapter 8, Part 4, Articles 4.3.8.1 and 4.3.8.2 and in AASHTO LRFD Bridge Construction Specifications Section 4, Part 4.4.4.

Dynamic pile load testing shall also be performed on one pile on each pile bent for new bridges.



## CHAPTER 6

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## 6.0 TRACK

### 6.1 SCOPE

This chapter establishes design criteria, for railroad track. Designers need to provide a track design that is safe, regulatory compliant, economical, and allows for efficient train operations. The design for the LOSSAN shared use Corridor should consider safety, travel times, passenger comfort, and maintenance costs, based on accepted railroad industry engineering practice and the experience of conventional mixed freight and passenger train operations.

Design of all elements of the system, such as grading, structures, utilities, and appurtenances, shall be secondary to the geometric design of track.

### 6.2 STANDARDS, CODES, AND GUIDELINES

The railroad design shall meet all applicable State of California laws, CPUC requirements, FRA safety requirements, and the specific project requirements. Where any conflict in criteria exists, the stricter criteria shall govern.

Unless specifically noted otherwise in these criteria, the latest edition of the standard, code, or guideline that is applicable at the time the design is initiated shall be used. If a new edition of or amendment to a standard, code, or guideline is issued before the design is completed, the design shall conform to the new requirements to the extent approved or required by the agency enforcing the standard, code, or guideline changed.

The design criteria assembled in this manual are based on industry standards, governmental regulations, local practices, and railroad guidelines and standards. The most recent editions of the following publications and documents shall be used:

- LOSSAN Engineering Standard Drawings and Standard Specifications

#### **Federal;**

- FRA Track Safety Standards, particularly 49 Code of Federal Regulations (CFR) 213, 214, 234, and 236
- 49 CFR 195, Transportation of Hazardous Liquids by Pipeline

#### **State;**

- Government Code of the State of California
- State of California Division of Occupational Safety and Health (Cal/OSHA) safety orders
- CPUC General Orders including but not limited to:
  - CPUC GO No. 26 - Clearances
  - CPUC GO No. 33 - Interlocking Plants
  - CPUC GO No. 36 - Abolition of Services
  - CPUC GO No. 72 - At-Grade Crossings
  - CPUC GO No. 75 - Protection of Crossings

- CPUC GO No. 88 - Rules for Altering Public Grade Crossings
  - CPUC GO No. 95 - Rules Governing Overhead Electric Line Construction
  - CPUC GO No. 112 - Utility Construction
  - CPUC GO No. 118 - Walkways Maintenance and Construction
  - CPUC GO No. 128 - Rules for Underground Electric Construction
- Caltrans Highway Design Manual (HDM)

### Industry Standards

- American Railway Engineering and Maintenance-of-Way Association (AREMA) Recommended Practice
- "Greenbook" Standard Specifications for Public Works Construction, written and promulgated by Public Works Standards, Inc.

Detailed alignment design information is available in LOSSAN ESD2201 through ESD2204. The values and formulae for design parameters presented in this chapter are to be used throughout the LOSSAN system. If in the process of design it becomes apparent that complying with the values presented in this chapter will result in unreasonable cost or significant physical impact on adjacent property and facilities, exceptions to the criteria may be presented on a case-by-case basis to request a variance.

New track construction shall at all times exceed the minimum FRA standards for Class 5 track or higher, as required in 49 CFR 213, Track Safety Standards, and CPUC GOs No. 26-D and No. 118. At no time may track be designed or operation be allowed on track that fails to meet FRA standards required for operation in that class.

The latest edition of the following standards, codes, and guidelines shall govern in the design of all LOSSAN trackwork in the following order:

1. LOSSAN Standard Specifications
2. LOSSAN Engineering Standard Plans
3. AREMA Manual for Railway Engineering
4. AREMA Portfolio of Trackwork Plans

### 6.2.1 CLEARANCES

Refer to the clearances in Chapter 4 of this criteria.

### 6.3 TRACK GEOMETRY

FRA Track Safety Standards, Part 213, Subpart C, and CPUC GO No. 26-D are the absolute limiting cases for the maintenance of track geometry; however, these are not necessarily the design limits that govern. LOSSAN standards are the minimum design limits and will govern track design.

### **6.3.1 DESIGN SPEED**

Unless otherwise specified, the maximum passenger design speed for all Main tracks shall be 90 mph, FRA Class 5, on all lines, unless constrained by curves and ROW limits. The maximum design speed for all freight service is currently 60 mph, unless constrained by curves, grade and ROW limits.

Shoofly tracks are temporary detour tracks that should be designed to match the current train operating speed. Where physical constraints make achievement of these design speeds difficult or costly, the designer may propose alternative design speeds for approval provided they do not significantly impact operating schedules. Physical constraint elements to be considered include ROW, topography, and existing adjacent structures.

#### Horizontal Alignment

The horizontal track alignment includes tangents, horizontal curves, and spiral transition curves. The design of curvature and superelevation are based on train speed and site condition. The criteria and design guidelines for horizontal track geometry are described below.

All new track shall be designed to the Standard Gauge of 4 feet 8-1/2 inches. Where the gage is measured between the heads of the rails at 5/8" below top of rail.

All new Mainline Track must also comply with FRA Track Safety Standards (49 CFR 213) Class 5 Standards or higher, as required.

Tangent track shall be level, and superelevation with runoff spirals shall be provided on all curves in conformance with ESD2201 through ESD2204. The horizontal curve shall be defined by the chord definition. The minimum length of a horizontal curve shall be 100-feet on the main line.

The designer shall confirm the design and operating speeds for the subdivision on which the project resides. The designer shall note that design speeds may be higher than current train operating speeds. Actual train operating speeds will be approved by NCTD, considering the alignment, grade, braking distance, station proximity and current track conditions.

Stationing and geometrics shall be denoted along the centerline of the left track in the direction of increasing stationing. Independent stationing and geometries for each track are required when the tracks are not parallel or where parallel tracks have independent profiles.

### **6.3.2 COMPONENTS**

The horizontal track alignment shall be defined as a continuous series of tangents and circular curves, connected with transition spirals as required. All circular curves shall be connected to tangents by transition spirals except in yards at speeds below 20 mph or if the spiral offset (p) is less than ¼ inch. Compound circular curves may be used, if necessary but avoided if possible. Transition spirals between such curves shall be used and approval for the use of compound circular curves must be obtained from NCTD and or SANDAG.

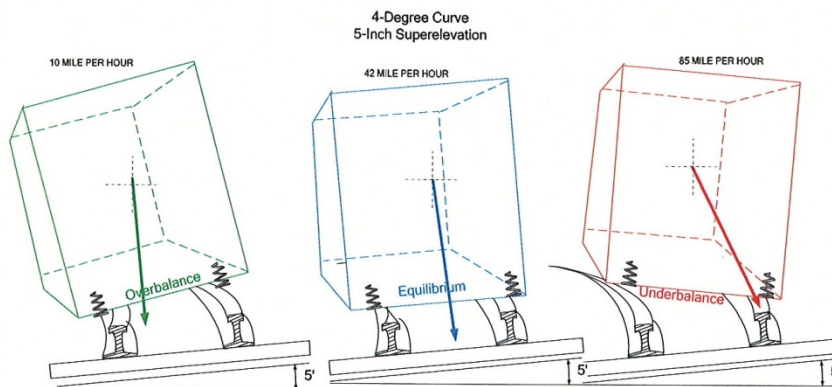
All circular curves shall be connected by a minimum tangent length unless the designer is retrofitting an old alignment with inadequate spirals and tangents where alternatives for correcting the condition do not exist and where SANDAG and or NCTD has granted an exception permitting the use of modified design tables ESD2204-03 and ESD2204-04.

### 6.3.3 CURVES AND SUPERELEVATION

Horizontal curvature shall be designed in accordance with ESD2202 through ESD2204. The designer shall choose a degree of curvature that will meet the subdivision speed criteria. If a curve must become the speed-limiting factor for the subdivision because of ROW or other concerns, the designer shall advise SANDAG and NCTD so that appropriate guidance can be issued.

General guidance for design of curves and superelevation is that freight speed will be designed to accommodate 2-inch unbalanced elevation or passenger speed will be designed to accommodate 3.5-inch unbalanced elevation, whichever results in the greater actual superelevation. (Per FRA Track Safety Standards, superelevation underbalance for Classes 1 to 5 is limited to 3 inches, except that up to 4 inches is permitted for authorized and approved equipment types. Bombardier passenger train cars currently in service on LOSSAN satisfy the criteria for approved equipment types.)

For mixed use freight/transit tracks, underbalance of track curvature needs to be verified for maximum freight speed. The resulting underbalance must be between 0 and 2 inches.



**Figure 6.1** (Source: FRA Chapter 5 Track Safety Standards)

In ESD2204, tables with the suffix “M” specify track geometry criteria for the maintenance and rehabilitation of certain existing segments of routes that have spiral lengths that are considered too short using standard current criteria. These “M” tables shall not be used for new construction, unless specifically directed to use them by SANDAG and NCTD.

The maximum degree of curve allowed for mainline tracks is 10 degrees, the preferred maximum actual superelevation is 4 ½ inches, and the absolute maximum actual superelevation is 5 inches. The maximum degree of curve for non-mainline track is 12 degrees, and the maximum actual superelevation is 5 inches. Certain combinations of superelevation and curvature are prohibited, as specified in ESD2204-01 through ESD2204-06. Minimum tangent lengths are discussed in ESD2203.

If superelevation is required, then the actual superelevation ( $E_a$ ) shall be ½’ or greater and shall be selected to the nearest ¼ inch increment. Equilibrium elevation ( $E$ ) and unbalanced elevation ( $E_u$ ) shall be rounded to two decimal places.

A closely spaced group of curves should be considered as a unit, with a common design speed that optimizes train dynamics and minimizes running time.

Curved alignment through grade crossings should be avoided when possible. If tracks are superelevated through the crossing, both the track and road profiles may need to be modified to provide a smooth road profile over the crossing.

Turnouts and other special trackwork shall not be placed in horizontal curves unless approved by NCTD and SANDAG.

Yard tracks shall be designed for 10 mph. Yard tracks shall not be superelevated.

Special trackwork shall not be superelevated.

#### **6.3.4 SPIRALS**

Spiral length is defined in ESD2203. Spiral length shall be selected to satisfy the degree of curve requirement for the maximum subdivision speed unless otherwise approved in writing by SANDAG and or NCTD. Even if the proposed maintenance operating track speed and resulting required superelevation will actually be less, the designer shall select the longer spiral length so that in the future as operations change, the track speed can be more easily increased. In the interim, the lesser superelevation can be constructed into the entire spiral at a lower rate of change. The designer should consider the maximum possible superelevation for degree of curve to help select the longest possible spiral curve length. Existing curvature and spiral length on portions of the LOSSAN lines may require application of shortened spiral lengths (M) depicted in ESD2204-03 and ESD2204-04 to accommodate the required track speeds on these high curvature former freight lines.

The designer shall note that a track segment currently designed as a passing siding track may become a second mainline track in the future; therefore, design of siding spiral curves shall accommodate future speeds and resulting superelevation and spiral lengths for mainline operation.

Note that spirals long enough for future higher speeds may be needed to allow future speed changes without curve realignment. Curves designed to these higher speeds will have actual superelevation constructed appropriate for the present anticipated operating speed.

#### **6.3.5 TANGENTS**

Standards regarding tangent lengths between curves and between curves and other track components are shown in ESD2203. These required tangent lengths shall not be shortened unless the design is tying into an existing subdivision where tracks were originally designed with shorter requirements. In such a case, shortened tangent lengths may be necessary but will only be allowed after it can be demonstrated that another solution is not practical.

Where tangents connect circular curves in the same direction, it is usually more acceptable to deviate from the standard through substitution of shorter tangent lengths rather than through substitution of shorter spiral curves. It is less acceptable to make this substitution in the case of reversing curves than in the case of circular curves in the same direction.

For Mainline tangent lengths, horizontal tangents shall be designed based on the longest rail car length for the railroad corridor and ride comfort for the passengers. The tangent length of

three times the speed ( $L = 3V$ ) for ride comfort is based on the rail car traveling at least two (2) seconds along the tangent track before changing direction.

For tangent lengths between reversing curves, design speed greater than 35 mph, tangent lengths between two curves in opposite directions should be a minimum of  $3V$ , where  $V$  is maximum design speed in miles-per-hour. Design exceptions to the  $3V$  rule would be requested for any location where minimum tangent lengths cannot reasonably be achieved without significant environmental or right-of-way impacts.

For reversing curves, tangent lengths may be reduced to  $1.5V$  where  $E_a$  is less than 1" in both curves. Reversing tangent lengths shall be maintained at least 100'.

Between curves in the same direction, Tangent lengths between curves in the same direction can be shorter than tangents between curves in opposite directions. Curves in the same direction will be designed to achieve a minimum tangent length of 100 feet between curves taking into allowance for any super elevation in the adjacents curves, to avoid a track twist condition.

## 6.4 VERTICAL ALIGNMENT

### 6.4.1 GENERAL

The profile grade shall represent the elevation of the top of the low rail (T/R) for the track. Additional tracks, including siding tracks, shall be constructed roughly parallel to and slightly lower than the mainline track in accordance with the cross-slope and offsets (15- to 25-foot track centers), as illustrated on the cross section template. Mainline track shall be constructed with a slight crown in the roadbed section at the centerline of the track.

When the T/R profile is given for one track only, the T/R elevations of the other tracks are to be calculated based on ESD2001 or a job-specific template cross slope. Gradients and lengths of vertical curves shall vary accordingly (slightly) to accommodate the differences in lengths through horizontal curves. All mainline and siding tracks shall be designed to the same vertical profile, although the T/R elevation may be different, and reflect the cross section.

### 6.4.2 GRADES

Maximum gradient for mainline and siding tracks, including curve compensation, shall not exceed the existing maximum ruling grade for that subdivision. (The ruling grade is 2.2% for the Miramar Hill (CP Sorrento to CP Miramar); and maximum compensated grade is 2.0% for the rest of the Corridor.)

Track profile grades shall be compensated for horizontal curvature according to AREMA Manual for Railway Engineering, compensated gradients, which is calculated as 0.04 percent equivalent grade per degree of curve.

$$G_c = G - 0.04D$$

Where:

$G$  = gradient before compensation, expressed in percent



D = degree of curve

$G_c$  = compensated gradient expressed in percent used through the horizontal curve

Curve compensation shall be satisfied by either extending the reduction in allowable grade through the entire gradient or through the entire circular curve, both spirals and for a length into the tangents on either end of the circular curve as determined in the following formula.

For mainline track, the desired length of constant profile grade between vertical curves shall be determined by the following formula, but shall not be less than 100 feet:

$$L = 3V$$

Where

L = minimum tangent length, feet but not less than 100 feet

V = design speed in the area, mph (which may be a future, higher speed)

Grades shall be minimized in siding tracks where trains meet or pass and shall be uniform at station platforms unless approved by SANDAG. Gradients shall be designed to prevent roll-out in yard tracks, especially where cars are stored, and yard track bowl grade shall not exceed a maximum gradient of 0.2 percent.

### 6.4.3 VERTICAL CURVES

Vertical curve design standards are shown in ESD2201.

Vertical curves shall be designed per the recommended practices in the AREMA Manual for Railway Engineering, as modified and shown in the following formula:

$$L = D V^2(K)/A$$

Where

A = vertical acceleration in feet/second<sup>2</sup>

D = absolute value of the difference in rates of grades expressed as a decimal

K = 2.15 conversion factor to give L in feet

L = length of vertical curve in feet

V = speed of train in miles per hour

The recommended value for vertical acceleration is 0.10 foot/second/second for freight traffic and is 0.60 foot/second/second (0.02 g) for passenger traffic for both sags and summits. The minimum vertical curve length is 100 feet. Mixed passenger freight traffic exception allowing 0.30 foot/second/second vertical acceleration for freight traffic may be used if required.

The minimum distance between vertical curves shall be 3V or 100-ft, whichever is greater, where V is maximum design speed in miles-per-hour. (Does not apply to yard tracks)

Vertical curves are not permitted in the platform area and shall begin or end no less than 100 feet from the ends of the platform unless approved by SANDAG. Likewise, vertical curves are not permitted in turnouts and other special trackwork.

Complex profiles, such as more than three reversing grade changes exceeding 1.0 percent, each within a distance of 3,000 feet, should be avoided as this may cause excessive dynamic forces and handling problems on the train. SANDAG/NCTD may require train performance simulations to verify that proposed Top of Rail (T/R) profiles will not produce unacceptable dynamic in-train forces.

## 6.5 TURNOUTS

### 6.5.1 LOCATION

Turnouts and crossovers shall be located to allow suitable placement of switch machines or switch stands and associated CPUC walkways, and with consideration of the placement and visibility of control signals.

Turnouts shall be located:

- At least 60 feet from any curve
- At least 20 feet from curves without superelevation and within yard tracks
- At least 50 feet from the edge of the traveled roadway or sidewalk, if a sidewalk is present
- Facing point turnout spacing shall conform to ESD2209

Crossovers shall be located:

- On tracks with 15-foot minimum spacing unless existing yard track centers have 14-foot spacing
- With no curves between opposing frogs

Switch machines for power-operated crossovers shall be located on the outside of the mainline track.

The minimum size of turnout to be designed for use in the mainline track will be a No. 11 Turnout.

### 6.5.2 SPEEDS

Maximum speeds through turnouts are defined in ESD2208. The designer shall select turnouts based on required operating speeds; Current preferences are 8, 10, 14, 20, & 24. The higher speed and tonnage operation should use the straight side of the turnout. Some existing yard ladders use turnout sizes 8, 10, & 14 which may need to be selected in order to match the existing yard ladder or operation, seek concurrence with rail operator prior to making this selection.

### 6.5.3 YARDS

For the configuration of turnouts, turnout return curves, and reversing curves in yards, the designer shall consider the following:

- Reverse curves, including turnouts, should have at least 50 feet of tangent separating them, if possible.
- A design exception may be considered to allow reverse curves used in slow speed (that is, 10 mph or less), low-use turnouts to be reduced to a minimum required tangent of 20 feet. Additional protection measures may be necessary if a design exception is granted.

- Placement of switch-stands shall provide walkway clearance per CPUC GO No. 118 and shall be in compliance with ESD2109.
- Placement of access/fire road at-grade crossings shall avoid crossings over turnouts.

## 6.6 TRACKWORK

### 6.6.1 TRACK CLASSIFICATION

#### Main Track

Main Track is track constructed for rail vehicles in revenue service (carrying revenue passengers). This includes mainline, siding, and station tracks.

#### Secondary Track

Secondary track includes all other track that is constructed for the purpose of switching, storing, yards or maintaining vehicles not occupied by passengers and not used in revenue service.

#### Freight Track

Freight track includes all tracks that are constructed and/or maintained by for use by freight railroads to serve their industrial clients, not generally used by passenger equipment.

### 6.6.2 TRACK CONSTRUCTION TYPES

Ballasted track is the standard for track construction. Ballasted track, except where allowed elsewhere in this section, shall be constructed using continuous welded rail (CWR).

Ballasted track without CWR is acceptable on low-use yard and secondary track as well as low- to moderate-use freight track.

Direct-fixation track shall not be designed for use except in special circumstances on secondary track where special inspection pits, wash racks, fueling facilities or other environmental-maintenance needs require consideration of this track construction type.

### 6.6.3 TRACK

#### Main Track

LOSSAN standards and specifications describe typical Main track construction as 136-pound, CWR fixed with elastic fasteners on concrete ties situated on a roadbed of ballast and sub-ballast. Small sections of wood ties or cut spikes may be required to maintain consistent sections and eliminate small, isolated sections of different track structures. Premium head-hardened rail shall be used for curves 2°-30' or greater, for turnouts, and on the Miramar Grade with standard rail everywhere else.

Main track construction employs the use of fully welded insulated joint plugs as indicated for special trackwork to the furthest extent possible to eliminate in-track joints. Track sections and fastener details are shown in the appropriate LOSSAN Engineering Standard Drawings.

On all main tracks, CWR shall be used. When connecting rail of differing sizes in lead tracks, transition rails shall be used. With CWR, forged compromise transition rails with field welds and fully welded joint plugs shall be used. Compromise welds or Compromise Joint Bars, used to connect two different-sized rails, shall not be used.

### Secondary Track

LOSSAN standards and specifications describe typical secondary track construction as 115-pound new or or heavier secondhand rail as directed by NCTD.

On low-use secondary tracks, jointed rail is acceptable. When jointed rail is used, poly-insulated joint bars and compromise bars are acceptable. Compromise bars shall also be considered acceptable for use on industrial freight spurs.

Secondary track may consist of either timber or concrete ties. When concrete ties are used, elastic fasteners shall be used to attach rails to ties. When timber ties are used, new cut spikes and anchors shall be used. Track sections and fastener details are shown in the appropriate LOSSAN Engineering Standards.

### Freight and Other Track

LOSSAN standards and specifications describe typical freight or industrial track construction as the same as secondary track construction, except jointed rail, compromise bars, and poly-insulated bars are all acceptable. Secondary track standards shall be maintained for use in major lead tracks. Track sections and fastener details are shown in the appropriate LOSSAN Engineering Standards.

## **6.6.4 TURNOUTS**

Premium timber or standard timber turnouts shall be used, as follows:

- Premium timber turnouts (PTT) consist of wing rail spring manganese (WSM) frogs using pseudo-tangential geometry constructed on timber ties with hollow steel control rod ties.
- Standard timber turnouts (STT) consist of rail-bound manganese (RBM) for mainline use or self-guarded solid manganese (SGSM) frogs for use within rail yards using standard geometry constructed on timber (wood) ties.

### Main Track

Turnouts shall be fully welded with elastic fasteners, timber ties. Turnouts will be insulated and interlocked. Lateral geometry shall be used unless NCTD and SANDAG specifically directs the use of equilateral geometry. Premium timber turnouts (PTT) will be selected for use.

The designer shall plan the design to facilitate turnout fabrication on an adjacent temporary construction pad and installation during short preplanned outage windows.

### Secondary Track

Turnouts shall be insulated and interlocked for any lead tracks or tracks that may be equipped with automated switch machine operations. Non-insulated turnouts are acceptable

for lower-use tracks that will never be remotely controlled or operated with power switch machines. Insulated joints in the closure rail may be poly-insulated joint bars. Standard timber turnouts (STT) will be selected for use.

#### Freight and Other Track

Turnouts shall be installed per the secondary track standard.

### **6.6.5 HIGHWAY-RAIL GRADE CROSSINGS**

The design of highway-rail grade crossings of Main track shall incorporate precast concrete panels. Running rail through the crossing area shall be electric flash-butt welded, and the cross ties shall be timber. Galvanized rail clips shall be used in all new Highway at Grade Crossings. Highway-rail grade crossings shall be located in tangent track wherever possible. No exothermic (thermite) rail welds, insulated joints, or bonds shall be placed in crossings or within 10 feet of a crossing. No turnouts or crossovers shall be located within a public at-grade crossing. LOSSAN standards on grade crossings are presented in ESD4001 through ESD4202.

Traffic lanes and striping information is presented in the USDOT MUTCD Manual and the California Department of Transportation supplement (CAMUTCD) to the MUTCD.

### **6.6.6 DERAILS**

Derails shall be located so that they derail equipment in a direction away from the Main or secondary track being protected. Derails shall be located beyond the clearance points of converging tracks. Switch-point derails shall be installed at locations as directed by SANDAG and or NCTD, including locations where operating locomotives are stored and where cars are moved or switched by non-railroad personnel. LOSSAN standards on derails are presented in ESD2600 series drawings. Derail shall also comply with CPUC GO 33B.

All new industrial or spur track designs will include an electric lock/come-out signal and appropriate double switch-point derail, as required below, that is controlled by and connected to the signal system for the adjacent mainline track. This would include new industrial spur tracks constructed on an existing lead track. The lead track, which will now have a new industrial spur, must also include in the design the appropriate double switch-point derail and electric lock/come-out signal where the modified lead track connects with the mainline.

Blue flag derails are required to protect workers on service tracks per 49 CFR 218 and to protect the unloading of hazardous materials per 49 CFR 172.

#### Secondary Track

Derails shall be used to prevent out-of-control rail vehicles from fouling adjoining main track or adjacent secondary tracks. All new derails shall be double switch-point derails except when the prevailing grade on secondary or industrial tracks descends away from the primary track with a gradient of 0.5 percent or greater; see ESD2604-02 for additional information regarding use of derails. Double switch-point derails are required if an industry has its own locomotive or trackmobile, regardless of the grade of the track.

#### Freight and Other Track

Derails shall be used to prevent out-of-control rail vehicles from fouling adjoining main line or

adjacent lead tracks. On freight lead tracks, derails shall be installed per the same standard as secondary track derails (See ESD2604-02).

### Construction and MOW Sidings

Construction and Maintenance of Way sidings where track equipment is stored can be protected with either Bi directional derails a shown on ESD-2614 or portable derails as shown on ESD 2605, to satisfy 49 CFR Part 214. In addition the siding track grade shall be descending away from the mainline and the contractor will supply the portable derails.

### **6.6.7 BUMPING POSTS**

Secondary and industrial track bumping posts shall be installed at the end of each stub-ended operating track where the grade is descending toward the bumping post. A minimum distance of 8 feet shall be provided from the face of the bumping post to the end of the track. An allowance of 3 feet shall be provided from the train stopping position to the face of the bumping post. Wheel stops shall be permitted if the grade is ascending toward the wheel stop location or if the grade is flat. Refer ESD 2616.

### **6.6.8 RAILROAD (DIAMOND) CROSSINGS**

Rail/rail crossings shall be installed only where there is no other option available to allow trains to reach their respective destinations. Although economics may strongly dictate the requirement to install a railroad crossing, all other options shall be explored and presented to for guidance before designing railroad (diamond) crossings. If determined to be necessary, the designer shall place the crossing in tangent tracks if possible. The designer shall not place the crossing where both tracks are in a horizontal curve.

Crossings shall be aligned as close to perpendicular as possible. Crossing at a shallow angle (typically under 30 degrees) requires moveable point frogs, which lead to increased complexity, cost, and maintenance. Crossings may require special signaling and/or other operating restrictions, particularly if Main tracks are involved. If train travel on the secondary track will be set to slow speeds (such as 10 mph), the designer shall consider the use of flange bearing crossing frogs. A hot-mix asphalt (HMA) underlayment shall be required for all new rail/rail crossings.

### **6.6.9 INNER GUARD RAILS**

Consideration should be given to the use of inner guard rails taking into account the alignment, train speed, deck type, density of traffic, as well as the height of the bridge. (AREMA 4.9.2)

The purpose of inner guard rails, although not a failsafe device, is to reduce the likelihood that derailed wheels strike an adjacent structural object or bridge component above the bridge deck and/or improve the likelihood that derailed equipment remains on the deck until the derailed train is stopped. Inner guard rails can reduce the ability for maintenance crews to surface track and correct minor profile or cross level irregularities and therefore should only be installed after thoughtful consideration on the impact for maintenance and the protection of a structure's integrity.

## Protection of Overhead Grade Separation Structures

Piers supporting overhead structures may be protected by either crash walls (AREMA 2.1.5) or inner guard rails (AREMA 4.9.2) as shown on ESD 2302 and ESD 2304.

Inner Guardrails are to be installed on all FRA Class 2 to 5 track if there are no pier protection walls.

- For Class 2 track inside guard rails are to be installed where horizontal clearances are less than 12'-6" feet from the centerline of track to the supporting member.
- For Class 3 to 5 track inside guard rails are to be installed where horizontal clearances are less than 18 feet from the centerline of track to the supporting member.

## Bridges on Class 3, 4 and 5 track

Double inside guard rails shall be required on bridges;

- For all spans where exposed structural steel is present above the top of rail and is subjected to structural damage by derailed equipment. I.E. Thru plate girder bridges and deck truss bridges.
- That are higher than 40 feet and are more than 150 feet in total length.
- With individual spans of 100 feet or greater in total length.
- Under highways where track curves exceed 3 degrees and the spans are 30 feet or more in length.
- Over highways.
- Over a waterway with water at least 15 feet deep at mean tide level.

In all cases the inner guard rails shall extend 50 feet beyond the span or spans to be protected as shown on ESD-2304.

Inner guard rails may be installed on any other bridge or other track location as directed by SANDAG or NCTD.

## 6.6.10 SPECIAL TRACKWORK

Special trackwork shall conform to current LOSSAN standards and specifications and AREMA recommended practices.

## 6.7 TRACK MATERIALS

### 6.7.1 RAIL

Main track shall be 136-pound (RE) rail section, carbon steel rail meeting current LOSSAN standard specifications and AREMA "Specifications for Steel Rail."

Premium head-hardened rail shall be used for curves 2°30' or greater, for turnouts, and on the Miramar Grade with standard rail everywhere else.

Secondary and industrial tracks that are used as lead tracks and high-use running tracks shall be 136-pound RE section, standard CWR. Other secondary and industrial tracks, such as yard body tracks, storage tracks, and spurs, may be 115-pound RE section, jointed rail.

All CWR shall be welded into continuous lengths by the electric flash-butt welding process except for certain field welds that may be exothermic welds. The exothermic welding process may be performed when joining strings in the field and at insulated joint plugs, compromise transition rails, frogs, closure rails, and other special trackwork. No compromise welds, joining differing rail sizes are allowed.

### **6.7.2 TIES**

Concrete ties with elastic fasteners shall be used for new Main track construction. Concrete ties shall be a minimum 8 feet 3 inches long and spaced at 24 inches, center to center (ESD2402). Timber ties shall be used for road crossing ties and for turnout construction. Timber ties may be used to construct temporary shoofly track and to rehabilitate existing timber tie track. Timber ties shall be new 9-foot-long and 7-inch-high by 9-inch-wide hardwood-treated main track (HWTR MT) grade 5 ties and spaced at 19.5 inches, center to center.

Transition ties shall be used where track modulus changes abruptly from concrete to timber, particularly at ends of track spiked turnouts, road crossings, open deck bridges, and other wood-to-concrete tie interfaces. LOSSAN standards for transition tie sections, including quantity and spacing requirements, are presented in ESD2351-1 to ESD2351-3. Transition ties shall be new 10-foot long x 7" x 9" timber ties.

At timber elastic fastener turnouts, no transition ties are required. Concrete ties may be used in track to both ends of the timber turnout panel.

Steel track ties shall be used in areas such as locomotive service and fueling facilities.

### **6.7.3 OTHER TRACK MATERIAL**

Other track material (OTM) shall conform to current LOSSAN and AREMA standards and specifications. Cut spikes may be used in timber tie construction where rail size remains the same. If cut spikes are used as primary fasteners, rail anchors must also be used. If the rail size changes, tie plates shall be changed and elastic fasteners shall be used. Required fastener types are presented in ESD2361 through ESD2368.

The designer shall call for approved tie pads and insulators on concrete ties in the designs. LOSSAN standards for approved tie pads and insulators are presented in ESD2363 through ESD2368.

### **6.7.4 BALLAST**

Main track and secondary track ballast shall conform to LOSSAN standard specifications and AREMA recommended practices (Type 4A). The ballast for all main tracks shall consist of a uniform minimum 12-inch layer below the ties unless directed by the geotechnical subconsultant. The minimum specific gravity of ballast shall be 2.70 unless otherwise approved. Ballast thickness for new construction shall not be less than 9" and shall not exceed 18" as determined by the geotechnical consultant considering ground conditions and subballast.



Walkway Ballast, where personnel are likely to walk while inspecting or maintaining equipment, shall be (AREMA Type 5)  $\frac{3}{4}$ " ballast conforming to CPUC GO 118A.

Standard ballast sections are presented in ESD2001 and ESD2002.

### **6.7.5 SUB-BALLAST**

Sub-ballast material shall conform to LOSSAN standard specifications and AREMA recommended practices. The sub-ballast for all tracks shall consist of a uniform minimum 6-inch layer, **or more as determined by geotechnical analysis**, placed and compacted over the entire width of the roadbed following the profile and cross section of the roadbed. Final design shall consider the use of a thicker sub-ballast section or geotextiles when subsoil conditions dictate, as presented in ESD2001 and ESD2002 for typical roadbed sections.

Design of subgrade and sub-ballast for relocated and transition sections shall consider the condition of the existing ballast and sub-ballast. Unless the existing ballast is contaminated with fines or organic material, or is not adequately drained, the existing ballast and sub-ballast may be used to support relocated and transition track segments.

### **6.7.6 JOINTS AND WELDS**

#### Main Track

Main track may be made from 1660 ft rail train delivered strings or may be made from 80 ft stick rail welded into continuous length strings by the electric flash-butt welding process on site to create CWR at least 440 feet long. These CWR rail strings may be joined on site using exothermic field welds to form the main track. The exothermic welding process may also be used when joining; insulated joint plugs, transition rails, frogs, closure rails, and other special trackwork. No compromise welds are allowed on new Main track.

No joints or field welds are allowed in road crossings. Temporary joints pending welding should not have bolts installed or holes drilled on the center two holes of six-hole bars.

#### Secondary Track

All leads where track is CWR shall be welded into continuous lengths by the electric flash-butt welding process except for certain field welds that may be exothermic welds. The exothermic welding process may be performed when joining strings in the field and insulated joint plugs, transition rails, frogs, closure rails, and other special trackwork. Compromise bars and poly-insulated joint bars may be used on jointed rail track.

### **6.7.7 INSULATED JOINTS**

Permanent insulated joints shall be installed by insulated joint plugs fully welded in Main track. Poly-insulated bars may be used in closure rail of turnouts and on jointed secondary track. No compromise welds are allowed. Refer ESD-2504 for prefabricated square cut bonded insulated joints.



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## 7.0 STATIONS

### 7.1 GENERAL

The purpose of this section is to provide station designers with a basis for design of new or modified NCTD Coaster Stations. All existing stations currently also serve Amtrak intercity trains. SCRRA Metrolink trains currently only serve Oceanside Transit Center. It's anticipated that Metrolink will share service at all NCTD Coaster Stations south to Santa Fe Depot in the near future. The majority of station design projects involve improvements to existing stations. The designer will need to coordinate closely with Amtrak and Metrolink to confirm additional platform configuration requirements in addition to those specified herein.

The design of a station is typically site-specific and reflects the surrounding community. However, the functionality of the stations must be practical and consistent in order to effectively serve NCTD trains and passengers. The criteria set forth in this DCM are intended to ensure that a station is designed to meet the minimum requirements for a NCTD commuter rail station.

### 7.2 CODES AND STANDARDS

NCTD commuter train service operates over trackage that is part of the general railroad system of transportation and, in most cases, NCTD Coaster trains share track with freight trains. Therefore, this manual must be used in conjunction with current versions of LOSSAN Engineering Standards, the AREMA Manual for Railway Engineering, and the AREMA Communications & Signals Manual of Recommended Practices.

Station design shall comply with the current editions of the codes and standards listed below. Should there be any conflicts between codes, then the most restrictive criteria shall apply.

- AREMA Manual for Railway Engineering
- LOSSAN Engineering Standard Plans
- California Public Utilities Commission
- Americans with Disabilities Act (ADA) Accessibility Guidelines
- Federal Transit Administration Americans with Disabilities Act (ADA) Standards for Transportation Facilities (effective 11/29/06)
- California Title 24 – Building Energy Efficiency Standards
- Local Building Codes
- Local Planning and Zoning Codes and Standards
- Other Codes/Agencies

For specific locations approvals may be required from the Army Corps of Engineers, California Coastal Commission, Caltrans or other agencies or authorities.

## 7.3 SITE SELECTION

### 7.3.1 STANDARDS FOR TRACK AT STATION SITES

For new stations:

1. Station tracks should be designed to be tangent and level (without superelevation) within the limits of the station platforms, where possible.
2. The standard minimum platform length is 1,000 feet.
3. Track grades of up to 0.5% will be allowed. Grades more than 0.5% require the approval of the SANDAG Director of Rail and/or NCTD Chief of Rail Operations.
4. Curved track shall be avoided if at all possible. If constructing a platform on a curve is unavoidable it should be as shallow a curve as possible, shall not exceed 1 degree 30 minutes, and shall not negatively impact current or anticipated future authorized train speeds. Track should be designed with no superelevation if possible, but in the worst case superelevation shall not exceed 1-1/2". If a station is located on a curve, the platform should be on the outside of the curve. Platforms on the inside of a curve present concerns for the train engineer and conductor, because the curve prevents them from seeing all of the cars and doors to ensure that all passengers have safely boarded or alighted prior to closing the doors. Any platform proposed for the inside of a curve is subject to the approval of the SANDAG Director of Rail. Designer shall provide a means for the train operator to see the full length of the train and the platform,
5. Track centers where two or more tracks are present at station platforms should be wide enough to allow for an inter-track fence. This will require a minimum track spacing of 18 feet. This spacing will only be required between one pair of tracks where there are more than two tracks. The expanded track centers should extend a minimum of 150 feet beyond the end of the proposed platform and any foreseeable platform extensions, at each end of the station.

### 7.3.2 SIGNAL SYSTEM IMPACTS

If the location of the station causes train operations to be affected by the "Delayed in Block" rule (GCOR 9.9), the station project shall include modifications to the signal system to avoid such a delay. This is usually accomplished by adding or re-spacing automatic block signals.

Platforms (including potential extensions) will be located at least 80 feet from the nearest road crossing in order to prevent the locomotive of a stopped train from obstructing the crossing.

### 7.3.3 APPROVALS

Proposed sites will be evaluated based on their impact to commuter and freight railroad operations. All sites are subject to the approval of NCTD and SANDAG.

The presence of utilities such as fiber optic cables and/or pipelines at the station site requires careful coordination with utility or fiber optic cable/pipeline companies, NCTD, and the right-of-way railroad. Refer to Chapter 2 – Survey, Right-Of-Way, and Utilities.

### **7.3.4 AGREEMENTS**

Agreements with a City, County or a construction, operation and maintenance agreement with the owner of the railroad right-of-way (NCTD or MTS) is required before a station can be built. SANDAG/NCTD/MTS are responsible for obtaining these agreements.

## **7.4 PARKING AND SITE CONFIGURATION**

### **7.4.1 MINIMUM NUMBER OF SPACES**

The minimum number of parking spaces at any new station will be determined using ridership modeling. Appropriate allowances shall be made for accessible spaces, short term parking, 20 minute van and carpool spaces, motorcycle parking, and bicycle lockers. Loading and unloading areas for buses, minibuses, vanpools and cars shall be provided as appropriate for the anticipated vehicle population. There shall be as many short term spaces as ADA accessible in a convenient location for drop off and pickup.

### **7.4.2 ADA CONSIDERATIONS, PLATFORM, PARKING LOT AND STREET ACCESS**

Access to the station shall conform to the requirements of the Americans with Disabilities Act, Title II, and California accessibility regulations, Title 24. A conforming path of travel must be provided continuously from the street to the platform and all platform and parking lot facilities must comply with the referenced codes. Also refer 28CFR 36 for full requirements.

<b>Table 7.1 Minimum Number of Accessible Parking Spaces</b>		
Total parking in Lot	Minimum Accessible Spaces	Van accessible with 96" access aisle
1 to 24	1	1
26 to 50	2	1
51 to 75	3	1
76 to 100	4	1
101 to 150	5	1
151 to 200	6	1
201 to 300	7	1
301 to 400	8	1

<b>Table 7.1 Minimum Number of Accessible Parking Spaces</b>		
Total parking in Lot	Minimum Accessible Spaces	Van accessible with 96" access aisle
401 to 500	9	2
501 to 1000	2% total	

### **7.4.3 INTERMODAL ISSUES**

To promote use of the station and to reduce dependence on automobiles, SANDAG/NCTD encourages the provision of intermodal connections at its stations. These may take the form of regular bus access to a location close to the platform, institution and encouragement of the use of minibus and van pool programs, provision of bike paths, dedicated walkways and pedestrian friendly paths of travel, etc.

#### Pedestrian access

Pedestrian access shall be provided along dedicated walkways complying with ADA and Title 24 requirements from the street to the platform. Direct access to a contiguous dedicated sidewalk or walkway system is desirable. An absence of a direct pedestrian path may result in "short cuts" being used by pedestrians. Pedestrian access to nearby traffic generators should not create an attractive path through the station or across the tracks.

#### Other Rail Transit Modes Access

Access to other rail transit modes such as MTS Trolley at Santa Fe Depot Station and Old Town Station, and NCTD Sprinter at Oceanside Transit Center should be incorporated into station design. If possible, cross-platform transfers should be incorporated into each modes platform design.

#### Bus access

Regular transit bus access to the station is desirable and should deposit passengers as close to the platform as practicable. Every effort should be made to separate pedestrian paths of travel from bus circulation routes. It is recommended that dedicated bus loops be used to reduce conflicts between buses, automobiles, and pedestrians. If bus service is located on the street outside of the station, the path of travel from the bus stop to the station platform must comply with ADA requirements.

#### Bicycle

Consider including bike paths in the design of the station and its environment, depending on local conditions and the local demand. Provision of bike lockers should be considered and if provided located in close proximity to the platform. Designers shall refer to SANDAG



regional Bike Plan, and confirm that the proposed project facilitates the use of bicycles according to the regional plan. Refer to [www.SANDAG.org](http://www.SANDAG.org).

### Motorcycle

Motorcycle parking should be considered and separate provisions made in the layout for secure and economical parking of motorcycles close to the platform in areas where car parking may not be possible.

### Passenger drop off areas

To encourage passengers to be dropped off at the station, rather than parking, NCTD requires that consideration be given to providing specific drop off areas close to the platform for passenger cars, minibuses or vanpools, and if designated in the program, regular bus services. A minimum of one accessible passenger drop-off/loading zone is required.

Short term - 20 minute parking area shall be provided with at least one 9-foot wide parking space and a 5-foot wide loading and unloading access aisle parking space (ADA Compliant) for disabled passengers.

## **7.5 SIGNAGE**

Consultants must prepare a signage schedule for Station signs including digital signs and for Track signs which will be included in the 90% and 100% submissions and detailed in the bid price form.

- Refer to the ESD 3300 series for standard station signs and
- Refer to the ESD 5200 series for ROW signs.

A station architect shall utilize the standard signs and any other signs necessary to comply with all laws and regulations.

The station parking lot must include an entrance sign containing the NCTD/Coaster/MTS logos as appropriate conforming to the LOSSAN graphics standards. Station sites will occasionally overlap the placement or railroad operating signs (e.g. speed limits, mileposts, and crossing signs) which must be accommodated in locations with visibility to train crews.

Stations signage will include train stopping indicators to aid crews in accurately positioning trains at boarding locations; these signs must be accommodated in the station architectural and site plans.

Signs shall be placed at sufficiently frequent intervals and at visible locations to provide clear directions and information to commuters without additional assistance. Wayfinding signage should be provided in multiple languages and in braille from the Drop-off area to the station platforms.

### **7.5.1 PROJECT FUNDING SIGNS**

See ESD5201 and ESD 5202 for LOSSAN Standard Funding Signs. Select a sign appropriate to the funding sources.

### **7.5.2 BRIDGE AND CULVERT SIGNAGE**

The year the Bridge is built shall be imprinted in the structures concrete façades centered on both the sides of the bridge.

See ESD5200 series for Bridge and Culvert Numbering signage.

### **7.5.3 PARKING LOT SIGNS**

The station parking lot must include an entrance sign containing the NCTD logo. The logo must be configured to comply with the NCTD graphics standards. The station entrance sign shall be a porcelain enamel monument sign. NCTD will assist in the design review of parking lot signs. Parking Lot Signs shall Include:

- ADA Parking Space and Towing Sign
- ADA Van Accessible
- 15 Minute Drop-Off Space
- Not Responsible for Theft Sign
- Directional if necessary
- Clearance

Refer to the ESD3300 series for standard station signage.

### **7.5.4 TRAILBLAZER SIGNS**

Trailblazer signs consist of freeway trailblazers and arterial road trailblazer signs. Freeway trailblazers are used to direct patrons from freeway off-ramps and major arterial highways to the stations. NCTD shall coordinate with Caltrans for the installation of Caltrans trailblazers when appropriate. White-on-green Caltrans guide signs (G95G – train station next exit) are used to indicate the freeway exit for a station. White-on-green Caltrans guide signs (G97 – train station with supplemental NCTD plate) are at the bottom of freeway off-ramps and on major arterial highways to direct motorists to the station.

Arterial road Coaster trail blazer signs shall be per ESD 3308 and shall be placed on existing City Light Poles on local streets.

### **7.5.5 PLATFORM SIGNS**

Platform signs are necessary for passenger information and train operations and are required by the ADA. Additional signs shall be configured to control passenger and trespasser access to the tracks and the ROW. See ESD3300 series for standard station signage. A station architect shall utilize the standard signs and any other signs necessary to comply with all laws and regulations.

### **7.5.6 RIGHT-OF-WAY SIGNS**

ROW signs are necessary to deter trespassers from the ROW and to assist train operations. See ESD5200 series for standard ROW signage.

## **7.6 PLATFORMS**

### **7.6.1 FUTURE TRACK AND PLATFORM LENGTH**

When selecting a site for a station, consideration should be given to possible track additions and possible extensions in the future for longer train consists. New stations will be constructed with 1,000-foot long platform. Where additional tracks are anticipated the designer shall consult with NCTD to confirm if the required future platform shall be constructed as part of the current design. If required, the permanent platform shall be constructed in place with an expansion joint and temporary/sacrificial platform between the existing track and the future edge of platform. The future edge of platform shall be based upon planned centerline of future track alignment including consideration of site constraints and requirements for inter-track fence.

### **7.6.2 COMBINATION AMTRAK/COASTER/METROLINK ISSUES**

NCTD stations provide service for Coaster, Amtrak, and Metrolink. This introduces compatibility issues into the design of the station. Specific issues are related to door location markers and the mini-platform. Coaster has a mini-high platform at the northern door of the southernmost car. Metrolink requires a mini-high platform at the north end of the train. Refer to Engineering Standard ESD3101 series for details and placement of mini-high platforms for new construction. Amtrak uses a portable lift which requires a secure storage space on the platform and an attendant to operate it at OTC, Solana Beach, and San Diego depot. Amtrak typically requires a 1,000 foot long platform as exists at OTC, Solana Beach and San Diego depot.

### **7.6.3 PLATFORM CLEARANCES**

Per NCTD direction to comply with level-boarding requirements (49 CFR Part 37 and 38), all new and altered station platforms will be constructed at 15-inches above top of rail, 64 inches from the centerline of track, and within the tolerances prescribed by the regulation. Until the California Public Utilities Commission's (CPUC) revises General Order 26-D to comply with the federal regulations, a variance will be required from the CPUC before a station platform is constructed or altered. All construction (other than the edge of platform) adjacent to track shall meet or exceed the requirements of CPUC GO 26-D for minimum clearances and GO 118 for walkways. Permanent clearances shall conform to Engineering Standard ESD2101 at station platforms. The station layout will 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 will be used to keep unauthorized vehicles from entering the right-of-way.

### **7.6.4 GENERAL CONFIGURATION**

#### Dimensions

Side platforms are preferred to center platforms. Side platforms shall be a minimum of 16 feet wide unless otherwise approved by SANDAG and/or NCTD. Center Platform shall be

designed with adequate width to conform to CPUC requirements, meet SANDAG/NCTD standard clearances to structures, accommodate required pedestrian overpass or underpass facilities, and allow adequate walkway widths to safely accommodate two way pedestrian flow. Center platform shall not be less than 26 feet wide unless approved by SANDAG and/or NCTD.

Additional width should be provided at side platforms, if possible, for canopies and overcrossing or undercrossing structures. NCTD prefers to keep the platform clear of any obstructions, all canopy supports should be at the back of the platform and platform furniture should be located in wider areas beyond the 16 foot minimum platform width. This allows better security for the passengers and enables the train crew to see that the doors are clear prior to closing them. All platforms should slope away from the track a minimum of 1%, at center platforms the slope shall be to a centerline swale with drainage inlets at maximum 25 feet centers.

Platform surface finish shall be broom finish or equivalent roughened finish for concrete and shall be anti-slip finish for tile or other platform surface materials. Drainage may be directed into existing right-of-way ditches that are at least three feet below the elevation of the rail.

Platforms shall be at an elevation fifteen (15) inches above the top of the adjacent rail. The platform edge shall be 5'-5" from the centerline of track. New platforms are to be constructed of concrete with flush vertical wall if possible on the track side. Platform and platform extensions constructed adjacent to an active track may be required to be designed with a cantilever edge in order to avoid impacts to existing rail operations. The designer shall verify requirements for platform facing design with NCTD during the concept design phase. Designers will also consult with NCTD on the final profile for the track, and establish the platform grade to match the final track grade (following any rehabilitation or modifications to the track.) In all cases, these two dimensions will control field construction and will supersede dimensions and/or elevations shown on the plans.

#### Detectable warning strip

A detectable warning strip 2'-0" wide is required at the rail side of the platform. The strip shall be Federal Yellow in color and must include the Federal Standard truncated domes. A 1" wide black contrast stripe is required at the back of the detectable strip.

#### Platform Warning Stripe

The entire length of platform shall have a warning stripe placed 8'6" from centerline of track that is at least 4" wide and federal yellow in color. The platform shall also have 4" high black text directly behind the warning stripe stating "Please Stand behind Yellow Line" at 30 foot intervals. Platforms constructed of colored concrete may require text in another contrasting color.

#### CPUC Ramps

Ramps are required at the ends of the platforms to allow train crews to safely walk alongside a slow moving train in accordance with CPUC General Order 118. The ramp must be a minimum of 3'-2" wide and have a slope of not more than 1:12. The foot of the ramp must descend to at least the bottom of tie to allow for some wash out. If the track walkway is lower than the bottom of tie then the foot of ramp must descend to 6" below the track walkway level.

If the ramp also functions as an emergency evacuation walkway, the maximum slope is 1:20.

### Conduit systems

Station platforms and facilities shall contain power and communications conduits and pull boxes required to support all NCTD equipment, including ticket vending machines, ticket validators, public address speakers, changeable message signs, and security cameras. It is recommended that wherever possible all conduit systems be located behind the platform and spare conduits be provided. This is to prevent platform closure in the event that there is a failure in the conduit system requiring excavation within the platform area.

The right of way is also used for fiber optic and signal lines which are buried in conduit systems within the right of way. To prevent closure of the platform to allow excavation for these lines it is NCTD's policy to provide at least four 4" diameter conduits for the full length of the platform with 4'-0" square pull boxes. These conduits are to be in addition to any other conduit systems installed for the platform.

NCTD's Operations and Information technology staff are to be consulted regarding the requirements for spare conduit to meet future needs.

### Mini-High Platform

In order to provide for level boarding of the train through the use of a bridge plate, a mini high platform is required. The mini-high platform is 6" above the general platform level for 15" platforms (or 1'-1" above top of rail for existing 8" platforms). The mini-high is set back 7'-11" from the centerline of track. Mini-High Platforms for NCTD Coaster trains shall be centered 60 feet from the south end of the station platform in order to align with the second door of the southernmost rail car. Refer to Engineering Standard ESD3101-01. At Oceanside Transit Center, mini-high platforms shall also be constructed 60 feet offset from the north end of the platforms to serve Metrolink trains.

### Concrete

In order to minimize surface cracking in platforms the consultant shall ensure that appropriate expansion and contraction joints are allowed for. In addition shrinkage compensating admixtures shall be used to minimize surface cracking in station platforms and ADA ramps leading to platforms. Calcium Chloride accelerating admixtures are not allowed. Appropriate curing methods shall be specified.

## **7.6.5 LIGHTING**

Platform lighting should have a minimum of 5 foot-candle intensity at platform level and should be configured so that no light source can be seen by the train engineer (this can cause the engineer to suffer temporary night blindness). For minimum illumination levels within stations at various areas see Table 7-3. Parking lot lighting may be designed to City standards; however, SANDAG suggests a minimum light intensity of at least 2 foot-candles.

Pedestrian undercrossings should have ample lighting, with a minimum of 10 foot-candle intensity.

Light poles should be strong enough to support installation of changeable message signs, static signs, speakers, banners, and CCTV. Refer to UBC, especially for wind loading requirements.

<b>Table 7-3 RECOMMENDED ILLUMINATION LEVELS</b>	
<b>Location</b>	<b>Average Illumination Level</b>
Platforms	5 foot candles
Canopies	10 foot candles
Overheads and Underpasses	10 foot candles
Stairways and Ramps	10 foot candles
Walkways	10 foot candles
TVM Areas	10 foot candles
Loading Area and Bus Platforms	5 foot candles
Parking Areas	Per local requirements (but not less than 2 foot candles)

### **7.6.6 CANOPIES**

The canopies should be set back clear of a line 12'-0" from the centerline of the track and it is suggested that the structural supports be set at the back of the platform clear of the 16 foot minimum platform width. It is also suggested that the minimum clear height below the canopy to be 10'-0". Canopy configuration and construction consideration shall be given to cities within to share costs for custom built canopies.

The principles of Crime Prevention through Environmental Design (CPTED) should be applied to canopy areas. That is, canopy structures should not create hiding areas and the materials should be vandal resistant.

The canopies are required to include conduits for public address/variable message sign equipment (PAVMS) and possible future CCTV equipment.

### **7.6.7 BENCHES AND OTHER PLATFORM FURNITURE**

Bench selection is at the discretion of the NCTD Station Operator. Concrete benches are preferred. The use of CPTED principles is recommended. Benches should be a vandal resistant design. They should be configured to discourage sleeping on the benches and use as skateboard ramps. Trash receptacles should be provided on the platform with at least one at each canopy. All platform furniture must be securely fastened to the platform to prevent vandals from throwing them onto the track. It is recommended that the platform furniture be located at the back of the platform away from the tracks.

### **7.6.8 TVM PAD**

A Ticket Vending Machine (TVM) pad shall be provided and located on the major path of travel to and close to the platform. The pad must be a minimum of twelve (12) inches thick. TVMs shall be protected from possible theft of the machine by installation of bollards or walls to prevent close access to the machines by a vehicle.

Stations shall have at least two TVM pads—two on or adjacent to the platform, or one on or adjacent to the platform and one on an adjacent platform or at a pedestrian focal point.

Each TVM pad will have at least one TVM, one multi-trip validator, and a compass card reader at each end of the platform.

Display cases for schedule and advisory bulletins shall be provided as close to the TVM pad as possible.

### **7.6.9 COMPASS CARD READERS**

Compass Card Readers are machines that validate a date and time for travel on that day. At least one Card Reader is required on each platform. Two per platform is preferred. Also, one should be located adjacent to the TVMs and at the main entry points to the platforms. At least one TVM pad shall be ADA accessible.

### **7.6.10 DRAINAGE**

Provide positive drainage away from the track and platforms. Drainage shall include the entire station site and contiguous railroad right of way. Please see the drainage chapter for additional drainage requirements

## **7.7 FENCING**

### **7.7.1 INTER-TRACK FENCE**

An Inter-Track Fence (ITF) is required for every station with platforms outside a set of two or more tracks to prevent passengers/pedestrians/trespassers from crossing the tracks. The fence shall be 6 feet high (4 feet within 150 feet of at-grade crossings) and extend 150 feet beyond the ends of the platforms. Track spacing through stations shall be 18 feet in order to provide CPUC GO 26D clearances to the fence from each track. The ITF shall be designed as a permanent steel “picket” fence (with pickets and slat spacing to permit visibility through the fence but to discourage climbing. See NCTD ESD5102 for ITF details.

Where the track structure consists of wood ties being maintained in a traditional “cycle” replacement mode, the ITF will be designed for removal and replacement in order to facilitate the replacement or track ties. The fence does not need to be removable if both of the tracks are concrete ties or are renewed with 100% new wood ties within a year prior to installation of the ITF. Designers should compare the costs of the ITF to the costs of upgrading the track to determine the most economical solution.

### **7.7.2 RIGHT-OF-WAY FENCING**

Where railroad Right-of-Way (R/W) within the vicinity of a station would allow passengers to trespass on the R/W as a short cut to the platform, the station designer shall provide R/W fencing to direct the passengers to the designated platform entrances. The fencing shall be welded wire and at least six feet high. R/W fencing shall include access gates for R/W and track maintenance.

## **7.8 PEDESTRIAN CROSSINGS**

SANDAG/NCTD/MTS must approve the final design of crossings at stations, depending on ownership of the station. The preferred design is to have completely grade-separated pedestrian access to separate platforms for each operating track, with an inter-track fence between the tracks to prevent persons from crossing between platforms at grade. At-grade crossings are generally gated and used only for emergency access and maintenance equipment. New station at grade pedestrian crossings are not allowed at Coaster Stations. New pedestrian grade crossings must also be approved through the formal CPUC application process. A design exception will be required for an at grade crossing in a station if that is the only feasible alternative.

Crossing surfaces will conform to Engineering Standard Drawing ESD4001, a minimum of 10 feet wide and with end ramps of hot mix asphalt at 1:4 slopes. Edges of crossings will be painted with 4-inch white borders.

If an existing public road crossing equipped with automatic warning devices exists directly adjacent to a station, it will be an acceptable at-grade passenger/pedestrian crossing. It is preferable to utilize an existing crossing rather than add an additional at-grade crossing. NCTD will evaluate the existing crossing to determine if improvements are necessary. Pedestrians should be channelized away from the tracks as they leave the platform.

### **7.8.1 PEDESTRIAN DESIGN**

Some transit users have mobility impairment at one point in their lives. Design of the pedestrian facilities at transit stations should allow for the greatest possible use for all segments of the population. The aesthetic elements of urban design should be considered to create inviting and interesting public spaces at stations.

Pedestrian pathways should be laid out in ways to optimize the shortest distances between destinations that meets the safety and security elements of Crime Prevention Through Environmental Design (CPTED). Design should channelize pedestrians into station areas and away from the railroad right-of-way outside of station areas. At stations, pedestrians should first be directed towards the fare payment area, then towards the paid fare zone on the station platforms, if applicable. Access to platforms on the other side of the railroad tracks should be clearly articulated in station architecture, wayfinding signage and/or signature elements such as paving details.



Pedestrian pathways should be designed to minimize obstacles to the mobility impaired while encouraging transit patron usage. Pedestrian walkways and/or ramps should meet all Americans with Disabilities (ADA) requirements. For non-street walkways, the desired maximum grade is 5% with absolute maximum grade of 8% in limited sections. Local street grades should control the sidewalk grades on existing streets.

### **7.8.2 OVERCROSSINGS**

Where the track is at or below natural grade then an overcrossing is suggested. The overcrossing bridge shall be a minimum of 26 feet clear above top of rail and shall be a minimum of 12 feet wide. Size of overpass should accommodate peak hour pedestrian loading. The overcrossing can be served by a stair and either an elevator or a ramp system complying with ADA requirements. Elevators may not be used unless otherwise approved by NCTD. The overcrossing tower structure shall not be closer than 12 feet from the centerline of track and all overcrossing supports within 25 feet of the centerline of track shall be protected by concrete crash walls 6 feet high, 30 inches wide and at least 12 feet long. Structural columns may be buried within the crash walls but shall be isolated from them by use of a minimum of 1" of compressible material. Fencing on overcrossings is required to prevent the dropping of large objects on passing trains. Overcrossings should be designed with due consideration for a method of construction staging that will minimize impacts to train operations. Train operations through the construction area will be under the control of an Employee-In-Charge (EIC) who will provide safe times for crane lifts that have the potential to foul the operating track.

### **7.8.3 STATION UNDERCROSSINGS**

Where the track is at a level grade or is elevated on an embankment the use of an undercrossing becomes the preferable alternative to an overcrossing. The inside clear dimensions of the pedestrian underpass structure may vary depending on the location and utilization;

- In Stations pedestrian undercrossings shall not be less than 20 feet wide by 9 feet high.
- For non station undercrossing clearances refer Chapter 4 of this design criteria.

The underpass should have as open an aspect as possible at each side. ADA compliant access must be provided in a similar manner to the overcrossings discussed above. Electrical and communications conduits should be installed at each end of an undercrossing to support electronic signage and CCTV.

Undercrossing construction staging shall be presented at all stages of design review. Undercrossing construction staging shall have minimal impacts to train operations. As a general guide, at two-track locations, both tracks must be in service every weekday and one track must be in service throughout the weekend. Train operations through the construction

area will be under the control of an Employee In Charge (EIC) who will provide safe times for crane lifts that have the potential to foul the operating track. Landscape Clearances

All landscaping shall be a minimum of 12 feet clear from the centerline of track. Trees and shrubs shall be located so that the anticipated canopy spread will not encroach closer than 12 feet to the centerline of the nearest track. Landscaping should not obstruct electronic or static signage. In parking lots, the principles of CPTED should be applied and landscaping should not create hiding areas. Drought tolerant native plants shall be used.

## **7.9 ARTWORK**

NCTD/SANDAG supports the inclusion of art in its transit projects. The artwork shall be at the discretion of the funding agency but shall not include colored lighting or night time lighting enhancement in close proximity to the track (it could be mistaken by the train engineer for train signals) and shall not encroach on railroad clearances or be in violation of lighting requirements.

## **7.10 COMMUNICATIONS**

### **7.10.1 COMMUNICATIONS BUILDING**

A communications building is required at each station to house signal and communication equipment that will serve the station. Electrical and telephone service is required to the communications building. The communications building should be set back from the right-of-way or located in such a way to allow for future platform extensions. Consideration for ingress and egress to the building should be addressed. Also, the elevation of the building should allow for proper drainage and access.

### **7.10.2 CCTV SYSTEMS**

Platforms and parking lots shall have conduits, communications and power systems installed for a CCTV system that must be provided. The CCTV security consultant will work with NCTD Security, Operations and Information Technology staff in designing the security surveillance to NCTD's needs.

At station platforms, consultants shall perform coverage analysis to confirm location and height of CCTV. Minimum requirements are coverage of TVM's, Platform entry and exit locations and facial recognition.

In parking lots, consultants shall perform coverage analysis to confirm location and height of CCTV. Minimum requirements are coverage of all entry and exit locations and ability to read number on licence plates and facial recognition.

Preferred camera height shall be between 12 and 16 feet.

Two 1-inch conduits (one for electrical and one for communications) shall run from the nearest set of pullboxes/ handholes to each device (e.g. light poles for cameras, VMS sign frames for bus information signage).

### **7.10.3 PASSENGER INFORMATION CALL BOXES**

Self-contained, solar powered; passenger information call boxes must be provided. Provision should be made to position one of these close to the TVM pad.

### **7.10.4 PA/VMS**

A public address and variable message sign system for the stations must be provided. Provision is made in the electrical conduit design for installation of this system. The PA speakers and VMS panels are usually attached to the canopy structure or light poles and provision should be made in the design for this.

### **7.10.5 EMP PANEL**

An emergency management panel is provided as part of the PA/VMS system which allows access to the PA system for emergency or railway personnel. Provision should be made in the station design for location of this panel close to the main entrance to the platform.

## **7.11 PLUMBING SYSTEMS**

### **7.11.1 PLATFORM WASH DOWN SYSTEM**

The platform shall be provided with ½ inch quick connect couplers in recessed boxes at the back of the platform. The couplers shall be at approximately 85 feet on center to allow full coverage with a 50 foot hose.

### **7.11.2 DRINKING FOUNTAINS**

Drinking fountains are provided on the COASTER trains for passengers, so are not required at the stations..

### **7.11.3 RESTROOM FACILITIES**

Restroom facilities are provided on the Coaster and Amtrak trains for passengers, so are generally not required at new stations. Installation of restrooms at new stations will be at the discretion of NCTD and the local jurisdiction. At new multimodal stations a locked unisex restroom may be required for use by transit staff or security personnel.

## **7.12 ELECTRICAL SYSTEMS**

### **7.12.1 ELECTRICAL SERVICE**

Separate electrical services may be required for the station platform, parking lot and for the communications building.

### **7.12.2 POWER REQUIREMENTS**

The minimum Station power supply shall be 120/208V with 200 amp capacity. Consultants shall allow for expansion of electric vehicle charging stations in selecting the appropriate power supply requirements.

### **7.12.3 CONDUIT SYSTEMS**

At the back of each platform a total of four 4" diameter conduits shall be provided with 4'-0" square pull boxes at each end for use by signals and fiber optic lessees. All platform conduit systems shall be located at the back of the platform wherever possible. All other conduit runs other than short laterals shall be a minimum of 2" diameter.

### **7.12.4 PLATFORM RECEPTACLES**

The designer should also consider provision of lockable receptacles at platform canopies for use by maintenance personnel and for special events. The designer shall also consult NCTD operations and maintenance for locations where they require lockable electrical power receptacles.

## **7.13 OTHER STATION EQUIPMENT**

### **7.13.1 TRASH CANS**

Trash cans shall be provided on the platform, and throughout the site as required, to reduce littering as far as possible. Trash can design shall conform to anti-terrorist and blast-resistant criteria particularly on station platforms.

### **7.13.2 BIKE LOCKERS**

Bike lockers may be provided in close proximity to, but not on, the platform. Number of lockers shall be dictated by local demand, demand varies based on many factors and is a site-specific issue. Contact SANDAG iCommute for bike locker requirements.

### **7.13.3 PUBLIC TELEPHONES**

Conduit provisions shall be included for provision of one public telephone by the local telephone provider. Recent experience has been that demand often does not warrant provision of pay phones due to expanded use of cell phones.

### **7.13.4 VENDING MACHINES**

Provision for vending machines is at the discretion of NCTD; however vending machines should not be placed on the platform. For any provisions, NCTD's Real Estate coordinator shall be consulted.

### 7.13.5 NEWSPAPER RACKS

Provision for newspaper racks is at the discretion of NCTD; however racks should not be placed on the platform. For any provisions, NCTD's Real Estate shall be consulted.

### 7.13.6 BEVERAGE KIOSKS

Provisions shall be made for beverage kiosks by NCTD vendors as agreed in advance with NCTD.

### 7.13.7 ELECTRIC VEHICLE CHARGING STATIONS (EVCS)

Electric vehicle charging stations will be provided in new and modified station parking lots as follows;

<b>Table 7.4 Minimum Number of EVCS in Parking Lots</b>		
Total parking in Lot	Design and conduit for the following Minimum Charging Stations	Install Minimum Charging Stations
1 to 24	1	1
26 to 50	2	1
51 to 75	3	2
76 to 100	4	2
101 to 150	5	3
151 to 200	6	3
201 to 300	7	4
301 to 400	8	4
401 to 500	9	5
501 to 1000	2% total	1% total

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## 8.0 DRAINAGE AND GRADING

### 8.1 SCOPE

This chapter establishes the design criteria for grading and drainage facilities located in the LOSSAN corridor, and for facilities that are affected by construction. The design of drainage facilities belonging to another agency that are relocated or modified because of construction, and do not encroach on the LOSSAN corridor, shall conform to the design criteria and standards of that agency. In general, relocation of existing drainage facilities shall be “replacement in kind” or “equal construction,” unless conditions of flow, loading, or operation are altered. If conditions are altered, designs shall conform to the design criteria and the standards of the agency involved.

These drainage design criteria are intended to protect the railroad and facilities from storm water damage and to drain the right of way quickly. Local water accumulation weakens the track subgrade, interferes with walkways and increases vegetation. Good drainage also protects NCTD/MTS/SANDAG from liability for damage to other property from storm water flows caused by the construction of LOSSAN corridor improvements. The surface of the embankment and nearby roads and station platforms shall be sloped away from the track. Discharge from building roofs, paved lots, and other sources of concentrated runoff shall be directed away from the track area and maintenance roads.

The design of drainage facilities belonging to an agency other than the LOSSAN relocated or modified because of LOSSAN construction should typically be replaced in kind. Every effort should be made to conform to the design criteria and standards prescribed herein, subject to the approval of the local agency. The design of any drainage facility shall take into account all requirements to reduce erosion and control sedimentation caused by the drainage facility or construction activities.

### 8.2 STANDARDS, CODES, AND GUIDELINES

The latest edition of the following standards, codes and guidelines shall be used in the design of LOSSAN corridor drainage facilities:

- SANDAG/NCTD Engineering Standard ESD 2002 Standard Roadbed Section
- American Railway Engineering and Maintenance of Way Association (AREMA), “Manual for Railway Engineering” Latest Edition.
  - AREMA Part 1 Track
  - AREMA Part 3 Natural Waterways
  - AREMA Part 4 Culverts
- California Department of Transportation (Caltrans) “Highway Design Manual”, (HDM) Chapters 800 to 890 Highway Drainage Design
- Federal Highway Administration (FHWA) Hydraulic Engineering Circulars (HEC) and Hydraulic Design Series (HDS) Reports.
- American Public Works Association (APWA), “Standard Plans for Public Works Construction”
- Federal and State of California NPDES and SWPPP requirements



- Federal Emergency Management Administration (FEMA) National flood Insurance Program (NFIP) guidelines for construction in FEMA-mapped regularly flood plains.

### **8.2.1 HYDROLOGY**

The hydraulic analysis shall conform to standards and practices as detailed in the latest edition or version of the following standards, codes, guidelines:

- State, regional, or local standards, ordinances, codes, and design criteria as applicable.
- San Diego Regional Standard Plans
- Federal Highway Administration, HDS 2, Peak Rates of Runoff from Small Watersheds.
- ASCE, Technical Engineering and Design Guides, adapted from the U.S. Army Corps of Engineers, No 19, Flood-Runoff Analysis.
- AREMA Guidelines

### **8.2.2 SITE DRAINAGE HYDRAULICS**

The design of drainage waterways, culverts and structures shall be based on sound hydraulic principles to achieve an optimum combination of efficiency and economy. The latest edition or version of the following standards, codes, guidelines and/or equivalent approved software packages is to be used for the hydraulic design:

- County of San Diego Department of Public Works Flood Control Section, "San Diego County Hydraulic Design Manual," September 2014
- U.S. Department of Commerce, Bureau of Public Roads, "Design Charts for Open-Channel Flow," Hydraulic Design Series No. 3
- U.S. Department of Commerce, Bureau of Public Roads, "Hydraulic Charts for the Selection of Highway Culverts," Hydraulic Engineering Circular No. 5
- U.S. Department of Commerce, Bureau of Public Roads, "Design of Roadside Drainage Channels," Hydraulic Design Series No. 4
- U.S. Department of Transportation, Federal Highway Administration, "Drainage of Highway Pavements", Hydraulic Engineering Circular No. 12
- U.S. Department of Transportation, Federal Highway Administration, "Hydraulic Design of Improved Inlets for Culverts," Hydraulic Engineering Circular No. 13
- U.S. Department of Transportation, Federal Highway Administration, "Hydraulic Design of Energy Dissipaters for Culverts and Channels," Hydraulic Engineering Circular No. 14
- U.S. Department of Transportation, Federal Highway Administration, "Design of Stable Channels with Flexible Linings," Hydraulic Engineering Circular No. 15
- ASCE, Technical Engineering and Design Guides, adapted from the U.S. Army Corps of Engineers, No 18, River Hydraulics
- ASCE, Technical Engineering and Design Guides, adapted from the U.S. Army Corps of Engineers, No 10, Hydraulic Design of Flood Control Channels.

### **8.2.3 RIVER & CHANNEL HYDRAULICS**

Hydraulic calculations for rivers, channels, culverts, and bridges shall conform to the following:

- American Railway Engineering and Maintenance of Way Association (AREMA), “Manual for Railway Engineering” Latest Edition.
- Federal Emergency Management Administration (FEMA) National flood Insurance Program (NFIP) guidelines for construction in FEMA-mapped regularly flood plains.
- Federal Highway Administration, Hydraulic Engineering Circular No. 18, Evaluating Scour At Bridges.
- ASCE, Technical Engineering and Design Guides, adapted from the U.S. Army Corps of Engineers, No 18, River Hydraulics
- ASCE, Technical Engineering and Design Guides, adapted from the U.S. Army Corps of Engineers, No 10, Hydraulic Design of Flood Control Channels.

### **8.2.4 RIP RAP DESIGN**

In addition to AREMA and NCTD standards and criteria, rip rap and erosion protection shall be designed per the following standards:

- ASCE, Technical Engineering and Design Guides, adapted from the U.S. Army Corps of Engineers, No 10, Hydraulic Design of Flood Control Channels.
- U.S. Department of Transportation, Federal Highway Administration, “Hydraulic Design of Energy Dissipaters for Culverts and Channels,” Hydraulic Engineering Circular No. 14

### **8.2.5 FLOODPLAIN ENCROACHMENT REQUIREMENTS**

Projects that result in grading within the 100-year floodplain identified for channels and streams that exceed drainage areas larger than 1.0 square mile shall comply with the following regulations.

- US DOT Order No. 5650.2 dated April 23, 1979
- Executive Order 11988 - Floodplain Management
- National Flood Insurance Act
- Chapters 23 and 44 of the Code of Federal Regulations
- Local floodplain management and floodplain ordinance requirements.

## **8.3 GENERAL REQUIREMENTS**

Criteria for design of LOSSAN project related drainage facilities are provided below. This section is based on national criteria published by AREMA, USDOT, FHWA, and FEMA. In addition, state of California, local and regional criteria published by Caltrans, San Diego County, the Local Municipality (City), or the local FEMA floodplain administrator may apply. The most stringent criteria shall be followed.

Drainage facilities for LOSSAN projects shall be designed to meet AREMA requirements,

The proposed improvements will not:

- Increase the flood or inundation hazard to adjacent property.
- Raise the flood level of a drainage way.
- Reduce the flood storage capacity or impede the movement of floodwater within a drainage way.
- Increase soil erosion or sedimentation.
- Increase in magnitude the peak outflow of drainage water from the subject area.
- Alter existing drainage patterns

Projects shall be designed to have adequate local drainage as outlined in section 4.5.

Projects shall be designed to meet Federal and Local floodplain encroachment requirements.

### **8.3.1 STANDARD DESIGN CRITERIA**

- A. The bridge opening will be sized so that the 50-year water surface for a low chord/soffit event will rise no higher than the lowest low chord of the bridge.
- B. A culvert opening will be sized so that the 25-year water surface will rise no higher than crown or top of the culvert headwall.
- C. The bridge opening will be sized so that the 100-year energy grade line will not rise above the adjacent subgrade elevation unless engineering justification is provided.
- D. Both LOSSAN criteria and local regulatory flood passage criteria shall be evaluated. The more restrictive criteria shall be adopted.
  1. If the existing bridge or culvert opening exceeds that required by the adopted criteria, the bridge or culvert opening should remain consistent with the existing size., unless written approval is obtained from the SANDAG Project Manager.
  2. If the existing bridge or culvert opening does not meet the minimum design criteria, a larger opening will be proposed provided that changes do not impact downstream development or violate other applicable flood regulations. For bridges, this enlargement will be lateral to the extent possible, and for culverts, the enlargement will be the fewest and largest culverts practicable to fit the existing channel width while meeting structural cover and spacing requirements and construction constraints.
  3. If it is found that insufficient channel area exists to meet the criteria, even with maximum widening, consideration will be given to adding relief structures on the overbank floodplain, raising the project grade, or other reasonable alternatives. Variances may be requested using a Design Exception Form, provided in Appendix C, if alternatives meeting criteria cause extensive track raises or if the addition of relief structures is not feasible given the site geometry.
  4. In all cases, a proposed project 100-year water surface elevation must be consistent with existing condition water surface elevations. A design

criteria exception requesting an increase in 100-year water surface levels may be requested.

- E. The design of any drainage facility shall incorporate all applicable requirements to reduce erosion and control sedimentation caused by the drainage facility or construction activities in accordance with State and Federal NPDES requirements.
- F. Any requests for incorporating designs with surcharge at culverts for the design frequency (low chord/soffit) event will be considered for an above-soffit variance only if the surcharge amounts do not exceed FHWA, Caltrans, city, county, reclamation board, flood control district, or other regional or local jurisdictional limits on the surcharge ratio of headwater depth to culvert opening height. In all cases, the 100-year surcharged water level must be below ballast.
- G. Projects proposing to retain or detain water must not exceed volume or height requirements published by the State of California, Department of Water Resources, and Division of Safety of Dams. Appropriate Engineering and Geotechnical studies may be required to support areas proposing retained or detained water.

### **8.3.2 MATERIALS**

Replacement and new drainage structures shall generally be with reinforced concrete box culverts or pipes. Corrugated metal pipe (CMP) is not allowed for new construction under mainline track. The resistivity of the soil backfill shall be considered when proposing the use of CMP under access roads. Use of PVC and/or HDPE is not allowed under track where there is a fire risk and open access to the pipe. All materials must satisfy the durability design life of the project.

Culverts and storm drains passing beneath tracks or maintenance roadways shall be reinforced concrete pipe rated at 3000D to 4000D depending on loading for the entire length of the buried pipe. Materials shall provide for a one hundred year service life and appropriate testing shall be done to assure the service life. Culverts and drains 18 inch diameter or less under platforms or in station areas that are not under tracks may be Schedule 80 PVC.

## **8.4 HYDROLOGY**

The design flood frequency to be used for drainage design is a matter of engineering judgment and economics. Several different storm events may need to be analyzed to provide economically feasible design of drainage elements.<sup>1</sup>

### **8.4.1 STORM FREQUENCY**

In General, projects shall be designed to convey the following flood discharges:

#### **A. Track Roadbed Drainage**

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<sup>1</sup> AREMA Part 3 Natural Waterways section 3.3.2 Methods Subsection 2c

- Track Side drains shall be designed to accommodate a 100 year flood level below the bottom of the ballast in the channel and at culvert/storm drain entrances. Also refer to *AREMA Part 1 Roadbed, Section 1.2.4 Drainage*

#### **B. Culverts**

- Culverts shall convey a 25 year flood without static head. *Reference: AREMA Part 4 Culverts section 4.8.2.b2 Design Method*
- The 100 year flood level shall be lower than the bottom of the ballast.
- All culvert inlets and outlets crossing beneath the track shall be protected with appropriate erosion control measures to prevent damage to the ballast or trackbed.

#### **C. Bridges**

New and replacement rail bridge openings shall be sized for two high-water design discharge events, designated “low chord/soffit” event and “Ballast” event.

- For mainline and mainline siding track;
  - The bridge low chord/soffit” shall be above the 50-year flood event with an allowance for freeboard and
  - The bottom of ballast shall be above the 100-year flood event.
- For industrial leads, yards, customer owned or third party track.
  - The bridge low chord/soffit” shall be above the 25-year flood event and
  - The bottom of ballast shall be above the 50-year flood event.
- If a drainage structure crosses both a mainline and non-mainline track the most restrictive criteria shall apply.

Bridges shall be designed to withstand any flood forces.

#### **D. Stations, parking lots, and access roads**

- Surface drainage facilities and storm drainage inlets and underground storm drain systems located within stations, streets, parking lots shall be designed to convey the 50-year peak flow rate or the local jurisdiction’s criteria, or whichever is more stringent.

#### **E. Other Considerations**

- Adjacent storm drainage facilities should be evaluated for adequacy and effect on railway property.

### **8.4.2 CALCULATING DESIGN DISCHARGES**

#### **A. Rational Method Modeling**

The maximum expected discharge from drainage areas less than 0.5 square miles shall be determined using the Rational Equation. For drainage areas between 0.5 and 1.0 square miles shall be determined using the Modified Rational Method.

Guidelines for development of Rational Method calculations can be found in the AREMA Manual for Railway Engineering, or in local hydrology manual(s).

## **B. NRCS Methodology**

For larger areas, exceeding 1.0 square miles, the maximum expected discharge shall be determined based on NRCS methodology, in accordance with procedures outlined in local hydrology manual(s).

Tributary watersheds should be assumed as developed to their current published planned land uses, to anticipate future runoff flow rates in the project design. AREMA 3.2.1 recommends “consideration should always be given to probably future changes in conditions”.

Standard, approved software packages specifically designed for hydrologic design, such as the Army Corps of Engineers’ computer programs, HEC-1 or HEC-HMS, may be used instead of tabular methods. Additional Considerations

When available, FEMA discharges can be used for conceptual design. Final design studies need to verify FEMA discharges for accuracy, in case of changes in watershed characteristics since initial FEMA studies were prepared.

Should new facilities require permits from local municipalities, then those guidelines should be used if more restrictive.

## **8.5 SITE DRAINAGE HYDRAULICS**

### **8.5.1 GENERAL**

Drainage facilities that remove water from the surface of bridge decks, the track, and adjacent ground shall have adequate capacity to safely discharge it to the adjacent conveyance system.

In all cases where drainage is picked up by means of a head wall, and inlet or outlet conditions control, the pipe shall be designed as a culvert. Where a pipe is part of a storm drain system and crosses the roadway, it shall be designed as a storm drain with the same design storm as the remainder of the system.

If there is a culvert on the same watercourse downstream from the drainage facility to be constructed, a review shall be made of the existing culvert’s ability to carry the same peak discharge as the rail system’s drainage facility, plus any discharge from the area between the two drainage facilities. If the existing culvert cannot carry the flow and the water has no other escape and will pond at the entrance of the existing culvert, then the backwater shall be routed by standard procedures to calculate the hydraulic grade line back to and upstream through the rail system’s drainage facility.

Many projects include parallel track construction. The designer should initially plan on having the drainage structure for the new track replicate that in place for the existing track. The agency or municipality responsible for any drainage channel should also be consulted prior to structure type selection.

Adverse backwater effects of others' under-sized facilities downstream of new or replacement structures may occur if the facilities have lower flood passage capacities than SANDAG/NCTD standards. These limited-capacity facilities may result in unreasonable costs in order to meet the criteria. If the limiting structure is likely to wash out during a design event, or if it is likely to be replaced with an appropriately matched structure in the near term, the design can proceed, upon approval, as though the condition is improved. Regardless, the backwater shall be assessed, and one alternative meeting design criteria shall be provided. The alternative may include a relief structure within the ROW to preclude inundation of the track, protect the downstream pipe, or protect downstream property owners.

## **8.5.2 CULVERT DESIGN GUIDELINES**

### **A. Size**

The minimum allowable diameter for culverts crossing under tracks shall be 24 inches per AREMA. However, the preferred minimum culvert size crossing under tracks is 30 inches for ease of maintenance. The minimum diameter of pipe for culverts under roadways and parking lots shall be 18 in. A culvert is defined as a drainage pipe crossing under a track or roadway embankment and connecting with open channels at both ends. Consideration shall also be given to hydromodification regulations and preventing increased water surface levels and downstream flooding if increasing the size the existing culvert.

Where headroom is restricted, multiple circular pipes, box culverts, or equivalent pipe arches may be used instead of circular pipe.

Maximum singular circular culvert diameter is 96-inches. Circular culverts exceeding this dimension shall consider the use of multiple parallel culverts, or a box culvert system, unless engineering justification dictates a single culvert of larger diameter.

Inlet and outfall headwalls exceeding 4 feet in height or within 20 feet of the nearest track require handrails per Engineering Standard ESD 6007 and CPUC General Order 118.

### **B. Slope**

The minimum slope in a culvert shall be 0.5 percent. Culverts shall be placed at the most economical depth, and on the most economical slope. Consideration of outlet velocity and potential for downstream erosion may influence culvert alignment and slope.

### **C. Headwater Depth**

Culvert headwater depth should be calculated based on FHWA inlet and outlet control methods. A maximum allowable headwater of 1.5 times the culvert diameter for circular culverts or the 1.5 times culvert height for box or arch culverts shall be used unless specific entrance conditions and good engineering judgment dictate otherwise. The 100 year headwater depth should be below the ballast. Areas proposing impounded water should be assessed by a licensed Geotechnical Engineer.

## **D. Minimum Cover**

Culverts under tracks shall have a minimum of 4 ft. of cover or half the diameter of the pipe, whichever is greater, measured from the top of pipe to bottom of track tie, unless specifically designed for less cover after a variance is obtained from the Director of Engineering.

### **8.5.3 STORM DRAIN DESIGN GUIDELINES**

#### **A. Size**

The minimum diameter of storm pipe for storm drains, including connections to inlets, shall be 18 in. Minimum diameter of pipe slope drains shall be 12 in.

Maximum singular circular storm drain diameter is 96-inches. Storm drains exceeding this dimension shall consider the use of multiple parallel pipes unless engineering justification dictates a single pipe of larger diameter.

#### **B. Slope & Alignment**

The minimum slope in a storm drain shall be 0.5 percent. Storm pipes shall be placed at the most economical depth, and on the most economical slope. Consideration of outlet velocity and potential for downstream erosion may influence the overall storm drain alignment and slope. Rip-rap protection at culvert outlets may need to be considered depending on the peak flow and velocity.

Abrupt changes in direction or slope of pipe shall be avoided. Where such abrupt changes are required, an inlet or cleanout shall be placed at the point of change. Cleanouts shall conform to San Diego Regional Standard Drawings as applicable.

Where there is a change in pipe size proposed, placement of a cleanout is required, and the elevation of the pipe soffits shall be the same, or the smaller pipe shall be higher. A minimum drop of 0.10 feet between the lowest inlet pipe and the outlet pipe is recommended in cleanouts.

Designing junctions between larger culverts and smaller downstream pipes should be avoided. Abrupt change of cross section might cause deposition of debris and clogging of the storm drain.

#### **C. Hydraulic Calculations**

The engineer shall check the available energy at all junctions and transitions within the storm drain system to determine whether the flow in the storm drain will be pressurized due to backwater effects resulting from angle changes, flow junctions, and hydraulic losses within the system, even when the design flow is less than the full flow capacity of the storm drain segment. Hydraulic modeling to determine water surface profiles within the system can be performed using tabular methods or using proprietary computer software that utilizes appropriate energy loss equations.



Capacity of storm drain improvements should assume the highest anticipated downstream tailwater at the outlet of the storm drain system. In the event the project discharges to a FEMA mapped river or stream the FEMA identified WSEL can be utilized as the downstream water surface elevation. In circumstances where this is problematic, consideration of the time to peak for the proposed system versus the mainline channel can be utilized, in accordance with the Army Corps of Engineers (ACOE) Hydraulic Engineering Circular (HEC), HEC-22 Methodology. If no downstream water surface elevation data is available, the hydraulic analysis can assume a tail water elevation equal to the top of pipe at the outlet (for capacity analysis). For sizing energy dissipation at an outfall, a no tail water condition should also be analyzed (i.e. – velocity run).

#### **D. Minimum Cover**

Storm drainage pipes shall have a minimum of 4 ft. of cover, or half the diameter of the pipe, whichever is greater measured from the top of pipe to bottom of track tie. Pipes not under tracks shall have 4 ft. of cover within 45 ft. of the track centerline and 3 ft. minimum elsewhere, unless specifically designed for less cover after a variance is obtained from the Director of Engineering.

#### **8.5.4 INLET SIZING**

Inlets shall conform to Caltrans Standard Plans or San Diego Regional Standard Drawings. Inlet capacities for specific types of inlets under various conditions shall be calculated using the approaches outlined in FHWA Hydraulic Engineering Circular No 12.

Inlets on a continuous grade should be designed for 100% interception for the 50-year design discharge where possible. However, bypass of a portion of the design flows can be accepted if the next downstream inlet is designed to provide additional capacity to intercept the bypassed flows. Inlets located in a sump shall be designed to intercept 100% of the design flow, including any upstream bypass, without inundation of adjacent roadways, properties, or inundation of the track ballast.

#### **8.5.5 PARALLEL TRACK CHANNELS**

Ditches and open channels may be proposed, generally parallel to, the track or highway for the purpose of carrying runoff from the track bed, pavement, shoulders and adjacent areas.

##### **A. Shape**

The most common types of ditches are triangular, trapezoidal and rectangular. All channels shall be designed with a permeable bottom where feasible.

The trapezoidal shape is preferred due to its higher hydraulic efficiency.

## B. Slope

Engineered open channels shall have a minimum longitudinal slope of 0.5%, unless engineering considerations justify the use of a flatter slope. Open channels with grades less than 0.5% may require additional or more frequent maintenance activities to avoid standing/nuisance water.

## C. Lining Materials

Where possible, channels shall be designed to be non-erosive without proposing hardened channel linings. When terrain dictates channel slopes that cannot support an unlined channel permeable channel linings such as Turf Reinforcement Mat (TRM), Articulated Concrete Block (ACB), or similar may be acceptable. Turfstone block is preferred as the channel erosion protection at drainage outlets. ACB can be cabled or uncabled. A determination for lining materials should be obtained from the project manager during design of the proposed channels.

<b>Material or Lining</b>	<b>Maximum Permissible Average Velocity (ft./sec)</b>
Fine Sand, Colloidal	1.50
Sandy Loam, Non-colloidal	1.75
Silt Loam, Non-colloidal	2.00
Alluvial Silts, Non-colloidal	2.00
Sandy Silt	2.00
Ordinary Firm Loam	2.50
Volcanic Ash	2.50
Fine Gravel	2.50
Silty Clay	2.50
Stiff Clay, Very Colloidal	3.75
Graded Loam To Cobbles When Non-colloidal	3.75
Alluvial Silts, Colloidal	3.75
Graded Silts To Cobbles When Colloidal	4.00
Coarse Gravel, Non-colloidal	4.00
Cobbles And Shingles	5.00
Shales And Hardpans	6.00
Clay.	6.00
Poor Sedimentary Rock	10.00

<b>Table 8-2 Permissible Velocities in Lined Channels</b>	
<b>Material or Lining</b>	<b>Maximum Permissible Average Velocity (ft./sec)</b>
Unreinforced Vegetation	5.0
Reinforced Turf	10.0
Loose Riprap	See RIP-RAP Design Section 8.7
Grouted Riprap	25.0
Gabions	15.0
Soil Cement	15.0
Turf Reinforcement Mat	Per Manufacturer Specifications
Turf stone Concrete block	Per Manufacturer Specifications
Articulated Concrete Block	Per Manufacturer Specifications
Concrete	35.0

Permissible velocities, and other design considerations and limitations, for manufacturer specific products such as TRM or ACB shall be obtained directly from the manufacturer.

#### **D. Bends/Superelevation**

Bends in channels can create cross-waves and superelevated flow in the bend section as well as further downstream. This impact is more significant in channels flowing supercritical. To minimize these influences, channels shall be designed with channel radii that limit the superelevation.

Open channel hydraulic analyses should consider the hydraulic impact of bends and superelevation on water surface elevations and freeboard within open channels. Where freeboard is reduced due to superelevation, splash walls should be constructed to confine flows with required freeboard.

#### **E. Additional Hydraulic Considerations**

For channels conveying less than 10 cfs, and flowing subcritical, the channels shall be designed to convey the 25-year flood with the Hydraulic Grade Line (HGL) 0.5 feet below the top of channel. For channels conveying more than 10 cfs, and flowing subcritical, the channels shall be designed to convey the 25-year flood with the Hydraulic HGL 1.0 feet below the top of channel. In all cases the channel shall be designed to convey the 100-year flood (HGL) without inundating the ballast. Hydraulic modeling to determine water surface profiles within the system can be performed using tabular methods or using proprietary computer software that utilizes appropriate equations for losses due to energy, friction, and momentum.

For channels conveying less than 10 cfs, and flowing supercritical, the channels shall be designed to convey the 25-year flood with the Energy Grade Line (EGL) 0.5 feet below the top of channel. For channels conveying more than 10 cfs, and flowing supercritical, the channels shall be designed to convey the 25-year flood with the EGL 1.0 feet below the top

of channel. In all cases the channel shall be designed to convey the 100-year flood (EGL) without inundating the ballast.

Transverse ditches shall not intersect parallel ditches at right angles. Transverse ditches shall join parallel ditches at an angle of approximately 30 degrees to minimize scour and sedimentation and hydraulic losses.

Each transverse crossing, including at grade and underpass roadway crossings, shall accommodate the longitudinal drainage that it intercepts.

### **8.5.6 SUBDRAINS & UNDERDRAINS**

Refer to Chapter 5 sub section 5.6 for requirements for subdrains.

#### **A. Size**

The minimum diameter of underdrains shall be 8 inches and cleanouts shall be provided every 100 feet. The minimum slope of underdrains shall be 0.5% or greater. Subdrains should connect to the storm drain system (surface or sewer)

## **8.6 RIVER & CHANNEL HYDRAULICS**

### **8.6.1 GENERAL**

Any project that proposes construction activities within a FEMA mapped floodplain, or in an area determined by the local municipality to be an area of flooding potential, should consider the hydraulic impact of the proposed project on the flood conveyance, storage, and flooding limits of the creek, river, or waterway.

Projects crossing over or proposing improvements parallel to creeks, rivers, or waterways that have a tributary watershed larger than 1 square-mile should consider the capacity of the adjacent waterway to convey flood waters, as this may have a significant impact on the project design.

### **8.6.2 HYDRAULIC MODELING**

Projects including bridges and culverts that propose to pass water from one side of the track structure to the other, or that propose longitudinal encroachments into a defined floodplain, shall be designed by developing models of water-surface profiles for both the low chord/soffit and subgrade events along the stream and through the structures, both for the existing conditions and proposed new or replacement conditions. Water-surface profiles shall be computed using the latest version of public-domain Army Corps of Engineers' computer programs, HEC-2 or HEC-RAS, and results shall document the version used.

Analyses shall be prepared using detailed topographic contour maps or surveyed cross sections and existing structure geometry information. Analyses shall include the following considerations:

- The impacts of Debris Accumulation on Bridge Piers or Culvert walls for multiple cell box culverts.
- The potential impacts (reduction) to channel capacity due to ultimate (dense) vegetation growth upstream and downstream of the proposed improvement.
- The potential impacts (reduction) to channel capacity due to known sedimentation concerns in waterways and/or lagoons.

The results of the analyses shall assess the project's impact on:

- 100-year Water Surface Elevations
- Frequency of flooding to adjacent properties
- Maximum channel flow velocity and potential erosion impacts from increased velocities.

Water surfaces resulting from design storm discharges at each structure and along the waterways shall be limited to the top of the ballast and shall not encroach upon the superstructure of bridge-type structures. Full flow through culvert-type structures is acceptable, provided the design criteria in Section 4.5.3 are met.

San Diego County, and the Cities within San Diego County, are participants in the Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP). Projects impacting FEMA defined floodplains, particularly regulatory Zone AE floodplains and floodways, will require analysis of the proposed project using the same software used in mapping the floodplains. In such cases, it will be acceptable for the engineer to complete the design and perform the required before-and-after comparison using the agency model. When encroachments into FEMA mapped floodplains are proposed, the effective FEMA hydraulic studies should be requested from FEMA, and used as a resource for the hydraulic modeling. The local agency shall serve as the floodplain manager and the direct coordinator with FEMA.

Hydraulic modeling should be prepared to reflect the existing condition (prior to project construction) of the adjacent creek or waterway, as well as the condition following construction of the proposed project. Minimally, 100-year analyses should be prepared to determine the impact on the existing floodplain limits, as well as verify the proposed rail improvements are designed with the proposed ballast above the 100-year floodplain. However, analysis of additional flood discharges may be necessary to support FEMA requirements and/or other project design criteria.

#### **A. Tail Water Conditions**

Projects, or projects within rivers or streams, which discharge to tidally influenced water bodies such as lagoons or the Pacific Ocean shall include two scenarios in the hydraulic modeling.

1. High Tide event – to determine the maximum anticipated water surface elevation(s) adjacent to the proposed improvements.
2. Sea Level, or Low-tide event – to determine maximum velocities within and

adjacent to the proposed improvements.

Pre-project and post-project analyses should be analyzed in both scenarios to verify the proposed project does not negatively impact adjacent properties, or increase potential for flood hazards.

Considerations of anticipated Sea level Rise should be analyzed for all projects proposing to outlet drainage improvements to areas identified by the Pacific Institute as subject to impact by sea level rise. [http://www.pacinst.org/reports/sea\\_level\\_rise/maps/](http://www.pacinst.org/reports/sea_level_rise/maps/)

In addition refer to chapter 3 of this Design Criteria for more detailed guidance on Climate Change and Sea Level Rise. The latest guidelines for the California Coastal Commission, titled shall be considered; "California Coastal Commission, 2015. Sea Level Rise Policy Guidance, Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits, Adopted August 12, 2015.

**B. Bridge Freeboard**

Design of bridge structures over waterways shall include the following considerations:

For Railway bridges the freight railway standards are to be used:

- Bridges shall be designed with the 50-year flood 2-feet of freeboard below the soffit of the bridge, including the impact of appropriate debris factors on the structure.
- Bridges shall be designed with the 100-year flood below the ballast of the bridge, with 2 feet of freeboard to the top of rail. Structural considerations should be made to the bridge design to withstand hydraulic forces for floodwaters and impact from large floating debris.

For Highway bridges the requirements of the State or Local jurisdiction govern.

There are numerous recommendations of freeboard requirements for Bridge Design over waterways, from Local, State, and Federal sources as illustrated in the following table that may be applicable to the replacement of the bridges. Some Organizations specifically request that debris factor(s) be included in the hydraulic modeling and those sources are noted in the table below.

<b>Table 8-3: Summary of Freeboard Requirements for Bridges</b>			
<b>Source Document</b>	<b>Recommended Freeboard</b>	<b>Debris Factor Included</b>	<b>Additional Comments</b>
AREMA 3.6.4.3	<ul style="list-style-type: none"> <li>• 2 feet is recommended for guide banks</li> </ul>		
San Diego County Hydraulic Design Manual,	<ul style="list-style-type: none"> <li>• Soffit 1-foot above the 100-yr</li> </ul>	NO	none

Table 8-3: Summary of Freeboard Requirements for Bridges			
Source Document	Recommended Freeboard	Debris Factor Included	Additional Comments
page 5-7, September 2014	100-yr 1-foot below road crest, and FF of any upstream structures	YES	This criteria applies if a Debris Factor is assumed, but there is no guidance on the Debris Factor Values
The City of San Diego (Criteria per city Staff) October 2009	Soffit 1-foot above the 100-year	NO	No documented freeboard requirement for bridges in their design manual(s)
California Highway Design Manual [§821.3,(1) ] Sept 1, 2006	Soffit 2-feet over 50-year Soffit at or above (pass) 100-yr	YES	This is a State Standard for Roads
AASHTO (California Amendments) §2.6.4.3 Bridge Waterway	Soffit 2-feet over 50-year Soffit at or above (pass) 100-year or flood of record (whichever is higher)	YES	none
UPRR Hydraulic Design Criteria	Soffit above 50-year Track Subgrade above 100-year	NO	No Freeboard noted, bridge/track elements just set "above" design storms
National Bridge Inspection Standards (23 CFR 650 subpart C § 650.115 (3))	"Freeboard shall be provided, where practicable, to protect bridge structures from debris- and scour-related failure".	YES	This is in the roadway section.
FHWA "Hydraulics of Bridge Waterways" 1978	Soffit above 50-year	NO	No specific FB, just a statement to "provide sufficient clearance"
USDOT, FLH "Project Development and Design Manual" § 7.4.3.4.1 2008	Soffit 2-feet over 50-year (greater if potential for Debris or Ice) Soffit at or above (pass) 100-year or flood of record (whichever is higher)	YES	Design the bridge with 3.5' to 5.0' of freeboard when the potential for woody debris is significant

The most commonly noted freeboard criteria based on the sources researched above is to place the bridge soffit 2-feet above the 50-year WSEL, and to pass the 100-year storm, with inclusion of a debris factor. The most stringent is from the USDOT PDDM requiring 3.5 feet of freeboard (or more) above the 50-year storm, and pass the 100-year if debris is anticipated. The documented freeboard requirements are typically in reference to roadway bridge design, and do not include separate criteria specific to railroad bridge design. Please note that additional criteria may be identified from other sources that could modify/append this list.

Note that Executive order 11988 is currently being revised and freeboard requirements may change based on the final order.

### **8.6.3 DEBRIS CONTROL**

Culverts and waterways shall be sized with sufficient headroom to accommodate all debris contained within maximum design flow. System drainage structures receiving flow from open channels and areas that may contribute debris shall not make use of static inlet head in determining the size of the opening.

If the drainage structure is protected from debris by existing conditions upstream, or if the structure is part of an enclosed storm drain system with all grated or protected inlets, static head may be considered in computing the capacity. The static head on the entrance to the culvert and the water-surface elevation in the system at peak conditions shall not be higher than can safely be contained by headwalls, ditch banks and tributary drainage systems.

Trash racks or screens for culvert-inlet protection shall not be proposed, as they are subject to clogging. Where culvert headroom is required for debris, the design shall not allow headwater and tail water depths to exceed 80% of the culvert diameter or height. Draw down at the entrance to this depth shall not be construed as meeting this requirement unless it can be shown that the draw down allows free passage of all debris.

Multiple Cell Box culverts may propose “debris-nose” structures on the upstream face of the box culvert system to prevent obstruction of the proposed box. However, the hydraulic impact of these features should be included in the hydraulic analysis of the system.

Bridge design should provide for access for debris removal from major storms upstream of bridge piers and abutments.

### **8.6.4 SCOUR**

Projects proposing new Bridges and significant longitudinal encroachments to natural channels should consider the impacts of both general channel scour and local pier scour on bridge design, and slope stabilization.

Bridge design should consider the impacts of local (contraction) scour on the design of bridge piers and abutments, as outlined by HEC Circular 18, and the AREMA guidelines. It is important to note that the latest HEC-RAS version may have the ability to perform HEC-18 calculations; however, the version of HEC-18 embedded within HEC-RAS is typically out of date. Therefore, supplemental hand calculations are required, based on the most current version of HEC-18.

The total scour depth at bridge piers shall be the combination of the general scour and the local scour.

Historically scour has resulted in the failure of several bridges along the LOSSAN railway, washing out piled structures with 30 foot deep wooden piled foundations in 1916 and 1927 as shown in section 8.8.5.



## 8.6.5 SEDIMENT TRANSPORT

Large amounts of sediment are naturally transported to the ocean and beaches by creeks and rivers during major storm events. Some sediment transport estimates from USACOE are as follows;

<b>Bridge/ Major River</b>	<b>Drainage Area in Sq Miles<sup>1</sup></b>	<b>Estimated Annual Sediment production CuYds<sup>2</sup> at Coast</b>
Br 223 Santa Margarita River	744	15,000 in 1969
Br 225 San Luis Rey River	560	351,000 in 1969
Br 243 San Dieguito River	346	110,000 in 1969
Br 263.8 San Diego River	432	110,000 in 1969

Notes;

1. Drainage basin area from USACOE Meteorological data Inventory for Southern California Coastal Zone December 1985.
2. Estimated annual sediment production from USACOE Coast of California Storm and Tidal Waves Study, Annual Report 1983

## 8.7 RIP RAP DESIGN

### 8.7.1 GENERAL

Riprap thickness and placement should comply with local standards. If no standard exists, the thickness of riprap layers should be two to three times the median stone diameter. For bridges, riprap placed on the side slopes and fill slopes at the abutments should extend up to the 100-year flow depth or subgrade level, whichever is less. The lateral extent of riprap placed on the slope around the abutments should begin along the upstream side slope of the approach a distance from the backwall equal to twice the 100-year depth. The slope paving should wrap around the abutment spill slopes under the bridge and terminate at the backwall station on the downstream side. If possible, a blanket of riprap should also be buried (rather than placed on the bed) to a depth matching its thickness in the streambed around the abutment, extending to a width approximately twice the 100-year flow depth outward from the catch line.

### 8.7.2 PIPE & CULVERT OUTLETS

The maximum discharge velocity for storm drain and culvert outlets should be calculated assuming no tailwater exists at the outlet. This maximum velocity should be utilized to design the required channel/bed stabilization and energy dissipation required at the storm drain outlet. Where riprap is planned for scour protection, the San Diego County guidelines shall be adopted as modified below;

Design Velocity	Rock Gradation	D50	W50 (stone weight)
2-6 fps* Refer table 8.1	No. 3 Backing	0.4 ft.	5 lb.
6 – 6.9 fps	No. 2 Backing	0.7 ft.	25 lb.
7 – 7.9 fps	No. 1 Backing	1.0 ft.	75 lb.
8 -9.9 fps	Light	1.3 ft.	200 lb.
10-11.9 fps	¼ ton	1.8 ft.	500 lb.
12-13.9 fps	½ ton	2.3 ft.	1000 lb.
14-15.9 fps	1 ton	2.9 ft.	2000 lb.
16-18-fps	2 ton	3.6 ft.	4000 lb.
> 18 fps	Special Design		

Riprap slope protection at culvert and storm drain discharge location should be constructed per San Diego Regional Standard Drawing D-40. The length of the riprap pad should be analyzed to verify the discharge velocity exiting the riprap pad is non-erosive.

Outlet velocities exceeding 18 feet per second of discharge velocity will require special design, which may include modified drainage alignment, grouted riprap, stilling basin, or downstream drainage improvements to mitigate the discharge velocities to non-erosive conditions.

### **8.7.3 CHANNEL LINING & FLOODPLAIN PROTECTION**

Riprap to line channels will have the following properties:

Design Velocity	Rock Gradation	D50	W50 (stone weight)
6-6.9 fps	No. 2 Backing	0.7 ft.	25 lb.
7-7.9 fps	No 1 backing	1.0 ft.	75 lb.
8-9.9 fps	Light	1.3 ft.	200 lb.
10-11.9 fps	¼ ton	1.8 ft.	500 lb.
12-13.9 fps	½ ton	2.3 ft.	1000 lb.
14-15.9 fps	1 ton	2.9 ft.	2000 lb.
16-18-fps	2 ton	3.6 ft.	4000 lb.
> 18 fps	Special Design		

Where rip-rap is proposed in channel sections, minimum rock size can also be determined

using maximum permissible shear force (tractive force) calculations (See U.S. Army Corps of Engineers, Engineer Manual No. 1110-2-1601).

Bank protection design for longitudinal encroachments requiring slope protection from adjacent flood flows should provide adequate key-down depth based on anticipated channel bed changes due to potential scour. Placement of launchable rock is an acceptable construction method for toe of slope protection, in lieu of constructing a rip-rap key.

#### **8.7.4 ROCK GRADATIONS/FILTER FABRIC**

Rock Gradations for rip rap including backing rock and appropriate filter fabric material shall be specified based on Caltrans or APWA Greenbook standards.

#### **8.7.5 GROUTED ROCK SCOUR PROTECTION GUIDELINES**

Where grouted rock riprap is planned for scour or erosion protection, the consultant's design shall comply with the grouted rock specifications included in SANDAG/NCTD Standard Specifications, Section 348011, Stone Revetment (Riprap), or Caltrans Standard Specifications for Grouted Rock.

### **8.8 FLOODPLAIN ENCROACHMENT REQUIREMENTS**

#### **8.8.1 GENERAL**

When the rail system alignment crosses a floodplain, the designer shall endeavor to prevent an increase in the flood hazard to adjacent, upstream, or downstream property consistent with FEMA and/or local flood plain management criteria.

- At locations where an established FEMA-mapped floodplain exists, bridges, culverts, and channel improvements shall also comply with the requirements of the NFIP as administered by the local FEMA floodplain administrator.
- Regardless of whether the structure is in a FEMA-designated floodplain, the 100-year water surface elevation of any replacement opening shall be compared with the existing condition 100-year water surface elevation, and the waterway shall be sized such that impacts on the water surface profile conform to State, FHWA, FEMA, or other local water surface or freeboard criteria, whichever is more restrictive.
- Drainage facilities for projects shall be designed with no increase of water levels on developed properties and no increases in erosion, sedimentation, or other adverse impacts on downstream developments.

Federally funded projects must comply with the following requirements when projects propose to encroach on a 100-year base floodplain:

- Avoid support of incompatible floodplain development,
- Minimize the impact of highway actions that adversely affect the base floodplain,
- Restore and preserve the natural and beneficial floodplain values, and
- Be consistent with the standards/criteria of the National Flood Insurance Program of the Federal Emergency Management Agency (FEMA).

### **8.8.2 DOT ORDER 5650.2**

Projects that propose to conduct, support, or allow action involving a significant encroachment to a defined floodplain shall include the consideration of alternatives to avoid encroachment and to reduce adverse base floodplain impacts.

If the preferred alternative involves significant encroachment (as defined by 23 CFR 650.105), the engineer must document in writing that the proposed alternative is the only practicable alternative including:

- A. A description of why the proposed project must be located in the floodplain, including the alternatives considered and why they were not practicable.
- B. A statement confirming that the action conforms to applicable FEMA, state and or local floodplain protection standards.

This information should be included in the project's environmental review document(s) and/or the project records. Also refer to chapter 3 section 3.4.3 of these design criteria for additional information.

### **8.8.3 FEMA COMPLIANCE**

Projects identified as within a FEMA defined floodplain and/or floodway shall comply with the requirements of the local Floodplain Manager for the impacted NFIP participating Community. Encroachments into the FEMA defined floodplain shall be avoided unless engineering calculations show the project does not result in any change to the floodplain limits and/or base flood elevations shown on the effective Flood Insurance Rate Map (FIRM). If the proposed project will result in changes (increases or decreases) in base flood elevations, or changes in the floodplain limits depicted on the FIRM, the project shall prepare and process a Conditional Letter of Map Revision (CLOMR) with the local floodplain administrator and FEMA, prior to the initiation of construction activities within the FEMA defined floodplain.

Projects identified as proposing grading activities within the FEMA defined floodway shall be avoided unless engineering calculations showing the project does not result in any change to the floodplain limits and/or base flood elevations (BFEs) shown on the effective Flood Insurance Rate Map (FIRM). If the proposed projects design does not result in any change to the FEMA defined BFEs, a No Rise Certification shall be prepared by a licensed Civil Engineer, and submitted to the Local Floodplain Administrator for acceptance.

If the proposed project design will result in any change (increase or decrease) in base flood elevations, or changes in the floodplain limits depicted on the FIRM, as a result of the activity proposed in the floodway, the project shall prepare and process a Conditional Letter of Map Revision (CLOMR) with the local floodplain administrator and FEMA, prior to the initiation of construction activities within the FEMA defined floodway. Projects proposing encroachments into the FEMA defined floodway must provide the following:

- A. An evaluation of alternatives which would not result in a base flood elevation increase above that permitted under NFIP requirements, demonstrating why these alternatives are not feasible;

- B. Certification that no structures are located in areas which would be impacted by the increased base flood elevation;
- C. Documentation of compliance with the other requirements of 44 CFR § 65.12

Following completion of construction of any projects that propose encroachments into a FEMA identified floodplain, which result in changes to the BFE and/or floodplain limits shown on the effective FIRM, the project will be required to prepare and process a Letter of Map Revision (LOMR) with the local floodplain administrator and FEMA within 6 months of the completion of construction, in compliance with 44 CFR § 65.3.

#### **8.8.4 FLOODPLAIN COASTAL INTERFACE**

Flood hydrodynamics (e.g., water levels and velocities) should be assessed using a numerical model to simulate fluvial and tsunami conditions in the project area to estimate the maximum flood elevations and water velocities at and near the proposed railroad bridge and embankment.

The impact of a proposed bridge on flooding throughout a lagoon shall be evaluated based on changes to flood water levels associated with proposed conditions compared to existing conditions.

The water velocities shall be used to assess scour depth around the bridge piers following the guidance of HEC-18 as well as in the vicinity of the embankments. The Federal Highway Administration Highway Engineering Circular No. 25 (FHWA 2008) recommends the use of two-dimensional (2-D) for highways in the coastal environment where the flow conditions cannot be properly represented by a one-dimensional model and to use the 2-D model velocities for the scour analysis based on the methods described in HEC-18.

The railroad bridges in Lagoons are generally located at the downstream end of a series of basins and the flow paths between various basins and bridge openings are too complex to be modeled with a one-dimensional model (e.g., HEC-RAS). To support railroad bridge and embankment design, the two-dimensional hydrodynamic model known as TUFLOW shall be used because the model accounts for all the necessary analysis components (e.g., tidal fluctuations, flood flows, grading changes, and lagoon configurations). TUFLOW is a finite difference model designed for tidal and fluvial hydraulics in rivers, estuaries, coastal bays, floodplains, and urban areas. The model has been used in other areas of the U.S. and it has been accepted by FEMA in other regions for floodplain modeling.

For sea level rise refer to chapter 3 of this criteria.

The following table 8.8 provides some information on the larger watersheds and historic floods on the LOSSAN railway.

### 8.8.5 FLOODING HISTORY ON LOSSAN RAILWAY

Major floods have caused damage to the LOSSAN railway bridges over the years. Some of the damage is listed below;

Bridge/ River	Major	Drainage Area in Sq Miles <sup>1</sup>	Qmax <sup>1</sup> CFS	Q max <sup>1</sup> year	Observations <sup>2</sup>
Br 223 Santa Margarita River		744	33,600	1927	Bridge washed away in 1916 and Pier B washed away in 2/16/1927 (Piles were 30 feet deep)
Br 225 San Luis Rey R		560	95,600	1916	Southern 400 feet trestle washed away in 1916 and replaced with steel bridge.
Br 243, San Dieguito River		346	72,000	1916	1/1916 flood; 346 feet of trestle washed away. Water over the tracks at south 15 spans of bridge. Bridge had 30 ft pile penetration in 1/1916
Br 263.8, San Diego River		432	70,200	1916	Washed away in 1916, damaged in 1927

Notes;

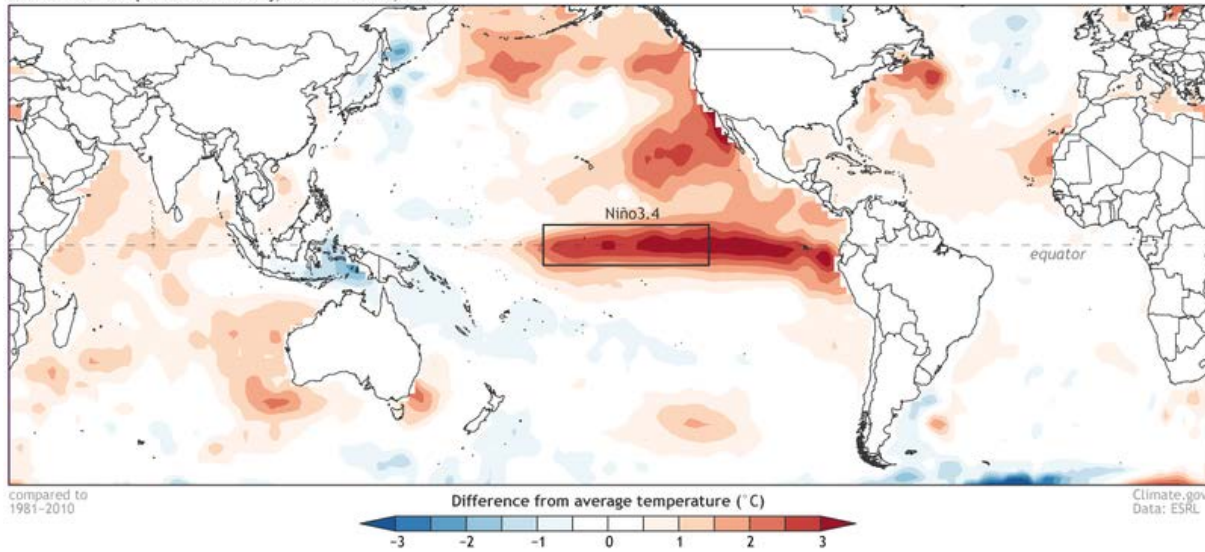
1. Drainage flows from USACOE Meterological data Inventory for Southern California Coastal Zone December 1985.
2. Observations from AS&SF as built plans and historic photos.
3. Since these floods dams have been built in the San Diego, San Dieguito and San Luis Rey River watersheds.

### 8.8.6 EL NINO SOUTHERN OSCILLATION

Scientists typically declare an official El Niño when sea-surface temperatures in the equatorial Pacific Ocean (namely, the Niño 3.4 region) rise 0.5°C above their historical average for three months in a row — and once atmospheric conditions and rainfall patterns shift accordingly.

The following heat map from NCEP-NCAR shows the rise in temperature during an El Nino.

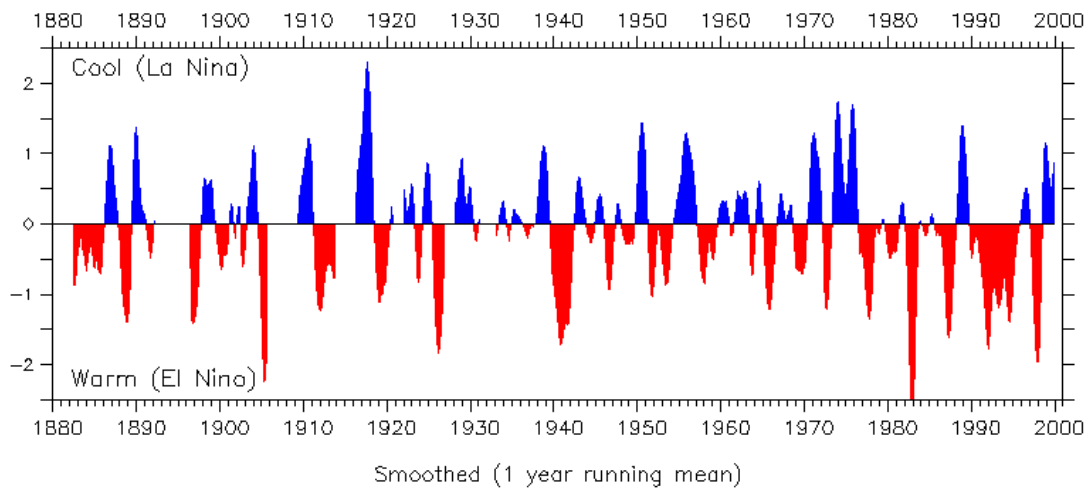
Sea surface temperature anomaly, Oct 11–Nov 7, 2015



Average sea surface temperature departure from the 1981-2010 average over the four weeks ending on November 7. Graphic by climate.gov, data from NCEP-NCAR reanalysis.

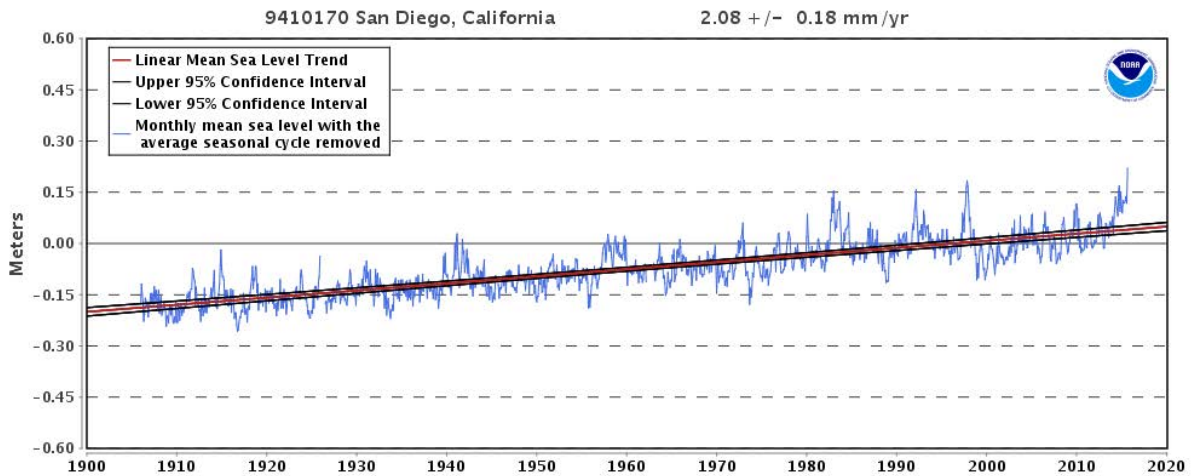
El Niño's tend to occur as shown below and alternate with cooler periods known as La Niña's. Some years have stronger episodes, some years have weaker ones, some years nothing happens. It is a hard to predict event. The two strongest El Niño events in the past 150 years occurred in 1982-'83 and 1997-'98. These are sometimes referred to as "super" El Niños. However the 100 year flood event of 1916 occurred in a La Niña year.

### Southern Oscillation Index



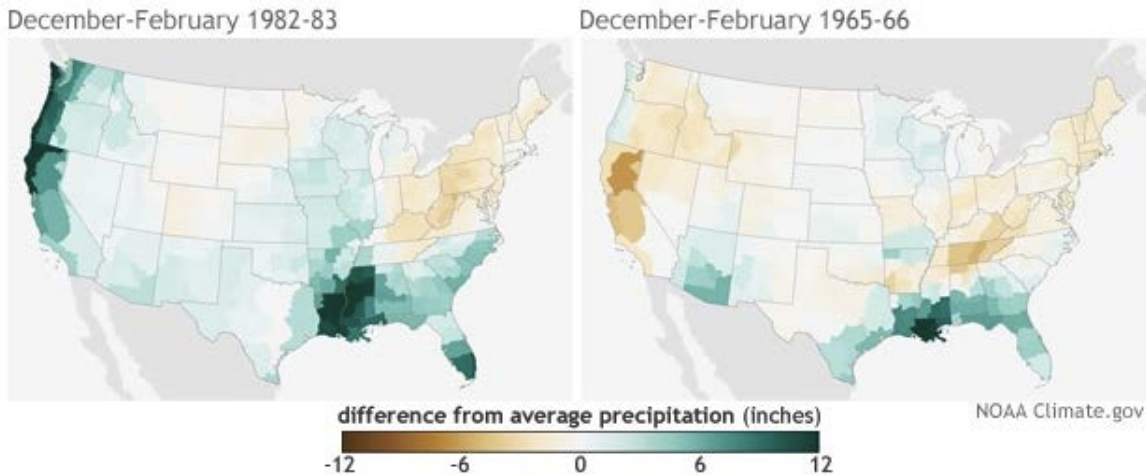
During El Niño years the warmer water and change in winds tends to increase the

sea level by up to six inches in San Diego as shown below on the San Diego Bay tide chart.



NOAA Tide Chart for San Diego Bay 11/23/2015

Every El Niño unfolds a bit differently and some have unexpected impacts. As NOAA points out, strong El Niño events usually bring rain to California in the winter (as in 1982-'83), but occasionally they don't (as in 1965-'66):



Winter precipitation (December-February) in 1982-83 and 1965-66—two strong El Niño events—compared to the 1981-2010 average. The winter of 1982-83 showed the "classic" wet signal that El Niño often brings to California, but the winter of 1965-66 did not. Maps by NOAA Climate.gov, based on NCEI climate division data provided by the Physical Sciences Division at NOAA ESRL.

Designers should note that sea level may rise by 6 inches during strong El Niño events, sea and air temperatures rise and rainfall is anticipated to increase by an average of 3 inches per year during El Niño years. These effects do not change the design storm events. Sea level rise predictions may need to include El Niño effects.



## **8.9 GRADING AND ACCESS**

### **8.9.1 GENERAL**

Ditches and other drainage features shall be graded to drain as shown in the plans. Water shall not be ponded on the Railway ROW unless approved by the Director of Engineering.

### **8.9.2 SIGNAL HOUSE GRADING**

Grading plans shall incorporate flat gravel areas for all signal house pads, signal masts and the walkways between them. Trackway walkways should follow the grade of the tracks.

### **8.9.3 MAINTENANCE VEHICLE ACCESS**

Maintenance vehicle access, particularly to turnouts, signals, and curve lubricators, shall be provided as long as wetlands or environmentally sensitive areas are not unduly impacted. When access ways cross drainages then the designer shall provide culverts or storm sewers, which may include the use of drop inlets, manholes, Arizona crossings or grated channels as necessary to provide continuous drainage on the railway ROW.

Maintenance access roadways shall be all weather and consist of a minimum of 5" of recycled Class 2 Crushed Aggregate Base, 3/4 inch maximum sized gravel. Desired roadway width is 12' with minimum roadway width 10' around obstacles. Desired maximum roadway grade is 10%. For short distances of 50 feet or less, the roadway grade may be increased up to the absolute maximum grade of 15%. Asphalt paving shall be required for roadway grades above 10%.

Preference is for access roads to exit to a public street at each end. For locations with no public street access and where room exist within the railroad ROW, turnarounds shall be provided.

Off-road parking spaces shall be provided at signal houses, control points, turnouts, culverts and bridge abutments. Roadway access and parking for bridge inspection and maintenance shall be provided preferably at both ends of each bridge, at minimum to one abutment.

Hi-Rail accesses should be sited at locations with direct access to public streets. For hi-rail locations not within an existing public street, space to stage multiple vehicles to access the hi-rail is preferred.

### **8.9.3 TEMPORARY CONSTRUCTION GRADING**

Positive drainage of all portions of all construction sites must be maintained in order to avoid saturation of the track embankment or deposition of silt in track ballast.

## CHAPTER 9

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## 9.0 UTILITIES AND PIPELINES

### 9.1 SCOPE

These procedures and design criteria govern new utility construction within the limits of the LOSSAN Corridor in San Diego County, including utilities relocated to accommodate rail projects. Consideration shall be given to the needs of the transportation system, the requirements and obligations of the public or private utility owner, and the service needs of adjoining properties when designing a new or modifying an existing utility encroachment.

Existing utility crossings are typically covered by an agreement between the railroad property owner; NCTD or MTS, or the former property owner ATSF /Burlington Northern and Santa Fe Railway and the utility owner. These agreements govern the terms and conditions of how the utility can access, maintain, and relocate its facilities, and the party responsible for costs if the utility needs to be relocated or protected in place because of a rail project.

All official correspondence to utilities should be performed by the ROW owner, however SANDAG/NCTD consultants may be used to facilitate coordination with the utility owner. SANDAG/NCTD consultants may not direct utility companies to do work without written consent of SANDAG and the ROW owners.

Betterments are not allowed to be funded by transportation projects.

Applicants for ROW utility encroachments shall follow NCTD and or MTS "Right-of-Way Encroachment Approval Procedures, as outlined in Chapter 2 of this Design Criteria.

### 9.2 STANDARDS, CODES AND GUIDELINES

The latest editions of the following standards, codes and guidelines shall be used in the design of utility work within the LOSSAN Corridor:

- SANDAG/NCTD LOSSAN Standards ESD5001 and ESD5002
- On NCTD Property, contact NCTD ROW Department, 810 Mission Avenue, Oceanside, CA 92054, Telephone No. (760) 966-6556 or on the NCTD website at (<http://www.gonctd.com/working-around-the-rails>).
- On MTS Property, the contact MTS ROW Department, 1225 Imperial Ave, San Diego, CA 92101. Tel 619 557 4501. Information can also be found on the MTS website (<http://www.sdmts.com/Business/Permits.asp>). A joint ROE permit will typically be required with MTS and NCTD.
- "FRA Track Safety Standards," 49 CFR Part 213 and "FRA Roadway Worker Safety" 49 CFR Part 214 [FRA](#)
- "Minimum Federal Safety Standards for Gas Lines," Title 49, Code of Federal Regulations, Part 192 [FRA](#)

- American National Standards Institute (ANSI): “Standard for Liquid Petroleum — Transportation Piping Systems,” Part B 31 .4 [American National Standards Institute - ANSI](#)
- American Railway Engineering and Maintenance of Way Association (AREMA), “Manual of Railway Engineering,” Chapter 1, “Pipelines”  
[AREMA - American Railway Engineering and Maintenance-of-Way Association](#)
- American Water Works Association (AWWA)  
[Safe Drinking Water - American Water Works Association - AWWA](#)
- American Society of Mechanical Engineers (ASME): Standard B 31.1, and “Guide for Gas Transmission and Distribution Systems of the ASME Gas Piping Standards Committee” [ASME - Standards](#)
- API Recommended Practice for Crossing Highways and Railroad at the API Website: [www.api.org](http://www.api.org)
- U.S. Department of Transportation, Part 195 of “Government Requirements for Transportation of Liquids by Pipeline
- National Electric Safety Code [National Electrical Installation Standards \(NEIS\)](#)
- California Public Utilities Commission (CPUC) [General Order No. 26-D](#), [General Order 95, Revised August 2009](#), and [General Order No. 118.pdf](#)
- Current standards of utility owners. [San Diego Gas & Electric](#) (SDG&E), Southern California Gas Company (So Cal Gas) and communications of cable providers ATT and Verizon.
- Current City Standards for Wet utility crossings within Cities.
- SDNR REQUIREMENTS FOR PIPELINES WITHIN RAILROAD RIGHT-OF-WAY February 25, 2005

### 9.3 UTILITY DESIGN AND COORDINATION REQUIREMENTS

The objective of pre-construction design activities is to ensure that pertinent utility information is obtained and properly incorporated into the design. Information to be acquired includes owner, type, size, location, casing type and limits, and depth above or below rail of existing and proposed utility facilities affected by new construction, and the disposition of utilities within any ROW to be acquired. Designers shall prepare a utility matrix during the alternatives analysis phase of projects and update it with each design plan submittal. The matrix shall list all utilities along and crossing the ROW, all agreements, and contact information for utility owners.

The following information shall be clearly identified on the contract drawings:

- Utilities to be supported and maintained in place during construction and maintained in service following construction;
- Utilities to be reconstructed supported and maintained in place;
- Utilities to be temporarily relocated and maintained then restored upon completion of the improvements.
- Utilities to be permanently relocated beyond the limits of new construction.
- Utilities to be abandoned or removed - Any pipeline to be abandoned in place shall be slurry filled and capped at the ROW line

- Existing utility lines and Right of Ways and easements and those acquired for their relocation.
- Potholed location and elevation of all existing utilities within the project limits.

If utilities are buried and cannot be located per visual field inspection, potential design conflicts may arise. **Pot holing is required for all buried utilities** during the design phase as the location of unfound utilities may negatively affect the project and the utility.

Utility service to adjoining properties shall not be interrupted except for brief temporary interruptions for new connections and only with notice to and agreement of the adjoining property owners.

Replacements for existing sewers, storm drains, or water mains shall, at a minimum, be designed to provide service equal to that provided by the existing facilities. No capacity changes or betterments shall be incorporated unless agreed to in writing by the utility owner and SANDAG/NCTD prior to final design.

No utilities shall be routed through existing culverts or existing underground structures. No utilities shall be attached to structures carrying railroad loading or structures owned by NCTD/MTS without prior approval. Utility attachments to structures not owned by NCTD/MTS shall be allowed only with prior written approval of the agency who owns the structure and SANDAG/NCTD/MTS. Utilities that run underneath roadways below railroad structures on LOSSAN ROW are permissible, but separate real estate agreements with NCTD/MTS must be obtained for each utility.

### **9.3.1 LICENSES**

NCTD and MTS will provide copies of existing railroad franchise agreements and licenses to SANDAG and their consultants for preparing the project utility matrix and coordinating utility relocation design and relocation responsibilities.

### **9.3.2 ASSESSMENT OF EXISTING UTILITIES**

Consulting teams shall make an assessment of the adequacy of existing utilities. As the railway has been in operation since the 1880's there are locations where current underground utility clearances are less than required by new codes of practice. When these utilities are identified the consulting teams will pothole the ends of the existing casings and measure the size and thickness of the casing or pipe during the final design stage of the project. The adequacy of the existing casing will be checked considering actual loadings and corrosion allowances based on soil testing. Should the casing be deemed structurally sound then a design exception may be applied for by the engineer of record or the affected utility company.

### **9.4 UTILITY MARKERS**

The presence of utility lines, including drains and culverts crossing the ROW below at-grade and embankment sections, shall be indicated on the site by markers placed at points where the centerline of the utilities intersect the boundaries of the ROW. Electrical utility markers shall follow NESC standards.

Markers shall identify each utility, its owner, Rail milepost, survey station and depth.

Typically, markers shall be placed just inside the Rail ROW, with the face of targets parallel to and facing the adjoining track. They shall not encroach on safety walkways, clearance areas, ditches and service roads.

When circumstances do not allow markers to be placed on the centerline of the utility, they shall be placed as close to the centerline as practicable with the direction and offset from marker to utility indicated.

## **9.5 PIPELINE UTILITY CROSSINGS**

New Pipelines crossing beneath the track shall conform to the AREMA Manual for Railway Engineering, Volume 1, Chapter 1, Part 5, Pipelines. Pipelines crossing beneath the track at-grade shall conform LOSSAN SD standards ESD5001 for non flammable substances and ESD5002 for flammable substances.

Casement pipes shall include seals and vents as set forth in the NCTD/SANDAG requirements and in the AREMA manual. The top of casement pipe crossing under the Rail system shall be a minimum of 5 ft. 6 in. below base of rail. The presence of other utilities, or requirements of adjacent railroads, may require that this dimension be increased.

Where the track is constructed above utilities to remain in service, the facilities shall be uncovered and encased before track is placed, or utilities replaced by a new system with a jacked or trenched casement pipe.

In order to accommodate future track construction, temporary or permanent track relocation, and/or construction and maintenance activity on the right of way, new pipe encasement shall extend 25ft. from the centerline of each main track, or to the right of way line, whichever is less.

### **9.5.1 STEEL CARRIER PIPES FOR FLAMMABLE SUBSTANCES**

New Pipelines crossing beneath the track shall conform to the AREMA Manual for Railway Engineering, Volume 1, Chapter 1, Part 5, Pipelines. Pipelines crossing beneath the track at-grade shall conform LOSSAN SD standards ESD5002 for flammable substances.

Pipelines that carry oil, liquefied petroleum gas, and other flammable liquid products shall be of steel and conform to the requirements of the current ANSI B 31.4 Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia, and Alcohols, and other applicable ANSI codes, except that the maximum allowable stress for design of steel pipe shall not exceed the following percentages of the specified minimum yield strength (multiplied by longitudinal joint factor) of the pipe as defined in the above codes:

- Seventy two percent (72%) for oil pipelines.
- Fifty percent (50%) for pipelines carrying condensate, natural gasoline, natural gas liquids, liquefied petroleum gas, and other liquid petroleum products.
- Sixty percent (60%) for gas pipelines.
- Pipe shall be laid with sufficient slack such that it is not in tension.

### **9.5.2 CARRIER PIPELINES FOR NON FLAMMABLE SUBSTANCES**

New Pipelines crossing beneath the track shall conform to the AREMA Manual for Railway Engineering, Volume 1, Chapter 1, Part 5, Pipelines. Pipelines crossing beneath the track at-grade shall conform LOSSAN SD standards ESD5001 for non flammable substances.

Carrier pipe and joints shall be of acceptable material and construction as approved by SDNR. The pipe shall be laid with sufficient slack so that it is not in tension. Acceptable plastic carrier pipe materials include Polyvinyl Chloride (PVC), Acrylonitrile Butadiene Styrene (ABS), Polyethylene (PE), Polybutylene (PB), Cellulose Acetate Butyrate (CAB), and Styrene Rubber (SR). Thermoset types include Reinforced Plastic Mortar (RPM), Reinforced Thermosetting Resin (RTR), and Fiberglass Reinforced Plastic (FRP).

Plastic pipe material shall be resistant to the chemicals with which contact can be anticipated. Plastic carrier pipe shall not be utilized where there is potential for contact with petroleum contaminated soils or other non-polar organic compounds that may be present in surrounding areas.

Design shall consider differential settlement of attachments, longitudinal bending, shear loadings due to uneven settlement of pipe bedding, temperature induced stresses, ground movement due to seasonal variations in moisture content (ie, expansive clays), seismic ground movement, and potential for ground cover surface erosion.

The plastic pipe material must be compatible with the type of product conveyed and the temperature range anticipated for the transported materials and surrounding environment. The maximum allowable operating pressure is 100 psi. Plastic carrier pipe design and installation shall conform to the ANSI B31.3 specifications and/or the following specifications as shown in the following Table 9.1 below:

<b>Table 9.1 Non Flammable Carrier Pipe Materials</b>	
<b>Specification Number</b>	<b>Carrier Pipe Properties</b>
ANSI / AWWA C900-89	Polyvinyl Chloride (PVC) pressure pipe, 4 in. to 12 in. for water
ANSI / AWWA C901-96	Polyethylene (PE) pressure pipe and tubing, ½ in. to 3 in. for water
ANSI / AWWA C902-88	Polybutylene (PB) pressure pipe and tubing, ½ in. to 3 in. for water
ANSI / AWWA C905-88	PVC water transmission pipe, nominal diameters 14 in. through 36 in.
ANSI / AWWA C906-90	PE pressure pipe and fittings, 4 in. through 63 in. for water distribution
ANSI / AWWA C907-90	PVC pressure fitting for water, 4 in. through 8 in.
ANSI / AWWA C950-95	Fiberglass pressure pipe

Codes, specifications, and regulations current at the time of constructing the pipeline shall govern the installation of the facility within the railroad right-of-way. The proof testing of the strength of the carrier pipe shall be in accordance with ANSI requirements.

### **9.5.3 STEEL CASING PIPES FOR ALL PIPELINES**

Casing pipe shall be of steel and of leakproof construction, capable of withstanding railway loading. The top of casement pipe crossing under the Rail system shall be a minimum of 5 ft. 6 inches below base of rail.



The inside diameter of the casing pipe shall be at least 2 inches greater than the largest outside diameter of the carrier pipe, joints, or couplings for carrier pipe less than 6 inches in diameter and at least 4 inches greater for carrier pipe 6 inches and over in diameter. It shall, in all cases, be great enough to allow the carrier pipe to be removed subsequently without disturbing the casing pipe or roadbed. All joints or couplings, supports, insulators, or centering devices for the carrier pipe within a casing in the railroad right-of-way shall be taken into account when determining the proper casing size.

When casing is installed without the benefit of a protective coating or the protective coating is not cathodically protected, the wall thickness shall be increased to the nearest standard size which is a minimum of 0.063 inches greater than the thickness required, except for diameters under 12 ¾ inches.

Steel pipe shall have a specified minimum yield strength, S.M.Y.S., of at least 35,000 psi. and a minimum thickness as shown in table 9.2 below;

NOMINAL DIAMETER (inches)	WHEN COATED OR CATHODICALLY PROTECTED - NOMINAL THICKNESS (inches)	WHEN NOT COATED OR CATHODICALLY PROTECTED - NOMINAL THICKNESS (inches)
12 ¾ and under	0.188	0.188
14	0.188	0.250
16	0.219	0.281
18	0.250	0.312
20 and 22	0.281	0.344
24	0.312	0.375
26	0.344	0.406
28	0.375	0.438
30	0.406	0.469
32	0.438	0.500
34 and 36	0.469	0.531
38	0.500	0.562
40	0.531	0.594
42	0.562	0.625
44 and 46	0.594	0.656
48	0.625	0.688
50	0.656	0.719
52	0.688	0.750
54	0.719	0.781
56 and 58	0.750	0.812
60	0.781	0.844
62	0.812	0.875
64	0.844	0.906
66 and 68	0.875	0.938
70	0.906	0.969
72	0.938	1.000

Casing pipe shall be constructed as to prevent leakage of any substance from the casing throughout its length. Casing pipe under railroad tracks and across railroad right-of-way shall

not be less than 6 feet from top of lowest railroad rail to the top of the casing at its closest point (refer ESD 5002). On portions of the right-of-way where casing is not directly beneath any track, the depth from the ground surface or from bottom of ditches to the top of the casing shall not be less than 4 feet (refer ESD 5002). Ends of the casing pipe shall be suitably sealed.

#### **9.5.4 VENT PIPES**

All Casing pipe shall be properly vented. Vent pipes shall be of sufficient diameter, but in no case less than 2 inches in diameter. Vent pipes shall be attached near the end of the casing pipe and project through the ground surface and shall be outside the railroad right-of-way or near the ROW boundary. Vent pipes shall be not extend less than 4 feet above ground surface. Top of vent pipe shall be fitted with a turned-down elbow properly screened, or a relief valve. Vents in locations subject to high water shall be extended above the maximum elevation of the 100 year high water level and shall be supported and protected in a manner that meets SANDAG/NCTD/MTS approval. Vent pipes shall be no closer than 4 feet (vertically) from aerial electric wires.

#### **9.5.5 SHUT-OFF VALVES**

Accessible emergency shut-off valves shall be installed within effective distances each side of the railroad as mutually agreed to by SANDAG/NCTD/MTS and the pipeline company. These valves should be marked with signs for identification. Where pipelines are provided with automatic control stations at locations and within distances approved by SANDAG/NCTD/MTS, no additional valves shall be required.

#### **9.5.6 CARRIER PIPE INSPECTION & TESTING**

Designers shall ensure that the following inspection and testing is included in project specifications: ANSI codes current at the time of construction of the pipeline shall govern the inspection and testing of the facility within the railroad right-of-way except:

1. One hundred percent (100%) of all steel pipe field welds shall be inspected by radiographic examination and such welds shall be inspected for one hundred percent (100%) of the circumference of the pipe.
2. The proof testing of the strength of the carrier pipe shall be in accordance with ANSI requirements.

### **9.6 JACKED AND BORED OR TUNNELLED PIPES**

During the design of proposed jacked or bored pipes, soils shall be sampled by a geotechnical engineer at all of the proposed sites of these pipe installations. Jacking or boring installation will not be permitted at locations with boulders, abandoned-in-place timber trestles, buried debris, or excessive groundwater or deemed unsuitable by the geotechnical engineer. All design calculations, plans, and drawings shall be prepared by a registered engineer and shall be submitted to the SANDAG/NCTD/MTS for review and approval.

Top of rail elevations shall be established at the proposed centerline of the pipe as it crosses under the tracks. Construction specification shall include provisions for monitoring track elevation during construction of jack and bored utilities. The Fibre optic lines shall be marked out by Verizon and signal cables marked out by NCTD signals engineer.

The jacking and boring method consists of pushing the casing into the earth with a boring auger rotating inside the casing, which removes the spoil. The front of the pipe shall be provided with mechanical arrangements or devices that prevent the auger from leading the casing so that no unsupported excavation is ahead of the casing.

The jacking and tunneling method consists of pushing the casing into the earth with jacks and excavation being performed by worker(s) using handheld tools from within the jacking shield at the head of the casing.

Jacking and boring, and/or jacking and tunneling shall not be used in sandy, loose, or otherwise unstable soils or where boulders are anticipated. The use of water or slurry under pressure (jetting) or puddling shall not be permitted to facilitate boring, pushing, or jacking operations. Water or slurry used to lubricate the cutter and pipe is acceptable.

Specifications shall call for the annular space between the casing and the soil to be grouted as follows. Such grout shall contain at least 8 sacks of cement per cubic yard of material. The hole diameter resulting from bored or tunneled installations shall not exceed the outside diameter of the casing by more than 1.5 inches for casings of less than 12 inches in outside diameter and by 2 inches for casings of greater than 12 inches in outside diameter. For casings with drainage culvert carrier pipes, the annular space between the casing and the carrier pipe shall be grouted. Such grout shall contain at least 8 sacks of cement per cubic yard of material.

Specifications shall call for the annular space between the casing and the excavated soil to be grouted should the operation be abandoned before completion. The annular space between the casing and excavated soil shall be grouted as specified above. In addition, the complete inside of the casing shall be grouted with at least 2 sacks of cement per cubic yard of material.

Specifications shall call for jacking or boring operations to be stopped for the passage of trains. The Contractor shall employ methods to prevent loss of the excavation face as approved in advance by the Engineer. Operations shall also be stopped if ground displacement is detected. The Contractor shall be required to develop a remediation plan that is approved by the Engineer before resuming operations. The Contractor will need to be held liable for all damage resulting from ground displacement. Should the track displace, corrective action shall be taken by the Contractors or NCTD's forces as approved by the Engineer. Casing installation under track shall be specified to progress on a continuous basis without stoppage (except for adding casing sections) until the leading edge of the pipe has reached the receiving pit.

## **9.7 DIRECTIONAL BORING AND DRILLING**

Directional boring/drilling may be used for casings 12" or less in diameter. This method consists of utilizing specialized drilling equipment and boring a small diameter pilot hole along the desired horizontal and vertical alignment, using a mechanical cutting head with high-pressure bentonite slurry to remove the cuttings. Bore pits at either end of the Installation are not necessarily required with this method. The drill string is advanced with the bentonite slurry pumped through the drill string to the cutting head and then forced back along the drill string, carrying the cuttings back to the surface for removal. After the cutting

head reaches the far side of the crossing, it is removed and a reamer (with a diameter wider than the cutting head) is attached to the lead end of the drill string. The casing is attached to the reamer and the casing is then pulled back into its final position. Methods that excavate the soil by means of jetting of fluid or slurry are not allowed.

Slurry use shall be kept to a minimum and shall only be used for head lubrication and/or spoils return. The Contractor shall calculate anticipated slurry use and shall monitor actual slurry use during the boring operation in order to determine the slurry loss into the surrounding soil. Slurry shall be bentonite slurry. The bentonite slurry shall seal the annular space between the casing and the excavated soil with a minimum return of 95%.

Bore stems or cutting tools that become immovable under the track shall be abandoned in place. Should the operation be abandoned before completion, the complete inside of the casing shall be grouted. Such grout shall contain at least 2 sacks of cement per cubic yard of Material.

Specifications shall stop have clauses to stop drilling if ground displacement is detected. The Contractor will be required to develop a remediation plan that is approved by the Engineer before resuming operations. The Contractor needs to be held liable for all damage resulting from ground displacement. Should the track displace, corrective action shall be taken by the Contractors or NCTD's forces as approved by the Engineer.

## **9.8 WIRELINE UTILITY CROSSINGS**

Wireline crossings beneath and over the track shall conform to ESD2104 and as outlined in these design criteria. In the case of conflict between the utility license agreement, ESD2104, and these design criteria, these design criteria shall govern for new or modifications to existing crossings unless otherwise approved by the Director of Engineering. For proposed electrical lines crossing tracks, SANDAG/NCTD/MTS may request that an inductive interference study be performed at the expense of the utility owner. Inductive interference from certain lines has the potential to disrupt the signal system in the track, causing failures in the track signals and grade crossing warning devices. SANDAG/NCTD/MTS will determine the need for a study on a case-by-case basis.

### **9.7.1 UNDERGROUND GREATER THAN 750 V**

Wireline encasement for underground lines carrying greater than 750 V shall be across the entire ROW in rigid metallic conduit a minimum of 4 feet below natural ground and a minimum of 5 feet 6 inches below base of rail. A 6-inch-wide warning tape shall be provided 2 feet below the ground line and 3 feet below base of rail outside of the ballast section. The wireline shall be located 50 feet from the end of any bridge, culvert, or switching area.

The casing and carrier must be a minimum of 2 feet below any fiber optic line, and installation must be hand excavated when within 5 feet of the fiber optic line.

### **9.7.2 UNDERGROUND LESS THAN 750 V**

Wireline encasement for underground lines carrying less than 750 V shall be as noted below in rigid metallic conduit a minimum of 3 feet below natural ground and a minimum of 5 feet 6

inches below base of rail.

The wireline shall be located 50 feet from the end of any bridge, culvert, or switching area.

The casing and carrier must be a minimum of 2 feet below any fiber optic line, and installation must be hand excavated when within 5 feet of the fiber optic line.

To accommodate future track construction, temporary or permanent track relocation, and/or construction and maintenance activity on the Railroad ROW, wireline encasement for lines carrying less than 750 V shall extend 50 feet from the centerline of each main track, or to the ROW line, whichever is less.

### **9.7.3 OVERHEAD GREATER THAN 750 V**

For overhead wirelines carrying greater than 750 V, a minimum vertical clearance shall be provided above top of rail per ESD2104. A minimum 4-foot vertical clearance shall be provided above any signal or communication poles.

Support poles shall be located a minimum of 50 feet (200 feet for lines carrying 100KV or more) from the centerline of the closest track. Poles shall be located a minimum distance from signal or communication lines equal to the height of the support pole or guy at right angles to the pole lines.

The wireline crossing shall be located a minimum of 500 feet from bridge backwalls and a minimum of 300 feet from the closest face of culverts or switching area.

### **9.7.4 OVERHEAD LESS THAN 750 V**

For overhead wirelines carrying less than 750 V, a minimum 25 foot vertical clearance shall be provided above top of rail. A minimum 4-foot vertical clearance shall be provided above any signal or communication poles.

Support poles shall be located a minimum of 50 feet from the centerline of the closest track. Poles shall be located a minimum distance from signal or communication lines equal to the height of the support pole or guy at right angles to the pole lines.

The wireline crossing shall be located a minimum of 500 feet from bridge backwalls and a minimum of 300 feet from the closest face of culverts or switching area.

## **9.9 FIBER OPTIC SYSTEMS**

Fiber systems should be installed near the outer limits of railroad ROW. The system's running line should be kept as straight as possible while maintaining a consistent distance from centerline of the nearest track. The system should be installed on the field side of all railroad structures, including bridges, signal facilities, buildings, and platforms.

If the fiber system has to be placed under an existing signal or communication structure, the system should be placed a minimum of 10 feet under natural ground. This extra depth may also be required in "signal sensitive areas," such as interlocking or control points.

If the fiber system has to be located under existing signal or communication lines, a minimum 2-foot vertical separation is required.

Fiber optic cable shall not be installed within 5 feet horizontally of underground power or signal lines, unless suitably insulated.

The fiber system should be designed to be installed a minimum of 3 feet 6 inches below natural ground, except as noted herein.

Warning tape shall be placed above the buried facility.

In the event that local ground conditions prohibit the placement of the fiber system at a depth of 3 feet 6 inches, the fiber system shall be encased, and approval of the Director of Engineering is required.

If rock is encountered and prevents a depth of 3 feet 6 inches, the fiber system should be cut into the rock at a depth of 18 inches or greater, provided proper grouting and cable protection is used. Cutting the rock less than 18 inches requires permission of the Director of Engineering.

The fiber system should be designed to be buried a minimum of 5 feet below the bottom of all culverts on railroad ROW, or around the end of the culvert 5 feet below the bottom of the cleaned out ditch. In no case shall the fiber system be buried over the top of any culvert on the railroad ROW.

Hand holes, splice boxes, and manholes located within 15 feet of centerline of nearest track should be designed to include Cooper E80 live load surcharge; if greater than 15 feet, installation should be designed to include current AASHTO live load surcharge in addition to all other loads.

The design location of the hand holes, splice holes, and manholes should not be within 100 feet of existing signal or communication buildings or facilities.

Overhead crossings of the track by the fiber system shall comply with ESD2104.

Under crossings of the track by the fiber system shall comply with ESD5001 and ESD5002.

The fiber system should not be laid out to be installed within the slope of cut or fill sections, and any cut or fill sections should not be benched. The fiber system should be located over the top and on the field side of the back-slope of a cut section whenever possible.

In the event that the fiber system has to be located in the drainage ditch, the system should be placed a minimum of 5 feet beyond the toe of the slope and a minimum of 60 inches from the bottom of the existing flow line. Placement of the fiber system at extra depth and/or in protective casing should be considered for protection during ditch cleaning maintenance.

Also, placement of the warning tape should be designated so that it would not be disturbed during cleaning maintenance.

The requirements of SCRRA "Excavation Support Guidelines" shall apply to all trenches and excavations.

In excavations and trenches, compacting and backfilling should be to 95 percent maximum dry density as defined in ASTM D698. Clean, suitable backfill material should be designated.

Where CPUC requirements meet or exceed the requirements of SANDAG/NCTD, those requirements will apply. This would include, but not be limited to, safety, clearances, and walkways.

## Chapter 10

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## 10.0 RAILWAY STRUCTURES

### 10.1 GENERAL

Structural design for all railway structures shall be consistent with standard railway practice. All structural designs shall follow these criteria, in conjunction with the Seismic Design, Corrosion Design, and the Bridge Chapters in this Design Criteria Manual. Passenger service trains through the corridor are authorized to travel at speeds of up to 90 mph and all new track supporting structures shall be designed to support this speed. Structures shall be designed to remain serviceable after damage by accidents and the appropriate service level earthquakes. All mainline structures supporting track shall be designed for a service life of 100 years.

#### 10.1.1 SCOPE

This chapter establishes the design criteria for LOSSAN Corridor structures, including bridges, cut and cover structures, retaining walls, buildings and miscellaneous structures. Where special design cases are encountered that are not specifically covered in these criteria, a project-specific basis of design report shall be submitted by the design consultant to SANDAG and NCTD for approval.

The design of a structure owned or maintained by an agency other than NCTD (or MTS if applicable) shall be in accordance with the standards used by that agency and must be consistent with NCTD/MTS operating and maintenance requirements. Structures owned or maintained by Caltrans, or by any jurisdiction adopting the standards of that agency, shall be designed in accordance with Caltrans criteria.

Clearance requirements for LOSSAN Corridor tracks to all adjacent structures above top of rail are discussed in the General Clearances Chapter of this Design Criteria Manual and all CPUC requirements. The designer shall consider these requirements in the design of all structures.

#### 10.1.2 STANDARDS, CODES, AND GUIDELINES

The design and construction of structures supporting railroad live loads shall be in accordance with the current edition of the AREMA Manual for Railway Engineering.

This Chapter of the Design Criteria Manual provides clarification of SANDAG/NCTD's use of AREMA guidelines, identifies amendments to AREMA guidelines, and describes SANDAG/NCTD's philosophy and criteria for aspects of bridge and structure design that are not specifically addressed by AREMA. Bridge designers are expected to familiarize themselves with the AREMA Manual for Railway Engineering, Chapters 1, 7, 8, 9, and 15, regardless of the material(s) being implemented in a specific bridge. The designers should recognize that the AREMA Manual for Railway Engineering contains provisions within these individual chapters that may also govern the design of seemingly unrelated materials.

The latest edition of the following standards, codes and guidelines shall be used in the design of structures as set forth in this chapter:

##### A. Railroad Structures

- American Railway Engineering and Maintenance of Way Association (AREMA), “Manual of Railway Engineering,” referred to in these criteria as “AREMA Manual”
  - <http://www.arema.org/catalog.aspx>

#### B. Highway Structures

- California Department of Transportation (Caltrans) “Highway Design Manual” to include, as a minimum, the following list of supplemental specifications, design sections, design aids and standard drawings, including all revisions, amendments and deletions:
  - Highway Design Manual
    - <http://www.dot.ca.gov/hq/oppd/hdm/hdmtoc.htm>
  - Bridge Design Specifications
    - <http://www.dot.ca.gov/hq/esc/techpubs/manual/bridgemanuals/bridge-design-specifications/page/section3.pdf>
  - Seismic Design Criteria
    - <http://www.dot.ca.gov/hq/esc/techpubs/manual/othermanual/other-engin-manual/seismic-design-criteria/sdc.html>
  - Bridge Memo to Designers
    - <http://www.dot.ca.gov/hq/esc/techpubs/manual/bridgemanuals/bridge-memo-to-designer/bmd.html>
  - Caltrans Standard Bridge Plans and Specifications
    - [http://www.dot.ca.gov/hq/esc/oe/construction\\_standards.html](http://www.dot.ca.gov/hq/esc/oe/construction_standards.html)

#### C. Railroad and Highway Structures

- American National Standards Institute (ANSI), “American Standard Building Code,”
- American Concrete Institute (ACI), “Building Code Requirements for Structural Concrete - ACI 318,” including its commentary
  - <http://www.concrete.org/bookstorenet/ProductDetail.aspx?itemid=31808PACK>
- American Institute of Steel Construction (AISC) “Steel Construction Manual”, “Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings,” and “Seismic Design Manual”, including their commentaries
  - <http://www.aisc.org/WorkArea/showcontent.aspx?id=26516>
- Underwriters’ Laboratories. Inc. (UL), “Testing for Public Safety, Building Materials List.” referred to in these criteria as “UL List”
- American Society of Civil Engineers (ASCE), “Minimum Design Loads for Buildings and Other Structures,” ASCE 7-95
  - <http://www.asce.org/Product.aspx?id=2147487569>
- International Code Council’s “International Building Code” (IBC) latest edition
- The code amendments to the IBC used by the local municipality where the structure is located

For structures and facilities not covered specifically in this chapter, the design shall conform to the International Building Code with all local applicable amendments.

### **10.1.3 DESIGN METHODOLOGY**

The design methodology for the various bridge components and other civil structures supporting railroad live loads shall be in accordance with AREMA recommended practices unless specified otherwise herein.

Simply supported bridge spans are preferred for ease of replacement or maintenance. For major long span crossings other structural types may be considered in the alternatives analysis phase and structural type selection phases. Bridges may be steel or concrete or both, depending on several factors studied during type selection including but not limited to: reliability, economic analysis, maintenance costs, constructability, repair and replacement, and corrosion.

Concrete elements of a bridge shall be designed using the Load Factor Design method.

The design of steel structural shapes or members that are not covered by AREMA guidelines shall be designed using Allowable Stress Design in accordance with the latest edition of the American Institute of Steel Construction (AISC) Steel Construction Manual and modified as necessary to be equivalent to AREMA allowable stresses and safety factors.

Seismic design methodology shall be in accordance with AREMA guidelines as supplemented with Chapter 9 of this Design Criteria Manual. Seismic detailing shall be in accordance with the most recent version of Caltrans "Seismic Design Criteria (SDC)." The current version is 1.7 dated April 2013.

- AREMA Chapter 9, "Seismic Design for Railway Structures," approach is to provide the framework for evaluating seismic effects on railroad structures. This is accomplished by a performance criteria approach using a three-level ground motion response level hierarchy. The three levels are serviceability, ultimate, and survivability, and define how the bridge is able to sustain ground motion forces.
- Caltrans SDC, addresses displacement ductility as it relates to global ductility and individual member ductility. Global, member yield, and member ultimate displacements are measured and these values are compared to each other, based on the components being designed. The resulting values give the designer an understanding of the ability of the members to resist the demand displacements imposed on the structure.

## **10.2 BRIDGE GENERAL DESIGN GUIDELINES**

### **10.2.1 MINIMUM CLEARANCES**

Minimum vertical clearance for Overhead and Underpass structures shall be in accordance with the General Clearances and Rolling Stock Chapter 1 and ESD2101 for railroad clearances.

The minimum vertical clearance for road Underpass structures shall meet all CPUC and Caltrans requirements;

Caltrans Highway design Manual requires;

(a) Freeways and Expressways, All construction except overlay projects – 16 feet 6 inches shall be the minimum vertical clearance over the roadbed of the State facility (e.g., main lanes, shoulders, ramps, collector-distributor roads, etc.).

(b) Freeways and Expressways, Overlay Projects – 16 feet shall be the minimum vertical clearance over the roadbed of the State facility.

(c) Conventional Highways, Parkways, and Local Facilities, All Projects – 15 feet shall be the minimum vertical clearance over the traveled way and 14 feet 6 inches shall be the minimum vertical clearance over the shoulders of all portions of the roadbed.

(d) Pedestrian Underpasses - 8 feet shall be the minimum vertical clearance and 10 feet the minimum horizontal width for new undercrossings. Also Refer to sections 4.4.2 for undercrossing clearances and 7.8.2 for station undercrossings.

The vertical clearance must not be violated due to the deflection of the superstructure.

Variations from vertical clearance defined above shall be submitted to SANDAG Director of Engineering for approval. The variance will be considered if the Railroad structure is not the lowest structure within the roadway network. All proposed new structures with substandard vertical clearances shall be protected with a sacrificial beam. Pedestrian access to the sacrificial beam shall be blocked on both ends and the sacrificial beam shall be located to safeguard the bridge from oncoming vehicles.

Sacrificial beam shall be steel shapes (wide flange or hollow structural sections) and of sufficient strength to limit horizontal deflection, caused by the impact from oversized vehicles or loads, to six (6) inches. The sacrificial beams shall also be securely anchored with cables at each end to prevent them from falling, and its soffit shall be at least two (2) inches below the bridge soffit.

Concrete fascia beams used as walkways and installed adjacent to the proposed structure may also serve as a sacrificial beam. The beam shall have a 6"x6"x1" embedded steel angle facing oncoming traffic and shall be adequately anchored to the bridge seats at an elevation at least two (2) inches below the bridge soffit.

Minimum clearances shall be adjusted in accordance with AREMA guidelines for curved tracks. Parallel, separated steel through plate girder structures shall have a minimum separation of 5 feet 0 inches to provide access for maintenance work and inspection.

Minimum horizontal clearance between bottom flanges of steel girders and steel beams shall be 12 inches for members 45 inches and less in depth and shall be 18 inches for members greater than 45 inches in depth.

### **10.2.2 BRIDGE DECKS**

All new bridges shall have ballasted decks.

Bridge decks shall have a preferred minimum longitudinal grade of 0.2 percent to provide positive drainage. If the track grade is less than 0.2 percent, the difference may be made up with additional ballast depth.

The structural portion of bridge decks shall be level, with no transverse cross-slope.

Two appropriately sized drainage pipes shall be provided at each side of the bridge deck adjacent to the ballast retainers.

Longitudinal deck drains shall be used for all waterproofed bridges. Water shall be collected and piped off of the bridge at the low end abutment. Depending on the bridge span lengths deck drains may require intermediate collection points. These intermediate collection points shall be near piers and piped to appropriate water treatment BMP, tied into a curb and gutter system, or tied into a storm sewer system in accordance with local or regional water quality requirements. The deck drainage shall be independent and shall not connect to the abutment wall subdrainage systems. Deck drainage may be channeled into a subsurface system to provide an appropriate level of treatment (i.e. vegetated bio swales).

Longitudinal deck drains shall not be placed within the live load distribution area. The maximum ballast design depth shall be used to determine the limits of this area. If possible, longitudinal deck drains shall be placed between tracks and access roads on multiple-track bridge structures.

A minimum ballast depth below wood ties shall be 12 inches and for concrete ties shall be 8 inches. This depth does not include waterproofing, which shall be in addition to minimum ballast requirements.

Ballast curbs shall be a minimum of 18 inches in height above the structural deck (not the HMA) for bridges that have fascia beams with walkways and 36 inches in height above the structural deck (not the HMA) for bridges that have no fascia beams. Ballast curb heights shall be increased as necessary to accommodate a superelevated track or increased ballast depth due to the required minimum 0.2 percent longitudinal grade.

### **10.2.3 HANDRAIL AND WALKWAYS**

Handrail and walkways shall be provided on both sides of the bridge. The location of the handrail shall provide a minimum clearance of 8 feet 6 inches from the centerline of the track to the nearest point of the handrail and 6 feet 6 inches from the centerline of the track to the nearest face of any ballast curb. 9 foot 0 inches shall be used at tangent tracks and 9 foot 6 inches shall be used at curved track to ensure the CPUC minimum is always obtained. For bridges with new walkway 8 foot 0 inches shall be used from centerline track to inside edge of ballast beam. See AREMA Manual for Railway Engineering, Chapter 28, Section 1.1 for additional requirements.

Bridges with multiple tracks and independent superstructures for each track shall have a walkway between superstructures for tracks having centerline spacing less than 25 feet. Tracks having centerline spacing equal to or greater than 25 feet may have separate walkways with handrails between tracks.

Walkways and handrails shall be designed in accordance with the AREMA Manual for Railway Engineering, Chapter 15, Sections 8.5.2 and 8.5.3. Platform, walkway, and handrail requirements when a bridge is at or near a station are provided in the Stations and Signage Chapter of this Design Criteria Manual. Standard bridges using ESD6000 series shall use the handrail approved for these standards as shown on ESD6007.

Walkways other than the ballast deck shall be concrete or serrated steel bar grating. Handrails shall have a minimum of three horizontal rails. Bridges over roadways shall include a toeboard on the handrailing. The horizontal rails can be made of steel cable or round tubular sections. Walkways and handrails shall be simple designs requiring minimum maintenance. Standard handrail configurations are shown on standard plan ESD6007.

### **10.2.4 PIER PROTECTION**

The pier protection wall shall be designed to resist the impact and redirect dragging equipment in case of derailment. Both sides of the pier shall be protected in locations where tracks are within 25 feet on both sides of the pier.

If seismic criteria are considered, pier design may require column isolation with the wall supported on an independent footing.

All replacement or modified structures shall comply with AREMA requirements for pier protection walls.

In locations where pier columns and protection walls interfere with drainage, an alternative drainage facility shall be provided to collect and carry water to a drainage system.

AREMA defines a pier of heavy construction as: "Cross-sectional area equal to or greater than that required for the pier protection wall and the larger of its dimensions is parallel to the track". For a single column the minimum cross-sectional area is 30 sq. ft. (12' length x 2.5' width = 30 sq. ft.). Columns with 30 square feet of cross sectional area must have the larger dimension parallel to the track; for example, a 5' x 6' column with the 6' dimension parallel to the track is considered as heavy construction.

## **10.3 LOADING**

### **10.3.1 LOADS AND FORCES**

Bridges and other civil structures supporting railroad live load shall be designed for all loads specified in the AREMA Manual for Railway Engineering, Chapters 8, 9, and 15, and as modified below.

#### **A. Dead Load**

In addition to the actual self-weight of the structure, the following minimum dead loads shall be applied as applicable:

Track rails, inside guard rails and their fastenings	200 lbs. per linear foot per track
Ballast	120 lbs. per cubic foot
Hot Mix Asphalt (HMA)	120 lbs. per cubic foot
Earth-filling materials	120 lbs. per cubic foot
Waterproofing and protective covering	Estimate weight
Future utilities	5 lbs. per square foot of deck

These are minimum values; however, the design engineer must consider rail type, tie type, and densities of locally available materials. Dead load for bridges shall include a minimum of 21 inches and a maximum 30 inches of ballast from top of deck to top of tie, including HMA when required.

For any structure within the railroad right of way, but not supporting train loading, they shall be designed for self-weight and permanent attachments using the densities/dead load values taken from AREMA Volume 2: 15-1-5.

#### B. Live Loads

Any structure supporting train loading along the LOSSAN Corridor shall be designed to support Cooper E-80 loading; steel structures shall also be designed to support the Alternate Live Load per AREMA Chapter 15. These structures shall also be designed to withstand the impact loading with rocking forces, longitudinal forces due to acceleration and braking, and for structures along curves centrifugal force applied perpendicular to the track. These additional forces shall be developed per the applicable materials chapters of AREMA.

For multiple track structures, the track shall be allowed to be placed anywhere on the structure. The number of tracks on the structure shall be determined using minimum track spacing as stated in the General Clearances Chapter of this Design Criteria Manual.

#### C. Impact Loads

Impact load shall be in accordance with AREMA guidelines.

The impact load prescribed by AREMA shall be used for the material under design. For example, concrete impact load shall be used for a concrete bent cap, and steel impact load shall be used for the supporting steel pile above the ground line, regardless of superstructure type.

#### D. Wind Loads

Any structure supporting train loading shall be designed withstand the wind load applied to the structure, in addition to a 300 pound per linear foot wind load shall be applied to the train at 8 feet above top of rail, as stated in the applicable material section of AREMA; for concrete structures, Volume 2: 8-2.2.3.h; for steel structures, Volume 2: 15-1.3.7.

Structures supporting highway traffic loading shall be designed to meet all the wind loading requirements as determined by the "Highway Design Manual".

For other structures not supporting train or highway loading, the wind loads shall be developed from the International Building Code with local code amendments applied. For these structures located within the railroad right of way, the applicable minimum AREMA criteria shall also be met.

For wind loads on temporary bird protection fences refer section 10.16 below.

#### E. Hydraulic Loads

For structures in lagoons and rivers hydraulic loads shall be considered as appropriate considering 100-year flood and storm events and resulting scour.

#### F. Seismic Loads

Seismic loading shall be developed in conformance with Chapter 12 of this Design Criteria Manual.

#### G. Other Loads

All structures shall take into consideration other types of loading as applicable. These include, but are not limited to, the following; earth/soil pressures, hydrostatic/water pressures, collision impacts, and any other loads unique to the structure. In addition, the effects of scour should be considered in how they affect the foundation configuration.

### **10.3.2 GENERAL LOAD DISTRIBUTION**

Live load distribution to supporting superstructure elements shall be in accordance with AREMA guidelines.

The live load shall be distributed transversely on ballasted deck bridges using an 8-foot-3-inch-long tie that is 8.5 inches in depth. The following load cases should be considered:

- A minimum of 12 inches of ballast below the wood tie, not including HMA when required
- A minimum of 8 inches of ballast below the concrete tie, not including HMA when required

The HMA may be considered as an additional ballast depth in determining the live load distribution to the deck.

### **10.3.3 LONGITUDINAL FORCE DISTRIBUTION**

Longitudinal force on bridges shall be distributed in accordance with AREMA guidelines. The effective longitudinal forces shall be distributed to the various components of the supporting structure, taking into account their relative stiffness. The resistance of the backfill behind the abutments shall be utilized where applicable. The mechanisms (rail, bearings, load transfer devices, anchor bolts etc.) available to transfer the force to the various components shall also be considered.

The superstructure deflection due to the longitudinal force shall not exceed 1 inch parallel to the track at the abutments assuming the entire superstructure moves together and the forces shall be distributed to the various components of the supporting structure and abutments as applicable. Vertical reactions at girder bearings resulting from the applied longitudinal force and associated force couples (if any) shall be considered in the substructure design.

### **10.3.4 LOAD COMBINATIONS**

Load combinations shall be as described in the AREMA Manual and as clarified below.

Variable conditions such as water level for buoyancy and scour depth shall be based on the condition which has a significant likelihood of occurring concurrently with the loads being combined. For longitudinal live load and seismic loads, scour depth should be based on the contraction scour for the 100 year event.

## **10.4 SEISMIC DESIGN CONSIDERATIONS**

Seismic design for railroad bridges shall be in accordance with the Seismic Design Chapter of this Design Criteria Manual.



## 10.5 STRUCTURE TYPE SELECTION

### 10.5.1 STRUCTURE SELECTION ANALYSIS AND REPORT

A structure type selection analysis shall be performed for all structures in accordance with the SANDAG Design Procedures Manual. The draft structural type selection report shall be developed and included with the 30% design submission. The final report shall include agency feedback, and be submitted with the 60% submission. The report shall include at a minimum, the following:

- Compare structure types and their impacts on the project cost and schedule.
- Compare structure types and their impacts on the environment and their impacts on existing physical constraints.

The result of the analysis shall be a recommended structure type that balances the impacts on costs (short term, including impacts on physical constraints and track outages for construction, and long term, including maintenance and track outages for possible damage), schedule, and the environment.

### 10.5.2 SUBSTRUCTURE AND FOUNDATION TYPES

Each structure site poses a unique set of circumstances for substructure and foundation type selection.

Every effort shall be made to design the abutments and intermediate supports normal to the track. If this is not achievable, then every effort shall be made to have all supports parallel to each other with beam lengths the same within each span. Approach slabs shall be used for all skewed abutments and the beginning of the approach slabs shall be normal to the track and end on the abutment wall.

Consideration shall be made to keep excavations to a minimum adjacent to active tracks. An example to reduce the excavation depth is using a top-down construction method such as columns or piles that can be constructed and then exposed later when the bridge is in service, thus requiring an initial excavation depth only to construct the pier caps.

Consideration shall also be made for construction under railroad traffic. Foundation and substructure elements shall be positioned and designed in such a manner to reduce their impact on railroad traffic when constructed.

Precast and/or prefabricated elements should be considered to speed construction and reduce impact on railroad traffic. Examples of this include locating a pile being driven through an existing bridge deck such that it does not interfere with the existing rail, or adding precast riser blocks to pier caps such that the pier cap can be constructed initially below the existing low chord.

The following foundation types may be used:

- Driven steel H piles
- Precast/Prestressed concrete pile
- Cast-in-Steel Shell (CISS) pile

- Cast-in-Drilled Hole (CIDH) pile (also known as drilled shaft)
- Spread footings

These foundation types have no order of preference; the preferred type has a direct correlation with the site geology and seismicity.

The CISS pile is usually a driven pipe pile filled with concrete, reinforced or unreinforced. Where the pipe is used as a sacrificial form in brackish and salt water areas or in corrosive soils; the core shall be reinforced concrete designed to support the bridge loads or the shell upsized to include a sacrificial thickness to account for 100-years of corrosion.

CIDH piles are typically holes drilled to a bearing stratum and then filled with reinforced concrete. The holes may have to be kept open with slurry, temporary casing, permanent casing, or a combination of these. Rock sockets may be required to achieve bearing requirements.

Spread footings shall not be used to support structures in a lagoons, streams, rivers or creeks where scour may undermine the foundations.

### **10.5.3 BRIDGE SUPERSTRUCTURE TYPES**

The following is a list of Bridge Structure types that may be used. The preferred superstructure type will be determined by the structural type selection report.

1. Rolled Beams with Steel Plate Deck. There shall be at least five (5) beams per track.
2. Steel Plate Girders with Steel Plate Deck. There shall be at least four (4) girders per track.
3. Rolled Beams with Concrete Deck. There shall be at least five (5) beams per track.
4. Steel Plate Girders with Concrete Deck. There shall be at least four (4) girders per track.
5. Railroad Standard Prestressed Precast Concrete Double Cell Box Beams.
6. Prestressed Precast Concrete Box Beams, single or double cell.
7. Prestressed Precast Concrete AASHTO Type Beams, (or similar) with Concrete Deck.
8. Steel Through Plate Girders with Steel Plate Deck will be considered by the Railroad when conditions preclude any other structure type.
9. Cast in Place Structures

**Table 10.1 Bridge Superstructure Types**

Superstructure Type	Common Span Range	Typical Depth Range
PC/PS Concrete Slab	up to 24 feet	14 inches
PC/PS Concrete Box Beam	20-32 feet	30 inches
PC/PS Concrete Box Beam	30-49 feet	42 inches
Rolled Steel Beam	31-69 feet	40 inches
Steel Deck Plate Girder	60-150 feet	Varies
Steel Through-Plate-Girder	75-150 feet	Varies
PC/PS Concrete Bulb Tee	90-140 feet	Varies to 7 feet
PC/PS Concrete Box Beam	60-130 feet	Varies to 6.5 feet
CIP PS Concrete Box Girder	70-200 feet	Varies to 10 feet

Span erection offline should be considered when constructing under railroad traffic. Offline erection may require rolling in the new span and/or rolling out the old span or picking and placing a complete span. Grade separation projects being constructed for a third party shall not be constructed under railroad traffic.

A bridge does not have to use all the same span types. The bridge can consist of different span types. While the main span may need to be a DPG span, the approaches could be standard double box beams.

## 10.6 STEEL STRUCTURES

### 10.6.1 GENERAL

Generally in the coastal marine environment; steel structures are not preferred. Designers proposing steel structures must allow for 100 year corrosion protection. All structural steel designs shall conform to this design criteria manual and the following codes as applicable:

Steel railroad bridges and other track supporting structures shall be designed in accordance with AREMA Chapter 15.

All highway bridges and highway supporting structures over rail shall be designed in accordance with the "Highway Design Manual".

### 10.6.2 MATERIALS

Material requirements shall be in accordance with AREMA and this Chapter of the Design Criteria Manual. Materials not specifically included in AREMA may be used on a project-by-project basis.

Steel member material shall be as follows:

<b>Table 10.2 Steel Member Materials</b>		
<b>Member</b>	<b>ASTM</b>	<b>Yield Stress</b>
Rolled Beams	ASTM A709 Gr. 50W T1	$F_y=50,000$ psi
Girder Web, Bottom Flange, End Floor Beam	ASTM A709 Gr. 50W F1	$F_y=50,000$ psi
Girder Top Flange, Bearing Stiffeners	ASTM A709 Gr. 50W T1	$F_y=50,000$ psi
Intermediate Floor Beams	ASTM A709 Gr. 50W T1	$F_y=50,000$ psi
Deck Plates	ASTM A709 Gr. 36 T1	$F_y=36,000$ psi
Cover Plates	ASTM A36	$F_y=36,000$ psi
Walkway Checkered Plates	ASTM A786 Gr. 36, Galv.	$F_y=36,000$ psi
Handrail	ASTM A847	$F_y=50,000$ psi
Drain Pipe Downspouts	ASTM A53 Gr. B	$F_y=35,000$ psi
Bearings	Project Specific	Project Specific
Pins	ASTM A576 Gr. 1018	$F_y=36,000$ psi
All other Material	ASTM A588	$F_y=50,000$ psi
Anchor Rods	ASTM F1554 Gr. 36	$F_y=36,000$ psi
H-Piling	ASTM A572 Gr. 50	$F_y=50,000$ psi
H-Piling	ASTM A588	$F_y=50,000$ psi
Pipe Piling	ASTM A53 Gr. B	$F_y=35,000$ psi
Pipe Piling	ASTM A252 Gr. 2	$F_y=35,000$ psi
Pipe Piling	ASTM A252 Gr. 3	$F_y=45,000$ psi
Pipe Piling	ASTM A500 Gr. B	$F_y=42,000$ psi
Pipe Piling	ASTM A500 Gr. C	$F_y=46,000$ psi
Steel Sheet Piling	ASTM A328	$F_y=39,000$ psi
Steel Sheet Piling	ASTM A690	$F_y=50,000$ psi
All other Structural Steel	ASTM A588	$F_y=50,000$ psi

### **10.6.3 DESIGN AND DETAILING REQUIREMENTS**

Deck composite action shall not be used for strength requirements but may be used for deflection requirements.

All structural steel for railroad structures material shall follow those specified in AREMA Chapter 15, Section 1.2.1 – Materials. Miscellaneous steel for minor loading applications, such as posts, handrails, walkways, and other similar minor loading uses, may be specified as ASTM A36 steel.

All steel structures within one (1) mile of the coast or exposed to the environment shall be galvanized or painted after fabrication, with all required field welds to be spray metalized. Galvanizing shall conform to the ASTM A123 specification. Spray metalizing shall conform to ASTM B833. Refer to the Corrosion Chapter of this Design Criteria Manual for additional design requirements. Cathodic protection may be used in addition to painting or galvanizing when authorized. If the structure will be painted or galvanized, non-weathering steel shall be substituted for the material being painted or galvanized.

Superstructure connection bolts shall be ASTM A325 minimum 7/8 inches in diameter and the bolt type shall be consistent with the material being connected. All other steel-to-steel connection bolts shall be ASTM A325 minimum 3/4 inches in diameter. All other bolts shall be ASTM A307.

Coping of members carrying railroad live load shall not be allowed. Stripping of flanges without modifying the web may be allowed.

All intermediate stiffeners acting as floor beam or transverse diaphragm connections shall be bolted to the bottom flange on only one side of the web.

## **10.7 CONCRETE STRUCTURES**

### **10.7.1 GENERAL**

All reinforced concrete designs shall conform to this design criteria manual and the following codes as applicable:

Reinforced concrete railroad bridges and other track supporting structures shall be designed in accordance with AREMA Chapter 8 Part 2 – Reinforced Concrete Design.

The service life of all concrete structures shall be assured by using the “**Service Life Design Guide for Corrosion Prevention of Concrete Structures on LOSSAN Rail Corridor in San Diego County**”. Consultants shall prepare a service life report for each bridge structure to verify the actual service life predicted from the as built bridges.

### **10.7.2 MATERIALS**

Material requirements shall be in accordance with the AREMA Manual for Railway Engineering, Chapter 8, Part 1, and the LOSSAN Standard Specifications. The Standard Specifications may be amended by Special Provision on a project-by-project basis for material that is not specifically included in the Standard Specifications.

Concrete subjected to wetting by or submersion in brackish or salt water shall be designed in accordance with the Corrosion Chapter of this Design Criteria Manual.

### **10.7.3 DESIGN REQUIREMENTS**

Reinforced concrete structures shall be designed in accordance with the Load Factor Design method.

Concrete shall contain supplementary cementitious materials where necessary to increase durability, resistance to corrosion, and design life. Refer to the Corrosion Chapter of this Design Criteria Manual for additional design requirements.

The minimum strength of all reinforcing steel shall be 60,000psi following the criteria of ASTM 615 for standard deformed reinforcing steel or ASTM 706 for weldable reinforcing steel. Concrete compressive strength for structural applications shall not be specified less than 3,000psi at 28 days.

### **10.7.4 CONCRETE SUPERSTRUCTURE REQUIREMENTS**

Concrete superstructures shall be in accordance with standard plans in the ESD6000 series.

### **10.7.5 CONCRETE SUBSTRUCTURE REQUIREMENTS**

The minimum compressive strength ( $f'_c$ ) shall be 4,000 psi at 28 days for structures further than one-half mile from the coast. The minimum compressive strength ( $f'_c$ ) shall be 5,000 psi at 28 days for structures within one-half mile of the coast.

Minimum wall thickness for high abutments, at the base, shall be 0.2 times the height of the abutment (footing or pile cap to seat).

Permanent casing shall be provided for CIDH piles within the limits of live load surcharge influence from adjacent active tracks during construction. The SCRRA Excavation Support Guidelines provide limits of live load surcharge.

Positive drainage shall be provided behind abutments. The drainage system shall remove free water as close to the bottom of the abutment as practical.

The positive ground water drainage system shall collect the water from behind the abutment using a drainage blanket and perforated pipe not less than 6 inches in diameter. The drainage blanket can be made from granular material. The drainage system shall be piped to daylight, tied into a curb and gutter system, or tied into a storm sewer system.

Weep holes not less than 4 inches in diameter can be used if the drain water will not have any detrimental impacts on what is in front of the abutment. Weep holes shall be spaced not greater than 5 feet on center and shall have a positive connection between adjacent weep holes and through the back of wall drainage system.

### **10.7.6 PRESTRESSED CONCRETE DESIGN**

All prestressed concrete designs shall conform to this design criteria manual and the following codes as applicable:

Prestressed concrete railroad bridge and other track supporting structures shall be designed in accordance with AREMA Chapter 8 Part 17 – Prestressed Concrete. The design shall

consist of the Load Factor Design method for strength analysis and Service Load Design for behavior. The designer shall refer to ESD6000 of the Engineering Standard Plans.

Concrete shall contain supplementary cementitious materials where necessary to increase durability, resistance to corrosion, and design life. Refer to the Corrosion Chapter of this Design Criteria Manual for additional design requirements.

The minimum yield stress of all non-prestressing reinforcing steel shall be 60,000psi following the criteria of ASTM A615 for standard deformed reinforcing steel or ASTM A706 for weldable reinforcing steel. Pre stressing steel shall conform to one of the following standards; ASTM A416, ASTM A421, or ASTM A722.

Compressive strength for prestressed concrete shall not be specified less than 5,000 psi at 28 days with a minimum of 75% of the compressive strength achieved at transfer.

Prestressing strands shall be of the low-relaxation type meeting ASTM A416 with a minimum ultimate strength of 270ksi.

## **10.8 DEEP FOUNDATIONS**

### **10.8.1 GENERAL**

Deep foundations include driven and drilled piles, and drilled piers, which are otherwise known as drilled shafts. A deep foundation shall be used when a shallow foundation cannot be designed to carry the applied loads safely and economically. It shall also be used where scour, erosion, or unacceptable settlement may occur, even though the bearing capacity of the soil is sufficient to make practical use of shallow foundations.

A geotechnical investigation shall be performed to determine the adequacy of the soil for the preferred foundation. The geotechnical engineer, collaborating with the design engineering, shall make suitable recommendations based on the soil data for the deep foundation system. The geotechnical report will provide site specific design criteria used to develop pile installation depths in accordance with the requirements set forth in the geotechnical chapter of these criteria.

### **10.8.2 CRITERIA FOR DRIVEN AND DRILLED PILES**

The design of driven and drilled piles within the railroad right of way shall be in accordance with AREMA Chapter 8, Part 4.

Consultants shall specify appropriate pile load testing for driven piles. At a minimum Dynamic Pile Driving Analysis (PDA) testing shall be done at every other bent of driven piles for 28ft or smaller spans and at every bent for longer spans.

Consultants shall specify appropriate pile testing for Cast-in-Drilled Hole (CIDH) piles. At a minimum Gamma-Gamma Logging (GGL) to nondestructively evaluate the condition of all (CIDH) piles shall be specified.

### **10.8.3 CRITERIA FOR DRILLED PIERS OR DRILLED SHAFTS**

The design of drilled piers or drilled shafts within the railroad right of way shall be in accordance with AREMA Chapter 8, Part 24.

### **10.8.4 BRIDGE BEARINGS**

Bridge bearings shall be designed in accordance with the AREMA Manual for Railway Engineering, Chapter 15, Part 10.

Material requirements shall be in accordance with the AREMA Manual for Railway Engineering, Chapter 15, Parts 10 and 11. .

Fiber-reinforced elastomeric bearing pads can be selected in the same manner as plain or reinforced elastomeric pads. The requirements for sizing a fiber-reinforced elastomeric bearing pad are provided below.

Random oriented fiber (ROF) reinforced elastomeric bearing pads may be used as bridge bearings without steel reinforcing layers up to 2 inches in thickness. Design of ROF pads shall be in accordance with the AREMA Manual for Railway Engineering, Chapter 15, Steel Structures, Part 10, Bearing Design, for “plain” elastomeric bearings with the following exceptions:

- 1) Modifying factor:  $k = 1.0$
- 2) Allowable compressive stress in psi  $f_a \leq 1000 + 100(S) \leq 1500$  psi
- 3) Allowable compressive deflection,  $d_c \leq 0.15$  (T)  $\leq 0.2$ ”
- 4) Allowable rotation,  $L (a_L) + W (a_W) \leq 0.30$  (T)

See the AREMA Manual for Railway Engineering, Chapter 15, Section 10.6.33, Notations, for variable definitions.

Bridge bearings may be supplemented by additional shear resisting devices mainly to help transfer seismic lateral forces provided that the movement required to engage the shear resisting devices does not cause failure of a bearing device itself under the Level 1 seismic event.

Maintenance considerations of Bridges shall be designed to allow jacking of the span for bearing maintenance under dead load only, during absolute work windows when the track has been taken out of service. The jacking load used for design shall be at least one half of the maximum dead load of the span, including superstructure, ballast, walkways, and track. For steel bridge beams, the end floor beam or diaphragm must be able to carry a single jack load at one end of the bridge, hence 50% of the max dead load of the span for steel bridges. For concrete bridge beams, provisions for the use of flat jacks shall be considered in the pile cap/abutment design by the designer, in particular at lagoon locations.

## **10.9 WATERPROOFING AND PROTECTION**

Waterproofing and waterproofing membrane shall be used on all bridge decks in accordance with AREMA Chapter 8 Part 29.

When hot-mix asphalt (HMA) is used it shall be placed on the decks with a minimum thickness of 2 ½ inches and a maximum thickness of 4 inches.



When HMA is used it shall be crowned with a 1 percent cross slope. When multiple longitudinal deck drains are needed for wide bridges, the HMA shall be crowned between longitudinal deck drains.

## **10.10 CULVERTS**

### **10.10.1 MATERIALS**

Material for culverts shall be in accordance with the AREMA Manual for Railway Engineering, Chapter 1, Part 4; Chapter 8, Part 1; and the LOSSAN Standard Specifications.

Replacement and new drainage structures shall generally be with reinforced concrete box culverts or pipes. Corrugated metal pipe (CMP) is typically not recommended for new construction, unless it's lined, and coated, and approval is obtained from the Principal Design Engineer. The resistivity of the soil backfill shall be considered when proposing the use of CMP. Use of PVC and/or HDPE is not allowed under track. All materials must satisfy the durability design life of the project.

Culverts and storm drains passing beneath tracks or maintenance roadways shall be reinforced concrete pipe rated at 4000D for the entire length of the buried pipe. Culverts and drains 18 inch diameter or less under platforms or in station areas, which are not under tracks, may be Schedule 80 PVC.

### **10.10.2 DESIGN AND DETAILING REQUIREMENTS**

Culverts shall be sized in accordance with the Drainage and Grading Chapter of this DCM.

Precast concrete box culverts shall be in accordance with Chapter 8, Section 10 of the AREMA Manual. Precast concrete box culverts outside the limits of these standards shall be designed in accordance with the AREMA Manual for Railway Engineering, Chapter 8, Part 16.

Cast-in-place concrete box culverts shall be designed in accordance with the AREMA Manual for Railway Engineering, Chapter 8, Part 16.

All culverts shall have a headwall at each end of the culvert. The culverts shall have appropriately flared headwalls to retain the embankment fill.

Energy dissipaters shall be in accordance with the Drainage and Grading Chapter of this DCM and Hydraulic Recommendation reports that are to be developed for the culvert.

## **10.11 TUNNELS**

### **10.11.1 GENERAL – BASIS OF DESIGN**

A Basis of Design Report shall be done during the alternatives analysis phase by the design consultant. Railroad tunnels present significant design, construction, operating and maintenance issues. New tunnels should be avoided if possible. If a tunnel is designed, additional care shall be given to providing a design that provides maximum safety and efficiency of operation and maintenance. Tunnel lining shall be designed in accordance with AREMA Chapter 8, Part 11.

### **10.11.2 MAINTENANCE**

Because of the obvious restrictions in maintenance activity in tunnels, design shall include premium components to maximize service life. Provision for maintenance access in tunnels is also an important design component.

### **10.11.3 CLEARANCES**

Follow the clearance requirements established in Chapter 1 of this Design Criteria Manual.

### **10.11.4 DRAINAGE**

Drainage is a primary concern in tunnels, particularly in terms of service life. Provide the maximum service life by designing drainage structures that will continue to function with substantial clogging.

### **10.11.5 NFPA 130**

NFPA 130 provides recommendations for fire safety in tunnels.

## **10.12 RETAINING WALLS**

The exposed vertical face of a retaining wall supporting tracks shall not be placed closer than 12 feet from the centerline of the nearest track. This clearance may need to increase to allow for construction adjacent to a live track.

The exposed vertical face of retaining walls not supporting tracks adjacent to the tracks shall provide a minimum clearance of 12 feet from the front face of the wall to the centerline of the nearest track. (Per LOSSAN Clearance Standards ESD2101) This clearance may need to increase to allow for construction adjacent to a live track.

Utilities shall not be attached to retaining walls.

Geotechnical subsurface requirements are discussed elsewhere in these guidelines.

Temporary shoring requirements are provided in the SCRRA Excavation Support Guidelines.

### **10.12.1 WALL TYPE SELECTION**

Each site for a retaining wall poses a unique set of circumstances for retaining wall type selection. The wall type selection should take into account the following:

- Subsurface conditions
- Constructability
- Loading conditions
- Aesthetics
- Maintenance
- Project cost

- Design life

Concrete wall types are preferred due to their corrosion resistance and minimum maintenance requirements.

Tie back walls are allowed on cut slopes and fill slopes provided they are outside the trackway zone of railway loading influence.

A wall type selection report must be prepared at the 30% design level and approved by NCTD and SANDAG.

Sufficient maintenance access space shall be provided in the front of the retaining walls for vehicular access where sufficient ROW exists. A five foot wide MOW path shall be provided where there is insufficient ROW in front of the wall.

### **10.12.2 RETAINING WALL DETAILS**

#### **H. Tie Backs**

Tie backs, when required to run below the track structure, shall be a minimum of 5 feet 0 inches below top of rail and shall be below top of subgrade. Consideration shall be made to allow for utilities (current or future) to be installed above the tie back anchors.

Tie backs shall be protected from corrosion. Acceptable methods are fully grouting the tie backs and wrapping the tie backs in a bituminous coating system.

#### **I. Drainage**

Positive drainage shall be provided behind retaining walls. The drainage system shall remove free water as close to the bottom of the retaining wall as practical.

The drainage system shall collect the water from behind the retaining wall using a drainage blanket and perforated pipe not less than 8 inches in diameter. The drainage blanket can be made from granular material. The drainage system shall be piped to daylight, tied into a curb and gutter system, or tied into a storm sewer system.

Weep holes not less than 6 inches in diameter can be used if the drain water will not have any detrimental impacts on what is in front of the retaining wall. Weep holes shall have a positive connection to adjacent weep holes and shall be spaced not greater than 10 feet on center, or as determined by the geotechnical engineer.

### **10.13 MECHANICALLY STABILIZED EARTH (MSE) RETAINING WALLS**

Mechanically Stabilized Earth (MSE) may only be used to support mainline track by design exception approved by the Directory of Engineering. MSE walls are not allowed within NCTD right-of-way adjacent to mainline track in lagoons or floodways. MSE wall types are not preferred for use in supporting railroad loading, but may be considered for other non railroad loading situations. For example when the MSE wall is separated from the mainline track by a ten foot wide maintenance road placed above and adjacent to an MSE retaining wall.

With prior approval by Director of Engineering at NCTD and SANDAG, MSE Walls may be considered where there are space limitations due to constraints such as environmental restrictions, in built-up areas or due to existing structures. MSE walls on LOSSAN shall be

designed in accordance with this LOSSAN Design Criteria taking preference over AREMA and AASHTO guidelines. Special detailing and specifications will be necessary to confirm the design life of an MSE retaining wall. In addition the following requirements are required;

- The maximum wall height shall be 30 feet.
- The design life shall be 100 years. (Note that the first MSE wall in the United States was built in 1971 on State Route 39 near Los Angeles).
- Minimum dead load surcharge shall be 240 PSF to account for future ballast depth of 30 inches.
- The MSE Wall shall also be designed to minimize straps or other structural elements in the top three feet of the subgrade to preserve that space for future signals or other utility uses.
- Limit differential settlements for wall facings as provided in Table 10-3.

<b>Table 10-3 Limiting Differential Settlement</b>		
<b>Facing Type</b>	<b>Joint Width</b>	<b>Limiting Differential Settlement (in/ft of wall)</b>
Precast concrete panel, 5 feet by 5 feet	0.75 inch	1/100
Precast concrete panel, 5 feet by 5 feet	0.50 inch	1/200
Precast concrete panel, 5 feet by 5 feet	0.25 inch	1/300
Full height concrete panel	0.50 inch	1/500
Segmental block		1/200
Wire mesh face		1/50
Geosynthetic wrap face		1/50

Differential settlements predicted by designers to be greater than the values shown in Table 10-3 and total settlements greater than 6 inches shall require ground improvements to reduce the differential settlements and total settlements to the required minimums.

### **10.13.1 BACKFILL SOIL REQUIREMENTS FOR MSE WALLS**

Backfill for MSE walls shall be free draining and shall meet the gradation requirements provided in Table 10-4.

Table 10.4 Backfill soil gradation requirements		
U.S. Sieve Size	Percentage Passing for Steel Reinforcements	Percentage Passing for Geosynthetic Reinforcements
4 inches	100	100
¾ inch		100
No. 40	0-60	0-60
No. 200	0-3	0-3

The quality of the backfill must be assured as the reinforcing straps will be subject to any corrosive ions present in the backfill material. To assist in minimizing the corrosive ions AASHTO has set regulations for both chemical composition of the backfill.

Table 10.5 Backfill Soil Corrosivity testing requirements		
Property	Standard	Test Procedure
Resistivity	> 3000 ohm-cm	AASHTO T-288
pH	10 > pH > 5	AASHTO T-289
Organic Content	1% Max	AASHTO T-267
Chlorides	≤ 100 ppm	ASTM D4327
sulfates	< 200 ppm	ASTM D4327

### 10.13.2 REINFORCEMENT STRAPS AND OR MATS

Steel reinforcement straps shall be designed to have corrosion resistance/durability for the 100-year design life of the wall. Galvanized steel, in accordance with AASHTO specifications, shall be used for reinforcement. PVC coatings, epoxy coatings, and resin bonded epoxy coatings shall not be used on reinforcement. The sacrificial thickness of steel reinforcement shall be in accordance with AASHTO guidelines using the electro-chemical criteria for backfill soils in the AASHTO guidelines.

When selecting steel soil reinforcements there are two options, galvanized steel or black steel. With both options the only available protection measure is to allow for sacrificial thickness of the reinforcement, which is a common protection measure of steel elements embedded in soils as coatings are easily scraped off during placement.

In order to calculate the sacrificial thickness required for both options, the corrosion rates utilized are listed in 10.6. These corrosion rates given by AASHTO are based on the backfill

properties listed in 10.5.

Table 10.6 Corrosion Rates	
Zinc for the first two years	15 $\mu\text{m}/\text{yr.}/\text{side}$
Zinc third year onwards	4 $\mu\text{m}/\text{yr.}/\text{side}$
Carbon steel	12 $\mu\text{m}/\text{yr.}/\text{side}$

The first scenario to analyze is the use of galvanized steel for the soil reinforcement. Assuming the backfill characteristics listed above, a zinc layer thickness of 150  $\mu\text{m}$  would provide sufficient sacrificial thickness for the first 35 years and for the remaining years in service, 780  $\mu\text{m}$  of black steel sacrificial thickness would be required. The second scenario, use of black steel and assuming the backfill characteristics listed above, would require 1200  $\mu\text{m}$  of sacrificial thickness. Table 10.7 below provides a summary of the sacrificial thicknesses calculated.

Table 10.7 – Example of Calculated sacrificial thickness					
Scenario	Steel Type	Material	Sacrificial Thickness required per Side ( $\mu\text{m}$ )	No. Years in service	Total Service Life in Years
1	Galvanized	Zinc	150	35	100
		Black Steel	780	65	
2	Black Steel	Black Steel	1200	100	100

It is important to note that the backfill chemistry is crucial for the steel soil reinforcement to achieve the desired service life. Therefore, quality control should be implemented during placement.

### 10.13.3 GEOSYNTHETIC REINFORCEMENT

Geosynthetic reinforcement may be used for walls in parking garages or for retaining soils that are in landscaped areas not subject to railway loadings.

Geosynthetic reinforcement shall be designed using the appropriate reduction factors for a 100-year design life. The chemical and biological degradation factor ( $RF_D$ ) shall be obtained from the product-specific data. The other reduction factors shall be in accordance with AASHTO guidelines. The creep reduction factor ( $RF_{ID}$ ) and the chemical and biological degradation factor ( $RF_D$ ) shall not be less than 1.1. The backfill shall be in accordance with AASHTO guidelines for electro-chemical criteria for backfills and geosynthetic reinforcements.

Special detailing, specifications, and construction requirements will be necessary to provide the 100 year design life of an MSE retaining wall as follows;

#### **10.13.4 CONCRETE PANELS**

The concrete panels unlike the soil reinforcement will have two exposures. The first is the atmospheric exposure on the visible side of the panels. The atmospheric exposure will differ based on the location of the MSE wall and will be classified in the same manner as all other concrete elements using the four exposures found in the Durability Guide in chapter 14 of this criteria. The other side of the concrete panels will be exposed to the same backfill that is placed around the soil reinforcement.

Assuming that the AASHTO specification listed above are followed for the backfill the exposure is minimal compared to the atmospheric exposure found on the visible side. Therefore, when designing the concrete the atmospheric exposure will be the defining variable. There are several protection mechanisms when it comes to durability of concrete, additional cover to reinforcement, galvanizing reinforcement and better quality concrete made using fly ash, silica fume and corrosion inhibiting admixtures. These measures are well defined in the durability guide in chapter 14 which should be used in selecting the proper concrete cover and quality.

#### **10.14 NORMAL AND MAXIMUM LOAD RATINGS**

Normal and Maximum load ratings shall be performed for all new bridge structures. The ratings shall be calculated in accordance with the Bridge Load Rating Chapter of this DCM. The ratings shall be calculated for the bridge as designed and revised should any as-built condition affect the rating. A Normal rating shall be performed for no speed restriction. A maximum rating shall be performed for no speed restriction and for a reduced speed of 10 mph. The Normal and Maximum Load Rating for each case shall be reported on the front sheet of the bridge drawings.

The FRA definition of a bridge structure (CFR 49 Part 237.5), which is defined as any structure with a deck, regardless of length, that supports one or more railroad tracks, and any other underground structure with an individual span length of 10 feet or more located at such a depth that it is affected by live loads.

#### **10.15 MISCELLANEOUS STRUCTURES**

For any structure owned and maintained by MTS/NCTD within the railroad right of way, but not supporting train loading, shall have live loads applied as stated in AREMA Chapter 6 – Buildings and Support Facilities.

Other structures outside of the railroad right of way shall have live loads developed from the International Building Code with local code amendments applied.

Structures supporting highway traffic loading shall be designed to meet all the live loading requirements as determined by the Caltrans “Highway Design Manual”.

All steel building structures shall be designed in accordance with the latest “American Institute of Steel Construction” (AISC) “Steel Construction Manual” and “Seismic Design Manual”, including their commentary, subject to the design loads conforming to those established by AREMA Chapter 6. Where loading conditions are required that are not defined by AREMA Chapter 6, the designer may use ASCE “Minimum Design Loads for Buildings and Other Structures”.

All reinforced concrete building structures shall be designed in accordance with the latest “Building Code Requirements for Reinforced Concrete” (ACI 318) subject to the design loads conforming to those established by AREMA Chapter 6. Where loading conditions are required that are not defined by AREMA Chapter 6, the designer may use ASCE “Minimum Design Loads for Buildings and Other Structures”.

All prestressed concrete building structures shall be designed in accordance with the latest “Building Code Requirements for Reinforced Concrete” (ACI 318) subject to the design loads conforming to those established by AREMA Chapter 6. Where loading conditions are required that are not defined by AREMA Chapter 6, the designer may use ASCE “Minimum Design Loads for Buildings and Other Structures”.

Piles, drilled piers or shafts for structures supporting highway loads shall be designed in conformance with the Caltrans “Highway Bridge Manual”.

All piles, drilled piers or shafts shall be designed to meet the requirements of the International Building Code and local building code amendments.

## **10.16 TEMPORARY BIRD PROTECTION BARRIERS**

Environmental permit conditions may require temporary bird protection barriers to be erected to protect nesting threatened or endangered species during project construction. These barriers are typically erected along the ROW fence line or Environmentally Sensitive Area (ESA) fence line within 500 feet of where breeding endangered species are found. These barriers are typically constructed of plywood and or sound attenuation blankets depending on how close the nest is from the construction activity and on the noise generated by the construction activity. These temporary barriers are typically needed for only 18 months and can be designed for an appropriate return period that is less than the requirement for permanent works. For temporary bird protection barriers refer to Table 10.8 for wind design data.



<b>Table 10.8 Wind Design Data for Temporary Bird Protection Barriers</b>			
Barrier Distance from nearest Rail	Barrier Height < distance to rail	< 25 ft	>25 ft
Mean Return Interval (MRI in Years)	MRI 50	MRI 25	MRI 10
Wind Speed (MPH)	85	79	72
Wind Pressure End Panels (PSF)	24.8	21.4	17.8
Wind pressure Interior Panels (PSF)	16.5	16.0	16.0

The end panels refer to the first and last freestanding panels in the barrier.

For noise attenuation requirements consult the project biologist and permits and SANDAG/NCTD Environmental staff will obtain approval from USFWS.

## Chapter 11

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## 11.0 BRIDGE LOAD RATINGS

In accordance with DOT FRA requirements, 49CFR Parts 213 and 237 Bridge Safety Standards, a detailed load rating that is representative of a structure's current condition shall be completed for each structure that carries railroad traffic. The load rating methodology, assumptions, analysis methods, and reporting requirements, provided below, shall be followed.

### 11.1 RATING METHODOLOGY

The load rating guidelines, presented herein, supplement the general bridge load rating requirements outlined in the AREMA Manual for Railway Engineering. The following sections of the AREMA manual provide direction on how to rate a railroad structure based on the material it is composed of:

- Chapter 7, Section 2.10, Rules for Rating Existing Wood Bridges and Trestles
- Chapter 8, Section 19, Rating of Existing Concrete Bridges
- Chapter 15, Section 7.3, Rating [of Existing Steel Bridges]

The load rating guidelines serve to provide clarification of AREMA load rating requirements and give direction where the AREMA Manual for Railway Engineering is silent. These guidelines shall supersede AREMA requirements where conflicts exist.

When as built plans for a bridge cannot be located, the bridge engineer must measure and document the configuration of the bridge in sufficient detail to provide an accurate determination of the safe capacity of the existing bridge, and observe the bridge under railroad passenger and freight train traffic. The bridge engineer shall use necessary judgment in applying appropriate rating method that maximizes utilization of AREMA manual and industry accepted evaluation.

Rating engineers" must have minimum 5 years of experience in railroad bridge design and they must submit their resumes to SANDAG/NCTD for approval as a "Designated Bridge Engineer". Once approved, NCTD staff will add the engineer to the "list of Designated Bridge Engineer" within NCTD Bridge Management Program.

### 11.2 PRE-RATING BRIDGE INSPECTION

Prior to load rating any structure, as-built plans shall be located and a pre-rating bridge inspection shall be completed by the rating engineer to verify the following information:

- Actual sections and details conform to the as-built drawings. The inspection should verify that repairs, strengthening, or other modifications have not occurred; if they have, dimensions should be recorded to determine accurate section properties and dead loads.
- An estimate of any additional dead load that has been added to the structure.
- Position of the track relative to the centerline of the structure.

- Superelevation of the track across the bridge.
- Degree of curvature of the track across the bridge.
- Horizontal and vertical alignment of the track over the bridge.
- Uneven settlement of piers.
- Structural condition of all members of the bridge, noting any deficiencies, defects, or deterioration that may exist that affect the load rating of the member or cause the rating of other members to be required. At a minimum, the following structural conditions should be noted:
  - Timber member rot or decay
  - Concrete condition (spalls, cracking, lost concrete, rust-colored efflorescence)
  - Reduction in steel reinforcement area
  - Steel member corrosion or section loss
  - Loose rivets, bolts, or connections in any type of member
  - Crooked or damaged members
  - Cracked welds

In addition to the above, the operating speed of the track shall be determined in order to accurately determine the impact factor that shall be applied to the bridge.

The intent of the inspection is to verify that the load rating engineer has accurate information of the condition of the structure and that all factors are appropriately considered during the load rating process. The load rating engineer needs to exercise engineering judgment to determine what defects, if any, found during the inspection are necessary to include in the rating.

The current AREMA Bridge Inspection Handbook provides further direction on how to conduct a thorough bridge inspection of a railroad structure. Each inspection should be coordinated with the NCTD Engineer and shall conform to all NCTD safety and procedural requirements between MP 207.4 and 247.7. In addition between MP 247.7 and MP 267.5 each inspection should be coordinated with the NCTD/MTS Engineer and shall conform to all NCTD and MTS safety and procedural requirements.

### 11.3 RATING LEVELS

Depending on the material type of the member, the component being rated may have up to three different ratings determined-Normal (Strength, Fatigue) and Maximum-which are described below:

- The Normal Rating of a structure (or component) is the load level that the structure can support on a repetitive basis for its expected service life. A Normal Rating is the lowest of a Strength Rating and a Fatigue Rating, as follows:
  - The Strength Rating of a structure (or component) is based on the full loading (Dead, Live, Impact, etc.) characteristics of the structure compared to design-level allowable member stresses or capacities.

- The Fatigue Rating of a structure (or component) applies only to steel spans or mild reinforcing in concrete that is in tension and considers the type of fabrication and assembly, as well as the cyclic characteristics of the Live Load. If necessary, the structure's Load History and projected future Live Loading can be used to predict the remaining fatigue life of the structure.
- The Maximum Rating of a structure (or component) is the maximum load level that the structure can support at infrequent intervals. It is based on the full loading (Dead, Live, Impact, etc.) characteristics of the structure compared to maximum overload-level member stresses or capacities.

The AREMA Manual for Railway Engineering includes the Fatigue Rating as part of the Normal Rating process, the results of which can sometimes mask the Strength capacity of a member. The Strength Rating of the bridge is a measure of its structural load capacity and indicates if the bridge is structurally deficient, whereas the Fatigue Rating is based on a reduced allowable live load stress range that varies based on the type of member and fabrication details. The risk associated with fatigue-sensitive bridge details can be mitigated through enhanced inspection intervals and techniques and are less severe on inherently redundant structures. For this reason, the Fatigue Rating of a bridge or component shall be listed separately from the Strength Rating and both shall be included under the Normal Rating heading. The Normal Rating of a structure is the lowest of the Strength or Fatigue Rating; conditions or details exist where either the Strength or the Fatigue Rating can control.

A detailed calculation of a structure's remaining life based on its load history and predicted Live Load shall only be done at the direction of the Director of Engineering.

### **11.3.1 TIMBER BRIDGES**

Timber bridges or components are only rated for Normal (Strength) and Maximum levels per the AREMA Manual for Railway Engineering, Chapter 7, Section 2.10.14. The Normal (Strength) rating is to be completed using allowable stresses for "Regularly Assigned Equipment or Locomotives," and the Maximum rating is to be completed using allowable stresses for "Equipment or Locomotives Not Regularly Assigned."

Timber bridges shall be rated using service level methods (i.e., working stress design, allowable stress design).

### **11.3.2 CONCRETE BRIDGES**

All concrete bridges or components are to be rated for Normal (Strength, Fatigue) and Maximum levels per the AREMA Manual for Railway Engineering, Chapter 8, Sections 19.2.2 and 19.2.3. The Normal (Fatigue) Rating of mild steel reinforcement in concrete in tension shall be determined per the AREMA Manual for Railway Engineering, Chapter 8, Section 2.26.2b.

Concrete bridges or components may be rated using service or strength level methods for either Normal (Strength) or Maximum rating levels. The service level rating method must be used to determine the Normal (Fatigue) rating of steel reinforcement in tension.

The AREMA Manual for Railway Engineering, Chapter 8, Sections 2.25 through 2.29, describe how to determine a concrete member's capacity using service level rating methods; Sections 2.30 through 2.39 describe how to determine a concrete member's capacity using strength design methods.

### **11.3.3 STEEL BRIDGES**

All steel bridges or components are to be rated for Normal (Strength, Fatigue) and Maximum levels per the AREMA Manual for Railway Engineering, Chapter 15, Sections 7.3.1.1 and 7.3.1.2.

Most steel members of a bridge will require a Normal (Fatigue) rating to be performed, unless the member does not experience tension due to live load effects or the bridge/component carries less than 5 million gross tons per year of mixed traffic (AREMA Manual for Railway Engineering, Chapter 15, Section 7.3.4.2a).

Steel bridges or components shall be rated using service level methods for Normal (Strength, Fatigue) and Maximum Rating levels.

## **11.4 LOADS TO CONSIDER FOR RATING**

Generally, the loads to be considered when determining a structure's rating are the same types that are considered during design. However, the loads applied to the structure are to represent the current conditions on the structure, and the live load effects shall be proportioned to equivalent levels that maximize a component's loading.

### **11.4.1 DEAD LOAD**

The dead load applied to a structure shall be based on the conditions observed during the inspection. Actual depth of ballast measured in the field shall be used. Appropriate weight shall be included for items that have been added to the structure since it was originally built (utilities, walkways, span protection devices, etc.).

Assumed material unit weights shall be as directed by the AREMA Manual for Railway Engineering, Chapter 7, Section 2.5.2; Chapter 8, Section 2.2.3b; or Chapter 15, Section 1.3.2.

Actual weights of steel members shall be calculated in accordance with the as-built plans or the field inspection. Estimates of member weight that increase the primary member's weight by a percentage to account for bracing, bolts, etc., will be allowed, but shall be refined if any member does not meet the required rating levels determined in Section 11.9, Equipment Demands on Structures, below.

### **11.4.2 LIVE LOAD**

The results of a rating analysis shall indicate the maximum Cooper's Equivalent load that the structure can handle for the Normal (Strength, Fatigue), and Maximum rating levels. As a result, the live load that shall be applied to the structure to determine the rating shall be the

Cooper E80 live load as detailed in the AREMA Manual for Railway Engineering, Chapter 8, Section 2.2.3c, or Chapter 15, Section 1.3.3, or an equivalent that uses the same axle spacing but has a proportional reduction or increase in the axle and uniform load (that is, the heaviest axle in an E-1 load shall be 1 kip). The Cooper E80 live load is shown in Section 11.9 Equipment Demands on Structures, Figure 11-1 below, for reference.

### **11.4.3 IMPACT**

For timber structures, increases in the live load effect due to impact have not been well established, but are expected to be less than the increase in allowable stresses that result from load duration multipliers that are used to determine allowable stress levels per the AREMA Manual for Railway Engineering, Chapter 7, Section 2.5.5.6. As a result, impact does not need to be applied to timber structures or components.

For concrete or steel bridges, the impact factor applied to the live load on the bridge or member shall be as follows:

- Concrete – per the AREMA Manual for Railway Engineering, Chapter 8, Section 2.2.3d, reduced for operating speed per Chapter 8, Section 19.3.4b
- Steel members – per Chapter 15, Section 1.3.5, reduced for operating speed per AREMA Chapter 15, Section 7.3.3.3

Considerations shall be made for length of bridge, ballast deck spans, rocking effect of cars, and type of locomotive, as appropriate.

The impact load for the Normal (Fatigue) Rating for steel members shall be reduced per the AREMA Manual for Railway Engineering, Chapter 15, Section 1.3.13.

### **11.4.4 CENTRIFUGAL FORCE**

If the track across the bridge is not tangent and has either a spiral or a circular curve, the live load effects shall be amplified for centrifugal force effects. Centrifugal force effects shall be calculated using the standard AREMA equation from either Chapter 7, Section 2.5.4; Chapter 8, Section 2.2.3.e; or Chapter 15, Section 1.3.6, except the center of gravity of the live load application shall be assumed to be 8 feet above the top of rail in all cases.

The maximum degree of curvature of the track across the bridge (measured in the field during the inspection) and the timetable operating speed shall be used in the centrifugal force equation. Track position relative to the centerline of the structure shall also be used to amplify/reduce live load force effects as appropriate.

### **11.4.5 LONGITUDINAL FORCE**

Longitudinal force effects due to train braking and traction forces manifest themselves in the superstructure by increasing or decreasing train car truck vertical reactions due to the center of force (drawbar elevation or center of gravity) acting above the top of rail elevation. As a result, axial forces, shear forces, and bending moments in the superstructure may increase.

Longitudinal force shall be determined per the AREMA Manual for Railway Engineering, Chapter 8, Section 2.2.3.j, or Chapter 15, Section 1.3.12; Chapter 7, Section 2.5.5.4.a, need



not apply for timber structures, and instead, the provisions of the concrete or steel sections shall be used. For the purposes of determining force coupling effects, an idealized consist of cars with trucks 30 feet apart on the same car and 10 feet apart on adjacent cars shall be assumed to determine the force effects on the superstructure.

#### **11.4.6 EARTH PRESSURE**

For arch structures filled with soil, the earth pressures that shall be applied to the masonry or concrete arches and their spandrel walls shall be calculated and applied in accordance with the AREMA Manual for Railway Engineering, Chapter 8, Part 5.

If as-built information regarding the soil used to fill the arch is not available, the soil shall be assumed to be dense sand with a friction angle of 45 degrees.

#### **11.4.7 OTHER LOADS**

Other lateral loads will not be required to be considered unless the bridge appears inadequate for buoyancy, wind effects, stream flow, ice pressure, or other forces.

### **11.5 BRIDGE MATERIAL ALLOWABLE CAPACITIES**

Allowable member capacities, either working stress or ultimate strength, shall be based on the material used during construction and will vary significantly depending on the year the structure was built. Preferably, as-built plans will exist for the structure that will specify the material grade, type, or species used during construction. If as-built plans are not available, the load rating engineer shall use the age of the structure along with historical data of typical material strengths that were predominant in the era of the bridge to determine the material properties of the structure. Material testing of the actual bridge materials shall not be done without approval from NCTD/MTS and or the Director of Engineering.

#### **11.5.1 TIMBER**

The species of the timber of an existing bridge shall be determined from as-built plans or from the standard plans used by the railroad that originally constructed the bridge. If as-built or standard plans are not available, the species of the wood shall be assumed based on what was predominantly used in the area at the time.

Allowable stresses to be used to determine the Normal (Strength) Rating of the structure or component shall be per the AREMA Manual for Railway Engineering, Chapter 7, Section 2.10.14.

#### **11.5.2 CONCRETE**

The compressive strength of the concrete, yield strength of the mild reinforcement, or ultimate strength of the prestressing strands shall be assumed to match the design requirements listed on the as-built plans, unless field observations or construction documentation suggests that reduced values should be used. If as-built plans are unavailable and the material strengths are unknown, the load rating engineer shall use the age of the structure along with historical data of typical material strengths that were

predominant in the area of the bridge to determine the material properties of the structure. If information specific to the area cannot be found, the AREMA Manual for Railway Engineering, Chapter 8, Sections 19.4.1.1 and 19.4.2.2.2, provide suggested values to use for concrete and reinforcement capacity.

#### A. Service Level Methods

For Normal and Maximum Rating levels, conventionally reinforced concrete's permissible stress shall be per the AREMA Manual for Railway Engineering, Chapter 8, Section 19.4.1.2a, and modified as appropriate using strength modification factors in the load rating equations in Chapter 8, Section 19.5.3.1.

For the Normal (Strength) Rating level, mild reinforcement steel's permissible stress shall be 1.2 times the allowable levels provided in the AREMA Manual for Railway Engineering, Chapter 8, Section 2.26.2a. For the Normal (Fatigue) Rating level, the permissible live load stress in mild reinforcement shall be limited to 1.2 times the allowable level per Chapter 8, Section 2.26.2b, and should only be checked using Equation 19-1 per the AREMA Manual for Railway Engineering, Chapter 8, Section 19.5.3. For the Maximum Rating level, mild reinforcement steel's permissible stress shall be per Chapter 8, Section 19.4.2.1, divided by 1.2.

For Normal (Strength) and Maximum rating levels, prestressed concrete's permissible stress shall be per the AREMA Manual for Railway Engineering, Chapter 8, Section 17.16.2.2, and modified per Chapter 8, Section 19.4.1.2a.

#### B. Load Factor Methods

The nominal strength capacity of a concrete member is calculated in the same manner for Normal (Strength) and Maximum Rating levels and is described in the AREMA Manual for Railway Engineering, Chapter 8, Sections 2.30 through 2.39. The differences between a Normal (Strength) and Maximum Rating result from the different load factors used in equations 19-7, 19-8, 19-10, and 19-11.

### **11.5.3 STEEL**

The yield and/or ultimate strength of the steel used in a steel bridge or component shall be determined from as-built plans or from the standard plans used by the railroad that originally constructed the bridge. If as-built plans are unavailable and the material strength is unknown, the load rating engineer shall use the age of the structure along with historical data of typical material strengths that were predominant in the area of the bridge to determine the material properties of the structure. The AREMA Manual for Railway Engineering, Chapter 15, Section 7.3.4.3a, provides suggested values to use for various types of steel.

Allowable stresses to be used for the Normal (Strength) Rating shall be per Chapter 15, Table 15-1-11.

Allowable stresses to be used for the Normal (Fatigue) Rating shall be per Chapter 15, Section 7.3.4.2.

Allowable stresses to be used for the Maximum Rating shall be per Chapter 15, Table 15-7-1, as described in Chapter 15, Section 7.3.4.3.b.

## 11.6 BRIDGE MEMBER SECTION PROPERTIES

Section properties of bridge components for both dead load calculations and geometric properties shall be based on the as-built plans supplemented with field observations. Calculated geometric properties shall accurately account for loss of section due to corrosion, damage, or wear.

For steel members, gross or net section properties shall be calculated as appropriate and shall account for the actual, in-situ condition or bolt/rivet pattern. Gross properties for dead load calculations may be overestimated by factoring up the primary member's gross area by a percentage to account for bracing, bolts, etc., but shall be refined if any member does not meet the required rating levels determined in Section 8.9, Equipment Demands on Structures, below. Net section properties shall be based on the actual net section; the net width maximum of 85 percent of the gross width allowed in the AREMA Manual for Railway Engineering, Chapter 15, Section 1.5.8b, shall not be used as an upper limit or estimate for net section properties of an element in bending.

## 11.7 REQUIRED RATING CHECKS AND ANALYSIS METHODS PER BRIDGE COMPONENT

Any rail supporting structure with a span length over 10 feet constitutes a bridge per the FRA definition and shall be rated.

Axial forces, shear forces, and bending moments shall be determined from an analysis that is consistent with the member support and connection conditions. Simple span support assumptions shall be used where the assumption matches the existing condition of the member, or where it would be conservative to assume a simple span condition. The following sections have suggestions for analysis methods; alternative rational analysis methods that provide the appropriate level of accuracy and detail may be used at the engineer's discretion.

Span deflections need not be checked unless the span is over a roadway.

Diaphragms, horizontal cross-bracing, lateral cross-bracing, and other secondary members themselves need not be rated unless the inspection reveals that such members are being overstressed. In all cases, the condition of secondary members used to laterally brace primary components shall be accounted for in the rating of primary members.

Components subject to combined loading effects (axial and bending effects) shall use the appropriate interaction equation that combines such effects.

### 11.7.1 OPEN-DECK TIMBER TIES

Timber ties that rest directly on the top flanges of the steel beams that comprise the superstructure are structural members and need to be evaluated and rated if their sizes do not meet the current LOSSAN design criteria, as shown in Table 11-1, or if their current condition justifies an analysis. Open-deck ties shall be rated for bending moment, shear, and bearing (between the bottom of the tie and the supporting top flange). Timber ties supported by chorded timber stringers do not need to be rated if the stringer chords are located directly beneath each rail.

Table 11.1 Open Deck Timber Ties	
Beam Spacing (#/track)	Minimum Tie Depth
5'-0"* (4/track)	7 1/8"
3'-9" (3/track)	8 1/8"
4'-0" (3/track)	9 1/2"
5'-0" (3/track)	11"
6'-0" (2/track)	6 1/8"
6'-6" (2/track)	7 1/2"
7'-0" (2/track)	9 1/4"
7'-6" (2/track)	10 1/2"
8'-0" (2/track)	12"
8'-6" (2/track)	15 1/2"
9'-0" (2/track)	16 1/2"
10'-0" (2/track)	18 3/8"

\* 2 beams/chord with 5'-0" between chord centerlines.  
 Ties shall extend a minimum of 1'-0" from CL of exterior beam or shall be 10'-0" minimum.  
 All ties shall be Douglas Fir.

Open-deck ties shall be analyzed as continuous beams, as appropriate, and modeled with one of the following possible support conditions provided by the supporting beams:

1. Point supports at each beam centerline
2. Point supports at each edge of the top flange (two supports per beam)
3. Uniform bearing pressure across the whole top flange

Longitudinal distribution of an axle load shall be per the AREMA Manual for Railway Engineering, Chapter 15, Section 1.3.4.1.

### 11.7.2 TIMBER DECK PLANKS

Timber deck planks that serve as the ballast pan of ballast deck bridges that rest on the top flanges of the beams that comprise the superstructure are structural members and need to be evaluated and rated if their sizes do not meet current BNSF or UP criteria (whichever is more stringent) or if their current condition justifies an analysis. Timber deck planks shall be rated for bending moment, shear, and bearing (between the bottom of the plank and the supporting top flange).

Timber deck planks shall be analyzed as continuous beams, as appropriate, and modeled with one of the possible support conditions listed in Section 11.7.1, Open-Deck Timber Ties, above. Distribution of an axle load shall be per the AREMA Manual for Railway Engineering, Chapter 15, Section 1.3.4.2.2.

### **11.7.3 TIMBER STRINGERS**

Timber stringers shall be rated for bending moment, horizontal shear, and compression perpendicular to grain.

Analysis of the stringers shall account for the continuity that may exist across bent caps due to the arrangement and layout of stringers within each chord that is typical of timber trestle construction, as discussed in the AREMA Manual for Railway Engineering, Chapter 7, Section 2.10.5c.

### **11.7.4 TIMBER PILE CAPS AND PILES**

Primary timber trestle substructure components shall be rated.

A standard bent with driven timber piling and a timber pile cap shall be modeled as a continuous beam (pile cap) on elastic springs (piles). The springs shall be calculated based on the piles' axial stiffness with an assumed depth to fixity of 10 feet, or as appropriate to the bridge site conditions.

Pile caps shall be rated for bending moment, horizontal shear, and compression perpendicular to grain. Piles shall be rated for axial capacity only. If design information does not exist, the allowable axial capacity shall be assumed to be 20 tons.

### **11.7.5 MASONRY ARCHES**

Masonry arch structures with a span length from spring line to spring line that is greater than 10 feet shall be rated. Masonry arch structures may be rated using any reasonable method that accounts for the passive resistance of the contained soil, the load path of the train effects onto the arch and spandrels, and the lack of tensile capacity of a masonry structure (unless it is somehow reinforced).

The arch component shall be rated based on its compressive capacity. A spandrel wall shall be rated for overturning and sliding; bearing pressure need not be checked.

Several different methods of analysis have been developed by engineers in the railroad industry in recent years. Further direction is provided in the 2001 and 2009 AREMA Conference Proceedings.

### **11.7.6 REINFORCED CONCRETE BOX CULVERTS**

Reinforced concrete box culverts with a span(s) over 10 feet shall be rated for positive/negative bending moment and shear on all slabs adjacent to soil and for axial compression on interior walls supporting the top slab.

Analysis of a reinforced concrete box culvert may be done in accordance with the AREMA Manual for Railway Engineering, Chapter 8, Section 16.4.2e. Alternatively, the box culvert may be modeled using assumed non-linear soil spring restraints at 1-foot intervals around the perimeter of the box with the appropriate loads applied perpendicular to each face of the box; in this analysis, the model shall not be rigidly supported at any node.

### **11.7.7 CONCRETE DECKS**

Concrete decks (composite and non-composite, conventionally reinforced and/or prestressed) shall be rated for positive/negative bending moment and shear in the transverse direction. In the transverse direction, the deck shall be modeled as a continuous beam with point supports at each beam centerline. Reinforcing steel fatigue checks need not be made for concrete decks in multi-beam applications.

In the longitudinal direction, rating of a composite concrete deck shall be included during the longitudinal beam rating of the structure and shall include a horizontal shear rating at the interface between the bottom of the deck and the top of the beam.

### **11.7.8 CONVENTIONALLY REINFORCED CONCRETE BEAMS**

Reinforced concrete beams with mild reinforcing shall be rated for positive bending moment and shear; beams shall be rated for negative bending moment if appropriate. At a minimum, ratings shall be completed at the section with maximum positive bending moment and at a distance “d” from the face of the support for shear; additional sections shall be rated if longitudinal reinforcing is not continuous or where transverse shear reinforcing changes spacing or size.

Composite action between a concrete deck and the beams may be used if an adequate shear transfer mechanism exists between the deck and the beams.

### **11.7.9 PRESTRESSED/POST-TENSIONED CONCRETE BEAMS**

Concrete beams with high-strength pre-stressing or post-tensioned strands shall be rated at service level and at strength level. Service level rating checks shall consist of a concrete compression stress rating, a concrete tension stress rating, and a pre-stressing / post-tensioning strand stress rating. Strength level checks shall consist of shear and positive moment ratings. At a minimum, ratings shall be completed at the section with maximum positive bending moment and at a distance “d” from the face of the support for shear; additional sections shall be rated if pre-stressing strands are harped or where transverse shear reinforcing changes spacing or size.

Composite action between a concrete deck and the beams may be used if an adequate shear transfer mechanism exists between the deck and the beams.

### **11.7.10 STEEL BALLAST PAN**

Steel plates that serve as the ballast pan of ballast deck bridges that rest on the top flanges of the beams that comprise the superstructure are structural members and need to be evaluated and rated. Steel ballast pans shall be rated for bending moment.

Steel ballast pans shall be analyzed as continuous beams, as appropriate, and modeled with one of the possible support conditions listed in Section 11.7.1, Open-Deck Timber Ties, above. Distribution of an axle load shall be per the AREMA Manual for Railway Engineering, Chapter 15, Section 1.3.4.2.2.

### **11.7.11 STEEL ROLLED BEAM SPANS**

Steel rolled beam spans shall be rated for bending moment and shear at the locations of maximum demand. If the beams are spliced, the splices shall be rated for the checks listed in Section 11.7.17, Splices in Steel Members, below.

Loads shall be appropriately distributed to each beam line according to the deck conditions, the bracing and diaphragm spacing, and the location of each beam relative to the group and centerline track. Further guidance on both open-deck and ballast-deck spans is provided in the AREMA Manual for Railway Engineering, Chapter 15, Section 1.3.4.

### **11.7.12 STEEL DECK PLATE GIRDERS**

Steel riveted/bolted/welded deck plate girder spans shall be rated for bending moment and shear at the locations of maximum demand and at all locations where the beam changes section properties. If the girders are spliced, the splices shall be rated for the checks listed in Section 11.7.17, Splices in Steel Members, below.

Loads shall be appropriately distributed to each girder line according to the deck conditions, the bracing and diaphragm spacing, and the location of each girder relative to the group and centerline track. Further guidance is provided in the AREMA Manual for Railway Engineering, Chapter 15, Section 1.3.4.

### **11.7.13 STEEL THROUGH-PLATE GIRDERS**

Steel TPG spans are built in a variety of ways, but generally are comprised of a flooring system that supports the track which transfers load to the TPGs on the outside of the track(s). The following sections detail the required rating checks that are to be made for TPG spans, as appropriate.

#### **A. Stringers**

Stringers that span between floor beams may be made up of either rolled beams or built-up members. In accordance with the AREMA Manual for Railway Engineering, Chapter 15, Section 1.2.7, stringers shall be assumed to be a simple span from centerline to centerline of the floor beams.

Stringers shall be rated in accordance with Section 11.7.11, Steel Rolled Beam Spans, or Section 11.7.12, Steel Deck Plate Girders, above, depending on if they are rolled shapes or built-up members, respectively.

#### **B. Floor beams**

Floor beams that span between TPGs may be made up of either rolled beams or built-up members. In accordance with the AREMA Manual for Railway Engineering, Chapter 15, Section 1.2.7, floor beams shall be assumed to be a simple span from centerline to centerline of TPGs. The shear and flexural rating of the floor beams shall account for the bracing load in Chapter 15, Section 1.3.11.

Floor beams shall be rated in accordance with Section 11.7.11, Steel Rolled Beam Spans, or Section 11.7.12, Steel Deck Plate Girders, above, depending on if they are rolled shapes or built-up members, respectively.

#### C. Through Plate Girders (TPG)

TPGs are usually steel riveted, bolted, or welded built-up members that are designed as a simple span member between bent or pier supports. Track loads shall be appropriately distributed to each TPG line considering track superelevation and position.

TPGs shall be rated in accordance with Section 11.7.12, Steel Deck Plate Girders, above, including the splice requirements discussed in Section 11.7.17, Splices in Steel Members, below.

### **11.7.14 STEEL TRUSSES**

Steel truss spans usually consist of a flooring system that supports the track which transfers the load to each truss line, either below or adjacent to the track. The following details the required rating checks that are to be made for various members of the truss spans, as appropriate.

#### A. Stringers

Stringers that span between floor beams may be made up of either rolled beams or built-up members. In accordance with the AREMA Manual for Railway Engineering, Chapter 15, Section 1.2.7, stringers shall be assumed to be a simple span from centerline to centerline of floor beams.

Stringers shall be rated in accordance with Section 11.7.11, Steel Rolled Beam Spans, or Section 11.7.12, Steel Deck Plate Girders, above, depending on if they are rolled shapes or built-up members, respectively.

#### B. Floor beams

Floor beams that span between truss lines may be made up of either rolled beams or built-up members. In accordance with the AREMA Manual for Railway Engineering, Chapter 15, Section 1.2.7, floor beams shall be assumed to be a simple span from centerline to centerline of trusses.

Floor beams shall be rated in accordance with Section 11.7.11, Steel Rolled Beam Spans, or Section 11.7.12, Steel Deck Plate Girders, above, depending on if they are rolled shapes or built-up members, respectively.

#### C. Trusses

Each individual member in a truss line shall be rated for axial tension or compression (or both), as applicable, using the maximum forces that develop in the truss configuration based on the track configuration and location. The following ratings shall be made per truss member type:

- Tension Members – Rate for yield on the gross section (with special consideration for eyebars) and fracture on the net section.



- Compression Members – Rate for gross axial compression.
- Dual Members – Rate for all tension member and compression member limit states.

#### D. Pins

Pins used to connect individual truss members together (except at bearings) shall be rated for flexure and shear. The actual position of the members attached to the pin shall be determined during the inspection to ensure that forces are accurately applied to the pin during the rating.

#### **11.7.15 BEARINGS**

Bearings shall generally not be required to be rated unless the inspection results indicate a need for a bearing to be analyzed. If necessary, pins shall be rated as described above, and all other bearings shall be rated for compression (or bearing) on the materials (typically concrete, steel, or elastomer) that are in contact. Load transfer may generally be assumed to follow a 1:1 slope from the top contact plane through a material to the bottom contact plane, unless limited by the dimensions of the layer.

#### **11.7.16 CONNECTIONS**

The capacity of connections between primary members (stringer to floor beam, floor beam to TPG, etc.) shall be rated for a minimum of bolt/rivet shear and bearing or weld/base metal shear capacity.

Connections between secondary and primary members need not be rated; however, the bracing capacity of secondary members shall be accurately accommodated during the rating of the primary member.

#### **11.7.17 SPLICES IN STEEL MEMBERS**

A primary superstructure member that is spliced shall have additional rating analyses performed on the splice itself. Typically, steel beams, DPGs, or TPGs are only spliced as a result of shipping or weight limitations that may have existed during fabrication; truss members are generally spliced at changes in section or to facilitate field erection. If other types of members are spliced, special consideration shall be required and coordinated with the Director of Engineering.

The following checks need to be made for steel I-shaped members and steel truss chords that are spliced:

- Top Flange/Compression Chord Splice – Verify that the splice plate area is greater than the flange being spliced, rate axial stress in the splice plate, and rate the connection material (weld, bolt, rivet) stress for shear flow and load transfer effects.
- Web (Shear) Splice – Verify that the splice plate area and net moment of inertia are greater than the web being spliced, rate the flexural capacity of the splice

plates, and rate the rivet or bolt capacity. Rating calculations shall include bending and eccentric load effects on the plates and bolts/rivets.

- Bottom Flange/Tension Chord Splice – Verify that the splice plate area is greater than the flange being spliced, rate axial stress in splice plate for yield on the gross and fracture on the net, and rate the connection material (weld, bolt, rivet) stress for shear flow and load transfer effects.

## 11.8 SUBSTRUCTURE RATING

A rating (Normal, Maximum) for a substructure component is generally not required unless the field inspection indicates signs of settlement, cracking, deflection, etc., that suggest the capacity of the substructure member is deficient.

If a substructure rating is determined to be necessary, adequate as-built information is required of the foundation type, materials, extents, etc., in order for an accurate rating to be completed. If adequate information does not exist to rate the substructure component, a permanent repair (or temporary repair until a permanent one can be completed) may be required in lieu of a load rating calculation.

## 11.9 EQUIPMENT DEMANDS ON STRUCTURES

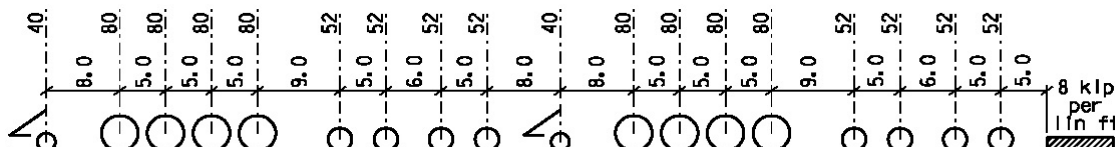
Once the controlling Normal (Strength, Fatigue) and Maximum Load Rating levels of all required elements has been determined, the demand required by typical train consists on tracks shall be calculated and contrasted to a member's capacity in order to determine which structures or components do not have the requisite strength necessary to carry the load.

The Normal (Strength) Rating comparison shall be used to determine structural repair or replacement recommendations and the immediacy with which they should be completed. The Normal (Fatigue) Rating comparison, where necessary, shall be used to estimate the structures or component's remaining life. The Maximum Rating shall be kept on file and used where infrequent heavy load clearance authorization is required.

Figures 11-1 through 11-7, below, have units of kips and feet. In all cases except the Cooper E80 consist, the number of trailing passenger or freight cars shall be extended to maximize the load on a long span, if necessary.

### 11.9.1 COOPER E80 CONSIST

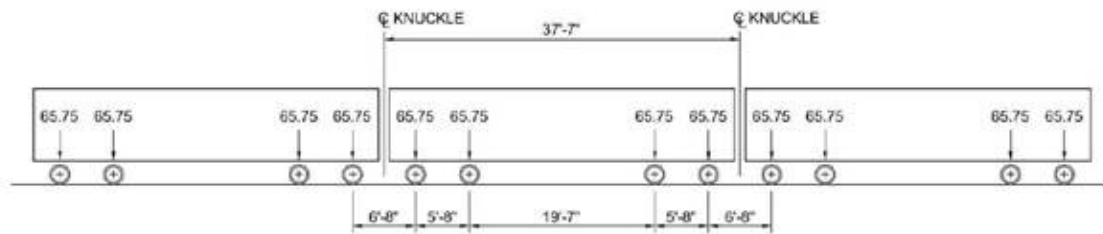
For reference, the Cooper E80 consist is shown in Figure 11-1 and shall be used as the basis for the load rating capacity calculations and the typical train consist demand requirements of a bridge component. All capacities and consist demands shall be listed as a Cooper's Equivalent.



**FIGURE 11-1 – Cooper E80**

**11.9.2 263-KIP GROSS WEIGHT FREIGHT CAR UNIT TRAIN CONSIST**

A typical 263-kip gross weight freight car unit train consist is shown in Figure 11-2



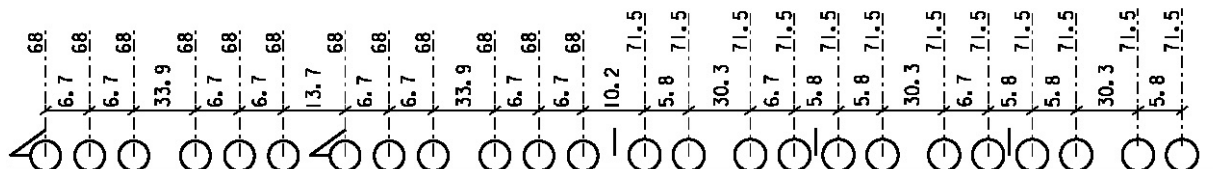
**263 K LOADING**

RATINGS ARE EXPRESSED IN KIPS PROPORTIONAL TO THE 263 KIP RAIL CAR SHOWN  
(THE RATINGS FOR THE 286 KIP RAIL CAR AND THE 263 KIP RAIL CAR ARE PROPORTIONATE)

**FIGURE 11-2 263 Kip freight**

**11.9.3 286-KIP GROSS WEIGHT FREIGHT CAR UNIT TRAIN CONSIST**

A typical 286-kip gross weight freight car unit train consist is shown in Figure 11-3. It assumes two SD70AC locomotives are pulling a consist of 286-kip freight cars.



**FIGURE 11-3 286 Kip freight**

### 11.9.4 315-KIP GROSS WEIGHT FREIGHT CAR UNIT TRAIN CONSIST

A typical 315-kip gross weight freight car unit train consist is shown in Figure 11-4. It assumes two SD70AC locomotives are pulling a consist of 315-kip freight cars.

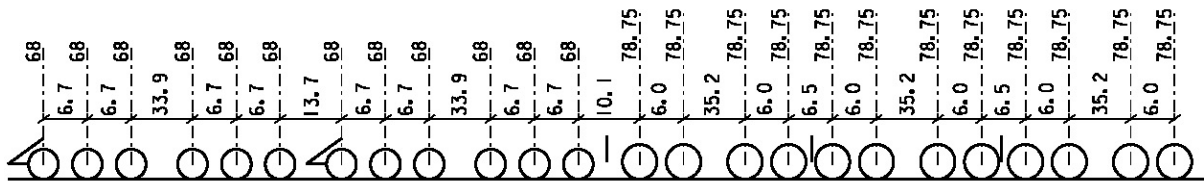


FIGURE 11-4 315 Kip freight

### 11.10 125-TON INTERMODAL DOUBLE STACK UNIT TRAIN CONSIST

A typical intermodal unit train consist is shown in Figure 11-5. It assumes two SD70AC locomotives are pulling a consist of 125-ton five-unit articulated intermodal well cars.

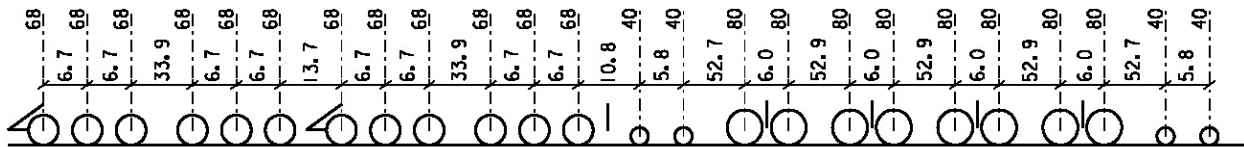
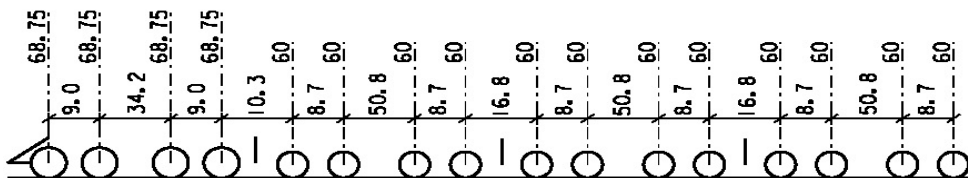


FIGURE 11-5 125 ton Intermodal Double Stack

**11.10.1 AMTRAK PASSENGER TRAIN CONSIST**

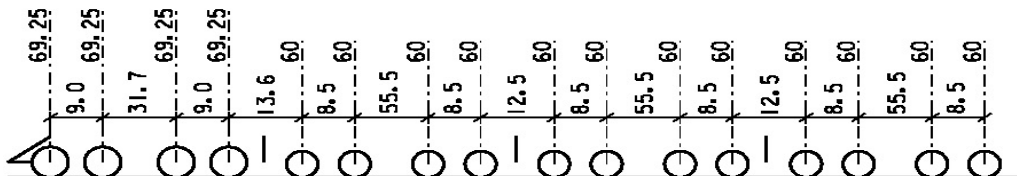
A typical Amtrak passenger train is shown in Figure 11-6. It assumes a single GE Genesis Series 1 locomotive pulling several Superliner coach cars.



**FIGURE 11-6 Amtrak**

**11.10.2 NCTD COASTER - BOMBARDIER BI-LEVEL PASSENGER TRAIN CONSIST**

A typical passenger train is shown in Figure 11-7. It assumes a single F40PHM locomotive pulling several Bombardier coach cars.



**FIGURE 11-7 Coaster**

### 11.11 RATING RESULTS FORMAT

The Normal (Strength, Fatigue) and Maximum Ratings for each member and for each required check shall be listed in tabular format and compared to the typical consist demands that occur over that bridge. The controlling Normal Rating (lowest between Strength and Fatigue) for each check performed shall be shown in **bold** text. A sample table for a steel rolled beam stringer that is not spliced with bolted connections is provided in Table 11-2.

The load rating report shall indicate any members whose ratings are below the actual train demands on the structure and shall suggest and recommend ways to safely carry train traffic.

TABLE 11-2 Sample Member Rating Table							
Rating Check		Normal		Maximum	286-kip Unit Train	Amtrak Passenger Train	Bombardier Bi-Level Passenger Train
		Strength	Fatigue				
Stringer Rating As-Built / Existing Conditions	Flexure	<b>E-72.1</b>	E-140.0	E-114.6	E-70.2	E-60.1	E-58.8
	Shear	<b>E-90.5</b>	N/A	E-150.2	E-65.5	E-58.1	E-56.8
	Bolt Shear	<b>E-95.4</b>	N/A	E-160.2	E-65.5	E-58.1	E-56.8
	Bolt Bearing	<b>E-105.7</b>	N/A	E-175.6	E-65.5	E-58.1	E-56.8

Only the 286-kip unit train, Amtrak passenger train, and Metrolink/Coaster passenger trains demands are shown in Table 11-2, as the example assumes that 315-kip unit trains and intermodal unit trains do not run across this bridge.

Load rating results that show that a member is significantly overstressed shall immediately be brought to the attention of the NCTD, MTS and SANDAG Directors of Engineering, LOSSAN Corridor Director and the NCTD Chief of Operations.

### **11.12 PRE CONSTRUCTION RATING / DESIGN LOAD RATING**

Prior to beginning construction of a new bridge or modification of an existing bridge, the bridge design calculations shall be submitted to NCTD as part of the final design submittal. These calculations shall identify the bridge design load rating for incorporation into NCTD's Railroad Bridge Management Program. The design load rating shall be noted on the bridge general arrangement plans.

### **11.13 POST CONSTRUCTION RATING**

Post-Construction Bridge Load Rating Reports shall be submitted to NCTD as part of the As Built process under the design services during construction task. The Load Rating shall be submitted within 3 months of bridge construction completion.

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## **12.0 SEISMIC DESIGN**

### **12.1 SCOPE**

The seismic design provisions included in this chapter shall apply to structures proposed for support of railroad tracks, including bridges, culverts, earth-retaining structures, and earthen embankments that directly support railroad live loads or may be influenced by railroad live load surcharge. Supplemental provisions are presented for seismic design of bridges, retaining walls, and soil slopes. Bridges and earth-retaining structures that do not support railroad tracks shall be designed in accordance with the latest editions of the AASHTO LRFD Bridge Design Specifications, and the Caltrans Amendments at the time of starting the final design. For building facilities and other structures, seismic design shall conform to the applicable building codes.

### **12.2 STANDARDS, CODES, AND GUIDELINES**

The provisions of the AREMA Manual for Railway Engineering, Chapter 9 shall apply unless specifically excluded by the provisions of this chapter. In addition to the AREMA Manual for Railway Engineering, the following documents were used in the development of this chapter:

1. AASHTO “LRFD Bridge Design Specifications,” with California Amendments
2. AASHTO “Guide Specifications for LRFD Seismic Bridge Design”
3. Caltrans “Seismic Design Criteria (SDC)”
4. Caltrans, “Caltrans California Seismic Hazard Map,” at [www.dot.ca.gov](http://www.dot.ca.gov)
5. ATC-32 “Improved Seismic Design Criteria for California Bridges”
6. Caltrans Memo to Designers 20-8 “Analysis of Ordinary Bridges That Cross Faults”
7. Caltrans Memo to Designers 20-10 “Fault Rupture”

### **12.3 SEISMIC HAZARDS**

Several potential hazards associated with seismic activity, including ground surface rupture, strong ground motion, liquefaction, lateral spreading of unconfined layers, seismically induced settlement and tsunami loading, must be considered during the design process and are discussed below.

#### **12.3.1 FAULT RUPTURE**

Each site shall be evaluated for hazard of fault rupture based on mapped active faults and geologic reconnaissance, which may include site visits, reference reports, geologic maps, and stereoscopic aerial photographs. Where evidence of known active fault splays (faults that have exhibited evidence of ground displacement within the last 11,000 years) exists within the limits of a proposed structure, then a Fault Rupture Study shall be prepared along with proposed mitigation strategies that should be considered. The potential for ground

rupture due to faulting at the site shall be determined, and if necessary, specific design considerations to prevent collapse in such an event shall be included.

The Fault Rupture Study shall be done in accordance with Caltrans Memo to Designers 20-10 and 20-8.

### **12.3.2 LIQUEFACTION, LATERAL SPREADING AND SEISMICALLY INDUCED SETTLEMENT**

Liquefaction is the phenomenon in which loosely deposited granular soils, that are located below the water table, undergo rapid loss of shear strength when subjected to strong earthquake-induced ground shaking. Ground shaking of a sufficient duration results in the loss of grain-to-grain contact due to a rapid rise in pore water pressure, causing the soil to behave as a fluid for a short period of time. Liquefaction is known generally to occur in saturated or near-saturated cohesion-less soils that are known to exist in alluvial valleys and lagoons along the Railroad.

The potential for liquefaction, lateral spreading, and seismically induced settlement shall be evaluated at each site through site-specific subsurface investigations and laboratory analyses during the design phase of the project. A licensed Geotechnical Engineer in the state of California shall establish the criteria for liquefaction, lateral spreading, and seismically induced settlement based on the site specific investigation.

### **12.3.3 GROUND MOTION**

To evaluate anticipated ground accelerations at each site, a site-specific probabilistic seismic hazard analysis for each site shall be performed. A probabilistic analysis incorporates uncertainties in time, recurrence intervals, size, and location (along faults) of hypothetical earthquakes. This method thus accounts for the likelihood, rather than certainty, of occurrence and provides levels of ground acceleration that might be more reasonably hypothesized for a finite exposure period. Criteria and interactive map can be found at:

[http://dap3.dot.ca.gov/ARS\\_Online](http://dap3.dot.ca.gov/ARS_Online)

The AREMA three-level ground motion hazards shall be used in conjunction with the Caltrans Maximum Credible Earthquake (MCE), when applicable. The estimated PGA values for each ground motion level, as well as the site-specific acceleration response spectra (ARS) curves for each ground motion level, shall be provided in graphic and tabular format for the site.

## **12.4 GENERAL REQUIREMENTS**

The seismic design guidelines included in the AREMA Manual for Railway Engineering, Chapter 9, are based on a three-level ground motion and performance criteria approach that is consistent with the railroad post-seismic-event response procedures (see Table 12-1 below).

<b>TABLE 12-1 Return Periods and Agency Expectations.</b>				
<b>Ground Motion Level</b>	<b>Performance Criteria Limit State</b>	<b>Frequency</b>	<b>Average Return Period (AREMA)</b>	<b>Agency Expectations</b>
1	Serviceability	Occasional	50 - 100 years	No structural damage track in service
2	Ultimate	Rare	200 - 500 years	Damage that can be repaired in a short period of time
3	Survivability	Very Rare	1,000 - 2,400years	No Collapse of structure but track out of service to replace bridge

### 12.4.1 DESIGN APPROACH

All structures shall be designed in accordance with the AREMA Manual for Railway Engineering, Chapter 9, as modified or augmented in this chapter based on pertinent sections of the following standards or codes:

- Caltrans “Seismic Design Criteria” (SDC)
- Caltrans, “Caltrans California Seismic Hazard Map” at [www.dot.ca.gov](http://www.dot.ca.gov)
- AASHTO “Guide Specifications for LRFD Seismic Bridge Design”, Section 7 “Structural Steel Components”
- ATC-32 “Improved Seismic Design Criteria for California Bridges”

AREMA Chapter 9 assumes that the detailing provisions and capacity protection provisions applied to a structure designed for a level 1 earthquake are adequate for satisfying the performance requirements for levels 2 and 3. The LOSSAN Corridor methodology requires additional analysis in some cases as defined in Table 12-2 below.

<b>Table 12-2 Seismic Analysis Requirements.</b>	
<b>Condition</b>	<b>Requirement</b>
All bridges	Analyze per AREMA Chapter 9. Perform Capacity/Demand analysis for level 3 in accordance with Caltrans SDC. Detail ductile members per Caltrans SDC. Design capacity-protected members per Caltrans SDC prescribed forces.
Bridges over Caltrans-owned facilities	Analyze per Caltrans SDC.

<b>Table 12-2 Seismic Analysis Requirements.</b>	
<b>Condition</b>	<b>Requirement</b>
Bridges with pile foundations extended above ground with same cross-section for use as columns (referred to by Caltrans as Type 1 foundations)	Analyze for AREMA levels 2 and 3. Capacity/Demand Analysis for level 3 shall be in accordance with Caltrans SDC or nonlinear time history analysis may be used. Stress/strain limits and behavior per Table 12-4.

### **12.4.2 STRUCTURE IMPORTANCE CLASSIFICATION**

Structure importance classification (SIC) is used to determine the appropriate return period for each of the three ground motion levels per AREMA Manual for Railway Engineering, Chapter 9. The SIC is determined by three measures, which are weighted according to the limit state to determine the overall SIC:

- Immediate Safety – Factor based on occupancy, hazardous material, and community lifelines.
- Immediate Value – Factor based on railroad utilization and the detour availability.
- Replacement Value – Factor based on span length, bridge length, and bridge height.

### **12.4.3 RISK FACTORS**

The factors provided in Table 12-3 may be assumed in calculating a set of Preliminary Bridge Structure importance classification for each of the three limit states.

<b>TABLE 12-3 Risk Factors</b>	
<b>Risk Factor</b>	<b>Value</b>
Immediate Safety	
Occupancy Factor	4
Hazardous Material Factor	1
Community Lifelines Factor	1
Combined Immediate Safety Factor	4
Immediate Value	
Railroad Utilization Factor	1
Detour Availability Factor	1
Combined Immediate Value Factor	1
Replacement Value <sup>1</sup>	
Span Length Factor	
Less than 35 feet	1
35 feet to 125 feet	2
Bridge Length Factor	
Less than 100 feet	1.0
100 feet to 1,000 feet	1.5
Greater than 1,000 feet	2.0
Bridge Height Factor	
Less than 20 feet	0.75
20 feet to 40 feet	1.00
Greater than 40 feet	1.25
Combined Replacement Value Factor	per AREMA

Notes:

<sup>1</sup> Values specific to the design layout of the individual bridge and shall be determined by the Engineer.

## 12.5 BRIDGE SEISMIC PERFORMANCE CRITERIA

The seismic performance criteria shall be based on the Limit States as listed below:

- Serviceability - All members shall respond elastically with no damage affecting the structural capacity of the bridge.
- Ultimate - Substructure elements detailed for ductility shall remain below the ultimate strength of the member and steel strain limits set in Table 12-4. All other members shall remain elastic. Minor structural damage to the bridge is expected. <sup>1</sup>The engineer shall design the bridge such that if damage results from the earthquake then it shall be designed to occur in accessible areas that are easy to repair.
- Survivability - All substructure members that are subject to the possibility of inelastic behavior and are not capacity protected shall be designed and detailed for ductile behavior under seismically induced movements and shall be capable of responding inelastically with full plastic deformation. Significant structural damage to the bridge can be expected, however collapse shall be prevented.

Notes:

<sup>1</sup>Type 1 foundations not in accessible areas that are easy to repair shall be designed to remain elastic at the Ultimate Limit State per the procedure described in Table 12-2.

## 12.6 BRIDGE RESPONSE LIMITS CRITERIA

Governing limits on the response of structures to seismic effects and the performance of structural members and connections differ based on structure configuration, material type, ground motion level, damage control, and expected ductility. The response limits provided in Table 12-4 shall be satisfied for each structure material:

TABLE 12-4 Stress Limits and Behavior		
Limit State	Material	Stress Limits/Behavior
Serviceability	Steel	AREMA Manual for Railway Engineering, Chapter 15, allowable stresses may be increased by 50%
	Concrete	AREMA Manual for Railway Engineering, Chapter 8, load factor design with load factors of 1.0
Ultimate	Steel	$F_{ye}=1.1F_y$ and AASHTO “Guide Specifications for LRFD Seismic Bridge Design,” as applicable. Steel Strain limit = larger of 0.003 or $1.5\epsilon_y$
	Concrete	AREMA Manual for Railway Engineering, Chapter 8, load factor design with load factors of 1.0
Survivability	Steel <sup>1</sup>	$F_{ye}=1.1F_y$ and AASHTO “Guide Specifications for LRFD Seismic Bridge Design,” as applicable. Steel Strain limit = 0.060.
	Concrete	Caltrans SDC

Notes:

<sup>1</sup>The same stress limit that is used at Ultimate Limit State is also used at Survivability Limit State. The maximum steel strain at Ultimate Limit State is based on Table 2.2.2 from “Caltrans Guide Specifications for Seismic Design of Steel Bridges-First Edition.” Maximum Strain for CISS piles is from Section 16.4.6.6 “Caltrans Bridge Design Practice – February 2015”.

## 12.7 BRIDGE TYPE SELECTION CRITERIA

### 12.7.1 STRUCTURE CONFIGURATION

When determining the structure configuration and layout, the designer shall consider factors including simplicity, regularity, integrity, redundancy, ductility, and ease of inspection and repair after a seismic event.

### 12.7.2 SUPERSTRUCTURE

Simply supported spans shall be used where possible. They can be repaired or replaced more readily than continuous spans. Alternate material types or continuous spans shall be approved by the Owner.

### 12.7.3 FOUNDATIONS

The designer shall use deep foundations for all new multi-span bridges unless shallow rock is present. A geotechnical engineer shall be retained to direct a sub-surface investigation and analysis to provide site specific soils information used for design as detailed in Chapter 5 of this design criteria. The use of battered piles shall be avoided on piers or bents subject to liquefaction.

## 12.8 BRIDGE DUCTILITY REQUIREMENTS

### 12.8.1 GENERAL

Ductility is the main criteria for satisfying the survivability limit state requirements. Requirements for ductility design for bridges along the LOSSAN Corridor shall be per Caltrans SDC for concrete structures and ATC-32 for steel structures. Ductility shall be limited to the substructure elements. Superstructure elements shall remain elastic.

### 12.8.2 STEEL STRUCTURES

Steel substructure elements shall be designed in accordance with AREMA and ATC-32 "Improved Seismic Design Criteria for California Bridges, Provisional Recommendations," augmented with the following revisions to Section 10.63.3:

$$\gamma/\gamma_{1,req} > 2.0$$

$$b/t \leq 21$$

$$P_{max}/Area \leq 0.6F_y$$

Where:

$\gamma_1$  = box wall buckling factor

$b/t$  = the width to thickness ratio of the skin wall between stiffeners

$P_{max}/Area$  = the maximum axial stress



In addition Steel axial elements that may be used in ductile elements of substructures include flanged piles, hollow tubed piles, pipe piles and cast in steel shell (CISS) piles. These pile elements shall be shown by calculation or testing to achieve the full plastic moment capacity of the section and the associated ductility required for the survivability event.

Braced frames may be approved during the Type Selection Process. The proposed framing system shall be a recognized system and demonstrate a clear load path to ductile members. The designer shall provide supplemental design criteria regarding the framing system during the Type Selection Process to be reviewed and approved by reviewing agencies.

When detailing structural frame elements bolted connections are preferable over welded connections. Field welds, intermittent welds, and partial penetration groove welds shall be avoided in regions of expected inelastic deformations.

## **12.9 BRIDGE DETAILING PROVISIONS**

### **12.9.1 CONTINUITY PROVISIONS**

#### Superstructure

The superstructure shall be designed to carry the lateral loads to the bearings or shear transfer connectors.

The lateral loads from the span may be carried to the end supports by the following load paths:

- Lateral bracing system
- Lateral bending of the girders, including torsional effects as applicable
- Diaphragm action of concrete decks or steel ballast pans provided that the deck is adequately connected to the girders
- Transfer girders on skewed through girder bridges

End cross frames or diaphragms shall be designed to carry the lateral loads to the bearings or shear transfer connectors.

#### Bearings

The bearings shall be designed to transfer the lateral loads to the substructure.

Bearing may be supplemented by shear connectors to help transfer the lateral loads without failure of the bearing devices.

### **12.9.2 PROVISION TO LIMIT DAMAGE**

#### Weak Column Provisions

Columns or piles that are designed to respond in the inelastic range shall be detailed to prevent damage to the adjacent superstructure, bent cap, and/or foundations:

- The bent cap and foundation shall be designed for the lesser of the Level 3 ground motion load per AREMA or capacity protected for the ductile member design forces per Caltrans SDC.

### Concrete Joints

Concrete joints shall be configured and reinforced to reduce the possibility of damage to the superstructure and bent cap:

- Provide longitudinal column reinforcement embedment and confinement per Caltrans SDC
- Provide joint shear reinforcement per Caltrans SDC.

### Steel Joints

Joints in main lateral load-carrying steel members shall be designed per ATC-32 “Improved Seismic Design Criteria for California Bridges”. Additionally, field welds shall not be used in the design of main lateral load-carrying connections.

## **12.9.3 REDUNDANCY PROVISIONS**

### Bearing Seats

Bearing seats shall be proportioned to accommodate the maximum relative movements caused by seismic actions.

### Shear Connectors

Shear connectors may be provided to resist the maximum seismic loads. The shear connectors, if used, should be positioned so that they engage prior to failure of the bearing device.

## **12.10 RETAINING WALLS AND EARTH-RETAINING STRUCTURES**

Seismic design of retaining walls and earth-retaining structures shall be done in accordance with AASHTO LRFD based on the seismic events defined in Table 12-5.

Earth-retaining structures shall be designed to fail by sliding rather than by overturning, thereby taking advantage of passive earth pressures developed by the sliding and also thereby reducing the seismically-induced active earth pressure. Earth-retaining structures that slide during an earthquake will dissipate a large amount of energy and reduce damage to the track structure supported on the embankment behind the structure. By limiting damage, the risk of losing track line and surface in amounts exceeding what may be readily corrected may be greatly reduced.

Structural components shall be designed to provide ultimate strength in excess of the expected demands of the AREMA Level 2 event and to remain within the elastic stress range. Ductile detailing shall be provided for critical structure members and connections.

For retaining walls and earth-retaining structures that are not part of a bridge structure, ground motion levels shall be determined by deterministic seismic hazard analysis (DSHA) for the events summarized in Table 12-5. DSHA shall be performed utilizing the fault parameters as defined in the Caltrans ARS Online fault model. Performance requirements for the seismic events shall be consistent within NCTD post seismic event operation guidelines contained in Chapter 5 and Damage Criteria in AREMA Chapter 9.

TABLE 12-5 Track, Roadbed and Retaining Wall Ground Motion Levels and Performance			
Response Level	DSHA Seismic Event	Agency Expectations <sup>1</sup>	Performance Requirements <sup>2</sup>
I	M5.0	Track remains in service at design speed	Differential settlement < 1" between structure and approach for Class 5 track
II	M5.5	Trains proceed at restricted speed of 30 mph until inspection is complete.	Differential settlement < 3" between structure and approach for class 2 track
II	M5.5	Trains proceed at restricted speed of 15 mph until inspection is complete.	Differential settlement < 3.5" between structure and approach for class 1 track
III	M6.0	Trains stop until inspection is complete	Wall does not collapse

Note 1. The track tolerances for corresponding safe operating speeds must comply with 49CFR Ch.II §213.9 for the appropriate track class.

Note 2. Performance requirements for differential settlement only apply at the embankment to bridge abutment interface. Track alignment tolerances must comply with 49CFR Ch.II §213.55 and track surface elevations must comply with 49CFR Ch.II §213.63 for the restricted speed.

If the predicted differential settlements exceed track profile tolerances for given earthquake events, then embankment designs shall require further modification, and/or ground improvements may be needed or the Operations Response to Earthquakes shall be modified.

## 12.11 EARTHEN EMBANKMENTS AND SOIL SLOPES

Embankments supporting or affecting bridge abutments shall be evaluated for stability using the AREMA Ground Motion Levels 2 and 3 events. For embankments and slopes not supporting bridges, the geotechnical engineer shall determine the stability of earthen embankments and soil slopes for the Response Level II and III events in Table 12-5 based on criteria described in Chapter 5. Deformations from liquefaction shall be evaluated using the ground motions in Table 12-5. Deformation shall be maintained within limits consistent

with the NCTD post seismic event operation guidelines contained in Chapter 5 and Table 9-1-2 Damage Criteria in AREMA Chapter 9.

## **12.12 STRUCTURES IN TSUNAMI INUNDATION ZONES**

### **12.12.1 GENERAL**

Tsunami zones are generally along the coast line near lagoons, bays, and wetlands. The California Department of Conservation developed tsunami inundation zone maps for the coast of California for emergency evacuation planning. These maps were used to develop the Tsunami hazard location zones documented in Table 12-6.

Tsunamis are typically caused by submarine earthquakes and landslides. They are long period, fast moving waves generated by large displacements of the seafloor (e.g., underwater earthquakes or landslides) or impacts from celestial bodies (e.g., meteors). Earthquake faults along colliding tectonic plates tend to be thrust faults that result in vertical land movement and ocean water displacement. These faults occur along the western Pacific Ocean near Asia and the Eastern Pacific along Alaska and South America. California is located along a boundary of sliding tectonic plates called strike-slip faults. The San Andreas Fault separates two plates with the one west of the fault moving north, and the plate east of the fault moving south. Strike-slip faults do not generally result in tsunamis unless they cause submarine landslides.

The tsunami generated by the Miyagi earthquake in Japan on April 7, 2011 reached Southern California with a very small tsunami wave (less than a foot) observed along the coast. A more pronounced tsunami wave was recorded after the Chile earthquake on February 27, 2010, where waves of approximately two feet were measured at San Diego. There have been several historical tsunamis of significant magnitude along the Southern California coast generated by seismic events in Alaska and Chile. A number of references were reviewed relative to the potential tsunami wave heights within the Project area and this information is summarized below.

### **12.12.2 TSUNAMI INUNDATION MAPS**

The “Tsunami Inundation Maps for Emergency Planning” were published on June 1, 2009 through a joint effort by the State of California Office of Emergency Services, the California Geologic Survey, the University of Southern California Tsunami Research Center, and NOAA. The maps present the impacts of both local and distant sources of tsunamis to the California coastline.

Tsunami inundation areas were depicted on these maps based on the assumption that the tsunami occurred during mean high water. The maps represent the maximum tsunami run-up from a number of credible, extreme, tsunami sources. The maps do not represent inundation from a single event; rather they display the maximum tsunami inundation generated from either a local or distant source event affecting a given region. This combination of the mean high water level and worst-case scenario tsunami event was used to create what was called a “credible upper bound” for each region of the coastline for the main purpose of emergency preparedness, as opposed to providing design guidance or criteria.

Since the maps represent the worst-case model results for each portion of the coastline, specific water level elevations associated with the tsunami inundation areas were not given. The recurrence interval of the events characterized by the California Geology Survey maps is not provided. Researchers associated with the map study indicate that they are likely on the order of 1 in every 2,500 years (Dykstra 2012). The maps are published on the following website.

[http://www.conservation.ca.gov/cgs/geologic\\_hazards/Tsunami/Inundation\\_Maps/SanDiego](http://www.conservation.ca.gov/cgs/geologic_hazards/Tsunami/Inundation_Maps/SanDiego)

### 12.12.3 TSUNAMI HAZARD LOCATIONS ALONG LOSSAN CORRIDOR

For projects located in tsunami risk zones the design consultant shall take Tsunami waves into consideration in designing major structures to ensure that the structures do not collapse as a result of tsunamis generated from the max credible earthquake. Many locations along the LOSSAN Corridor are considered in a Tsunami Hazard zone. Table 12-6 lists the ranges of Mile Posts along the LOSSAN Corridor in San Diego County that the California Department of Conservation has stated are susceptible to Tsunamis.

<b>Table 12-6 Tsunami Hazard Location Zones on LOSSAN Corridor in San Diego.</b>		
<b>Quadrangle Location</b>	<b>Beginning Mile Post</b>	<b>Ending Mile Post</b>
San Mateo Creek and swamp	207.4	208
San Onofre Bluff and Creek	208	208.9
San Luis Rey (Santa Margarita River)	222.8	223.2
San Luis Rey (San Luis Rey River)	225.1	225.6
San Luis Rey (Loma Alta Creek)	227.5	227.7
San Luis Rey (Buena Vista Lagoon)	228.3	228.7
San Luis Rey (Aqua Hedionda)	230.4	230.7
Encinitas (Batiquitos Lagoon)	234.5	235.2
Encinitas (San Elijo Lagoon)	240.0	241.1
Del Mar (San Dieguito River)	242.8	244.0
Del Mar (Los Penesquitos Lagoon)	244.5	246.8
La Jolla (Mission Bay)	262.7	262.9
San Diego River	263.75	263.85

The tsunami inundation maps represent the worst case model results for each portion of the coastline for a 1 in every 2,500 years seismic event. Specific water level elevations associated with the tsunami inundation areas were not given. However, approximate elevations were manually extracted from the maps in the vicinity of the rail bridges within the study area. These approximate run up elevations are given in Table 12-7 below.

<b>Table 12-7 Approximate Maximum Tsunami Run-Up along LOSSAN Corridor in San Diego County for Emergency Preparedness</b>				
<b>No.</b>	<b>Lagoon Name</b>	<b>Approximate Max. Tsunami Run Up Elevation (Feet, NGVD)</b>	<b>Bridge/Track Overtopped (Y/N)</b>	<b>Track Elevation</b>
<b>1</b>	San Mateo Creek	12.3	N	17.5
	San Mateo Swamp	12.3	N	12.2
<b>2</b>	Santa Margarita	12.3 to 22.3	N	30
<b>3</b>	San Luis Rey	17.3	N	24
<b>4</b>	Loma Alta	17.3	N	24.5
<b>5</b>	Buena Vista	17.3	Y	15
<b>6</b>	Agua Hedionda	17.3	N	31.75
<b>7</b>	Batiquitos	12.3 to 17.3	N	16
<b>8</b>	San Elijo	12.3	N	13.7
<b>9</b>	San Dieguito	17.3	Y	12
<b>10</b>	Los Penasquitos	12.3 to 17.3	Y	11

#### **12.12.4 SONGS TSUNAMI STUDY (2011)**

The study updated the San Onofre Nuclear Generating Station (SONGS) tsunami hazard analysis and found that the new maximum tsunami height is approximately 19.9 to 22.9 feet MLLW (17.6 to 20.6 NGVD29) (SCE 2011). The study utilized the State of California Tsunami Inundation Maps (2009) with a slight modification to account for the maps' exclusion of a seawall that fronts a portion of the SONGS facility. As mentioned above, the State's modeling effort is considered conservative in that its objective was to provide a "credible upper bound" of tsunami inundation at any location along the coastline for the main purpose of emergency preparedness and not necessarily for design criteria.

#### **12.12.5 PORTS OF LONG BEACH & LOS ANGELES TSUNAMI STUDY (2007)**

The Ports of Long Beach and Los Angeles (POLA/POLB) completed a study in 2007 of potential exposure to tsunamis to identify concerns. The study utilized a Boussinesq wave model to simulate tsunami wave propagation into the POLA/POLB. Seven potential tsunami sources were modeled, including four local tectonic scenarios, two local submarine landslide scenarios, and one distant tsunami source scenario. Model results suggest the worst-case scenario tsunami for the region would be from a landslide in the vicinity of Palos Verdes. This tsunami could result in water levels in excess of 23 feet and current speeds up to 8.2 feet

/second in some locations. Regarding frequency of occurrence, the study found that based on the seismicity, geodetics, and geology of the region, a large locally-generated tsunami from either local seismic activity or a local submarine landslide would likely not occur more than once every 10,000 years.

The study provides information on Southern California's exposure to more distant tsunami sources. Exposure of Southern California to tsunamis is based on ocean bathymetry and coastal reflections. The 2007 study was presented at the Prevention First Conference in 2010 (organized by the State Lands Commission). The study shows specific information about historical tsunamis in Southern California. Historical tsunamis in Southern California are from earthquakes in Chile and Alaska. These events were some of the largest earthquakes on record and, therefore, represent probable worst-case events.

San Diego experienced a water level rise of approximately 1 foot above the tidal elevation upon arrival of a tsunami in 2010 from Chile. Water displacement occurred initially upward by 1 foot (in the positive direction) followed by a drop of approximately the same magnitude, for a total water surface deviation of approximately 2 feet. The POLA/POLB experienced water surface displacement of nearly 2.7 feet total. Neither Port reported damage from the event.

Analysis of wave height distribution of historical tsunamis is also presented. The region may have experienced the maximum far-field tsunamis, from Chile with a magnitude of 9.5 in 1960 and from Alaska with a magnitude of 9.2 in 1964. Thus, the water surface elevation changes experienced from these events may be the maximum to be expected. The data indicate that the POLA/POLB area may experience waves up to 2 to 3 feet on a decadal basis from these events.

#### **12.12.6 OBSERVED TSUNAMI WATER LEVELS IN SAN DIEGO**

Major earthquakes have occurred at all of the far-field San Diego tsunami source locations over the last century. Observed versus predicted water levels from the La Jolla station were evaluated to determine the actual tsunami wave height in San Diego from these events. However, only hourly data were available from the NOAA website before the year 2000. The resolution of the hourly data is not sufficient to resolve tsunami wave heights. Therefore, tsunami wave heights available from the Ports of Long Angeles and Long Beach are provided in Table 12.8 along with the water elevations from observed tsunamis in Southern California. As shown, these events resulted in only nominal wave heights in La Jolla of less than 3 feet in height and up to 5.5 ft in Long Beach. Detailed plots of each of these events are provided in the San Diego County Coastal Sea level Rise Analysis dated September 2013.

**Table 12.8 Observed Tsunami's along the Southern Californian Coast**

Source	Date	Earthquake Magnitude	Tsunami Wave Height at La Jolla* (ft)	Tsunami Wave Height at Long Beach/Los Angeles Harbor (ft)
Japan	March 11, 2011	9.0	1.5	2.5
Chile	February 27, 2010	8.8	1.25	2.7
Alaska	March 28, 1964	9.2	Hourly Data Not Adequate to Resolve the Tsunami	3.3
Chile	May 23, 1960	9.5	Hourly Data Not Adequate to Resolve the Tsunami	5.5
Aleutian Trench	April 1, 1946	7.4	Hourly Data Not Adequate to Resolve the Tsunami	3.2

\* As observed at the La Jolla tide gage. Wave height is defined from wave crest to trough.

### 12.12.7 TSUNAMI WATER LEVELS AND DESIGN CONSIDERATIONS

The San Diego region may conservatively experience tsunami waves at the coast from 3 feet to 4 feet in height on a decadal basis in the judgment of the tsunami study engineer (Dykstra 2012) for the work described above. However, observed data from La Jolla show wave heights of approximately 3 feet or less, refer Table 12.8

Incident tsunamis at coastal streams and lagoons will likely experience wave diffraction and wave height reduction when propagating upstream, and could be significantly lower by the time they reach rail and highway bridge locations that are set back from the ocean. Consequently, design guidance for bridge elevation should not need to account for ocean water level increases associated with tsunamis.

Tsunamis will, however, likely set up a temporarily high current under the bridges due to a hydraulic head created during their approach to shore, their arrival, and their passing. Therefore, design guidelines should assume periods of higher than average currents under bridges during a tsunami for a period lasting potentially for several hours. Other design considerations should include:

- Lateral support for the bridge for wave impact loading
- Super-structure tie downs to counter-act buoyancy effects
- Pile foundations for bridges less vulnerable to scour
- Armoring of embankments to protect them from erosion during a tsunami.



In addition Caltrans has prepared design guidelines for tsunami hazards in 2010 (Caltrans memo to Designers 20-13 Tsunami Hazard Guidelines, 2010) for bridges that will apply to the I-5 corridor. The guidelines specifically apply to new bridges below an elevation of 40 feet mean sea level (analogous to NGVD 29) and those within one-half mile from the ocean. The guidelines outline a process for designing bridges affected by the guidance.

Tsunamis have the potential to impact the LOSSAN Corridor bridges and track embankments. Based on observed data, the study area could be impacted by a tsunami with a maximum wave height of approximately 3 feet every ten years and 5 feet every 50 years. This wave will diminish in height as it propagates into a lagoon and would likely be below the elevation of the 100-year stormflow, so its height is not the primary design concern. The concern from a tsunami is the increase in flow velocities under bridges from high current velocities. Consequently, bridges should be designed with additional scour protection on both sides of the bridge abutments and be supported on piles/piers to resist erosion associated with the high water velocities that are expected to occur during tsunamis. A secondary concern may be lateral forces exerted by any impact, and potential uplift, requiring bolting to the foundation. Bridge design should consider additional lateral support and uplift to resist tsunamis, when they occur.

Additional information on tsunami's in Southern California can be found in the San Diego Region Coastal Sea level Rise Analysis dated September 2013 at:

[http://www.dot.ca.gov/dist11/Env\\_docs/I-5PWP/Appendices/AppDSeaLevelRise.pdf](http://www.dot.ca.gov/dist11/Env_docs/I-5PWP/Appendices/AppDSeaLevelRise.pdf)

## CHAPTER 13

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## 13.0 MECHANICAL SYSTEMS

*There are currently no building facilities planned for the LOSSAN Corridor in San Diego County. This section serves as a place holder for use in developing project-specific design criteria that will be required for future building facilities.*

### 13.1 Scope

This chapter contains mechanical criteria developed for facilities within the LOSSAN Corridor system. These criteria govern the functional requirements, operation and control of the heating systems, ventilation systems, air conditioning systems, water and sewerage systems, drainage facilities (except at-grade sections) and fire protection systems. These criteria are intended to promote uniformity of design and standardization of equipment and its location throughout the LOSSAN Corridor.

### 13.2 Standards, Codes and Guidelines

The latest edition of the applicable standards, codes and guidelines of the following organizations shall be used for all designs unless otherwise required by this section:

- International Building Code (IBC)
- California Building Code (CBC)
- Occupational Safety and Health Act (OSHA)
- California Occupational Safety and Health Act (Cal-OSHA)
- California Title 24 Energy Regulations
- American National Standards Institute (ANSI)
- American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)
- American Society for Testing and Materials (ASTM)
- Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA)
- National Fire Protection Association (NFPA), "National Fire Codes"
- National Electric Code (NEC)
- Safety code for mechanical refrigeration
- Codes of applicable local jurisdictions

Mechanical equipment and systems shall be designed so that the maximum noise levels generated and transmitted by the systems do not exceed allowable limits for interior or outdoor noise levels.

### 13.3 Heating, Ventilation, and Cooling (HVAC)

HVAC requirements shall be defined for each specific project and shall be based on the appropriate local codes and standards.

### 13.4 Plumbing

Plumbing requirements shall be defined for each specific project and shall be based on the appropriate local codes and standards.

### **13.4.1 Pipe and Fittings**

Pipes and fittings shall be as follows:

- Waste and soil pipe shall be service-weight cast iron pipe with bell and spigot fittings. Soil pipe from fixtures shall have a slope of 2 percent.
- Vent pipes within structures shall be galvanized steel threaded pipe or service-weight cast iron pipe with bell and spigot fittings.
- Hot and cold water piping embedded in structures shall be hard-drawn copper tubing Type K; all other hot and cold water piping shall be hard drawn-copper tubing Type L with wrought brass or copper fittings.
- Force mains shall be of standard-weight steel pipe with joints of a type approved by the local authority with jurisdiction.
- Water service entrances shall be ductile iron mechanical joint pipe.
- Hose bibs shall be provided with vacuum breakers.
- The minimum diameter of waste pipe installed underground shall be 4 inches. The minimum diameter of waste pipe installed in structural slabs shall be 3 inches.
- Dielectric couplings shall be provided for the connection of pipes of dissimilar metals and in all metallic piping entering a facility.
- Corrosion control measures shall be provided for buried pipes.
- Isolation and drain valves shall be located so they are easily accessible

### **13.4.2 Water Service**

The domestic water-service connection shall have a minimum diameter of two inches or larger as required by the site demand, and shall be metered. Fire water-service connections shall have a minimum diameter of 4 inches and shall be metered with a bypass meter as approved by the local water agency or utility company. Each service shall have a main shut-off valve immediately inside the structure wall. Backflow preventers shall be provided to conform to local code requirements. The minimum unit values may be reduced by local water conservation requirements, such as low flush toilets, and shall be according to the applicable local code. Pressure regulators may be required, and shall be located immediately outside the building where the water service enters the building/facility.

The Engineer shall estimate separately the service requirements of outlets that are likely to impose continuous demand, such as hose connections, and add to the fixture service requirements to determine the required total-service connection capacity.

### **13.4.3 Hot Water Service**

Hot water shall be supplied to all toilet rooms and custodial rooms.

Water heater capacities shall be based on 100 degrees F recovery, and sized to meet the demands of the fixtures to be served by each heater.

Combination pressure-temperature relief valves shall be provided in accordance with code requirements, and piped to the indirect waste system.

A recirculation system shall be provided where the supply piping is more than 100 ft. long.

#### **13.4.4 Insulation**

Hot water piping and portions of drainage and cold water piping subject to sweating shall be insulated.

#### **13.4.5 Sewage Pump Stations**

Sewage pump stations, if required, shall be designed according to the local agencies' requirements.

#### **13.4.6 Eyewash Facilities**

Emergency eyewash facilities shall be provided within, or immediately adjacent to, areas with batteries. The capability for eye lavage shall not be provided by a portable eyewash apparatus. Where needed, a water service connection with a floor drain to a stationary type of eyewash system shall be provided. A flow switch shall be provided to signal local and remote alarms when eyewash is activated.

#### **13.4.7 Hose Bibs and Floor Drains**

Hose bibs in service facilities shall have copper fittings, with bronze or brass outlet and valve.

Hose bibs and floor drains in stations with restrooms shall be provided in accordance with the following instructions:

<b>Location</b>	<b>Requirements</b>
Custodial Room	Hot- and cold-water single spout, mop sink drain and or floor drain.
Trash Rooms	$\frac{3}{4}$ inch cold-water hose bib with an individual floor drain located immediately beneath the hose bib.
Toilet Rooms	Cold-water and hot-water service and a means of floordrainage.
Water Heaters	A floor drain for wastewater produced by maintenance procedures and relief-valve actuation.

#### **13.4.8 Sanitary Facilities**

Wherever feasible, all drains from shop sinks, lavatories, water closets and other miscellaneous drains/sanitary waste shall be designed to flow by gravity to existing sewers. If a gravity flow cannot be accomplished, drain/sanitary waste lines shall be run to sewage ejector pits containing duplex sewage pumps. The discharge shall then be pumped to the nearest sewer line(s).

Natural Gas systems Natural gas for heating, and cooling shall be considered in the design of all facilities, all natural gas apparatus' shall conform to the requirements of local codes and SDG&E designs using propane (except for temporary use) shall not be utilized.

## 13.5 Fire Protection

### 13.5.1 Fire Protection Systems

The following fire protection systems may be employed. The specific system used shall be determined based on facility type, local code requirements, Fire Department requirements, and any applicable insurance requirements.

Sprinkler systems, wet and dry  
Standpipe systems, wet and dry  
Fire hose cabinets

Portable fire extinguishers  
Smoke and heat alarm systems

### 13.5.2 Sprinkler Systems

Sprinkler systems shall include a main water supply; fire department inlet connections; piping from inlet connections and water supply mains to the sprinkler heads; sprinkler heads (with spares); drain lines; provisions for remote alarm devices: pipe fittings; valves; hangers; inserts; sleeves; and appurtenances. Sprinkler systems shall conform to the requirements of NFPA Standard No. 13.

### 13.5.3 Standpipe Systems

Standpipe systems shall include fire department inlet connections as agreed with Fire Marshal; piping from inlet connections to supply main; hose valves; fire hose cabinets; drain lines; pipe fittings; control valves; hangers; inserts; sleeves; and appurtenances. Standpipe systems shall conform to the requirements of NFPA Standard No. 14.

### 13.5.4 Fire Hose Cabinets

Fire hose cabinets shall be provided as required by the applicable NFPA code.

### 13.5.5 Portable Fire Extinguishers

Portable fire extinguishers shall be installed in accordance with NFPA Standard No. 10 and as modified by these design criteria in offices and electrical rooms.

### 13.5.6 Smoke and Heat Detection Systems

Smoke and heat detection systems shall be provided as required by the applicable NFPA code.

### 13.5.7 Fire Hydrants

Local Fire Marshalls and Fire Departments may have more stringent requirements and should be consulted at conceptual design stage. They may require testing of the water supply, multiple sources (for larger facilities), on-site pumps or even on-site storage.

Provide the required water pressure and backflow control.

#### Fire Hydrant Location

In new facilities, fire hydrants of a type approved by the local authority with jurisdiction shall be provided at each of the following locations (if one is not already present):

- Within 500 ft. of each fire department connection to a standpipe system;
- Within 500 ft. of the fire department connection to each sprinkler system.

The 500 ft. limits listed above are maximum; it is desirable that a fire hydrant be located within 200 ft. of each of the points indicated above.

### Water Supply

The adequacy of the water supply shall be supplied from records of the agency owning the water supply system.

Street mains (i.e., the mains of the local government supplying water service for fire protection) shall be sized to carry the design flow, but in no case shall have a diameter less than 6 in. The capacity of the connected water supply (of the local government) must be adequate for the supply of only the sprinkler portion of the fire protection systems. It may be assumed that standpipe systems will be charged by local fire departments after their arrival on the scene, even though the standpipe systems are connected to the supply main.

Where both sprinkler and standpipe systems are served, the building fire main shall not be less than 6 in. in diameter; where only standpipe systems are served, the building fire main shall not be less than 4 in. in diameter. No pressure-regulating valves shall be used in fire water-supply mains, except by special permission of the local authority with jurisdiction.

Where connections are made to a public water system, it may be necessary to guard against possible contamination of the public water supply. The requirements of the local authority shall be determined and met.

### ***13.5.8 Fire Department Connections***

Provide fire protection systems with Siamese connections through which the fire department can pump water into the sprinkler system. Standpipe, or other system furnishing water for fire extinguishing, shall be provided according to local department

There shall be no shut-off valve in the fire department connection for dry stand pipes.

An approved silent check valve shall be installed in each fire department connection, located as close as practicable to the point where it joins the system.

The pipe between the check valve and the outside hose coupling shall be equipped with an approved automatic drip, arranged to discharge to a proper place.

Hose connections shall be approved by the local fire department and shall be of a listed type in accordance with NFPA codes. A clear area of 48" shall be designed and maintained around all hose connections.

Hose coupling threads shall conform to those used by the local fire department. (American) National Standard fire-hose coupling screw threads shall be used wherever they fit the local fire department hoses.

Hose connections shall be at the access road side of buildings and be located and arranged so that hose lines can be readily and conveniently attached to the inlets without interference with any nearby objects, including buildings, fences, posts, or other fire department connections.



Fire department connections shall be designated by a sign with raised letters, at least one inch in size, cast on a plate or fitting reading: “Autospkr,” “Open Spkr,” or “Standpipe,” whichever is appropriate. The sign shall also indicate the buildings or structures, or parts thereof, served by the connection. The Rail Transit Authority’s logo shall be provided at each fire department connection for identification.

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Reference Document for this chapter;

Service Life Design Guide for Corrosion Prevention of Concrete structures on LOSSAN Rail Corridor in San Diego County, SANDAG/TCG.

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## 14.0 CORROSION PREVENTION

### 14.1 SCOPE

The intent of this section is to ensure that projects remain in service for the specified design life in a relatively maintenance free condition. Corrosion prevention provisions based on service life analysis shall be required for all facilities and structures when corrosion failure of such facilities and structures may affect safety or interrupt continuity of operations. Corrosion prevention systems shall provide the required service life the most economical manner. The geotechnical engineer shall provide recommendations regarding the corrosivity of the soil and water and the chloride loading of adjacent structures. A service life consultant shall provide specific design recommendations. The Project Development Team lead shall show that service life recommendations implemented provide long term value for money to the Railway.

### 14.2 GENERAL

The corrosion of embedded steel reinforcement in concrete due to the penetration of chlorides from deicing salts, groundwater or seawater is the most prevalent form of premature concrete deterioration worldwide and costs billions of dollars a year in terms of infrastructure repair and premature replacement. By extending the service life of structures along the LOSSAN Corridor from 75 to 100 years, it is estimated that future generations will save \$200 million in today's terms.

The Corrosion Prevention section of the LOSSAN Rail Corridor Design Criteria Manual shall apply to all new structures built in the Corridor, new stations and any new support facilities like parking garages. The LOSSAN Railway runs down the Southern Californian Coastline, passes over many coastal lagoons, rivers, creeks and through geological formations that were once under the sea. The climate is a temperate and the structures are subject to varying exposure conditions. The goal of this chapter is to provide sufficient information so that designers are able to design new structures that cross streams, rivers and tidal lagoons that are serviceable and will require minimal repairs or maintenance for up to a 100-year service life. These Service Life Design Guidelines present a methodology for service life engineering of new structures.

Structures can be exposed to many degradation mechanisms that, over their service life, may require costly repairs if not adequately designed for. The degradation mechanisms specific to San Diego County will be discussed in this chapter, as will outline specification requirements, corrosion protection systems and durability enhancements to mitigate for these degradation mechanisms.

Several strategies shall be considered to achieve the design service life of reinforced and prestressed concrete structures exposed to chloride salts, and may include the use of the following:

- low-permeability or high-performance concrete with appropriate cover
- corrosion inhibiting admixtures for concrete with appropriate cover
- protective coatings or treatment to steel reinforcement (e.g. epoxy-coated or galvanized steel)
- non-ferrous reinforcement (e.g. fibre-reinforced plastics)
- waterproofing membranes or sealers applied to the exposed surface of the concrete

- allowing for additional thickness of materials
- cathodic protection, and/or
- combinations of the above

The selection of the most appropriate strategy will be left up the Project Development Teams and shall be based on service life analysis including a cost benefit analysis prepared during the final design stage of the project.

### 14.3 STANDARDS CODES AND GUIDELINES

The latest edition of the following standards, codes and guidelines shall also be used for corrosion prevention of structures. However the STADIUM® modelling technique results presented in the “Service Life Design Guide for Corrosion Prevention of Concrete Structures on LOSSAN Rail Corridor in San Diego County” provide a more rigorous guideline than the other references;

#### 14.3.1 National Industry Standards

- ACI 201.2R Guide for Durable Concrete.
- ACI 212.3R-10 Report on Chemical Admixtures for Concrete, *Chapter 13 Corrosion Inhibiting Admixtures*.
- ACI 304R-00 Guide for Measuring, Mixing, Transporting, and Placing Concrete.
- ACI 308.1-11 Specification for Curing Concrete.
- ACI 318 Building Code for Structural Concrete.
- ACI 365.1R-00 Service Life Prediction.
- ISO 8044-89 Corrosion of Metals and Alloys
- ACI 515.2R-13 Guide to Selecting Protective Treatments for Concrete.
- AREMA Manual of Railway Engineering.
- ASTM Standards Volume 01.04, *Iron and Steel Products, Steel-Structural, Reinforcing, Pressure Vessel, Railway*, ASTM International, W. Conshohocken, PA.

#### 14.3.2 State Standards and Guides

- CALTRANS Corrosion Guidelines, Division of Engineering Services, November 2012.
- CALTRANS Bridge Design Specifications, September 2003, Section 8 Reinforced Concrete.
- CALTRANS Protection of Reinforcement against Corrosion Due to Chlorides, Acids, and Sulfates, Memo to Designers, 10-5, January 2002.
- CALTRANS Highway Design Manual, Section 850, 2011.
- PCI Tolerance Manual for Precast and Prestressed Concrete Construction, MNL 135-00. Precast/Prestressed Concrete Institute.

#### 14.3.3 Local Guideline

- Service Life Design Guide for Corrosion Prevention of Concrete structures on LOSSAN Rail Corridor in San Diego County, SANDAG/TCG.

#### 14.3.4 Publications

1. A. Bentur, S. Diamond, and NS. Berke, *Steel Corrosion in Concrete—Fundamentals and Civil Engineering Practice*, E & FN SPON, 1997.

The recommendations of the “Service Life Design Guide for Corrosion Prevention of Concrete Structures on LOSSAN Rail Corridor in San Diego County” or other similar methods of service life modelling shall be used to ensure that the design service life is achieved.

#### 14.4 SERVICE LIFE

SANDAG requirements for design lives of transit and rail related structures are made by subdividing the structures according to their usage and importance level as shown in Table 14.1. The design life of a structure is the utilization period specified by the owner or SANDAG, with respect to structural safety, serviceability and durability. That is the period for which the structure is to be used for its intended purpose with anticipated minimum maintenance but without major repair being necessary.

<b>Usage</b>	<b>Local Importance Level 1 in years</b>	<b>Interstate Importance Level 2 in years</b>
General Infrastructure like Bridges and parking garages	75	100
Buildings & Stations	75	100
Industrial Infrastructure & Rail Yards	50	75

Importance can be categorized as follows;

Importance Level 1. Works of Local interest, with a small risk of loss of human life or environmental damage in the case of failure. Including work in branch lines, urban trolley networks, local rail and road bridges, retaining walls and culverts.

Importance Level 2. Works of Interstate interest, or with an elevated risk of human loss or environmental damage in the case of failure. Including interstate freeways and intercity railway structures, large trolley bridges; including bridges over rivers or canyons, culverts, retaining walls.

Consultants shall use the SANDAG Service Life Design Guide for Corrosion Prevention of Concrete Structures or another approved service life modelling technique to verify the design meets the minimum specified service life in table 14.1.

#### 14.4 Proposed Minimum requirements for concrete exposed to chlorides

Minimum requirements for concrete exposed to chlorides are provided in Table 14.2 for differing Chloride exposures. The actual site chloride exposure and minimum concrete mix requirements will need to be verified by soil testing and diffusion modeling at the location of projects;

<b>Chloride Exposure Classification</b>	<b>Typical Chloride Exposure</b>	<b>Max W/C<sup>1</sup></b>	<b>Minimum Mix requirements<sup>1</sup></b>	<b>Min Cover<sup>1</sup></b>
Marine Severe	Marine Tidal or splash zone within 10 feet of the mean low water line in a Temperate Climate (Max Chloride measured to 8,000ppm)	0.38	6,000 PSI and 20% Fly ash and 2 gallons of CaNi with Type II/V Cement	3 inches
Marine Moderate	Coastal zone from 10 feet above MLLW to within 1000 feet of the high tide line in Temperate Climate (Max Chloride measured to 4,500ppm)	0.4	5,000 PSI and 20% Fly ash with Type II/V Cement	2.5 inches
Inland Moderate Wet	Coastal Zone from 1000 feet to 1 mile inland exposed to seasonal groundwater (Max Chloride measured to 3,000ppm)	0.45	4,500 PSI and 20% Fly ash with Type II/V Cement	2 inches
Inland Low Dry	Exposed to chlorides from soils further that 1 mile inland. (Max Chloride measured to 1,500ppm)	0.50	4,000 PSI Type II/V Cement	2 inches

Note 1. Refer to the Service Life Design guide for specific requirements.

#### 10.1.3 Service Life Design Guide for Concrete Structures

“The Service Life Design Guide for Concrete Structures on the LOSSAN Corridor” has been prepared to aid designers in the selection appropriate concrete mixtures, including supplemental materials, corrosion inhibitors and various types of reinforcing bars and concrete covers that are needed for the required service life.

Designers shall choose an appropriate mix from the mix design verses cover figures depending on a verified exposure condition and specify adequate cover to the reinforcement to ensure the service life of the structure. Designers shall also ensure that concrete structures exposed to chlorides are designed to be crack free under dead loads.

New bridge and retaining walls along LOSSAN shall conform to a 100-year service life for major bridges and structures supporting rail track along the main line. Corrosion prevention provisions shall be required for all facilities when corrosion failure of such facilities may affect safety or interrupt continuity of operations. The choice of a corrosion prevention system shall be based on total life cycle costs.

The geotechnical engineer shall provide recommendations regarding the corrosivity of the soil and ground water and potential control measures, the project engineers and corrosion specialist shall use this information to formulate a detailed corrosion protection design.

Corrosion prevention systems will;

- Reduce future capital investment costs.
- Maximize the service life of new system facilities
- Reduce maintenance costs associated with material deterioration.
- Minimize or eliminating corrosion-related failures of systems and subsystems.

Protection of concrete structures shall include, but may not necessarily be limited to corrosion control techniques such as; increased concrete cover, increased concrete strength, decreased w/c ratio, enhancing cementitious material properties by adding supplemental materials like fly ash and silica fume, corrosion inhibiting admixtures.. Reinforcement may be black steel, galvanized steel, epoxy coated steel or MMFX Chrom4000 reinforcement or in extreme conditions cathodic protection may be used should the other methods not provide adequate service life.

Protection of metal structures shall include, but may not necessarily be limited to corrosion control techniques such as increasing metallic thickness, coating, electrical isolation, electrical continuity, and cathodic protection.

To ensure that concrete remains in an acceptable condition over the life of a structure, the following factors should be considered during the design and construction stages of the project:

- Design phase
  - Soil and water testing at site of proposed structure
  - Testing adjacent structures to verify chloride loading at site of proposed structure
  - Design concrete mix using Service Life Design Guide
- Construction phase
  - Specify a workable slump of 125 to 150mm to ensure no honeycombing.
  - Test for strength of concrete placed
  - Test for chloride levels of concrete placed
  - Test diffusion properties of concrete placed



## 14.5 QA/QC PROCEDURES FOR DURABLE CONCRETE

To ensure the service life of concrete structures additional QA/QC testing is required.

While many aspects of concrete performance impact the ultimate durability of a structure, there are several key concrete parameters that require confirmation prior to initiating concrete placement. Minimum performance requirements such as compressive or flexural strength are set by the project specification based on the engineering requirements of structure. This document addresses unique requirements related to the durability aspects of concrete. Specifically, drying shrinkage, chloride content, alkali aggregate reactivity, and ion & moisture transport properties. These are considered critical aspects of concrete durability and need to be assessed as part of the submittal and acceptance process.

It is recommended that at least three batches should be produced for each mixture and tested by an accredited laboratory experienced in this field. At least 120 days prior to concrete placement is recommended, submit concrete mixture proportions, ingredient material certificates, trial batch test data, and service life report for each class of concrete proposed for use on the project. Submittal should clearly indicate where each mixture will be used when more than one mix design is submitted. Durability and service life approval must be obtained prior to placement.

If the contractor or materials supplier changes materials, material type, material class, chemical composition, material sources or suppliers, and or mix proportions, the contractor should provide the specifier with the necessary material information to determine the significance of the change on the durability of the material and additional testing requirements.

### 14.5.1 DRYING SHRINKAGE

Determine drying shrinkage of concrete mixture(s). A drying shrinkage test result should be the mean value from three or more individual specimens constituting a test set. Casting more than three specimens for each set is permitted. Test procedures and test specimens should conform to the following:

- Drying shrinkage specimens, typically 3 by 3 by 11.25 inch prisms for 1-inch maximum size aggregate or smaller, should be fabricated, cured, dried, and measured in the manner outlined in ASTM C157/C157M except as modified herein:
- Obtain original length measurements after demolding and conditioning as described in the standard.
- Cure specimens in lime water for 7 days maintained at 73 degrees F and then obtain the initial length measurements.
- Place specimens in the drying environment as described in the standard and obtain periodic length measurements after 7, 14, 21, and 28 days of drying (36 days age).
- Calculate the drying shrinkage length change as a percentage of the initial length obtained after 7 days of curing.
- Report individual measurements in tabular format and plot the mean value at each test age.
- The drying shrinkage after 21 days of drying (28 days) should be less than 0.04%.

### 14.5.2 ALKALI-AGGREGATE REACTIVITY

Aggregate tests should be conducted within 120 days from the date of concrete mixture submittal.

- Provide ASTM C1260 or ASTM C1567 test results conducted with 4 months of the submittal date showing the proposed coarse and fine aggregates are either: innocuous to alkali silica reaction; or that reactivity has been mitigated by the proposed cementitious materials as modified herein.
- Conduct ASTM C1260 tests on each aggregate source separately. The maximum allowable expansion should be the limit currently specified by CALTRANS. If this criterion is not met, conduct ASTM C1567 tests on the aggregate using the proposed blend of cementitious materials intended for use on the project. The maximum allowable expansion for the ASTM C1567 test should be should be the limit currently specified by CALTRANS.
- Aggregates that fail to meet the alkali silica reactivity criteria should be rejected.
- Historic usage or listing on State DOT approved source list is not a substitute for this requirement.

### 14.5.3 WATER SOLUBLE CHLORIDE ION CONTENT

Determine the chloride ion content of concrete mixture(s). Determine water soluble chloride ion content in accordance with ASTM C1218/C1218M. Maximum water soluble chloride ion concentrations in hardened concrete at ages from 28 to 42 days contributed from the ingredients including water, aggregates, cementitious materials, and admixtures should not exceed the limits of Table 14.3 below.

<b>Table 1 – Maximum Chloride Ion Content for Corrosion Protection</b>	
<b>Type of Member</b>	<b>Maximum water soluble chloride ion (C1) in concrete, percent by weight of cement</b>
Prestressed concrete	0.06
Reinforced concrete exposed to chloride in service	0.08
Reinforced concrete that will be dry or protected from moisture in Service	0.15

### 14.5.4 TRANSPORT PROPERTIES

Transport properties are required as inputs into the service life modeling software include: The volume of permeable voids (porosity); the ion diffusion coefficient (IDC); the moisture transport coefficient (MTC), and an aging factor. A brief description of the test procedures

is provided below.

**Porosity:** The volume of permeable voids (porosity) of concrete is determined in accordance with ASTM C642. Porosity is determined for pre-qualification of concrete mixtures and for quality acceptance testing.

**Ion Diffusion Coefficient (IDC):** This test method uses an electrical field to migrate chloride ions through concrete specimen for approximately 14 days. The electrical charge flowing through the concrete is related to the diffusion coefficient of ionic species in cementitious materials. A test is defined as the average of two specimens run together and who's results are analyzed together to produce a single IDC value. The IDC is determined for pre-qualification of concrete mixtures and for quality acceptance testing. This test method is not yet adopted by ASTM, so the test method will provided by the modeling software provider.

**Moisture Transport Test:** This test method determines the drying rate of pre saturated cementitious materials by measuring the evaporative mass loss of concrete slices with different thickness exposed to constant temperature and relative humidity environment. This test method is not yet adopted by ASTM or AASHTO, so the test method is provided by the modeling software provider. The MTC is most useful in modeling chloride ingress in cyclic wet-dry exposures, or when ions move primarily through evaporative transport.

**Aging factor:** The aging factor is used by service life modeling software to estimate the change in diffusion coefficient over time. The aging factor is defined as the ratio of the ultimate IDC to the 28-day IDC. Since we cannot wait for two or more years to characterize project concrete, a surrogate aging factor is used in this specification. This surrogate aging factor is calculated based on the 28-day IDC value, 90-day IDC value, and accelerated 90-day cure IDC value.

The submittal will include a report on the service life of the proposed concrete system using service life modeling software and: the environmental exposures, the characteristic porosity and IDC and MTC values; the aging factor; the modeling concrete cover; the chloride threshold for the proposed reinforcing steel and corrosion propagation time

#### **14.5.5 PROJECT PRODUCTION QA/QC TESTING**

For ongoing placement of existing approved concretes, the following project testing requirements are required: Test representative concrete cylinders for porosity and ion diffusion coefficient for each day of production or 100 CY of concrete placed, whichever is greater. Determine the ionic diffusion coefficient (IDC). When tested concrete with IDC and porosity values greater than the acceptance values determined during submittal, retesting using spare cylinders and/or re-simulation of the service life using these higher values will be conducted. If the retest exceeds the quality acceptance limit or the revised simulation does not meet the service life requirements, this should be grounds to stop concrete placement and to review quality control issues.

Other, more traditional, QC/QA testing, such as compressive strength or plastic concrete properties, is not addressed in this corrosion prevention durability guide. This QC/QA

section is a SUPPLEMENT to, not a replacement for, the QC/QA requirements of the project specification.

Any significant changes to approved materials, material type, material class, chemical composition, material sources or suppliers, and or mix proportions, necessitates the full durability resubmittal and testing for (drying shrinkage, chloride content, alkali aggregate reactivity, and ion & moisture transport properties) be repeated.

## **14.6 CORROSION PREVENTION OF PIPING**

### ***14.6.1 METALLIC PRESSURE PIPING***

All pressure piping and conduit shall be non-metallic, unless metallic materials are required to adhere to SANDAG standards and/or the utility owner's standards. Aluminum and aluminum alloys shall not be used.

All new buried cast iron, ductile iron, and steel pressure piping within NCTD/MTS ROW shall be cathodically protected. In general, sacrificial galvanic anodes to minimize interaction with other underground utilities are the preferred corrosion protection system. Corrosion protection systems will adhere to the following minimum criteria:

- Comply with existing standards and specifications of the owner.
- Comply with federal, state, and local codes for regulated piping.
- Apply protective coating as needed.
- Provide electrical insulation of pipe from interconnecting pipe, casings, and other structures and segregation into discrete electrically isolated sections.
- Provide electrical continuity through the installation of copper wires across all mechanical pipe joints.
- Provide permanent test/access facilities to allow for verification of electrical effectiveness of insulators and coating and electrical continuity. Additional test/access facilities installed at intermediate locations shall be at the discretion of SANDAG.

### ***14.6.2 COPPER PIPING***

Buried copper piping shall be electrically isolated from non-buried piping, such as that contained in a station structure, through use of an accessible insulating union installed where the piping enters through a wall or floor. Pipe penetrations through the walls and floors shall be electrically isolated from building structural elements. The insulator shall be located inside the structure and not buried.

### ***14.6.3 GRAVITY FLOW PIPING (NON-PRESSURED)***

Corrugated steel piping shall be internally and externally coated with a sacrificial metallic coating and a protective organic coating. Cast or ductile iron piping shall be designed and fabricated to include the following provisions:

- An internal mortar lining with an external bituminous coating on ductile iron pipe only (not required for cast iron soil pipe)
- A bonded protective coating or unbonded dielectric encasement on the external surfaces in contact with soils (AWWA C105)

- A bituminous mastic coating on the external surfaces of pipe 6 inches on each side of a concrete/soil interface

Reinforced concrete non-pressure piping shall include the following provisions:

- Water/cement ratios meeting the minimum provisions of ASTM C76, Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
- Maximum 250-ppm chloride concentration in the total concrete mix (mixing water, cement, admixture, and aggregates)

#### **14.6.4 CASING PIPES**

Buried metallic casing pipes shall be cathodically protected unless the casing pipe thickness is increased to allow for corrosion without compromising the structural integrity of the casing pipe.

#### **14.6.5 ELECTRICAL CONDUITS**

Buried metallic conduits shall include the following provisions:

- Galvanized steel with PVC or other coating acceptable for direct burial, including couplings and fittings. The PVC coating is not required when conduits are installed in concrete.
- Electrical continuity through use of standard threaded joints or bond wires installed across non-threaded joints.

### **14.7 PROTECTION OF UNDERGROUND STRUCTURES**

#### **14.7.1 ELECTRICAL INSULATION OF PIPING**

Where required, electrical insulation of piping shall be achieved using insulating flanges, couplings, unions, non-metallic inserts, and/or concentric support spacers that meet the following minimum requirements:

- Minimum clearance of 12 inches shall be provided between new and existing metallic structures. SANDAG shall be notified if this clearance cannot be achieved due to site-specific constraints.
- Buried or elevated insulators shall be equipped with accessible permanent test facilities.
- A protective coating shall be applied to all metallic devices exposed to high humidity, partial immersion, and/or soils.
- Temperature and mechanical ratings shall be equivalent to the attached structure.
- There shall be sufficient electrical resistance after insertion into the operating piping system such that no more than 2 percent of a test current applied across the device flows through the insulator, including flow through conductive fluids, if present.
- There shall be a minimum resistance of 10 megohms prior to installation.

#### **14.7.2 ELECTRICAL CONTINUITY OF UNDERGROUND PIPING**

Electrical continuity shall be provided for all non-welded metallic pipe joints and shall meet the following criteria:

- Direct burial, insulated, stranded, copper wire shall be used with the minimum length necessary to span the joint being bonded.
- Wire size shall be a minimum of 14 AWG and shall be based on the electrical characteristics of the structure and the resulting electrical network to minimize attenuation and allow for cathodic protection.
- A minimum of two wires per joint shall be used for redundancy.
- Surface preparation of the structure to be coated shall be required in accordance with the coating manufacturer's recommendations.
- Copper piping joints shall be soldered.

## 14.8 COATINGS

### 14.8.1 GENERAL

The corrosion control design shall specify surface preparation, application procedure, primer, number of coats, and minimum dry film thickness for each coating system. Shop-applied coatings shall be specified wherever possible, with the use of compatible coating systems for field touchup and repairs. Coatings specified for buried metallic or concrete facilities shall satisfy the following criteria:

- Minimum 5-year performance record
- Ability to withstand reasonable abuse during handling and earth pressure after installation
- Minimum volume resistivity of 10,000,000,000 ohm-centimeters per ASTM D257
- Minimum thickness as recommended for the specific system, but not less than 15 mils

Potentially acceptable generic coating systems include, but are not limited to, the following:

- Extruded polyethylene/butyl-based system
- Coal-tar epoxies (two-component systems)
- Polyethylene-backed butyl mastic tapes (cold applied)
- Bituminous mastics (airless spray)

Non-bonding corrosion protection systems (polyethylene wrap) may be used in special instances after review and approval by SANDAG.

### 14.8.2 BARRIER COATING SYSTEMS

Painting Council (SSPC) Surface Preparation Standards and Specifications, (<http://www.sspc.org/market-place/standards/surface-preparation-sp/>) shall be used where corrosion protection is needed but appearance is not a primary concern:

- Near-white blast surface according to SSPC-SP 10. Follow with a three-coat epoxy system.
- Commercial blast surface according to SSPC-SP 6. Follow with a two-coat inorganic zinc, high build epoxy system.
- Near-white blast surface according to SSPC-SP 10. Follow with a three-coat inorganic zinc, high build epoxy system.

One of the following barrier coating systems, in accordance with SSPC Surface Preparation Standards and Specifications, shall be used where both corrosion protection and good appearance are needed:

- Near-white blast surface according to SSPC-SP 10. Follow with a three-coat inorganic zinc, high build epoxy, polyester urethane system.
- Near-white blast surface according to SSPC-SP 10. Follow with a three-coat vinyl system.
- Commercial blast surface according to SSPC-SP 6. Follow with a three-coat inorganic zinc, high build epoxy, polyester urethane system.
- Commercial blast surface according to SSPC-SP 6. Follow with a three-coat inorganic zinc, high build epoxy, acrylic urethane system.

All coatings shall be applied according to the manufacturer's specifications. Coatings shall have established performance records for the intended service and shall be compatible with the base metal to which they are applied. Coatings shall be able to demonstrate satisfactory gloss retention, color retention, and resistance to chalking over their minimum life expectancies. Coatings shall have minimum life expectancies, defined as the time prior to major maintenance or reapplication, of 15 to 20 years.

### **14.8.3 METALLIC-SACRIFICIAL COATINGS**

Acceptable coatings for carbon and alloy steels for use in tunnels, crawlspaces, vaults, or above grade are as follows:

- Zinc (hot-dip galvanized [2 ounces per square foot] or flame sprayed)
- Aluminum (hot-dip galvanized [2-mil thickness] or flame sprayed)
- Aluminum-zinc
- Electroplated zinc (sheltered areas only)
- Inorganic zinc (as a primer)

Cadmium shall not be allowed.

## **14.9 CATHODIC PROTECTION**

Cathodic protection installations shall be designed consistent with structure life objectives and NACE International standards. Design of cathodic protection shall be by a NACE International Certified Cathodic Protection Specialist. In general, sacrificial galvanic anodes to minimize interaction with other underground utilities are the preferred corrosion protection system. The use of impressed current systems in lieu of sacrificial anodes will be allowed only after review and approval by SANDAG.

Designs shall be based on NACE International standards, recommended practices, and theoretical calculations. At a minimum, the design process shall assess the following:

- Soil Environment
- Mutual structure protection or interference configuration
- Limitation of protection potentials
- Test monitoring stations and facilities
- Anode service life and ground bed resistance
- Minimum anode service life of 25 years

## 14.10 QC TESTING - CONTINUITY, CATHODIC PROTECTION & COATINGS

### 14.10.1 ELECTRICAL CONTINUITY

The electrical continuity of select utility structures and pipelines is required by the design criteria. The requirements for determining and testing the proper electrical characteristics of these structures shall be incorporated into the design of the structure. Guidelines for developing the quality control test procedures for electrical continuity are as follows:

- All structures that are to be made electrically continuous shall be tested for electrical continuity and compared to theoretically based criteria, and shall meet or exceed the accepted criteria.
- A specific set of test procedures and acceptance criteria for the electrical continuity testing shall be incorporated into the project specifications.
- Selection criteria for the entities to perform the quality control testing shall be incorporated into the project documents. The criteria shall include the qualifications of the agency, personnel requirements, and equipment requirements. A minimum of 5 years of experience performing this work is required.
- Specific reporting requirements for the electrical continuity testing shall be incorporated into the project documents.

### 14.10.2 CATHODIC PROTECTION

The application of cathodic protection on select underground utility structures and pipelines is required by the design criteria. The requirements for determining proper application of cathodic protection include the verification of electrical continuity and verification of cathodic protection compliance with industry standards (NACE International). Guidelines for developing the quality control test procedures for verification of cathodic protection levels are as follows:

- All structures that are required to have cathodic protection shall be tested in accordance with NACE International RP0169. A test plan shall be submitted by the testing agency to be approved by SANDAG.
- Specific reporting requirements for the cathodic protection testing shall be incorporated into the project documents.
- Selection criteria for the entities to perform the quality control testing shall be incorporated into the project documents. The criteria shall include the qualifications of the agency, personnel requirements, and equipment requirements. A minimum of 5 years of experience performing this work is required.

### 14.10.3 COATINGS

The quality control measures required for the verification of proper application and handling vary greatly depending on the coating type. Guidelines for establishing general procedures for quality control testing are as follows:

- Coatings shall be tested in accordance with the manufacturer's recommendations and in accordance with NACE International recommended practices.
- A quality control test plan shall be required for the application and testing of all coated surfaces. The test plan shall address the allowable coating thickness measurements, adhesion requirements, hold points for test, test procedures to be used in the quality control process, and reporting and acceptance requirements for each specific type of coating system being used.



- All shop coated surfaces shall first be tested, witnessed, and accepted at the coating facility.
- Additional field quality control hold points shall be required.
- Selection criteria for the entities to perform the quality control testing shall be incorporated into the project documents. The criteria shall include the qualifications of the agency, personnel requirements, and equipment requirements. A minimum of 5 years of experience performing this work is required.

The following tables give guidance to the Design Engineer in determining minimum required concrete cover and/or the use of ECR and CRC.

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## 15.0 FACILITIES ELECTRICAL SYSTEMS

*There are currently no building facilities planned for the LOSSAN Corridor in San Diego County. This section serves as a place holder for use in developing project-specific design criteria that will be required for future building facilities.*

### 15.1 SCOPE

This chapter lists the requirements for the design, installation and operation of all electrical equipment throughout LOSSAN Corridor facilities. These criteria cover AC and DC power electrical systems required to serve lighting; heating, ventilating and air conditioning equipment; mechanical equipment; communications systems; power supply control equipment; emergency power systems; illuminated and variable message signs; clocks and alarm systems; CCTV and station public address systems; fire protection systems; and pumping equipment.

### 15.2 STANDARDS, CODES, AND GUIDELINES

The latest edition of the following standards, codes and guidelines shall be used for design of the electrical system:

- American Railway Engineering and Maintenance-of-Way Association (AREMA)
- National Electric Code (NEC)
- California Electrical Code
- California Title 24 Energy Regulations
- National Electrical Safety Code (NESC)
- American National Standards Institute (ANSI)
- National Electrical Manufacturers Association (NEMA)
- Institute of Electrical and Electronics Engineers (IEEE)
- Insulated Cable Engineers Association (ICEA)
- National Fire Protection Association (NFPA)
- Illuminating Engineering Society (IES)
- SDG&E Standards

NEC Compliance for signal equipment; NCTD will self inspect all signal equipment facilities and will certify all electrical services installed on NCTD property to ensure that they meet all NEC regulations.

### 15.3 ESSENTIAL LOADS

The designer shall determine essential loads based on the facility type and service requirements. Certain types of loads shall be considered essential. For example, it is absolutely essential to minimize interruption of power to safety and system operations. Thus, power interruption should be limited to the normal transfer time of automatic transfer. Loads requiring uninterruptible power shall be defined in consultation with LOSSAN Corridor maintenance, signal, communications, and information systems staff.

## **15.4 ELECTRICAL DISTRIBUTION CENTER**

### **15.4.1 POWER SOURCE**

Incoming electric service for each facility shall be terminated at the AC switchboard. The switchboard shall include the utility metering, as required by SDG&E, and the necessary circuit breakers and transfer switches for distribution to AC power loads within the facilities.

Utility metering shall be located in an accessible area of the station per the requirements of SDG&E, to allow meter reading without requiring special access or assistance from the owner. Where required, essential and non-essential buses shall be established for distribution to the loads.

### **15.4.2 SERVICE DUCTS**

Ductwork for SDG&E service drops shall be furnished in the structures as required by SDG&E.

## **15.5 EMERGENCY POWER SYSTEM**

### **15.5.1 REQUIREMENTS**

Emergency power shall be provided for selected portions of the LOSSAN Corridor train control (signal) and communications equipment located at the (MOC) facility and field locations, as required. The emergency power systems shall consist of an uninterruptible power supply (UPS), which includes a rectifier-charger, battery, inverter and high-speed static transfer switch, with energy supplied from the battery during the emergency period. Emergency Battery and Charger.

The batteries shall have sufficient capacity to provide the full emergency load continuously for 30 minutes after a power supply failure, with a minimum final terminal voltage of 105 volts. If required by local code, a separate, adequately ventilated battery room shall be provided.

The battery charger shall be a silicon-rectifier type with the capacity to supply emergency loads and charge the battery from a completely discharged condition in approximately 12 hours. It shall have an adjustable charge rate for equalization, and shall provide “no-charge” indication to the supervisory control system.

### **15.5.2 INVERTER**

The inverter shall be solid state, 120-volt dc input to 120-volt, 1-phase, 60-Hz, sine wave output, powered from the 120-volt battery during emergencies. Under normal operation, the emergency load will be supplied through the inverter.

### **15.5.3 STATIC TRANSFER SWITCH**

An automatic high-speed static transfer switch shall transfer the load of the emergency panel from the inverter to the essential bus if there is a fault in the load or the inverter fails, with transfer in less than a quarter cycle.

The transfer switch shall provide an indication of transfer to the supervisory control system. When the trouble has cleared, and the essential-bus voltage remains stable, the transfer switch shall automatically retransfer the emergency panel load from the essential bus back to the inverter after 15 minutes.

#### **15.5.4 SUPPLY VOLTAGES**

Power for facilities shall be supplied at a nominal 480/277 volts, 3-phase, 4-wire, 60-Hz.

##### Motors

In general, equipment motors shall be squirrel-cage induction motors, NEMA Design B, unless the application requires other classifications. Enclosures shall be selected to suit the environmental conditions. Refer to Chapter 13.0 - “Mechanical” for specific requirements.

In general, circuit breaker combination starters in a motor control center construction shall be used for the 480-volt motors. However, individually mounted circuit breaker combination starters may be used where practicable. Starters shall be magnetic, full-voltage start, single-speed and non-reversing, except where the equipment characteristics or power company limitations require other types. Each starter shall be equipped with a 120-volt control transformer and three thermal overload relays. In general, enclosures shall be NEMA Type 12, except where environmental conditions make other types more suitable. Refer to Chapter 13.0 - “Mechanical” for specific requirements.

Wiring shall not be permitted to exceed 5 percent of nominal voltage.

### **15.6 EXPOSED CONDUIT WIRING METHODS**

#### **15.6.1 ALLOWABLE APPLICATIONS**

In general, exposed conduit for wiring within facility areas shall be in metallic conduit or ducts. Both rigid galvanized steel and intermediate metal conduit are acceptable for exposed conduit installation. Cable trays may be used in areas where approved.

#### **15.6.2 CONDUIT SIZE**

Exposed conduit smaller than 5/8 in. electrical trade size shall not be used.

#### **15.6.3 INSTALLATION CRITERIA**

Expansion fittings shall be used where conduits cross structural expansion joints, and as required by the thermal expansion and contraction in a length of conduit.

Metallic conduit shall be grounded and bonded to assure electrical continuity and the capacity to safely conduct any fault current likely to be imposed. Where bare ground wire is run in metallic conduit, the ground wire shall be bonded to the conduit at both ends to avoid inductive choke effects. See Chapter 14.0 - “Corrosion Protection” for additional requirements.

## **15.7 EMBEDDED CONDUIT WIRING METHODS**

### **15.7.1 ALLOWABLE APPLICATIONS**

Embedded conduit for wiring within facility slabs, walls, and underground shall be rigid galvanized steel or rigid nonmetallic conduit. Both Schedule 40 and Schedule 80 PVC and fiberglass-reinforced epoxy (FRE) conduit are acceptable rigid nonmetallic compositions for embedded conduit installations.

### **15.7.2 CONDUIT SIZE**

Embedded conduit smaller than 1 in. electrical trade size shall not be used.

### **15.7.3 INSTALLATION CRITERIA**

Expansion fittings shall be used where embedded conduit passes through structural expansion joints. In general, expansion fittings are not required for embedded conduit installations where underground temperatures are relatively constant. However, due to the large change in length per degree change in temperature exhibited by nonmetallic conduit, such installation shall be backfilled or concrete-encased immediately.

Minimum cover requirements shall meet or exceed the requirements of NEC for the conduit composition and voltage class of wiring installed. Areas subject to heavy vehicular traffic shall have a minimum cover of 24 in. with a 3 in. concrete encasement. Concrete duct banks under roadways or railroad tracks shall be reinforced. See Chapter 14.0 - "Corrosion Protection" for criteria regarding conduits crossing under tracks.

Where multiple conduits or ducts are run as a duct bank, plastic spacers shall be used to support the rows of conduit and to maintain a clear separation of 2 in. between conduits. The separation provides space for backfill or concrete aggregates; permits the mounting of end bells or bushings at terminations; and facilitates heat dissipation. Plastic warning tape shall be installed above all conduits.

Duct banks shall be laid out in as straight a line as possible with a slope of 0.50 percent to 1 percent toward drain points. Where bends are required, large-radius field bends are preferable. The minimum conduit bending radius shall not be less than that permitted by the NEC. Small-radius conduit bends should generally be constructed with factory-made fittings. The total number of bends in one run of conduit shall not exceed the equivalent of four quarter bends (360 degrees total).

Conduits shall be cleaned with a mandrel or rod after installation and before cable installation. If cable is not to be installed immediately, a pull-string shall be installed in the conduit.

Vertical conduit turn-ups from embedded conduit may be installed with either rigid galvanized steel or PVC conduit. The PVC conduit for use in this installation shall be ultraviolet-resistant.

## **15.8 MANHOLES AND HANDHOLES**

Manholes and handholes are located in underground duct banks to provide cable pull-points and junction points and to accommodate splices. Manholes should be large enough to accommodate the depth and cross-sectional area of the duct banks entering and to provide a

minimum horizontal workspace of 36 in. clear of cable supports and a minimum vertical dimension of 7 ft.

Manhole openings provide both access and cable-installation space. Round access openings shall be a minimum 26 in. in diameter. Rectangular access openings shall not have dimensions less than 22 in by 26 in. Grade adjustment rings can be installed around manhole openings to accommodate the depth of the duct banks.

Manholes shall be provided with sumps, and the floor shall be sloped toward the sump. Portable sump pumps can be used to pump out accumulated water.

Handholes shall be a maximum 42 in. in depth and shall be covered with a removable or hinged checkered plate lid.

### ***15.8.1 DIRECT-BURIED CABLE***

#### Allowable Applications

Direct-buried cable may be used instead of aerial or conduit-encased wire or cable for signal and communications systems, electrolysis control cables and stray-current return cables.

#### Installation Criteria

Direct buried cable installation shall conform to applicable requirements of NESC Section 35, "Direct Buried Cable," and NEC Article 300-5, "Underground Installations," except the minimum depth of cable shall be 30 in. and cables shall be embedded in sand before the trench is backfilled with excavated material. Plowing of direct buried cable is not permitted due to presence of other underground facilities within the ROW.



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## 16 AESTHETIC CONSIDERATIONS

### 16.1 SCOPE

The aesthetic appeal of bridges and retaining walls has become increasingly important to communities along the Los Angeles–San Diego–San Luis Obispo (LOSSAN) Coastal Rail Corridor. Residents, businesses, cities, and other stakeholders are encouraging SANDAG to incorporate aesthetic enhancements that reflect community and nearby character and help bridges blend in with their natural environment. Aesthetic elements could including structural, color, architectural and surface treatments.

### 16.2 GUIDELINES

#### 16.2.1 General guidelines

General aesthetic guidelines have been previously published in the LOSSAN Programmatic EIR/EIS and in the Caltrans North Coast Corridor/PWP Policy 5.7.1

#### 16.2.2 General aesthetic considerations

- i. Public visibility would be a primary consideration for evaluating the aesthetics of a new structure. Designers should consider aesthetic enhancement of rail bridges along the LOSSAN corridor that meet one or more of the following criteria:
  - Close proximity to public view points.
  - Viewed from a designated scenic corridor
  - Location considered a “gateway” to a community
  - Bridge regarded as part of the community character
  - Adjacent to a nature or visitor center
  - Along a public nature trail
  - Part of a public view corridor
- ii. Determine the appropriate level of aesthetics needed and present design options that address proposed aesthetic treatments.
- iii. NCTD Review. Operations and Maintenance Considerations:
  - Minimize ongoing maintenance to the greatest extent possible.
  - Consider aesthetic features that can minimize graffiti.
- iv. For high visibility structures the SANDAG Communications Staff will be consulted to determine appropriate public outreach for the project.

### 16.2.3 Specific aesthetic considerations

Determined based on the following consideration;

- i. Low public visibility – no aesthetic treatments needed
- ii. Medium public visibility recommended aesthetic treatments would be;
  1. Color – Concrete coloring
  2. Texture – Form liners
  3. Enhanced – abutments, pile caps or columns.
- iii. High public visibility recommended aesthetic treatments would be;
  1. Context sensitive to each project area
  2. Requires project architect to develop alternatives
  3. Architecturally enhanced columns, spans, abutments, railings.
  4. Lighting to be incorporated into design where public access is needed after dark.
  5. Colors and textures to be considered
  6. Public Input should be considered

**Table 16.1 Aesthetic Considerations**

Visibility	Examples	Treatment Level may include:
<b>High</b>	Joint Amtrak/Metrolink/Coaster Stations; Stations in downtown districts, Stations in or adjacent to historic districts, Parking Garages, Transit-Oriented-Developments And Regional destinations	Context sensitive to each project area Requires project architect to develop alternatives Architecturally enhanced columns, spans, abutments, railings Lighting to be incorporated into design where public access is needed after dark Colors and textures to be considered Public input should be considered
<b>Medium</b>	Station areas, pedestrian underpasses Roadway underpasses with sidewalks Lagoon Bridges	Color – concrete coloring/staining Texture – form liners/stamping Enhancements – abutments, pile caps or columns and lighting Landscaping (where applicable)
<b>Low</b>	For those items not in areas of High or Medium Visibility:  Railroad bridges and retaining walls not at stations; roadway underpasses without sidewalks. Pre-existing BNSF (grandfathered) bridges, retaining walls and underpasses. Other railroad elements (culverts, drainage ditches, signal houses and antennas, communications houses, station equipment and amenities)	Minimal footprint and profile but otherwise no aesthetic treatment Anti-graffiti treatment if necessary
<b>Non-NCTD Responsibility</b>	Roadway or pedestrian overpass bridges Roadway or pedestrian underpasses not at stations	None

## 16.3 AESTHETIC TREATMENT EXAMPLES

### 16.3.1 Stations



- i. Santa Fe Depot in Downtown San Diego - Joint Coaster, Amtrak and MTS Trolley Station in historic setting.





ii. Old Town – Joint Coaster, Amtrak and MTS Station in Historic setting.





iii. Sorrento Valley Station under I-805 merge.



iv. Solana Beach – Joint Coaster and Amtrack Station in Downtown Solana Beach.





v. Encinitas



vi. Carlsbad Poinsettia



vii. Carlsbad Village Station in Downtown District.



viii. Oceanside Transit Center – Joint Coaster, Amtrak, Metrolink and Sprinter Station in Downtown Oceanside.



- ix. Oceanside Transit Center Platform – Joint Coaster, Amtrak, Metrolink and Sprinter Station in Downtown Oceanside.

### 16.3.2.1 Pedestrian Crossings - Underpasses

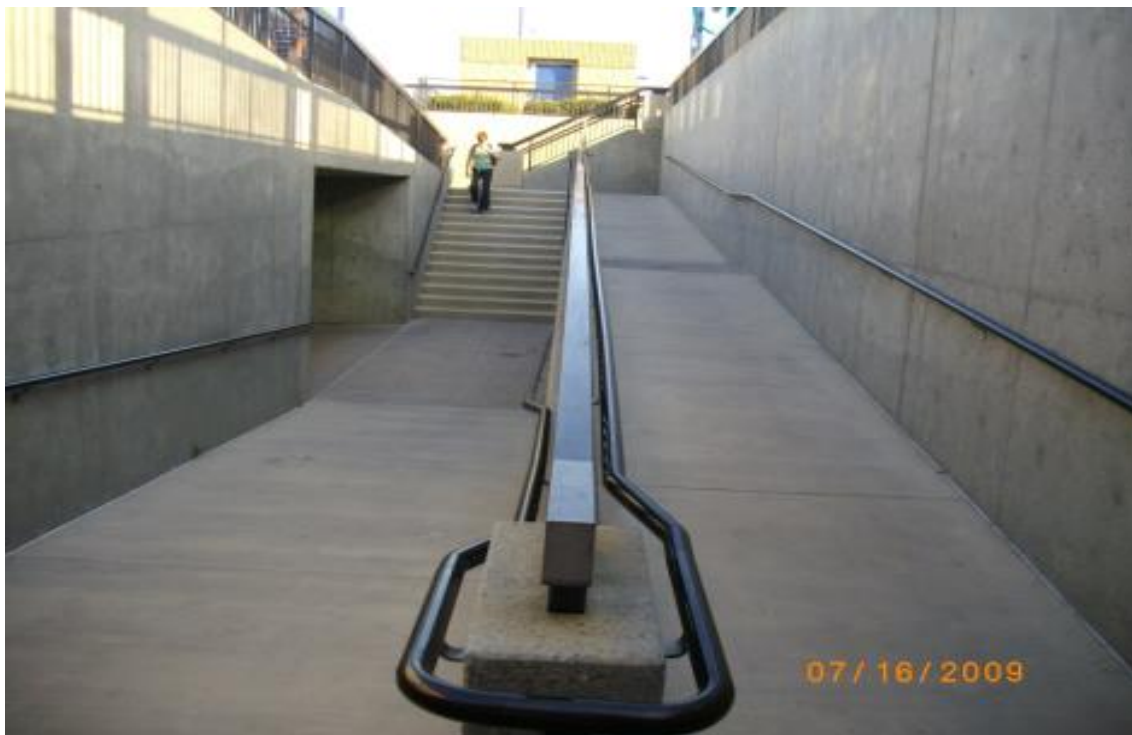


i. Old Town Undercrossing





ii. Santa Fe Drive Encinitas – Swamis crossing.



iii. Oceanside Station Undercrossing



iv. Pier View Way



v. Oceanside Harbor Undercrossing

### 16.3.2.2 Pedestrian Bridges



i. Solana Beach Station Bridge

### 16.3.3 Parking Structures



i. Oceanside Transit Center



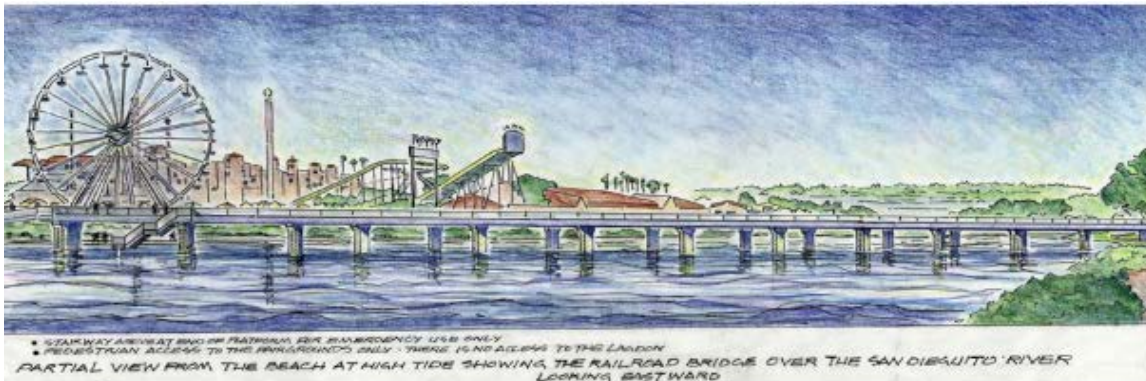
ii. Sabre Springs Transit Center



### 16.3.4 Bridges



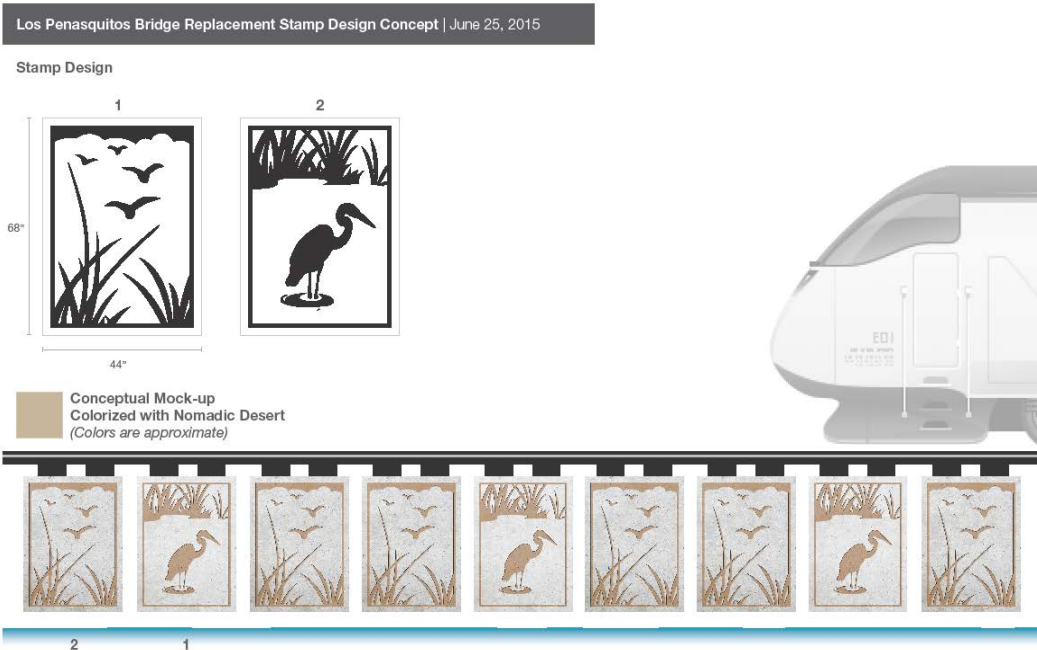
i. Santa Margarita River Bridge.



ii. San Dieguito Bridge (Concept rendering)  
 (Regional Destination Station at Del Mar Fairgrounds and Lagoon Bridge)



iii. Trestles Bridge over San Mateo Creek.



iv. Los Penasquitos Lagoon Bridge (Concept)



- v. Sorrento Valley Double Track bridge over Los Penasquitos Creek has low public visibility and needs no special treatment.

### 16.3.5 WALLS AND SLOPES



i. Sorrento to Miramar phase 1 soil nail slope treatment .



ii. Sorrento to Miramar phase 1 Retaining wall treatment.



iii. Lomas Santa Fe wall on Interstate 5



iv. Solana Beach Station west access stair and slope treatment

## CHAPTER 17

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## 17.0 TRAIN CONTROL SIGNALS

### 17.1 GENERAL DESIGN REQUIREMENTS

The addition of control points, wayside signals, highway grade crossing warning, and hazard detection systems may increase long-term maintenance and inspection expenses. Such improvements will likely enhance train operations and passenger rail service, but may not result in increased ridership or revenues for the agency. The increased operating and maintenance expense will likely be recovered in the form of fare increases which in turn can have an adverse effect and result in even lower revenues. Through simple yet effective design principles, the designer shall not only attempt to control capital cost expenditures per project, but also long-term operating expenses.

The designer shall specify equipment and applications that will not only provide optimum safety, but will also maximize the efficiency and reliability of commuter and freight train operations. The design shall incorporate systems and equipment that have a proven performance history on major rail networks throughout the continental United States of America (USA). The design shall incorporate features that aid Communications and Signal (C&S) personnel in the inspection, testing, repair, and overall maintenance of the system.

The contract drawings provided by the designer shall be detailed and reflect products that are currently in use on NCTD operated territory and that have a proven history of reliable performance on major USA rail networks, such as the Burlington Northern Santa Fe (BNSF). Major railroads perform in depth tests and evaluations of equipment and work closely with manufacturers in the refinement of equipment prior to full deployment. Once performance has been proven, a major railroad will purchase substantial quantities. Manufacturers and suppliers will provide long term technical support for products purchased in mass quantities by major railroads. It is in the best interest of SANDAG and NCTD to ensure that long term technical support can be provided, that parts can be repaired or purchased and are readily available, and in case of emergencies, equipment and replacement parts can be obtained from local railroad operators.

Equipment shall be easy to maintain and troubleshoot. Systems that require the support of highly skilled technicians or an engineer should be avoided. Once installed, the system should be relatively self-supporting and require limited interaction from maintenance forces. The designer shall consider that the rail line and equipment is not exposed to extremely low temperatures, but may be exposed to very high temperatures and salt-air conditions.

New products shall only be introduced after careful evaluation and with the approval of NCTD. Most C&S components are expected to provide service for 30 years or more. New products may not be supported by manufacturers for such an extended period unless the product is accepted and deployed by the major railroads that purchase large quantities of products on a regular basis.

NCTD maintains an inventory of spare and replacement parts for existing Communications and Signal equipment. Introducing new products requires the procurement of additional spares in sufficient quantities to ensure repairs can be made quickly with little or no

operational impacts. The designer shall ensure that specifications require the contractor to provide an adequate quantity of spares. NCTD shall provide guidance in this area.

Training shall be provided to maintenance personnel for any new products introduced to the system. The training shall be provided by a representative of the product manufacturer. The representative shall be knowledgeable of the product specifications, operational characteristics and limitations.

All maintenance personnel shall not attend training at the same session. The contract specifications shall require several training sessions be scheduled to ensure there is an adequate number of maintenance personnel available to support rail operations.

The design approach shall attempt to:

- Minimize the use of auxiliary components and equipment;
- Where possible, incorporate features that will reduce maintenance, testing, and troubleshooting;
- Incorporate equipment and components that are presently in operation on the NCTD rail network, thus eliminating the need for additional spare parts and training of personnel.
- Design simple systems that can be maintained and repaired by personnel with limited technical skills. Avoid installation of systems and components that require periodic adjustment and/or inspection by highly skilled technicians or engineers.

No system or subsystem shall be accepted for service until thoroughly tested. Contract specifications shall ensure that no system or subsystem is accepted until tested under actual operating conditions. Construction management personnel are responsible for enforcement of the technical specifications and shall not diminish or otherwise lessen the submittal or installation requirements as specified in the contract documents.

Application logic software shall conform to all applicable rules and regulations, but shall also be simple in form so as to be easily understood by personnel responsible for the maintenance and care of the system. As much as is practical within the scope of a project, equipment to be installed shall be scalable for future expansion, and the signal houses shall be sized accordingly.

Where this criterion makes reference to system logic and design using vital relays, the same logic shall be applied to microprocessor-based controller applications. All designs shall adhere to the rules and regulations contained in Title 49 Code of Federal Regulations (CFR) Parts 234, 235, and 236. All designs shall incorporate the rules and instructions as contained in the most current version of the California Public Utilities Commission (CPUC) General Orders; California Manual of Uniform Traffic Control Devices (CA MUTCD); General Code of Operating Rules (GCOR); North County Transit District (NCTD) General Orders, Timetable, and Special Instructions; and American Railway Engineering and Maintenance-of-Way Association (AREMA) Communications & Signals Manual of



Recommended Practices. Where the AREMA manual is used, “may” and “should” are to be interpreted as “shall” unless in conflict with these criterion or otherwise directed by responsible authorities. Note that the NCTD General Orders, Timetable, and Special Instructions supersede the GCOR where they are in conflict.

Any modification to train control signal systems has the potential to necessitate changes to the grade crossing warning systems. It should be noted that any changes to track structure, including installation of insulated joints and imposition of audio frequencies on the rails, need to be evaluated to determine the potential effect on grade crossing warning systems. Refer to Chapter 18.0, Grade Crossing Warning Systems, for grade crossing considerations and design criteria.

Designs shall incorporate the standards reflected in the SANDAG/NCTD Engineering Standard Drawings. Any variations to the standards required to conform to site conditions shall be approved by NCTD.

## **17.2 STANDARDS, CODES AND GUIDELINES**

The latest editions of the following standards, codes, and guidelines shall be used, as applicable, for the design and implementation of the wayside signal system:

- Federal Railroad Administration (FRA) standards, 49 CFR 234, 235, and 236
- American Railway Engineering and Maintenance-of-Way Association (AREMA)
- California Public Utilities Commission (CPUC)
- NCTD Timetable, Special Instructions and General Orders
- SANDAG/NCTD Engineering Standard Drawings
- NCTD Software Configuration Management Plan
- National Electrical Code (NEC)
- Institute of Electrical and Electronics Engineers (IEEE)
- American National Standards Institute (ANSI)
- Electronic Industries Association (EIA)
- Federal Communications Commission (FCC)

## **17.3 SAFE BRAKING CRITERIA**

### **17.3.1 SIGNAL SPACING**

The signal system, while allowing for safe freight train braking, will also be designed for the greatest possible passenger train efficiency. In addition to providing safe stopping distance, the signals must provide safe reduction distance for turnouts. Signal spacing shall consider all factors necessary to provide a safe and efficient operation.

Where practical, the signal block length should be between 6,000 and 9,000 feet in length. Such spacing allows mixed traffic to operate with optimum headways, and combined with the use of fourth aspect signaling (i.e. flashing yellow), provides safe braking distance for freight trains.

On the San Diego Subdivision, freight trains operating with less than 90 Tons Per

Operative Brake (TPOB) may travel at a maximum speed of 55 mph, and freight trains operating at 90 TPOB but not exceeding 143 TPOB may travel at a maximum speed of 45 mph. On the Escondido Subdivision, freight trains operating up to but not exceeding 143 TPOB may travel at a maximum speed of 40 mph. Passenger train braking should be based on Amtrak braking standards (CE-205 Standards). These standards should be used in calculating safe braking distance. It is the responsibility of the design firm to verify current speeds and tonnage restrictions through the governing Timetable, Special Instructions and current General Orders. Any discrepancies must be brought to the attention of LOSSAN authorities and resolved.

### **17.3.2 AVERAGE GRADE**

For freight train braking calculations, the 4,000 feet in approach of the beginning of the block must be considered when calculating the average grade for the entire block. If the average grade within the 4,000-foot approach length is negative (i.e., descending), then this 4,000 feet shall be added to the overall block length in calculating the average grade for the block.

For passenger train braking calculations, 1,000 feet in approach of the block must be considered in averaging. If the average grade within the 1,000 foot approach length is negative (i.e., descending), then this 1,000 feet shall be added to the overall block length in calculating the average grade for the block.

- A. Using scaled drawings, measure the distance between all grade change points in the block. The sum of the distances is equal to the Total Block Length (TBL).
- B. Multiply each distance by the grade indicated between each point. This is known as the Distance Grade (DG).
- C. Sum the Distance Grades and divide by the Total Block Length. This is the Average Grade (AG) of the block. (Sum of DG / TBL = AG)

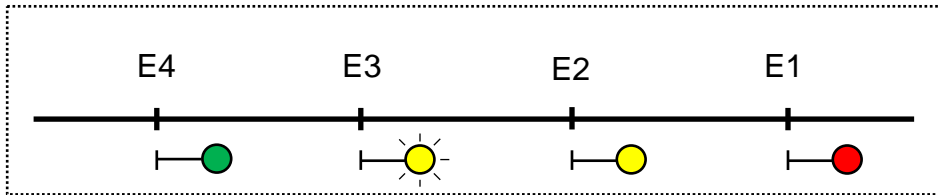
$$\frac{DG + DG + DG + DG + \dots}{\text{TOTAL BLOCK LENGTH}} = \text{AVERAGE GRADE}$$

If grade information is not available from the track designer, use the grade data utilized for Positive Train Control (PTC).

The calculation of safe braking distance where multiple classes of trains operate shall be based on the most restrictive of the braking criteria. Braking distances for freight trains are relatively long when compared to passenger trains due to their significant distributed mass, speed, braking characteristics, and signal block average grades. Consequently, braking distances become a critical consideration when determining the position of the first warning aspect with respect to the stop signal to which it applies, especially where there is a mix of freight and commuter traffic operating over the same track.

### **17.3.3 SIGNAL ASPECT SELECTION**

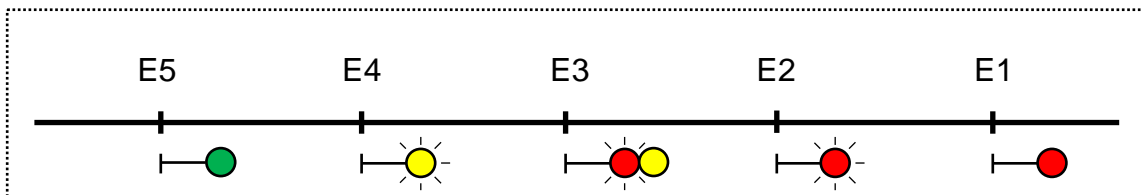
The desired aspects in approach to a **RED** signal are:



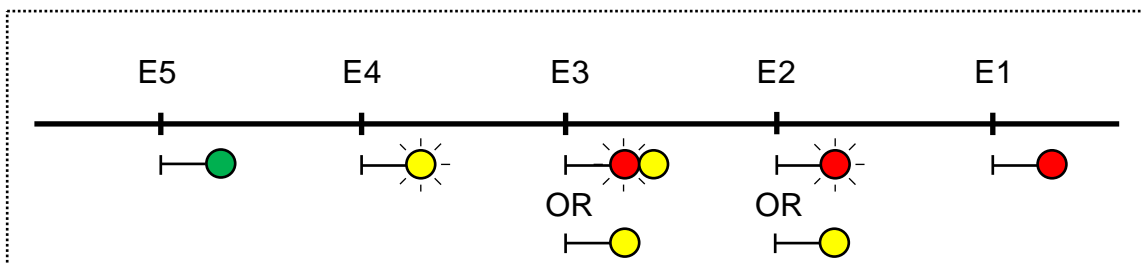
The average grade shall be computed for each signal block in order to perform the safe braking calculation. The grade and distance between **E3** and **E1** shall provide safe braking for all types of trains operating at maximum authorized speed (**MAS**). The grade and distance between **E2** and **E1** shall provide safe braking for trains operating at **30 MPH** when passing **E2**. The grade and distance between **E3** and **E2** should be sufficient for all trains to reduce from **MAS** to **30 MPH** when passing **E2**.

The designer shall attempt to space signals so that the aspect configuration shown above can be provided. The signal designer may need to encourage the track designer to shift new crossovers and turnouts to achieve the desired signal spacing. If the desired signal spacing cannot be provided because of the close proximity of control points, or stations close to control points, the designer shall utilize the following guidelines:

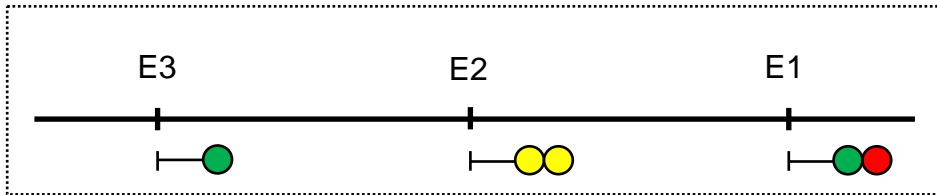
Where the distance between signal **E2** and **E1** is less than 3000 ft., signal **E2** shall display a **FLASHING RED** in approach to a **RED** at **E1**. See example below:



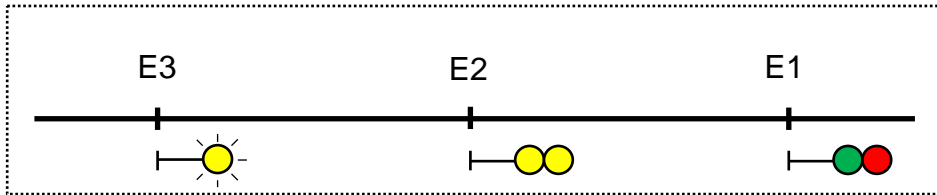
Where the distance between **E2** and **E1** is greater than 3000 ft. but not sufficient to provide safe braking for a train passing **E2** at **30 MPH** the designer shall either 1) display a **FLASHING RED** in approach to a **RED** at **E1** or 2) repeat the **YELLOW** at **E3**. Designer shall consult with NCTD to determine the preferred operation. See example below:



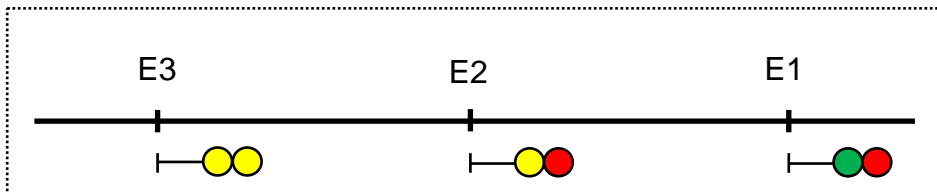
The distance between a signal **E2** in advance of a home signal **E1** displaying a diverging aspect must be sufficient to enable a train to reduce from **MAS** to the maximum speed of the route governed by the home signal. See example below:



If the distance between a signal **E2** in advance of a home signal **E1** is not sufficient to enable a train to reduce from **MAS** to the maximum speed of the route governed by the home signal, then display a **FLASHING YELLOW** at **E3**. See example below:



When two control points are adjacent to each other with no intermediate signal between the control points and the downstream home signal (**E1**) is displaying a diverging aspect then the home signal (**E2**) in advance, if also displaying a diverging aspect, shall not display an aspect better than **RED over YELLOW**. See example below:



The information above does not cover all scenarios. The designer shall develop **Signal Layout** drawings (to scale) and **Aspect Charts** at the 30 percent design level. The designer shall review the **Aspect Charts** with NCTD operations to ensure the proposed aspects support the desired operation plan.

## 17.4 SIGNAL CONTROL SYSTEMS

Control points shall utilize vital microprocessor-based control systems configured for use with colorlight LED signal units. Interlocking systems shall be capable of interfacing with existing controllers utilizing a serial or modem connection. Microprocessor-based control systems shall be General Electric Transportation Systems (GETS) ElectrologIXS Vital Logic Controller or equivalent systems. Intermediate signals shall use electronic coded track circuit systems such as GETS ElectrologIXS Electrocode 5 or equivalent systems. The use of “vital or non-vital relays” shall be minimized where possible. All signal systems shall be equipped with data recorders that will record information useful in maintenance and repair of the system (minimum 72 hours of recording without overwrite).

Electronic coded track circuits shall be used wherever practical to transmit and receive vital block signal data. New application logic software must be approved prior to installation. The following code rates and corresponding information in **Table 17-1** shall be used.

**TABLE 17-1**

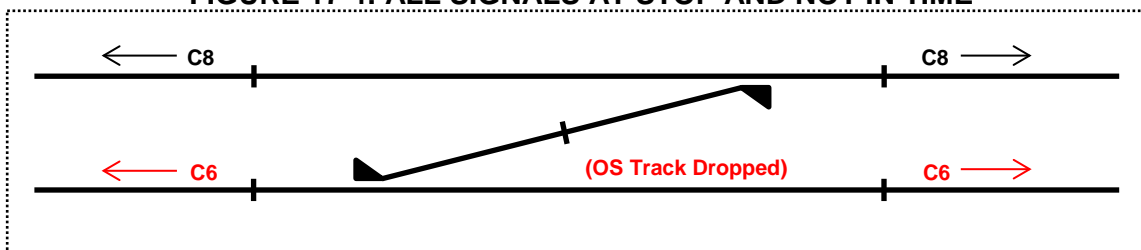
Code Rate In	Indication (Aspect) Displayed or Function
1	Vital Track Code
2	Approach Diverging (Yellow over Yellow)
*3	Approach Restricting (Yellow over Flashing Red) (*See note below)
4	Advance Approach
5	Non-Vital Block Indication or Hand Throw Switch in Block Out-Of-Correspondence
6	Accelerated Tumble Down
7	Clear (Green)
8	Approach (Yellow)
9	Approach Restricting (Yellow over Flashing Red)
M	Non-Vital Special Code

*\*(Code 3 used for Approach Restricting only when older equipment executive software does not support Code 9 rates and can not be upgraded)*

Electrocode code rates will be transmitted simultaneously in both directions throughout signal blocks. “Turn of Traffic” signaling shall be used. Tumbledown will take place after a signal has been requested into a block, and as a train moves through the signaled route. As soon as the lead train is within the OS track, a code 8 may be sent into the block behind the signal so the Approach Signal displays Yellow aspect up to the Red Absolute.

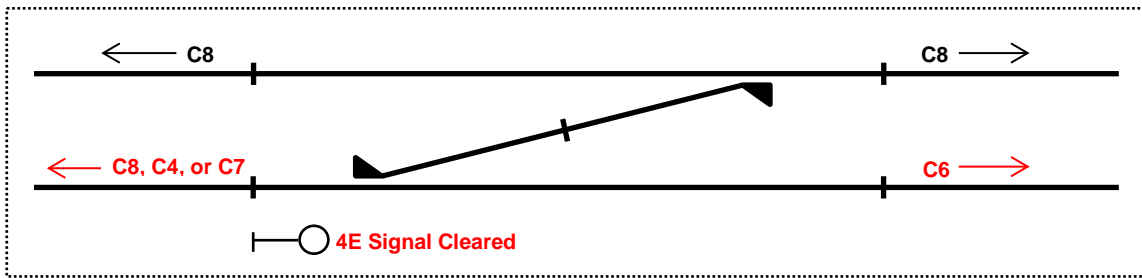
Code 6 is used to accelerate the tumbledown. Code 6 will be used when a signal is cleared into a block. When a train is flagging past a signal or a switch point pumps, the affected signals will go to STOP and vital codes will be removed, and code 6 will be transmitted into all affected routes. Code 6 may also be used to release the directional stick at intermediate signals.

Figures 17-4 through 17-6 demonstrate the principles of the tumbledown under different scenarios.

**FIGURE 17-4: ALL SIGNALS AT STOP AND NOT IN TIME**


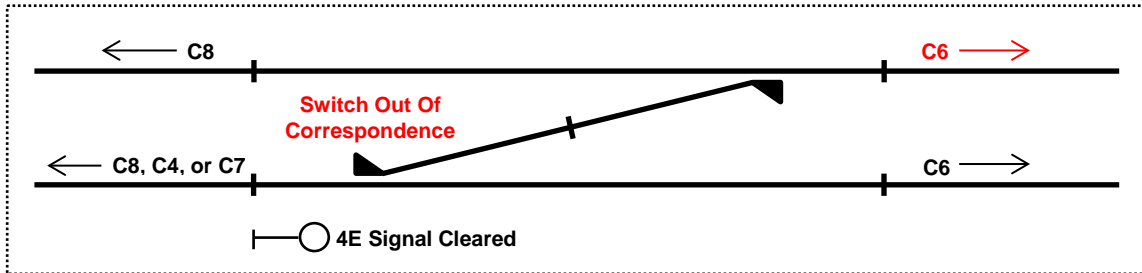
In Figure 17-4, if all signals are at stop and not in time, CODE 8 is transmitted in all directions. If the OS track is dropped, CODE 6 will be transmitted.

**FIGURE 17-5: SIGNAL 4E CLEARED**



In Figure 17-5, Signal 4E has been cleared over the normal switch and the 4EWLR term is false. Code 6 is transmitted in the direction of travel. The code transmitted in approach to signal 4E will be as called for by the aspect displayed.

**FIGURE 17-6: SIGNAL 4E CLEARED AND SWITCH IS OUT OF CORRESPONDENCE**



In Figure 17-6, Signal 4E has been cleared over the normal switch and the 4EWLR term is false. Code 6 is transmitted in the direction of travel. The switch on the traveled track goes out of correspondence. If the crossover is conventional, the parallel track will tumble down.

When a train is to enter a signal block between Control Points over a hand operated switch, a Leaving Signal (or Come Out Signal) is preferred over an Electric Lock. In the case of a Leaving Signal or an Electric Lock, a short tumbledown timer shall run and code 6 shall be transmitted in both directions, then if vital codes are received in both directions, the Electric Lock will release, and in the case of a Leaving Signal, after the hand operated switch is full reverse, the signal will clear.

Lamp-out application logic shall incorporate aspect downgrades that minimize train delay. Under normal conditions, the upper and lower units of a two unit signal shall be illuminated. The principle can be summarized as follows: a Top or Bottom Green will downgrade to a Flashing Yellow or Yellow as appropriate, all other lamp-outs will downgrade to a Restricting aspect unless the Dark aspect does not affect safety. The principle is that the lamp-out condition will be acted upon more quickly when a Restricting aspect is displayed. When elaborate lamp-out downgrade schemes are used, signals may not be reported until there are multiple lamps out. Lamp-out schemes should be shown on the aspect charts or circuit plans for each location. The following typical downgrade logic shall be incorporated;

Refer to the following Tables 17-2 through Table 17-4:

**TABLE 17-2**

<b>One Unit Signal with Lamp Out</b>	
<b>Aspect with Lamp Out</b>	<b>Downgrade Aspect</b>
Green	Flashing Yellow
Flashing Yellow	Flashing Red
Yellow	Flashing Red
Red	Dark

**TABLE 17-3**

<b>Two Unit Signal with Top Lamp Out</b>	
<b>Aspect with Top Lamp Out</b>	<b>Downgrade Aspect</b>
Green over Red	Flashing Yellow over Red
Yellow over Yellow (for Automatic Signals)	Dark over Yellow
Yellow over Yellow (for Absolute Signals)	Flashing Red over Red
Flashing Yellow over Red	Flashing Red over Red
Yellow over Flashing Red	Flashing Red over Red
Yellow over Red	Flashing Red over Red
Flashing Red over Red	Dark over Flashing Red
Red over Green	Dark over Flashing Red
Red over Flashing Yellow	Dark over Flashing Red
Red over Yellow	Dark over Flashing Red
Red over Flashing Red	Dark over Flashing Red
Red over Red	Dark over Red

**TABLE 17-4**

<b>Two Unit Signal with Bottom Lamp Out</b>	
<b>Aspect with Bottom Lamp Out</b>	<b>Downgrade Aspect</b>
Green over Red	Green over Dark
Yellow over Yellow	Yellow over Red
Flashing Yellow over Red	Flashing Yellow over Dark
Yellow over Flashing Red	Yellow over Dark
Yellow over Red	Yellow over Dark
Flashing Red over Red	Flashing Red over Dark
Red over Green	Red over Flashing Yellow
Red over Flashing Yellow	Red over Flashing Red
Red over Yellow	Red over Flashing Red
Red over Flashing Red	Flashing Red over Dark
Red over Red	Red over Dark

The applicable code transmitted from signals displaying the lamp-out condition indicated above shall also downgrade.

Application logic shall be configured to provide approach lighting of signals. Control signals shall light on approach, when a signal control bit is received from the control station, and when a test clip or switch is closed (i.e. lamp test switch). Automatic Signals (Intermediates) shall light on approach, when a test clip or switch is closed (i.e. lamp test switch), and when the signal block has been cleared into.

Where multiple track operations are present, all signals on adjacent tracks governing movements in the same direction shall be illuminated where practical. Where a signal on one track is dark, the signal on the adjacent track(s) will not be put to Stop or Restricting unless there are concerns that the lit signal will be mistaken as governing movement on the track with the dark signal. One example is a bridge or cantilever signal with a curve in the approach and an overhead structure that inhibits preview. In those instances, the signal on the parallel track will be put to Stop or Restricting, and approaches downgraded.

Special lighting circuits should be considered to illuminate a signal displaying a Stop aspect where an approach lighting circuit is effective less than 3,000 feet in approach of the signal. Although each design will provide for utilizing approach lighting, LOSSAN authorities shall be consulted regarding whether the feature will be applied. The designer shall evaluate each location to determine if special circuits should be applied to ensure aspects can be readily observed and acted upon by the locomotive engineer.

The conductor size within the signal cable between the instrument enclosure and the signal junction box shall conform to the manufacturer's recommendations except the cable shall not consist of less than 7 conductors and the conductor size shall be no less than No. 6 AWG to control each signal head. Two conductors shall be dedicated to provide the negative voltage source to each signal head.

#### **17.4.1 APPLICATION LOGIC**

Application logic software shall conform to all regulatory requirements. Applicable Route Locking, Indication Locking and Time Locking shall be used. Route Locking shall be released utilizing the first two consecutive track circuits. Program nomenclature is to follow existing and current San Diego and Escondido Subdivision naming conventions. Application logic is to follow the typical convention most recently being utilized on the San Diego and Escondido Subdivision, respectively. Any relay installations are to follow the same principles utilized in application logic for microprocessor-based systems.

Hard copies of application programs shall be provided where microprocessor-based controllers are installed. This includes applications developed for both wayside signal and positive train control systems. It shall be the responsibility of the design firm to furnish the application files on an appropriate medium for field installation and configuration. Each application shall be clearly identified for its contents and the intended location, and shall follow the practice as outlined in the NCTD Software Configuration Management Plan. After the location has been placed in service, the in-service files will be furnished to the Software Configuration Manager.

Entities providing application logic programs must have a documented process of checking, computer simulating, and rack testing all programs. Upon being placed in service, all



programs and supporting documentation are to be stored on a secure site as directed by NCTD.

Designer shall ensure specifications require Contractors to complete a minimum of 3 levels of testing:

- Level 1 = Rack testing
- Level 2 = Pretesting in the field
- Level 3 = Final in-service testing

When modifications are made to an existing location, the entity providing the application program shall recommend whether reduced test validation is sufficient. Such recommendations shall include documentation of the changes, necessary test procedures, and must be approved by NCTD prior to implementation.

Application logic shall follow the following sequence of activities for clearing a signal:

- A. Request the signal and switch.
- B. Tumble down to the adjoining Control Point upon request of a route into that block.
- C. Check the Route – Switches in position, opposing signals at stop and not in time, vital codes received, detector tracks up, and any other applicable conditions.
- D. Apply the Locking (Lock terms go false).
- E. Upon verification of locking (Lock terms false, Switch Motor Control Relays de-energized), clear the signal.
- F. Upon confirmation of signal aspects, upgrade the codes to the Approach Signal to display the proper signal aspect.

With no signals cleared, vital codes are transmitted in both directions on each track, only at the Control Point as in a two wire HD model.

#### **17.4.2 DEFINITIONS FOR ELECTRIC LOCKING**

##### **Lock, Electric – Part 236.757**

A device to prevent or restrict the movement of a lever, a switch or a movable bridge, unless the locking member is withdrawn by an electrical device, such as an electromagnet, solenoid or motor.

##### **Locking, Electric – Part 236.761**

The combination of one or more electric locks and controlling circuits by means of which levers of an interlocking machine, or switches or other apparatus operated in connection with signaling and interlocking, are secured against operation under certain conditions.

##### **Locking, Approach – Part 236.760**

Electric locking effective while a train is approaching, within a specified distance, a signal displaying an aspect to proceed, and which prevents, until after the expiration of a pre-

determined time interval after such signal has been caused to display its most restrictive aspect, the movement of any interlocked or electrically-locked switch, movable point frog, or derail in the route governed by the signal, and which prevents an aspect to proceed from being displayed for any conflicting route.

#### **Locking, Indication – Part 236.762**

Electric locking which prevents manipulation of levers that would result in an unsafe condition for a train movement if a signal, switch, or other operative unit fails to make a movement corresponding to that of its controlling lever, or which directly prevents the operation of a signal, switch, or other operative unit, in case another unit which should operate first fails to make the required movement.

#### **Locking, Route – Part 236.767**

Electric locking, effective when a train passes a signal displaying an aspect for it to proceed, which prevents the movement of any switch, movable point frog, or derail, in advance of the train within the route entered. It may be so arranged that as a train clears a track section of the route, the locking affecting that section is released. (Note: Generally referred to as “sectional route locking”).

#### **Locking, Time – Part 236.768**

A method of locking, either mechanical or electrical, which, after a signal has been caused to display an aspect to proceed, prevents, until after the expiration of a predetermined time interval after such signal has been caused to display its most restrictive aspect, the operation of any interlocked or electrically locked switch, movable-point frog, or derail in the route governed by the signal, and which prevents an aspect to proceed from being displayed for any conflicting route.

#### **Locking, Traffic – Part 236.769 (not provided in Traffic Control Systems - TCS)**

Electric locking, which prevents the manipulation of levers or other devices for changing the direction of traffic on a section of track while that section is occupied or while a signal displays an aspect for a movement to proceed into that section.

### ***17.4.3 REQUISITES FOR CENTRALIZED TRAFFIC CONTROL***

The requisites for centralized traffic control (CTC) are as follows:

- A. Time Locking shall be applied to all approaches.
- B. Indication Locking is required in connection with all electrically locked switches, movable-point frogs, or power derails at control points and interlockings.
- C. Route Locking is required. Sectional route locking shall only be used after careful consideration and as authorized by NCTD.
- D. Detector Loss of Shunt time shall be 10 seconds.

#### **17.4.4 TIME LOCKING**

Time Locking will be provided in connection with all control signals. Time Locking is used to assure that after a signal has been cleared and subsequently put to STOP without a through train movement, that a conflicting or opposing signal cannot be cleared or the position of a switch or derail in the established route cannot be changed until expiration of a predetermined time interval.

Time Locking should be released by a train occupying two consecutive track circuits beyond the control signal. On low speed routes, where a second track circuit is not available, one track circuit may be used to release Time Locking; however, two track circuit releasing is preferred. It should also be released by a time element relay, or electronic timer, with automatic control. Signal control circuits shall be arranged so that they cannot display proceed when the timing device is not normal.

Where the back contact of a detector section track relay or track relay repeater is used to release time locking, the control circuit for either the electric locking of the interlocked switches, or the control circuits for the interlocked signals, must be cut through the front contacts of the same relay whose back contact is used for releasing, or a repeater of that relay. Preferably, the control circuits for both the electric locking of the interlocked switches and the interlocked signals should be through front contacts of the same relay whose back contact is used for releasing.

The time setting for the release of locked apparatus shall be calculated in accordance with AREMA recommendations. At control signals governing movements within CTC territory, the minimum time setting applied shall be 6 minutes. If the time calculated using AREMA recommended practice is greater than 6 minutes, that time setting shall be rounded up to the nearest 30 second interval and utilized. A 60 second time setting may be used where trains are entering control point limits from non-signaled track.

#### **17.4.5 INDICATION LOCKING**

Indication locking shall be provided in connection with all interlocking switches. Indication locking does not apply to colorlight signals. The principle of Indication Locking applies to mechanical devices such as searchlight signals and dual control switch machines.

#### **17.4.6 ROUTE LOCKING**

Route locking shall be provided in connection with all mechanical or dual control switches. It maintains the switch locking after the signal has been passed, and the train is in the route. It must be accomplished by a system of track circuits extending throughout the interlocking which control normal and reverse locks for switches, derails, and movable point frogs.

Where there are multiple tracks and track circuits in a route, a more complicated scheme of route locking will be necessary. In some cases, where there are a number of track sections in a route, it will be found convenient to use route locking relays to secure continuous switch protection throughout the route.

On plants where traffic is so heavy that maximum facility is needed, a system of sectional

route locking may be installed, to provide for the release of switches behind a train as soon as the rear end of a train has reached a point sufficiently beyond clearance to ensure safety from conflicting moves. Sectional route locking should not be used without the approval of the NCTD Chief Engineer.

## 17.5 SIGNAL PLACEMENT

Where possible, block signals shall be placed to the right of the track governed, except back-to-back ground signals shall be placed where practical to minimize construction cost and/or environmental impact. Some signals shall be placed to the left of the track governed where track centers do not accommodate right-hand placement.

Cantilever signal structures shall be placed where two or more tracks must be signaled and where right-of-way or environmental constraints will not permit placement of ground signals. Bridge signal structures shall be used when more than two tracks must be signaled and where track centers don't allow for placement of signals between tracks. Additionally, bridge and cantilever signals may be used to improve signal visibility, where applicable.

The use of dwarf signals is restricted to areas where trains operate at slow speeds or where conventional ground signals are not practical.

Signals shall be placed and aligned to allow optimum viewing by the locomotive engineer. Where possible, signals shall be placed adjacent to tangent track. Where practical, the locomotive engineer shall be provided an unrestricted view of the signal for a minimum of 2,000 feet in advance of the signal. The 2,000 foot preview provides approximately 15 seconds of preview for a 90 mph train. In lower speed territory where 2,000 feet preview is not practical, 15 seconds of preview at timetable speed will be acceptable subject to approval by LOSSAN authorities. The design may incorporate more restrictive aspects in approach to a STOP signal with restricted preview.

When a signal is placed on tangent track and where there are no curves in approach to the signal, "long range" signal lamp units shall be used. Where placing a signal adjacent to tangent track is not feasible or where there are curves within the 2000' approach to the signal, consideration shall be given to utilize "mid range" signal lamp units.

Where practical, signals shall be placed so that a train leaving a station can see the signal before reaching 40 mph so that no "delay in block" will occur. In some cases, it will be desirable to locate a signal at a grade crossing to eliminate additional insulated joints and economize on equipment.

Each signal head consists of three lamp units. The signal heads shall be of the stacked colorlight type and equipped with removable lamp units for ease of maintenance. Signal housing shall be designed to allow easy removal of lamp units from the rear of the housing. Each lamp unit shall be equipped with an LED lamp that has been approved for use with equipment controlling the lamp and as described in the AREMA C&S Manual, Part 7.5.1. Unused lamps are to be provided with Blank Cover Plates.

The designer shall make a thorough review of proposed signal locations to ensure that signals placed in accordance with approved standards will not be obstructed by vegetation,

buildings, highway overpasses or other structures. Each location shall provide adequate space for each signal, signal house and other apparatus and be of sufficient size to provide ample walkways per CPUC requirements. Where signals are located on curves and adjacent tracks are present, signal height should be sufficient to ensure that signals can be viewed above standing rail cars. The designer should ensure that upper and lower signal units are visible.

## **17.6 SIGNAL STRUCTURES**

### **17.6.1 GENERAL**

In general, absolute signals at Control Points will have two heads, approach signals to Control Points will have two heads, and intermediate signals that do not serve as approach signals to absolute signals will have one head.

If a signal is equipped with a single head (“A” head), it shall be placed on all wayside structures as top justified to allow for the potential future installation of a lower signal head. For signals that govern train movements in a single direction, cabling shall support a minimum of two signal heads per signaled track. For signals that govern movement in both directions, cabling shall support the installation of four signal heads per signaled track.

### **17.6.2 GROUND SIGNALS**

The preferred location of ground signals is 15 ft. from centerline of track to the centerline of the signal mast. The signal shall not be located closer than 12 ft. from the centerline of track and the use of any dimension less than the preferred location requires NCTD approval. The outer edge of the signal ladder will be approximately 5 ft. from centerline of the mast. The preferred placement requires an unobstructed right-of-way 20 ft. from centerline of track. Drainage ditches, retaining walls and other fixtures in the vicinity of signals must be designed to allow maintenance personnel unobstructed access to the signal structure. Special platform structures may be constructed to provide access over drainage ditches and slopes where needed.

Ground signals shall be approximately 22 feet high measured from the base on the ground to the top of signal mast. This height will accommodate the placement of an upper and lower unit. Masts of this height will also provide adequate space for the addition of a lower unit to a single-headed signal. Mast, ladders, and platforms shall be galvanized steel. Bolts, fasteners, and hardware shall be stainless steel and resistant to corrosion.

### **17.6.3 CANTILEVER AND BRIDGE SIGNALS**

Bridge or cantilever signal structures shall be utilized where two or more tracks must be signaled and where right-of-way constraints will not permit placement of ground signals. The mast of a cantilever or bridge structure nearest the track shall be located 15 ft. from centerline of the track unless otherwise authorized by NCTD.

Cantilever and bridge structures shall be installed with a nominal clearance of 28 feet above top of rail. This placement will accommodate future track elevation increases and electrification.

The top lamp unit on a bridge or cantilever structure may be 38 ft. or more above the top of

rail. When determining placement of the structure, the designer shall ensure no overhead highway or pedestrian structures obscure the view of any signals for a distance of 2000 ft. in advance of the signal unless otherwise approved by NCTD.

Cantilever and bridge signal structure ladders shall be equipped with an engineered climbing safety support system. Structure bolts, fasteners, and hardware shall be stainless steel and resistant to corrosion. Structures shall be aluminum and foundations shall be designed by the contractor as the foundation design is dependent upon the weight and loading requirements of the structure. Foundation designs shall be stamped by a California registered professional civil or structural engineer.

#### **17.6.4 DWARF SIGNALS**

The use of dwarf signals is restricted to areas where trains operate at slow speeds, where ground signals are not practical, and as approved by NCTD. No portion of a dwarf signal shall be placed closer than 6 feet from centerline of either track when placed between tracks. At these locations, no portion of the dwarf signal shall be located higher than 34 inches above top of rail. (Note: Although the CPUC regulation allows placement of signal apparatus up to 36 inches above top of rail, the two inch variation should accommodate settling of the track, thus ensuring compliance with the regulation.)

Where dwarf signals are placed to the outside of a track (i.e. not between tracks), no portion of the signal shall be located within 8 feet 6 inches of the centerline of track on tangent track and 9 feet 6 inches on curved track. An obstruction, such as a retaining wall that will not allow placement outside of the 8 ft. 6 in. or 9 ft. 6 in. envelope does not waive these CPUC placement rules (i.e. the signal does not qualify for placing the signal in accordance with the “between tracks” rule). Additional right-of-way must be obtained or the location moved to a point where the signal can be placed outside of the 8 ft. 6 in. or 9 ft. 6 in. envelope.

### **17.7 SWITCHES**

#### **17.7.1 POWER SWITCH MACHINES**

Power switch machines shall be low voltage Ansaldo (US&S) Model M-23A machines with Electronic Circuit Controller (ECC) and Motor Control Unit (MCU), 528:1 gear ratio. If alternative machines are furnished for a project, the designer shall ensure technical specifications require a minimum of 2 each right-hand and 2 each left-hand machines and associated layouts are furnished as spares. In addition, 4 sets of mounting plates shall be furnished.

Switch motor power cabling between switch machine and instrument enclosure controlling the machine shall be 7 conductor No. 6 AWG at a minimum. Cabling required for powering the ECC and interfacing switch indication circuits shall be 12 conductor No. 14 AWG at a minimum. A minimum of four conductors shall be used to supply power for motor control as well as switch indication. The maximum cable length between the controlling enclosure and the machine will be 600 ft. Six conductors shall be used if the length is greater than 600 ft. and up to a maximum length of 900 ft. A separate enclosure shall be installed where the cable length exceeds 900 ft.

A minimum of 15 cells of lead-acid battery (2.25 VDC per cell) shall be used to power the

switch machine motor.

Relays named NWR and RWR will be used for switch motor control. The last called for relay will be held in the energized position until such time as locking is applied. The switch contact will be back-checked in the microprocessor program.

In double track corridors where there is high traffic density, consideration will be given to mounting the switch machines on the outside (field side) of the tracks.

### **17.7.2 HAND THROW SWITCHES**

Hand throw switches shall be equipped with a switch circuit controller and either a leaving signal or electric lock. Leaving signal configurations are preferred over electric lock configurations. Leaving signal configurations are generally less expensive and allow the train to clear the main track without the use of special track circuits.

If the switch is not in the vicinity of an intermediate signal location or control point, Audio Frequency Overlay (AFO) track circuits shall be used to check that the switch points are properly lined for main track movement and that the fouling section of the turnout is not occupied. A second AFO track circuit shall be used to transmit a “control” that allows the leaving signal to display a YELLOW aspect when safe signaling conditions are established.

This same method of AFO control and indication may be used for locations where electric locks are installed. At electric lock locations, a time element relay shall be used for release of the electric lock when block signal conditions prevent release by the AFO control circuit.

## **17.8 WAYSIDE SIGNAL POWER SYSTEMS**

Power to each location shall be provided from a commercial power source. Each location shall be evaluated and the appropriate service connection provided. At a minimum, a 3 wire, single phase 120/240 VAC 100-Amp service shall be provided at new locations. Where power is not readily available, an express cable shall be installed to the nearest power source or a new meter service installed. The size of the express cable conductor required shall be determined by utilizing National Electrical Code Standards. Each instrument house shall have an external plug connection for a generator to provide power to the house in the event of an extended outage.

Standby battery shall be provided at all locations. Battery chargers shall be of the programmable type equipped with temperature monitoring sensors. All storage cells shall be Lead Acid. Batteries shall be of sufficient capacity to provide 48 hours of standby time under normal operating conditions. Normal operating conditions is defined as “the signal system operating with all signals lit for 24 hours and four switch machine throws per hour, and all track circuits occupied for 12 hours.

Battery chargers at control points shall be equipped with internal dry contacts capable of indicating a fault in the charging system. These contacts shall monitor the chargers for proper operation and interface with an alarm circuit that will generate a power off indication to the dispatch center in the event of a failure.

Battery chargers at intermediate signals shall also be equipped with internal dry contacts capable of indicating a fault in the charging system. These contacts shall monitor the chargers for proper operation and interface with a strobe light (Velcorp GEMS P/N LC2-001WB-W, or approved equal) that will generate a power off indication to a passing train or maintenance forces in the event of a failure. Reference NCTD Timetable Special Instructions Rule 6.32.7 and SANDAG/NCTD Engineering Standard Drawing ESD-8215-01.

## **17.9 QUALITY CONTROL**

### **17.9.1 SIGNAL DESIGNERS**

Signal designers who work on signal system circuits or programs must be approved by LOSSAN Authorities. The classification *Signal Designer* is generic and refers to the individual responsible for producing signal circuits or programs. A company or third-party agency may classify this position as a Signal Engineer or other title. In general, a circuit designer should have a minimum of 5 years of experience designing for a Class I or Regional Railroad which operates under the jurisdiction of 49 CFR Parts 234, 235, and 236.

The requirements for signal designers also apply to programmers of vital application logic programs. Designers may be called upon to demonstrate their familiarity with applicable regulations, both State and Federal, and their familiarity with traditional relay logic, ladder logic and boolean equations. Principles of railroad signaling, including automatic block signals, centralized traffic control and interlockings must be demonstrated to the satisfaction of LOSSAN authorities. An understanding of train operations and the interaction with the signal system is required, as well as the ability to analyze braking distances, and calculation of locking release times. In addition to this, knowledge of Highway-Rail Grade Crossing Warning systems must be demonstrated.

The designer may be interviewed at the discretion of the LOSSAN authorities. The interview may require a demonstration of circuit and program analysis.

### **17.9.2 SIGNAL CHECKERS**

Signal Checkers who work on signal system circuits or programs must be approved by LOSSAN authorities. The classification Signal Checker is generic and refers to the responsible individual who performs Quality Control (QC) and safety analysis on signal circuits or programs. A company or third-party agency may classify this position as a Senior Signal Engineer or other title. In general, a circuit checker should have a minimum of 5 years of experience designing for a Class I or Regional Railroad which operates under the jurisdiction of 49 CFR Parts 234, 235 and 236, and an additional 5 years of experience checking signal designs and vital signal programs.

Checkers may be called upon to demonstrate their familiarity with applicable regulations, both state and Federal, and their familiarity with traditional relay logic, ladder logic and boolean equations. Principles of railroad signaling, including automatic block signals, centralized traffic control and interlockings must be demonstrated to the satisfaction of LOSSAN authorities. An understanding of train operations and the interaction with the signal system is required, as well as the ability to analyze braking



distances and calculate locking release times. In addition to this, knowledge of Highway-Rail Grade Crossing Warning systems must be demonstrated.

The signal checker may be interviewed, at the discretion of LOSSAN authorities. The interview may require a demonstration of circuit and program analysis.

### **17.9.3 FINAL CHECK INSTRUCTIONS**

In an effort to ensure the quality and integrity of wayside signal and highway grade crossing warning system design, all designs shall receive a final check. The final check shall ensure that all designs meet the minimum requirements of 49 CFR Parts 234, 235 and 236. Designs shall also conform to SANDAG/NCTD standards and all applicable federal, state, and local regulations. All design applications shall adhere to the manufacturer's minimum recommendations.

Included with the plan sets shall be any pertinent information that may aid the final checker in performing this work. Pertinent information shall include field surveys, service contracts, CPUC application documents, project correspondence, calculations, etc. Pertinent information shall include circuit plans of adjoining locations sufficient to check all circuits and controls in the affected location to both the point of origination and termination.

The final checker shall review the drawings for conformance with approved standards, field survey requirements, service contracts agreements, CPUC application drawings, and circuit integrity. On one plan set, the final checker shall indicate any corrections that are needed. Once completed, a marked up plan set shall be returned to the originator for correction. Upon completing the revisions, a corrected copy shall be sent to the final checker for approval. Once approved, the design firm shall place the final checker's initials in the appropriate field and distribute the plans for construction.

In instances where construction must immediately begin and sufficient time is not available to complete the final check procedure prior to distribution, the plans shall be clearly marked **PRELIMINARY** and the checker's field shall be left blank. At the time of this preliminary distribution, two plan sets shall be sent to a final checker. **A final check shall be completed prior to placing the modifications in operation.** Once the final check of the preliminary plan set is completed and corrections have been made, a final plan set shall be distributed. Prior to distribution, a new date shall be entered in the appropriate date field.

In an emergency situation, and only in such situations, modifications to the signal system may be made by field forces with concurrence of LOSSAN authorities. In such instances, the modifications shall be clearly marked on a plan set and the modified plan set delivered to a final checker as soon as possible. All field modifications shall be thoroughly tested to ensure the integrity of the system.

### **17.9.4 FILE MANAGEMENT**

49 CFR Part 236 Section 1 and Part 234 Section 201 requires that up-to-date and accurate signal plans are kept at each location. CFR Title 49 Part 236 Section 18 requires a Software Management Control Plan for Vital Signal Application programs.

Signal Drawings and Signal Programs are living documents that must be properly

maintained to ensure the integrity of the signal system. Duplicate file copies increases the possibility of misleading or inaccurate drawings and programs being distributed to construction or maintenance forces. Files shall not be duplicated without the consent of NCTD.

### **17.10 CADD REQUIREMENTS**

Communication and Signal (C&S) CADD files are living documents that must be properly maintained to ensure the integrity of the train control and highway grade crossing warning systems. Duplicate file copies increase the possibility of misleading or inaccurate information being distributed to construction or maintenance forces. Files shall not be duplicated. Drawings shall be developed utilizing Microstation Version 8, 2-dimensional format. Designers shall adhere to the FORMAT REQUIREMENTS as specified in this document.

Prior to beginning any C&S design project, the designer shall request CADD files from the NCTD File Manager. A general description of the project(s) shall be submitted along with specific milepost limits. In addition to the CADD files that portray detailed circuitry and equipment, The designer shall acquire border files – one contract border for contract documents and one NCTD border for maintenance drawings. Files shall be provided to the designer through acceptable conventional methods, such as email, or on a CD/DVD. Contractor shall retain the original files for a minimum of 2 years after the project is constructed and systems placed in operation.

Extensive C&S improvements were implemented in 1995. Upon completion of the project, the installation contractor provided as-built drawings to NCTD. The contents of the drawings did not fit within the limits of the MAINTENANCE BORDER. Unfortunately, the contractor scaled down the contents to fit within this border. These files are easily recognized. The designer shall redraw these files when performing work in conjunction with new construction. Only those files that will be retained upon completion of the project shall be redrawn to the standards specified herein.

Upon completion of the conformed set of contract design, the designer shall return the CADD files to the NCTD File Manager. The designer shall include an itemized list of the files returned. If revisions are required during the construction process, the designer shall request the affected files back from the NCTD File Manager. Upon completing the revisions, the designer shall return the files to the NCTD File Manager with an itemized list as specified above. Upon completion of the project, the designer shall request the files back from the NCTD File Manager and make the necessary as-built corrections. The designer shall provide a hard copy (i.e. record copy) of the drawings to the Construction Manager. The designer shall detach the contract border and attach the NCTD border to each file, and return the files to the NCTD File Manager along with an itemized list as referenced above.

Drawings, borders, and cells shall not be scaled up or down. New cells shall be submitted to NCTD for approval and shall not be created without proper authority. Contract borders shall be “reference attached” to facilitate removal. Construction drawings shall utilize RED=IN/YELLOW=OUT color conventions.

### **17.10.1 FILE NAMING CONVENTION**

#### NCTD Projects and Maintenance Drawings

File names shall be 13-characters long followed by a 3-character extension (EXAMPLE: SAD239\_70\_C01.DGN and SAD239\_70\_M02.DGN are the file names for sheet 1 and sheet 2 of a location on the San Diego Subdivision at Milepost 239.70). The “C” in the filename indicates that the drawing contains CONSTRUCTION elements; an “M” in the filename indicates the file is a MAINTENANCE plan; a “B” in the filename indicates the file has “FIELD VERIFY” elements; and a “T” in the filename indicates the file is temporary and will be deleted upon completion of construction.

#### EXAMPLES:

SAD239_70_C09.DGN	Construction Drawing
SAD239_70_M04.DGN	Maintenance Drawing
SAD239_70_T03.DGN	Temporary Drawing
SAD239_70_B01.DGN	Field Verification Required

#### SANDAG Projects

File names shall be designated with the first character being “S” for Signal, and the second character being A through Z to identify a section of drawings, followed by designations of 01 through 99 for the number of sheets required in each section. Typically, section “A” is reserved for General Information and Detail Drawings (if required), section “B” is reserved for Aspect Charts, section “C” is reserved for Track and Location Plans (Signal Circuit Plans), and then sections “D” through “Z” are reserved for Site Specific Location Plans. For example:

SA-01.DGN	Sheet 1 of the General Information Section
SB-02.DGN	Sheet 2 of the Aspect Chart Section
SC-05.DGN	Sheet 5 of the Track and Location Plan Section
SF-23.DGN	Sheet 23 of a Site Specific Location Plan Section

Additionally, when there are major changes to an existing drawing, and placing both the RED=IN and YELLOW=OUT information on a single sheet is not practical, an “A” and “B” suffix identifier can be used to separate the removals from the installations. For example:

SC-04A.DGN	Sheet 4A of the Track and Location Plans (YELLOW=OUT only)
SC-04B.DGN	Sheet 4B of the Track and Location Plans (RED=IN only)

At the completion of a project and as part of the as-built process, files names shall be changed back to the conventions as defined under the “NCTD Projects and Maintenance Drawings”.

### **17.10.2 FORMAT REQUIREMENTS**

The following design file settings shall be used on all C&S design files:

- A. All new design files shall be a single drawing sheet, with lower left corner starting at

X,Y=0,0 (GLOBAL ORIGIN)

B. SAVE SETTINGS as follows:

1. ENTER DATA FIELDS turned off (all views)
2. SNAP and GRID locks ON, LEVEL lock OFF
3. TX=;.08 (Text Size)
4. FT=0 (Font)
5. Justification=CC
6. LINE SPACING=;.05
7. WT=1 (Line Weight)
8. LV=1 (Active Level)
9. AS=1 (Active Scale)
10. AA=0 (Active Angle)
11. CO=0 (Color)

C. The design file name shall be placed in the lower left-hand corner of the design file border. EXAMPLE: SAD239\_70\_B01.DGN (except for active SANDAG Projects)

D. Distance between tracks = 6 grids

E. Track WT=7

F. Circuits WT=2

G. Black boxes (shapes) WT=3

H. Wire nomenclature (use appropriate samples)

I. Relay nomenclature (use appropriate samples)

J. Relay contact numbering (use appropriate samples)

K. Relay information (use appropriate samples)

L. Font=0 WT=1 TX=;.08 Justification=CC Line Spacing=;.05

M. All NEW circuits shall be in RED

N. All circuits to be removed shall be BLACK with YELLOW shape

O. Existing circuits shall be BLACK

Additionally, examples as illustrated in the SANDAG/NCTD Engineering Standard Drawings shall be used as a guide when designing train control and/or grade crossing warning systems. Detailed circuit designs and component depictions shall follow the convention used on all recent Coaster and Sprinter projects, respectively.

### **17.11 TRAIN CONTROL COMMUNICATIONS**

When a project requires the addition of a new control point(s), it is the responsibility of the designer to determine whether the additional control point(s) will require the addition of new codelines or additional regions to the Supervisory Control Office. The designer should make an analysis of the impact of increased radio traffic and office system capacity as a part of the design.

NCTD is currently migrating to a Fiber Optic Network for field to office communications. On the existing radio codeline, where fiber optic lines are introduced, the radio system shall be maintained as a back-up communications path. The basic principle is to provide a diverse communications path to increase the reliability of railway systems.

### **17.12 INTERFACING WITH ADJACENT RAILROADS**

The LOSSAN Corridor in San Diego County interfaces with adjacent railroads (BNSF, MTS, SCRRA) in several locations. When designing a signal system interface, the ideal configuration is end to end with discrete signals each controlled by the governing railroad. This may not be possible due to inadequate signal preview, or parallel tracks where trains cross over from one railroad to the other. The design must account for operational differences between the two railroads. Failure modes must be analyzed and mitigated to the extent possible. In general, it is preferable to have discrete circuits or Electrocode circuits for the interface and minimize the dependency on a serial connection. Where there is a crossover between railroads, it is important that a fault on one railroad does not adversely impact on the other railroad's parallel routes. The design should also account for the need to perform routine tests and maintenance without requiring permission from or coordination with the adjacent railroad. If the railroads connect end to end, the ability to provide a Restricting signal to the adjacent railroad's entering signal may accomplish this.

### **17.13 POSITIVE TRAIN CONTROL**

The type of PTC system most efficiently implemented is an overlay system. This system builds on the existing safety critical signal system to first enforce compliance with signal aspects, and then to provide a greater level of on track safety for roadway workers and on-track equipment. The PTC system will rely on radio communication of wayside signal information to the locomotive, and a separate path of train to office communications for civil enforcements, mandatory directives and track occupancy permission.

It is important to understand that communications must be established with Coaster trains, Amtrak trains, Metrolink trains and BNSF trains. The system must be interoperable to be truly effective. Wayside interfaces shall utilize existing vital signal equipment. GETS PTC compatible modules will be used on both new and existing systems. At a minimum, signal lamp wires will be monitored at the terminal board at both intermediate signals and control points. Power switch indication circuits will be monitored at the control points.

#### **17.14 MINIMUM SAFE BRAKING CHARTS**

The following pages provide safe braking distances for trains;

### 17.14.1 90 TPOB FREIGHT TRAIN – M.A.S. TO FULL STOP

TONS PER BRAKE: 90  
 REDUCTION TO: 0 MPH

AVG. GRADE	SPEED									AVG. GRADE
	15	20	25	30	35	40	45	50	55	
<b>3.0</b>	<b>477</b>	<b>705</b>	<b>975</b>	<b>1286</b>	<b>1641</b>	<b>2038</b>	<b>2479</b>	<b>2964</b>	<b>3492</b>	<b>3.0</b>
2.9	491	723	997	1313	1671	2073	2518	3006	3539	2.9
2.8	506	742	1020	1340	1703	2109	2558	3051	3587	2.8
2.7	521	762	1045	1370	1737	2147	2601	3098	3639	2.7
2.6	537	784	1071	1401	1773	2188	2646	3148	3694	2.6
2.5	554	806	1099	1433	1811	2231	2695	3201	3752	2.5
2.4	571	829	1128	1468	1851	2277	2745	3258	3814	2.4
2.3	590	854	1158	1504	1893	2325	2799	3317	3879	2.3
2.2	610	880	1190	1543	1938	2376	2856	3380	3948	2.2
2.1	630	907	1224	1584	1985	2429	2917	3447	4021	2.1
<b>2.0</b>	<b>652</b>	<b>936</b>	<b>1260</b>	<b>1626</b>	<b>2035</b>	<b>2486</b>	<b>2980</b>	<b>3518</b>	<b>4099</b>	<b>2.0</b>
1.9	674	966	1298	1672	2088	2546	3048	3593	4181	1.9
1.8	698	998	1338	1719	2143	2610	3120	3672	4269	1.8
1.7	723	1031	1380	1770	2202	2677	3195	3757	4361	1.7
1.6	749	1066	1424	1823	2264	2748	3275	3846	4459	1.6
1.5	777	1103	1470	1879	2330	2824	3360	3940	4563	1.5
1.4	806	1142	1519	1938	2399	2903	3450	4040	4673	1.4
1.3	836	1183	1571	2001	2473	2987	3545	4146	4790	1.3
1.2	868	1226	1626	2067	2550	3076	3645	4258	4914	1.2
1.1	901	1272	1683	2136	2632	3170	3752	4376	5045	1.1
<b>1.0</b>	<b>937</b>	<b>1320</b>	<b>1744</b>	<b>2210</b>	<b>2718</b>	<b>3270</b>	<b>3864</b>	<b>4502</b>	<b>5184</b>	<b>1.0</b>
0.9	973	1370	1808	2287	2810	3375	3983	4635	5331	0.9
0.8	1012	1423	1875	2369	2906	3486	4109	4776	5487	0.8
0.7	1053	1479	1946	2455	3008	3604	4243	4926	5652	0.7
0.6	1096	1537	2021	2547	3116	3728	4384	5084	5827	0.6
0.5	1141	1599	2099	2643	3229	3860	4533	5251	6013	0.5
0.4	1188	1664	2182	2744	3349	3999	4692	5429	6210	0.4
0.3	1238	1732	2270	2851	3476	4146	4859	5617	6418	0.3
0.2	1290	1804	2362	2964	3611	4301	5036	5816	6639	0.2
0.1	1345	1880	2459	3084	3752	4466	5224	6026	6874	0.1
<b>0.0%</b>	<b>1402</b>	<b>1960</b>	<b>2562</b>	<b>3210</b>	<b>3902</b>	<b>4640</b>	<b>5422</b>	<b>6250</b>	<b>7122</b>	<b>0</b>
-0.1	1462	2043	2670	3342	4060	4823	5632	6486	7385	-0.1
-0.2	1526	2132	2784	3483	4227	5018	5854	6736	7664	-0.2
-0.3	1592	2224	2904	3631	4404	5223	6089	7001	7960	-0.3
-0.4	1662	2322	3031	3787	4590	5441	6338	7282	8273	-0.4
-0.5	1736	2425	3164	3952	4787	5671	6602	7580	8605	-0.5
-0.6	1813	2533	3305	4126	4996	5914	6881	7895	8956	-0.6
-0.7	1894	2647	3453	4309	5216	6171	7176	8228	9329	-0.7
-0.8	1979	2767	3609	4503	5448	6443	7488	8582	9724	-0.8
-0.9	2069	2893	3774	4707	5693	6731	7818	8956	10143	-0.9
<b>-1.0</b>	<b>2162</b>	<b>3026</b>	<b>3947</b>	<b>4923</b>	<b>5953</b>	<b>7035</b>	<b>8168</b>	<b>9352</b>	<b>10587</b>	<b>-1.0</b>
-1.1	2261	3166	4130	5151	6227	7356	8538	9772	11057	-1.1
-1.2	2365	3313	4323	5391	6516	7696	8930	10217	11556	-1.2
-1.3	2473	3468	4526	5645	6822	8056	9345	10688	12084	-1.3
-1.4	2588	3630	4740	5913	7145	8436	9783	11186	12644	-1.4
-1.5	2708	3802	4966	6195	7487	8838	10248	11714	13237	-1.5
-1.6	2834	3982	5204	6493	7847	9263	10739	12274	13866	-1.6
-1.7	2966	4172	5455	6808	8228	9713	11259	12866	14532	-1.7
-1.8	3105	4372	5719	7140	8631	10188	11810	13494	15239	-1.8
-1.9	3251	4582	5998	7490	9056	10691	12392	14158	15987	-1.9
<b>-2.0</b>	<b>3405</b>	<b>4803</b>	<b>6291</b>	<b>7860</b>	<b>9505</b>	<b>11223</b>	<b>13009</b>	<b>14862</b>	<b>16780</b>	<b>-2.0</b>
-2.1	3566	5036	6601	8251	9980	11785	13662	15608	17621	-2.1
-2.2	3735	5281	6927	8663	10482	12379	14352	16397	18512	-2.2
-2.3	3913	5539	7271	9097	11011	13008	15083	17233	19456	-2.3
-2.4	4100	5811	7633	9556	11571	13673	15856	18119	20457	-2.4
-2.5	4296	6096	8016	10040	12163	14376	16675	19057	21517	-2.5
-2.6	4502	6397	8418	10552	12787	15119	17541	20050	22641	-2.6
-2.7	4718	6713	8843	11091	13448	15905	18458	21102	23832	-2.7
-2.8	4945	7046	9290	11660	14145	16737	19429	22216	25095	-2.8
-2.9	5184	7397	9762	12261	14882	17616	20456	23396	26433	-2.9
<b>-3.0</b>	<b>5434</b>	<b>7766</b>	<b>10259</b>	<b>12895</b>	<b>15660</b>	<b>18545</b>	<b>21543</b>	<b>24646</b>	<b>27851</b>	<b>-3.0</b>
AVG. GRADE	15	20	25	30	35	40	45	50	55	AVG. GRADE

May-15

**17.14.2 90 TPOB FREIGHT TRAIN – M.A.S. TO 20 MPH**

TONS PER BRAKE: 90  
 REDUCTION TO: 20 MPH

AVG. GRADE	SPEED									AVG. GRADE
	15	20	25	30	35	40	45	50	55	
<b>3.0</b>		<b>549</b>	<b>819</b>	<b>1130</b>	<b>1485</b>	<b>1882</b>	<b>2323</b>	<b>2808</b>	<b>3336</b>	<b>3.0</b>
2.9		563	836	1152	1511	1912	2357	2846	3378	2.9
2.8		577	855	1175	1538	1944	2393	2886	3422	2.8
2.7		593	875	1200	1567	1978	2431	2929	3470	2.7
2.6		609	897	1226	1599	2014	2472	2974	3520	2.6
2.5		626	919	1254	1632	2052	2515	3022	3573	2.5
2.4		645	943	1284	1666	2092	2561	3073	3629	2.4
2.3		664	969	1315	1704	2135	2610	3128	3689	2.3
2.2		685	995	1348	1743	2181	2661	3185	3753	2.2
2.1		706	1024	1383	1785	2229	2716	3247	3821	2.1
<b>2.0</b>		<b>729</b>	<b>1054</b>	<b>1420</b>	<b>1829</b>	<b>2280</b>	<b>2774</b>	<b>3312</b>	<b>3893</b>	<b>2.0</b>
1.9		754	1086	1460	1876	2334	2836	3381	3970	1.9
1.8		780	1120	1501	1925	2392	2902	3455	4051	1.8
1.7		807	1155	1546	1978	2453	2971	3532	4137	1.7
1.6		836	1193	1592	2034	2518	3045	3615	4229	1.6
1.5		866	1233	1642	2093	2587	3123	3703	4326	1.5
1.4		898	1276	1695	2156	2659	3206	3796	4430	1.4
1.3		933	1321	1750	2222	2737	3294	3895	4539	1.3
1.2		969	1368	1809	2292	2819	3388	4000	4656	1.2
1.1		1007	1418	1871	2367	2905	3487	4111	4780	1.1
<b>1.0</b>		<b>1047</b>	<b>1471</b>	<b>1937</b>	<b>2446</b>	<b>2997</b>	<b>3592</b>	<b>4230</b>	<b>4911</b>	<b>1.0</b>
0.9		1090	1527	2007	2529	3095	3703	4355	5051	0.9
0.8		1135	1587	2081	2618	3198	3821	4488	5199	0.8
0.7		1182	1650	2159	2712	3307	3947	4629	5356	0.7
0.6		1233	1716	2242	2811	3423	4079	4779	5523	0.6
0.5		1286	1786	2330	2916	3546	4220	4938	5700	0.5
0.4		1342	1860	2422	3027	3677	4370	5107	5888	0.4
0.3		1401	1939	2520	3145	3815	4528	5285	6087	0.3
0.2		1464	2022	2624	3270	3961	4696	5475	6299	0.2
0.1		1530	2109	2733	3402	4116	4873	5676	6524	0.1
<b>0.0%</b>		<b>1600</b>	<b>2202</b>	<b>2850</b>	<b>3542</b>	<b>4280</b>	<b>5062</b>	<b>5890</b>	<b>6762</b>	<b>0</b>
-0.1		1673	2300	2972	3690	4453	5262	6116	7015	-0.1
-0.2		1751	2403	3102	3847	4637	5474	6356	7283	-0.2
-0.3		1833	2513	3239	4012	4832	5698	6610	7568	-0.3
-0.4		1920	2628	3384	4188	5038	5936	6880	7870	-0.4
-0.5		2011	2750	3538	4374	5257	6188	7166	8191	-0.5
-0.6		2108	2879	3700	4570	5488	6455	7469	8531	-0.6
-0.7		2210	3015	3872	4778	5734	6738	7791	8892	-0.7
-0.8		2317	3159	4053	4998	5993	7038	8132	9274	-0.8
-0.9		2431	3311	4245	5231	6268	7356	8493	9680	-0.9
<b>-1.0</b>		<b>2550</b>	<b>3471</b>	<b>4447</b>	<b>5477</b>	<b>6559</b>	<b>7692</b>	<b>8877</b>	<b>10111</b>	<b>-1.0</b>
-1.1		2677	3641	4662	5738	6867	8049	9283	10568	-1.1
-1.2		2810	3820	4888	6013	7193	8427	9714	11053	-1.2
-1.3		2950	4009	5128	6305	7539	8827	10170	11567	-1.3
-1.4		3099	4208	5381	6613	7904	9252	10654	12112	-1.4
-1.5		3255	4419	5648	6940	8291	9701	11168	12690	-1.5
-1.6		3420	4641	5931	7285	8701	10177	11711	13303	-1.6
-1.7		3594	4876	6230	7650	9135	10681	12288	13954	-1.7
-1.8		3777	5124	6545	8036	9594	11215	12899	14644	-1.8
-1.9		3971	5386	6879	8445	10080	11781	13547	15376	-1.9
<b>-2.0</b>		<b>4175</b>	<b>5662</b>	<b>7232</b>	<b>8877</b>	<b>10594</b>	<b>12380</b>	<b>14233</b>	<b>16151</b>	<b>-2.0</b>
-2.1		4390	5954	7604	9334	11138	13015	14961	16974	-2.1
-2.2		4617	6262	7998	9817	11715	13687	15732	17847	-2.2
-2.3		4856	6587	8414	10328	12324	14399	16550	18772	-2.3
-2.4		5108	6931	8853	10868	12970	15154	17416	19754	-2.4
-2.5		5374	7293	9318	11440	13653	15952	18334	20795	-2.5
-2.6		5654	7675	9808	12044	14376	16798	19307	21898	-2.6
-2.7		5949	8078	10327	12683	15141	17694	20338	23068	-2.7
-2.8		6261	8504	10874	13359	15951	18643	21430	24309	-2.8
-2.9		6589	8954	11453	14074	16808	19648	22588	25625	-2.9
<b>-3.0</b>		<b>6935</b>	<b>9428</b>	<b>12064</b>	<b>14829</b>	<b>17714</b>	<b>20712</b>	<b>23815</b>	<b>27020</b>	<b>-3.0</b>
AVG. GRADE	15	20	25	30	35	40	45	50	55	AVG. GRADE

May-15



### 17.14.3 90 TPOB FREIGHT TRAIN – M.A.S. TO 30 MPH

TONS PER BRAKE: 90  
 REDUCTION TO: 30 MPH

AVG. GRADE	SPEED										AVG. GRADE
	15	20	25	30	35	40	45	50	55		
<b>3.0</b>					<b>1328</b>	<b>1725</b>	<b>2166</b>	<b>2651</b>	<b>3180</b>	<b>3.0</b>	
2.9					1348	1750	2195	2683	3216	2.9	
2.8					1370	1776	2225	2718	3254	2.8	
2.7					1393	1803	2257	2754	3295	2.7	
2.6					1418	1833	2291	2793	3339	2.6	
2.5					1444	1865	2328	2835	3386	2.5	
2.4					1473	1898	2367	2879	3435	2.4	
2.3					1503	1934	2409	2927	3488	2.3	
2.2					1535	1972	2453	2977	3545	2.2	
2.1					1569	2013	2501	3031	3605	2.1	
<b>2.0</b>					<b>1605</b>	<b>2057</b>	<b>2551</b>	<b>3089</b>	<b>3670</b>	<b>2.0</b>	
1.9					1644	2103	2605	3150	3738	1.9	
1.8					1686	2152	2662	3215	3811	1.8	
1.7					1730	2205	2723	3284	3889	1.7	
1.6					1777	2261	2788	3358	3972	1.6	
1.5					1827	2320	2857	3437	4060	1.5	
1.4					1880	2384	2930	3520	4154	1.4	
1.3					1936	2451	3009	3609	4254	1.3	
1.2					1996	2523	3092	3704	4360	1.2	
1.1					2060	2599	3180	3805	4473	1.1	
<b>1.0</b>					<b>2128</b>	<b>2680</b>	<b>3274</b>	<b>3912</b>	<b>4594</b>	<b>1.0</b>	
0.9					2201	2766	3374	4026	4722	0.9	
0.8					2278	2858	3481	4148	4858	0.8	
0.7					2359	2955	3594	4277	5003	0.7	
0.6					2446	3058	3714	4414	5158	0.6	
0.5					2538	3168	3842	4560	5322	0.5	
0.4					2636	3285	3978	4715	5496	0.4	
0.3					2740	3409	4123	4880	5682	0.3	
0.2					2850	3541	4276	5055	5879	0.2	
0.1					2968	3681	4439	5242	6089	0.1	
<b>0.0%</b>					<b>3092</b>	<b>3830</b>	<b>4612</b>	<b>5440</b>	<b>6312</b>	<b>0</b>	
-0.1					3224	3987	4796	5650	6549	-0.1	
-0.2					3364	4155	4991	5873	6801	-0.2	
-0.3					3513	4333	5199	6111	7069	-0.3	
-0.4					3671	4521	5419	6363	7353	-0.4	
-0.5					3838	4722	5653	6631	7655	-0.5	
-0.6					4016	4934	5901	6915	7977	-0.6	
-0.7					4204	5160	6164	7217	8318	-0.7	
-0.8					4404	5399	6444	7538	8680	-0.8	
-0.9					4616	5653	6741	7878	9065	-0.9	
<b>-1.0</b>					<b>4840</b>	<b>5922</b>	<b>7056</b>	<b>8240</b>	<b>9474</b>	<b>-1.0</b>	
-1.1					5079	6208	7390	8624	9909	-1.1	
-1.2					5331	6511	7745	9031	10370	-1.2	
-1.3					5599	6832	8121	9464	10860	-1.3	
-1.4					5882	7173	8521	9923	11381	-1.4	
-1.5					6183	7534	8944	10411	11933	-1.5	
-1.6					6502	7918	9394	10928	12520	-1.6	
-1.7					6839	8324	9870	11477	13143	-1.7	
-1.8					7197	8754	10376	12060	13805	-1.8	
-1.9					7576	9211	10912	12678	14507	-1.9	
<b>-2.0</b>					<b>7978</b>	<b>9695</b>	<b>11481</b>	<b>13335</b>	<b>15253</b>	<b>-2.0</b>	
-2.1					8403	10208	12085	14031	16044	-2.1	
-2.2					8854	10752	12724	14769	16884	-2.2	
-2.3					9331	11328	13403	15553	17776	-2.3	
-2.4					9837	11938	14122	16384	18722	-2.4	
-2.5					10372	12586	14885	17266	19727	-2.5	
-2.6					10940	13271	15693	18202	20793	-2.6	
-2.7					11540	13998	16551	19194	21925	-2.7	
-2.8					12176	14768	17460	20247	23126	-2.8	
-2.9					12849	15583	18423	21364	24400	-2.9	
<b>-3.0</b>					<b>13562</b>	<b>16447</b>	<b>19445</b>	<b>22548</b>	<b>25753</b>	<b>-3.0</b>	
AVG. GRADE	15	20	25	30	35	40	45	50	55	AVG. GRADE	
	SPEED										

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### 17.14.4 90 TPOB FREIGHT TRAIN – M.A.S. TO 40 MPH

TONS PER BRAKE: 90  
 REDUCTION TO: 40 MPH

AVG. GRADE	SPEED									AVG. GRADE
	15	20	25	30	35	40	45	50	55	
<b>3.0</b>							<b>1967</b>	<b>2452</b>	<b>2980</b>	<b>3.0</b>
2.9							1987	2476	3008	2.9
2.8							2009	2502	3038	2.8
2.7							2033	2530	3071	2.7
2.6							2058	2560	3106	2.6
2.5							2086	2593	3143	2.5
2.4							2115	2628	3184	2.4
2.3							2147	2665	3227	2.3
2.2							2181	2706	3273	2.2
2.1							2218	2749	3323	2.1
<b>2.0</b>							<b>2257</b>	<b>2795</b>	<b>3376</b>	<b>2.0</b>
1.9							2300	2845	3433	1.9
1.8							2345	2898	3494	1.8
1.7							2394	2955	3560	1.7
1.6							2446	3016	3629	1.6
1.5							2501	3081	3704	1.5
1.4							2561	3151	3784	1.4
1.3							2625	3225	3870	1.3
1.2							2693	3305	3961	1.2
1.1							2766	3391	4059	1.1
<b>1.0</b>							<b>2844</b>	<b>3482</b>	<b>4163</b>	<b>1.0</b>
0.9							2927	3579	4275	0.9
0.8							3016	3683	4394	0.8
0.7							3111	3794	4521	0.7
0.6							3213	3913	4656	0.6
0.5							3321	4039	4801	0.5
0.4							3437	4174	4955	0.4
0.3							3560	4318	5120	0.3
0.2							3692	4471	5295	0.2
0.1							3832	4635	5482	0.1
<b>0.0%</b>							<b>3982</b>	<b>4810</b>	<b>5682</b>	<b>0</b>
-0.1							4142	4995	5895	-0.1
-0.2							4312	5194	6121	-0.2
-0.3							4493	5405	6363	-0.3
-0.4							4686	5630	6620	-0.4
-0.5							4891	5869	6894	-0.5
-0.6							5110	6124	7186	-0.6
-0.7							5343	6396	7497	-0.7
-0.8							5591	6685	7827	-0.8
-0.9							5855	6993	8180	-0.9
<b>-1.0</b>							<b>6136</b>	<b>7320</b>	<b>8555</b>	<b>-1.0</b>
-1.1							6435	7669	8954	-1.1
-1.2							6753	8040	9378	-1.2
-1.3							7091	8434	9830	-1.3
-1.4							7451	8854	10311	-1.4
-1.5							7834	9300	10823	-1.5
-1.6							8240	9775	11367	-1.6
-1.7							8673	10280	11946	-1.7
-1.8							9133	10817	12561	-1.8
-1.9							9622	11387	13216	-1.9
<b>-2.0</b>							<b>10141</b>	<b>11994</b>	<b>13912</b>	<b>-2.0</b>
-2.1							10693	12639	14652	-2.1
-2.2							11280	13325	15439	-2.2
-2.3							11903	14053	16276	-2.3
-2.4							12565	14827	17165	-2.4
-2.5							13268	15650	18110	-2.5
-2.6							14015	16523	19115	-2.6
-2.7							14808	17452	20182	-2.7
-2.8							15651	18438	21317	-2.8
-2.9							16545	19486	22522	-2.9
<b>-3.0</b>							<b>17495</b>	<b>20599</b>	<b>23803</b>	<b>-3.0</b>
AVG. GRADE	15	20	25	30	35	40	45	50	55	AVG. GRADE
	SPEED									

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### 17.14.5 90 TPOB FREIGHT TRAIN – M.A.S. TO 50 MPH

TONS PER BRAKE: 90  
 REDUCTION TO: 50 MPH

AVG. GRADE	SPEED									AVG. GRADE																		
	15	20	25	30	35	40	45	50	55																			
<b>3.0</b>										<b>2741</b>	<b>3.0</b>																	
2.9										2759	2.9																	
2.8										2779	2.8																	
2.7										2801	2.7																	
2.6										2824	2.6																	
2.5										2850	2.5																	
2.4										2878	2.4																	
2.3										2908	2.3																	
2.2										2942	2.2																	
2.1										2977	2.1																	
<b>2.0</b>																			<b>3016</b>	<b>2.0</b>								
1.9																			3058	1.9								
1.8																			3104	1.8								
1.7																			3153	1.7								
1.6																			3206	1.6								
1.5	3263	1.5																										
1.4	3325	1.4																										
1.3	3391	1.3																										
1.2	3463	1.2																										
1.1	3540	1.1																										
<b>1.0</b>																			<b>3623</b>	<b>1.0</b>								
0.9																			3712	0.9								
0.8																			3807	0.8								
0.7																			3910	0.7								
0.6																			4021	0.6								
0.5										4139	0.5																	
0.4										4266	0.4																	
0.3										4402	0.3																	
0.2										4548	0.2																	
0.1										4705	0.1																	
<b>0.0%</b>																			<b>4872</b>	<b>0</b>								
-0.1																			5051	-0.1								
-0.2																			5243	-0.2								
-0.3																			5449	-0.3								
-0.4																			5668	-0.4								
-0.5	5903	-0.5																										
-0.6	6155	-0.6																										
-0.7	6423	-0.7																										
-0.8	6710	-0.8																										
-0.9	7016	-0.9																										
<b>-1.0</b>																			<b>7344</b>	<b>-1.0</b>								
-1.1																			7693	-1.1								
-1.2																			8066	-1.2								
-1.3																			8465	-1.3								
-1.4																			8890	-1.4								
-1.5										9343	-1.5																	
-1.6										9827	-1.6																	
-1.7										10343	-1.7																	
-1.8										10893	-1.8																	
-1.9										11480	-1.9																	
<b>-2.0</b>																			<b>12105</b>	<b>-2.0</b>								
-2.1																			12772	-2.1								
-2.2																			13482	-2.2								
-2.3																			14239	-2.3								
-2.4																			15046	-2.4								
-2.5	15905	-2.5																										
-2.6	16820	-2.6																										
-2.7	17794	-2.7																										
-2.8	18832	-2.8																										
-2.9	19936	-2.9																										
<b>-3.0</b>																			<b>21112</b>	<b>-3.0</b>								
AVG. GRADE																			15	20	25	30	35	40	45	50	55	AVG. GRADE
																			SPEED									

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### 17.14.6 143 TPOB FREIGHT TRAIN – M.A.S. TO FULL STOP

TONS PER BRAKE: 143  
 REDUCTION TO: 0 MPH

AVG. GRADE	SPEED							AVG. GRADE
	15	20	25	30	35	40	45	
<b>3.0</b>	<b>437</b>	<b>712</b>	<b>1056</b>	<b>1470</b>	<b>1955</b>	<b>2511</b>	<b>3137</b>	<b>3.0</b>
2.9	446	724	1070	1487	1974	2531	3159	2.9
2.8	456	736	1086	1505	1994	2554	3184	2.8
2.7	467	750	1102	1524	2016	2579	3212	2.7
2.6	479	765	1121	1546	2040	2606	3241	2.6
2.5	492	782	1141	1569	2067	2635	3274	2.5
2.4	506	800	1162	1594	2096	2668	3310	2.4
2.3	521	819	1186	1621	2127	2703	3349	2.3
2.2	537	840	1211	1651	2161	2741	3391	2.2
2.1	555	863	1239	1684	2199	2783	3438	2.1
<b>2.0</b>	<b>573</b>	<b>887</b>	<b>1269</b>	<b>1720</b>	<b>2240</b>	<b>2830</b>	<b>3489</b>	<b>2.0</b>
1.9	594	914	1302	1758	2284	2880	3545	1.9
1.8	616	943	1337	1800	2333	2935	3607	1.8
1.7	640	974	1376	1846	2386	2995	3674	1.7
1.6	666	1008	1418	1896	2444	3061	3747	1.6
1.5	694	1045	1464	1951	2507	3132	3827	1.5
1.4	724	1085	1514	2010	2576	3211	3915	1.4
1.3	757	1129	1568	2075	2651	3297	4011	1.3
1.2	792	1176	1627	2146	2733	3390	4117	1.2
1.1	830	1227	1691	2222	2823	3493	4232	1.1
<b>1.0</b>	<b>871</b>	<b>1282</b>	<b>1760</b>	<b>2306</b>	<b>2921</b>	<b>3604</b>	<b>4358</b>	<b>1.0</b>
0.9	916	1342	1836	2397	3027	3727	4496	0.9
0.8	964	1407	1918	2496	3144	3860	4646	0.8
0.7	1016	1478	2007	2605	3271	4006	4812	0.7
0.6	1073	1555	2104	2722	3409	4166	4992	0.6
0.5	1134	1638	2210	2851	3561	4340	5190	0.5
0.4	1200	1728	2325	2991	3726	4531	5406	0.4
0.3	1271	1826	2450	3143	3906	4739	5643	0.3
0.2	1348	1932	2585	3309	4103	4967	5902	0.2
0.1	1431	2047	2733	3490	4317	5216	6185	0.1
<b>0.0%</b>	<b>1521</b>	<b>2172</b>	<b>2893</b>	<b>3687</b>	<b>4551</b>	<b>5488</b>	<b>6495</b>	<b>0</b>
-0.1	1619	2307	3068	3901	4807	5785	6835	-0.1
-0.2	1724	2453	3257	4135	5085	6109	7206	-0.2
-0.3	1838	2613	3463	4389	5390	6464	7612	-0.3
-0.4	1961	2785	3688	4667	5722	6852	8057	-0.4
-0.5	2094	2972	3931	4969	6084	7276	8543	-0.5
-0.6	2237	3175	4196	5298	6479	7739	9076	-0.6
-0.7	2393	3395	4484	5657	6911	8245	9658	-0.7
-0.8	2561	3634	4797	6047	7381	8798	10296	-0.8
-0.9	2742	3893	5138	6473	7895	9402	10993	-0.9
<b>-1.0</b>	<b>2939</b>	<b>4174</b>	<b>5508</b>	<b>6936</b>	<b>8455</b>	<b>10063</b>	<b>11757</b>	<b>-1.0</b>
-1.1	3151	4478	5910	7441	9067	10785	12592	-1.1
-1.2	3381	4809	6348	7992	9735	11574	13506	-1.2
-1.3	3629	5167	6824	8591	10463	12436	14506	-1.3
-1.4	3897	5555	7341	9244	11258	13378	15600	-1.4
-1.5	4187	5977	7903	9955	12125	14407	16798	-1.5
-1.6	4501	6433	8514	10730	13072	15533	18108	-1.6
-1.7	4840	6929	9179	11574	14104	16762	19542	-1.7
-1.8	5206	7467	9901	12494	15231	18106	21111	-1.8
-1.9	5602	8049	10687	13495	16461	19575	22828	-1.9
<b>-2.0</b>	<b>6031</b>	<b>8682</b>	<b>11541</b>	<b>14587</b>	<b>17803</b>	<b>21180</b>	<b>24707</b>	<b>-2.0</b>
-2.1	6494	9367	12470	15776	19268	22934	26763	-2.1
-2.2	6995	10111	13479	17071	20866	24850	29013	-2.2
-2.3	7536	10917	14577	18482	22610	26945	31474	-2.3
-2.4	8121	11792	15770	20019	24513	29234	34168	-2.4
-2.5	8754	12740	17067	21693	26590	31736	37116	-2.5
-2.6	9438	13769	18478	23517	28856	34470	40341	-2.6
-2.7	10177	14885	20011	25504	31329	37458	43871	-2.7
-2.8	10977	16095	21678	27669	34027	40723	47733	-2.8
-2.9	11841	17407	23491	30027	36972	44292	51959	-2.9
<b>-3.0</b>	<b>12775</b>	<b>18831</b>	<b>25461</b>	<b>32596</b>	<b>40186</b>	<b>48191</b>	<b>56584</b>	<b>-3.0</b>
AVG. GRADE	15	20	25	30	35	40	45	AVG. GRADE
	SPEED							

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### 17.14.7 143 TPOB FREIGHT TRAIN – M.A.S. TO 20 MPH

TONS PER BRAKE: 143  
 REDUCTION TO: 20 MPH

AVG. GRADE	SPEED							AVG. GRADE
	15	20	25	30	35	40	45	
<b>3.0</b>			<b>920</b>	<b>1334</b>	<b>1819</b>	<b>2374</b>	<b>3000</b>	<b>3.0</b>
2.9			927	1344	1831	2388	3016	2.9
2.8			936	1355	1844	2404	3034	2.8
2.7			945	1367	1859	2421	3054	2.7
2.6			956	1380	1875	2441	3076	2.6
2.5			967	1396	1894	2462	3101	2.5
2.4			980	1412	1914	2486	3128	2.4
2.3			995	1431	1937	2512	3158	2.3
2.2			1011	1452	1961	2541	3192	2.2
2.1			1029	1474	1989	2574	3229	2.1
<b>2.0</b>			<b>1049</b>	<b>1500</b>	<b>2020</b>	<b>2610</b>	<b>3269</b>	<b>2.0</b>
1.9			1071	1528	2053	2649	3315	1.9
1.8			1095	1558	2091	2693	3365	1.8
1.7			1122	1593	2132	2741	3420	1.7
1.6			1152	1630	2178	2794	3481	1.6
1.5			1185	1672	2228	2853	3548	1.5
1.4			1221	1717	2283	2918	3622	1.4
1.3			1260	1768	2344	2989	3704	1.3
1.2			1304	1823	2411	3068	3794	1.2
1.1			1352	1884	2485	3154	3894	1.1
<b>1.0</b>			<b>1405</b>	<b>1951</b>	<b>2566</b>	<b>3250</b>	<b>4003</b>	<b>1.0</b>
0.9			1464	2025	2655	3355	4124	0.9
0.8			1528	2106	2754	3470	4256	0.8
0.7			1598	2195	2861	3597	4402	0.7
0.6			1675	2293	2980	3737	4563	0.6
0.5			1759	2400	3110	3890	4739	0.5
0.4			1852	2518	3253	4059	4934	0.4
0.3			1954	2647	3410	4244	5147	0.3
0.2			2065	2789	3583	4447	5382	0.2
0.1			2188	2944	3772	4670	5640	0.1
<b>0.0%</b>			<b>2321</b>	<b>3115</b>	<b>3979</b>	<b>4916</b>	<b>5923</b>	<b>0</b>
-0.1			2468	3301	4207	5185	6235	-0.1
-0.2			2628	3505	4456	5480	6577	-0.2
-0.3			2803	3729	4730	5804	6952	-0.3
-0.4			2995	3974	5029	6159	7364	-0.4
-0.5			3205	4242	5358	6549	7817	-0.5
-0.6			3434	4536	5717	6977	8314	-0.6
-0.7			3685	4857	6111	7446	8859	-0.7
-0.8			3959	5209	6543	7959	9457	-0.8
-0.9			4258	5593	7016	8523	10114	-0.9
<b>-1.0</b>			<b>4586</b>	<b>6014</b>	<b>7533</b>	<b>9140</b>	<b>10834</b>	<b>-1.0</b>
-1.1			4943	6474	8100	9817	11624	-1.1
-1.2			5333	6977	8720	10559	12491	-1.2
-1.3			5759	7526	9398	11371	13441	-1.3
-1.4			6224	8127	10141	12261	14483	-1.4
-1.5			6732	8784	10954	13236	15626	-1.5
-1.6			7286	9501	11843	14304	16879	-1.6
-1.7			7890	10285	12816	15473	18253	-1.7
-1.8			8549	11142	13879	16754	19759	-1.8
-1.9			9269	12077	15043	18157	21410	-1.9
<b>-2.0</b>			<b>10053</b>	<b>13099</b>	<b>16316</b>	<b>19692</b>	<b>23219</b>	<b>-2.0</b>
-2.1			10909	14215	17708	21373	25203	-2.1
-2.2			11842	15434	19229	23214	27376	-2.2
-2.3			12860	16765	20893	25228	29757	-2.3
-2.4			13969	18218	22712	27434	32367	-2.4
-2.5			15178	19804	24701	29847	35227	-2.5
-2.6			16496	21536	26875	32489	38360	-2.6
-2.7			17933	23426	29251	35380	41792	-2.7
-2.8			19498	25489	31847	38543	45553	-2.8
-2.9			21204	27740	34685	42005	49672	-2.9
<b>-3.0</b>			<b>23062</b>	<b>30198</b>	<b>37787</b>	<b>45793</b>	<b>54185</b>	<b>-3.0</b>
AVG. GRADE	15	20	25	30	35	40	45	AVG. GRADE
	SPEED							

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### 17.14.8 143 TPOB FREIGHT TRAIN – M.A.S. TO 30 MPH

TONS PER BRAKE: 143  
 REDUCTION TO: 30 MPH

AVG. GRADE	SPEED							AVG. GRADE
	15	20	25	30	35	40	45	
<b>3.0</b>					<b>1700</b>	<b>2255</b>	<b>2881</b>	<b>3.0</b>
2.9					1704	2262	2890	2.9
2.8					1710	2269	2900	2.8
2.7					1716	2278	2911	2.7
2.6					1723	2289	2924	2.6
2.5					1732	2301	2939	2.5
2.4					1743	2314	2957	2.4
2.3					1754	2330	2976	2.3
2.2					1768	2348	2998	2.2
2.1					1784	2368	3023	2.1
<b>2.0</b>					<b>1802</b>	<b>2391</b>	<b>3051</b>	<b>2.0</b>
1.9					1822	2418	3083	1.9
1.8					1845	2447	3119	1.8
1.7					1871	2480	3159	1.7
1.6					1900	2517	3204	1.6
1.5					1934	2559	3254	1.5
1.4					1971	2606	3310	1.4
1.3					2012	2658	3373	1.3
1.2					2059	2716	3443	1.2
1.1					2111	2781	3520	1.1
<b>1.0</b>					<b>2170</b>	<b>2854</b>	<b>3607</b>	<b>1.0</b>
0.9					2235	2934	3703	0.9
0.8					2308	3024	3810	0.8
0.7					2388	3124	3929	0.7
0.6					2478	3235	4061	0.6
0.5					2578	3357	4207	0.5
0.4					2688	3494	4369	0.4
0.3					2811	3644	4548	0.3
0.2					2947	3811	4746	0.2
0.1					3098	3996	4966	0.1
<b>0.0%</b>					<b>3264</b>	<b>4201</b>	<b>5208</b>	<b>0</b>
-0.1					3448	4426	5476	-0.1
-0.2					3652	4676	5772	-0.2
-0.3					3877	4951	6099	-0.3
-0.4					4125	5255	6460	-0.4
-0.5					4399	5591	6858	-0.5
-0.6					4701	5960	7297	-0.6
-0.7					5034	6368	7781	-0.7
-0.8					5401	6817	8315	-0.8
-0.9					5805	7312	8903	-0.9
<b>-1.0</b>					<b>6249</b>	<b>7857</b>	<b>9550</b>	<b>-1.0</b>
-1.1					6739	8456	10264	-1.1
-1.2					7277	9116	11049	-1.2
-1.3					7870	9842	11913	-1.3
-1.4					8521	10641	12863	-1.4
-1.5					9237	11519	13909	-1.5
-1.6					10023	12484	15060	-1.6
-1.7					10887	13545	16325	-1.7
-1.8					11836	14711	17716	-1.8
-1.9					12878	15992	19245	-1.9
<b>-2.0</b>					<b>14022</b>	<b>17398</b>	<b>20926</b>	<b>-2.0</b>
-2.1					15277	18943	22772	-2.1
-2.2					16654	20639	24801	-2.2
-2.3					18165	22500	27029	-2.3
-2.4					19822	24543	29477	-2.4
-2.5					21639	26785	32165	-2.5
-2.6					23631	29245	35116	-2.6
-2.7					25815	31944	38357	-2.7
-2.8					28208	34904	41914	-2.8
-2.9					30831	38150	45818	-2.9
<b>-3.0</b>					<b>33704</b>	<b>41710</b>	<b>50102</b>	<b>-3.0</b>
AVG. GRADE	15	20	25	30	35	40	45	AVG. GRADE
	SPEED							

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**17.14.9 143 TPOB FREIGHT TRAIN – M.A.S. TO 40 MPH**

TONS PER BRAKE: 143  
 REDUCTION TO: 40 MPH

AVG. GRADE	SPEED							AVG. GRADE
	15	20	25	30	35	40	45	
<b>3.0</b>							<b>2738</b>	<b>3.0</b>
2.9							2737	2.9
2.8							2736	2.8
2.7							2736	2.7
2.6							2738	2.6
2.5							2740	2.5
2.4							2744	2.4
2.3							2749	2.3
2.2							2756	2.2
2.1							2765	2.1
<b>2.0</b>							<b>2775</b>	<b>2.0</b>
1.9							2789	1.9
1.8							2804	1.8
1.7							2823	1.7
1.6							2846	1.6
1.5							2872	1.5
1.4							2903	1.4
1.3							2938	1.3
1.2							2979	1.2
1.1							3026	1.1
<b>1.0</b>							<b>3080</b>	<b>1.0</b>
0.9							3141	0.9
0.8							3210	0.8
0.7							3289	0.7
0.6							3379	0.6
0.5							3480	0.5
0.4							3593	0.4
0.3							3721	0.3
0.2							3865	0.2
0.1							4027	0.1
<b>0.0%</b>							<b>4207</b>	<b>0</b>
-0.1							4409	-0.1
-0.2							4635	-0.2
-0.3							4888	-0.3
-0.4							5169	-0.4
-0.5							5482	-0.5
-0.6							5831	-0.6
-0.7							6219	-0.7
-0.8							6650	-0.8
-0.9							7129	-0.9
<b>-1.0</b>							<b>7661</b>	<b>-1.0</b>
-1.1							8251	-1.1
-1.2							8905	-1.2
-1.3							9629	-1.3
-1.4							10431	-1.4
-1.5							11318	-1.5
-1.6							12300	-1.6
-1.7							13386	-1.7
-1.8							14586	-1.8
-1.9							15912	-1.9
<b>-2.0</b>							<b>17376</b>	<b>-2.0</b>
-2.1							18993	-2.1
-2.2							20777	-2.2
-2.3							22745	-2.3
-2.4							24915	-2.4
-2.5							27308	-2.5
-2.6							29946	-2.6
-2.7							32852	-2.7
-2.8							36054	-2.8
-2.9							39580	-2.9
<b>-3.0</b>							<b>43462</b>	<b>-3.0</b>
AVG. GRADE	15	20	25	30	35	40	45	AVG. GRADE
	SPEED							

May-15

### 17.14.10 PASSENGER TRAIN – M.A.S. TO FULL STOP

AMTRAK CE-205 STANDARD

REDUCTION TO: 0 MPH

AVG. GRADE	SPEED												AVG. GRADE
	35	40	45	50	55	60	65	70	75	80	85	90	
<b>3.0</b>	<b>994</b>	<b>1231</b>	<b>1492</b>	<b>1777</b>	<b>2086</b>	<b>2418</b>	<b>2774</b>	<b>3154</b>	<b>3558</b>	<b>3986</b>	<b>4437</b>	<b>4913</b>	<b>3.0</b>
2.9	1002	1242	1506	1794	2106	2443	2803	3188	3597	4030	4487	4969	2.9
2.8	1011	1253	1520	1812	2128	2468	2833	3223	3637	4076	4539	5026	2.8
2.7	1020	1265	1535	1830	2150	2495	2864	3259	3678	4122	4591	5085	2.7
2.6	1029	1277	1551	1849	2173	2522	2896	3296	3721	4171	4646	5146	2.6
2.5	1039	1290	1566	1869	2196	2550	2929	3334	3764	4220	4702	5209	2.5
2.4	1049	1303	1582	1889	2221	2579	2963	3373	3809	4272	4760	5274	2.4
2.3	1059	1316	1599	1909	2246	2608	2998	3414	3856	4325	4820	5341	2.3
2.2	1069	1329	1617	1931	2271	2639	3034	3455	3904	4379	4881	5410	2.2
2.1	1080	1343	1634	1953	2298	2671	3071	3499	3953	4436	4945	5482	2.1
<b>2.0</b>	<b>1091</b>	<b>1358</b>	<b>1653</b>	<b>1975</b>	<b>2326</b>	<b>2704</b>	<b>3110</b>	<b>3543</b>	<b>4005</b>	<b>4494</b>	<b>5011</b>	<b>5556</b>	<b>2.0</b>
1.9	1103	1373	1672	1999	2354	2738	3149	3589	4058	4554	5079	5632	1.9
1.8	1115	1389	1692	2023	2384	2773	3191	3637	4122	4616	5149	5711	1.8
1.7	1127	1405	1712	2048	2414	2809	3233	3686	4169	4681	5222	5792	1.7
1.6	1140	1422	1733	2075	2446	2847	3277	3738	4228	4748	5297	5877	1.6
1.5	1153	1439	1755	2102	2478	2886	3323	3791	4289	4817	5376	5965	1.5
1.4	1167	1457	1778	2130	2512	2926	3370	3846	4352	4889	5457	6056	1.4
1.3	1181	1475	1801	2159	2548	2968	3420	3903	4417	4963	5541	6150	1.3
1.2	1196	1495	1826	2189	2584	3011	3471	3962	4485	5041	5628	6248	1.2
1.1	1211	1515	1851	2220	2622	3057	3524	4024	4556	5121	5719	6350	1.1
<b>1.0</b>	<b>1227</b>	<b>1536</b>	<b>1878</b>	<b>2253</b>	<b>2662</b>	<b>3104</b>	<b>3579</b>	<b>4088</b>	<b>4630</b>	<b>5205</b>	<b>5814</b>	<b>6455</b>	<b>1.0</b>
0.9	1244	1558	1905	2287	2703	3153	3636	4154	4706	5292	5912	6566	0.9
0.8	1261	1580	1934	2323	2746	3204	3696	4224	4786	5383	6014	6680	0.8
0.7	1279	1604	1964	2359	2790	3257	3759	4296	4869	5477	6121	6800	0.7
0.6	1298	1629	1995	2398	2837	3312	3824	4372	4956	5576	6232	6925	0.6
0.5	1318	1654	2028	2438	2886	3370	3892	4451	5046	5679	6349	7055	0.5
0.4	1339	1681	2062	2480	2937	3431	3963	4533	5141	5787	6470	7192	0.4
0.3	1360	1709	2098	2524	2990	3494	4038	4619	5240	5899	6598	7335	0.3
0.2	1383	1739	2135	2571	3046	3561	4115	4710	5344	6018	6731	7484	0.2
0.1	1406	1770	2174	2619	3104	3631	4197	4805	5453	6141	6871	7641	0.1
<b>0.0%</b>	<b>1431</b>	<b>1802</b>	<b>2215</b>	<b>2670</b>	<b>3166</b>	<b>3704</b>	<b>4283</b>	<b>4904</b>	<b>5567</b>	<b>6272</b>	<b>7018</b>	<b>7805</b>	<b>0</b>
-0.1	1458	1837	2259	2723	3231	3781	4373	5009	5687	6408	7172	7979	-0.1
-0.2	1485	1873	2304	2779	3299	3862	4468	5119	5814	6552	7335	8161	-0.2
-0.3	1514	1911	2352	2839	3370	3947	4569	5235	5947	6704	7506	8353	-0.3
-0.4	1545	1951	2403	2901	3446	4037	4674	5358	6088	6864	7687	8555	-0.4
-0.5	1577	1993	2456	2967	3526	4132	4786	5488	6237	7033	7878	8770	-0.5
-0.6	1611	2038	2513	3037	3611	4233	4904	5625	6394	7213	8080	8997	-0.6
-0.7	1648	2085	2573	3112	3701	4340	5030	5770	6561	7403	8295	9237	-0.7
-0.8	1687	2136	2637	3191	3796	4454	5163	5925	6739	7605	8523	9493	-0.8
-0.9	1728	2190	2705	3275	3898	4575	5305	6090	6928	7820	8766	9765	-0.9
<b>-1.0</b>	<b>1772</b>	<b>2247</b>	<b>2778</b>	<b>3364</b>	<b>4006</b>	<b>4704</b>	<b>5457</b>	<b>6265</b>	<b>7130</b>	<b>8049</b>	<b>9025</b>	<b>10055</b>	<b>-1.0</b>
-1.1	1819	2308	2855	3460	4122	4842	5619	6453	7345	8294	9301	10366	-1.1
-1.2	1869	2374	2938	3563	4246	4989	5792	6654	7576	8557	9598	10698	-1.2
-1.3	1923	2444	3028	3673	4380	5148	5978	6870	7824	8839	9916	11055	-1.3
-1.4	1981	2520	3124	3792	4523	5319	6179	7103	8091	9143	10260	11440	-1.4
-1.5	2044	2602	3228	3920	4678	5504	6396	7354	8379	9471	10630	11855	-1.5
-1.6	2112	2691	3340	4059	4846	5704	6630	7626	8692	9827	11031	12305	-1.6
-1.7	2186	2788	3463	4210	5029	5921	6885	7922	9032	10213	11468	12794	-1.7
-1.8	2267	2893	3596	4374	5228	6158	7164	8245	9402	10635	11944	13328	-1.8
-1.9	2355	3009	3742	4555	5447	6418	7469	8599	9808	11097	12465	13912	-1.9
<b>-2.0</b>	<b>2452</b>	<b>3136</b>	<b>3903</b>	<b>4753</b>	<b>5687</b>	<b>6704</b>	<b>7804</b>	<b>8987</b>	<b>10254</b>	<b>11605</b>	<b>13038</b>	<b>14555</b>	<b>-2.0</b>
-2.1	2560	3276	4080	4972	5952	7019	8174	9417	10748	12166	13672	15266	-2.1
-2.2	2679	3432	4278	5216	6247	7370	8586	9895	11296	12790	14376	16055	-2.2
-2.3	2812	3606	4498	5488	6576	7762	9046	10429	11909	13487	15163	16937	-2.3
-2.4	2963	3802	4746	5795	6947	8204	9564	11029	12598	14271	16049	17930	-2.4
-2.5	3133	4025	5028	6142	7367	8703	10151	11710	13379	15160	17052	19055	-2.5
-2.6	3327	4279	5349	6539	7847	9275	10822	12487	14272	16176	18199	20341	-2.6
-2.7	3551	4572	5720	6997	8401	9934	11595	13385	15302	17348	19522	21824	-2.7
-2.8	3813	4913	6153	7531	9048	10703	12498	14432	16504	18715	21066	23555	-2.8
-2.9	4123	5317	6664	8162	9811	11612	13565	15669	17925	20332	22890	25600	-2.9
<b>-3.0</b>	<b>4494</b>	<b>5802</b>	<b>7278</b>	<b>8920</b>	<b>10728</b>	<b>12703</b>	<b>14845</b>	<b>17154</b>	<b>19629</b>	<b>22271</b>	<b>25079</b>	<b>28055</b>	<b>-3.0</b>
AVG. GRADE	SPEED												AVG. GRADE
	35	40	45	50	55	60	65	70	75	80	85	90	

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### 17.14.11 PASSENGER TRAIN – M.A.S. TO 30 MPH

AMTRAK CE-205 STANDARD

REDUCTION TO: 30 MPH

AVG. GRADE	SPEED												AVG. GRADE
	35	40	45	50	55	60	65	70	75	80	85	90	
<b>3.0</b>	<b>550</b>	<b>769</b>	<b>1010</b>	<b>1272</b>	<b>1556</b>	<b>1861</b>	<b>2187</b>	<b>2535</b>	<b>2905</b>	<b>3296</b>	<b>3708</b>	<b>4141</b>	<b>3.0</b>
2.9	552	774	1017	1282	1569	1878	2208	2560	2934	3330	3747	4186	2.9
2.8	554	778	1024	1292	1583	1895	2229	2586	2964	3365	3787	4232	2.8
2.7	556	783	1032	1303	1597	1913	2251	2612	2995	3401	3829	4280	2.7
2.6	558	787	1039	1314	1611	1931	2274	2639	3027	3438	3872	4328	2.6
2.5	561	792	1047	1325	1626	1950	2297	2667	3061	3477	3916	4379	2.5
2.4	563	797	1055	1337	1641	1969	2321	2696	3095	3517	3962	4431	2.4
2.3	565	803	1064	1348	1657	1990	2346	2726	3130	3557	4009	4484	2.3
2.2	568	808	1072	1361	1673	2010	2371	2757	3166	3600	4058	4540	2.2
2.1	570	813	1081	1373	1690	2032	2398	2788	3204	3643	4108	4597	2.1
<b>2.0</b>	<b>573</b>	<b>819</b>	<b>1090</b>	<b>1387</b>	<b>1708</b>	<b>2054</b>	<b>2425</b>	<b>2821</b>	<b>3242</b>	<b>3688</b>	<b>4160</b>	<b>4656</b>	<b>2.0</b>
1.9	576	825	1100	1400	1726	2077	2453	2855	3282	3735	4213	4717	1.9
1.8	579	831	1110	1414	1744	2100	2482	2890	3324	3783	4269	4780	1.8
1.7	582	838	1120	1429	1764	2125	2512	2926	3367	3833	4326	4845	1.7
1.6	585	844	1131	1444	1784	2150	2544	2964	3411	3885	4385	4913	1.6
1.5	588	851	1141	1459	1804	2177	2576	3003	3457	3938	4447	4983	1.5
1.4	591	858	1153	1475	1826	2204	2610	3043	3505	3994	4511	5056	1.4
1.3	595	865	1165	1492	1848	2232	2645	3085	3554	4052	4577	5131	1.3
1.2	598	873	1177	1510	1871	2261	2681	3129	3606	4111	4646	5210	1.2
1.1	602	881	1190	1528	1895	2292	2718	3174	3659	4174	4718	5291	1.1
<b>1.0</b>	<b>606</b>	<b>889</b>	<b>1203</b>	<b>1547</b>	<b>1920</b>	<b>2324</b>	<b>2757</b>	<b>3221</b>	<b>3715</b>	<b>4238</b>	<b>4792</b>	<b>5376</b>	<b>1.0</b>
0.9	610	898	1217	1566	1946	2357	2798	3270	3773	4306	4869	5464	0.9
0.8	614	907	1231	1587	1973	2391	2841	3321	3833	4376	4950	5556	0.8
0.7	618	916	1246	1608	2002	2427	2885	3374	3896	4449	5034	5651	0.7
0.6	623	926	1262	1630	2031	2465	2931	3430	3961	4525	5122	5751	0.6
0.5	627	936	1278	1653	2062	2504	2979	3488	4030	4605	5214	5856	0.5
0.4	632	946	1295	1677	2094	2545	3029	3548	4101	4688	5310	5965	0.4
0.3	637	958	1313	1703	2128	2588	3082	3612	4176	4776	5410	6079	0.3
0.2	643	969	1331	1729	2163	2632	3137	3678	4255	4867	5515	6199	0.2
0.1	648	981	1351	1757	2200	2679	3195	3748	4337	4963	5625	6324	0.1
<b>0.0%</b>	<b>654</b>	<b>994</b>	<b>1372</b>	<b>1787</b>	<b>2239</b>	<b>2729</b>	<b>3256</b>	<b>3821</b>	<b>4424</b>	<b>5063</b>	<b>5741</b>	<b>6456</b>	<b>0</b>
-0.1	661	1008	1393	1817	2280	2781	3320	3898	4514	5169	5862	6594	-0.1
-0.2	667	1022	1416	1850	2323	2835	3387	3979	4610	5281	5990	6740	-0.2
-0.3	674	1037	1440	1884	2368	2893	3458	4064	4711	5398	6125	6894	-0.3
-0.4	681	1053	1465	1920	2416	2954	3533	4154	4817	5522	6268	7056	-0.4
-0.5	689	1069	1492	1958	2467	3018	3612	4250	4930	5653	6418	7227	-0.5
-0.6	697	1087	1520	1998	2520	3086	3696	4351	5049	5791	6578	7409	-0.6
-0.7	706	1106	1551	2041	2577	3158	3785	4457	5175	5938	6747	7601	-0.7
-0.8	715	1125	1583	2087	2637	3235	3880	4571	5309	6095	6927	7806	-0.8
-0.9	725	1147	1617	2135	2702	3317	3980	4692	5452	6261	7118	8023	-0.9
<b>-1.0</b>	<b>736</b>	<b>1169</b>	<b>1653</b>	<b>2187</b>	<b>2770</b>	<b>3404</b>	<b>4087</b>	<b>4821</b>	<b>5605</b>	<b>6438</b>	<b>7322</b>	<b>8256</b>	<b>-1.0</b>
-1.1	747	1193	1692	2242	2843	3497	4202	4959	5768	6628	7540	8504	-1.1
-1.2	759	1219	1733	2301	2922	3597	4325	5107	5942	6831	7774	8770	-1.2
-1.3	772	1247	1778	2364	3006	3704	4457	5266	6130	7050	8025	9056	-1.3
-1.4	786	1277	1826	2433	3097	3819	4599	5436	6332	7285	8295	9363	-1.4
-1.5	801	1309	1878	2507	3195	3944	4752	5621	6550	7538	8587	9696	-1.5
-1.6	817	1344	1934	2587	3301	4079	4919	5821	6786	7813	8903	10056	-1.6
-1.7	834	1382	1995	2673	3417	4226	5099	6038	7043	8112	9247	10447	-1.7
-1.8	854	1424	2062	2768	3543	4386	5297	6276	7323	8438	9622	10874	-1.8
-1.9	875	1469	2135	2872	3681	4561	5512	6535	7630	8796	10033	11341	-1.9
<b>-2.0</b>	<b>898</b>	<b>1519</b>	<b>2215</b>	<b>2987</b>	<b>3833</b>	<b>4754</b>	<b>5750</b>	<b>6821</b>	<b>7967</b>	<b>9188</b>	<b>10485</b>	<b>11856</b>	<b>-2.0</b>
-2.1	924	1574	2304	3113	4000	4967	6012	7137	8340	9623	10984	12424	-2.1
-2.2	952	1636	2403	3253	4187	5204	6304	7488	8755	10105	11539	13056	-2.2
-2.3	984	1704	2513	3410	4395	5469	6630	7880	9218	10644	12159	13762	-2.3
-2.4	1020	1782	2637	3587	4630	5766	6997	8321	9739	11251	12856	14556	-2.4
-2.5	1061	1869	2778	3787	4895	6104	7412	8821	10330	11938	13647	15456	-2.5
-2.6	1107	1969	2939	4015	5199	6490	7887	9393	11005	12724	14551	16484	-2.6
-2.7	1161	2085	3124	4279	5549	6935	8436	10052	11784	13631	15593	17671	-2.7
-2.8	1223	2219	3340	4587	5958	7454	9075	10821	12692	14688	16810	19056	-2.8
-2.9	1297	2378	3596	4950	6441	8067	9831	11730	13766	15938	18247	20692	-2.9
<b>-3.0</b>	<b>1386</b>	<b>2569</b>	<b>3903</b>	<b>5387</b>	<b>7020</b>	<b>8804</b>	<b>10737</b>	<b>12821</b>	<b>15055</b>	<b>17438</b>	<b>19972</b>	<b>22656</b>	<b>-3.0</b>
AVG. GRADE	SPEED												AVG. GRADE
	35	40	45	50	55	60	65	70	75	80	85	90	

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### 17.14.12 PASSENGER TRAIN – M.A.S. TO 40 MPH

AMTRAK CE-205 STANDARD

REDUCTION TO: 40 MPH

AVG. GRADE	SPEED												AVG. GRADE
	35	40	45	50	55	60	65	70	75	80	85	90	
<b>3.0</b>			<b>710</b>	<b>972</b>	<b>1256</b>	<b>1561</b>	<b>1887</b>	<b>2235</b>	<b>2605</b>	<b>2996</b>	<b>3408</b>	<b>3841</b>	<b>3.0</b>
2.9			713	978	1265	1573	1904	2256	2630	3025	3443	3882	2.9
2.8			715	984	1274	1586	1921	2277	2655	3056	3479	3923	2.8
2.7			718	989	1283	1599	1938	2299	2682	3088	3516	3966	2.7
2.6			721	996	1293	1613	1956	2321	2709	3120	3554	4010	2.6
2.5			724	1002	1303	1627	1974	2344	2737	3154	3593	4056	2.5
2.4			727	1008	1313	1641	1993	2368	2766	3188	3634	4103	2.4
2.3			730	1015	1324	1656	2012	2393	2796	3224	3676	4151	2.3
2.2			733	1022	1335	1672	2033	2418	2827	3261	3719	4201	2.2
2.1			737	1029	1346	1687	2053	2444	2859	3299	3763	4252	2.1
<b>2.0</b>			<b>740</b>	<b>1037</b>	<b>1358</b>	<b>1704</b>	<b>2075</b>	<b>2471</b>	<b>2892</b>	<b>3338</b>	<b>3810</b>	<b>4306</b>	<b>2.0</b>
1.9			744	1044	1370	1721	2097	2499	2926	3379	3857	4361	1.9
1.8			748	1052	1382	1738	2120	2528	2962	3421	3907	4418	1.8
1.7			752	1060	1395	1756	2144	2558	2998	3465	3958	4477	1.7
1.6			756	1069	1409	1775	2169	2589	3036	3510	4010	4538	1.6
1.5			760	1077	1422	1795	2194	2621	3075	3557	4065	4601	1.5
1.4			764	1087	1437	1815	2221	2654	3116	3605	4122	4667	1.4
1.3			768	1096	1452	1836	2248	2689	3158	3655	4181	4735	1.3
1.2			773	1106	1467	1858	2277	2725	3202	3708	4242	4806	1.2
1.1			778	1116	1483	1880	2307	2762	3247	3762	4306	4879	1.1
<b>1.0</b>			<b>783</b>	<b>1127</b>	<b>1500</b>	<b>1904</b>	<b>2337</b>	<b>2801</b>	<b>3295</b>	<b>3818</b>	<b>4372</b>	<b>4956</b>	<b>1.0</b>
0.9			788	1138	1518	1928	2370	2842	3344	3877	4441	5035	0.9
0.8			793	1149	1536	1954	2403	2884	3395	3938	4513	5118	0.8
0.7			799	1161	1555	1980	2438	2927	3449	4002	4587	5205	0.7
0.6			805	1173	1574	2008	2474	2973	3505	4069	4666	5295	0.6
0.5			811	1187	1595	2037	2512	3021	3563	4138	4747	5389	0.5
0.4			818	1200	1617	2067	2552	3071	3624	4211	4832	5488	0.4
0.3			824	1214	1639	2099	2594	3123	3688	4287	4921	5591	0.3
0.2			831	1229	1663	2132	2637	3178	3755	4367	5015	5699	0.2
0.1			839	1245	1688	2167	2683	3236	3825	4451	5113	5812	0.1
<b>0.0%</b>			<b>847</b>	<b>1262</b>	<b>1714</b>	<b>2204</b>	<b>2731</b>	<b>3296</b>	<b>3899</b>	<b>4538</b>	<b>5216</b>	<b>5931</b>	<b>0</b>
-0.1			855	1279	1741	2242	2782	3360	3976	4631	5324	6056	-0.1
-0.2			863	1297	1770	2283	2835	3426	4057	4728	5438	6187	-0.2
-0.3			872	1316	1801	2325	2891	3497	4143	4830	5558	6326	-0.3
-0.4			882	1337	1833	2370	2950	3571	4234	4938	5685	6472	-0.4
-0.5			892	1358	1867	2418	3012	3650	4330	5053	5818	6627	-0.5
-0.6			903	1381	1903	2469	3079	3733	4431	5174	5960	6791	-0.6
-0.7			914	1405	1941	2522	3149	3821	4539	5302	6111	6965	-0.7
-0.8			926	1430	1981	2579	3223	3915	4653	5438	6270	7149	-0.8
-0.9			939	1457	2024	2639	3303	4015	4775	5584	6441	7346	-0.9
<b>-1.0</b>			<b>953</b>	<b>1487</b>	<b>2070</b>	<b>2704</b>	<b>3387</b>	<b>4121</b>	<b>4905</b>	<b>5738</b>	<b>6622</b>	<b>7556</b>	<b>-1.0</b>
-1.1			968	1518	2119	2773	3478	4235	5044	5904	6816	7780	-1.1
-1.2			983	1551	2172	2847	3575	4357	5192	6081	7024	8020	-1.2
-1.3			1000	1587	2228	2926	3679	4488	5352	6272	7247	8278	-1.3
-1.4			1018	1625	2289	3011	3791	4629	5524	6477	7487	8556	-1.4
-1.5			1038	1667	2355	3104	3912	4781	5710	6698	7747	8856	-1.5
-1.6			1059	1712	2426	3204	4044	4946	5911	6938	8028	9181	-1.6
-1.7			1082	1760	2504	3312	4186	5125	6130	7199	8334	9534	-1.7
-1.8			1107	1814	2588	3431	4342	5321	6368	7484	8668	9919	-1.8
-1.9			1135	1872	2681	3561	4512	5535	6630	7796	9033	10341	-1.9
<b>-2.0</b>			<b>1165</b>	<b>1937</b>	<b>2783</b>	<b>3704</b>	<b>4700</b>	<b>5771</b>	<b>6917</b>	<b>8138</b>	<b>9435</b>	<b>10806</b>	<b>-2.0</b>
-2.1			1199	2008	2895	3862	4907	6032	7235	8517	9879	11319	-2.1
-2.2			1236	2087	3020	4037	5137	6321	7588	8938	10372	11889	-2.2
-2.3			1278	2175	3160	4233	5395	6645	7983	9409	10924	12526	-2.3
-2.4			1325	2274	3317	4454	5684	7009	8427	9938	11544	13243	-2.4
-2.5			1378	2387	3495	4704	6012	7421	8930	10538	12247	14056	-2.5
-2.6			1439	2515	3699	4990	6387	7893	9505	11224	13051	14984	-2.6
-2.7			1509	2663	3934	5319	6820	8436	10168	12015	13978	16056	-2.7
-2.8			1590	2837	4208	5704	7325	9071	10942	12938	15060	17306	-2.8
-2.9			1687	3041	4532	6158	7922	9821	11857	14029	16338	18783	-2.9
<b>-3.0</b>			<b>1803</b>	<b>3287</b>	<b>4920</b>	<b>6704</b>	<b>8637</b>	<b>10721</b>	<b>12955</b>	<b>15338</b>	<b>17872</b>	<b>20556</b>	<b>-3.0</b>
AVG. GRADE	35	40	45	50	55	60	65	70	75	80	85	90	AVG. GRADE
	SPEED												

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### 17.14.13 PASSENGER TRAIN – M.A.S. TO 50 MPH

AMTRAK CE-205 STANDARD

REDUCTION TO: 50 MPH

AVG. GRADE	SPEED											AVG. GRADE	
	35	40	45	50	55	60	65	70	75	80	85		90
<b>3.0</b>					<b>870</b>	<b>1175</b>	<b>1502</b>	<b>1850</b>	<b>2219</b>	<b>2610</b>	<b>3022</b>	<b>3456</b>	<b>3.0</b>
2.9					873	1182	1512	1865	2238	2634	3051	3490	2.9
2.8					877	1189	1523	1880	2258	2659	3082	3526	2.8
2.7					880	1196	1535	1896	2279	2685	3113	3563	2.7
2.6					884	1204	1547	1912	2300	2711	3145	3601	2.6
2.5					887	1211	1559	1929	2322	2738	3178	3640	2.5
2.4					891	1219	1571	1946	2345	2767	3212	3681	2.4
2.3					895	1228	1584	1964	2368	2796	3247	3722	2.3
2.2					899	1236	1597	1982	2392	2825	3283	3765	2.2
2.1					903	1245	1611	2001	2417	2856	3321	3810	2.1
<b>2.0</b>					<b>908</b>	<b>1254</b>	<b>1625</b>	<b>2021</b>	<b>2442</b>	<b>2888</b>	<b>3360</b>	<b>3856</b>	<b>2.0</b>
1.9					912	1263	1640	2041	2469	2921	3400	3903	1.9
1.8					917	1273	1655	2062	2496	2956	3441	3952	1.8
1.7					921	1283	1670	2084	2524	2991	3484	4003	1.7
1.6					926	1293	1687	2107	2554	3028	3528	4056	1.6
1.5					932	1304	1703	2130	2584	3066	3574	4110	1.5
1.4					937	1315	1721	2154	2616	3105	3622	4167	1.4
1.3					942	1326	1739	2180	2649	3146	3672	4226	1.3
1.2					948	1338	1758	2206	2683	3188	3723	4286	1.2
1.1					954	1351	1777	2233	2718	3233	3776	4350	1.1
<b>1.0</b>					<b>960</b>	<b>1364</b>	<b>1797</b>	<b>2261</b>	<b>2755</b>	<b>3278</b>	<b>3832</b>	<b>4416</b>	<b>1.0</b>
0.9					967	1377	1819	2290	2793	3326	3890	4484	0.9
0.8					973	1391	1841	2321	2833	3376	3950	4556	0.8
0.7					980	1406	1864	2353	2874	3428	4013	4630	0.7
0.6					988	1421	1887	2386	2918	3482	4079	4708	0.6
0.5					995	1437	1912	2421	2963	3538	4147	4789	0.5
0.4					1003	1454	1939	2457	3010	3597	4219	4874	0.4
0.3					1011	1471	1966	2496	3060	3659	4294	4963	0.3
0.2					1020	1490	1995	2535	3112	3724	4372	5056	0.2
0.1					1029	1509	2025	2577	3166	3792	4454	5153	0.1
<b>0.0%</b>					<b>1039</b>	<b>1529</b>	<b>2056</b>	<b>2621</b>	<b>3224</b>	<b>3863</b>	<b>4541</b>	<b>5256</b>	<b>0</b>
-0.1					1049	1550	2089	2667	3284	3938	4632	5363	-0.1
-0.2					1060	1572	2124	2716	3347	4017	4727	5477	-0.2
-0.3					1071	1596	2161	2767	3414	4101	4828	5596	-0.3
-0.4					1083	1620	2200	2821	3484	4188	4935	5722	-0.4
-0.5					1095	1647	2241	2878	3558	4281	5047	5856	-0.5
-0.6					1108	1674	2285	2939	3637	4380	5166	5997	-0.6
-0.7					1122	1704	2331	3003	3721	4484	5293	6147	-0.7
-0.8					1137	1735	2380	3071	3809	4595	5427	6306	-0.8
-0.9					1153	1768	2432	3144	3904	4713	5570	6475	-0.9
<b>-1.0</b>					<b>1170</b>	<b>1804</b>	<b>2487</b>	<b>3221</b>	<b>4005</b>	<b>4838</b>	<b>5722</b>	<b>6656</b>	<b>-1.0</b>
-1.1					1188	1842	2547	3304	4113	4973	5885	6849	-1.1
-1.2					1208	1882	2611	3393	4228	5117	6060	7056	-1.2
-1.3					1228	1926	2679	3488	4352	5272	6247	7278	-1.3
-1.4					1251	1973	2753	3590	4486	5438	6449	7517	-1.4
-1.5					1275	2024	2832	3701	4630	5618	6667	7776	-1.5
-1.6					1301	2079	2919	3821	4786	5813	6903	8056	-1.6
-1.7					1330	2139	3012	3952	4956	6025	7160	8360	-1.7
-1.8					1361	2204	3115	4094	5141	6257	7440	8692	-1.8
-1.9					1395	2275	3227	4250	5344	6510	7747	9056	-1.9
<b>-2.0</b>					<b>1433</b>	<b>2354</b>	<b>3350</b>	<b>4421</b>	<b>5567</b>	<b>6788</b>	<b>8085</b>	<b>9456</b>	<b>-2.0</b>
-2.1					1474	2441	3486	4611	5814	7096	8458	9898	-2.1
-2.2					1520	2537	3637	4821	6088	7438	8872	10389	-2.2
-2.3					1572	2645	3807	5056	6394	7821	9335	10938	-2.3
-2.4					1630	2766	3997	5321	6739	8251	9856	11556	-2.4
-2.5					1695	2904	4212	5621	7130	8738	10447	12256	-2.5
-2.6					1770	3061	4459	5964	7576	9296	11122	13056	-2.6
-2.7					1857	3242	4743	6360	8091	9938	11901	13979	-2.7
-2.8					1958	3454	5075	6821	8692	10688	12810	15056	-2.8
-2.9					2077	3704	5467	7367	9402	11575	13883	16328	-2.9
<b>-3.0</b>					<b>2220</b>	<b>4004</b>	<b>5937</b>	<b>8021</b>	<b>10255</b>	<b>12638</b>	<b>15172</b>	<b>17856</b>	<b>-3.0</b>
AVG. GRADE	35	40	45	50	55	60	65	70	75	80	85	90	AVG. GRADE
	SPEED												

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### 17.14.14 PASSENGER TRAIN – M.A.S. TO 60 MPH

AMTRAK CE-205 STANDARD

REDUCTION TO: 60 MPH

AVG. GRADE	SPEED												AVG. GRADE
	35	40	45	50	55	60	65	70	75	80	85	90	
<b>3.0</b>							<b>1030</b>	<b>1378</b>	<b>1748</b>	<b>2138</b>	<b>2551</b>	<b>2984</b>	<b>3.0</b>
2.9							1034	1386	1760	2156	2573	3012	2.9
2.8							1038	1395	1773	2174	2596	3041	2.8
2.7							1042	1403	1786	2192	2620	3071	2.7
2.6							1047	1412	1800	2211	2645	3101	2.6
2.5							1051	1421	1814	2231	2670	3133	2.5
2.4							1055	1430	1829	2251	2696	3165	2.4
2.3							1060	1440	1844	2272	2723	3199	2.3
2.2							1065	1450	1860	2293	2751	3233	2.2
2.1							1070	1460	1876	2315	2780	3269	2.1
<b>2.0</b>							<b>1075</b>	<b>1471</b>	<b>1892</b>	<b>2338</b>	<b>2810</b>	<b>3306</b>	<b>2.0</b>
1.9							1080	1482	1909	2362	2840	3344	1.9
1.8							1086	1494	1927	2387	2872	3383	1.8
1.7							1091	1505	1946	2412	2905	3424	1.7
1.6							1097	1518	1965	2438	2939	3466	1.6
1.5							1103	1530	1984	2466	2974	3510	1.5
1.4							1110	1543	2005	2494	3011	3556	1.4
1.3							1116	1557	2026	2523	3049	3603	1.3
1.2							1123	1571	2048	2554	3088	3652	1.2
1.1							1130	1586	2071	2585	3129	3703	1.1
<b>1.0</b>							<b>1137</b>	<b>1601</b>	<b>2095</b>	<b>2618</b>	<b>3172</b>	<b>3756</b>	<b>1.0</b>
0.9							1145	1617	2120	2653	3216	3811	0.9
0.8							1153	1634	2145	2688	3263	3868	0.8
0.7							1161	1651	2172	2726	3311	3928	0.7
0.6							1170	1669	2200	2764	3361	3990	0.6
0.5							1179	1688	2230	2805	3414	4056	0.5
0.4							1189	1707	2260	2847	3469	4124	0.4
0.3							1198	1728	2293	2892	3526	4195	0.3
0.2							1209	1750	2326	2938	3586	4270	0.2
0.1							1220	1772	2361	2987	3649	4348	0.1
<b>0.0%</b>							<b>1231</b>	<b>1796</b>	<b>2399</b>	<b>3038</b>	<b>3716</b>	<b>4431</b>	<b>0</b>
-0.1							1243	1821	2437	3092	3786	4517	-0.1
-0.2							1256	1847	2478	3149	3859	4608	-0.2
-0.3							1269	1875	2522	3209	3936	4704	-0.3
-0.4							1283	1904	2567	3272	4018	4806	-0.4
-0.5							1298	1935	2615	3338	4104	4913	-0.5
-0.6							1314	1968	2667	3409	4196	5026	-0.6
-0.7							1331	2003	2721	3484	4293	5147	-0.7
-0.8							1348	2040	2778	3563	4395	5274	-0.8
-0.9							1367	2079	2839	3648	4505	5411	-0.9
<b>-1.0</b>							<b>1387</b>	<b>2121</b>	<b>2905</b>	<b>3738</b>	<b>4622</b>	<b>5556</b>	<b>-1.0</b>
-1.1							1409	2166	2975	3835	4747	5711	-1.1
-1.2							1432	2214	3049	3938	4881	5877	-1.2
-1.3							1457	2266	3130	4050	5025	6056	-1.3
-1.4							1484	2321	3216	4169	5180	6248	-1.4
-1.5							1512	2381	3310	4298	5347	6456	-1.5
-1.6							1544	2446	3411	4438	5528	6681	-1.6
-1.7							1578	2517	3521	4591	5725	6925	-1.7
-1.8							1615	2594	3641	4757	5940	7192	-1.8
-1.9							1655	2678	3773	4938	6176	7484	-1.9
<b>-2.0</b>							<b>1700</b>	<b>2771</b>	<b>3917</b>	<b>5138</b>	<b>6435</b>	<b>7806</b>	<b>-2.0</b>
-2.1							1749	2874	4077	5359	6721	8161	-2.1
-2.2							1804	2988	4255	5605	7039	8556	-2.2
-2.3							1865	3115	4453	5880	7394	8997	-2.3
-2.4							1934	3259	4677	6188	7794	9493	-2.4
-2.5							2012	3421	4930	6538	8247	10056	-2.5
-2.6							2102	3607	5219	6938	8765	10699	-2.6
-2.7							2205	3821	5553	7400	9362	11440	-2.7
-2.8							2325	4071	5942	7938	10060	12306	-2.8
-2.9							2467	4367	6402	8575	10883	13328	-2.9
<b>-3.0</b>							<b>2637</b>	<b>4721</b>	<b>6955</b>	<b>9338</b>	<b>11872</b>	<b>14556</b>	<b>-3.0</b>
AVG. GRADE	35	40	45	50	55	60	65	70	75	80	85	90	AVG. GRADE
	SPEED												

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## 18.0 GRADE CROSSING WARNING SYSTEMS

### 18.1 GENERAL DESIGN REQUIREMENTS

#### 18.1.1 SCOPE

The addition of control points, wayside signals, highway grade crossing warning, and hazard detection systems may increase long-term maintenance and inspection expenses. Such improvements will likely enhance train operations and passenger rail service, but may not result in increased ridership or revenues for the agency. The increased operating and maintenance expense will likely be recovered in the form of fare increases which in turn can have an adverse effect and result in even lower revenues. Through simple yet effective design principles, the designer shall not only attempt to control capital cost expenditures per project, but also long-term operating expenses.

The designer shall specify equipment and applications that will not only provide optimum safety, but will also maximize the efficiency and reliability of commuter and freight train operations. The design shall incorporate systems and equipment that have been proven to be reliable, durable, effective and currently in use on rail networks throughout the continental United States. The design shall incorporate features that aid signal personnel in the inspection, testing, repair, and overall maintenance of the system.

The contract drawings provided by the designer shall be detailed and reflect products that are currently in use on NCTD operated territory and that have a proven history of reliable performance on major USA rail networks, such as the Burlington Northern Santa Fe (BNSF). Major railroads perform in depth tests and evaluations of equipment and work closely with manufacturers in the refinement of equipment prior to full deployment. Once performance has been proven, a major railroad will purchase substantial quantities. Manufacturers and suppliers will provide long term technical support for products purchased in mass quantities by major railroads. It is in the best interest of SANDAG and NCTD to ensure that long term technical support can be provided, that parts can be repaired or purchased and are readily available, and in case of emergencies, equipment and replacement parts can be obtained from local railroad operators.

Equipment shall be easy to maintain and troubleshoot. Systems that require the support of highly skilled technicians or an engineer should be avoided. Once installed, the system should be relatively self-supporting and require limited interaction from maintenance forces. The designer shall consider that the rail line and equipment is not exposed to extremely low temperatures, but may be exposed to very high temperatures and salt-air conditions.

New products shall only be introduced after careful evaluation and with the approval of NCTD. Most C&S components are expected to provide service for 30 years or more. New products may not be supported by manufacturers for such an extended period unless the product is accepted and deployed by the major railroads that purchase large quantities of products on a regular basis.

NCTD maintains an inventory of spare and replacement parts for existing Communications

and Signal equipment. Introducing new products requires the procurement of additional spares in sufficient quantities to ensure repairs can be made quickly with little or no operational impacts. The designer shall ensure that specifications require the contractor to provide an adequate quantity of spares. NCTD shall provide guidance in this area.

Training shall be provided to maintenance personnel for any new products introduced to the system. The training shall be provided by a representative of the product manufacturer. The representative shall be knowledgeable of the product specifications, operational characteristics and limitations.

All maintenance personnel shall not attend training at the same session. The contract specifications shall require several training sessions be scheduled to ensure there is an adequate number of maintenance personnel available to support rail operations.

The design approach shall attempt to:

- Minimize the use of auxiliary components and equipment;
- Where possible, incorporate features that will reduce maintenance, testing, and troubleshooting;
- Incorporate equipment and components that are presently in operation on the NCTD rail network, thus eliminating the need for additional spare parts and training of personnel.
- Design simple systems that can be maintained and repaired by personnel with limited technical skills. Avoid installation of systems and components that require periodic adjustment and/or inspection by highly skilled technicians or engineers.

No system or subsystem shall be accepted for service until thoroughly tested. Contract specifications shall ensure that no system or subsystem is accepted until tested under actual operating conditions. Construction management personnel are responsible for enforcement of the technical specifications and shall not diminish or otherwise lessen the submittal or installation requirements as specified in the contract documents.

As much as is practical within the scope of a project, equipment to be installed shall be scalable for future expansion, and the signal houses shall be sized accordingly.

All designs shall adhere to the rules and regulations contained in Title 49 Code of Federal Regulations (CFR) Parts 234, 235, and 236. Signal design criteria shall incorporate the rules and instructions as contained in the most current version of the California Public Utilities Commission (CPUC) General Orders; California Manual of Uniform Traffic Control Devices (CA MUTCD); General Code of Operating Rules (GCOR); North County Transit District (NCTD) General Orders, Timetable, and Special Instructions; and American Railway Engineering and Maintenance-of-Way Association (AREMA) Communications & Signals Manual of Recommended Practices. Where the AREMA manual is used, “may” and “should” are to be interpreted as “shall” unless in conflict with these standards or otherwise directed by NCTD. Note that the NCTD General Orders, Timetable, and Special Instructions supersede the GCOR where they are in conflict.



Any modification to grade crossing warning systems has the potential to necessitate changes to train control signal systems. It should be noted that all changes to track structure, including installation of insulated joints and imposition of audio frequencies on the rails, need to be evaluated to determine the potential effect on train control signal systems. Refer to Chapter 17.0, Train Control Signal Systems, for wayside signal considerations and design criteria.

Designs shall incorporate the standards reflected in the SANDAG/NCTD Engineering Standard Drawings. Any variations to the standards required to conform to site conditions shall be approved by NCTD.

### **18.1.2 STANDARDS, CODES AND GUIDELINES**

The latest editions of the following standards, codes, and guidelines shall be used, as applicable, for the design and implementation of grade crossing warning systems:

- Federal Railroad Administration (FRA) standards, 49 CFR 234, 235, and 236
- American Railway Engineering and Maintenance-of-Way Association (AREMA)
- California Public Utilities Commission (CPUC)
- SANDAG/NCTD Engineering Standard Drawings
- NCTD Timetable, Special Instructions and General Orders
- National Electrical Code (NEC)
- Institute of Electrical and Electronics Engineers (IEEE)
- American National Standards Institute (ANSI)
- Electronic Industries Association (EIA)
- Federal Communications Commission (FCC)

### **18.1.3 TRAIN DETECTION SYSTEM**

Care shall be taken in the selection of train detection systems. Tracks along the coast are subjected to highly corrosive atmospheric conditions. The wheel to rail shunting characteristics of GE Transportation Systems (GETS) Contact Warning Devices (CWD) has proven reliability on the San Diego and Econdido Subdivision. The designer shall obtain NCTD's authorization before deploying another manufacturer's CWD besides GETS.

The preferred train detection configuration incorporates the use of uni-directional, simulated bi-directional or bi-directional redundant constant warning devices (i.e., units fully contained with an internal transfer function) without utilization of wrap circuits. These train detection systems shall be complemented with solid-state crossing controllers to ensure compliance with "lamp voltage" and "standby lamp voltage" regulations. Event recorders shall be utilized to record data useful in the maintenance, troubleshooting, and repair of the entire system. Where it is necessary to deviate from preferred grade crossing control standards, approval must be obtained from LOSSAN authorities.

Where practical, configurations for constant warning device track circuits shall follow application typical provided by the manufacturer. Typically, on multiple track segments where uni-directional applications are required, a two-track unit shall control warning for train movements approaching from one direction and a second two-track unit shall control

warning for train movements approaching from the other direction. The units shall be interconnected to reduce the need for vital relays and other components that require period testing or adjustment.

On single track bi-directional applications, a multiple track cabinet shall be installed. This will facilitate the inclusion of additional tracks in the future or modifications that may require the reconfiguration of the system to support a uni-directional application. Single track cabinets shall not be deployed without NCTD authorization.

The installation of additional insulated joints, electronic coded track repeaters, and uni-directional CWD's increase maintenance and have a detrimental effect to commuter service. The installation of electronic coded track circuit repeaters can add significant time to the process of changing traffic direction thus impacting service times. The designer shall make every effort to limit the installation of these additional appurtenances.

An application program sheet shall be included in the plan set where Constant Warning Device units are installed. Where ElectrologIXS XP4's are used, it shall be the responsibility of the design firm to furnish the application file on a USB Drive for field configuration of the location. After the location has been placed in service, the in-service files will be furnished to the Software Configuration Manager.

#### **18.1.4 WARNING TIME**

All constant warning devices should be configured to provide thirty 30 seconds of warning time for normal through trains operating at the maximum authorized district speed. Although regulations require a minimum of 20 seconds warning time, the 30 second application should allow sufficient warning time for train acceleration in the approach and fluctuations in ballast conditions. The only exception to the requirement for a 20 second minimum warning time occurs when a train stops and subsequently restarts in the approach to a grade crossing.

Additional warning time may be required for "wide track" applications, advanced preemption of traffic signals and increased time that may be desired in delaying the lowering of a gate to accommodate slow moving vehicles clearing the track area.

Additional time required to support "wide track" applications is determined by measuring the distance parallel to the centerline of the highway between the governing warning device and 6 feet beyond the furthest track on which trains operate. When this distance is greater than 35 feet, one second shall be added for each additional 10 feet, or fraction thereof.

The warning time at a grade crossing must be sufficient for both vehicles and pedestrians to clear the grade crossing area. While vehicular minimum warning times are regulated by federal and state law, there are no comparable guidelines for pedestrian warning time requirements as it relates to highway-rail grade crossing warning systems. Refer to Part 18.3 "Pedestrian Crossings" of this chapter for further guidance regarding warning time selection as it pertains to pedestrian clearance time requirements at grade crossings.

The termination shunt shall be placed in accordance with the manufacturers recommendations. Placement of termination shunts shall be the required distance to

provide the minimum required warning time, plus the required reaction time of the device (normally 4 seconds for GETS CWD's). Additional time may be required to preempt an adjacent traffic signal and/or to accommodate clearing vehicles in a "wide track" scenario.

Once the total time requirement is calculated, the designer shall determine the required approach circuit distance. The actual location of the termination shunt shall be measured from the point where the signal island circuit is terminated on each side of the crossing.

A detailed, written description of the traffic signal operation shall be obtained from the traffic engineer having maintenance jurisdiction of the traffic control devices at grade crossings where "traffic preemption" is requested by a local authority. Phasing and clear-out times shall be clearly indicated. A written agreement shall be executed indicating "no changes in the traffic signal operation shall be made without NCTD concurrence".

#### **18.1.5 FREQUENCY SELECTION AND APPLICATION**

All systems shall be applied in accordance with the manufacturer's recommendations. The preferred application is bi-directional or simulated bi-directional, although uni-directional applications shall be utilized to provide adequate frequency separation, where following train movements may occur, and where insulated joints must be maintained in the vicinity of crossings to support wayside signal systems.

Remote applications should be used where insulated joints exist within the approach limits to the crossing. Tuned joint couplers may be used only when applied in accordance with the manufacturer's recommendations. Additional systems may be required to accommodate special applications and unique train operations. When a grade crossing adjoins a Control Point, the designer must carefully analyze moves towards the grade crossing and determine whether special circuits are required to mitigate a potential momentary loss of detection as the train diverges from the track on which detection is active.

The preferred constant warning device frequencies to be utilized are **86, 114, 156, 211, 285, 348, 430, 525, 645, 790, and 970 Hertz** for the primary system. Utilization of the 348 HZ frequency shall be confined to areas where 60 HZ interference is not likely and electrified transit systems do not parallel the tracks. The frequency selected shall be dependent upon the required approach distance and ballast conditions. A 4 Ohm/1000 ft. distributed ballast resistance value shall be utilized in comparing frequency to the required approach distance. Six wire applications shall be avoided where possible.

Island frequencies shall be programmable and selected in accordance with the manufacturer's guidelines. Careful evaluation of existing frequencies and equipment shall be made prior to selecting island frequencies.

Narrow-band frequency selectable shunts shall be used on new construction. The relocation of existing shunts is not practical and new shunts shall be installed to support new construction or approach distance modifications.

A careful and detailed review of train operations shall be completed prior to finalizing the application to be used. Where trains accelerate from a station, or slow to stop at a station, additional considerations may need to be incorporated.

The design drawings shall reflect recommended equipment and program settings. Technical specifications shall ensure the installation contractor is responsible for fine tuning the system for optimal operation. This will require observing numerous train movements in both directions.

#### **18.1.6 CROSSINGS WITH EXIT GATES**

Exit gates require vital vehicle detection loops and special control equipment to ensure vehicles are not trapped behind a gate in the horizontal position. Exit gates increase maintenance and raise the potential for service delays. The failure of a loop or broken gate can result in significant train delay.

Vehicle detection loops shall be embedded in the asphalt or concrete roadway. Only preformed loops are acceptable and installation of saw cut loops is unacceptable unless otherwise approved by NCTD. Loop integrity and reliability is of the utmost importance and only loop detectors in use on the BNSF Railway Company, Union Pacific Railway Company, or Metrolink system in California are acceptable for use.

The exit control system may be a vital microprocessor controller or other rail industry accepted device. The controller shall be housed in the same enclosure as the train detection and grade crossing warning device control system. Additional warning time shall be included in warning time calculations for vehicle clearance in accordance with AREMA recommendations.

Refer to Part 18.2 of this chapter for further guidance regarding exit gate systems.

#### **18.1.7 PEDESTRIAN CROSSINGS**

The design elements of a pedestrian crossing shall incorporate the same considerations as a vehicle crossing. The placement of warning devices must provide unobstructed visibility of the lamps and bells shall be clearly audible in accordance with AREMA recommendations.

Warning device placement shall not encroach into the pedestrians' walkway and must provide adequate clearance from the track in accordance with CPUC General Order 26-D. Train detection and control equipment shall be housed in an enclosure close to the pedestrian crossing. The station design shall provide adequate space for the placement of an instrument enclosure near the crossing, where the crossing is located in a station platform.

Refer to Part 18.3 of this chapter for further guidance regarding pedestrian crossings.

#### **18.1.8 TRAFFIC PREEMPTION**

Where an intersection equipped with traffic signals is located within 200 ft. of the railroad grade crossing, the train detection system shall be interconnected with the traffic signal

controller so that the traffic signal phasing can be preempted and vehicular traffic cleared off the track prior to the train arriving at the crossing. In heavy traffic areas where the intersection is greater than 200 ft. from the crossing and vehicles cue on the track, traffic preemption shall be considered.

As indicated above, additional time for traffic signal preemption shall be included in the warning time calculation. This time shall be obtained from the roadway agency having maintenance responsibility for the traffic signals. The railway systems designer shall not perform the traffic signal preemption time calculation.

CWD approach distance limitations, when applied to tracks where trains operate at 79 MPH or greater, may not be able to support the requested preemption time. Upon obtaining the roadway agency's time request the designer shall calculate the total warning time required and determine if the time request is feasible with respect to railroad equipment limitations. If the roadway agency's preemption time request is not feasible the designer will inform the roadway agency and provide the time setting that is feasible with respect to the technical limitations of the railroad equipment. The roadway agency is responsible for any modifications to the traffic signal system that may be required to support this reduced time calculation.

A warning decal indicating "WARNING! HIGHWAY-RAIL GRADE CROSSING WARNING SYSTEM AND HIGHWAY TRAFFIC SIGNALS ARE INTERCONNECTED", located in both the traffic signal cabinet and railroad instrument shelter, as well as indicated on the signal plans, shall be present at a location where the railroad provides traffic signal preemption.

Refer to Part 18.4 of this chapter for further guidance regarding traffic signal preemption.

### **18.1.9 NEARSIDE SIGNAL CONTROL**

On the Escondido Subdivision, at various Sprinter stations, a nearside control signal has been installed. The purpose of the signal is to enable Sprinter vehicles to approach a station without activating downstream highway grade crossing warning systems.

The dispatch center transmits a "nearside control bit" to the signal in advance of a Sprinter train that will be stopping at the station. The nearside signal remains at STOP (RED). Once the train occupies a track circuit at the platform, a series of time cycles are completed, the downstream crossings are activated, and the nearside signal clears for movement.

If the movement fails to clear the station area within a specified time (typically 90 seconds) the signal will display a STOP indication and the downstream crossing warning systems will shut off.

An "express control bit" will be transmitted to the nearside signal if the movement is not required to stop at the station. In this scenario, the nearside signal will clear and the downstream grade crossing warning systems will activate well before the vehicle reaches the station.

Nearside Signals are utilized on the Escondido Subdivision where Sprinter trains operate. Nearside applications as described above may be utilized on the San Diego Subdivision, but

shall require the authority of NCTD.

#### **18.1.10 POWER SUPPLIES**

Power to each location shall be provided from a commercial power source. Each location shall be evaluated and the appropriate service connection provided. At a minimum, a 3 wire, single phase 120/240 VAC 100-Amp service shall be provided at new locations. Where power is not readily available, an express cable shall be installed to the nearest power source or a new meter service installed. The size of the express cable conductor required shall be determined by utilizing National Electrical Code Standards. Each instrument house shall have an external plug connection for a generator to provide power to the house in the event of an extended outage.

An independent battery set and charging equipment shall be furnished for the constant warning device and auxiliary equipment. A separate battery set and charging equipment shall be utilized for the control of crossing warning devices. Chargers shall be equipped with temperature compensation devices.

Battery capacity shall be sufficient to provide 8 hours standby with the lights flashing and gate arms in the full horizontal position. Battery capacity for the constant warning device shall be sufficient to provide a minimum of 48 hours of normal operation. The manufacturers' recommended surge protection apparatus shall be incorporated into all grade crossing design. Surge protection units shall be installed on the ac supply source, battery supply, and track leads.

Battery chargers at grade crossings shall be equipped with internal dry contacts capable of indicating a fault in the charging system. These contacts shall monitor the chargers for proper operation and interface with a strobe light (Velcorp GEMS P/N LC2-001WB-W, or approved equal) that will generate a power off indication to a passing train or maintenance forces in the event of a failure. Reference NCTD Timetable Special Instructions Rule 6.32.7 and SANDAG/NCTD Engineering Standard Drawing ESD-8215-02. The power off indicator light shall be on the track side of the signal house/cabinet.

DC power input terminals on battery surge suppressors should be connected directly to battery terminals. This will permit the battery to filter out small power surges from the battery charger before they enter the surge suppressor.

Ground rods shall be installed at each corner of houses and on each end of cases. Ground rods shall be 10 feet in length and connections to the rod shall be as direct as possible, with no short radius bends (less than 18") in ground leads. Resistance to ground shall be no more than 15 ohms.

#### **18.1.11 WIRE AND CABLE**

Grade crossing design shall include proper sizing of all electrical wiring to ensure proper operation of the equipment, based upon the equipment loads and the operating parameters determined by the equipment manufacturers. Minimum conductor sizes to be used are as follows:

### Internal House/Case Wire

Battery chargers and feeds	#6 AWG flex
Flasher lighting circuits	#10 AWG flex
Track circuits	#10 AWG flex
Loads in excess of 1 ampere	#10 AWG flex
Loads less than 1 ampere	#16 AWG flex

### Flashing Light Signals/Gates

Light wires	#6 AWG flex
All other circuits	#10 AWG flex

### Underground Signal Cable

Flasher lighting circuits & gate power	#6 AWG solid
CWD track wires	#6 AWG solid/twisted pair
All other circuits	#14 AWG solid

### Flasher Lamps

Grade crossing flasher lamps must be provided 8.5 VDC at a minimum. Cable shall be sized to limit voltage drop to 3 VDC.

### LED's

LED's shall be installed on all new installations or significant upgrades to existing locations.

### Electronic Bell

A uni-directional electronic bell shall be installed in each quadrant containing gates.

### Solid State Crossing Controller (SSCC)

Solid-state crossing controller such as the GETS IXC-20S+, Siemens SSCCIV or later models should be installed when modifying a crossing.

## **18.2 EXIT GATE SYSTEMS**

### **18.2.1 BACKGROUND**

Formerly called Four Quadrant Gate Systems, exit gate systems consist of the Exit gate assembly (CPUC Standard 9E), a vehicular intrusion detection system between the Entrance Gate and the Exit Gate, and the necessary safety critical logic equipment to control the operation of the Exit Gates and the vehicular intrusion detection system.

Exit Gates may be installed in order to:

- Improve safety at crossings
- Increased deterrence of vehicles driving around lowered entrance gates
- Create an effectively "Sealed Corridor" for train travel

The safety and operations through the vehicular crossings are the responsibility of both LOSSAN authorities and the Local Agency having jurisdiction of the roadway. Installation

of Exit Gates must be approved by the CPUC. In general, the installation of Exit Gates will be recommended by a diagnostic team (CA MUTCD 8A.01). The diagnostic team shall perform a site specific review which considers crossing attributes, highway environment and risk mitigation criteria.

### **18.2.2 REGULATORY REQUIREMENTS**

The following are regulatory requirements for Exit Gates:

- A. Exit Gates shall be designed to fail in the raised position. (CPUC General Order 75-D, CA MUTCD 8D.05)
- B. Entrance Gates shall begin their descent before Exit Gates and shall be horizontal before the Exit Gates are Horizontal. (CPUC General order 75-D)
- C. A vehicle intrusion detection system shall be installed whenever exit gates are used. (CPUC General Order 75-D, CA MUTCD 8D.05)
- D. At locations where gate arms are offset a sufficient distance for vehicles to drive between the entrance and exit gate arms, median islands shall be installed in accordance with the requirements established by an engineering study. (CA MUTCD 8D.05)
- E. Exit gate arm activation and downward motion shall be based on detection or timing requirements established by an engineering study of the individual site. (CA MUTCD 8D.05)

### **18.2.3 FUNCTIONAL REQUIREMENTS**

Where Exit Gates are installed, the latest recommendations of the AREMA Communications and Signals Manual of Recommended Practices and the latest recommendations of the Institute of Transportation Engineers should be followed.

Entrance Gates are required to be fully horizontal 5 seconds prior to a train arriving at a crossing. This requirement does not apply to Exit Gates (CFR 49, part 234, section 223). Where Exit Gates are required, highway-rail grade crossing warning systems shall use a microprocessor-based control system for the timing of the Exit Gates that are integrated with the roadway vehicle detection system. The Exit Gate Management System, as manufactured by Siemens or equivalent, shall be used.

The Inductive Loops for vehicle detection shall be able to detect motor vehicles with a wheel base equal to or greater than 96 inches, whether moving or stationary, within the roadway driving surface and within 20° of the roadway axis, between the Entrance Gates and the Exit Gates. The Vehicle Intrusion Detection System shall be a microprocessor based system of a safety critical design with necessary self-checking. Vehicle detection loops shall be pre-formed and water repellent with an integral check loop such as that manufactured by Reno A&E. In general, the loops will be placed between the entrance gate and the nearest rail, between each set of tracks, and between the furthest rail and the exit gate. The vehicle detection loop system shall hold up the exit gate based upon the vehicle's direction of travel. Separate detection loops shall be provided for each direction of roadway travel such that detection of a roadway vehicle that is wholly within a single lane of travel for a given direction will not hold up both exit gates due to a vehicle in the crossing.



The Vehicle Intrusion Detection Devices shall be able to handle the following functions:

- A. Detect all motor vehicles, including all passenger motor vehicles, school buses and trucks, but not including motorcycles, bicycles.
- B. Provide “occupied/not occupied” indications to railroad control circuits within two seconds of any state change.
- C. Verify, not less often than one time each time that the crossing warning devices are activated, that the Vehicle Intrusion Detection Devices are functioning and able to detect motor vehicle presence.
- D. Verify each time that the warning devices are activated and the occupied indication is working.
- E. Not to generate false highway vehicle occupied indications, more often than minimum threshold values to be determined by the Engineering Study.
- F. Operate under battery back-up power or to default immediately to an occupied condition when external power is lost, based on the result of the Engineering Study.
- G. Meet the current applicable national and local standards.
- H. Provide individually isolated outputs for each loop that are energized to indicate “not occupied”, in such a manner that a failed output circuit or wiring fault will result in a de-energized state and “occupied indication”
- I. Provide separate, individually isolated outputs for each loop that are energized to indicate “loop health”, in such a manner that a failed output circuit or wiring fault will result in a de-energized state and a “loop health failure” indication.
- J. Not generate or induce levels of energy into the rails or other railway communication medium of such magnitude that will cause false occupancy or false vacancy of trains under any normal or abnormal mode of operation.
- K. Detection loops shall not be vulnerable to EMI that is generated within the environment of an electrified railway under normal or fault conditions.
- L. When highway vehicular occupancy is not detected, the exit gate must be controlled to begin its descent within one second after the minimum highway vehicle clearance time expires and the detection loops indicate that the crossing is unoccupied. Exit gates shall remain lowered until the train has completed its movement through the grade crossing. Detection of vehicular occupancy will cause a descending exit gate to reverse direction and raise.
- M. The loop detection system shall not interpret a train movement through the crossing as a vehicle occupancy.

Systems having exit gate systems should have remote health monitoring systems capable of automatically notifying maintenance personnel when anomalies have occurred within the system (CA MUTCD 8D.05).

Back lights directed toward the motorist shall not be installed on exit gates due to the possibility of confusing a motorist crossing the tracks (Preemption of Traffic Signals Near Railroad Crossings, A Recommended Practice of the Institute of Transportation Engineers 2006).

Where Pedestrian gates are used, a separate gate mechanism shall be used in the quadrant containing the Exit Gate. Either the Exit Gate or the Pedestrian Gate shall have a bell.

Upon detection of an approaching train, the lights will begin to flash and the bells will begin to ring. A minimum of three seconds after the activation of the lights and bells, the Entrance Gates will begin their descent. If no vehicles are present in the crossing, the Exit Gates will begin their descent after the Entrance Gates. After the train has passed the crossing, the Exit Gates will begin their ascent. The Entrance gates will begin their ascent after the Exit Gates have begun their ascent. The time differential between Exit gate operation and Entrance Operation should be determined by the Engineering Study.

The need for Exit Gate Clearance time shall be evaluated based upon the criteria in the AREMA Communications and Signals Manual of Recommended Practices. When warning time is calculated at crossings with Exit Gates, the warning time is calculated to the Exit Gate rather than to the point clear of the furthest rail.

### **18.3 PEDESTRIAN CROSSINGS**

Normal operation is for the bells to activate, lights to flash, and three seconds later, the gates to descend. The bells will continue to sound until the train has cleared the island circuit and the gates complete their ascent. At that time, the bells will cease to ring. Bells are considered pedestrian warning devices, and a grade crossing shall have enough bells so that a bell can be heard by pedestrians in each approach. All new bells shall be electronic and uni-directional.

#### **18.3.1 PEDESTRIAN WARNING TIME CONSIDERATIONS**

The standard warning time at LOSSAN grade crossings is 30 seconds. There are special circumstances where the warning times are lengthened as described in Part 18.1 of this chapter. The public is accustomed to this standard warning time, as well as to a slightly longer time caused by decelerating trains.

In general, pedestrian walking times are calculated at a walking rate of 3.5 feet per second. The distance is measured from the warning device approaching the crossing to the point of clearance on the far side of the pedestrian crossing.

However, there are existing pedestrian clearance time guidelines under CA MUTCD Part 4 Section 4E.06 for Traffic Control Systems which states that a pedestrian walking speed of 3.5 feet per seconds or less be used to calculate pedestrian clearance time where no engineering studies have been performed. Also, a publication by the United States Access Board, who is responsible for developing and updating the ADA Accessibility Guidelines (ADAAG), states that “all pedestrian signal phase timing shall be calculated using a pedestrian walk speed of 3.5 feet per second or less”.

One cannot rely on a locomotive engineer to see a slow moving person in the crossing and be able to brake in sufficient time, and the mobility impaired individual is relying on the

warning devices to provide sufficient warning time. Since the flashing lights (when used) for pedestrians are aimed across the tracks and the bells are primarily a pedestrian warning device, the ADAAG walking times will be calculated for the mobility impaired person (at 1.5 feet per second) from the clearance point on the start point to the clearance point across the tracks. So a warning time of 30 seconds allows a mobility impaired individual to safely traverse 45 feet. In this manner, the needs of the able bodied and the mobility impaired will be considered without increasing warning times and compromising pedestrian patience.

The Roadway Worker Protection Act defines fouling as “the placement of an individual or an item of equipment in such proximity to a track that the individual or equipment could be struck by a moving train or on-track equipment, or in any case is within four feet of the field side of the near running rail”.

Four feet from the nearest running rail is approximately six and one half feet from track center. CPUC clearance is eight feet six inches from track center. The designer should use the 8’-6” distance from track center on both the entering and leaving side of the tracks to calculate the walking distance for the mobility impaired individual.

### **18.3.2 CENTER FENCE**

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

Where applicable, a fence will span the platform length 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.

### **18.3.3 PEDESTRIAN WARNING DEVICES**

- A. Gate 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 grade crossing.
- B. Swing Gates: At a crossing with pedestrian gates, a person may have begun crossing the tracks when an approaching train activates the crossing. For this person not to be 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 as an exit only. Swing gates shall be per ESD4002.

### **18.3.4 SAFETY BUFFER ZONE**

A pedestrian safety buffer zone is created between the clear point and the gate and swing gate. This will allow a person to recognize the gate and open it with room for a small group to stand in safety, or a wheel chair to maneuver. The perpendicular alignment of

gate to rail allows a maximum safety buffer zone. This is the preferred arrangement, although where available space prohibits it, a parallel or skewed alignment may be used.

A safety buffer zone is provided for the slower moving individual to turn back and take refuge if he has passed the gate and sees and/or hears the activation.

### **18.3.5 WARNING ASSEMBLIES**

Pedestrian warning assemblies which require lights other than one on the gate arm will consist of lights arranged in a conventional horizontal arrangement. The CPUC standard No. 10 pedestrian flasher is obsolete and a single burnt out lamp will make the crossing out of compliance with FRA regulations (CFR49 Part 234). It is imperative that lights aimed across the tracks be aligned so that a motorist will not perceive them as a device directing him to stop. If the pedestrian gate arm length does not exceed 8 feet, a counterweight assembly may not be required. Pedestrian gate assemblies should be located to allow maintenance accessibility to the mechanism.

At stations, lights will be aimed down the platform and across the tracks. The light aimed across the tracks is 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.

### **18.3.6 GATE RECOVERY**

After a train stops at the station, the gates 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.

## **18.4 TRAFFIC SIGNAL PREEMPTION**

### **18.4.1 BACKGROUND**

Traffic signal preemption is a complex dynamic, little studied prior to the incident at Fox River Grove. Knowledge in this area continues to evolve. Prior to design of a traffic signal preemption circuit, the designer should review the latest guidelines regarding traffic signal preemption as prepared by the Institute of Traffic Engineers, AREMA, MUTCD, CA MUTCD, CPUC and other knowledgeable parties. Circuits described below are based upon fail-safe closed loop methodology. A vital serial data circuit in accordance with IEEE Standard 1570-2002 may be used with the approval of NCTD in lieu of the referenced circuits.

Design and testing of traffic signal preemption interconnection circuits must be coordinated with the railroad and the agency having jurisdiction.

### **18.4.2 HISTORY**

Older, widely used traffic signal controller units use interconnection circuits between the

railroad active warning system cabinet and the traffic control signal cabinet for preemption. This interconnection circuit consists of two wires/cables buried in the ground between the above two points. The approach of a train to a highway-rail grade crossing opens the electrical circuit, which in turn activates the traffic signal controller preemptor. This establishes and maintains the preemption condition during the time the highway-rail grade crossing warning system is activated. If there is a break in either or both wires or cables of the interconnection circuit, (as example, an excavation inadvertently breaks the wires or cables) the traffic signal controller unit would respond as if a train is approaching, clearing vehicles off the tracks, even though a train may not be approaching. The traffic signals remain in the preemption mode as long as the circuit remains open. If a train approaches during such a malfunction, the railroad active warning devices will activate, yet the traffic signal preemption cannot be reinitiated to clear vehicles off the tracks.

One potential problem with the two wire interconnection is a short in the circuits. If the wires between the traffic signal control cabinet and the railroad active warning system cabinet became shorted together, the preemption relay in the traffic control signal cabinet could be falsely energized even if the relay contact opened. The active warning devices would operate, but the traffic signal controller unit would not receive the preemption input.

To address these potential problems, a supervised double break, double wire circuit shall be installed between the railroad and the traffic signal control system.

#### **18.4.3 PREEMPTION CIRCUITS**

In order to detect a shorted or open interconnection circuit, additional wires are used to provide a supervised circuit. The energy sources originate at the traffic signal controller, and two wires provide a return path verifying the railroad preemption control relay is energized and there is no call for preemption. Two additional wires remain de-energized. When the state of the preemption control relay changes, the two energized wires become de-energized, and the two previously de-energized wire become energized. One circuit indicating energized and the other indicating de-energized is indicative of a problem with the interconnect circuit, and the traffic signal controller should assume a state known to be safe and to issue a notification that there is a circuit deficiency.

#### **18.4.4 CROSSING ACTIVATED CIRCUITS**

In some cases, particularly when a train may be accelerating in the approach to a grade crossing, or when a train is restarting from a station or a STOP signal, the constant warning device will not provide the fully designed advanced preemption timing. As information to the traffic signal system, an crossing activation circuit is provided notifying traffic signal that the warning devices have become active.

#### **18.4.5 GATE DOWN/ISLAND OCCUPIED CIRCUITS**

A preempt trap is that condition where the clear track green interval ends before the flashing light signals start to flash and gates start to descend, and it can occur with advance preemption. One of the solutions to avoid preempt trap is to use a “gate down/island occupied” circuit. The purpose of the “gate down/island occupied” circuit is to prevent the traffic signal from leaving clear track green interval until it is determined that the gates

controlling access over the tracks are fully lowered or the crossing island circuit has been occupied by a train. The traffic signal controller unit shall change phasing to the clear track green interval as usual, but should dwell in the clear track green interval until the “gate-down/island occupied” confirmation is received.

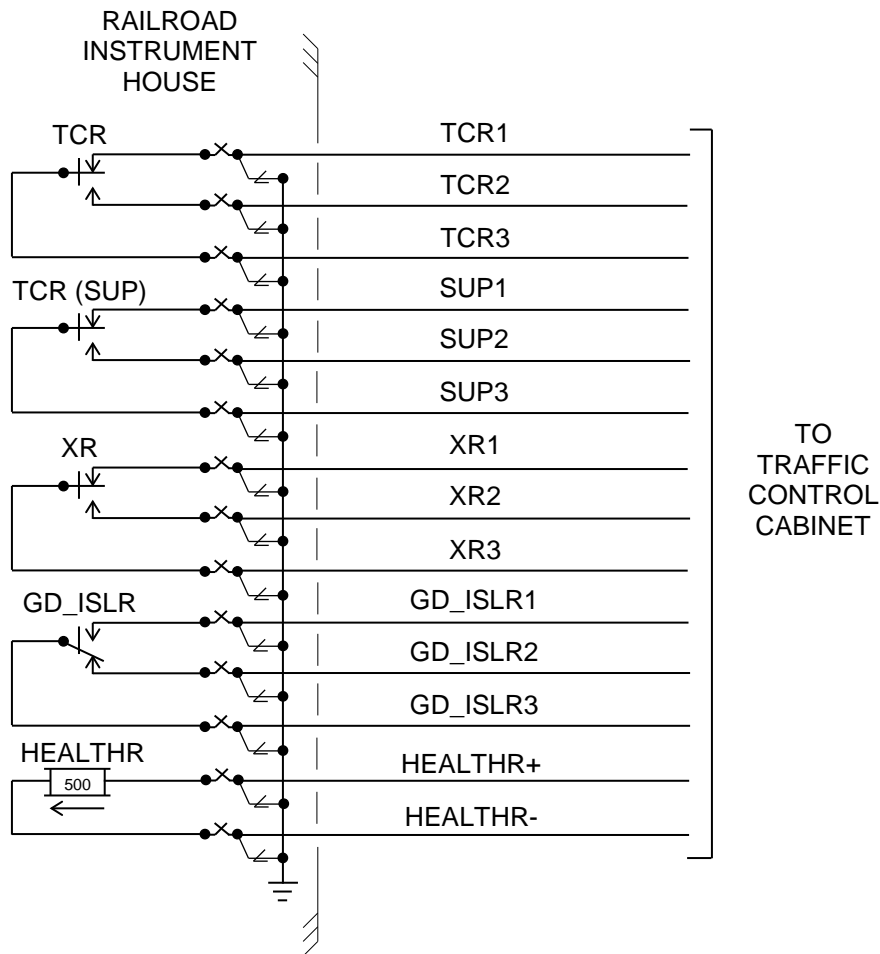
#### 18.4.6 TRAFFIC SIGNAL HEALTH CHECK CIRCUITS

A health check circuit provides an indication to the railroad active warning system cabinet when the traffic signals are in flashing mode or dark, such as when the controller is in failure. This health check circuit requires additional wires/cables between the traffic control signal cabinet and the railroad active warning system cabinet. Consideration should be given to a fail-safe design for the health check circuit so that there shall be no case in which the circuit shall remain energized while the traffic signals are flashing or dark.

The following table identifies the number of wires and functions for the supervised interconnection circuit for simultaneous and advanced preemption, in addition to the crossing active and gate down/island occupied circuits:

TABLE 18-1		
Wires	Simultaneous Preemption	Advanced Preemption
1	Preempt Relay Front Contact (Normally Energized)	Preempt Relay Front Contact (Normally Energized)
2	Preempt Relay Back Contact (Normally De-energized)	Preempt Relay Back Contact (Normally De-energized)
3	Preempt Relay Heel (Source Energy)	Preempt Relay Heel (Source Energy)
4	Preempt Relay Front Contact (Supervisor) (Normally Energized)	Preempt Relay Front Contact (Supervisor) (Normally Energized)
5	Preempt Relay Back Contact (Supervisor) (Normally De-energized)	Preempt Relay Back Contact (Supervisor) (Normally De-energized)
6	Preempt Relay Heel (Source Energy)	Preempt Relay Heel (Source Energy)
7		Crossing Activation Relay Front Contact (Normally Energized)
8		Crossing Activation Relay Back Contact (Normally De-energized)
9		Crossing Activation Relay Heel (Source Energy)
10		Gate Down/Island Relay Front Contact (Normally De-energized)
11		Gate Down/Island Relay Back Contact (Normally Energized)
12		Gate Down/Island Relay Heel (Source Energy)

**FIGURE 18-1**



**INTERCONNECTION CIRCUITS WITH PREEMPTION, SUPERVISION, GATE ACTIVATION, GATE DOWN/ISLAND OCCUPIED AND HEALTH CIRCUITRY**

**18.4.7 INTERCONNECTION CIRCUITS**

In Figure 18-1, above, source energy is supplied to the railroad from the traffic control cabinet. The TCR is the relay which provides the call to preempt. This relay is normally energized and returns energy through its front contacts to the traffic signal cabinet. The TCR relay also provides a secondary preempt call, which is the supervisory circuit. When a train is detected and the call for preemption is generated, the TCR is de-energized and the energy is returned to the traffic signal cabinet through its back contacts. The traffic control equipment shall use these indications from the railroad to verify the integrity of the

preempt interconnect circuit. The circuit labeled XR2 is energized when the crossing becomes active. This input is provided to the traffic control cabinet as information that the grade crossing warning system has become active. The wire labeled GD\_ISLR1 is energized when the gates approaching the signalized intersection are down after a call to preempt. Upon receipt of this input, the traffic signal controller can terminate Track Clearance Green (TCG) and transition to the phases allowed during preemption. The gate down contact shall be bypassed by contacts of the island circuit(s) so that TCG can terminate when the island is occupied by a train, in the event of a gate which does not fully lower.

The health of the traffic signal controller is communicated to the railroad via the Health Relay (HEALTHR). If the traffic signal controller is not functioning or is in all-flash, the health relay will be de-energized and the railroad grade crossing warning system may cause the gates to be down longer for an approaching train since the traffic signals will not be able to clear out traffic as designed.

#### **18.4.8 SECOND TRAIN LOGIC**

Where there is more than one track, a second train can approach at any time. If there is an advanced preemption interconnection between the traffic signals and the railroad, the appearance of a second train can hold the traffic signals in preemption and have the gates rise momentarily allowing vehicles to pull up on to the tracks. Where second train logic is employed, if a second train is detected on the outer approach, the gates will remain down until after the second train passes. Second train logic may be employed where no traffic signals are present if circumstances warrant.

Where second train logic is employed, Exit Gates or non-surmountable medians shall be considered. Due to the increased amount of gate down time where second train logic is employed, there is the possibility motorists may interpret the gate remaining down after a train has passed as a malfunction of the warning system. Exit gates discourage running around the entrance gates. This is especially critical where there is limited visibility on the approaches, or traffic density is such that the gates may be held down for 3 consecutive trains.



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## 19.0 GRADE CROSSING TRAFFIC CONTROL SYSTEMS

### 19.1 SCOPE

A highway agency or municipality has ownership and jurisdiction over the highway and highway approaches on which the highway-rail grade crossing is located. While agreements between the railroad and the agency define the physical limits of the highway-rail grade crossing, the approach highways and sidewalks outside of those defined limits falls under the jurisdiction of the local highway agency. (The lead Engineer is referred to CPUC General Order 72 for a description of these limits).

In carrying out this responsibility, the local highway agency will define the engineering standards and design practices to be used in the development of designs for the highway-rail grade crossing's approaches. These standards must be minimally compliant with the CAMUTCD and should be consistent with the recommended design practices and standards in this Design Criteria Manual.

Highway-rail grade crossing and the associated highway and sidewalk approaches typically involve the intersection of three transportation modes (rail, motor vehicles, and non-motor vehicle pedestrian and bicycles) and include overlapping ownership, design, construction, maintenance, operation and funding responsibilities. NCTD, the local highway owner, CPUC, and other stakeholders should develop highly-collaborative approaches when planning and designing highway-rail grade crossing modifications or new crossings.

The local highway agency responsible for the highway approach is strongly encouraged to follow the recommended design practices and standards included within this Manual when planning and designing physical or use changes to the highway-rail grade crossing and highway approaches.

### 19.2 STANDARDS, CODES AND GUIDELINES

The latest editions of the following standards, codes, and guidelines shall be used, as applicable, for the design and implementation of grade crossing warning systems:

- 2014 California Manual on Traffic Control Devices
- Institute of Transportation Engineers (ITE) Preemption of Traffic Signals Near Railroad Crossings
- American Railway Engineering and Maintenance-of-Way Association (AREMA)
- California Public Utilities Commission (CPUC)
- Local Highway Agency Standard Drawings and Specifications
- SANDAG/NCTD Engineering Standard Drawings
- NCTD Timetable, Special Instructions and General Orders

### 19.3 DIAGNOSTIC TEAM

NCTD, the Local Highway Agency, CPUC, and other concerned parties as the stakeholders of a vehicular grade crossing system shall form a Diagnostic Team to jointly coordinate and share the responsibilities of the management of design, construction, and maintenance of the improvements for the operation of the grade crossing system. It is a multi-disciplinary team that requires a systematic approach.

The Local Highway Agency is responsible for providing a detailed written description of the roadway traffic signal operation, including the phasing and clear-out times clearly indicated. This information is typically contained on design plans. The Local Highway Agency is also responsible for the continuity of interconnection wire/cable (underground), traffic signal phasing and timing, and traffic signal enclosure and field equipment. NCTD is responsible for the railroad equipment and its associated operation, and to provide the preemption interconnect circuit contacts. Where “traffic preemption” is required, any changes in the traffic signal operation or changes to the operation of the railroad warning devices will be communicated and jointly evaluated prior to implementation.

### 19.4 DESIGN PHASE

Communicate and coordinate design requirements and data to establish the interconnection design between NCTD and the local highway agency as follows:

- Identify and agree on site specific issues and requirements
- Identify and agree on the regulatory, local highway agency, and NCTD objectives and requirements
- Maintain compliance with regulatory standards
- Identify and agree on roles and responsibility between the two agencies
- Considerations for enhancements to the operation of the crossing

The design approach shall attempt to:

- Designs shall incorporate the standards reflected in the SANDAG/NCTD Engineering Standard Drawings. Any variations to the standards required to conform to site conditions shall be approved by NCTD.

### 19.5 MAINTENANCE AND OPERATIONAL RESPONSIBILITIES

NCTD and the local highway agency shall jointly perform the following:

- Testing and commissioning of preemption equipment and systems during the installation of the system.
- Diagnostics and/ or trouble shooting and operational tests and inspection of equipment and systems to expedite rectification of the system.
- Maintenance and operational tests and inspection of equipment and systems as part of routine maintenance activities.

## **19.6 GRADE CROSSING GENERAL DESIGN REQUIREMENTS**

Each grade crossing is site specific having its own uniqueness and complexites. Each of the three (3) different types of user groups (trains, vehicles, pedestrians) has distinct characteristics in crossing behavior and limitations, and 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 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 traffic control and warning devices which are appropriate to the different target users.

### **19.6.1 GEOMETRY**

#### **19.6.1.1 VISIBILITY**

Approaching crossings (within 150 feet), fences higher than four (4) feet, vegetation higher than three (3) 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 traffic control and warning devices are discouraged. Pedestrian and vehicular visibility of traffic control and warning devices should be considered along the highway approach to the grade crossing.

#### **19.6.1.2 ILLUMINATION**

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

#### **19.6.1.3 CROSSING SURFACE ACCESSIBILITY**

The crossing surface requirements through grade crossings are dictated by the following requirements: drainage, access for maintenance, and users safety, accessibility, and comfort. Removable prefabricated concrete panels achieve these objectives.

Curb ramps shall be installed or tapered to daylight not closer than six (6) feet from the nearest rail, with a six (6) inch solid thermoplastic white line to connect the curb lines across. This line marks the edge of the roadway, hence to keep the motorists from entering into the tracks.

The crossing panels shall be extended by a minimum of eight (8) feet from the street side of the curb line. This eight (8) feet sidewalk extension provides a buffer zone between the vehicular lane from the sidewalks, and to accommodate uninterrupted passing. The buffer zone increases the comfort level and preceived safety of pedestrians.

The crossing cross slopes follow the track grade, and since the track grade is typically one percent or less, the cross slopes will always be within ADA requirements. The pedestrian sidewalk or pathway should be clearly delineated through the track area.

Large gaps in concrete panels, such as panel pickup points, should be filled where pedestrians or bicycles are reasonably expected, such as long sidewalks and bike lanes. To eliminate tripping hazards, the lifting lugs of the crossing panels shall be filled flush with the manufacturer's recommended filler. The hot-mixed asphalt concrete (HMAC) section between the crossing panels and between the panels and the sidewalk shall always be maintained smooth to eliminate or minimize cracks, uneven surface, broken pavement, potholes, etc. so as not to increase travel time. This is critical especially for mobility impaired people, for the elderly, and people with strollers.

The edge of concrete panels should be at least three feet outside the traveled way, including pedestrian and bicycle routes. The rail flangeway between the rail and the crossing panels shall be treated with rubber filler to reduce the possibility of entrapment of wheelchairs, bicycles, foot, and strollers.

## **19.7 TRAFFIC CONTROL DEVICES**

Traffic control devices are devices that are intended to provide the required system integration so that the grade crossing will function in a safe manner for the users. In other words, the devices regulate, guide, control and/ or warn traffic. Traffic control devices consist of active traffic control devices and passive traffic control devices.

### **19.7.1 PASSIVE TRAFFIC CONTROL DEVICES**

#### **19.7.1.1 STRIPING AND PAVEMENT MARKINGS**

Edgelines should be used along the roadway, particularly on crossings with multiple tracks and/ or adjacent intersections.

#### **19.7.1.2 RAISED MEDIAN ISLANDS**

Medians should be considered at crossings with automatic gate arms.

#### **19.7.1.3 PEDESTRIAN DETECTABLE WARNING**

Pavement texturing shall be a 36 inch warning tactile panel with the Federal Standard truncated cones installed across the entire width of the sidewalk. The purpose of the tactile warning is to provide an indication to the visually impaired persons of the limit to the tracks, as well as an indication to the pedestrians of a safe stopping location and safe refuge area that is outside the rail dynamic envelope.

### **19.7.2 ACTIVE TRAFFIC CONTROL DEVICES**

Approaching trains activate active railroad traffic control devices as well as the adjacent active roadway traffic control devices. The key component of active railroad traffic control devices are traffic signals which control users' access to the highway accessing the grade crossing.

### **19.7.2.1 TRAFFIC SIGNAL PREEMPTION**

See Chapter 18, section 18.4 for background and a detailed discussion of traffic signal preemption circuits and their function as part of the grade crossing warning system. This section considers traffic signal preemption as part of the grade crossing highway traffic control system including:

- Queue prevention and queue clearing treatments
- Preemption warning time calculations and feasibility
- Traffic signal preemption phasing sequence intervals and timing
- Traffic signal preemption circuitry

The following design criteria adhere to the guidance provided in the latest edition of the CAMUTCD (2014). Additional design elements particular to NCTD grade crossings and regional standards of practice are considered. It is important to note that minimum standards will never be able to address the needs of an entire system due to local complexities encountered at individual grade crossings. One size does not fit all. It is critical that all preempted crossings be reviewed by a diagnostic team consisting of the local highway agency, NCTD, CPUC, design consultants, and other stakeholders to determine the preemption design requirements best suited for the localized conditions.

### **19.7.2.2 PREEMPTION GUIDELINES AND STANDARDS**

The purpose of preemption is to the transfer the normal operation of a traffic signal to avoid entrapment of highway vehicles on the grade crossing in advance of an approaching train. CAMUTCD (2014) Section 8C.09 – Traffic Control Signals at or near Highway-Rail Grade Crossings; Guidance paragraph 04 and 05 state:

*04 If a highway-rail grade crossing is equipped with a flashing-light signal system and is located within 200 feet of an intersection or midblock location controlled by a traffic control signal, the traffic control signal should be provided with preemption in accordance with Section 4D.27.*

*05 Coordination with the flashing-light signal system, queue detection, or other alternatives should be considered for traffic control signals located farther than 200 feet from the highway-rail grade crossing. Factors to be considered should include traffic volumes, highway vehicle mix, highway vehicle and train approach speeds, frequency of trains, and queue lengths.*

### **19.7.2.3 PREEMPTION REQUIREMENTS**

- Traffic signal preemption shall be installed at highway-rail grade crossings located within 200 feet of a signalized intersection or midblock crossing.
- If traffic queues are observed to extend to a crossing that is more than 200 feet from a signalized intersection; consider installing preemption, a queue cutter signal, or an alternative provision shall be made to clear highway traffic from the grade crossing prior to train arrival.

- Coordinated traffic signal systems and/ or closely spaced traffic signals where one signal requires preemption consider installing preemption or an alternative provision to alleviate the disruption of highway traffic due to grade crossing operations.
- If the crossing is near a stop controlled intersection where traffic queues across the grade crossing, then signal warrants shall be reviewed to determine if a traffic signal is warranted for the nearby intersection.
  - If traffic signal warrants are not met, traffic signals may still be appropriate as part of a project to improve safety at the railroad crossing.
  - If traffic signal warrants are met preemption shall be a part of the new signal installation.
  - Consider removing stop control on the approach crossing the tracks.

### **19.7.3 PRE-SIGNAL GUIDELINES AND STANDARDS**

A presignal provides indications for motorists to stop prior to the tracks. CAMUTCD (2014) Section 8C.09, Guidance paragraph 11 and Standard paragraph 12 states:

*11 If a highway-rail grade crossing is located within 50 feet (or within 75 feet for a highway that is regularly used by multi-unit highway vehicles) of an intersection controlled by a traffic control signal, the use of pre-signals to control traffic approaching the grade crossing should be considered.*

*12 If used, the pre-signals shall display a steady red signal indication during the track clearance portion of a signal preemption sequence to prohibit additional highway vehicles from crossing the railroad track.*

### **19.7.4 PRESIGNAL REQUIREMENTS**

Consider pre-signal installation when the crossing is within 50 feet (or 75 feet –see above) of an intersection controlled by a traffic signal.

Consider a pre-signal based on a diagnostic review which determines that queuing on the tracks is a primary safety concern at the crossing.

A pre-signal is appropriate where vehicles frequently stop on the tracks due to close proximity to a signalized intersection. The presignal must be an integral part of the intersection traffic signal. The presignal controls vehicles from encroaching into the track area during normal and preempted signal operations. The post signal would provide clearance so that the track area is kept clear. Pre-signals are utilized at grade crossings on the Escondido Subdivision where the Sprinter service operates and on the San Diego Subdivision where the Coaster operates (in the Downtown area).

### **19.7.5 QUEUE CUTTER SIGNAL REQUIREMENTS**

A queue cutter signal provides indications for motorists to stop prior to the tracks.

- Consider a queue cutter signal based on a diagnostic review which determines that queuing on the tracks is a primary safety concern at the crossing.



A queue cutter signal is typically used at locations where the highway-rail grade crossing is located more than 400 feet from the traffic signal and queuing is a concern. Interconnecting a grade crossing with a signalized intersection that is more than 400 feet away would result in long preemption times and excessive delay to highway traffic. A queue cutter signal typically operates independent of the downstream traffic signal. The queue cutter signal is tied to the grade crossing warning system and actuated when a queue is detected near to the tracks (approximately 100 feet) or on the train approach. Upon actuation the queue cutter signal will turn red requiring motorists to stop in advance of the grade crossing. The queue cutter signal will provide a green indication when the vehicle queue is no longer detected and the crossing warning system is inactive. Queue cutter signals are utilized at grade crossings on the San Diego Subdivision at the Laurel Street and Grape Street crossings where the Coaster operates.

### **19.7.6 CROSSING AREA VEHICLE DETECTION SYSTEM**

The crossing area vehicle detection system detects motor vehicles in the Minimum Track Clearance Distance (track area).

The Minimum Track Clearance Distance for a standard two-quadrant warning device crossing, is the length along a highway at one or more railroad tracks, measured from the highway stop line, warning device, or 12 feet perpendicular to the track center line, to 6 feet beyond the track(s) measured perpendicular to the far rail, along the center line or edge line of the highway, as appropriate, to obtain the longer distance. For Four-Quadrant Gate systems, the minimum track clearance distance is the length along a highway at one or more railroad tracks, measured either from the highway stop line or entrance warning device, to the point where the rear of the vehicle would be clear of the exit gate arm. In cases where the exit gate arm is parallel to the track(s) and is not perpendicular to the highway, the distance is measured either along the center line or edge line of the highway, as appropriate, to obtain the longer distance.

- Consider crossing area vehicle detection for any preempted traffic signal based on a diagnostic review which determines that queuing on the tracks is a primary safety concern at the crossing.

Crossing area vehicle detection is typically installed on projects with full depth pavement reconstruction at the grade crossing. Crossing area vehicle detection is also installed where exit gates are installed. Vehicle detection in the track area provides an indication to the traffic signal controller that the detection system is occupied (vehicle present) or not occupied (vehicle not present). This detection allows the controller to hold or release the traffic signal phase controlling the track approach based on detection occupancy. The detection system shall meet the in pavement inductive loop functional requirements described in Part 18.2.3 (Exit Gate System). Coordination between the rail signal design and traffic signal design will be required where an exit gate system is installed. Track area vehicle detection is utilized at grade crossings on the San Diego Subdivision where the Coaster operates including Chesterfield Drive and the Downtown crossings.

### **19.7.7 TRAFFIC SIGNAL PREEMPTION OPERATION AND TIMING**

For highway-rail grade crossings with preempted traffic signals the CAMUTCD (2014) Section 8C.09, Guidance paragraph 06 and Standard paragraph 08 states:

*06 The highway agency or authority with jurisdiction and the regulatory agency with statutory authority, if applicable, should jointly determine the preemption operation and the timing of traffic control signals interconnected with highway-rail grade crossings adjacent to signalized highway intersections.*

*08 Information regarding the type of preemption and any related timing parameters shall be provided to the railroad company so that they can design the appropriate train detection circuitry.*

### **19.7.8 TRAFFIC SIGNAL PREEMPTION OPERATION AND TIMING REQUIREMENTS**

Determination of the appropriate warning time to make road users aware of an approaching train and clear the track area is a critical element of grade crossing safety. The nearby intersection traffic signal needs to be controlled so that traffic can clear the grade crossing and traffic movements towards the track area are restricted during the preemption event. Several timing characteristics need to be reviewed to determine the appropriate timing.

- The local highway agency shall determine the preemption operation and the timing of traffic control signals interconnected with the highway-rail grade crossings and shall provide the information to the railroad agency so that they can design the appropriate track circuitry.

The LADOT Railroad Preemption Form is utilized by local highway traffic agencies to determine time requirements for traffic signal preemption at NCTD grade crossings. The form is an excel worksheet version of the TxDOT Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings. The form provides a convenient Excel worksheet and standard approach for calculating the time required to clear a design vehicle in the track area (Minimum Track Clear Distance), clear of the tracks during preemption. The calculations on this form are based on crossing geometrics, design vehicle parameters, signal timing, and railroad operations.

The feasibility of the amount of preemption warning time that can be provided by the railroad is contingent on the limits of the existing or new track circuitry designed by the railroad. The LADOT Railroad Preemption Form calculates the maximum possible preemption time demand based on the values input and this is often significantly different than the minimum preemption time standards set forth in the CAMUTCD. This difference is typically related to pedestrian clearance time requirements and the flashing don't walk interval.

- Where feasible provide the full pedestrian flashing don't walk time as part of an advance preemption time interval.
- Where a pedestrian crosswalk is present between the tracks and the adjacent intersection, consider elimination of that crosswalk or providing additional preemption time to clear the intersection of pedestrians prior to display of the track clearance green phase.

It is necessary for the results of the LADOT form to be interpreted practically rather than literally and in particular consideration of the feasibility with respect to railroad equipment limitations. Refer to Part 18.1.8 for further guidance regarding traffic signal preemption and grade crossing warning systems.

The most critical time generated by the LADOT form is the Track Clearance Green interval. The CAMUTCD defines the queue clearance time as:

*Queue Clearance Time—when used in Part 8, the time required for the design vehicle of maximum length stopped just inside the minimum track clearance distance to start up and move through and clear the entire minimum track clearance distance. If pre-signals are present, this time shall be long enough to allow the vehicle to move through the intersection, or to clear the tracks if there is sufficient clear storage distance. If a Four-Quadrant Gate system is present, this time shall be long enough to permit the exit gate arm to lower after the design vehicle is clear of the minimum track clearance distance.*

**The Track Clearance Green time is the minimum amount of time necessary to display a track clearance green to highway vehicles to clear the minimum track clearance distance of a queue of vehicles and the design vehicle.**

- Any deviations from the form calculated Track Clearance Green time should be documented.
- The track clearance green time should be displayed at least three seconds prior to the activation of the grade crossing warning system.
- The track clearance green time should be displayed until the track clearance green timer is timed out.
- The track clearance green should be displayed until the gates block access to the crossing.
- The track clearance green time should be extended until the gate down circuit confirmation is received and the track area vehicle detection system is not occupied (where this information is available).
- Termination of the of the track clearance green display upon confirmation of the gate down circuit and confirmation the track area detection system is not occupied requires special consideration.

## 19.8 TRAFFIC SIGNAL BACKUP POWER SYSTEM

The traffic signal backup power system provides an uninterruptible power supply in the event of a power outage. CAMUTCD (2014) Section 4D.27 – Preemption and Priority Control of Traffic Control Signals, Guidance paragraph 11:

*11 Except for traffic control signals interconnected with light rail transit systems, traffic control signals with railroad preemption or coordinated with flashing-light signal systems should be provided with a back-up power supply.*

- All new and modified traffic signals connected to highway-rail grade crossings shall be outfitted with a battery backup power supply.

The traffic signal battery backup power supply shall operate the traffic signal normally until the battery charge drops to a level that flashing operation is necessary to maintain flashing traffic signal control during an extended power outage. The traffic signal shall cycle through the track clear phase prior to operating flashing mode.

## 19.9 TRAFFIC SIGNAL PREEMPTION CIRCUITS

Refer to Part 18.4.3 (Grade Crossing Warning Systems Preemption Circuits) for a detailed description of the standard preemption interconnect circuits utilized between NCTD and the local highway agency. This section details the preemption interconnect circuitry and functions relative to the traffic signal operation.

NCTD will provide a series of preemption circuit closures at specific times to preempt the traffic signal. The following is a list of the standard preemption interconnect circuits and the standard controller action based on the active circuit.

- Advance Preemption (TCR)
- Supervisor (SUP)
- Crossing Activation (XR)
- Gate Down/ Island (GD/ ISL)
- Health (HLT)

## 19.10 ADVANCE PREEMPTION (TCR)

The Advance Preemption circuit is the normal railroad input for the traffic controller. The input is active before the warning devices activate to give time to clear highway vehicle and or pedestrian traffic movements. There are several timing options contingent on the desired operation and preemption time available:

- Terminate all Pedestrian Walk intervals
- Time the complete Flashing Don't Walk interval.
- Time a shortened Flashing Don't Walk interval.
- Terminate all non-track clearance phases immediately.
- Time a minimum green before terminating non-track clearance phases.
- Time the track clearance phase minimum time.
- Time the track clearance maximum time or until the gate down input is active.
- Transition to Railroad Flashing operation or Limited Service operation. Unless there are special circumstances limited service operation is preferred over flashing operation. Limited service operation should prohibit movements toward the tracks during the approach and passage of a train.

## 19.11 SUPERVISION (SUP)

The supervisory circuit is used to check the integrity of the preemption circuit. The Supervision input is the reverse relay contact of the advance preemption input. Preemption is

considered active if either one of the two inputs change state or are the same state. If the Advance Preemption and Supervisor circuits are in a fault state (same state) the controller shall enter into flash operation until the fault is resolved.

### **19.12 CROSSING ACTIVE (XR)**

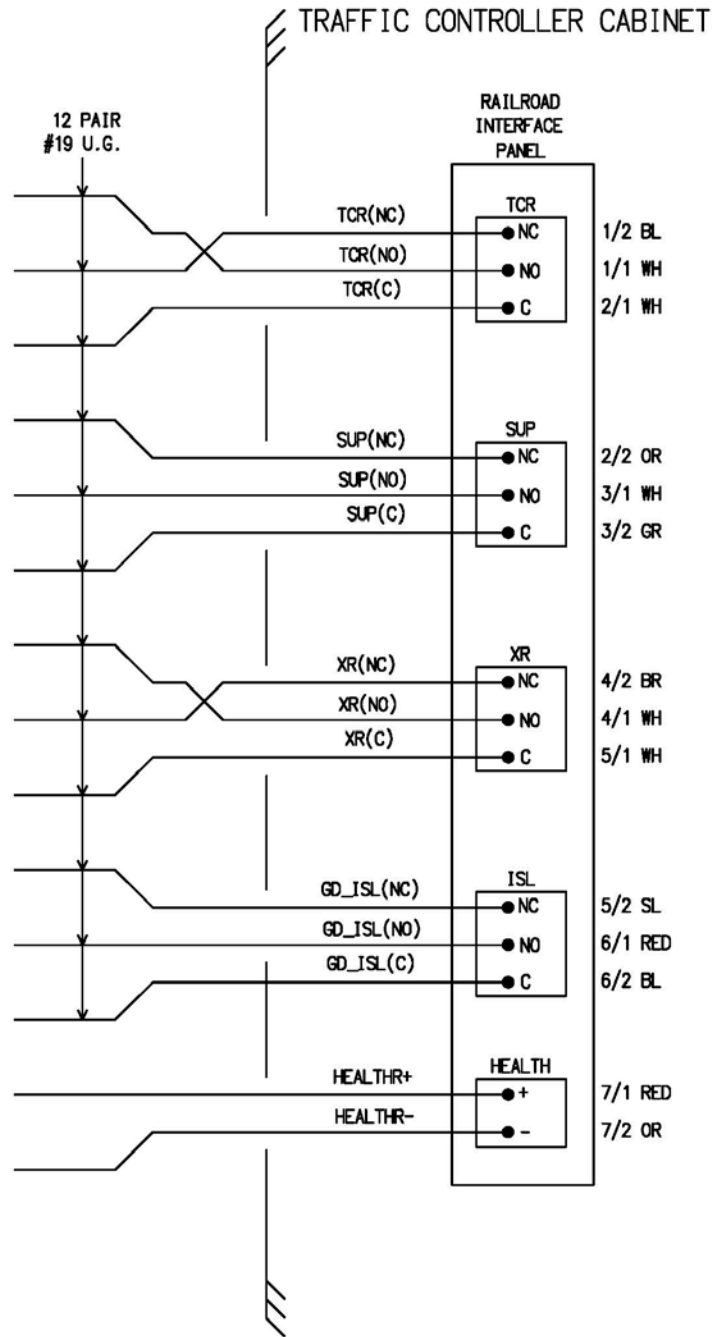
The Crossing Active input is activated when the grade crossing warning system is activated. This input will immediately terminate all non-track clearance phases.

### **19.13 GATE DOWN / ISLAND (GD/ ISL)**

The gate down input is generated when the gates are lowered to about 5 degrees of horizontal or the train occupies the island circuit. The traffic controller shall extend the track clearance green interval until the gate down input is received or the island input is received. These circuits are typically wrapped together on the rail side of the preemption interconnect circuit providing a single input to the controller.

### **19.14 HEALTH CIRCUIT (HLT)**

The traffic signal cabinet's signal bus powers a health relay circuit to the railroad instrument house. If the cabinet goes into hardware flash or there is a power outage, the relay power is removed breaking the health circuit and providing an indication to the railroad.



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# **Appendices**

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## **20. SERVICE AND LAYOVER FACILITIES**

### **20.1 SCOPE**

There are currently no service and layover facilities planned for the LOSSAN Corridor in San Diego County. This section serves as a place holder for use in developing project-specific design criteria that will be required for future service and layover facilities.

### **20.2 GENERAL**

Layover facilities are designed to store trains overnight and to perform varying levels of servicing, primarily cleaning car interiors and emptying toilet tanks. To the extent possible, size and layout of the facilities should reflect the current and future train counts and consists sizes for that location.

Designers of service and layover facilities must consult with the Directors of Engineering at the start of any design to assure that the project's functional goals are met.

### **20.3 TRACK LENGTHS AND SPACING**

Track lengths should reflect the required and planned train count and consists, as well as any additional requirements, such as roadway crossings, turnouts, and blue flag protection.

Spacing between service tracks shall consider the planned maintenance activity and the available space. Service equipment, light poles, water connections, CPUC requirements, etc., will all impact the required track spacing.

### **20.4 SERVICE ROADWAYS**

Service roadways shall allow vehicle access to the various service areas to service trains and on-site equipment. Such roadways should also serve as fire access roads. A service road shall be provided between alternate tracks, minimum width 10 feet. All service roads shall be paved with AC or PCC.

### **20.5 INSPECTION PIT**

Depending on the size of the facility and the anticipated service plan, a below ground inspection pit with lighting and drainage may be required.

### **20.6 JACKING PADS**

Portions of the service tracks may require jacking pads alongside the tracks. These shall be located such that vehicles can still pass by when equipment is being used on the jacking pads.

### **20.7 LIGHTING**

Site lighting shall reflect the planned use, including the presence of the large railroad coaches.

A minimum lighting level of 10 to 15 footcandles shall be provided.

## 20.8 SECURITY

Fencing and shall be provided around the entire site per Engineering Standard ESD 5106. Controlled access gates may be used if appropriate for the site. Provision for remote CCTV cameras and other security measures shall also be considered.

## 20.9 ELECTRICAL

Electrical service shall include Head End Power (HEP) connections adequate to perform the planned servicing activity. The site power requirements shall also reflect any planned expansion of the facility. All electrical facilities shall comply with all local electrical codes, and the requirements of SDG&E. Refer ES 2901 (2005)

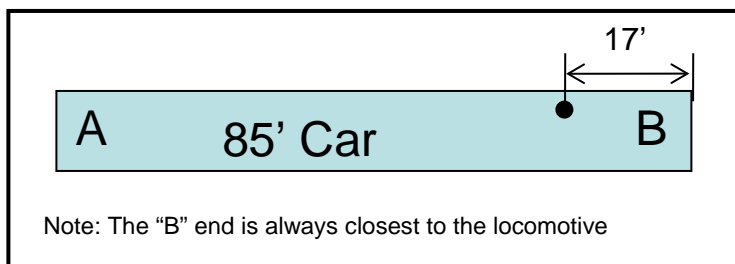
## 20.10 EMPLOYEE FACILITIES

Planning for the site offices, welfare spaces, and parking should reflect current needs as well as any future expansion plans. Plan for space for:

- Service Personnel
- Train Crews
- Supervisors
- Maintenance Personnel

## 20.11 TOILET DUMP SYSTEMS

New LOSSAN Corridor layover and service facilities shall have a manifold toilet dump system. To permit servicing the trains stored in the layover facility without moving the trains, spacing and location of the dump stations shall be consistent with the consist location and size. The following graphic shows the location of the connection on the car. Layouts may need to accommodate trains that are both pushing and pulling. Multiple track arrangements offer opportunities to minimize the number of connections.



## 20.12 COMPRESSED AIR SYSTEMS

LOSSAN Corridor layover and service facilities shall have a compressed air system with a centralized compressor (with a dryer) and compressed air connections available at the B end of each car.

### **20.13 TRACK**

Track for service and layover facilities will be constructed of new or second hand CWR of the size specified by the Director of Engineering, and wood or concrete ties. Turnouts shall be new 136-pound rail, insulated. Hand-operated switch stands shall be “ergo-metric” design with long, high operating handles to minimize operating effort by employees. Geometric layout must consider placement of switch stands vis-à-vis nearby tracks and roadways.

### **20.14 DERAIS**

Blue flag protection for workers is provided by portable derails. Location of derails must be approved by the Director of Engineering. Locations for such derails shall not be in roadway crossings. Derails shall comply with the requirements of Chapter 6 of this Design Criteria.

## APPENDIX A TERMS AND DEFINITIONS

<b>aerial structure</b>	A bridge or elevated structure with a track deck designed to accommodate direct fixation or ballasted track.
<b>alignment</b>	The horizontal and vertical location of the track, street, or highway as described by curves and tangents
<b>ampere</b>	A unit of electric current.
<b>Amtrak</b>	National Railroad Passenger Corporation
<b>Annealing</b>	A metal softening process, based on heating and slow cooling.
<b>Anticlimber</b>	<p>A horizontally ribbed steel fabrication mounted at floor level at each end of a rail car.</p> <p>The anticlimbers on colliding vehicles will interlock with each other and reduce the tendency of the vehicles to “telescope”.</p>
<b>approach slab</b>	A reinforced concrete slab located at the interface of ballasted track with direct fixation track, embedded track or an open deck bridge to provide a transition between ballasted track and the types of track with significantly higher track modulus.
<b>aspect (signal aspect)</b>	The appearance of a fixed signal conveying an indication as viewed from the direction of an approaching vehicle; the appearance of a cab signal conveying an indication as viewed by an observer in the cab.
<b>at-grade crossing</b>	The crossing of a railway track and a vehicular roadway at the same elevation. They are conventionally constructed of timber, asphalt, rubber, or concrete.
<b>audio frequency overlay (AFO)</b>	Track circuits that utilize audio frequencies that overlay another track circuit to detect another vehicle. The AFO is mainly used for highway grad-crossing warning systems.
<b>automatic train dispatching (ATD)</b>	A function of the Operations Control Center computer system in which train dispatching from all terminal points, including the yard, is automatically driven by the current system timetable.
<b>automatic train protection (ATP)</b>	The subsystem of the train control system that maintains safe vehicle operation through a combination of vehicle detection, vehicle separation, interlocking and speed-limit requests and enforcement.

<b>automatic train stop (ATS)</b>	System which automatically applies the brakes on a train if the engineer fails to respond to a signal when the train passes over an inductor. Inductors are typically placed at signals or speed restrictions.
<b>backwater</b>	Water held, or restricted from flowing, by a dam or other obstruction within a stream or channel.
<b>ballast</b>	<p>An integral part of the track structure, generally composed of crushed stone in which ties are embedded and is essential to good maintenance of track surface and alignment. FRA Track Safety Standards stipulate that:</p> <p>“Unless it is otherwise structurally supported, all track must be supported by material which will: (1) transmit and distribute the load of the track and railroad rolling equipment to the subgrade; (2) restrain the track laterally, longitudinally, and vertically under dynamic loads imposed by railroad rolling equipment and thermal stress exerted by the rails; (3) provide adequate drainage for the track; (4) maintain proper track cross-level, surface, and alignment.</p>
<b>baseline stray current survey</b>	A survey conducted during pre-construction in which soil and groundwater corrosive characteristics are determined. These data serve as a basis for corrosion control designs
<b>block</b>	A length of track with defined limits set by the train control system design.
<b>bond</b>	An electrical or circuit connection made between rail ends.
<b>Braking Requirement</b>	A braking requirement reflects the maximum safe speed at any given point in the system based on the conditions of the systems.
<b>cab signal</b>	The automatic train protection speed limit as transmitted to the vehicle by the wayside equipment.
<b>Caltrans catenary</b>	California Department of Transportation In electrified territory, an overhead contact system of one or more bare wires including contact wire, messenger wire, and the interconnecting hangers.
<b>cathodic protection</b>	A means of limiting the electrochemical process of corrosion

whereby: (1) corrosion is diverted from the item to be protected (the cathode) to a sacrificial item (the sacrificial anode), which eventually corrodes and must be replaced, or (2) an outside electrical current is applied to the item to be protected to control differences in electrical potential between the item (now the cathode) and the soil (the anode).

**Centralized Traffic Control (CTC)** A term applied to a system of railroad operation by means of which the movement of vehicles over routes and through blocks on a designated section of track or tracks is directed by signals controlled from a designated point without requiring the use of train orders and without the superiority of trains.

**central supervisory control machine** A computer which receives traffic signal inputs from all traffic control cabinets and displays each of the intersections and their signal indications.

**central business district (CBD)** The center or core within an embracing region in which the most intensive commercial activity is concentrated.

**channelization** The process of controlling automobile traffic by channeling vehicles into specific traffic lanes via barrier curbs and islands. Also, the process of controlling pedestrian traffic by channelizing pedestrians via fencing, barrier, and gates (particularly applicable to improving pedestrian safety at grade crossings). Also, a method for improving the flow capacity of waterway.

**Class 1** A railroad of the largest size (measured by annual revenues) by the Surface Transportation Board. The BNSF is a Class 1 railroad.

**Class of Track** A rating of tracks as a function of the permitted operating speeds for freight or passenger trains defined by the FRA for application of Track Safety Standards (49CFR213) ranging from “excepted” through 1 to 9 with incrementally decreasing tolerances for deviations. Most of the SANDAG/NCTD main tracks are Class 3 to 5.

**clearance envelope** Distance in all directions around a train that must be kept clear of obstructions.

**closure rails** The rails between the parts of any special trackwork layout, such as the rails between the switch and the frog in a turnout; also the rails connecting the frogs of a crossing or of the adjacent crossing, but not forming parts thereof.

**coasting** The mode of operation of a train in which propulsion (positive

- traction) and braking (negative traction) are inactive.
- compound curve** Track curve composed of more than one curve in the same direction, each with a different curvature or radius.
- compromise joint** A joint matching two rails of different sections or sizes. The four bars for the two joints make up a set of compromise bars for two compromise joints (left & right).
- compromise weld** A welded joint matching two rails of different sections or sizes.
- contact** A conducting part which co-acts with another conducting part to open or close an electric circuit
- contact wire** Portion of the overhead power distribution system which comes into contact with the sliding current-collector strips on the pantograph, thus transferring electrical power to the train, usually a solid grooved wire.
- continuous cab system** A cab system that provides speed commands and other data to the vehicles throughout the system.
- continuous welded rail (CWR)** A number of shorter length rails welded together into a single length of generally 400 ft. or greater.
- contract documents** Engineering design documents, such as design drawings and specifications, incorporated into a composite package for the purpose of soliciting construction bids.
- contractor** A person or entity who agrees to furnish materials or perform services at a specified price, especially for construction.
- Coupler** An appliance on a railroad car for coupling two vehicles.
- creep** The tendency of materials to flow plastically due to increase in strain under sustained load.
- crest curve** A convex vertical curve.
- cross-bond** An electrical connection from one track to another track to distribute traction power returns currents.
- crossing diamond** Special trackwork installed to allow two tracks to cross at grade.
- crossover (single)** Two turnouts, with track located between the frogs and arranged to form a continuous passage between two adjacent and generally parallel tracks.



<b>crossover (double)</b>	Two single crossovers which intersect each other between the two adjacent and generally parallel tracks forming a connection between them. Sometimes referred to as a “scissors” crossover or “diamond” crossover.
<b>Crossover (universal interlocking)</b>	Two single crossovers not intersecting each other but adjacent, allowing passage from one track to another in either direction.
<b>crosstie</b>	The portion of the track structure that supports the rails and maintains gage. Ties are constructed of wood, concrete or steel and are usually spaced 18-30 inches at right angles to the rails.
<b>Culvert</b>	A drainage structure or pipe crossing under a track or roadway.
<b>curb return</b>	The portion of a curb at which vehicles make sharp turns
<b>cut-out (train control)</b>	A circuit at the exiting point of an automatic train control system or cab signal territory by means of which a vehicle ATP system is actuated so as to be in the street running or yard control condition.
<b>Data Capture and Reporting System</b>	A function of central control. A system to record all change-of-state information and system transactions for analysis and reporting purposes. The data capture and reporting system will produce an audit trail listing all controls and indications, as well as how and when they were initiated.
<b>derail</b>	Mechanical device used to derail or otherwise direct rail vehicles away from adjoining or connecting tracks.
<b>design Criteria</b>	A document whose purpose is to describe the engineering design criteria to be used during preliminary and final design.
<b>design load</b>	Load which includes stresses due to effective prestress after losses, dead loads, maximum specified live loads, and impact loads.
<b>detector locking</b>	Electric locking, effective while a vehicle occupies a given section of a route, which prevents operation of switch-and-lock movements within that section.
<b>diagnostic team</b>	A joint design team that develops the configuration for a new or upgraded public road crossing. The team include representatives of the CPUC, the using railroads, SCRRA, NCTD, SDNRR,

	SANDAG the roadway owner, and other involved agencies such as fire, school, etc.
<b>direct fixation</b>	Type of track construction in which the rails are fastened to a concrete slab using fasteners which provide lateral and longitudinal restraint, electrical and vibration isolation, and allow for adjustment of the rail position as the rail wears.
<b>direct reverse curves</b>	Sequential and opposite track curves with no intermediate section of straight track (S-shaped curve).
<b>dispatcher</b>	Person stationed in the Operations Control Center who monitors and controls train operations on the main line of the rail system.
<b>Division</b>	Portion of the SCRRA and LOSSAN Corridor system; made up of subdivisions.
<b>draft gear</b>	The component integrating the coupler to the vehicle underframe anchorage. The draft gear is designed to absorb the shocks incidental to multi-vehicle movements and coupling of vehicles and thereby cushion the force of impact to minimize stresses imposed on the vehicle structure.
<b>dual control switch machine</b>	A power-operated switch machine that can also be thrown by hand.
<b>dwarf signal</b>	A low wayside signal.
<b>dynamic braking</b>	A system of electric braking in which the traction motors, when used as controlled generators, retard the vehicle.
<b>dynamic vehicle outline</b>	The lateral limits of a train in motion considering factors such as vehicle roll, side sway, and fishtailing.
<b>easement</b>	The right legally afforded a person or entity to make limited use of another person's real property as the right-of-way.
<b>electric lock</b>	A device to prevent the movement of a track switch unless the locking member is withdrawn by an electrical device such as an electromagnet, solenoid, or motor.
<b>Electromagnetic interference (EMI)</b>	Electrical interference of communication signals caused by undesired electromagnetic energy within the atmosphere.
<b>emergency load</b>	An electrical load that is required to be energized from the

emergency power source for a specific time interval after the loss of both normal and backup power.

**equal construction** The process of constructing a new facility of the same type construction and capacity of existing facilities. Similar to replacement-in-kind.

**essential load** An electrical load that is considered essential for safety and system operation so that interruption of power to these loads shall be held to a minimum time. This minimum time is the normal transfer time of automatic transfer equipment and the start time of standby generating equipment.

**fail-safe** A term describing the characteristic of a device, system, or circuit which ensures that any malfunction affecting safety will cause the device, system, or controlled function of the circuit to revert to a state that is known to be safe.

**feeder** An electrical conductor that connects a load or distribution point to its source of power.

**field weld** A rail joint weld done in the field, typically using the thermite process.

**fixed facilities** Facilities to be constructed as part of the project that are stationary (passenger stations, trackway, etc.) rather than mobile (rail vehicles).

**flood storage capacity** The capacity of a drainageway to store, or significantly delay, runoff from a storm event to prevent “flash” flooding.

**floodplain** Area within and adjacent to a watercourse that would be expected to be inundated (flooded) during a storm event of a particular frequency (e.g., a 100-year storm).

**Foul** Being within the space that could be occupied by a passing train or roadway machine, generally within 10 feet of centerline of the track

**friction braking** Vehicle braking method that uses brake pads to exert friction forces on a rotating wheel to stop that wheel from rotating.

**frog** A track structure or device used at the intersection of two running rails to provide support for wheel treads and passageways for their flanges, thus permitting wheels traversing either rail to cross the other.

<b>frog number</b>	The number used to designate the size of a frog, and being equal to ratio of length to divergence.
<b>galvanic corrosion</b>	The electrochemical process of corrosion caused by a difference in electrical potential between dissimilar metals, dissimilar soils, or metals and soils.
<b>General Code</b>	The General Code of Operating Rules (GCOR) is the baseline document for authorizing and controlling movement of trains and for controlling access to the main tracks.
<b>girder rail</b>	Any one of several types of rail sections most commonly used in electric or street railway construction. Girder groove rails are asymmetrical rails which provide a wheel flangeway adjacent to the gauge side of the railhead. Girder guardrails use a similar flangeway but with a raised lip to provide a guarding action similar to that provided by a separate restraining rail.
<b>Graceful Degradation (recovery)</b>	A phrase referring to an equipment failure during which the system will function with little ill effect: When the failure is resolved, recovery has little effect on other parts of the system.
<b>ground return</b>	Current that returns to the source through the ground, such as in a current damp road crossing.
<b>ground return bonding</b>	Bonding to prevent the above.
<b>guard rail</b>	An assembly in a turnout placed opposite the frog point to prevent wheel flanges from contacting the frog point. Also used on crossing frogs.
<b>guarded track</b>	Track with an additional component located inside one or both running rails to bear against the back of the wheels to guide them in traversing small radius curves.
<b>headblock</b>	The tie arrangement under the point of the switch to hold the switch machine and the connecting rods. There are usually two headblock ties.
<b>headway</b>	The time-separation between two trains, both traveling in the same direction on the same track. It is measured from the time the headend of the leading train passes a given reference point to the time the head-end of the immediately following train passes the same reference point
<b>heel of frog</b>	the end of the frog in the turnout—farthest from the point.

<b>hertz</b>	A unit of measurement that measures alternating electricity by the number of cycles in one second.
<b>high frequency inverter/ballast unit</b>	Self-contained power supplies for fluorescent lamp fixtures which use a high frequency switching rate to produce ac from dc input.
<b>High rail</b>	The outside rail of a curve, so named because it is raised to achieve superelevation in a curve
<b>highway grade crossing</b>	An intersection of a highway, road, or alley with railroad tracks at the same elevation.
<b>highway grade crossing warning device</b>	A device that provides a visual and/or audible warning and restricts access to the intersection of a highway grade crossing.
<b>horizontal curve</b>	A track curve connecting two horizontal tangents of different bearing.
<b>impedance bond</b>	A metallic device of low resistance and relatively high reactance, used to provide continuous path for the return propulsion current around insulated joints and to confine the audio frequency signaling energy to its own track circuit.
<b>insulated joint</b>	A structural connection between adjoining rails that provides electrical insulation between the rails
<b>interlocking</b>	An arrangement of signals and signal appliances interconnected so that their movements must succeed each other in proper sequence and for which interlocking rules are in effect. It may be operated automatically or by sections.
<b>interlocking limits</b>	The boundaries of an area of track controlled by an interlocking, as defined by the extreme opposing home signals of that interlocking.
<b>intermittent block cab system</b>	A cab system that provides speed commands to the vehicle at predetermined points.
<b>inverter system</b>	System dedicated to accepting primary dc power in, changing it to ac voltages, single or multiple phases, as required.

<b>jerk limit</b>	Maximum rate of change of lateral or longitudinal acceleration for a train. The normal units are feet per second cubed.
<b>jointed rail</b>	Running rail that is a series of separate rails connected end to end by means of joint bars and bolts.
<b>jumper cables</b>	Electrical cables that provide electrical continuity in the overhead power distribution system at special trackwork and other locations where it is necessary to have mechanical separations between conductors.
<b>junction box</b>	Any enclosure in which electrical wires and cables are intersected or spliced.
<b>kiss-and-ride</b>	An access mode to a transit station that does not provide for long-term parking; the patron is brought to the station by private automobile, which departs after dropping off the patron.
<b>last long tie</b>	The last switch tie in a turnout—farthest from the point.
<b>leaky coaxial antenna</b>	Slotted coaxial cable installed within the length of a tunnel that receives and distributes the rail operations and control radio signals; the cable allows operation of the radio channels while a train is in a tunnel.
<b>light unit</b>	An assembly of one or more lenses, roundels or reflectors, arranged in a suitable frame or case with fixture and electrical lamp or lamps from which a light beam or beams can be projected and controlled.
<b>local control panel</b>	A panel provided in each train control room for monitoring and control of their movement in a designated area. The control panel displays the track diagram of the designated area and provides associated control devices and indicators
<b>local section</b>	Section control equipment located at the site of the mechanical or electrical process that is being controlled.
<b>lock rod</b>	Part of a track switch or derail that locks the switch points or derail into normal or reverse position. Consists of a rod, attached to the front rod or log, through which a locking

	<p>plunger may extend when points or derail are in the normal or reverse position.</p>
<b>long-term parking facilities</b>	<p>Parking facilities designed for vehicles parking for extended periods Parking facilities designed for vehicles parking for extended periods (i.e., greater than 15 minutes). Park-and-Ride lots are designed as long-term parking facilities.</p>
<b>loop detector</b>	<p>Vehicle detection coil imbedded in the roadway or trackway that detects vehicles requiring entry into the system. Part of the traffic control system.</p>
<b>Low rail</b>	<p>The inside rail of a curve, so named because it is lower than the outside rail in order to provide superelevation in a curve; it is also the reference for track profile through curves.</p>
<b>mainline</b>	<p>A section of track on which trains move at design operating speed, primarily for the purpose of transporting patrons during revenue service.</p>
<b>main track</b>	<p>A track extending through yards and between stations that must not be occupied without authority or protection.</p>
<b>master clock</b>	<p>A single clock provided for the purpose of synchronizing all computer subsystems with the time received from a common master time source.</p>
<b>Master Utility Relocation Agreement</b>	<p>An agreement between SCRRA, NCTD/SANDAG/SDNRR and local utility companies that spells out the procedure, responsibility and financial liability for any required utility relocations, replacements, or other utility work.</p>
<b>messenger wire</b>	<p>A suspended wire attached to primary structural supports, from which is suspended a cable or conductor. In a Catenary system, the conductive messenger wire supports the contact wire through hangers.</p>
<b>Metrolink Operations Center</b>	<p>The operations control center for SCRRA and LOSSAN Corridor, located in Pomona.</p>
<b>non-essential load</b>	<p>An electrical load of such a nature that interruption of power to it for a short period will not affect safety and system operation. Nonessential loads do not require a backup power source</p>

<b>non-signaled territory</b>	Sections of the track system in which no signals exist. The centralized traffic control system identifies all trains as they enter and exit non-signaled territory.
<b>non-vital relays</b>	Any relay that does not affect the safety of train operations
<b>ohm</b>	An electrical unit that measures the resistance to the flow of current in a conductor.
<b>omnibus backbone network</b>	Electronic network that accommodates the data, voice and closed circuit television transmission needs of the communications system and the voice and remote control connections to rail radio base stations.
<b>operating rod</b>	The rod through which motion is transmitted.
<b>overhead contact system (OCS)</b>	An electrical power distribution system designed to conduct and transfer power from substations to the trains. The system comprises the bare wire overhead contact system, supporting structures and their foundations, supporting attachments to overhead bridge structures, parallel insulated traction power supply cable hardware and connections to the overhead contact system, and cable cross arm supports and hardware for locations where aerial support is selected for the signal control and communications cables. A collapsible and adjustable frame that is mounted on top of a vehicle and to which a sliding current-collector shoe is fitted at the upper end.
<b>Park-and-Ride</b>	A transit access mode in which a patron drives a private automobile to a station, parks in the areas provided for that purpose, and enters the transit system.
<b>Patron</b>	A person who paid fare to use the transportation service provided by Metrolink or North County Transit District Coaster.
<b>pocket track</b>	A track located between two primary tracks that is used to store out-of-service, layover, or turning back trains.
<b>point of vertical curvature (PVC)</b>	Point of connection of a tangent track line to a vertical curve.



<b>Point of vertical tangency (PVT)</b>	Point of connection of a vertical curve to a tangent track line.
<b>point detector rod</b>	A rod through which position is transmitted to the circuit controller to indicate position of the switch points.
<b>primary track</b>	Track constructed for vehicles that carry revenue passengers.
<b>profile</b>	The vertical alignment of the track, usually shown as the top of rail elevation.
<b>profile grade (grade line)</b>	The datum line which defines the vertical alignment of the track, applied at the top of the low rail.
<b>radio frequency interference (RFI)</b>	Electrical interference of communication signals caused by undesired radio frequency energy within the atmosphere.
<b>radio release</b>	A reset command sent by radio communications to release the automatic trip stop (ATS) system.
<b>rail anchor</b>	A device attached to the rail that contacts the tie and prevents longitudinal rail movement.
<b>rail clip</b>	A resilient device used to secure running rails to crossties to provide vertical, lateral and longitudinal restraint of the rail.
<b>rail fastener</b>	A device used to secure running rails to crossties to provide vertical and lateral restraint of the rail. This includes track spikes and resilient fasteners.
<b>receiver</b>	A device that converts electric energy input to the device to indicate electric energy is present.
<b>receive (train control, cab control)</b>	Receiver so placed that it is in a position to be influenced inductively or actuated by an automatic train stop, train control, or cab signal element.
<b>receiver (track circuit)</b>	Receiver so placed that upon detection of a voltage or frequency, a contact or voltage is supplied to controlling circuits to indicate its presence.

<b>redundancy</b>	The existence in a system of more than one independent means of accomplishing a function.
<b>Regenerative Braking</b>	A system of electric braking, in which the traction motors, when used as controlled generators, return a portion of the braking energy as electrical energy to the contact wire for use by other trains or other train subsystems.
<b>relay</b>	A device that is operated by a variation in the conditions of one electric circuit to affect the operation of other devices in the same or another electric circuit.
<b>relay-based equipment</b>	An electromagnetic device operated by a variation in the conditions of one electric circuit to affect the operation of other devices in the same or another electric current.
<b>relay-based interlocking</b>	See interlocking. Equipment used to control an interlock that consists primarily of relays.
<b>replacement-in-kind</b>	The process of replacing a facility with a facility of the same type, construction, and capacity. Similar to equal construction.
<b>resistance-to-earth criteria</b>	The design desirable in-service electrical resistance per mile of mainline running rails, special trackwork and ancillary system connections.
<b>reverse running</b>	The operation of a vehicle against the normal direction of operation on a particular track.
<b>rheostatic brake</b>	Braking in which the power generated by the traction motors, when driven as generators, is dissipated through a resistor bank. Also called dynamic braking
<b>right-of-way (ROW)</b>	Land or rights to land used or held for railroad operations or for public way.
<b>running rail</b>	That rail upon which the tread of rolling stock wheels bear.
<b>sacrificial anodes</b>	An item, such as a zinc plate, that limits the electrochemical process of corrosion by diverting corrosion from the item to be protected (the cathode) to itself (the anode), which eventually corrodes and must be replaced.
<b>safe braking</b>	The distance allowed for the safe stopping of a train from

<b>distance (SBD)</b>	a given speed, or for reducing velocity from one speed to another speed. The SBD will include the distance traveled at the initial speed during operator and equipment reaction time, stopping distance, or distance required to reduce to the new speed desired, and an appropriate safety-factor.
<b>sag curve</b>	A vertical curve which is concave.
<b>sand box</b>	Timber box structure filled with sand and located at the ends of stubend tracks to stop rail cars and minimize damage to them.
<b>secondary track</b>	Includes all track which is not primary track; or track constructed for the purpose of switching, storing, or maintaining vehicles that do not carry revenue passengers.
<b>self-service fare collection</b>	A proof-of-payment fare collection system.
<b>shop track</b>	Track which consists of all yard and secondary track constructed within the limits of the maintenance buildings.
<b>short-term parking facilities</b>	Parking facilities designed for vehicles parking for a limited time (i.e., less than 15 minutes). Kiss-and-Ride lots are designed as short-term parking facilities.
<b>signals (automatic)</b>	A signal at the beginning of a signal block that automatically changes its aspect to indicate whether the block is clear or occupied.
<b>signals (controlled)</b>	A signal that requires a request for its operation, i.e., a signal that is not automatic.
<b>signals (wayside)</b>	A signal of fixed location along the track right-of-way.
<b>simulation</b>	The representation of the functioning or process of one system by means of another; especially when examining a problem not subject to direct experimentation.
<b>slip</b>	The act of train wheels sliding (rather than rolling) over the rails due to excessive brake forces during rapid deceleration of the train. Slip is detected and controlled by slip-spin protection.

<b>spin</b>	The act of train wheels spinning (rather than rolling) over the rails due to excessive tractive effort typically during rapid acceleration of a passenger train or when attempting to start or move heavy freight trains. Spin is detected and controlled by slip-spin protection.
<b>special trackwork</b>	A generic term referring to turnouts, single and double crossovers, track crossings, and other items that permit tracks to merge, diverge, or cross one another.
<b>specific minimum yield stress (SMYS)</b>	The minimum design pressure or stress at which a steel pipe will fail or yield.
<b>speed</b>	The maximum speed of operation for trains, often different for passenger and freight trains.
<b>spiral curve</b>	Horizontal curve elements of varying radius that are used on mainline track alignments to transition from a tangent to a circular curve. The length of the spiral element is also used to gradually develop the superelevation of the track.
<b>stand-alone validator</b>	A device available at stations to imprint information on riders' tickets for self-service fare collection verification.
<b>static vehicle outline</b>	The lateral limits of a vehicle body, not in motion, and with all mechanical features in nominal factory condition.
<b>station</b>	A facility equipped with platforms to enable patrons to enter and leave trains.
<b>stock rail</b>	A running rail against which a switch point operates.
<b>stray currents</b>	Electrical currents, other than those generated for use by the rail system, that exist in the environment due to the electromagnetic and/or electrochemical interactions of the rail equipment, atmosphere, groundwater and soils.
<b>stub-up</b>	Portion of underground electrical conduit that rises to or through the ground surface.
<b>sub-ballast</b>	A material superior in composition to the roadbed material which provides a semi-impervious layer between the track ballast and the roadbed for better drainage and distribution of load to the roadbed.

<b>subdivision</b>	Portion of the SCRRA or SDNRR/NCTD/SAN DIEGO system, such as the San Diego Subdivision.
<b>substation</b>	A facility containing electrical equipment which typically provides for the transformation of high transmission voltage electric power to one or more lower voltages for distribution of the electric power to consumers.
<b>substructure</b>	The part of an aerial structure or bridge below the bridge seats, tops of piers, haunches of rigid frames, or below the springlines of arches. Backwalls and parapets of abutments and wingwalls of bridges shall be considered part of the substructures.
<b>superelevation (Ea)</b>	Tilting or “banking” of the running surface of a roadway or trackway in areas of curved horizontal alignment which permits vehicles to negotiate the curves at higher speeds than would be possible if the running surface were level, expressed as the number of inches the outside rail is above the inside rail on a curve.
<b>Superstructure</b>	The part of an aerial structure or bridge above the bridge seats, tops of piers, haunches of rigid frames, or above the springlines of arches, including the floor, and not including the substructure.
<b>support equipment</b>	Equipment used together to provide the basis of subsistence for a complete system.
<b>switch control</b>	An electrical circuit that directs the movement of a track switch.
<b>switch machine</b>	A device used to operate a track switch; a switch and lock is one type of switch machine.
<b>switch point</b>	The movable tapered rail of a split switch.
<b>switch, point of</b>	The end of a switch point farthest from the frog.
<b>switch, split</b>	A track switch consisting of two movable switch points.
<b>switch stand</b>	A device next to the point of the switch that includes the switch lever mechanism.

<b>Switch tie</b>	Special crossties of varying lengths used under a turnout.
<b>switch-and-lock</b>	A device which performs the three functions of unlocking, operating, and locking a track switch or derail.
<b>ticket-issuing machine</b>	A device to issue single ride documents showing that the passenger has paid the fare.
<b>tie</b>	A long timber or concrete member on which ballasted track is constructed. Also referred to as a crosstie.
<b>tie plate</b>	A steel plate installed between the rail and the crosstie to distribute the load and restraint lateral movement.
<b>time of concentration</b>	The travel time required for overland flow plus the travel time required for channel flow of stormwater from the most remote point of the drainage area to the point under consideration.
<b>timing device</b>	A device that provides a contact or closure data indicating that a preset time has elapsed from a predetermined condition.
<b>toe of frog</b>	The end of the frog closest to the switch points.
<b>track crossing</b>	The point at which two lines of track cross, consisting of four crossing frogs, one for each intersection of the rails
<b>track circuit</b>	An arrangement of electrical circuits and/or electronic equipment, including a length of the running rails, which permits detection of vehicles.
<b>track circuit (ac)</b>	A track circuit that uses ac voltage to the rails to detect vehicles in a block.
<b>track circuit (AF)</b>	A track circuit that uses audio frequency to detect vehicles in a block.
<b>track circuit (digital)</b>	A processor track circuit that provides a means to transmit data to a train from the rails.
<b>track circuit (double rail)</b>	An ac track circuit that uses both rails for vehicle detection and uses impedance bonds for propulsion return.

<b>track circuit (PF)</b>	An ac track circuit that uses the supplied ac for detection of vehicles. (PF power frequency).
<b>track circuit (single rail PF) vehicle</b>	A PF track circuit that uses one rail solely for detection.
<b>track circuit boundaries</b>	An area defined from the end point on the track circuit to to the other end of the track circuit. See block.
<b>track detection</b>	A device detecting the presence of a vehicle that is used by the signal system for controlling train operation.
<b>track, direct fixation</b>	Track constructed of rail and rail fasteners attached by means of anchor bolts to a concrete trackbed
<b>track, embedded</b>	Track constructed of rails and steel ties on a reinforced concrete slab and, except for the flangeways, embedded in asphalt or concrete to the top of rail to facilitate pedestrian or vehicle traffic over the tracks. For track located in streets, grade crossing, or vehicle maintenance facilities.
<b>track gauge</b>	The distance between the inside faces of running rails of a track measured at a point $\frac{5}{8}$ in. below the top of rail. Standard gauge is 56 $\frac{1}{2}$ inches.
<b>traction power</b>	Power used by the train for propulsion.
<b>traction current return</b>	The path followed by traction power electrical current from the train back to the substation.
<b>train</b>	Locomotive and one or more vehicles coupled together (a consist) and acting as a single unit.
<b>train stop</b>	A device used by the signal system to command a train to stop.
<b>train stop (inductive)</b>	An automatic train stop which uses electric coils as a as a means to command a train to stop.
<b>train to wayside (TTW) system</b>	A system that routes trains to their scheduled destinations and provides central control with vehicle identification.
<b>Transit Communications</b>	Standards developed by the Institute of Electrical and Electronics Engineers and subsequently maintained by

<b>Interface Protocols</b>	the American Public Transit Association defining communications protocols to be used in the transit industry.
<b>transition length</b>	The portion of a tangent track in which superelevation is developed immediately preceding a circular curve and removed immediately following a circular curve, when spiral curves are not used.
<b>transmitter</b>	A device that generates electrical energy to be used by a receiver.
<b>transponder</b>	A device located on the track side that transmits data and/or receives data
<b>tunnel</b>	An underground guideway constructed by methods such as soft ground tunneling, mixed face tunneling, or other means of boring into soil strata.
<b>turnout</b>	An arrangement of a switch and a frog with stock rails and closure rails that enables rail vehicles to be diverted from one track to another.
<b>ultimate load</b>	The load which causes failure of a structure with a single static application.
<b>Unbalanced Superelevation</b>	Trains typically operate at speeds higher than equilibrium or balanced speeds. The speed greater than equilibrium is expressed as an additional, imaginary, portion of the total superelevation. It is not actually built into the track.
<b>Uninterruptible power supply (UPS)</b>	A battery power backup for the operation of critical signal and communications systems.
<b>vending equipment interface</b>	A specification for communication between elements of a fare vending system.
<b>vertical curve</b>	A parabolic curve connecting two vertical tangents in a track profile.
<b>vital processor unit</b>	A device in which a central processing unit provides a logical evaluation of predefined commands to determine an output. This device is designed to insure any failure conditions will provide no voltage, or zero data, to an



	output used for controlling circuits. See processor-based equipment.
<b>vital relays</b>	Relays that contain circuits that affect the safety of train operations.
<b>volt</b>	The unit of electromotive force, or that difference of potential that, when steadily applied against a resistance of one ohm, will produce a current of one ampere.
<b>wayside</b>	A term generally used to refer to the area alongside the path Of a rail vehicle, but clear of its dynamic outline.
<b>yardmaster</b>	Person stationed at central control who coordinates all moves into or out of the yard.

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## APPENDIX B ABBREVIATIONS/ACRONYMS

<b>AASHTO</b>	American Association for State Highway Officials
<b>ABS</b>	Acrylontrile-Butadieue Styrene pipe or automatic block signal
<b>AC</b>	Asphaltic Concrete or alternating current
<b>ACGIH</b>	American Conference of Governmental Industrial Hygienists
<b>ACHP</b>	Advisory Council on Historic Preservation
<b>ACI</b>	American Concrete Institute
<b>ACOE</b>	Army Corps of Engineers
<b>ADA</b>	Americans with Disabilities Act
<b>ADU</b>	aspect display unit
<b>AF</b>	audio frequency
<b>AFBMA</b>	Anti-Friction Bearings Manufacturers' Association
<b>AFI</b>	Air Filter Institute
<b>AFO</b>	audio frequency overlay
<b>AGC</b>	automatic-gain control
<b>AISC</b>	American Institute of Steel Construction
<b>AISI</b>	American Iron and Steel Institute
<b>AMCA</b>	Air Moving Control Association, Inc
<b>A</b>	ampere
<b>AA</b>	Aluminum Association
<b>AAR</b>	Association of American Railroads
<b>AASHTO</b>	American Association of State Highways and Transportation Officials
<b>AMTOR</b>	above mean top of rail

<b>ANSI</b>	American National Standards Institute
<b>API</b>	American Petroleum Institute
<b>APTA</b>	American Public Transit Association
<b>APWA</b>	American Public Works Association
<b>AREMA</b>	American Railway Engineering and Maintenance of Way Association and its two current publications: “Manual of Railway Engineering,” and “Portfolio of Trackwork Plans”
<b>ASCE</b>	American Society of Civil Engineers
<b>ASHRAE</b>	American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.
<b>ASME</b>	American Society of Mechanical Engineers
<b>ASQC</b>	American Society for Quality Control
<b>ASTM</b>	American Society for Testing and Materials
<b>A.T.</b>	automatically tensioned
<b>ATD</b>	automatic train dispatching
<b>ATP</b>	automatic train protection
<b>ATS</b>	automatic train stop (sometimes automatic trip stop)
<b>AVAS</b>	Automatic Voice Announcement System
<b>AWO</b>	empty car operating weight
<b>AW1</b>	seated load car weight
<b>AW2</b>	normal load car weight
<b>AW3</b>	crush load car weight
<b>AWS</b>	American Welding Society
<b>AWWA</b>	American Water Works Association
<b>B</b>	bus

<b>BC</b>	Beginning of curve
<b>BOCA</b>	Building Officials and Code Administrators
<b>BNSF</b>	Burlington Northern Santa Fe
<b>BPS</b>	bits per second
<b>BVC</b>	Beginning of Vertical Curve
<b>BWA</b>	balance weight anchor
<b>C</b>	degrees Celsius
<b>CA</b>	California
<b>CADD</b>	Computer Aided Design and Drafting
<b>CADFG</b>	California Department of Fish and Game
<b>CALTRANS</b>	California Department of Transportation
<b>CBC</b>	California Building Code
<b>CBD</b>	central business district
<b>CC</b>	center of curve
<b>CCC</b>	California Coastal Commission
<b>CCD</b>	charge-couple device
<b>CCTV</b>	closed circuit television
<b>CDF</b>	California Department of Forestry
<b>CDF&amp;F</b>	California Department of Fish & Game
<b>CDRL</b>	Contract Document Requirements List
<b>CEQA</b>	California Environmental Quality Act
<b>CF</b>	centrifugal force
<b>CFR</b>	Code of Federal Regulations

<b>CIH</b>	central instrument house
<b>CMS</b>	Central Maintenance Facility
<b>COTS</b>	commercial off-the-shelf
<b>CPTED</b>	Crime Prevention through Environmental Design
<b>CPUC</b>	California Public Utilities Commission
<b>CS</b>	curve to spiral
<b>CSB</b>	client-server based
<b>CSI</b>	Construction Specifications Institute
<b>CTC</b>	centralized traffic control
<b>CTS</b>	Carrier Transmission system
<b>CWH</b>	contact wire height
<b>CWR</b>	continuous welded rail
<b>CZMP</b>	coastal zone management plan
<b>dB</b>	decibels
<b>dBA</b>	decibel A-weighted sound level
<b>dc</b>	direct current
<b>DCRS</b>	Data collection and Reporting system
<b>DIDW</b>	double inlet, double width
<b>DOT</b>	Department of Transportation (U.S.)
<b>Ea</b>	actual (active) superelevation
<b>Et</b>	total superelevation
<b>Eu</b>	unbalanced superelevation, or cant deficiency
<b>EC</b>	End of Curve

<b>EEPROM</b>	Erasable electronically programmable read-only memory
<b>EIA</b>	Electronic Industries Association
<b>EIC</b>	Employee In Charge
<b>EMI</b>	electromagnetic interference
<b>EMP</b>	emergency management panel
<b>EPA</b>	U.S. Environmental Protection Agency
<b>EPROM</b>	Electronically programmable read-only memory
<b>ES</b>	Engineering Standards (NCTD/SANDAG/CALTRANS standard drawings)
<b>EVC</b>	End of Vertical Curve
<b>F</b>	Fahrenheit
<b>FAA</b>	Federal Aviation Administration
<b>FCC</b>	Federal Communications Commission
<b>FEMA</b>	Federal Emergency Management Agency
<b>FFTVM</b>	full-function ticket vending machine
<b>FHWA</b>	Federal Highway Administration
<b>FMVSS</b>	Federal Motor Vehicle Safety Standards
<b>FONSI</b>	Finding of No Significant Impact
<b>FRA</b>	Federal Railroad Administration
<b>FRE</b>	fiberglass-reinforced epoxy
<b>FRP</b>	fiberglass reinforced plastic
<b>FS</b>	Federal specification or standard
<b>F.T.</b>	fixed termination

<b>ft.</b>	foot, feet
<b>FTA</b>	Federal Transit Administration
<b>g</b>	gram, or acceleration due to gravity
<b>GCOR</b>	General Code of Operating Rules
<b>GEC</b>	General Engineering Consultant
<b>GDM</b>	Graphic Design Management system
<b>GO</b>	General Order (term used by both the CPUC and the GCOR)
<b>GPS</b>	global positioning system
<b>H</b>	horizontal
<b>HDM</b>	Highway Design Manual (Caltrans)
<b>HEC</b>	Hydraulic Engineering Circular
<b>HEP</b>	Head End Power
<b>HEPA</b>	high efficiency particulate air
<b>HGCWS</b>	Highway Grade Crossing Warning system
<b>HID</b>	high-intensity discharge (lighting)
<b>HVAC</b>	heating, ventilation and air conditioning
<b>Hz</b>	hertz; one hertz = one cycle per second
<b>IEC</b>	International Electrotechnical Committee
<b>IEEE</b>	Institute of Electrical and Electronics Engineers
<b>IES</b>	Illuminating Engineering Society
<b>ICEA</b>	Insulated Cable Engineers Association
<b>IJ</b>	insulated joint
<b>in.</b>	inch, inches



<b>I/O</b>	input/output
<b>IPCEA</b>	Insulated Power Cable Engineers Association
<b>ISO</b>	International Standards Organization
<b>kg</b>	kilogram
<b>km</b>	kilometer
<b>kN</b>	kilonewton
<b>kV</b>	kilovolt
<b>kVA</b>	kilovolt ampere
<b>kW</b>	kilowatt
<b>L</b>	liter
<b>LAHT</b>	low-alloy high-tensile
<b>LCD</b>	liquid crystal display
<b>LCP</b>	local control panel
<b>LED</b>	light-emitting diode
<b>Leq</b>	equivalent noise levels
<b>LF</b>	longitudinal force
<b>LFTVM</b>	limited-function ticket vending machine
<b>Ls</b>	length of spiral
<b>LCP</b>	Local Coastal Plan
<b>LOSSAN</b>	San Diego
<b>LVC</b>	length of vertical curve
<b>m</b>	meter
<b>mA</b>	milliampere

<b>MAS</b>	maximum authorized line speed
<b>max.</b>	maximum
<b>MED</b>	maximum expected discharge
<b>MIL</b>	Military Specification
<b>min.</b>	minimum
<b>MIS</b>	Management Information system
<b>mm</b>	millimeter
<b>MOA</b>	Memorandum of Agreement
<b>MOU</b>	Memorandum of Understanding
<b>MOW</b>	maintenance of way
<b>MP</b>	milepost
<b>MPa</b>	megapascal
<b>MPA</b>	midpoint anchor
<b>mph</b>	miles per hour
<b>MTBF</b>	mean time between failures
<b>MTS</b>	Metropolitan Transit System
<b>MTTR</b>	mean time to restore
<b>MTTV</b>	multi-trip ticket validator
<b>MUTCD</b>	Manual of Uniform Traffic Control Devices
<b>MVA</b>	megavolt ampere
<b>NCTD</b>	North County Transit District
<b>NEMA</b>	National Electrical Manufacturers Association
<b>NEPA</b>	National Environmental Protection Act

<b>NEC</b>	National Electrical Code
<b>NESC</b>	National Electrical Safety Code
<b>NFPA</b>	National Fire Protection Association
<b>NHL</b>	National Historic Landmarks
<b>NOAA</b>	National Oceanic and Atmospheric Administration
<b>NPDES</b>	National Pollutant Discharge Elimination System
<b>NRHP</b>	National Register of Historic Places
<b>NRPC</b>	National Railroad Passenger Corporation (Amtrak)
<b>o.c.</b>	on center
<b>OCC</b>	Operations Control Center
<b>OCS</b>	overhead contact system
<b>OSHA</b>	Occupational Safety and Health Administration
<b>OTM</b>	other track materials
<b>P</b>	passenger automobile
<b>Pa</b>	Pascal
<b>PA</b>	public address
<b>PA/CMS</b>	Public Address/Changeable Message Sign
<b>PC</b>	point of curvature
<b>PCA</b>	Portland Cement Association
<b>PCB</b>	printed circuit board
<b>PCC</b>	Portland Cement Concrete
<b>PF</b>	power frequency
<b>pH</b>	the measure of acidity or alkalinity of a solution, measured on a scale from 0 to 14 with 0 = acid, 7 = neutral, and 14 = alkaline

<b>PI</b>	point of intersection
<b>PIVC</b>	point of intersection vertical curve
<b>PLC</b>	programmable logic controller
<b>ppm</b>	parts per million
<b>PS</b>	Point of Switch
<b>PT</b>	point of tangency
<b>PTT</b>	push-to-talk
<b>PTZ</b>	pan, tilt and zoom
<b>PVC</b>	polyvinyl chloride, or point of vertical curvature (trackwork)
<b>PVT</b>	point of vertical tangency
<b>QA</b>	quality assurance
<b>RDBMS</b>	relational database management system
<b>RE</b>	designation of AREMA standard rail end section
<b>RF</b>	radio frequency
<b>RFI</b>	radio frequency interference
<b>RMS</b>	root-mean-squared
<b>ROW</b>	right-of-way
<b>Rpm</b>	revolutions per minute
<b>RTU</b>	remote terminal unit
<b>RWQCB</b>	Regional Water Quality Control Board
<b>RWP</b>	Roadway Worker Protection
<b>RX</b>	receive
<b>SAE</b>	Society of Automotive Engineers

<b>SANDAG</b>	San Diego Association of Governments
<b>SAV</b>	stand-alone validators
<b>SBD</b>	safe braking distance
<b>SC</b>	spiral to curve
<b>SCADA</b>	supervisory control and data acquisition
<b>SCAG</b>	Southern California Association of Governments
<b>SCRRA</b>	Southern California Regional Rail Authority
<b>SDG&amp;E</b>	San Diego Gas and Electric
<b>SHPO</b>	State Historic Preservation Office
<b>SISW</b>	single inlet, single width
<b>SMACNA</b>	Sheet Metal and Air Conditioning Contractors' National Association
<b>SMYS</b>	specific minimum yield stress
<b>SONET</b>	Synchronous Optical Network
<b>SPI</b>	spiral point of intersection
<b>sq. mi.</b>	square mile
<b>SSFC</b>	self-service fare collection
<b>SSPC</b>	Steel Structures Painting Council
<b>STB</b>	Surface Transportation Board
<b>SWPPP</b>	Storm Water Pollution Prevention Plan
<b>SWRCB</b>	State Water Resources Control Board
<b>TCIP</b>	Transit Communications Interface Protocols
<b>TIA</b>	Telecommunications Industry Association
<b>ST</b>	spiral to tangent

<b>TIM</b>	ticket-issuing machines
<b>T/R</b>	top of rail
<b>TS</b>	tangent to spiral
<b>TTW</b>	Train To Wayside
<b>TVM</b>	ticket vending machine
<b>TWC</b>	Train to Wayside Communication, also Track Warrant Control
<b>TX</b>	transmit
<b>UBC</b>	Uniform Building Code
<b>UL</b>	Underwriters' Laboratories, Inc.
<b>UMTA</b>	Urban Mass Transportation Administration (now known as Federal Transit Administration (FTA))
<b>UPS</b>	uninterruptible power supply
<b>USC</b>	United States Code
<b>USCG</b>	United States Coast Guard
<b>USDOT</b>	United States Department of Transportation
<b>V</b>	velocity or vertical
<b>VC</b>	Vertical Curve
<b>VCS</b>	Voice Communication system
<b>VdB</b>	vibration decibel
<b>Vdc</b>	volts direct current
<b>VEI</b>	vending equipment interface
<b>VMS</b>	Variable Message Sign system
<b>W</b>	watt
<b>WATCH</b>	Work Area Traffic Control Handbook

w.g. water gauge

WQCB Water Quality Control Board

**End of Section**

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## Appendix C - Request to Deviate from Baseline Document



### Request to Deviate from Baseline Document

Date of Request: \_\_\_\_\_ Request No. \_\_\_\_\_

<b>ORIGINATOR</b>	Requested By: _____ Consultant _____ Project Name: _____ Project Number: _____						
<b>DEVIATION SOUGHT</b>	Attach relevant standard/design criteria/drawing/document showing "before" and "after" proposed deviation. Specify Baseline Documents including item number to be deviated from below:						
<b>REASON FOR REQUEST</b>	Explain Reason For Request (Benefit or impact if not pursued.):						
<b>SANDAG APPROVALS</b>	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 70%; border-bottom: 1px solid black;">Project Manager</td> <td style="width: 30%; border-bottom: 1px solid black;">Date</td> </tr> <tr> <td style="border-bottom: 1px solid black;">Corridor Director</td> <td style="border-bottom: 1px solid black;">Date</td> </tr> <tr> <td style="border-bottom: 1px solid black;">SANDAG Director of Rail</td> <td style="border-bottom: 1px solid black;">Date</td> </tr> </table>	Project Manager	Date	Corridor Director	Date	SANDAG Director of Rail	Date
Project Manager	Date						
Corridor Director	Date						
SANDAG Director of Rail	Date						
<b>RTA Acknowledgement*</b>	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 70%; border-bottom: 1px solid black;">NCTD</td> <td style="width: 30%; border-bottom: 1px solid black;">Date</td> </tr> </table>	NCTD	Date				
NCTD	Date						