

California High-Speed Train Project



TECHNICAL MEMORANDUM

High-Speed Train Tunnel Portal Facilities TM 2.4.6

Prepared by: Signed document on file 15 Jun 10
David McAllister Date

Checked by: Signed document on file 21 Jun 10
Jimmy Thompson Date

Approved by: Signed document on file 21 Jun 10
Ken Jong, PE, Engineering Manager Date

Released by: Signed document on file 22 Jun 10
Anthony Daniels, Program Director Date

Revision	Date	Description
0	21 Jun 10	Initial Release

Note: Signatures apply for the latest technical memorandum revision as noted above.

This document has been prepared by **Parsons Brinckerhoff** for the California High-Speed Rail Authority and for application to the California High-Speed Train Project. Any use of this document for purposes other than this Project, or the specific portion of the Project stated in the document, shall be at the sole risk of the user, and without liability to PB for any losses or injuries arising for such use.

System Level Technical and Integration Reviews

The purpose of the review is to ensure:

- Technical consistency and appropriateness
- Check for integration issues and conflicts
-

System level reviews are required for all technical memoranda. Technical Leads for each subsystem are responsible for completing the reviews in a timely manner and identifying appropriate senior staff to perform the review. Exemption to the system level technical and integration review by any subsystem must be approved by the Engineering Manager.

System Level Technical Reviews by Subsystem:

Systems:	<u>Signed document on file</u> Rick Schmedes	<u>4 Jun 10</u> Date
Infrastructure:	<u>Signed document on file</u> Gordon Clark:	<u>14 Jun 10</u> Date
Operations:	<u>Signed document on file</u> Paul Mosier	<u>6 Jun 10</u> Date
Maintenance:	<u>Signed document on file</u> Paul Mosier	<u>6 Jun 10</u> Date
Rolling Stock:	<u>Signed document on file</u> Frank Banko	<u>20 May 10</u> Date

Note: Signatures apply for the technical memorandum revision corresponding to revision number in header and as noted on cover.

TABLE OF CONTENTS

ABSTRACT	1
1.0 INTRODUCTION	2
1.1 PURPOSE OF TECHNICAL MEMORANDUM	2
1.2 STATEMENT OF TECHNICAL ISSUE	2
1.3 GENERAL INFORMATION	2
1.3.1 DEFINITION OF TERMS	2
1.3.2 UNITS.....	3
2.0 DEFINITION OF TECHNICAL TOPIC	3
2.1 GENERAL	3
2.1.1 CHSTP DESIGN CONSIDERATIONS.....	3
2.1.2 CHSTP DESIGN PARAMETERS	3
2.2 CHSTP STANDARD	3
2.2.1 APPLICABILITY	3
2.2.2 REGULATORY REQUIREMENTS	3
2.3 LAWS AND CODES	4
3.0 ASSESSMENT / ANALYSIS	4
3.1 GENERAL	4
3.2 PORTAL INFRASTRUCTURE ELEMENTS	4
3.2.1 NOISE MITIGATION HOOD	4
3.2.2 PORTAL VENTILATION BUILDING	5
3.2.3 POWER FACILITIES.....	5
3.2.4 ACCESS ROAD	6
3.2.5 EMERGENCY VEHICLE ASSEMBLY AND TURNAROUND AREA	6
3.2.6 RESCUE AREA / PASSENGER ASSEMBLY AREA	6
3.2.7 FIRE HYDRANTS AND WATER SUPPLY	6
3.2.8 AREA LIGHTING	7
3.2.9 AREA LIGHTING SHALL ALSO MEET THE REQUIREMENTS OF NFPA. CROSS TRACK EMERGENCY VEHICLE ACCESS	7
3.2.10 PAVED EMERGENCY EGRESS FROM TUNNELS.....	7
3.2.11 TRAIN SURFACE EVACUATION AND FIRE CONTROL ZONE	7
3.2.12 EMERGENCY TELEPHONE FACILITIES	7
3.2.13 OVERHEAD CONTACT SYSTEM MOTORIZED DISCONNECT SWITCH	7
3.2.14 EMERGENCY COMMAND POST	8
3.2.15 COMMUNICATIONS FACILITIES	8
3.2.16 EMERGENCY POWER SUPPLY	8
3.2.17 ROCK FALL AND DEBRIS CONTAINMENT	8
3.2.18 SURFACE DRAINAGE	8
3.2.19 TUNNEL SEEPAGE AND WASH WATER	8
3.2.20 DETENTION POND.....	8
3.2.21 PARKING FOR TUNNEL MAINTENANCE AND TRACTION POWER FACILITY	8

3.2.22	INTRUSION FENCE	9
3.2.23	SECURITY GATES	9
3.2.24	HELICOPTER LANDING PAD	9
3.2.25	LANDSCAPING	9
3.2.26	AESTHETIC TREATMENT OF ROCK AND CONCRETE SURFACES.....	9
3.2.27	PUBLIC UTILITIES.....	9
3.2.28	CROSSOVERS	9
3.3	PORTAL INFRASTRUCTURE REQUIREMENTS FOR DIFFERENT CATEGORIES OF TUNNEL	10
3.3.1	A SHORTER TUNNEL UP TO APPROXIMATELY ONE HALF-MILE IN LENGTH	10
3.3.2	SEVERAL SHORT TUNNELS CLOSE TOGETHER.....	10
3.3.3	SHORTER TUNNEL WITH CONSTRAINED ACCESS	11
3.3.4	TUNNEL LONGER THAN APPROXIMATELY ONE HALF-MILE IN LENGTH:	11
3.3.5	LONGER TUNNEL WITH CONSTRAINED PORTAL ACCESS.....	11
3.4	SITE AREA REQUIREMENTS	12
4.0	SUMMARY AND RECOMMENDATIONS.....	12
5.0	SOURCE INFORMATION AND REFERENCES.....	13
6.0	DESIGN MANUAL CRITERIA.....	18
6.1	HIGH SPEED TRAIN TUNNEL PORTAL FACILITIES	18
6.2	PORTAL INFRASTRUCTURE ELEMENTS.....	18
6.2.1	NOISE MITIGATION HOOD	18
6.2.2	PORTAL VENTILATION BUILDING	18
6.2.3	POWER FACILITIES.....	19
6.2.4	ACCESS ROAD	19
6.2.5	EMERGENCY VEHICLE ASSEMBLY AND TURNAROUND AREA	20
6.2.6	RESCUE AREA / PASSENGER ASSEMBLY AREA	20
6.2.7	FIRE HYDRANTS AND WATER SUPPLY	20
6.2.8	AREA LIGHTING	20
6.2.9	CROSS TRACK EMERGENCY VEHICLE ACCESS.....	20
6.2.10	PAVED EMERGENCY EGRESS FROM TUNNELS.....	21
6.2.11	TRAIN SURFACE EVACUATION AND FIRE CONTROL ZONE	21
6.2.12	EMERGENCY TELEPHONE FACILITIES	21
6.2.13	OVERHEAD CONTACT SYSTEM MOTORIZED DISCONNECT SWITCH	21
6.2.14	EMERGENCY COMMAND POST	21
6.2.15	COMMUNICATIONS FACILITIES	21
6.2.16	EMERGENCY POWER SUPPLY	22
6.2.17	ROCK FALL AND DEBRIS CONTAINMENT.....	22
6.2.18	SURFACE DRAINAGE	22
6.2.19	TUNNEL SEEPAGE AND WASH WATER	22
6.2.20	DETENTION POND.....	22
6.2.21	PARKING FOR TUNNEL MAINTENANCE AND TRACTION POWER FACILITY	22
6.2.22	INTRUSION FENCE	22
6.2.23	SECURITY GATES	22
6.2.24	HELICOPTER LANDING PAD	22
6.2.25	LANDSCAPING	23
6.2.26	AESTHETIC TREATMENT OF ROCK AND CONCRETE SURFACES.....	23
6.2.27	PUBLIC UTILITIES.....	23
6.2.28	CROSSOVERS	23

6.3 PORTAL INFRASTRUCTURE REQUIREMENTS FOR DIFFERENT CATEGORIES OF TUNNEL 23

6.3.1 A SHORTER TUNNEL UP TO APPROXIMATELY ONE HALF-MILE IN LENGTH 23

6.3.2 SEVERAL SHORT TUNNELS CLOSE TOGETHER 24

6.3.3 SHORTER TUNNEL WITH CONSTRAINED ACCESS 24

6.3.4 TUNNEL LONGER THAN APPROXIMATELY ONE HALF-MILE IN LENGTH: 24

6.3.5 LONGER TUNNEL WITH CONSTRAINED PORTAL ACCESS 25

6.4 SITE AREA REQUIREMENTS 25

APPENDICES 25

APPENDIX A INFRASTRUCTURE FOR SINGLE TRACK TUNNEL PORTALS 26

APPENDIX B INFRASTRUCTURE FOR TWIN TRACK TUNNEL PORTALS..... 27

APPENDIX C ADDITIONAL PORTAL FACILITIES..... 28

ABSTRACT

This technical memorandum identifies portal infrastructure to be considered and evaluated for tunnels used exclusively by high-speed passenger trains. The determination of the infrastructure elements required at each tunnel portal will allow for initial estimates of the permanent property needed at portal locations. The estimates of portal infrastructure elements and site area requirements will be used for planning and cost-estimating. Further, decisions on which items of portal infrastructure should be located at portals will be made based on evaluation of the different tunnels and the various portal locations.

Infrastructure elements to be assessed include:

- Portal buildings for ventilation and draft-relief, emergency management and tunnel maintenance
- Special measures such as arch -shaped hoods to mitigate noise radiating from the trains as they enter and exit the tunnels
- Ground-support structures to accommodate the portal cut, including any necessary protection to prevent rock falls, debris or storm water flows from reaching the railway
- Fencing to prevent unauthorized access to the tunnels and to prevent wildlife from entering the portal area
- Access roads to provide emergency, operational, and maintenance access to the portal
- Rescue areas for safe evacuation of passengers in an emergency, for emergency vehicle access and turnaround, and for parking of operations, emergency and maintenance vehicles
- Water supply facilities for fire-protection and tunnel cleaning
- Facilities for handling tunnel drainage and wastewater
- General portal site provisions.

Requirements for communications towers and power substations, which may be sited at portals, are not included in this document,

Several types of tunnel portals are described and are presented in drawings that illustrate the infrastructure elements to be considered. Also included is limited guidance for determining which portal infrastructure elements may or may not be needed at a particular portal.

This memorandum also establishes approximate areas required to accommodate portal structures and portal infrastructure for different tunnel configurations designed for the exclusive use of high-speed trains. The facilities and areas are defined in order to allow determination of property and access requirements at the tunnel portals and for use in developing preliminary cost estimates.

Areas are established only for permanent conditions and do not include the larger areas that may be required for tunnel construction. The identified areas allow for a likely maximum footprint necessary to accommodate ground excavation support structures, which will be confirmed individually based on geology and geography.

1.0 INTRODUCTION

This technical memorandum identifies portal infrastructure elements to be considered and evaluated for each portal of every tunnel on the California High-Speed Train Project (CHSTP) that is to be used exclusively by high-speed passenger trains. It is particularly focused on the tunnels planned to be constructed through the mountainous terrain of the Pacheco Pass, Tehachapi and San Gabriel ranges. Not all items will be required for every portal; and, after study of the different tunnels and the various portal locations, decisions on which items of portal infrastructure should be located at which portals will need to be made.

The different types of tunnel portals considered in this memorandum are described and are presented in drawings that illustrate the infrastructure elements to be considered. Also included is limited guidance for determining which portal infrastructure elements may or may not be needed at a particular portal.

This determination of the different infrastructure elements required at each tunnel portal will allow for initial estimates of the permanent property needed for the portals. The estimates of portal infrastructure elements and site area requirements will be used for planning and cost-estimating during the preliminary design phase.

1.1 PURPOSE OF TECHNICAL MEMORANDUM

This technical memorandum identifies items of portal infrastructure to be evaluated for tunnel portals. Guidance is presented for use in determining which portal infrastructure elements may or may not be needed at a particular portal. The determination of the infrastructure elements required at each tunnel portal will allow for initial estimates of the facilities and permanent property requirements for the portals during the preliminary design phase.

1.2 STATEMENT OF TECHNICAL ISSUE

Portal infrastructure elements must be evaluated for each portal of every tunnel used by high-speed passenger trains. As not all elements will be required for every portal, an assessment of which items of portal infrastructure should be located at each portal will need to be made based on tunnel configuration and portal locations,

This determination of the different infrastructure elements required at each tunnel portal will allow for initial estimates of the permanent property needed for the portals. The estimates of portal infrastructure elements and site area requirements will be used for cost-estimating during the preliminary design phase.

1.3 GENERAL INFORMATION

1.3.1 Definition of Terms

None

Abbreviations

CFR	Code of Federal Regulations
CHSTP	California High-Speed Train Project
HST	High -Speed Train
ID	Internal Diameter
INF	Infrastructure Subsystem
MDS	Motorized Disconnect Switch
NIST	National Institute of Standards and Technology
NFPA	National Fire Protection Association
OCS	Overhead Contact System
PS	Paralleling Station
SEM	Sequential Excavation Method
sf	square feet
SR	System Requirement
SS	Substation

SWS	Switching Station
TM	Technical Memorandum
TPF	Traction Power Facility
TBM	Tunnel Boring Machine
UPS	Uninterruptible Power Supply

1.3.2 Units

The CHSTP is based on U.S. Customary Units consistent with guidelines prepared by the California Department of Transportation (Caltrans) and defined by the National Institute of Standards and Technology (NIST). U.S. Customary Units are officially used in the U.S. and are also known in the U.S. as “English” or “Imperial” units. In order to avoid any confusion, all formal references to units of measure should be made in terms of U.S. Customary Units.

2.0 DEFINITION OF TECHNICAL TOPIC

2.1 GENERAL

This technical memorandum identifies items of portal infrastructure to be considered and evaluated for tunnels in which high-speed passenger trains run exclusively. This document describes the types of tunnel portals and illustrates the infrastructure elements to be considered at each portal location. Guidance is presented for use in determining which infrastructure elements may be needed at a particular portal.

All of the identified infrastructure may be required at both portals for a tunnel, or some elements may only be needed at one portal, with tunnel length being one major determining factor for necessity. Some tunnels may be identified where certain (portal) infrastructure needs to be accommodated at a mid-tunnel access drift or shaft location due to exceptional geography or environmental sensitivity in the portal areas. The determination of the infrastructure elements required at each tunnel portal will allow for preparation of initial estimates of the facilities and permanent property requirements for the portals during the preliminary design phase.

2.1.1 CHSTP Design Considerations

Preliminary design will consider the trade-offs associated with lower grade/longer tunnels versus higher grade/shorter tunnels. Different configurations, including single or twin tunnels, and types of construction, including bored, cut and cover, and mined, will be considered and evaluated. Factors such as fire and life-safety requirements, vehicle aerodynamics, travel time impacts, power usage, costs, construction feasibility, and train operations are to be included in these analyses.

Evaluations and documentation of these considerations will be presented in separate documents.

2.1.2 CHSTP Design Parameters

Design parameters for high-speed train tunnels are under development and are defined in separate documents, including the following technical memoranda (TM):

TM 2.4.2 – Basic Tunnel Configurations

TM 2.4.5 – Tunnel Structural Design

TM 2.4.8 - Service and Maintenance Requirements

2.2 CHSTP STANDARD

2.2.1 Applicability

Assessment of applicability to specific North American and/or California criteria is pending.

2.2.2 Regulatory Requirements

Applicable regulatory requirements are under development.

2.3 LAWS AND CODES

Initial high-speed train (HST) design criteria will be issued in technical memoranda that provide guidance and procedures to advance the preliminary engineering. When completed, a Design Manual will present design standards and criteria specifically for the design, construction and operation of the CHSTP's high-speed railway.

Criteria for design elements not specific to HST operations will be governed by existing applicable standards, laws and codes. Applicable local building, planning and zoning codes and laws are to be reviewed for the stations, particularly those located within multiple municipal jurisdictions, state rights-of-way, and/or unincorporated jurisdictions.

In the case of differing values, the standard followed shall be that which results in the satisfaction of all applicable requirements. In the case of conflicts, documentation for the conflicting standard is to be prepared and approval is to be secured as required by the affected agency for which an exception is required, whether it be an exception to the CHSTP standards or another agency standards.

3.0 ASSESSMENT / ANALYSIS

3.1 GENERAL

Portals for two categories of tunnels are considered in this memorandum when examining portal infrastructure requirements for the HST running tunnels through the mountain ranges. The tunnels are:

1. Twin single-track tunnels: each approximately 29.5 feet internal diameter (ID), to be driven by tunnel boring machine (TBM), with a pillar between tunnels approximately one diameter wide at the portals, and with cover at the portals ranging from one-half-diameter to one-diameter thick. Cross-passages will be constructed for safety egress purposes (at a spacing yet to be determined) to allow passenger evacuation to the portals through the non-incident tunnel. [Reference drawings attached in Appendix A]
2. A single double-track tunnel: constructed by sequential excavation method (SEM) mining, with an internal width of approximately 49 feet and with cover at the portals ranging from one-half-the-excavated width to the excavated-width thick. A central, fire-rated dividing wall will separate the single tunnel into two independently ventilated railways, and safety egress will be achieved via doorways through the dividing wall (at spacing yet to be determined). The doorways will be fitted with sliding, fire-rated doors. Passenger evacuation will be to the portals through the non-incident railway. [Reference drawings attached in Appendix B]

A tunnel constructed by cut-and-cover methods, if determined to be appropriate, would likely have portal infrastructure requirements similar to the single double-track tunnel [(2) above and illustrated in Appendix B].

3.2 PORTAL INFRASTRUCTURE ELEMENTS

All infrastructure elements listed in Section 3.2 shall be considered and evaluated for potential inclusion at each tunnel portal in the HST system. Not all items will be necessary at every portal. Following assessment, decisions will need to be made on which items should be located at which portal. Guidance on whether or not a particular element of infrastructure should be included at a particular portal is provided in Section 3.3.

3.2.1 Noise Mitigation Hood

Portals may need to provide space to accommodate a smooth tapered hood (trumpet) designed to mitigate aerodynamic noise (sonic boom) effects. This hood may be up to 150 feet long.

The face of the hood-structure (if provided) will be inclined at least 45 degrees from the vertical for noise mitigation purposes.

It is possible that tunnels more than 2 miles in length will need portal hood-structures at least 65 feet long designed for pressure-relief. Under these circumstances, the free-area cross-sectional area at the open end of the hood may need to be at least 1.5 times the free-area cross-sectional area of the tunnel. Two pressure-relief openings each with minimum area of approximately 100 sf may be needed into each railway within the length of the pressure-relief structure. These openings may vent into the adjacent railway or via ducts directly to the open air.

3.2.2 Portal Ventilation Building

Other than short tunnels of approximately one half-mile or less in length, which might employ jet-fans located within the tunnels or in locally widened-areas of the tunnels to dissipate smoke, all tunnels may need assemblies of fans located in ventilation buildings located at the tunnel portals. Alternatively, fans may be located at mid-line ventilation shafts or inclined ventilation tunnels to enable smoke to be extracted from the tunnels as described in NFPA 130,-7.1.2.2 Mechanical Emergency Ventilation.

Portal ventilation buildings will require direct access to the tunnels and will normally be located immediately over the tunnel portals.

The footprint of tunnel portal ventilation buildings may be approximately 7500 sf, and extend to two or three floors or 50 feet or more in height. Heights of individual rooms will vary according to equipment planned to be installed.

The buildings will be designed to blend into the natural surroundings as much as practical. Landscaped backfill and embankments may be employed with appropriate vegetation.

3.2.3 Power Facilities

3.2.3.1 Traction Power

It is planned that a Traction Power Facility (TPF) will be located at approximately five-mile intervals along the length of the alignment. TPFs include Substations (SS), Switching Stations (SWS) and Paralleling Stations (PS). Substations will be approximately 30-miles apart, as will Switching Stations.

The sequence of TPF installations will normally be:

SS – PS – PS – SWS – PS – PS – SS

The TPFs will be located immediately adjacent to or within approximately 100 feet of the track, and will require external road access.

TPFs should be located away from tunnels to the extent possible. It is preferred that substations and switching stations are located at least two miles from tunnel portals. If a TPF must be located near a portal, it shall be located no closer than one train length (approximately 1350 feet) from an Emergency Vehicle Assembly Area. Alternately, if no space is available at the preferred locations, TPFs may be located in a shared use building at the tunnel portal. In this location, traction power, switch gear, control room and other equipment may be located in the building having approximately 40,000 sf floor area. Traction powers substation transformers shall be located outside and immediately adjacent to the shared use building facility. The main gantry and strain gantry shall in all cases be located a minimum of 1350 from the portal entrance.

Traction Power Substations require connection to a high-voltage utility supply and this requirement will have a deciding influence on whether or not a particular portal is a suitable location.

3.2.3.2 Fixed Facility Power

High or low voltage power will be required to operate fixed tunnel and tunnel portal infrastructure. For preliminary design and to assure reasonable, maximum-conceivable space requirements are identified.

Fixed facility power will be located in a shared use building facility constructed above the tracks at the tunnel portal. This building might also include tunnel maintenance and other facilities. Under

these circumstances, the floor area of the building required to house the combined facilities, including traction power, may total approximately 40,000 sf and be spread over at least three floor-levels. Details of equipment which might be housed in the building have been included in Appendix C of this Technical Memorandum. Heavy equipment such as transformers and generators may be housed separately at ground level, with working access to the site access road to better accommodate installation and future replacement.

3.2.4 Access Road

Road access to portals must be considered for use by emergency responders, for evacuating passengers and for maintenance staff access.

Paved roadway or track-bed will be provided to enable emergency response staff and equipment to reach the tunnel portal from the access road and emergency-vehicle assembly and turn-around areas. Separate paved walkways will be provided to enable passengers to egress the tunnel under emergency conditions without conflict with emergency responders.[Reference Section 3.2.9 and 3.2.10, and Appendices A and B] .

Minimum width of access roadways within the fenced site area will be 18 ft to allow emergency vehicles to safely pass anywhere within the site.

If a length of access road outside the site area is less than 18 ft wide, then adequate passing areas will need to be provided.

If a TPF is located in proximity to a tunnel portal where road access has been established for other purposes, the TPF may make use of the same access road. Access roads will extend through the fenced portal site area to within approximately 100 ft of the tunnel portal.

3.2.5 Emergency Vehicle Assembly and Turnaround Area

Assembly and turn-around areas for emergency vehicles will be provided adjacent to the tunnel portal, at the end of the access road within the fenced portal area.

- Emergency vehicle assembly areas should be located within approximately 100 feet of the tunnel portal.
- A 75 feet x 75 feet area will be provided as a minimum for an emergency vehicle assembly and turn-around area.
- An emergency vehicle assembly and turn-around area located on each side of the twin tracks at the tunnel portal should be provided if practical.

3.2.6 Rescue Area / Passenger Assembly Area

A Rescue Area / Passenger Assembly Area will be provided as close as practical to the tunnel portal.

- The Rescue Area will be a minimum of 5000 sf.
- The Rescue Area will be close and with good access to the Site Access Road.
- The Rescue Area will be well lit.

3.2.7 Fire Hydrants and Water Supply

A water supply for tunnel fire-fighting purposes will be provided to points near the Emergency Vehicle Assembly Areas.

Hydrants connected to adequate public water-supply systems or alternative permitted water supply of 130 cubic yards (minimum) will be provided adjacent to the Emergency Vehicle Assembly Areas.

The water supply system will be capable of providing a minimum of 500 gpm at a residual pressure of 100 psig, for a period of at least 2 hours.

3.2.8 Area Lighting

Lighting systems will be provided so that during a train evacuation, illumination levels at the ground surface of the portal site area can be maintained at no less than 1.5 ft-candles (16) lux in the following areas:

- Passenger Assembly / Rescue Area
- Evacuation route from portal to Rescue Area
- Evacuation route from the train in the Surface Evacuation Zone to the Rescue Area
- Emergency Vehicle Assembly and Turn-around Area
- Helicopter Landing Area (where provided)
- Access Road within the fenced portal site area.

3.2.9 Area lighting shall also meet the requirements of NFPA. Cross Track Emergency Vehicle Access

Provide paved access roads across the tracks for emergency vehicle use only, which connect the emergency vehicle assembly area to each tunnel railway for emergency vehicle access to the tunnels.

Provide access for Hi-Rail emergency vehicles to be placed on either track.

3.2.10 Paved Emergency Egress from Tunnels

A well-lit paved walkway outside the tunnel portal will connect the tunnel safety walkways to the Passenger Assembly / Rescue Area.

The emergency egress walkway will be a minimum 10 ft wide (3m).

3.2.11 Train Surface Evacuation and Fire Control Zone

A Train Surface Evacuation and Fire Control Zone may be established immediately outside a tunnel portal where a train exiting a tunnel under emergency conditions can stop to allow passengers to safely disembark, and which will allow emergency responders to reach the train for fire-fighting purposes or to deal with other emergency situations.

- The zone will be at least 1350 feet long to allow a full-length train to be accommodated.
- The zone will have minimum 10-foot wide paved access-ways extending the length of the zone on both sides of the tracks to allow rapid emergency egress of the passengers from the train to the Rescue Area / Passenger Assembly Area, and to allow emergency responders external access to all parts of a train stopped on either track.
- Fire hydrants will be located to adequately support emergency operations anywhere within the zone, or arrangements will be made for other permitted water supply to be available for fire-fighting purposes anywhere within the zone.

3.2.12 Emergency Telephone Facilities

Emergency telephones will be provided within immediate proximity to the portal area Emergency Vehicle Assembly and the Passenger Assembly / Rescue Areas.

Emergency telephones at the portal will connect to emergency phones located within the tunnel and to the Operations Control Center.

Emergency Responders may have access to separate, secure communications systems that are entirely independent from these facilities which are intended to be readily available to patrons and staff under emergency conditions, and for use of maintenance personnel.

3.2.13 Overhead Contact System Motorized Disconnect Switch

A protected motorized disconnect switch (MDS) for the overhead contact system (OCS) will be provided in close proximity to the tunnel portal for use by authorized emergency responders. A

Wayside Power Control Cubicle (WPC) shall be provided to support the disconnect and grounding switches, 10 ft x 8 ft in plan area.

3.2.14 Emergency Command Post

An Emergency Command Post will be established in a portal area. It will be located as close as practical to the Tunnel Portal, Emergency Vehicle Assembly Area, and Rescue Area / Passenger Assembly Areas.

The Emergency Command Post location will be well-lighted using site area lighting. It will contain an Emergency Telephone, OCS motorized disconnect switch, portal lighting controls and sufficient elements of a public address system to adequately support emergency responders.

A Ventilation Control Panel (VCP) which allows Fire Department personnel to ascertain the status, and operate the tunnel emergency ventilation system may also be installed at the Emergency Command Post, particularly if a Portal Ventilation Building is not located at that portal.

3.2.15 Communications Facilities

All necessary facilities to support emergency and non-emergency communications transmissions between the portal area and HST operations (which might include radio, telephone and fiber-optic cable capability) will be provided. A Communications Tower may be required to assure reliable transmission.

3.2.16 Emergency Power Supply

Emergency back-up generators sufficient to support equipment assembled within the portal area facilities that require an Uninterruptible Power Supply (UPS) service will be provided

3.2.17 Rock fall and Debris Containment

Where necessary, construct rock fall and debris diversion or containment features (traps) utilizing trench excavations and berms to positively assure that no rocks, rock-slides or other debris such as soil or snow-slides from mountain slopes above the portal area can reach the tracks or damage equipment or structures. Appropriate simulation-software may be used to support determination of trench depths and fence sizes.

Where a portal opens directly from a very steep slope or cliff, such that a simple rock trap is not practical, then the noise mitigation hood or other hood protection will be extended far enough from the face of the cliff to protect the tracks and other structures. These protective structures need to be designed to withstand impact loads from all rock falls or slides that can be reasonably anticipated.

Each individual situation must be evaluated through extensive, site-specific risk-assessment analysis.

3.2.18 Surface Drainage

Surface run-off from disturbed site-areas will be routed to a detention pond to prevent contamination of area groundwater.

3.2.19 Tunnel Seepage and Wash water

Tunnel seepage water, wash-water from any tunnel cleaning, and water from a fire-fighting incident, system-test, or a pipe-leak will be routed through a detention pond or directly to a local sanitary sewer if available.

3.2.20 Detention Pond

A detention pond of adequate size will be constructed to handle run-off quantities calculated for the individual portal locations

3.2.21 Parking for Tunnel Maintenance and Traction Power Facility

Separate parking away from the emergency parking areas will be provided for maintenance staff for tunnels and other site facilities.

3.2.22 Intrusion Fence

The portal site area and facilities will be completely surrounded by a security fence. The height and profile of the fence will vary depending on location and on the facilities contained within the particular portal area.

- Code of Federal Regulations (CFR) Section 213.361 addresses Right of Way fencing for areas outside tunnels. This subject is covered in System Requirements – Infrastructure (SR INF) 3-22 Control of access to or intrusion into HST line installations.
- TM 2.2.8 – Access Control for High-Speed Rail Right-of-Way and Facilities.

3.2.23 Security Gates

Security gates will be provided in the intrusion protection fence across the site access road.

- Gates will match the height and security requirements of the fence. Requirements for control of access will be developed in TM 2.2.8 – Access Control for High-Speed Rail Right-of-Way and Facilities.
- CFR Section 213.361 addresses access gates in Right of Way fencing for areas outside tunnels. This subject is covered in SR INF 3-22 Control of access to or intrusion into HST line installations.

3.2.24 Helicopter Landing Pad

A helicopter landing pad will not usually be required at a tunnel portal. In emergencies, medical/rescue aircraft or security helicopters will land on an Emergency Vehicle Assembly Area, another site parking area, or on the Access Road.

If a particularly remote portal area is identified where emergency access is required, but where road access is considered impractical, then a helicopter landing area will be established.

- A helicopter landing pad will measure a minimum of 65 ft x 65 ft.;
- The area will be well lighted;
- The landing pad will be sited adequately clear of flight hazards, such as towers.

3.2.25 Landscaping

Landscaping with backfilling, grading and vegetation might be employed to help blend structures into the surrounding natural condition.

Access will be provided to allow maintenance of landscape vegetation.

3.2.26 Aesthetic Treatment of Rock and Concrete Surfaces

Freshly-exposed rock surfaces in portal excavations planned to be left permanently exposed may be treated to appear naturally-formed and weathered.

Concrete or shotcrete surfaces may be colored and sculpted to blend into the surrounding landscape.

3.2.27 Public Utilities

Public utilities to be considered for servicing the portal site areas may include water, electricity, telephone and sewers.

3.2.28 Crossovers

The proximity of crossover tracks to the different tunnel portals needs to be carefully assessed so that single-track working can be maintained effectively through the tunnels during emergencies and when one tunnel railway is closed for major maintenance or repair.

3.3 PORTAL INFRASTRUCTURE REQUIREMENTS FOR DIFFERENT CATEGORIES OF TUNNEL

Not every item of infrastructure described in the preceding Section 3.2 will be required at every HST tunnel portal. The following sections provide general guidance in determining which of these elements of portal infrastructure may or may not be required at a particular tunnel portal, or under certain circumstances, where some listed items of “portal” infrastructure may need to be located some distance from a portal.

The principal factors which will influence the decision are:

- length of tunnel;
- proximity of one tunnel to another;
- accessibility to portal locations; and
- environmental impacts at a portal location.

Any particular tunnel portal may have additional site-specific requirements.

3.3.1 A Shorter Tunnel up to Approximately One Half-Mile in Length

All infrastructure listed in Section 3.2 should be considered for one of the two portals [except for tunnel emergency ventilation which will probably be accomplished by jet-fans within the shorter tunnel and consequently the need for a portal ventilation building (3.2.2) would be unlikely].

The following items would need to be considered for the second portal:

- Noise mitigation hood (3.2.1)
- Intrusion protection fence (3.2.22)
- Rock fall and debris containment (3.2.17)
- Surface drainage (3.2.18)
- Tunnel seepage and wash water (3.2.19) [If downgrade from the other portal which was preferred for the principal infrastructure installations]
- Detention pond (3.2.20) [If downgrade from the other portal]
- Area lighting (3.2.8) [Assumes temporary passenger assembly might be needed on the tracks outside the portal prior to relocating through the non-incident tunnel to the Rescue Area at the other portal]
- Landscaping (3.2.25)
- Aesthetic treatment of rock and concrete surfaces (3.2.26)
- Emergency telephone facilities (3.2.12)
- OCS Motorized Disconnect Switch (3.2.13)

3.3.2 Several Short Tunnels Close Together

For a group of short tunnels close together, all portal infrastructure emergency facilities (as listed in Section 3.2) that are provided for one portal of one tunnel may serve the emergency requirements of several tunnels provided that:

1. such emergency facilities are spaced no further apart than approximately one-and-one-half to two miles (3000m), and;
2. emergency access and egress to required standards can be provided from the location where the emergency facilities have been located, along paved track-slab extending through and between the several tunnels, or along an adjacent roadway.

Other tunnel portals in the group of short tunnels will consider the particular infrastructure items separately listed in Section 3.3.1.

3.3.3 Shorter Tunnel with Constrained Access

A shorter tunnel up to approximately one-half mile in length with physical conditions at both portals that prevent construction of required permanent emergency access and egress infrastructure elements (Section 3.2), or where exceptional environmental conditions exist which render this construction unacceptable will require additional elements and considerations.

To serve the tunnel under these circumstances, all permanent emergency infrastructure elements listed in Section 3.2 shall be provided to each portal, or to a location along the track within one half-mile of each portal, provided that emergency access and egress to required standards can be provided to the tunnel from the location where emergency facilities have been located, along paved track-slab or along an adjacent roadway

At each portal, the following elements are required to be considered at the immediate location of the portal:

- Noise mitigation hood (3.2.1)
- Intrusion protection fence (3.2.22)
- Rock fall and debris containment (3.2.17)
- Surface drainage (3.2.18)
- Area lighting (3.2.8)
- Landscaping (3.2.25)
- Aesthetic treatment of rock and concrete surfaces (3.2.26)
- Emergency telephone facilities (3.2.12)
- OCS Motorized Disconnect Switch (3.2.13)

3.3.4 Tunnel Longer than Approximately one half-mile in length:

Infrastructure listed in Section 3.2 shall be considered for both portals, including the need for portal ventilation buildings at both portals. Tunnel seepage and wash water (Section 3.2.19) and Detention Pond (Section 3.2.20) requirements normally only need to be considered at the portal at lower elevation.

3.3.5 Longer Tunnel with Constrained Portal Access

Where a tunnel more than one half-mile in length has physical conditions at one or both of the portals which prevent construction of required permanent emergency access and egress infrastructure elements (Section 3.2), or where exceptional environmental conditions exist which render this construction unacceptable:

1. Provide all permanent emergency access and egress infrastructure elements (Section 3.2) at an unaffected portal.
2. Provide all permanent emergency infrastructure elements (Section 3.2) to each portal or to a location on the track within one half-mile of portals, provided that emergency access and egress to required standards can be provided to the tunnel along paved track-slab or along an adjacent roadway from the location where the emergency facilities have been located. Alternatively, provide emergency access and egress via a mid-line tunnel rescue shaft or rescue tunnel located within one half-mile of affected portals.
3. The infrastructure elements which are listed in Section 3.3.3 as requiring consideration at both portals of a shorter tunnel with constrained access similarly require consideration at both portals of a longer tunnel with constrained access.

A design variance is required if access to both tunnel portals cannot be provided,

3.4 SITE AREA REQUIREMENTS

The examination of portal requirements indicates that a single tunnel portal area, if equipped with all elements of infrastructure considered necessary and listed herein, would require at least 6.5 acres of usable site area. This area does not include the area of widened trackway outside the portal area proper, which extends for approximately 1100 feet further away from the portal to accommodate the train surface evacuation zone. More significantly for tunnels in mountainous areas, it does not include any unusable site area which may have to be incorporated into the fenced portal area in order to obtain the required amount of usable area.

However, tunnels shorter than one-half mile long are not required to accommodate the entire portal infrastructure and would not require the full 6.5 acres. Thus, an allowance of 6.5 to 7 acres per portal may be an appropriate assumption until specific tunnel lengths and locations can be identified. Areas for new access roads outside the fenced portal areas would be in addition to the 6.5 to 7 acres.

4.0 SUMMARY AND RECOMMENDATIONS

It is recommended that all tunnels carrying high-speed trains be assessed for the installation of the portal and support facilities identified in Section 6.1 of this technical memorandum.

It is recognized that many of the tunnels and tunnel portal locations will be subject to revision as the design advances. Accordingly, it is recommended that environmental clearance be obtained for a footprint that is inclusive of all potential portal facilities with the anticipation that facility requirements at specific tunnel portals sites may be eliminated as design advances in conjunction with site-specific hazard analysis and risk assessment.

5.0 SOURCE INFORMATION AND REFERENCES

This Technical Memorandum has drawn on the following documentation in its development:

1. CHSTP Technical Memorandum 2.4.2 - Basic High-Speed Train Tunnel Configuration
2. CHSTP Technical Memorandum 3.1.1.3: Draft Traction Power Facilities, General Standardization Requirements
3. Taiwan High Speed Rail Corporation Civil Works Volume 9 Design Specifications:
 - 3.1. Section 6 : Tunnel Design Specification
 - 3.2. Section 8: System Safety and System-wide Interface Design Specification
4. CHSTP System Requirements
 - 4.1. SR 4-02.6 - Facilities for self-rescue, evacuation and rescue in the event of an incident
 - 4.2. SR 4-02.8 - Emergency lighting on evacuation routes in tunnels
 - 4.3. SR 4-02.10 - Emergency communications
 - 4.4. SR 4-02.11 - Access for Rescue Services
 - 4.5. SR 4-02.12 - Rescue areas outside tunnels
 - 4.6. SR 4-02.13 - Water supply for fire-fighting
5. CHSTP Memoranda
 - 5.1. Environmental Document – High Speed Train Tunnels Description, March 29, 2010
 - 5.2. Schmedes to Thompson, Mar.02, 2010: “Provisional System Requirements for Accommodation at Tunnel Portals and in Tunnels”
 - 5.3. CHSTP Technical Memorandum 2.2.8 – Access Control for High-Speed Rail Right-of-Way and Facilities, Draft, June 2010.
6. Detailed Cross References

TM Section	Portal Infrastructure Element	Reference		
		No.	Documentation	Additional Information
3.1	General	1	CHSTP Technical Memorandum 2.4.2 - Basic High-Speed Train Tunnel Configuration	-
3.2.1	Noise Mitigation Hood	3.1	Taiwan High Speed Rail Corporation Civil Works Volume 9 Design Specifications	Section 6.3 Portals
		5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 6: Tunnel Portals
3.2.2	Portal Ventilation Building	5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 5: Ventilation
				Page 6: Ventilation Buildings
3.2.3	Traction Power Facility	2	CHSTP Technical Memorandum 3.1.1.3: Draft Traction Power Facilities, General Standardization Requirements	-

		5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 7
3.2.4	Access Road	3.2	Taiwan High Speed Rail Corporation Civil Works Volume 9 Design Specifications	Section 8.3.5 Safety Rescue Area and Access Requirements
		4.1	SR 4-02.6 - Facilities for self-rescue, evacuation and rescue in the event of an incident	-
		4.4	SR 4-02.11 - Access for Rescue Services	-
3.2.5	Emergency Vehicle Assembly and Turnaround Area	3.2	Taiwan High Speed Rail Corporation Civil Works Volume 9 Design Specifications	Section 8.3.5 Safety Rescue Area and Access Requirements
		4.5	SR 4-02.12 - Rescue areas outside tunnels	-
3.2.6	Rescue Area / Passenger Assembly Area	3.2	Taiwan High Speed Rail Corporation Civil Works Volume 9 Design Specifications	Section 8.3.5 Safety Rescue Area and Access Requirements
		4.5	SR 4-02.12 - Rescue areas outside tunnels	-
		5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 7: Rescue, Parking and Storage Areas
3.2.7	Fire Hydrants and Water Supply	4.5	SR 4-02.12 - Rescue areas outside tunnels	-
		4.6	SR 4-02.13 - Water supply for fire-fighting	-
3.2.8	Area Lighting	4.2	SR 4-02.8 - Emergency lighting on evacuation routes in tunnels	-
		4.5	SR 4-02.12 - Rescue areas outside tunnels	-
		5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 7: Lighting
3.2.9	Cross track Emergency Vehicle Access	4.4	SR 4-02.11 - Access for Rescue Services	-
3.2.10	Paved Emergency Egress from Tunnels	3.2	Taiwan High Speed Rail Corporation Civil Works Volume 9 Design Specifications	Section 8.3.5 Safety Rescue Area and Access Requirements
3.2.11	Train Surface Evacuation and Fire Control Zone	3.2	Taiwan High Speed Rail Corporation Civil Works Volume 9 Design Specifications	Section 8.3.5 Safety Rescue Area and Access Requirements

3.2.12	Emergency Telephone Facilities	3.2	Taiwan High Speed Rail Corporation Civil Works Volume 9 Design Specifications	Section 8.3.5 Safety Rescue Area and Access Requirements
		4.3	SR 4-02.10 - Emergency communications	-
3.2.13	OCS Motorized Disconnect Switch (MDS)	2	CHSTP Technical Memorandum 3.1.1.3: Draft Traction Power Facilities, General Standardization Requirements	-
		5.2	CHSTP Memorandum: Schmedes to Thompson, Mar. 02, 2010: "Provisional System Requirements for Accommodation at Tunnel Portals and in Tunnels"	Page 2: OCS Motorized Disconnect Switch
3.2.14	Emergency Command Post	4.3	SR 4-02.10 - Emergency communications	[NFPA 130: 9.8; 10.2]
3.2.15	Communications Facilities	4.3	SR 4-02.10 - Emergency communications	-
		5.2	CHSTP Memorandum: Schmedes to Thompson, Mar.02, 2010: "Provisional System Requirements for Accommodation at Tunnel Portals and in Tunnels"	Page 3: Communications
3.2.16	Emergency Power Supply	5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 7: Utilities
3.2.17	Rock fall and Debris Containment	3.1	Taiwan High Speed Rail Corporation Civil Works Volume 9 Design Specifications	Section 6.3.1 (f)
3.2.18	Surface Drainage	5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 7: Waste water
3.2.19	Tunnel Seepage and Wash-water	5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 7: Waste water
3.2.20	Detention Pond	5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 7: Waste water
3.2.21	Parking for Tunnel Maintenance and Traction Power Facility	2	CHSTP Technical Memorandum 3.1.1.3: Draft Traction Power Facilities, General Standardization Requirements	-

		5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 7: Rescue Areas, Parking and Storage
3.2.22	Intrusion Protection Fence	3.2	Taiwan High Speed Rail Corporation Civil Works Volume 9 Design Specifications	Section 8.9.2 Security Fencing
		5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 7: Fencing
		6.0	CHSTP Technical Memorandum 2.2.8 – Access Control for High-Speed Rail Right-of-Way and Facilities, Draft, June 2010.	Section 6.3.9: Trackway Underground
3.2.23	Security Gates	3.2	Taiwan High Speed Rail Corporation Civil Works Volume 9 Design Specifications	Section 8.9.2 Security Fencing
		5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 7: Fencing
		6.0	CHSTP Technical Memorandum 2.2.8 – Access Control for High-Speed Rail Right-of-Way and Facilities, Draft, June 2010.	Section 6.3.9: Trackway Underground
3.2.24	Helicopter Landing Pad	4.1	SR 4-02.6 - Facilities for self-rescue, evacuation and rescue in the event of an incident	[UIC Code 779-9:1-63]
		5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 7: Rescue Areas, Parking and Storage
3.2.25	Landscaping	3.1	Taiwan High Speed Rail Corporation Civil Works Volume 9 Design Specifications	Section 6.3.1 Principles of Portal Layouts (h) & (i)
		5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 6: Tunnel Portals
3.2.26	Aesthetic Treatment of Rock and Concrete Surfaces	5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 6: Tunnel Portals
3.2.27	Public Utilities	4.6	SR 4-02.13 - Water supply for fire-fighting	-

		5.1	CHSTP Memorandum - Environmental Document – High Speed Train Tunnels Description, March 29, 2010	Page 7: Utilities
3.3	Portal Infrastructure Requirements for Different Categories of Tunnel	3.2	Taiwan High Speed Rail Corporation Civil Works Volume 9 Design Specifications	Section 8.3.1 Egress Location Requirements

6.0 DESIGN MANUAL CRITERIA

6.1 HIGH SPEED TRAIN TUNNEL PORTAL FACILITIES

Portals for two categories of tunnels are considered in this memorandum when examining portal infrastructure requirements for the HST running tunnels through the mountain ranges. The tunnels are:

1. Twin single-track tunnels: each approximately 29.5 feet internal diameter (ID), to be driven by tunnel boring machine (TBM), with a pillar between tunnels approximately one diameter wide at the portals, and with cover at the portals ranging from one-half-a-diameter to one-diameter thick. Cross-passages will be constructed for safety egress purposes (at a spacing yet to be determined) to allow passenger evacuation to the portals through the non-incident tunnel. [Reference drawings attached in Appendix A]
2. A single double-track tunnel: constructed by sequential excavation method (SEM) mining, with an internal width of approximately 49 feet and with cover at the portals ranging from one-half-the-excavated width to the excavated-width thick. A central, fire-rated dividing wall will separate the single tunnel into two independently ventilated railways, and safety egress will be achieved via doorways through the dividing wall (at spacing yet to be determined). The doorways will be fitted with sliding, fire-rated doors. Passenger evacuation will be to the portals through the non-incident railway. [Reference drawings attached in Appendix B]

A tunnel constructed by cut-and-cover methods, if determined to be appropriate, would likely have portal infrastructure requirements similar to the single double-track tunnel [(2) above and illustrated in Appendix B].

6.2 PORTAL INFRASTRUCTURE ELEMENTS

All infrastructure elements listed in Section 6.2 shall be considered and evaluated for potential inclusion at each tunnel portal in the HST system. Not all items will be necessary at every portal. Following assessment, decisions will need to be made on which items should be located at which portal. Guidance on whether or not a particular element of infrastructure should be included at a particular portal is provided in Section 6.3.

6.2.1 Noise Mitigation Hood

Portals may need to provide space to accommodate a smooth tapered hood (trumpet) designed to mitigate aerodynamic noise (sonic boom) effects. This hood may be up to 150 feet long.

The face of the hood-structure (if provided) will be inclined at least 45 degrees from the vertical for noise mitigation purposes.

It is possible that tunnels more than 2 miles in length will need portal hood-structures at least 65 feet long designed for pressure-relief. Under these circumstances, the free-area cross-sectional area at the open end of the hood will need to be at least 1.5 times the free-area cross-sectional area of the tunnel. Two pressure-relief openings each of 108 sf minimum area will be needed into each railway within the length of the pressure-relief structure. These openings may vent into the adjacent railway or via ducts directly to the open air.

6.2.2 Portal Ventilation Building

Other than short tunnels of approximately one half-mile or less in length, which might employ jet-fans located within the tunnels or in locally widened-areas of the tunnels to dissipate smoke, longer tunnels may need assemblies of fans located in ventilation buildings located at the tunnel portals and/or located at mid-line ventilation shafts or inclined ventilation tunnels to enable smoke to be extracted from the tunnels.

Portal ventilation buildings will require direct access to the tunnels and will normally be located immediately over the tunnel portals.

The footprint of tunnel portal ventilation buildings may be approximately 7500 sf, and extend to two or three floors or up to 50 feet or more in height.

The buildings will be designed to blend into the natural surroundings as much as practical. Landscaped backfill and embankments may be employed with appropriate vegetation.

6.2.3 Power Facilities

6.2.3.1 Traction Power

It is planned that a Traction Power Facility (TPF) will be located at approximately five-mile intervals along the length of the alignment. TPFs include Substations (SS), Switching Stations (SWS) and Paralleling Stations (PS). Substations will be approximately 30-miles apart, as will Switching Stations.

The sequence of TPF installations will normally be:

SS – PS – PS – SWS – PS – PS – SS

The TPFs will be located immediately adjacent to or within approximately 100 feet of the track, and will require external road access.

TPFs should be located away from tunnels to the extent possible. It is preferred that substations and switching stations are located at least two miles from tunnel portals. If a TPF must be located near a portal, it shall be located no closer than one train length (approximately 1350 feet) from an Emergency Vehicle Assembly Area. Alternately, if no space is available at the preferred locations, TPFs may be located in a shared use building at the tunnel portal. In this location, traction power, switch gear, control room and other equipment may be located in the building having approximately 40,000 sf floor area. Traction powers substation transformers shall be located outside and immediately adjacent to the shared use building facility. The main gantry and strain gantry shall in all cases be located a minimum of 1350 from the portal entrance.

Traction Power Substations require connection to a high-voltage utility supply and this requirement will have a deciding influence on whether or not a particular portal is a suitable location.

6.2.3.2 Fixed Facility Power

High or low voltage power will be required to operate fixed tunnel and tunnel portal infrastructure. For preliminary design and to assure reasonable, maximum-conceivable space requirements are identified.

Fixed facility power will be located in a shared use building facility constructed above the tracks at the tunnel portal. This building might also include tunnel maintenance and other facilities. Under these circumstances, the floor area of the building required to house the combined facilities, including traction power, may total approximately 40,000 sf and be spread over at least three floor-levels. Details of equipment which might be housed in the building have been included in Appendix C of this Technical Memorandum. Heavy equipment such as transformers and generators may be housed separately at ground level, with working access to the site access road to better accommodate installation and future replacement.

6.2.4 Access Road

Road access to portals must be considered for use by emergency responders, for evacuating passengers and for maintenance staff access. Access roads will extend through the fenced portal site area to within approximately 100 ft of the tunnel portal.

Paved roadway or track-bed will be provided to enable emergency response staff and equipment to reach the tunnel portal from the access road and emergency-vehicle assembly and turn-around areas. Separate paved walkways will be provided to enable passengers to egress the tunnel under emergency conditions without conflict with emergency responders. Minimum width of access roadways within the fenced site area will be 18 ft to allow emergency vehicles to safely pass anywhere within the site.

If a length of access road outside the site area is less than 18 ft wide, then adequate passing areas will need to be provided.

If a TPF is located in proximity to a tunnel portal where road access has been established for other purposes, the TPF may make use of the same access road.

6.2.5 Emergency Vehicle Assembly and Turnaround Area

If required, assembly and turn-around areas for emergency vehicles will be provided adjacent to the tunnel portal, at the end of the access road within the fenced portal area.

- Emergency vehicle assembly areas should be located within approximately 100 feet of the tunnel portal.
- A 75 feet x 75 feet area will be provided as a minimum for an emergency vehicle assembly and turn-around area.
- An emergency vehicle assembly and turn-around area located on each side of the twin tracks at the tunnel portal should be provided if practical.

6.2.6 Rescue Area / Passenger Assembly Area

If required, a Rescue Area / Passenger Assembly Area will be provided as close as practical to the tunnel portal.

- The Rescue Area will be a minimum of 5000 sf.
- The Rescue Area will be close and with good access to the Site Access Road.
- The Rescue Area will be well lit.

6.2.7 Fire Hydrants and Water Supply

If required, a water supply for tunnel fire-fighting purposes will be provided to points near the Emergency Vehicle Assembly Areas.

Hydrants connected to adequate public water-supply systems or alternative permitted water supply of 130 cubic yards (minimum) will be provided adjacent to the Emergency Vehicle Assembly Areas.

The water supply system will be capable of providing a minimum of 500 gpm at a residual pressure of 100 psig, for a period of at least 2 hours.

6.2.8 Area Lighting

Lighting systems will be provided so that during a train evacuation, illumination levels at the ground surface of the portal site area can be maintained at no less than 1.5 ft-candles (16) lux in the following areas:

- Passenger Assembly / Rescue Area
- Evacuation route from portal to Rescue Area
- Evacuation route from the train in the Surface Evacuation Zone to the Rescue Area
- Emergency Vehicle Assembly and Turn-around Area
- Helicopter Landing Area (where provided)
- Access Road within the fenced portal site area.

Area lighting shall also meet the requirements of NFPA.

6.2.9 Cross Track Emergency Vehicle Access

Provide paved access roads across the tracks for emergency vehicle use only, which connect the emergency vehicle assembly area to each tunnel railway for emergency vehicle access to the tunnels.

Provide access for Hi-Rail emergency vehicles to be placed on either track.

6.2.10 Paved Emergency Egress from Tunnels

A well-lit paved walkway outside the tunnel portal will connect the tunnel safety walkways to the Passenger Assembly / Rescue Area.

The emergency egress walkway will be a minimum 10 ft wide.

6.2.11 Train Surface Evacuation and Fire Control Zone

A Train Surface Evacuation and Fire Control Zone may be established immediately outside a tunnel portal where a train exiting a tunnel under emergency conditions can stop to allow passengers to safely disembark, and which will allow emergency responders to reach the train for fire-fighting purposes or to deal with other emergency situations.

- The zone will be at least 1350 feet long to allow a full-length train to be accommodated.
- The zone will have minimum 10 foot wide paved access-ways extending the length of the zone on both sides of the tracks to allow rapid emergency egress of the passengers from the train to the Rescue Area / Passenger Assembly Area, and to allow emergency responders external access to all parts of a train stopped on either track.
- Fire hydrants will be located to adequately support emergency operations anywhere within the zone, or arrangements will be made for other permitted water supply to be available for fire-fighting purposes anywhere within the zone.

6.2.12 Emergency Telephone Facilities

Emergency telephones will be provided within immediate proximity to the portal area Emergency Vehicle Assembly and the Passenger Assembly / Rescue Areas.

Emergency telephones at the portal will connect to emergency phones located within the tunnel and to the Operations Control Center.

Emergency Responders may have access to separate, secure communications systems that are entirely independent from these facilities which are intended to be readily available to patrons and staff under emergency conditions, and for use of maintenance personnel.

6.2.13 Overhead Contact System Motorized Disconnect Switch

A protected motorized disconnect switch (MDS) for the overhead contact system (OCS) will be provided in close proximity to the tunnel portal for use by authorized emergency responders. A Wayside Power Control Cubicle (WPC) will provided to support the disconnect and grounding switches, 10 ft x 8 ft in plan area.

6.2.14 Emergency Command Post

An Emergency Command Post will be established in a portal area. It will be located as close as practical to the Tunnel Portal, Emergency Vehicle Assembly Area, and Rescue Area / Passenger Assembly Areas.

The Emergency Command Post location will be well-lighted using site area lighting. It will contain an Emergency Telephone, OCS motorized disconnect switch, portal lighting controls and sufficient elements of a public address system to adequately support emergency responders.

A Ventilation Control Panel (VCP) which allows Fire Department personnel to ascertain the status, and operate the tunnel emergency ventilation system may also be installed at the Emergency Command Post, particularly if a Portal Ventilation Building is not located at that portal.

6.2.15 Communications Facilities

All necessary facilities to support emergency and non-emergency communications transmissions between the portal area and HST operations (which might include radio, telephone and fiber-optic cable capability) will be provided. A Communications Tower may be required to assure reliable transmission.

6.2.16 Emergency Power Supply

Emergency back-up generators sufficient to support equipment assembled within the portal area facilities that require an Uninterruptible Power Supply (UPS) service may be required.

6.2.17 Rock fall and Debris Containment

Where necessary, construct rock fall and debris diversion or containment features (traps) utilizing trench excavations and berms to positively assure that no rocks, rock-slides or other debris such as soil or snow-slides from mountain slopes above the portal area can reach the tracks or damage equipment or structures. Appropriate simulation-software may be used to support determination of trench depths and fence sizes.

Where a portal opens directly from a very steep slope or cliff, such that a simple rock trap is not practical, then the noise mitigation hood or other hood protection will be extended far enough from the face of the cliff to protect the tracks and other structures. Protective structures shall be designed to withstand impact loads from all rock falls or slides that can be reasonably anticipated.

Each individual situation shall be evaluated through site-specific risk-assessment analysis.

6.2.18 Surface Drainage

Surface run-off from disturbed site-areas shall be routed to a detention pond to prevent contamination of area groundwater.

6.2.19 Tunnel Seepage and Wash water

Tunnel seepage water, wash-water from any tunnel cleaning, and water from a fire-fighting incident, system-test, or a pipe-leak will be routed through a detention pond or directly to a local sanitary sewer if available.

6.2.20 Detention Pond

If required, a detention pond of adequate size will be constructed to handle run-off quantities calculated for the individual portal locations

6.2.21 Parking for Tunnel Maintenance and Traction Power Facility

Separate parking away from the emergency parking areas will be provided for maintenance staff for tunnels and other site facilities.

6.2.22 Intrusion Fence

The portal site area and facilities will be completely surrounded by a security fence. The height and profile of the fence will vary depending on location and on the facilities contained within the particular portal area.

6.2.23 Security Gates

Security gates will be provided in the intrusion protection fence across the site access road. Gates will match the height and security requirements of the fence.

6.2.24 Helicopter Landing Pad

A helicopter landing pad will not usually be required at a tunnel portal. In emergencies, medical/rescue aircraft or security helicopters will land on an Emergency Vehicle Assembly Area, another site parking area, or on the Access Road.

If a particularly remote portal area is identified where emergency access is required, but where road access is considered impractical, then a helicopter landing area will be established.

- A helicopter landing pad will measure a minimum of 65 ft x 65 ft.;
- The area will be well lighted;
- The landing pad will be sited adequately clear of flight hazards, such as towers.

6.2.25 Landscaping

Landscaping with backfilling, grading and vegetation might be employed to help blend structures into the surrounding natural condition.

Access will be provided to allow maintenance of landscape vegetation.

6.2.26 Aesthetic Treatment of Rock and Concrete Surfaces

Freshly-exposed rock surfaces in portal excavations planned to be left permanently exposed may be treated to appear naturally-formed and weathered.

Concrete or shotcrete surfaces may be colored and sculpted to blend into the surrounding landscape.

6.2.27 Public Utilities

Public utilities to be considered for servicing the portal site areas may include water, electricity, telephone and sewers.

6.2.28 Crossovers

The proximity of crossover tracks to the different tunnel portals needs to be carefully assessed so that single-track working can be maintained effectively through the tunnels during emergencies and when one tunnel railway is closed for major maintenance or repair.

6.3 PORTAL INFRASTRUCTURE REQUIREMENTS FOR DIFFERENT CATEGORIES OF TUNNEL

Not every item of infrastructure described in Section 6.2 will be required at every HST tunnel portal. The following sections provide general guidance in determining which of these elements of portal infrastructure may or may not be required at a particular tunnel portal, or under certain circumstances, where some listed items of "portal" infrastructure may need to be located some distance from a portal.

The principal factors which will influence the decision are:

- length of tunnel;
- proximity of one tunnel to another;
- accessibility to portal locations; and
- environmental impacts at a portal location.

Any particular tunnel portal may have additional site-specific requirements.

6.3.1 A Shorter Tunnel up to Approximately One Half-Mile in Length

All infrastructure listed in Section 6.2 should be considered for one of the two portals [except for tunnel emergency ventilation which will probably be accomplished by jet-fans within the shorter tunnel and consequently the need for a portal ventilation building (6.2.2) would be unlikely].

The following items would need to be considered for the second portal:

- Noise mitigation hood (6.2.1)
- Intrusion protection fence (6.2.22)
- Rock fall and debris containment (6.2.17)
- Surface drainage (6.2.18)
- Tunnel seepage and wash water (6.2.19) [If downgrade from the other portal which was preferred for the principal infrastructure installations]
- Detention pond (6.2.20) [If downgrade from the other portal]
- Area lighting (6.2.8) [Assumes temporary passenger assembly might be needed on the tracks outside the portal prior to relocating through the non-incident tunnel to the Rescue Area at the other portal]

- Landscaping (6.2.25)
- Aesthetic treatment of rock and concrete surfaces (6.2.26)
- Emergency telephone facilities (6.2.12)
- OCS Motorized Disconnect Switch (6.2.13)

6.3.2 Several Short Tunnels Close Together

For a group of short tunnels close together, emergency access and egress and other portal infrastructure facilities (as listed in Section 6.2) that are provided for one portal of one tunnel may serve the emergency requirements of several tunnels provided that:

1. such emergency facilities are spaced no further apart than approximately one-and-one-half to two miles, and;
2. emergency access and egress to required standards can be provided from the location where the emergency facilities have been located, along paved track-slab extending through and between the several tunnels, or along an adjacent roadway.

Other tunnel portals in the group of short tunnels would need to consider the particular infrastructure items separately listed in Section 6.3.1.

6.3.3 Shorter Tunnel with Constrained Access

A shorter tunnel up to approximately one-half mile in length with physical conditions at both portals that prevent construction of required permanent emergency access and egress infrastructure elements (Section 6.2), or where exceptional environmental conditions exist which render this construction unacceptable will require additional elements and considerations.

To serve the tunnel under these circumstances, all permanent emergency infrastructure elements listed in Section 6.2 shall be provided to each portal, or to a location along the track within one half-mile of each portal, provided that emergency access and egress to required standards can be provided to the tunnel from the location where emergency facilities have been located, along paved track-slab or along an adjacent roadway

At each portal, the following elements are required to be considered at the immediate location of the portal:

- Noise mitigation hood (6.2.1)
- Intrusion protection fence (6.2.22)
- Rock fall and debris containment (6.2.17)
- Surface drainage (6.2.18)
- Area lighting (6.2.8)
- Landscaping (6.2.25)
- Aesthetic treatment of rock and concrete surfaces (6.2.26)
- Emergency telephone facilities (6.2.12)
- OCS Motorized Disconnect Switch (6.2.13)

6.3.4 Tunnel Longer than Approximately one half-mile in length:

Infrastructure listed in Section 6.2 shall be considered for both portals, including the need for portal ventilation buildings at both portals. Tunnel seepage and wash water (Section 6.2.19) and Detention Pond (Section 6.2.20) requirements normally only need to be considered at the portal at lower elevation.

6.3.5 Longer Tunnel with Constrained Portal Access

Where a tunnel more than one half-mile in length has physical conditions at one or both of the portals which prevent construction of required permanent emergency access and egress infrastructure elements (Section 6.2) or where exceptional environmental conditions exist which render this construction unacceptable:

1. Provide all permanent emergency access and egress infrastructure elements (Section 6.2) at an unaffected portal.
2. Provide all permanent emergency infrastructure elements (Section 6.2) to each portal or to a location on the track within one half-mile of portals, provided that emergency access and egress to required standards can be provided to the tunnel along paved track-slab or along an adjacent roadway from the location where the emergency facilities have been located. Alternatively, provide emergency access and egress via a mid-line tunnel rescue shaft or rescue tunnel located within one half-mile of affected portals.
3. The infrastructure elements which are listed in Section 6.3.3 as requiring consideration at both portals of a shorter tunnel with constrained access similarly require consideration at both portals of a longer tunnel with constrained access.

A design variance is required if access to both tunnel portals cannot be provided.

6.4 SITE AREA REQUIREMENTS

The examination of portal requirements indicates that a single tunnel portal area, if equipped with all elements of infrastructure considered necessary and listed herein, would require at least 6.5 acres of usable site area. This area does not include the area of widened trackway outside the portal area proper, which extends for approximately 1100 feet further away from the portal to accommodate the train surface evacuation zone. More significantly for tunnels in mountainous areas, it does not include any unusable site area which may have to be incorporated into the fenced portal area in order to obtain the required amount of usable area.

However, tunnels shorter than one-half mile long are not required to accommodate the entire portal infrastructure and would not require the full 6.5 acres. Thus, an allowance of 6.5 to 7 acres per portal may be an appropriate assumption until specific tunnel lengths and locations can be identified. Areas for new access roads outside the fenced portal areas would be in addition to the 6.5 to 7 acres.

APPENDICES

Appendix A includes illustrations identifying elements of portal infrastructure which need to be considered at twin, single-track tunnel portals.

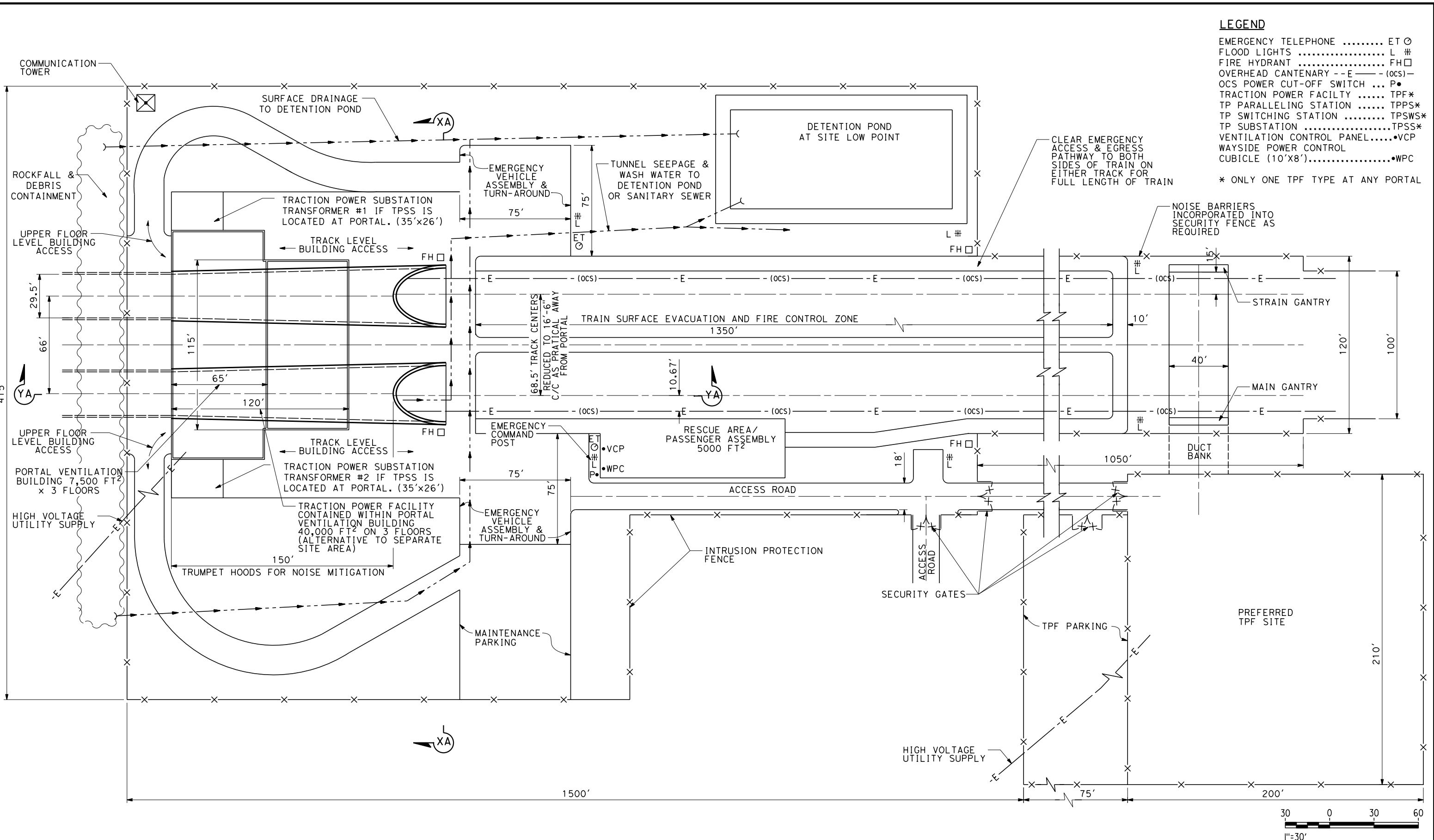
Appendix B includes illustrations identifying elements of portal infrastructure which need to be considered at single, twin-track tunnel portals.

Appendix C lists tunnel ventilation, traction power, facilities power, telecommunications and signaling and maintenance equipment, and space requirements at an existing Tunnel Portal Building, for reference purposes.

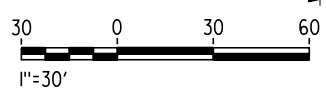
APPENDIX A INFRASTRUCTURE FOR SINGLE TRACK TUNNEL PORTALS

Twin Single-Track Bored Tunnels, with Portal Ventilation Building and Traction Power Facilities
[(Sh.1_Plan A) ; (Sh.2_ Cross-Sect. Xa-Xa) ; (Sh.3_Long. Sect. Ya-Ya)]

6/21/2010 6:32:20 PM T:\13259B Calif High Speed Rail\CADD\Directive Drawings\2.4.6 - Portals, Entrances and Ramps\working\2.4.6-A.dgn



- LEGEND**
- EMERGENCY TELEPHONE ET ⊙
 - FLOOD LIGHTS L #
 - FIRE HYDRANT FH □
 - OVERHEAD CANTENARY --E-- (OCS)
 - OCS POWER CUT-OFF SWITCH ... P•
 - TRACTION POWER FACILITY TPF*
 - TP PARALLELING STATION TPSS*
 - TP SWITCHING STATION TPSWS*
 - TP SUBSTATION TPSS*
 - VENTILATION CONTROL PANEL.....VCP
 - WAYSIDE POWER CONTROL CUBICLE (10'X8').....WPC
- * ONLY ONE TPF TYPE AT ANY PORTAL



REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY
D. McALLISTER

DRAWN BY
D. SOLTERO

CHECKED BY
J. THOMPSON

IN CHARGE
J. CHIRCO

DATE
06/17/10

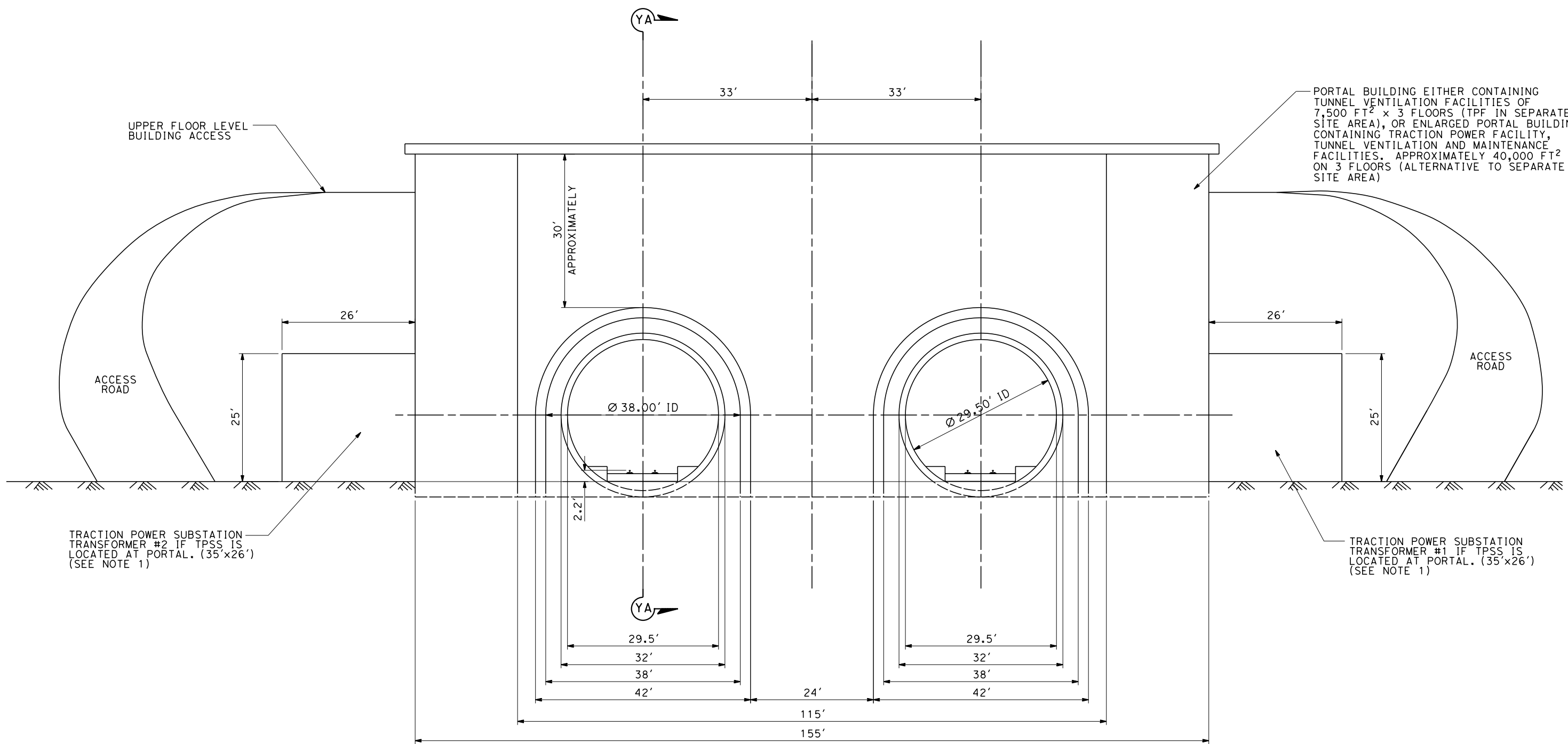


CALIFORNIA HIGH-SPEED TRAIN PROJECT

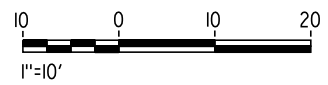
TYPICAL TUNNEL PORTAL FACILITIES
AT GRADE TWIN TUNNEL CONFIGURATION
PLAN

CONTRACT NO. 13259
DRAWING NO. TM 2.4.6-A
SCALE 1"=30'
SHEET NO.

- NOTES:**
- TRANSFORMERS TO BE LOCATED OUTSIDE BUILDING, WITH NO STRUCTURES ABOVE TRANSFORMER. CLEAR SPACE INCLUDES ELECTRICAL CLEARANCE.



SECTION XA-XA



6/21/2010 6:32:50 PM T:\13259B Calif High Speed Rail\CADD\Directive Drawings\2.4.6 - Portals, Entrances and Ramps\working\2.4.6-B.dgn

REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY
D. McALLISTER

DRAWN BY
D. SOLTERO

CHECKED BY
J. THOMPSON

IN CHARGE
J. CHIRCO

DATE
06/17/10



CALIFORNIA HIGH-SPEED TRAIN PROJECT

TYPICAL TUNNEL PORTAL FACILITIES
AT GRADE TWIN TUNNEL CONFIGURATION
ELEVATION

CONTRACT NO.
13259

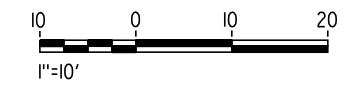
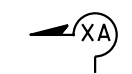
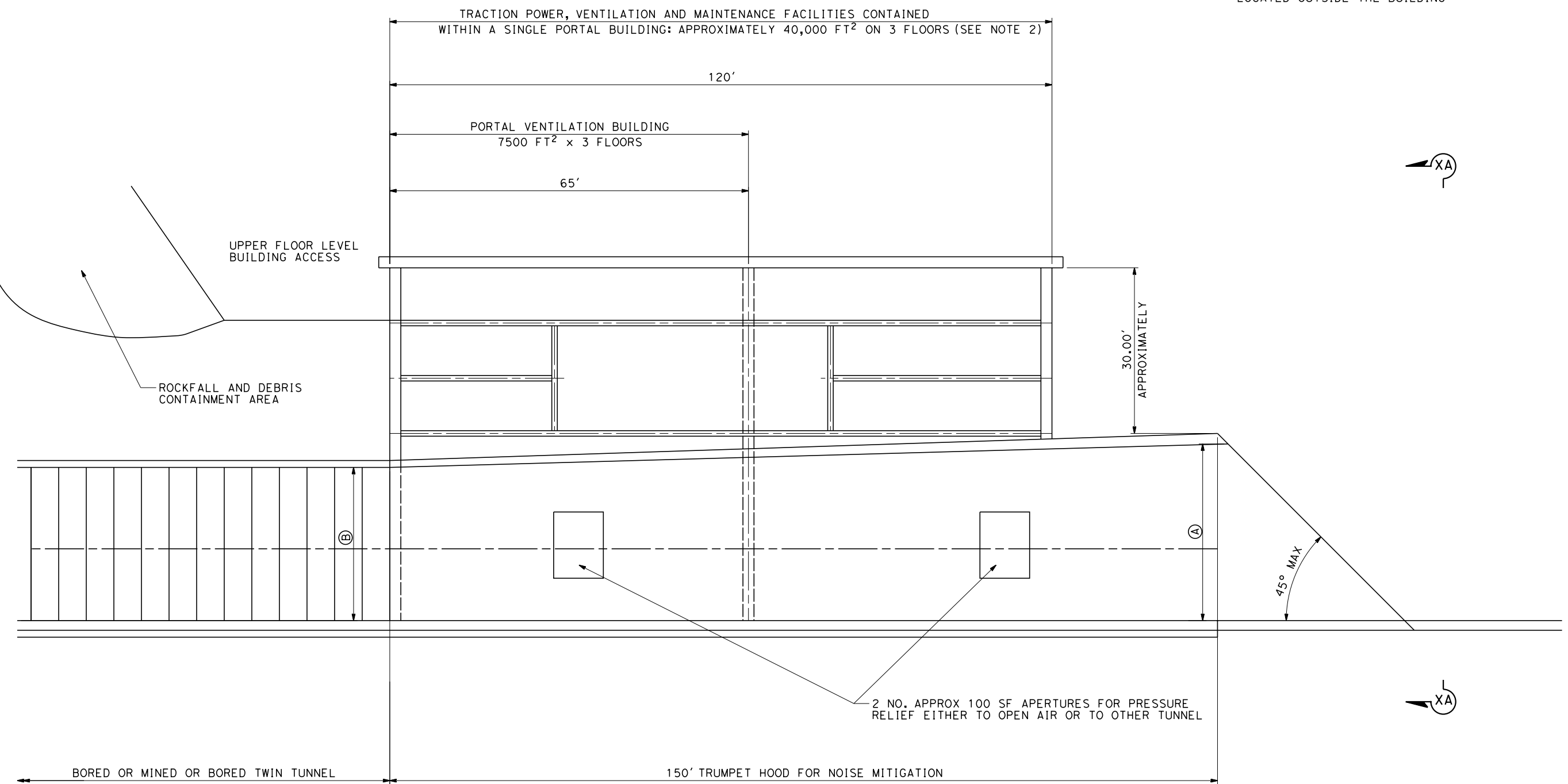
DRAWING NO.
TM 2.4.6-B

SCALE
1"=10'

SHEET NO.

6/21/2010 5:38:07 PM T:\13259B Calif High Speed Rail\CADD\Directive Drawings\2.4.6 - Portals, Entrances and Ramps\working\2.4.6-C.dgn

- NOTES:**
1. FREE AREA CSA (A) = 150% OF FREE AREA CSA (B)
 2. FLOOR AREA EXCLUDES TRACTION POWER TRANSFORMERS WHICH ARE LOCATED OUTSIDE THE BUILDING



REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY
D. McALLISTER

DRAWN BY
D. SOLTERO

CHECKED BY
J. THOMPSON

IN CHARGE
J. CHIRCO

DATE
06/17/10



CALIFORNIA HIGH-SPEED TRAIN PROJECT

TYPICAL TUNNEL PORTAL FACILITIES
AT GRADE TWIN TUNNEL CONFIGURATION
LONG SECTION

CONTRACT NO.
13259

DRAWING NO.
TM 2.4.6-C

SCALE
1"=10'

SHEET NO.

APPENDIX B INFRASTRUCTURE FOR TWIN TRACK TUNNEL PORTALS

Single Twin-Track Mined Tunnel with Central Dividing Wall, with Portal Ventilation Building and Traction Power Facilities

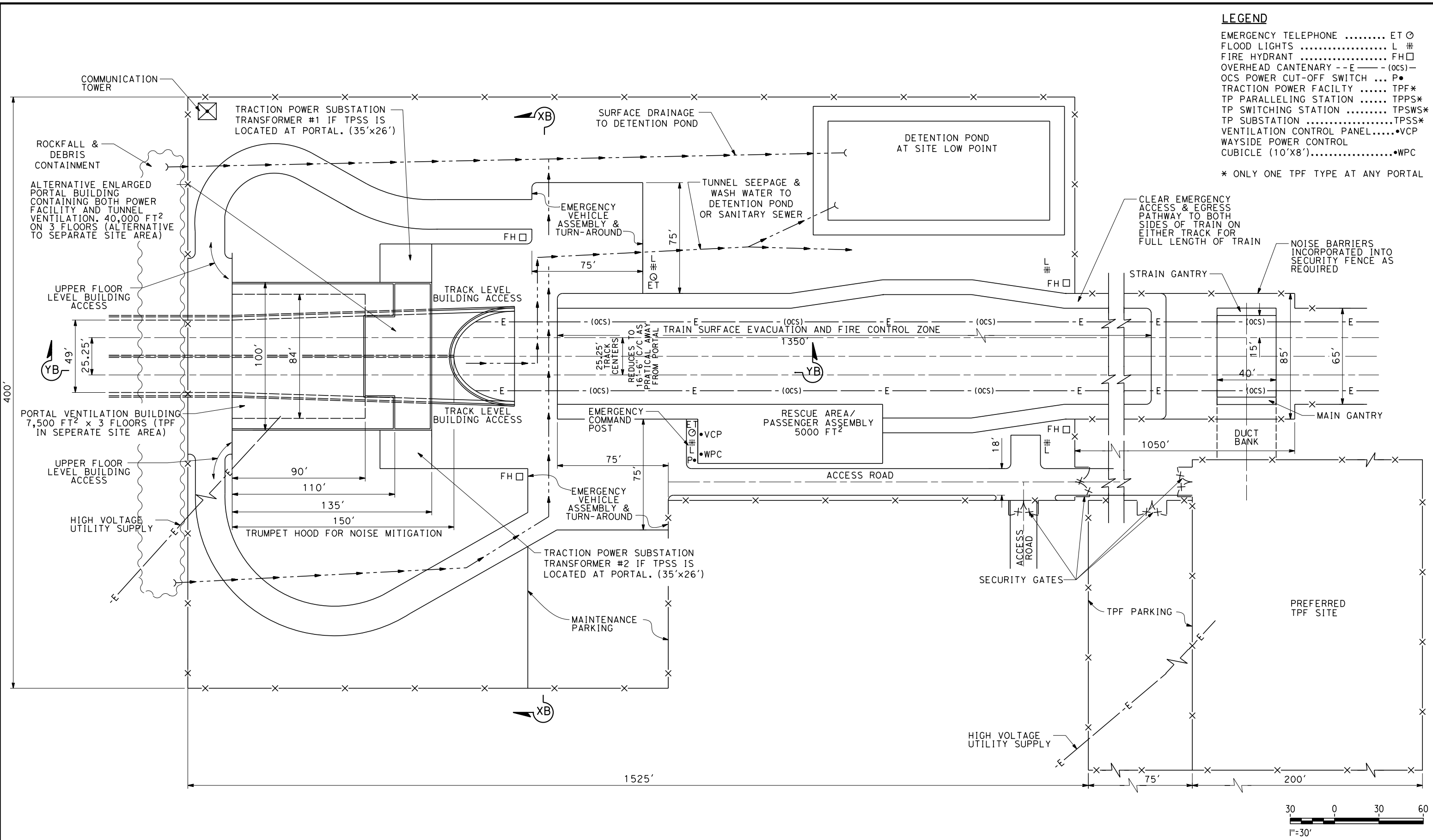
[(Sh.4_Plan B) ; (Sh.5_Cross-Sect. Xb-Xb) ; (Sh.6_Long. Sect. Yb-Yb)]

LEGEND

- EMERGENCY TELEPHONE ET ○
- FLOOD LIGHTS L #
- FIRE HYDRANT FH □
- OVERHEAD CANTENARY --E-- (ocs)
- OCS POWER CUT-OFF SWITCH ... P●
- TRACTION POWER FACILITY TPF*
- TP PARALLELING STATION TPSS*
- TP SWITCHING STATION TPSWS*
- TP SUBSTATION TPSS*
- VENTILATION CONTROL PANEL.....VCP
- WAYSIDE POWER CONTROL CUBICLE (10'x8').....WPC

* ONLY ONE TPF TYPE AT ANY PORTAL

6/21/2010 6:49:15 PM T:\13259B Calif High Speed Rail\CADD\Directive Drawings\2.4.6 - Portals, Entrances and Ramps\working\2.4.6-D.dgn



REV	DATE	BY	CHK	APP	DESCRIPTION

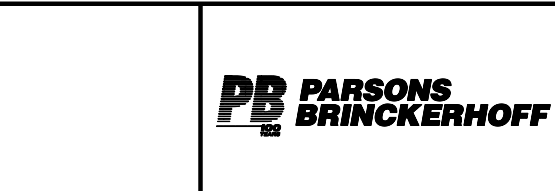
DESIGNED BY
D. McALLISTER

DRAWN BY
D. SOLTERO

CHECKED BY
J. THOMPSON

IN CHARGE
J. CHIRCO

DATE
06/17/10



CALIFORNIA HIGH-SPEED TRAIN PROJECT

TYPICAL TUNNEL PORTAL FACILITIES
AT GRADE SINGLE TUNNEL CONFIGURATION
PLAN

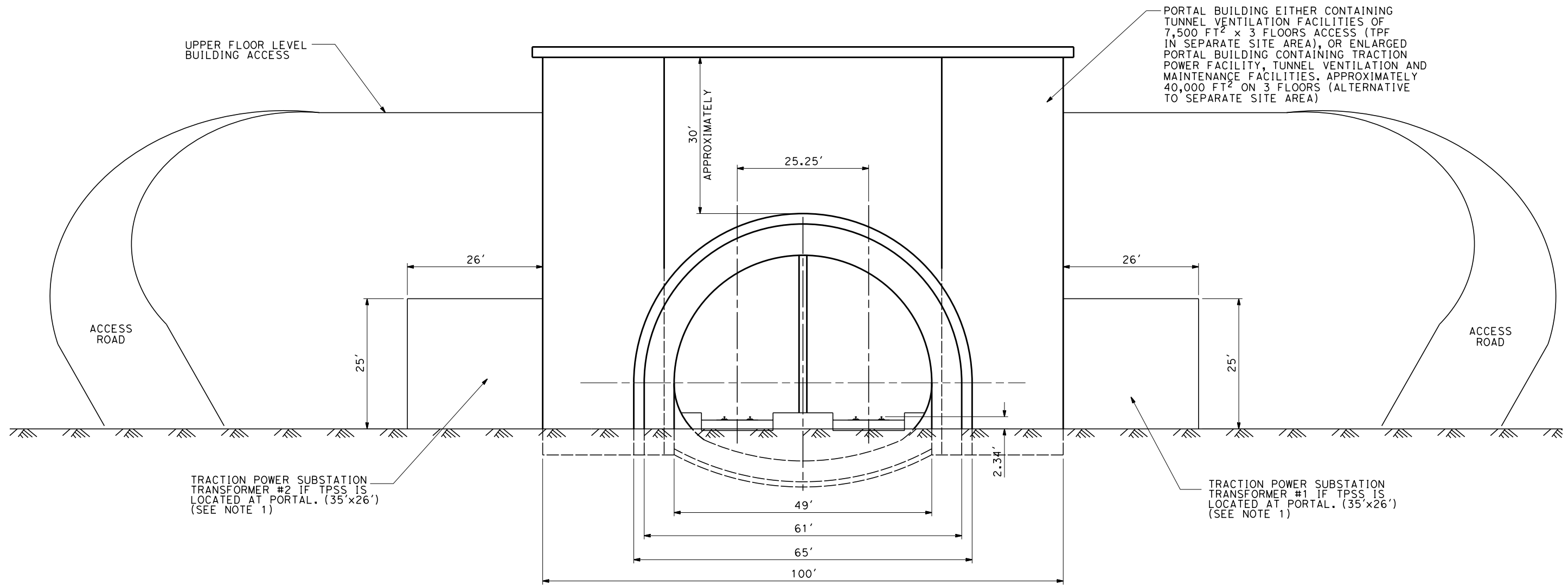
CONTRACT NO.
13259

DRAWING NO.
TM 2.4.6-D

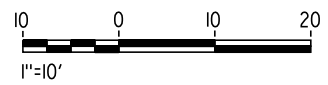
SCALE
1"=30'

SHEET NO.

- NOTES:**
1. TRANSFORMERS TO BE LOCATED OUTSIDE BUILDING, WITH NO STRUCTURES ABOVE TRANSFORMER. CLEAR SPACE INCLUDES ELECTRICAL CLEARANCE.



SECTION XB-XB



6/21/2010 6:33:18 PM T:\13259B Calif High Speed Rail\CADD\Directive Drawings\2.4.6 - Portals, Entrances and Ramps\working\2.4.6-E.dgn

REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY
D. McALLISTER
DRAWN BY
D. SOLTERO
CHECKED BY
J. THOMPSON
IN CHARGE
J. CHIRCO
DATE
06/17/10



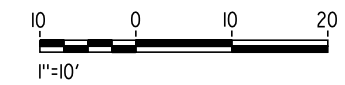
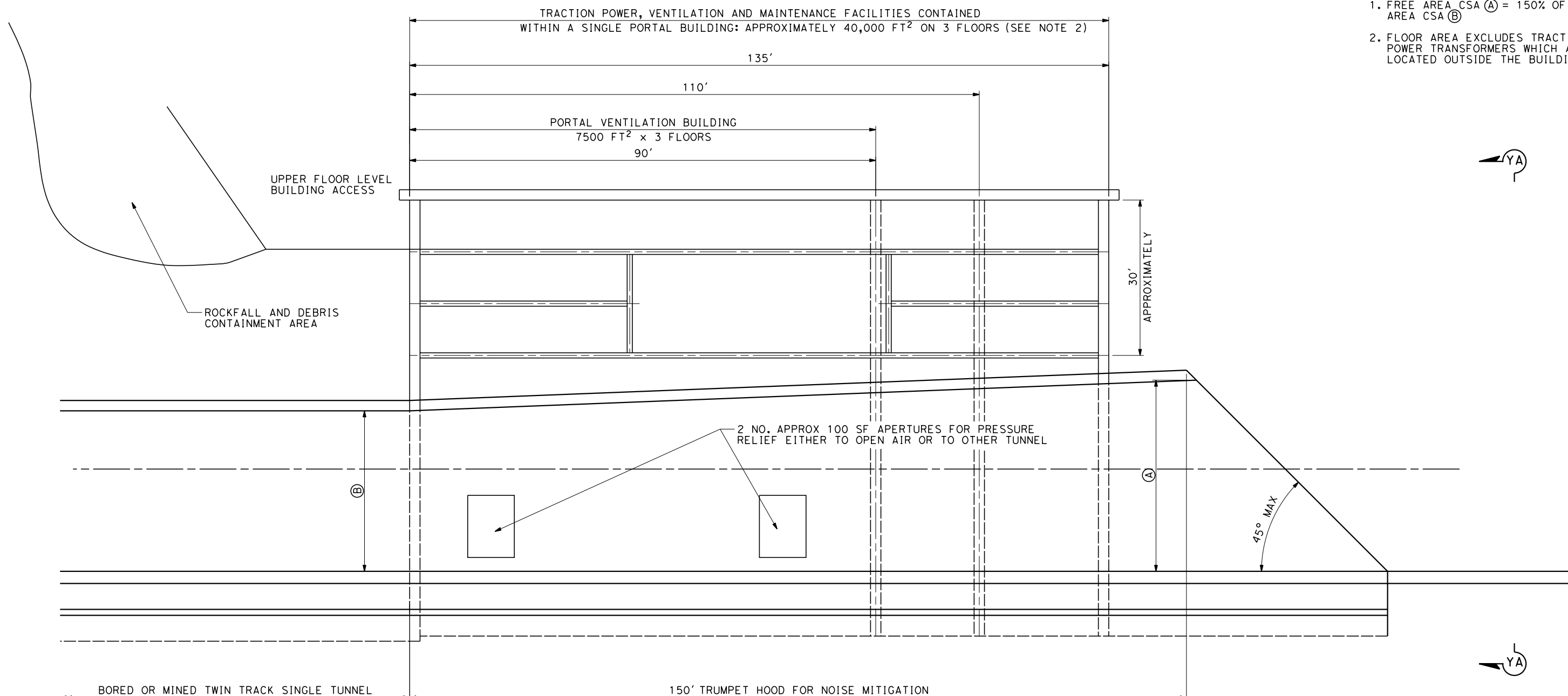
CALIFORNIA HIGH-SPEED TRAIN PROJECT

TYPICAL TUNNEL PORTAL FACILITIES
AT GRADE SINGLE TUNNEL CONFIGURATION
ELEVATION

CONTRACT NO.
13259
DRAWING NO.
TM 2.4.6-E
SCALE
1"=10'
SHEET NO.

NOTES:

1. FREE AREA CSA (A) = 150% OF FREE AREA CSA (B)
2. FLOOR AREA EXCLUDES TRACTION POWER TRANSFORMERS WHICH ARE LOCATED OUTSIDE THE BUILDING



6/21/2010 6:18:23 PM T:\13259B Calif High Speed Rail\CADD\Directive Drawings\2.4.6 - Portals, Entrances and Ramps\working\2.4.6-F.dgn

REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY
D. McALLISTER

DRAWN BY
D. SOLTERO

CHECKED BY
J. THOMPSON

IN CHARGE
J. CHIRCO

DATE
06/17/10



CALIFORNIA HIGH-SPEED TRAIN PROJECT

TYPICAL TUNNEL PORTAL FACILITIES
AT GRADE SINGLE TUNNEL CONFIGURATIONS
LONG SECTION

CONTRACT NO.
13259

DRAWING NO.
TM 2.4.6-F

SCALE
1"=10'

SHEET NO.

APPENDIX C ADDITIONAL PORTAL FACILITIES

Equipment which might be housed in a multi-purpose Tunnel Portal Building with total floor area of approximately 40,000 sf. (Data from an existing facility - for reference purposes). [Reference Section 3.2.3]

Tunnel Ventilation Facilities:

- Tunnel ventilation fans, motors and dampers; ventilation plenums; control rooms: Space requirements might add to approximately 16000 sf.

Traction Power Facilities:

- Switchgear, transformers, relay and control rooms: Space requirements might add to approximately 4000 sf within building. Additionally, two transformers (total of 2,000 sf including electrical clearances) to be located outside of building.

Facilities Power:

- Switchgear, transformers, batteries, rectifiers, UPS facilities and control room: Space requirements might add to approximately 5000 sf.

Telecommunications and Signaling Facilities:

- Telecommunications and signaling equipment: Space requirements might add to approximately 1000 sf.

Maintenance Facilities, Corridors and Stairways:

- Rooms to support tunnel and building maintenance, corridors and stairways: Space requirements might add to approximately 10,000 sf.

Fire Protection Facilities:

- Pumps and water-tanks: Space requirements might add to approximately 2000 sf.