Dallas to Houston High-Speed Rail
Draft Environmental Impact Statement

Appendix F:
Dallas to Houston High-Speed Rail
Final Draft Conceptual Engineering Report – FDCEv7
Set 2 of 2

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Transmittal

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REPORTS			
9/15/17	F	1 of 2	TCRR FDCE v7 REPORT.PDF *(Final Draft Conceptual Engineering Report v7 – Project Definition for publication with Draft EIS)*
9/15/17	F	2 of 2	TCRR CONSTRUCTABILITY v4 REPORT.PDF
TCRR FDCE v7 DWGS VOLUME 1 *(General Sheets and Typical Sections)*			
9/15/17	G	1 of 21	TCRR FDCE v7 DWGS VOLUME 1.PDF *(General Sheets and Typical Sections)*
TCRR FDCE v7 DWGS VOLUME 2 *(Railway Alignment Plan and Profile Sheets)*			
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TCRR FDCE v7 DWGS VOLUME 5 *(Wildlife Crossing Sheets)*			
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REMARKS:

The files transmitted herewith represent a final submittal of the Final Draft Conceptual Engineering (FDCE) design report and drawings for the Dallas to Houston High-Speed Rail Project. This v7 submittal of the FDCE report is intended for distribution on the FRA website with the Draft EIS (DEIS) for public review.

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PREPARED BY: Christopher Taylor **Date**: November 17, 2017

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Texas Central
Dallas to Houston High-Speed Rail
Constructability Report v4

234180-AFN-REP-TCRR Constructability Report

September 15, 2017

Job number

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Acronyms

Acronym	Meaning
BNSF	Burlington Northern Santa Fe Railway
CIP	Cast-In-Place
DCE	Draft Conceptual Engineering
DS	Drilled Shaft
EIS	Environmental Impact Statement
FDCE	Final Draft Conceptual Engineering
FRA	Federal Railroad Administration
HSR	High-Speed Rail
IH	Interstate Highway
ILM	Incremental Launching Method
LEDPA	Least Environmentally Damaging and Practicable Alternative
MOW	Maintenance Of Way
MSE	Mechanically Stabilized Earth
MSS	Movable Scaffolding System
NEPA	National Environmental Policy Act
ROD	Record of Decision
ROW	Right Of Way
TCEQ	Texas Commission on Environmental Quality
TCRR	Texas Central Railroad
TMF	Trainset Maintenance Facility
TxDOT	Texas Department of Transportation
UPRR	Union Pacific Railroad
USACE	US Army Corps of Engineers
zCE	Central Zone (Texas State Plane Coordinates)
zNC	North Central Zone (Texas State Plane Coordinates)
zSC	South Central Zone (Texas State Plane Coordinates)

1 Introduction

This constructability review provides a conceptual engineering evaluation of general construction types, temporary construction facilities, and proposed locations of staging and precasting sites required to construct the Project. This review is based upon the Final Draft Conceptual Engineering (FDCE) Report v6 and drawings dated June 30, 2017.

The FDCE report and drawings provide information on the design of infrastructure and facilities required for development of the six end-to-end alignments alternatives being studied in the environmental analysis by the FRA, which will be documented in the EIS resulting from that study. Information in the FDCE Report and drawings is organized by sections of alignment, which can be combined into segments. The segments can be assembled into the six alignment alternatives. These alignment alternatives and the segments and sections used to build them up are shown in Appendix A1.

At this conceptual design stage, the areas required for construction have been assessed relatively conservatively. It is likely that more advanced planning and design would reduce property requirements, particularly where right-of-way (ROW) purchases are proposed specifically for construction staging and laydown areas.

At this conceptual design stage, the main purpose of the constructability review is to inform the environmental impact statement (EIS) analysis being advanced by the FRA. A further detailed constructability analysis would need to be performed to confirm the feasibility of construction and refine the expected construction methods and phasing of project segments when a greater level of design is available.

Texas Central Railroad, LLC ("TCRR"), a private Texas-based company, plans to operate and maintain a reliable, safe and profitable passenger rail transportation system between Houston and Dallas, Texas using proven Japanese high-speed rail ("HSR") technology (hereafter the "Project"). TCRR and its Affiliates (see paragraph below) are seeking multiple regulatory approvals, including a favorable Record of Decision (ROD) resulting from an Environmental Impact Statement (EIS) as required under the National Environmental Policy Act (NEPA). The Federal Railroad Administration ("FRA") is preparing the Environmental Impact Statement (EIS) for the Project.

TCRR is a wholly-owned subsidiary of Texas Central Rail Holdings, LLC ("TCRH") which, in turn, is a subsidiary of Texas Central Partners, LLC ("TCP") a Delaware limited liability company. Other Affiliates of TCRR including Texas Central Railroad & Infrastructure, Inc. ("TCRI") and Texas Central High-Speed Railway, LLC ("TCR"), are collectively referred to as "Texas Central." TCRI will be responsible for constructing the tracks, stations, platforms and other infrastructure along the route. When completed, the Texas Central Line will be operated and maintained by TCRR and TCRI. Within this report, the Texas Central (TCP, TCRH, TCRI, TCRR and TCR) are collectively referred to as "TCRR."

2 General Construction Methods

This section presents a brief summary of the proposed construction methods for each of the components of the Project. The construction methods described below would be required to comply with the applicable terms and conditions of construction permits issued by the FRA or other government agencies (USACE, TCEQ). (See the FDCE report for more details regarding USACE permits.) All work would be performed in strict accordance with applicable regulatory requirements and best practices.

2.1 Clearing and Grubbing

After mobilizing and setting up the construction staging area(s), the contractor would commence with clearing and grubbing the Project's ROW in advance of the major building, roadway, and utility relocations. This activity would involve clearing natural and manmade obstacles such as trees, shrubs, signs, etc. Stripping a layer of topsoil in advance of the excavation activity may also occur at this stage. Where practicable, removed soils and other fill materials would be stockpiled for reuse. All materials not identified as suitable for reuse would be disposed of in accordance with all applicable regulatory requirements.

2.2 Demolition

The next stage of construction would involve the demolition of building and roadway structures directly impacted by the Project. Before the demolition work could commence, the building occupants would be relocated and roadway diversions or relocations established. Property purchasing, advance works to mitigate impacts of construction, and any relocations would require a considerable amount of planning in advance of commencing demolition work. Demolition surveys would be carried out and a plan developed on how any structures would be demolished. If any hazardous materials such as asbestos are identified, a specialist would be engaged to remove and dispose of hazardous materials in a safe and controlled manner. Plans would be developed and followed to ensure proper disposal of materials, to mitigate impacts such as traffic and dust, and to ensure safety. Once these steps occur and the structures are ready to be demolished, the actual demolition activity would be completed expeditiously.

2.3 Earthwork

The earthwork activity involves the movement of soil from one location to another and the process of forming the soil (or earth) into a desired shape. The earthwork component of the Project would be extensive and involve the use of large construction machinery such as the following:

- dozers
- motor graders

- scrapers
- excavators
- off-road earth haul units (trucks)
- on-road earth haul units (trucks)
- water trucks
- earth compaction equipment

Within the job site, earthmoving would be done using conventional methods. For very short distances (less than 300 feet (91.4m)), dozers would be used to shift earth. For distances from 300 feet (91.4m) up to 2,500 feet (762m), scrapers would be used. For distances greater than 2,500 feet (762m) (e.g., when moving earth for underpasses and overpasses), trucks would be employed. Figure 1 presents general haul distances for various types of equipment as outlined in the Caterpillar Performance Handbook, Edition 38.

2.4 Aggregates

The majority of the aggregates used for sub-ballast and the aggregates used for concrete and other needs will come from existing quarries within the State of Texas. However, due to the aggressive schedule of this project, the Project does anticipate a need to purchase some aggregates from out of state quarries. Moreover, the specific quality requirements for track ballast, and the quantity of track ballast required, may require purchase of these aggregates out of state. Freight railroads typically own, operate, or partner with ballast quarries given their own needs. Therefore, it is expected that the project will work with the freight railroads to deliver ballast for the project. Connections to the freight railroad network have been included in the conceptual design of staging and laydown areas as shown in the FDCE drawing set. The initial approach in regards to transportation of aggregates will be to utilize the existing rail road infrastructure as much as possible.

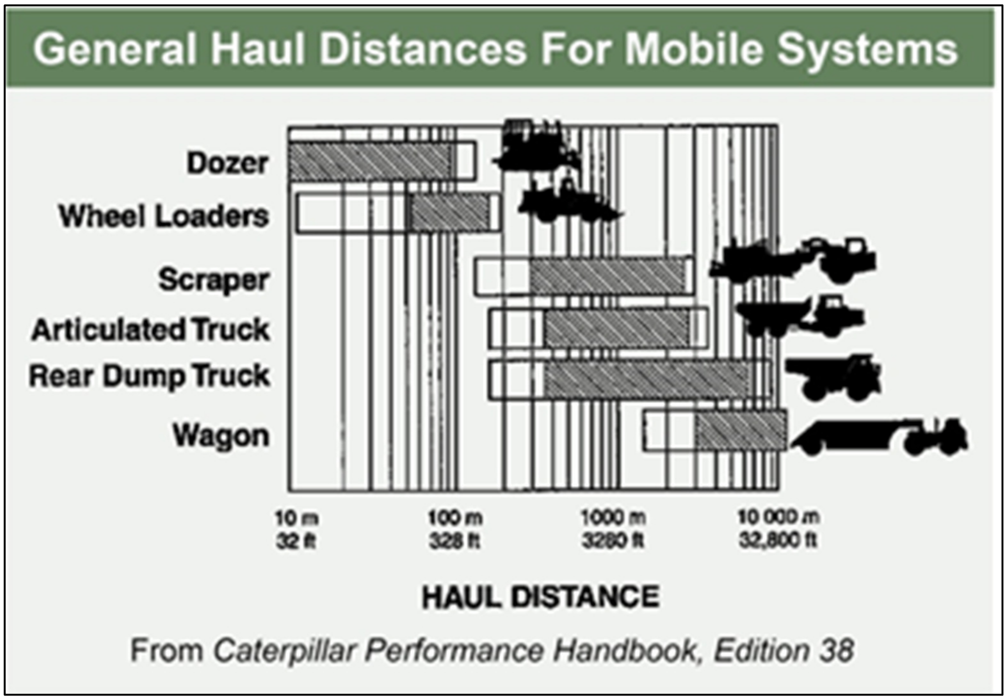


Figure 1: General Haul Distances

The contractor would also be responsible for the stripping and removing any unsuitable materials (contaminated and/or hazardous) which would require off-site disposal to an appropriate waste facility. Undercut material unsuitable for structural sections of the embankments would be hauled off site to landfill areas or placed in adjacent areas of the project where geotechnical requirements are less stringent.

2.5 Highways/Roadways

The proposed Project's alignment alternatives would require road and highway realignments. Some of the realignments are associated with grade separations, and some are required due to conflicts with the proposed Project alignment alternatives. The proposed realignments or modifications are shown on the roadway plans. In areas where the High Speed Rail would run parallel to existing highways (Hempstead Highway and IH-45), construction would have to be staged with various lane closures. It is anticipated that highway and roadway work associated with the Project would be done using conventional methods, in the following sequence as appropriate:

- Demolition
- Utility relocations (utility relocation timing may influence the highway work schedule), which could require trenching, segmental pipe construction, concrete pipe or conduit poured in situ, storm drain catch basins poured in situ, or placing precast units.
- Traffic control set up and maintenance.

- Install and remove detours.
- Excavation
- Grading
- Placement of aggregate base.
- Construction of concrete curb and gutter (in some cases this may be carried out before the previous stage), which could be done by building forms and pouring concrete in place, or by using a curb and gutter placing machine.
- Placement of concrete or asphalt concrete top surface base and top surfaces.

Coordination with local roadway agencies, TxDOT (for state highways), and various stakeholder and community groups would be required as final design progresses. Special attention would be paid to development of Maintenance and Protection of Traffic (MPT) plans, with a focus on mitigating traffic impacts and ensuring uninterrupted emergency response capabilities to the impacted communities. The plan would provide traffic controls pursuant to the Texas Manual on Uniform Traffic Control Devices' sections on temporary traffic controls (by TxDOT) and would include a traffic control plan. The plan must provide for mitigation of pedestrian impacts, particularly in the more urban areas.

2.6 Drainage

The drainage requirements of the Project are to:

- Maintain existing drainage flow patterns to the greatest extent possible.
- Disperse on-site runoff to encourage local infiltration when possible. Water must be dispersed efficiently so not to expose expansive clays to runoff water.
- Incorporate existing drainage systems into design approach.
- Improve existing drainage capacity if the Project exacerbates existing drainage problems or flooding at a location where the existing system is known to be undersized.
- Treat runoff from pollution-generating impervious surfaces (stations, parking lots, trainset maintenance facilities) to the maximum extent practicable to meet TCEQ water quality objectives and water quality standards before discharging to receiving waters.

Where the track is located at-grade on embankment or retained fill, and where new access roads are provided along the HSR alignment, drainage ditches or swales would be required on both sides of the track to collect rainfall and overland flow. The emphasis would be placed on on-site infiltration of runoff or maintaining existing flow patterns where required. Drainage basins, where required, would be unlined and would be designed to facilitate removal of settle able solids (litter and debris), and to manage total suspended solids and pollutants.

For embankment segments, trackbed drainage would be collected and conveyed to drainage swales or retention basins as appropriate. Storm drains may also be incorporated behind the top of the retaining walls to accommodate peak events. All concentrated flow would be addressed in a non-eroding manner.

Tracks set below grade or in a trench section would have drainage elements to collect stormwater and properly connect it to the drainage system. Pump stations would be used only if needed to minimize construction and maintenance requirements.

For elevated track segments, where the Project crosses an unpaved rural landscape, the runoff would be collected and conveyed in pipes down the sides of the pier columns to infiltration swales. Where the guideway crosses developed urban areas, the runoff would again be conveyed in pipes down the sides of the piers, but usually would be discharged into the local stormwater drainage system.

2.7 Structures

This section provides a general review of alternative methods of construction that could be used for the various project structures required.

2.7.1 Viaducts

There are several proposed viaducts throughout the alignments. Viaducts are located in various locations all along the alignments, but would be predominantly used in the more developed areas where road crossing frequency is high in order to reduce impacts. Viaducts may be used in rural areas to facilitate landowner and wildlife movements.

All viaducts are likely to have large diameter bored pile foundations, cast-in-place concrete pile caps, formed concrete columns and precast or cast-in-place concrete decks. The deck design and construction would be partially dependent on the location of the viaduct.

In addition to traditional precast concrete girder with cast-in-place deck superstructure designs, below are some alternative viaduct designs that will be also be considered on a case by case basis based on site specific conditions.

2.7.1.1 Precast Segmental Span by Span Method

For this type of construction, concrete segments of 10 to 12 feet (3 to 3.7m) in length are precast in an offsite precasting facility and delivered to site by trucks using the road network. Opportunities to use the previously constructed deck for access to the work site would be investigated during more detailed planning to minimize impacts. Precast Segmental span-by-span bridges provide a very high speed of construction, and can be constructed over or parallel to existing highways with little or no impact on traffic. Precast segmental bridges can be constructed using an erection truss under the segments or using an overhead erection gantry as shown in Figure 2. The segments are lifted into place, the joints are treated, and the deck is post-tensioned to complete the span construction cycle.

Figure 2: Deep Bay Link Bridge in Hong Kong, Precast Segmental Span-by-Span Method Using Overhead Gantry

2.7.1.2 Concrete Crossover Structures

Nonstandard concrete structures that will bridge over existing infrastructure, such as the UPRR in the Houston Segment would likely utilize precast beam crossover structures. Typically, this type of construction would involve the following.

A slab section would be constructed using precast, prestressed concrete I-girders and supported on in-situ concrete column cap beams, which would run parallel to the infrastructure being bridged. The I-girder spans would be approximately perpendicular to the infrastructure being bridged, and would be placed immediately adjacent to one another on predetermined centers. A cast-in-place (CIP) concrete deck slab would act compositely with the beams. The superstructure would be designed to reduce thermal displacements and force effects. Movement between adjacent segments would be controlled with dowelled connections, which would allow relative longitudinal displacements, but not relative transverse displacements.

2.7.1.3 Full Support Method or Cast-in-Place

CIP construction is also considered the full support method and is a traditional method of viaduct construction. With this approach, the superstructure formwork would be supported directly off the ground using substantial scaffold and formwork/falsework. While this type of construction is generally the slowest and most labor intensive of all viaduct construction methods, it has considerable advantages where it would not be practical to construct the viaduct in sequence span by span.

The CIP method would most likely be used for localized short viaduct segments, unique segments, short bridge segments, and other support structures where the economies of scale would not allow for a more efficient linear method.

The full support method would also be the most flexible form of construction because the contractor could reallocate resources from one site to another and the pace of construction could be geared to the availability of resources and program priorities.

Figure 3: Staging and Falsework Supporting the Formwork for In Situ Construction *(Photo courtesy of Taiwan High-Speed Rail Corporation [THSRC])*

2.7.1.4 Incremental Launching Method

Bridge construction using the incremental launching method (ILM) is not very common in the United States, but may be used on this project where determined to be the best method to minimize impacts. With this method of construction, the bridge is usually constructed from one side and then launched into place using mechanical jacks. It is also possible to launch from both sides of the obstacle to be crossed, but this can be more expensive due to the requirement of two sets of jacking equipment and supporting equipment or sliding bearings. This method of construction is generally very expensive due to the requirements for a considerable amount of design analysis, specialized construction equipment, and contractor knowledge/experience. However, ILM would be considered when access to a site would be extremely limited or if the construction would be over an environmentally protected area where other means and methods are not feasible.

ILM can be applied to bridges made of either steel or concrete. Concrete bridges built using this method are normally cast in stationary forms behind an abutment with each new segment cast directly against the preceding one. Once the concrete has cured, the entire structure is launched to create sufficient room for casting the subsequent segment. A steel bridge constructed by ILM is completely assembled (typically one segment at a time), including steel cross bracing, prior to launching.

There are two systems that the contractor can use in order to reduce the cantilever moments and the amount of deflection that occurs during launching, and in some cases both systems may be used. A tapered launching nose on the leading end of the girder can be installed to reduce the dead load of the cantilever span and to assist in lifting the mass of the girders as they are launched forward onto the landing pier. Alternatively, the contractor could elect to use a kingpost system utilizing temporary stays to reduce the deflection of the leading end of the girders during launching.

Figure 4: Incremental Launching Method Equipment Used on the Tou Chien Bridge Second Freeway, Taiwan *(Photo courtesy of Wiecon)*

2.7.1.5 Full-Span Precast Launching Method

The full-span precast launching method is the construction industry’s equivalent of just-in-time mass production for viaducts. This technique would require the establishment of a dedicated fabrication yard alongside the route of the viaduct where the girders would be prefabricated under factory-like conditions. The girders would weigh upward of 700 US tons (635 tonnes) each. The girders would be cast in molds and allowed to cure, after which a completed girder would be lifted from the yard onto a self-propelled traveling gantry, which would travel along the already completed guideway to where the girder is to be lifted into place. This type of construction would be the fastest construction method, but would require considerable up-front investment by the contractor in the fabrication yard, lifting equipment, and traveling gantries. This method also requires structural design of viaduct sections to support the construction loadings.

With the full-span precast launching, after the foundations and bents are completed, the bulk of the follow-on construction activities would be at the superstructure level. The completed guideway would be the primary route for access between the fabrication yard and the leading edge of the viaduct, which would limit construction impacts. This form of construction is particularly suited to long, continuous viaducts, which are proposed in each of the alignment alternatives.

Figure 5: Launching/High-Speed Rail System under Construction in Taiwan, ROC *(Photo courtesy of THSRC)*

Figure 6: The Full-Span Precast Launching Method Launching/High-Speed Rail under Construction in Taiwan, ROC (Photo courtesy of THSRC)

2.7.1.6 Free Cantilever Method/Balanced Cantilever Construction

The free cantilever method/balanced cantilever construction method allows the superstructure to be constructed in a segmental manner from the top of a bent. Segments could be precast off-site and brought to site on the back of a low loader, where they would be lifted into place and extended outward from the bent. The size of the precast segment is usually constrained by accessibility, meaning that segments transported by road rarely exceed 10 to 12 feet (3 to 3.7m) in length or weigh more than 70 US tons (63.5 tonnes).

Alternatively, where ground access would be severely limited, the segments could be cast in situ and the formwork advanced segment by segment across the span. With this method, segments are held in place by prestressing. The free cantilever method/balanced cantilever construction would be particularly useful for constructing longer spans and for crossing rivers, railroads, and roadways where ground support might not be practical. CIP segmental construction is often used where non-prismatic sections are used to reduce depth (and weight) at midspan. In these situations, girder stems are often made vertical to facilitate mold depth adjustment.

Figure 7: Balanced Cantilever, STAR Light Rail, Kuala Lumpur, Malaysia *(Photo courtesy Arup)*

2.7.1.7 Movable Scaffolding System/Advance Shoring System

The movable scaffolding system (MSS) and advance shoring system involves construction of the main formwork between two adjoining bents. The girder is then cast in place. After curing, the formwork is not dismantled, but is instead pushed forward to the next span where the casting and curing is repeated. There is no need to reassemble the formwork at the next span.

The formwork is mechanically advanced and is supported at all times off the previously constructed structure bents. This technique is considered one of the fastest methods of in-situ construction but is only economical where there is a continuous series of spans.

Figure 8: MSS in Place Awaiting in Situ Construction, Taiwan High-Speed Rail, ROC *(Photo courtesy of THSRC)*

Figure 9: MSS Moving Forward to the Next Span, Bent Construction Well Advanced of the Girder Placement, Taiwan High-Speed Rail, ROC *(Photo courtesy of THSRC)*

2.7.2 Grade Separations

The Project's alignment alternatives would need to be fully segregated from other road or rail traffic. As such, any HSR crossing with roadways, private drives, or railroads would be grade separated. Grade crossing elimination could be achieved in the following ways:

- Elevate the HSR over the road. The HSR would be on a viaduct or short bridge structure with either embankment or retained fill approaches. Proposed alignment alternatives are generally on the order of 60% viaduct, so approximately half of the grade separations are handled in this manner. All freight railroad crossings were designed so the HSR passes above the freight railroad without reprofiling of the freight line.
- Lower the HSR beneath the road by cutting the HSR below grade in a retained trench.
- Elevate the road so it passes over the HSR. The roadway approaches to the structure were predominately proposed as embankments in the conceptual engineering to minimize maintenance requirements and for the most conservative approach to evaluating property and environmental impacts. Roadway approaches could be mechanically stabilized earth (MSE) retaining walls to minimize project footprint and impact based on results of environmental reviews. The roadway bridge would typically be a standard highway-over-rail bridge.
- Lower the road so it passes beneath the HSR. The roadway approaches were predominately proposed as sloped cuts in the conceptual engineering to minimize maintenance requirements and for the most conservative approach to evaluating property and environmental impacts. Roadway approaches could be lowered through the use of mechanically stabilized earth (MSE) retaining walls to minimize project footprint and impact based on results of environmental reviews. The HSR would typically be on bridge structure where these crossings were within HSR embankment sections.
- Reroute or close the road at the crossing location. This would happen only in rare cases where adjacent landowner access would be negligible or non-existent, such as where the Project acquires the full parcel. No public roads were proposed for closure.

2.7.3 Bridges

Throughout the alignment alternatives there would be several locations where surface features such as rivers and washes would be crossed using bridges or viaducts. At this stage it is assumed that no intermediate supports would be acceptable in river channels, except for where the long span makes intermediate supports unavoidable.

2.7.4 Open Trench Excavation

Widths and depths of rail trenches would vary depending on track configuration and location. The structural form of the trench would likely be standard along its length.

There are several candidate wall systems for trench structures, outlined in Table 1.

Table 1: Candidate Wall System for Trench Structures

System	Description
Secant Pile Wall	Formed from overlapping drilled piers installed next to each other
Structural Diaphragm Slurry Wall	Formed from adjacent reinforced concrete panels
Contiguous Pile Wall	Formed from a row of piles installed next to each other, spaced with a gap between adjacent piles.
Soldier Pile and Lagging Wall	Vertical steel members embedded in piles with wood or shotcrete lagging forming the wall face
Deep Soil Mix Wall	Formed from overlapping soil-cement piles
MSE Wall in cut	TBD
Anchor Tie Back walls	TBD
Soil Nail Walls	TBD
Sheet Pile Walls	TBD

The trench walls would be constructed before the material between the walls would be excavated to form the trench. The walls would then be exposed during the excavation, with the exception of the soldier pile and lagging method where the lagging is installed in parallel with the material excavation. As excavation proceeds, temporary shoring would be added to control wall movement. Any facing required for the walls for aesthetic or maintenance reasons could be constructed following the completion of the trench construction.

It is possible that permanent struts would be required to brace the tops of retaining walls. At the ends of trenches, struts would not be possible due to the required Project vertical clearance. At these locations, tie-back supports may be required. They would be installed when the trench has been partially excavated. A permanent subsurface easement would be required for the tie-backs to protect against future subsurface developments including foundations and utilities. A photo of a trench under construction is shown in Figure 10.

Figure 10: Trench Diridon Tunnels, San Jose, CA

2.7.5 Retaining Walls

Retaining walls would be used on the approaches to structures where there is no room for sloped embankments. The retaining walls may be constructed using conventional CIP methods, crib walls, or by the MSE method which uses precast concrete facing panels and either metal or fabric reinforcement between layers of compacted engineered fill to create embankment with vertical or near-vertical sides.

An example of an MSE wall under construction is shown in Figure 11.

Figure 11: MSE Wall, Route 85/US 101 (South) Interchange Project, CA

2.8 Utility Relocations

Utility relocation would be performed in advance of the main works where possible. The contractor would provide temporary construction utilities as required.

2.9 Trackwork

No major constructability issues are anticipated with regards to trackwork. The mainline tracks would be typical sections of ballast with concrete crossties, elastic fasteners, and standard rail materials to meet the Tokaido Shinkansen technical requirements. Track in stations would be direct fixation track of reinforced concrete sections, to ensure correct horizontal and vertical positioning of the vehicles relative to the platform edges.

2.10 Systems

No major constructability issues are anticipated with regards to systems sites on this alignment. However, there are a number of sites that are in the vicinity of new roadway overpasses/access roads, and the clearing and grubbing of the sites would be coordinated with the overpass and access road construction.

2.11 Non-Standard Structures

All bridge spans greater than 120ft (36.6m) and all skewed crossings requiring straddle bent or crossover structures were considered non-standard structures within the constructability review.

Appendix A2 lists all the proposed non-standard structures. The span lengths provided are based on a preliminary level of design in support of conceptual engineering and is subject to revision as the design develops. Span lengths may vary from those shown based on further structural and geotechnical investigations, constructability reviews, or environmental concerns as identified within the DEIS. To determine typical spans shown in Appendix A2 the following assumptions were used.

- For steel trusses, a single span of the required crossing distance was assumed.
- For a required crossing distance of between 120ft (36.6m) and 140ft (42.7m), a three span concrete system was adopted. The system would consist of segmentally precast post-tensioned concrete trapezoidal box girders spanning continuously over concrete piers. The box girders would have a constant depth in this system. The longest span of the three spans is the crossing distance. The other two spans would typically be 120ft, but may vary to suit the adjacent spans and structural design. These crossings are noted as “Long Span” in Appendix A2 and only the longest span is called out.
- For a required crossing distance between 140ft (42.7m) and 200ft (61.0m), a similar three span system was applied. However, the middle span is the crossing distance and the first and last spans were assumed to be 70% of the crossing distance. Stationing shown in Appendix A2 assumed the span distance would be symmetrical. These crossing are also noted as “Long Span” in Appendix A2, but all 3 spans are called out.
- For a required crossing distance larger than 200ft (61.0m), a similar three span system was applied, but with haunched viaducts at the piers. The middle span is the crossing distance and the first and last spans were assumed to be 70% of the crossing distance. Stationing shown in Appendix A2 assumed the span distance would be symmetrical. These crossings are noted as “Haunched Girder” in Appendix A2.
- For skewed crossings, structures are noted as “Crossover” in Appendix A2. The stationing shown in Appendix A2 provides the overall length of the crossing and span segments of 120ft (36.6m) between bents were used. The span of straddle bent underneath the crossover would vary based on location. Typical straddle bent spans would be 60ft, 80ft, 100ft, 120ft, and 140ft (18.3m, 24.4m, 30.5m, 36.6m, and 42.7m). Stationing assumes the span distance is symmetrical.
- When a pier would need to be replaced with a straddle bent to avoid utility lines or existing infrastructure, it was noted as “Straddle Bent” in Appendix A2.

2.12 Preliminary Structural Alternatives

Several structural alternatives are being considered at this point and would be further defined as design develops. For the typical viaduct section, several superstructure alternatives are being considered such as precast I-beams, precast U-beams or isostatic single-cell concrete box girders. Typical spans for the aforementioned alternatives range between 70 and 140 ft (21 to 43m). For larger spans, which may be needed in select locations due to geometric constraints, hyperstatic (continuous) single-cell concrete box girders are being considered along with steel plate girders or steel trusses. Design of structures in these locations would require more detailed site-specific analyses.

With respect to substructure, column and foundation configurations would be dependent on the viaduct height as well as local geotechnical conditions. Preliminarily, multicolumn solutions are proposed for bents shorter than 30ft (9.1m) with two columns with one drilled shaft (DS) each. DS and pile diameters range from 4 to 10ft (1.2 to 3m) for the multicolumn solutions depending on height and location along the alignment.

For tall bents (around 60ft (18.3m)), a hammerhead column with pile cap foundation would typically be required to reduce flexibility and minimize displacements at top of bent. A footing with 4 drilled shafts would typically be designed for such locations.

2.13 Material Haul

The Project would require large quantities of various construction materials to be transported to project locations from various sources. The materials listed below would be brought in from off site.

- Earthworks: Common earthwork design and construction practice is to make efforts to balance earthwork cut and fill volumes to the extent practicable, but it is expected that all materials excavated will not be of the quality required for construction of the HSR line and associated structural fills. As such, materials of suitable quality will need to be secured. Efforts will be made to excavate from borrow sites as near to the fill as possible to minimize transportation costs and impacts. Since no sites have currently been identified along the alignment for sourcing the material, a 10-30 mile radius from the corridor can be assumed for easy transport by truck. A potential alternative approach would be to bring in fill from existing stockpiles or borrow sites along the BNSF or UPRR railroad lines since construction staging areas along the alignment have been located close to these freight railroads. To the extent practicable, all excavated materials will be used to support project finish grading on site. Where excess materials must be removed from the project site efforts will also be made to transport materials to local fill or waste sites by truck or to more distant sites by rail. All borrow and fill efforts will be done in strict accordance with all applicable regulatory requirements.
- Ballast/Sub-Ballast: Railroad ballast is produced from natural deposits of high quality granite, trap rock, quartzite, or dolomite. No area between Dallas and Houston has been identified to draw from that has the acceptable quality or combination of these deposits. Although aggregate specifications have not yet been established, UPRR or BNSF qualified quarries may be considered as sources to support transport by freight rail to work sites.
- Steel: Sources, foreign and domestic, of steel are dynamic in nature. Sourcing of steel for the project will respond to market conditions and be influenced by other ongoing projects in

the corridor. The focus of steel procurement efforts will be made to comply with Buy America requirements and to source steel materials and fabrication efforts from local sources to the extent practicable.

  - Reinforcing Steel: It is assumed that there are local steel manufacturers that can provide reinforcing steel close to the project site. The average distance from these suppliers to the project mid-point is estimated to be roughly 100 miles. It would not be uncommon for fabrication companies to receive steel shipments from manufacturers, tie sections of reinforcement together, and then to ship them to the construction site for installation.
  - Rail: Rail fabrication of the quality required for the project will not be available locally along the project corridor. Rails will be shipped via train to project staging areas. Upon reaching the material staging site the rail will then be further fabricated and pulled into place by specialty rail construction equipment.
  - Structural Steel: The largest structural steel member requirements will be for truss bridges required for the project and potentially for project stations and facilities. . Fabricators of manufactured steel are located regionally. Current construction practice is to fabricate and assemble pieces as large as possible with the limiting factor being transportation restrictions.
  - Other minor structural steel shapes will be incorporated into various components of the project such as bridges, stations, and facilities.

- Concrete: Significant quantities of concrete will be used for ties, viaduct foundations, subgrade piers, footings, and pre-cast elements of the superstructure.
  - Railroad Ties: It is common practice in the industry to install new tie plants near the alignment for projects of this magnitude. Concrete tie companies commonly seek to secure a long-term contract and build a tie plant near the alignment for initial construction and for ongoing maintenance of concrete ties needed for the project.
  - Subgrade Piers and Foundations: Concrete for the subgrade piers and foundations will be mixed, batched, and dispatched from batch plants at various locations along and immediately adjacent to the HSR right of way. Haul distances would be expected to be between 25 and 50 miles.
  - Precast Concrete: Concrete for use in the manufacture of pre-cast elements will be mixed and batched within pre-cast manufacture facilities constructed for the project and sited immediately adjacent to the right of way. Large pre-cast girders would be hauled along and or on top of the HSR right of way a maximum of 50 miles.
  - Sand and rock aggregates and cementious materials utilized for concrete mixes will come from regional sources of commercially established quarries and mills within 50 to 200 miles.

3 Construction Staging and Precast Operations

Locations of each temporary construction facility and the surrounding infrastructure can be seen in the table in Appendix A3 and aerial imagery of each location is included in Appendix A7.

The sites presented in Appendix A7 have been initially selected for temporary construction facilities, which could be used for temporary staging and precast operations. Appendix A3 includes the Segment, Area, Location and alignment alternatives' stationing of those sites. It is anticipated that the contractor may elect to find additional or different properties for construction activities subject to all applicable regulations and requirements. Additionally, the contractor would be able to utilize the permanent construction areas such as station footprints, maintenance-of-way, and heavy maintenance facilities for temporary purposes. These areas are not shown in Appendix A3 or A7. Several of the areas identified for construction staging in the conceptual engineering drawings were selected because they are adjacent to existing freight rail lines and would allow for the placement of circular or parallel rail spurs to allow for the delivery of materials by rail. These areas typically are approximately 100 acres (40,4686m^2) in order to get the freight cars completely off the main track. Any additional areas or impacts required for freight connections that are ultimately agreed between contractors and freight rail operators would require separate pursuit of any required property and applicable regulatory approvals.

4 Sites for Precast Operations

The precast operations yards were located near to extended lengths of precast viaduct to minimize distances between the precast operations yards and the locations of erection. A precasting facility could be set up in most of the construction staging areas identified in this report.

4.1 Summary of Precast Operations

The following sites have been initially chosen as preliminary precast operation yards. The final locations for precast facilities within the staging areas identified would be subject to change as the design of the permanent facilities is refined and as the construction schedule develops. Where possible, the footprint of permanent construction facilities would be used for temporary works to reduce the overall land purchase. For this initial analysis, at least one precast operation yard has been selected in each segment as shown in Appendix A3. Aerial imagery for each location is included in Appendix A7.

4.2 Site Selection Criteria

Fabrication sites must be chosen carefully because large precast sections would only be used for significant lengths of viaduct. Site selection would greatly affect the production efficiency of the large precast members — particularly the length of time to fabricate and the time and cost to transport and erect precast members.

There are several key considerations to selection of a fabrication site. Fabrication sites must have the benefit of access to existing utilities to reduce construction-site development time and costs. Potential impacts to traffic would also be a main consideration in the selection of suitable sites. The contractor would put a location-specific, activity-based trip schedule in place to minimize those impacts. Good access to the sites would be required for delivery of materials and efficient rates of production.

Sites must meet the minimum area requirements because the amount of available space affects the production schedule, especially for the precast structural sections. The following five criteria are guidelines for choosing precast operations yards. The locations discussed in this document meet these minimum criteria.

4.2.1 Utilities

Precasting facilities would require a full range of standard utilities, including communications, power, potable and industrial water, drainage, and sewer. Ideally, existing utilities would have sufficient capacity. In the event they are not sufficient, the site selection would consider the proximity of existing utility connections and the cost of bringing the required utilities to the site.

The overlap of temporary facilities with later permanent support installations would be cost-effective. For example, a high-speed train station, heavy maintenance facility, or maintenance-of-way facility would provide ample utility service improvements that could be reused. In addition, other site improvements that could support both construction operations and long-term use would include building foundations and slabs, offices, parking improvements, fencing, and security.

4.2.2 Traffic

Selected sites would need to have direct access to arterials from major highways, and freight railroads where practicable. Direct access to the Project's ROW would afford direct transport of materials and equipment to construction sites with minimal impacts on traffic. Transporting materials by rail would reduce impacts to roadway traffic. Sites should also be selected to minimize interference with pedestrians, bicyclists, and transit as much as possible.

Precast operations yards should be located within the same footprint as construction staging areas to minimize cost and potential environmental impacts.

The load and volume capacity of existing structures and roads would need to support construction operations. An analysis of existing roads and structures along planned construction and material delivery routes would be undertaken by the contractor prior to final site selection. Preliminary routes are shown in Appendix A7. Similarly, a site-specific investigation of horizontal and vertical clearances and of existing geometric road conditions, as they pertain to construction equipment mobility and transport, would be undertaken by the contractor.

4.2.3 Area

Approximately 17.5 acres (70,700 m²) would be needed for casting operations. Additional areas would be necessary for equipment storage, a maintenance yard, shipping and receiving of materials, and possibly precast storage. Detailed quantities for the additional areas and specific equipment of each individual site have not been set; however, 40 to 50 total acres (0.16 to 0.20 km²) for all activities would be sufficient, and each selected site exceeds this.

Table 2 outlines how the space within a typical precast year would be allocated. Figure 12 graphically shows the proportions into which the area would be divided.

Table 2: Composition of Precast Operations Yards

Facility Type	Area (ft^2)	Area (m^2)
Batch Plant	70,000	6,503
Ancillary Space	70,000	6,503
Rebar Storage & Bending Area	43,000	3,995
Power Station	11,000	1,022
Equipment Yard	22,000	2,044
Material Storage Yard	300,000	27,871
Molding Area	50,000	4,645
Rebar Jig Area	65,000	6,039
Material Testing & Office Area	65,000	6,039
Access Roads	65,000	6,039
Total	761,000 (17.5 acres)	70,700

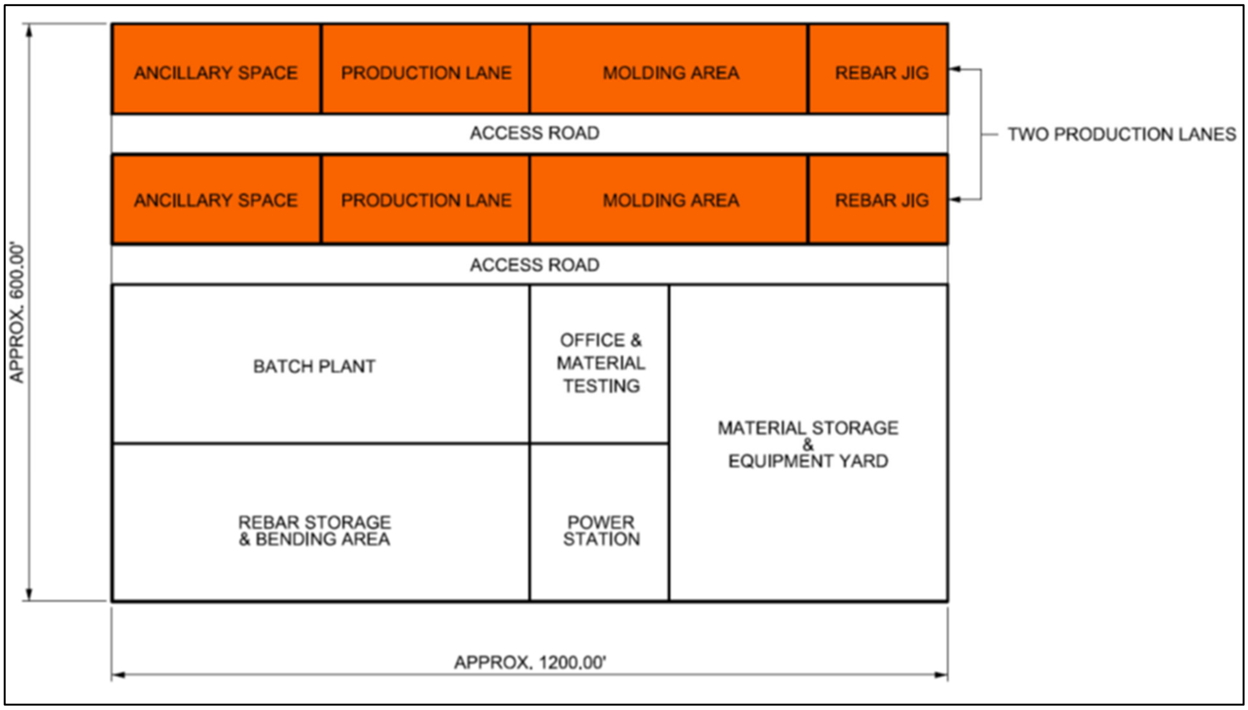


Figure 12: Proportions of Typical Precast Operations Yards

4.2.4 Location

To minimize the distances that the large precast sections would be transported, proposed precast operations yards should be close to where the precast sections would be erected. Locations within the Project's ROW would minimize land purchases. Floodplains and environmentally sensitive areas should be avoided not only to avoid impacts, but to minimize the risk to the contractor. All sites would be outside of UPRR and BNSF facilities' rights-of-way and would observe a minimum of 25 feet (7.6m) offset from their tracks/operations. To reduce the contractor's cost and risk, precast operations should not be in areas that are sensitive to noise or that could restrict working hours.

4.2.5 Accessibility

Locations should be close to major roadways (on- and off-ramps) and to freight railroads where practicable. Direct access to major roadways aids shipping to and receiving from the precast operations yards and minimizes travel on side roads. Transport of materials into the Project by rail will reduce roadway impacts.

5 Sites for Construction Staging Area

The construction staging areas would house incoming materials; provide areas for material preparation, equipment storage, equipment maintenance, operations preparation, and construction offices; and, would allow good housekeeping throughout the alignment. Haphazard staging of materials and equipment throughout the alignment alternatives would not be conducive to the construction process or safety. As such, preliminary locations for construction staging areas were identified at regular intervals along the Project's route. The locations are intended to require low maintenance and out of the general public's way. Each site would regularly and frequently receive materials and equipment; therefore, proximity to main roads and direct access to construction side roads and arterial roads were considered in order to reduce the expected impact on the general flow of traffic.

As discussed for the fabrication yards above, the key criteria used in selection of proposed staging areas were accessibility, traffic impact, utilities provision, environmental sensitivity, location, spacing, and size of site available.

5.1 Site Selection Criteria

The areas in Appendix A3 have been identified for temporary staging areas site selection. This list would be refined through continuing analysis, is flexible, and would be adjusted to unique impacts based on environmental reviews. The following four criteria were used as guidelines for the selection of construction staging areas.

5.1.1 Traffic

Selected areas were identified with reasonably direct access to arterials from major highways, and to freight railroads where practicable. Direct access to the Project's ROW would afford efficient transport of materials and equipment to construction sites with minimal impacts on traffic. Sites were also selected to minimize interference with pedestrians, bicyclists, and transit as much as possible.

Construction staging areas would be located within the same footprint as precast operations where practical to minimize cost and potential environmental impacts. Potential impacts of construction on traffic were also considered in the selection of suitable sites. The contractor would establish a location-specific, activity-based trip schedule to minimize those impacts.

The load and volume capacity of existing structures and roads along transport routes would need to support construction operations. An analysis of existing roads and structures along construction routes would be undertaken by the contractor prior to final site selection. Preliminary routes are shown in Appendix A7. Similarly, a site-specific investigation of horizontal and vertical clearances and of existing geometric road conditions, would be undertaken by the contractor to ensure construction equipment mobility and transport.

5.1.2 Area

The size of the staging areas would vary and depend on environmental constraints, development, and parcel boundaries in each location.

5.1.3 Location

Construction staging areas would be evenly distributed along the alignments to minimize the distances between construction sites. The staging areas would generally be spaced 15 to 25 miles (24.1 to 40.2km) apart.

5.1.4 Accessibility

The locations selected are generally close to major roadways and to on- and off-ramps. Access to major roadways would aid in shipping to and receiving from the construction site and would minimize travel on side roads, reducing traffic impacts. Transport of materials by rail could also be used to reduce traffic impacts.

Proximity of existing utilities was considered in selection of sites to reduce construction-site development time and costs. Accessibility to construction staging would be a key factor in efficient rates of production.

6 Construction Considerations

Typical and specific constructability concerns are described in the following sections. A more detailed analysis would need to be performed as the design progresses.

6.1 Accessibility

The ease of access to the construction area is a critical element in the constructability assessment. Access limitations would determine the amount of auxiliary work required to reach work sites with equipment and materials such as temporary access roads, with obvious implications to project cost and schedule. Access would also determine the types of equipment that would be required to reach the work zone and perform the work. Insufficient access might preclude large precast elements or large construction equipment from accessing the construction area, and could require additional work to improve existing adjacent infrastructure.

Additionally, the availability of space for construction operations (free of obtrusive infrastructure or obstacles) would be a key constructability factor. Sufficient space for staging, storage, and construction operations would be needed along the alignment. Space would be required for not only large equipment and major construction operations, but also for construction crew access, parking lots, and work areas.

6.2 Pre-Construction Activities

Roads and freight rail lines would be used for hauling materials and equipment. Construction haul routes would add traffic to local areas and could damage infrastructure not designed for heavy loads. Preliminary routes are shown in Appendix A7. Thus, reinforcement of local roads and bridges would likely be required in advance of major works.

Freight rail lines were also considered and sites were identified for proposed freight rail connections to deliver and haul larger quantities of construction materials and equipment. These proposed freight rail connections were strategically identified to support not only Project construction but long-term freight rail access at the TMFs and select MOW bases, which would serve as construction staging sites during Project development. Construction of auxiliary freight tracks to access these construction sites would be part of the early works.

6.3 Floodplain Crossings

Alignments passing through major floodplains, wetland, and environmentally sensitive areas would require mitigation measures and bring construction difficulties. Long lengths of the alignments in wetland areas would require viaducts with long spans to avoid disruption of the original conditions of soil and vegetation. Additionally, construction in floodplain areas, which typically contain poor soil conditions, would result in cost increases associated with the removal of inadequate materials and require the excavation and hauling of significant amounts of borrow pit materials.

6.4 Road Crossings

Grade separations at intersections between the alignments and existing roadways requiring bridge structures for either the HSR line or for the roadway, would require complex coordination efforts that would increase the schedule, and the schedule risk, of the project. Road crossings frequently require complicated structures and carefully phased construction to maintain existing traffic operations. The number of such road crossings would be minimized by running the alignment on a viaduct crossing over the existing roadways where possible.

6.5 Traffic

In the more developed areas the HSR would frequently cross significant roadways, which can provide for good construction access. In the more rural areas, there would be fewer locations where the alignment alternative crosses existing streets. In these areas, there are existing private and local access roads which could be used for construction access. Consent would be required from the landowner and it is likely that easements would be required to allow future maintenance access. Some of these roads are narrow and unpaved and would need to be improved to be suitable for construction traffic. Improvements may include widening, re-grading, drainage, and surfacing. Where no local or private roads exist new access roads could be provided.

Local and interstate highways would be affected by the movement of materials and equipment, and the contractor would be required to develop a construction transportation plan to minimize impacts. This plan would address, in detail, the activities to be carried out in each construction phase, with the requirement of maintaining traffic flow during peak travel periods. Such activities include, but are not limited to, the routing and scheduling of materials deliveries, materials staging and storage areas, construction employee arrival and departure schedules, employee parking locations, and temporary road closures, if any.

6.6 Railroad Coordination

Construction of crossings over freight railroad lines (fully grade separated) and all work adjacent to existing freight railroad lines would require coordination and approval from railroad operators. Construction in the vicinity of live freight operations would require additional safety considerations and defined procedures such as the use of flagmen. Particular consideration would need to be taken in both Houston and Dallas where long viaducts run parallel with active freight railroads. Close coordination will be required to minimize risk to schedule of railroad.

6.7 Complex and Skewed Structures

When intersecting with current infrastructure (e.g. highways, roadways, railways), skewed elevated crossings add to construction complexity. Perpendicular crossings can typically be designed and constructed as a conventional bridge with smaller spans, whereas skewed structures would require a more complicated site-specific design and construction with longer spans or long straddle bents.

6.8 Utilities

Utility relocations would increase construction cost and schedule risk due to third-party coordination and protection requirements. Working in the proximity of utilities such as electric power lines or gas pipelines would require careful site management and coordination with the respective utilities. An existing utility investigation will be performed as part of the design phase.

6.9 Right-of-Way (ROW)

Lack of site access would cause schedule delays and increased construction costs. Accordingly, alignments with more complicated ROW acquisition requirements would require significant advance efforts and third-party coordination. As such, alignment alternatives with lower requirements for acquisitions would reduce project cost and schedule risks.

6.10 Ground Improvements

A variety of ground improvement techniques are expected for the TCRR project to mitigate both expansive soil and soft ground conditions. The primary ground improvement technique is expected to be cut and replacement with imported select materials, such as lean clayey sands or crushed rock materials. It may also be feasible to engineer suitable materials in-place by amending the existing soil with the application of some combination of hydrated lime, Portland cement, and/or fly-ash, or to moisture-condition the expansive soil and encapsulate it to limit moisture variations. Other techniques are available and would be used as deemed necessary. These could include deep soil mixing, vibro-compaction, permeation or compaction grouting, jet grouting, dynamic falling-weight compaction, pile-slab solutions and stone columns.

7 Major Quantities

The following section details the major construction quantities along the six potential route options.

7.1 Construction Materials Quantities

An estimate of construction quantities was developed for each alignment alternative and is provided in Appendix A4. These numbers are rough order-of-magnitude estimates at this planning level of design development, but allow for a comparative evaluation of construction requirements for environmental analyses.

The list below describes several of the line items in Appendix A4:

- Excavation includes excavation, topsoil stripping, and undercut
- Filling includes embankment core and shell, undercut replacement
- Construction waste quantities do not include building, road or any other infrastructure demolition
- Hazardous waste material has not been quantified separately
- Miscellaneous other refers to crash walls, noise walls, MSE, retained cut wall, catenary bases, and facilities

In addition, several assumptions were made in this estimate, including:

- To produce a 3000 psi cubic yard of concrete (27 cubic feet) the typical concrete mixture ratio of 517 pounds of cement, 1560 pounds of sand, 1600 pounds of stone, and 32 - 34 gallons of water was used.
- Water will be available at batching/precasting sites
- 1 delivery of ballast every two weeks via locomotive
- 1 delivery of cement, sand and gravel every two weeks via locomotive
- 12 pm^2 for station structural steel
- No construction waste for earthworks operations as any spilloff will be transported to borrow sites or deposited along the job site.
- Construction waste for overall concrete operations is 5.0%; it is assumed that 0.5% will finally be deposited in landfill or recycled

The majority of the aggregates used for ballast, sub-ballast and aggregates for concrete will come from within the State of Texas to meet the majority of the project's needs. However, due to the aggressive schedule of this project, the Project does anticipate the need to purchase some aggregates from out-of-state quarries. The initial approach for transportation of aggregates will be to utilize the existing freight railroad infrastructure as much as possible. Some alternatives and some alignment segments will rely more heavily on truck transport given distance from freight railroad network and proximity to highway infrastructure, for example along IH-45.

Appendix A3 provides infrastructure configuration types per linear route mile, and linear kilometer, for the HSR.

7.2 Construction Equipment

An estimate of construction equipment needs was developed for each alignment alternative and is provided in Appendix A6. These numbers are rough order-of-magnitude estimates at this planning level of design development, but allow for a comparative evaluation of construction requirements for environmental analyses.

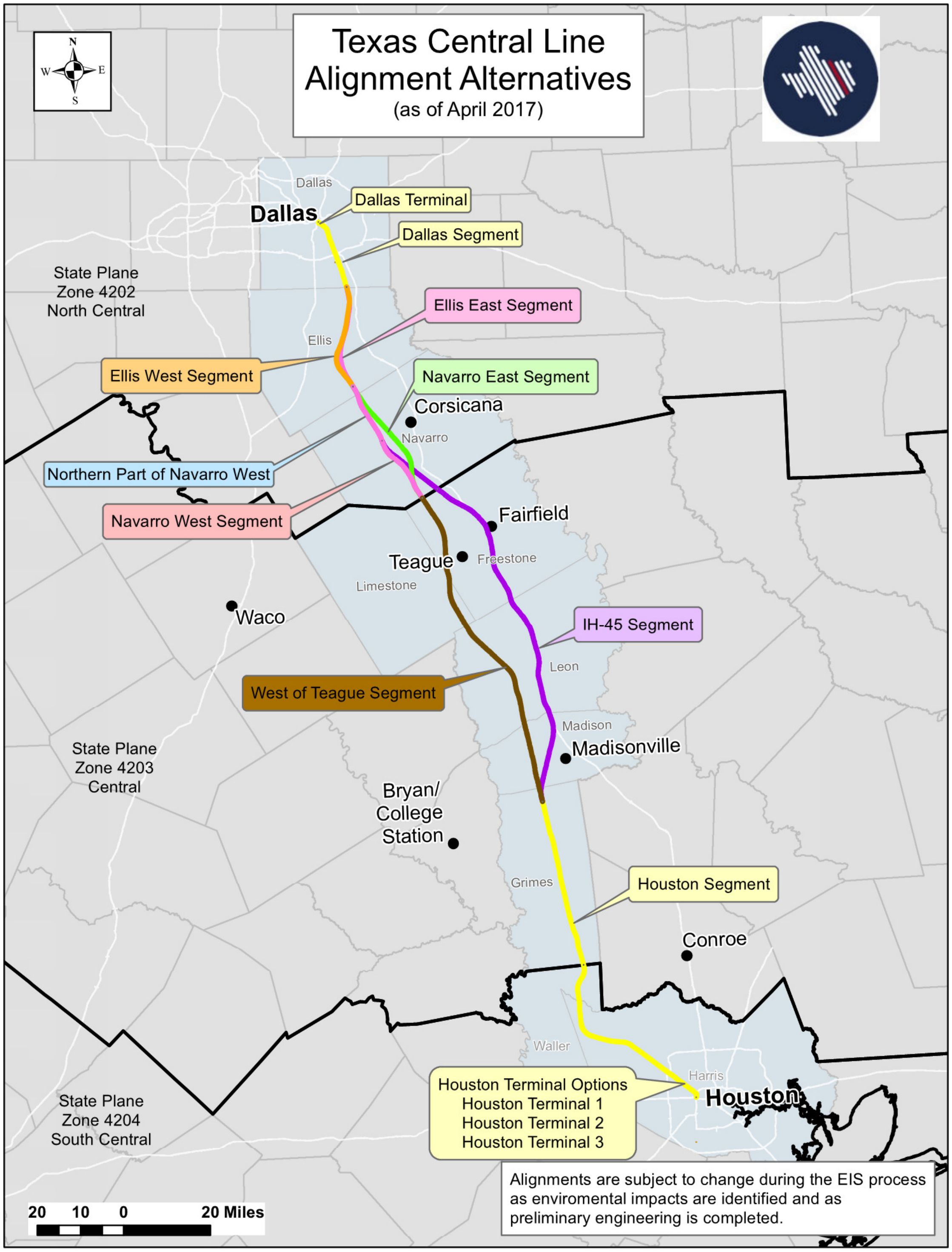
8 Construction Cost Estimate and Schedule

Appendix A8 provides TCRR's expected project capital cost and construction schedule.

TCRR has been closely coordinating with the construction community within Texas and with HSR owners, operators, and systems suppliers worldwide over the course of project development to gather insight into project infrastructure and facilities design and delivery approaches. TCRR has also undertaken early contractor engagement by bringing a design-build partner on board the project development team to ensure that likely construction means and methods are adequately considered in the development of our financial modeling.

As this is a privately developed project, we are not seeking public funding. As such, our capital cost and construction schedules are considered proprietary and additional details are not required at this time. TCRR believes that the level of detail provided is sufficient to meet EIS needs.

A1 Segments



Alignments are subject to change during the EIS process as enviromental impacts are identified and as preliminary engineering is completed.

Segment Name (ID; abbreviation)	Section Name (and ID)	Start	End	Length		FRA Alignment Alternatives					
				mi	km	**A**	**B**	**C**	**D**	**E**	**F**
Dallas (1, DS)	Dallas zNC (DT)	DT 10+00	DT 217+02	3.9	6.3	X	X	X	X	X	X
	Dallas zNC (DS)	DS 10+00	DS 770+78	14.4	23.2	X	X	X	X	X	X
Ellis West (2A, EW)	Ellis West zNC (EW)	EW 10+00	EW 1242+50	23.3	37.6	X	X	X			
Ellis East (2B, EE)	Ellis East zNC (EE)	EE 10+00	EE 1208+15	22.7	36.5				X	X	X
Navarro West (3A, NW)	Navarro West zNC (NW)	NW 10+00	NW 1637+09	30.8	49.6	X			X		
Navarro East (3B, NE)	Navarro East zNC (NE)	NE 10+00	NE 1654+02	31.1	50.1		X			X	
IH-45 (3C, IH)	Navarro West zNC (NWIH)	NW 880+02	NW 1637+09	14.3	23.1			X			X
	IH-45 zNC (IH2)	IH2 10+00	IH2 913+96	17.1	27.6			X			X
	IH-45 zCE (IH1)	IH1 10+00	IH1 4329+69	81.8	131.7			X			X
West of Teague (4, WT)	West of Teague zCE (WT)	WT 10+00	WT 4118+87	77.8	125.2	X	X		X	X	
Houston (5, HN)	Houston Zce (HN2)	HN2 10+00	HN2 2073+80	39.1	62.9	X	X	X	X	X	X
	Houston zSC (HN1)	HN1 10+00	HN1 2387+62	45.0	72.4	X	X	X	X	X	X
	Houston Terminal Industrial Site (HT3)	HT3 10+00	HT3 54+21	0.8	1.3						
	Houston Terminal Northwest Mall Site (HT2)	HT2 10+00	HT2 68+24	1.1	1.8						
	Houston Terminal Northwest Transit Center Site (HT1)	HT1 11+00	HT1 110+00	1.9	3.0	X	X	X	X	X	X
Total Length in miles assuming HT1 (miles)						236	237	241	236	236	240
Total Length in miles assuming HT1 (km)						380	381	388	379	380	387

A2 Non-Standard Structures

Section	STA Start	STA End	Structure Type	Key Considerations	Typical Span (ft)	Typical Span (m)
HT1	54+60	59+40	Crossover with straddle bents (concrete)	Cross over UPRR, on approx, 20 deg Skew	4 - 120' spans	4 - 37m spans
HN1	40+12	41+42	Long span (concrete)	Over Antoine Dr	130	40
HN1	75+55	79+15	Long span (concrete)	Over Kempwood Dr	105-150-105	32-46-32
HN1	118+20	121+80	Long span (concrete)	Over Bingle Rd	105-150-105	32-46-32
HN1	163+48	167+08	Long span (concrete)	Over Clay Rd	105-150-105	32-46-32
HN1	242+68	246+52	Long span (concrete)	Over Blalock	112-160-112	34-49-34
HN1	324+80	328+40	Long span (concrete)	Over Gessner	105-150-105	32-46-32
HN1	334+71	357+51	Crossover with straddle bents (concrete)	Crossovers UPRR	19 -120' spans	19 - 37m spans
HN1	404+70	406+10	Long span (concrete)	Sam Houston Hwy	140	43
HN1	429+46	434+50	Haunched Girder	FM 529	147-210-147	45-64-45
HN1	490+54	494+62	Long span (concrete)	Over Jones Road	119-170-119	36-52-36
HN1	562+95	566+55	Long span (concrete)	N Eldrdge Pkwy	105-150-105	32-46-32
HN1	632+41	638+17	Haunched Girder	Over TX-6	168-240-168	51-70-51
HN1	668+21	672+29	Long span (concrete)	Huffmeister Rd	119-170-119	36-5236
HN1	755+65	759+25	Long span (concrete)	Telge Road	105-150-105	32-46-32
HN1	963+40	964+80	Long span (concrete)	Fry Rd	140	43
HN1	1634+45	1635+75	Long span (concrete)	UPRR track	130	40
HN2	360+70	364+42	Long span (concrete)	Over UPRR rail tracks	108.5-155-108.5	33-47-33
HN2	363+34	366+51	Steel truss	Over UPRR rail yard	317	97
HN2	366+51	373+10	Haunched Girder	Over UPRR rail yard	192-275-192	59-84-59
HN2	1570+43	1573+93	Longspan (concrete)	Over BNSF rail tracks	102-146-102	31-45-31
WT	1810+90	1818+10	Haunched Girder	Over BNSF rail tracks	210-300-210	64-91-64
WT	2060+90	2068+10	Haunched Girder	Over UPRR rail tracks	210-300-210	64-91-64
WT	4034+50	4040+50	Crossover with straddle bents (concrete)	Over UPRR rail tracks	5 - 120’ spans;	5 - 37m spans
IH1	1564+40	1569+40	Haunched Girder	Over Realigned Road	140-200-140	43-61-43

Section	STA Start	STA End	Structure Type	Key Considerations	Typical Span (ft)	Typical Span (m)
IH1	3777+60	3782+40	Haunched Girder	Over UPRR and County Road	140-200-140	43-61-43
IH1	4167+60	4172+40	Haunched Girder	Over BNSF	140-200-140	43-61-43
IH2	275+60	280+40	Haunched Girder	Over UPRR rail tracks	140-200-140	43-61-43
NW	113+29	120+70	Haunched Girder	Over UPRR rail tracks	216-309-216	66-94-66
NE	113+43	121+83	Haunched Girder	Over UPRR rail tracks	245-350-245	75-107-75
EW	430+93	435+61	Haunched Girder	Over UPRR	136.5-195-136.5	42-59-42
EW	668+14	671+98	Long span (concrete)	Over UPRR	112-160-112	34-49-34
EE	345+03	350+00	Haunched Girder	Over UPRR rail tracks	145-207-145	44-63-44
EE	630+51	634+35	Long span (concrete)	Over UPRR rail yard	112-160-112	34-49-34
DS	750+34	761+14	Haunched Girder	Over Cemetery	315-450-315	96-137-96
DS	762+34	763+74	Long span (concrete)	Cross E Overton Rd.	140	43
DT	18+20	27+54	Haunched Girder	To avoid Water Line, Transmission Line; To avoid Levee toe of an existing facility	192-275-275-192	59-84-84-59
DT	31+14	37+73	Haunched Girder	To avoid Storm Sewer	192-275-192	59-84-59
DT	51+47	58+06	Haunched Girder	Trinity River Crossing	192-275-192	59-84-59
DT	65+26	-	80ft Straddle Bent	To avoid Storm Sewer	-	-
DT	107+06	116+66	Haunched Girder	Over future Trinity Pkwy	280-400-280	85-122-85
DT	119+66	129+00	Haunched Girder	To avoid Storm Sewer; To avoid BNSF and siding track	192-275-275-192	59-84-84-59
DT	124+34	-	120ft Straddle Bent	BNSF and siding track	-	-
DT	130+05	131+45	Long span (concrete)	Avoid Occidental Access	140	43
DT	139+70	146+29	Haunched Girder	Over Forest Ave; To avoid facility access road pavement; To avoid Storm Sewer	192-275-192	59-84-59
DT	158+09	159+49	Long span (concrete)	To avoid Storm Sewer	140	43

A3 Temporary Construction Facility Information

Ref #		Section	Station	Area (Acres)	Area (m^2)	Notes
HOUSTON STATION (HT1)				22.9	92672	Northwest Transit Center Site
1	Staging Area	HT1	11+00	16.3	65963	
2	Staging Area	HT1	45+00	6.6	26709	
HOUSTON STATION (HT2)				24.4	98743	Northwest Mall Site
3	Staging Area	HT2	10+00	24.4	98743	
HOUSTON STATION (HT3)				39.5	159850	Northwest Industrial Site
4	Staging Area	HT3	10+00	39.5	159850	
HOUSTON (HN1)				407	1648677	
5	Staging Area	HN1	444+00	19.5	78913	
6	Staging Area	HN1	660+00	16.4	66368	
7	Proposed Precasting Yard	HN1	1160+00	298.2	1206763	Short railroad connection proposed
8	Staging Area	HN1	1540+00	15.7	63535	
9	Staging Area	HN1	1650+00	50.7	205174	
10	Staging Area	HN1	2055+00	6.9	27923	
HOUSTON (HN2)				462	1869633	
11	Proposed Precasting Yard	HN2	350+00	178.6	722763	Adjacent to existing railroad
12	Staging Area	HN2	370+00	29.4	118977	Adjacent to existing railroad
13	Staging Area	HN2	1260+00	31.5	127475	
14	Staging Area	HN2	1290+00	9.0	36421	
15	Staging Area	HN2	1300+00	13.7	55442	
16	Proposed Precasting Yard	HN2	1590+00	199.8	808556	Adjacent to existing railroad
WEST OF TEAGUE (WT)				528	2136724	
17	Staging Area	WT	440+00	34.8	140830	
18	Staging Area	WT	460+00	17.4	70415	
19	Proposed Precasting Yard	WT	960+00	103.0	416823	Railroad connection proposed
20	Staging Area	WT	1732+00	9.6	38850	
21	Staging Area	WT	1740+00	15.4	62321	
22	Staging Area	WT	2060+00	22.7	91863	
23	Staging Area	WT	2070+00	27.4	110883	
24	Staging Area	WT	2075+00	57.3	231883	
25	Staging Area	WT	2090+00	48.1	194652	
26	Staging Area	WT	2890+00	12.7	51395	
27	Staging Area	WT	3460+00	75.7	306345	
28	Proposed Precasting Yard	WT	4060+00	103.9	420465	Adjacent to existing railroad
IH-45 (IH1)				383	1548720	
29	Proposed Precasting Yard	IH1	1530+00	62.2	251713	Potential location for precasting facility, construction of a short railroad spur proposed
30	Staging Area	IH1	2490+00	5.3	21448	
31	Staging Area	IH1	2500+00	6.0	24281	
32	Staging Area	IH1	2560+00	23.6	95505	
33	Proposed Precasting Yard	IH1	4150+00	285.6	1155773	Adjacent to existing railroad
IH-45 (IH2)				183	740974	
34	Staging Area	IH2	280+00	13.0	52609	

Ref #		Section	Station	Area (Acres)	Area (m^2)	Notes
35	Proposed Precasting Yard	IH2	400+00	90.2	365024	Railroad connection proposed
37	Staging Area	IH2	870+00	41.7	168753	
38	Staging Area	IH2	880+00	38.2	154589	
NAVARRO WEST (NW)				244	986616	
36	Proposed Precasting Yard	NW	400+00	106.0	428963	Railroad connection proposed
37	Staging Area	NW	840+00	41.7	168753	
38	Staging Area	NW	850+00	38.2	154589	
39	Proposed Precasting Yard	NW	1210+00	38.0	153779	Long railroad connection proposed
40	Staging Area	NW	1230+00	19.9	80532	
NAVARRO EAST (NE)				240	969214.6	
35	Proposed Precasting Yard	NE	400+00	90.2	365024	Railroad connection proposed
41	Proposed Precasting Yard	NE	880+00	87.8	355311	Railroad connection proposed
42	Staging Area	NE	1160+00	38.6	156207	
43	Staging Area	NE	1180+00	22.9	92672	
ELLIS WEST (EW)				245	990258	
44	Staging Area	EW	190+00	6.3	25495	
45	Staging Area	EW	540+00	27.1	109669	
46	Proposed Precasting Yard	EW	660+00	107.2	433820	Adjacent to existing railroad
47	Staging Area	EW	670+00	51.9	210030	Adjacent to existing railroad
48	Staging Area	EW	1200+00	52.2	211244	
ELLIS EAST (EE)				220.4	891920	
49	Staging Area	EE	199+00	9.1	36826	
46	Proposed Precasting Yard	EE	620+00	107.2	433820	Adjacent to existing railroad
47	Staging Area	EE	630+00	51.9	210030	Adjacent to existing railroad
48	Staging Area	EE	1185+00	52.2	211244	
DALLAS (DS)				431	1743372	
50	Staging Area	DS	110+00	23.6	95505	
51	Staging Area	DS	120+00	22.8	92268	
52	Staging Area	DS	260+00	108.2	437866	
53	Proposed Precasting Yard	DS	290+00	165.9	671368	Short railroad connection proposed
54	Staging Area	DS	360+00	28.7	116144	
55	Staging Area	DS	370+00	28.8	116549	
56	Staging Area	DS	500+00	39.0	157826	
57	Staging Area	DS	690+00	6.2	25090	
58	Staging Area	DS	700+00	3.9	15783	
59	Staging Area	DS	720+00	3.7	14973	
DALLAS (DT)				80.8	326984	
60	Staging Area	DT	10+00	8.5	34398	
61	Staging Area	DT	95+00	6.4	25900	
62	Staging Area	DT	175+00	2.9	11736	Dallas Station
63	Staging Area	DT	200+00	52.8	213672	Dallas Station
64	Staging Area	DT	210+00	10.2	41278	Dallas Station

A4 Construction Material Quantities

		Quantity					
Item	**Unit**	**End to End Alignment A**	**End to End Alignment B**	**End to End Alignment C**	**End to End Alignment D**	**End to End Alignment E**	**End to End Alignment F**
Total Length	miles	236.30	236.62	240.94	235.65	235.97	240.29
Drill Shafts	CY	2,314,343	2,317,484	2,359,746	2,307,971	2,311,112	2,353,374
Column	CY	1,456,598	1,458,575	1,485,174	1,452,588	1,454,565	1,481,163
Cap (Bent & Pile)	CY	533,867	534,591	544,340	532,397	533,121	542,870
Beams	CY	0	0	0	0	0	0
Deck / Girder	CY	3,232,871	3,237,259	3,296,293	3,223,971	3,228,358	3,287,393
Drainage	CY	250,000	250,339	254,904	249,312	249,651	254,216
Systems	CY	133,000	133,181	135,609	132,634	132,814	135,243
Electrical	CY	20,000	20,027	20,392	19,945	19,972	20,337
Stations	CY	330,000	330,448	336,474	329,091	329,539	335,565
Misc Other	CY	221,534	221,835	225,880	220,924	221,225	225,270
Total Concrete	CY	8,492,213	8,503,739	8,658,813	8,468,833	8,480,358	8,635,432
Cement	Ton	1,297,186	1,298,946	1,322,634	1,293,614	1,295,375	1,319,062
Sand	Ton	3,078,427	3,082,605	3,138,820	3,069,952	3,074,130	3,130,344
Gravel	Ton	3,396,885	3,401,495	3,463,525	3,387,533	3,392,143	3,454,173
Reinforcement	lbs	2,123,053,269	2,125,934,626	2,164,703,172	2,117,208,170	2,120,089,527	2,158,858,073
Structural Steel	lbs	13,205,875	13,223,798	13,464,947	13,169,517	13,187,440	13,428,589
Sub-Ballast	CY	974,819	976,142	993,943	972,135	973,458	991,259
Ballast	CY	2,293,441	2,296,554	2,338,434	2,287,127	2,290,239	2,332,119
Concrete Ties	Each	1,371,124	1,372,984	1,398,022	1,367,349	1,369,210	1,394,247
Rail	TF	2,742,247	2,745,969	2,796,044	2,734,697	2,738,419	2,788,495

Item	**Unit**	**End to End Alignment A**	**End to End Alignment B**	**End to End Alignment C**	**End to End Alignment D**	**End to End Alignment E**	**End to End Alignment F**
Excavation*	CY	7,388,226	7,398,253	7,533,168	7,367,885	7,377,912	7,512,827
Filling**	CY	24,937,158	24,971,002	25,426,374	24,868,502	24,902,347	25,357,718
Construction waste - concrete	CY	58,204	58,283	59,346	58,044	58,123	59,186
Construction waste - rebar	Lbs	31,845,799	31,889,019	32,470,548	31,758,123	31,801,343	32,382,871
Notes:							
To produce a 3000 psi cubic yard of concrete (27 cubic feet) the concrete mixture ratio is: 1. 517 pounds of cement 2. 1560 pounds of sand 3. 1600 pounds of stone 4. 32 - 34 gallons of water							
Assume water available at batching/precasting sites							
Assume 1 delivery of ballast every two weeks via locomotive							
Assume 1 delivery of cement, sand and gravel every two weeks via locomotive							
Assume 12 psf for station structural steel							
Assuming no construction waste for earthworks operations as any spilloff will be transported to borrow sites or deposited along the job site.							
Construction waste for overall concrete operations is 5.0%, it is assumed that 0.5% will finally be deposited in landfill or recycled							
Construction waste for reinforcement is 7.5%, it is assumed that 1.5% will finally be deposited in landfill or recycled							
Hazardeous waste material has not been quantified seperately							
Construction waste quantities do not include building, road or any other infastructure demolition							
*Excavation includes excavation, drilled shaft spoil, topsoil stripping, and undercut (4' deep)							
**Filling includes embankment, undercut replacement, filling at road over rail crossings							

A5 Infrastructure Configuration Types

Infrastructure Configuration Types by Alignment (miles)

Alignment	**End to End A**		**End to End B**		**End to End C**		**End to End D**		**End to End E**		**End to End F**	
Section Type	Total (miles)	% of Route	Total (miles)	% of Route	Total (miles)	% of Route	Total (miles)	% of Route	Total (miles)	% of Route	Total (miles)	% of Route
Retained Cut	1.4	1%	2.3	1%	2.4	1%	1.4	1%	2.3	1%	2.4	1%
Cut	18	8%	17.6	7%	16.4	7%	19	8%	18.6	8%	17.4	7%
Embankment	74.5	32%	76.4	32%	67.3	28%	75.2	32%	77.1	33%	68	28%
Retained Fill	1.3	1%	1.4	1%	4.2	2%	1.3	1%	1.4	1%	4.2	2%
Viaduct	141.1	60%	138.9	59%	150.7	63%	138.7	59%	136.6	58%	148.3	62%
Total Length (miles)	236.3	100%	236.6	100%	241.0	100%	235.6	100%	236	100%	240.3	100%

Infrastructure Configuration Types by Alignment (km)

Alignment	**End to End A**		**End to End B**		**End to End C**		**End to End D**		**End to End E**		**End to End F**	
Section Type	Total (km)	% of Route	Total (km)	% of Route	Total (km)	% of Route	Total (km)	% of Route	Total (km)	% of Route	Total (km)	% of Route
Retained Cut	2.3	1%	3.7	1%	3.9	1%	2.3	1%	3.7	1%	3.9	1%
Cut	29.0	8%	28.3	7%	26.4	7%	30.6	8%	29.9	8%	28.0	7%
Embankment	119.9	32%	123.0	32%	108.3	28%	121.0	32%	124.1	33%	109.4	28%
Retained Fill	2.1	1%	2.3	1%	6.8	2%	2.1	1%	2.3	1%	6.8	2%
Viaduct	227.1	60%	223.6	59%	242.4	63%	223.3	59%	219.8	58%	238.6	62%
Total Length (miles)	380.3	100%	380.8	100%	387.7	100%	379.2	100%	379.8	100%	386.7	100%