U.S. Department of Transportation

Federal Railroad Administration

Dallas to Houston High-Speed Rail Project
Alignment Alternatives Analysis Report

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AECOM

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LIST OF ACRONYMS/ABBREVIATIONS

ACS	American Community Survey
BA	Bardwell Geographic Group
BNSF	BNSF Railroad
CAD	computer-aided design
CEQ	Council on Environmental Quality
CR	Corsicana Geographic Group
CS	Common Segment Geographic Group
DH	Downtown Houston Geographic Group
EIS	Environmental Impact Statement
EJ	Environmental Justice
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FM1488	Farm to Market 1488
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GIS	Geographic Information Systems
GNIS	Geographic Names Information Service
IH-10	Interstate Highway 10
IH-45	Interstate Highway 45
IH-610	Interstate Highway 610

HC	Hockley Geographic Group
km/h	kilometer per hour
kV	kilovolt
MD	Middle Geographic Group
mph	mile per hour
MPO	Metropolitan Planning Organization
NEPA	National Environmental Policy Act
NHD	National Hydrography Dataset
NLCD	National Land Cover Dataset
NRCS	National Resources Conservation Service
NRHP	National Register of Historic Places
NWI	National Wetland Inventory
ROW	Right-of-Way
SH 99	State Highway 99
SSURGO	Soil Survey Geographic Database
STB	Surface Transportation Board
TCEQ	Texas Commission on Environmental Quality
TCR	Texas Central High-Speed Railway
THC	Texas Historical Commission
TPWD	Texas Parks and Wildlife Department
TxDOT	Texas Department of Transportation
TXNDD	Texas Natural Diversity Database
UPRR	Union Pacific Railroad
US 290	U.S. Highway 290
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

1.0 INTRODUCTION

This report forms the framework for conducting an environmental impact analysis in accordance with the National Environmental Policy Act (NEPA) and its implementing regulations. The purpose of this report is to document the Federal Railroad Administration's (FRA) independent evaluation of potential route alternatives for the proposed Dallas to Houston High-Speed Rail Project (Project).

FRA initiated a NEPA evaluation of Texas Central High-Speed Railway, LLC's and its affiliates (TCR or the Proponent) proposal to construct and operate a private, for-profit, high-speed passenger rail system connecting Dallas and Houston using the Japanese N700-I Tokaido Shinkansen high-speed rail technology. The Project encompasses an approximately 240-mile-long corridor between the two cities. TCR's proposed high-speed rail system requires a fully sealed corridor with grade-separated crossings and dedicated right-of-way (ROW) that is approximately 125 feet wide in order to accommodate a two-track railroad and an access road. It requires a "closed" system, meaning that the train must run on dedicated high-speed rail tracks for passenger rail service only and cannot travel on existing or planned freight rail lines or share tracks with other passenger services, such as Amtrak.

FRA has the authority to regulate the safety of railroads, including the Project. For the Project, FRA may issue a Rule of Particular Applicability (regulations that apply to a specific railroad or a specific type of operation), a series of waivers, or another action to ensure the Project is operated safely. This regulatory action(s) constitutes a federal action requiring an environmental review under NEPA.

As required by NEPA, FRA initiated an Environmental Impact Statement (EIS) to document the possible environmental impacts of the Project. This evaluation is required by 42 U.S.C. 4321 et seq., Council on Environmental Quality (CEQ) NEPA regulations (40 CFR 1500-1508), and the FRA's implementing regulations, *FRA Procedures for Considering Environmental Impacts,* as set forth in 64 FR 28545 (1999). An EIS is being prepared by the FRA in cooperation with Federal Highway Administration (FHWA), U.S. Army Corps of Engineers (USACE), Federal Transit Administration (FTA), the Surface Transportation Board (STB), and U.S. Fish and Wildlife Service (USFWS). The Texas Department of Transportation (TxDOT) is providing technical assistance to FRA in the preparation of the EIS.

Supporting the early development of the EIS, this report defines the scope of the Project and the reasonable alternatives FRA will evaluate in the EIS. FRA's alignment alternatives analysis reflects FRA's independent evaluation and judgment in its capacity as the federal lead agency for the EIS. Given that TCR, the Proponent of the Project, is a private railroad, it is incumbent on TCR to develop feasible alternatives that would achieve its operational criteria for FRA's consideration and evaluation. This report serves as the basis for evaluating those potential route alternatives in relation to the Project's purpose and need. FRA concludes the report by identifying the potential route alternatives, or build alternatives that fully meet the Project's purpose and need and that FRA will carry forward for evaluation in the Draft EIS. The Draft EIS potential alignments will continue to be refined and evaluated as potential environmental impacts are identified, as required by NEPA. The No Build or No Action Alternative, as required by NEPA, will serve as the basis for comparison of the environmental impacts of the build alternatives and will be evaluated in the Draft EIS.

This document provides the:

- Project background
- Evaluation of potential route alternatives
- Alternatives considered but eliminated from further consideration
- Alternatives carried forward for further consideration

1.1 Background

A formal alternatives analysis is critical to the decision-making process and to ultimately fulfill obligations under NEPA. Section 102(C) of NEPA requires that agencies "include in every recommendation or report on proposals for legislation and other major federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on:

(i) The environmental impact of the proposed action;
(ii) Any adverse environmental effects which cannot be avoided should the proposal be implemented;
(iii) Alternatives to the proposed action;
(iv) The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and
(v) Any irreversible and irretrievable commitments of resources which would be involved in the proposed action, should it be implemented."

CEQ NEPA regulations regarding the analysis of alternatives require agencies to:

"(a) Rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated;
(b) Devote substantial treatment to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits;
(c) Include reasonable alternatives not within the jurisdiction of the lead agency;
(d) Include the alternative of no action;
(e) Identify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative in the final statement unless another law prohibits the expression of such a preference; and
(f) Include appropriate mitigation measures not already included in the proposed action or alternatives." (40 CFR 1502.14)

As described in FRA's *Corridor Alternatives Analysis Technical Report,* dated August 10, 2015 and available online at https://www.fra.dot.gov/eLib/Details/L16978), FRA undertook a two stage alternatives analysis screening process. The first stage identified corridor alternatives for the proposed high-speed rail system from which potential route alternatives within corridors could be developed. The second stage in FRA's alternatives analysis screening process is documented in this report. The results of this alternatives analysis provide the basis for in-depth environmental studies of the most feasible and practical potential route alternatives in the Draft EIS.

1.1.1 FRA's Corridor Alternatives Analysis

FRA completed a corridor-level alternatives analysis to identify and evaluate the potential corridors that could become "alternatives" in the EIS. This first step narrowed the universe of potential alternatives by identifying viable high-speed rail corridors within which specific high-speed rail potential route alternatives could be developed.

FRA developed the range of potential corridors using the high-speed rail corridors identified in previous studies and those using existing linear infrastructure corridors. FRA did not complete any engineering or design work as part of this analysis. The four potential high-speed rail corridors FRA evaluated included:

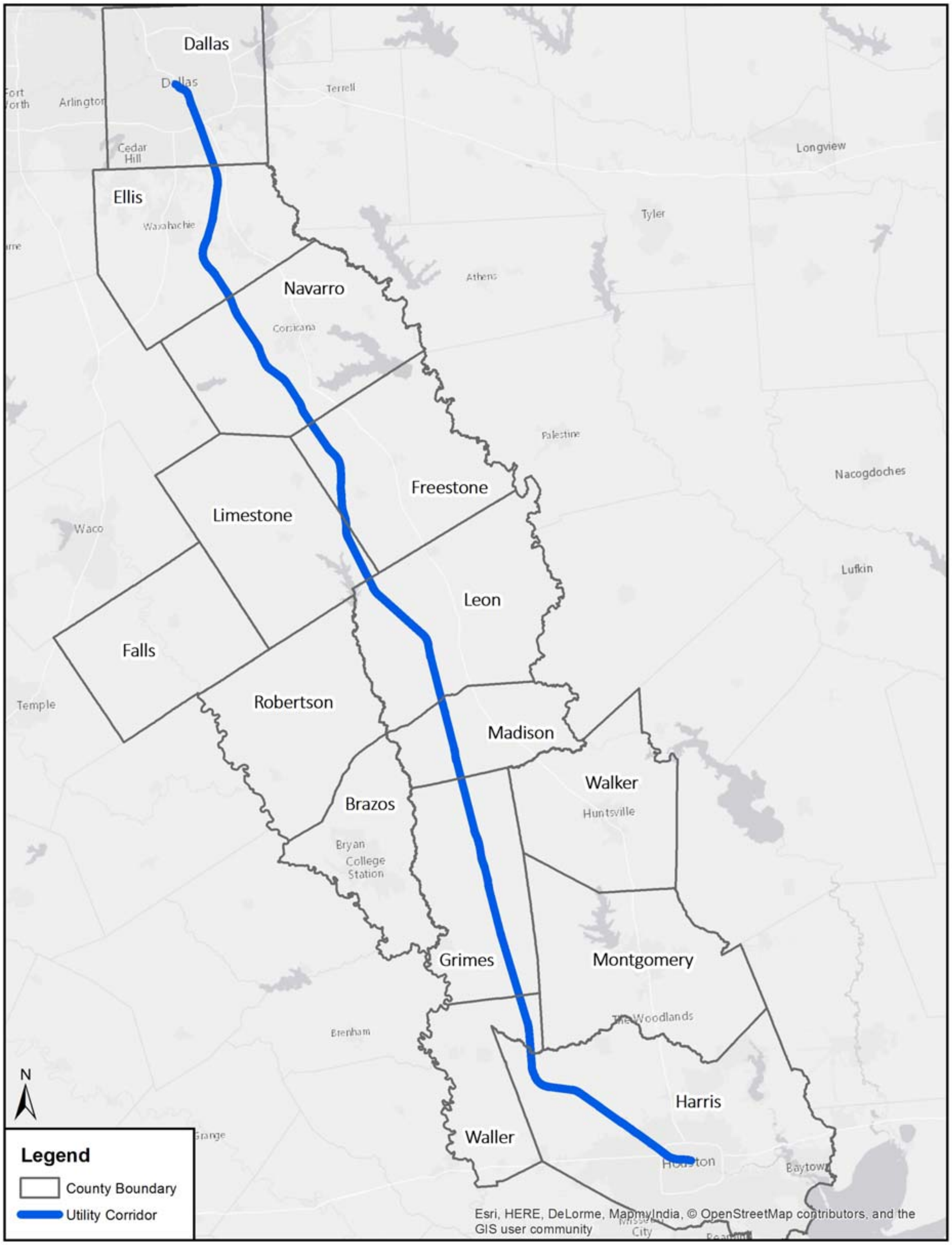
- BNSF Corridor
- UPRR Corridor
- IH-45 Greenfield Corridor
- Utility Corridor

FRA also considered alternatives to high-speed rail service that included higher-speed and conventional speed rail services, direct bus service, and expansion of Interstate Highway 45 (IH-45).

Through the corridor alternatives analysis, FRA determined that the Utility Corridor be retained for further investigation of potential route alternatives during the next stage of the alternatives analysis. The Utility Corridor follows the CenterPoint Energy and Oncor Electric Delivery high-voltage electrical transmission lines (345 to 500 kilovolts (kV)). The utility easement does not extend into downtown Dallas or downtown Houston. The easement originates near Palmer and terminates near Hockley to the south. Therefore, between Dallas and Palmer, the Utility Corridor follows and uses the Union Pacific Railroad (UPRR) Corridor to the downtown Dallas area. Between Hockley and Houston, the Utility Corridor follows and uses the UPRR Eureka Subdivision into downtown Houston. Figure 1-1 shows the Utility Corridor, which includes the use of the UPRR Corridor, in the terminus areas in Dallas and Houston.

FRA also determined that portions of the BNSF Railroad (BNSF), UPRR, and IH-45 Greenfield Corridors be retained for further investigation in the event that constraints arise along the Utility Corridor that warrant potential route alternatives within portions of these eliminated corridors that avoid the constraints.

Figure 1-1: Utility Corridor



1.1.2 TCR's Last Mile Analysis

As part of this Project, TCR proposed terminus stations in Dallas and Houston that would serve intercity travel demand and commerce, provide for economic redevelopment, and provide connectivity with each region's major transit and roadway systems. TCR's station analysis is documented in its *Last Mile Analysis Report* (TCR 2015a), dated March 27, 2015, and available online at http://www.texascentralhighspeedrail.com/page4/index.html. In its report, TCR's stated goal in locating stations was to minimize impacts, maximize multi-modal connectivity, optimize ridership with respect to revenue, and optimize adjacent land-uses to provide long-term local development opportunities.

TCR also determined that its stations should be configured to support near-term operating goals and allow for future expansions and extensions (stations as well as tracks) so that the Project could serve as an extendable passenger rail network spine, connecting with regional transportation services.

Both Dallas and Houston have multiple commercial and economic centers spread across their respective metropolitan areas, including each having a downtown central business district. These many commercial centers are served by highly developed highway and roadway networks. Consequently, TCR determined that it was appropriate to consider opportunities for "downtown" and "suburban" locations in Dallas and Houston. TCR also identified an intermediate station to serve the Bryan/College Station area along the UPRR Corridor and a Shiro Station area along the Utility Corridor.

Based on its screening criteria, TCR determined that the most viable terminus locations in Dallas and Houston along the Utility Corridor are Downtown Dallas (noted in their report as Last Mile Alternative C) and U.S. Highway 290/Interstate Highway 610 (US 290/IH-610) in Houston (noted in their report as Last Mile Alternative B). TCR determined that a station near Shiro is viable due to its proximity to Bryan/College Station and Huntsville.

1.1.3 TCR's Step 2 Screening of Alternative Alignments

After completing its Step 1 Screening of Alternatives and Last Mile Analysis, TCR initiated its next level of analysis to develop potential alignment alternatives within the Utility Corridor. TCR issued its *Step 2 Screening of Alternative Alignments Report* (TCR 2015b) dated November 5, 2015 (available online at http://www.texascentralhighspeedrail.com/page4/index.html). In its report, TCR proposed a Base Alignment paralleling the existing CenterPoint Energy and Oncor Electric Delivery utility easements and recommended 21 potential route alternatives. TCR identified constraints along the Base Alignment, including "areas of environmental concern, construction complexity, geometric challenges, economic impact and other major concerns," in six geographic areas from which it identified the potential route alternatives. These potential route alternatives were created using the alignment objectives and design guidelines developed by TCR. The six geographic areas include:

- Corsicana (CR)
- Bardwell (BA)
- Interstate Highway 45 (IH-45)
- Middle (MD)
- Hockley (HC)
- Downtown Houston (DH)

TCR completed a two-phase alternatives analysis. In its Phase 1 Analysis, TCR quantitatively evaluated the Base Alignment and the potential route alternatives using the following criteria:

- Engineering: alignment length and adjacency to the existing utility line
- Alignment geometry: superelevation,[1] total number of curves, and curves and speed restrictions
- Viaduct length and major structures: total viaduct length and number of complex structures
- Crossings: major road crossings, moderate road crossings, minor road crossings, freight crossings, and utility crossings
- Hydrology: tier 1 hydrologic features – Federal Emergency Management Agency (FEMA) crossings and tier 2 hydrologic features – other crossings
- Environmental: streams, waterbodies and wetlands; natural resources and land cover; cultural resources; environmental justice; and hazardous sites

In its Phase 2 Analysis, TCR qualitatively evaluated the Base Alignment and the potential route alternatives using project delivery concerns. TCR's Phase 2 Analysis evaluation criteria included capital cost, construction duration, and constructability.

TCR concluded its *Step 2 Screening of Alignment Alternatives Report* (2015b) by recommending four end-to-end alignment alternatives to FRA for further evaluation in the Draft EIS.

2.0 PURPOSE AND NEED FOR THE PROJECT

As defined by TCR, the purpose of the privately proposed Project is to provide reliable, safe and economically viable passenger rail transportation using proven high-speed rail technology between Dallas and Houston. It would provide a convenient and competitive alternative to automobile travel on IH-45 or air travel between the two major metropolitan areas and introduce rail capacity in the vicinity of the corridor. To achieve TCR's economic viability and safety requirements, the Project must meet the following technical requirements:

- Technological: bullet train vehicle and operating procedures based on the N700-I Tokaido Shinkansen
- Operational: approximate 90 minute travel time between Dallas and Houston, with achievable speeds exceeding 200 miles per hour (mph) in a fully sealed corridor
- Environmental: minimal impacts to the natural and built environments by maximizing adjacency to existing infrastructure ROW

FRA, in accordance with federal requirements, must ensure that the system can be operated safely. As the federal lead agency for the NEPA analysis, FRA is obligated to avoid and minimize impacts to the human and natural environment. FRA must also ensure that the Project complies with all applicable federal laws and executive orders.

Current transportation options between Dallas and Houston rely on automobile and air travel. Due to increasing congestion on IH-45, automobile travel times between the two regions are projected to increase as travel speeds decrease. Flights between the two regions are approximately 65 minutes, in addition to the recommended airport arrival time at the gate approximately 60 minutes before the scheduled departure time. Flights are sensitive to inclement weather and other delay-causing events from inside and outside of Texas. As a result of these constraints, combined with the distance between

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[1] Superelevation is the vertical distance between the heights of inner and outer edges or the slope of the railroad rails.

the two metropolitan areas and potential ridership demand, TCR identified an opportunity to develop a profitable privately-financed and operated high-speed passenger rail system. The mobility and congestion issues on the IH-45 corridor that TCR's proposed Project potentially addresses represents identification of the typical "need" for a FRA project, which FRA usually addresses through service-level corridor planning.

3.0 DESCRIPTION OF PROPOSED PROJECT

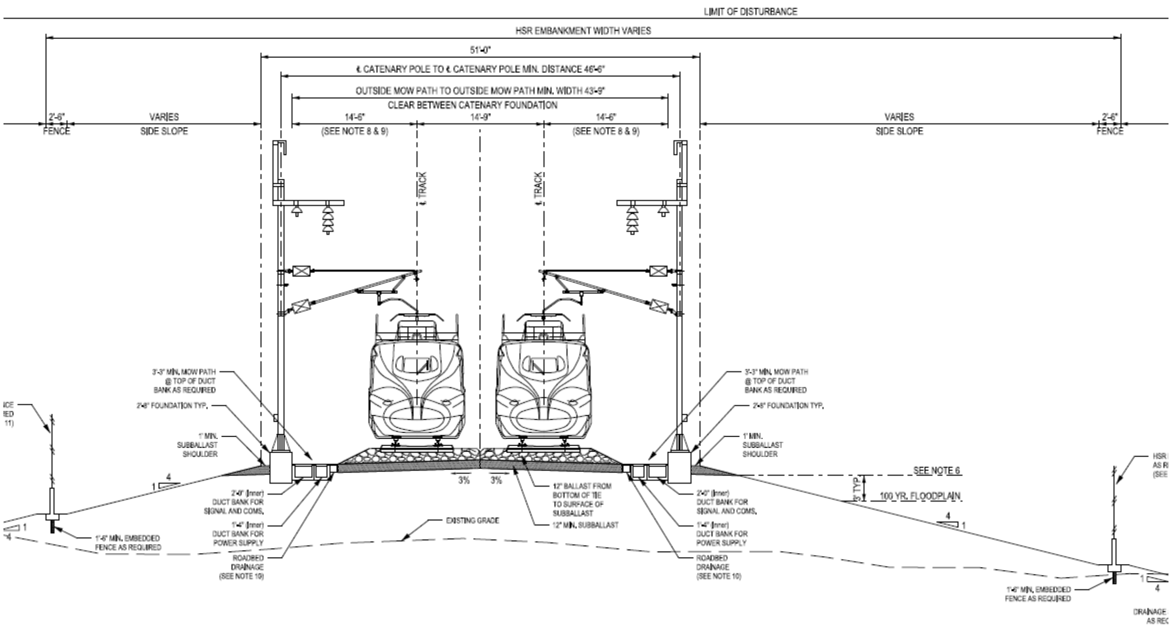
As described in Section 2.0, Purpose and Need, the Dallas to Houston High-Speed Rail Project must meet specific technological and operational criteria. This includes the deployment of an electric-powered, high-speed rail system based on Central Japan Railway Company's N700-I Tokaido Shinkansen. To minimize risk and enhance passenger safety, the Project would operate in a fully sealed corridor. A fully sealed corridor is not interconnected with any other railroad systems and the high-speed rail train will either travel below or above existing roadways and other infrastructure. This will enable trains to achieve speeds exceeding 200 mph and maintain the 90-minute travel time between Dallas and Houston.

Figure 3-1: Shinkansen Trainset

Source: TCR

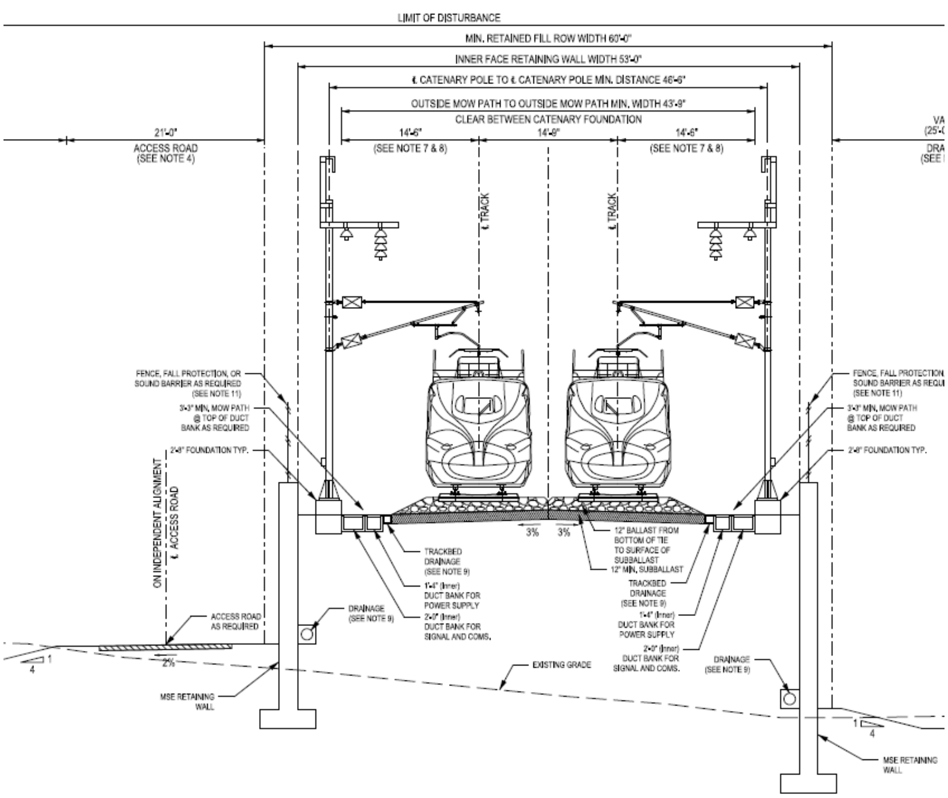
The following figures illustrate at-grade, retained fill and viaduct typical sections of the train infrastructure requirements.

Figure 3-2: At-grade Typical Section



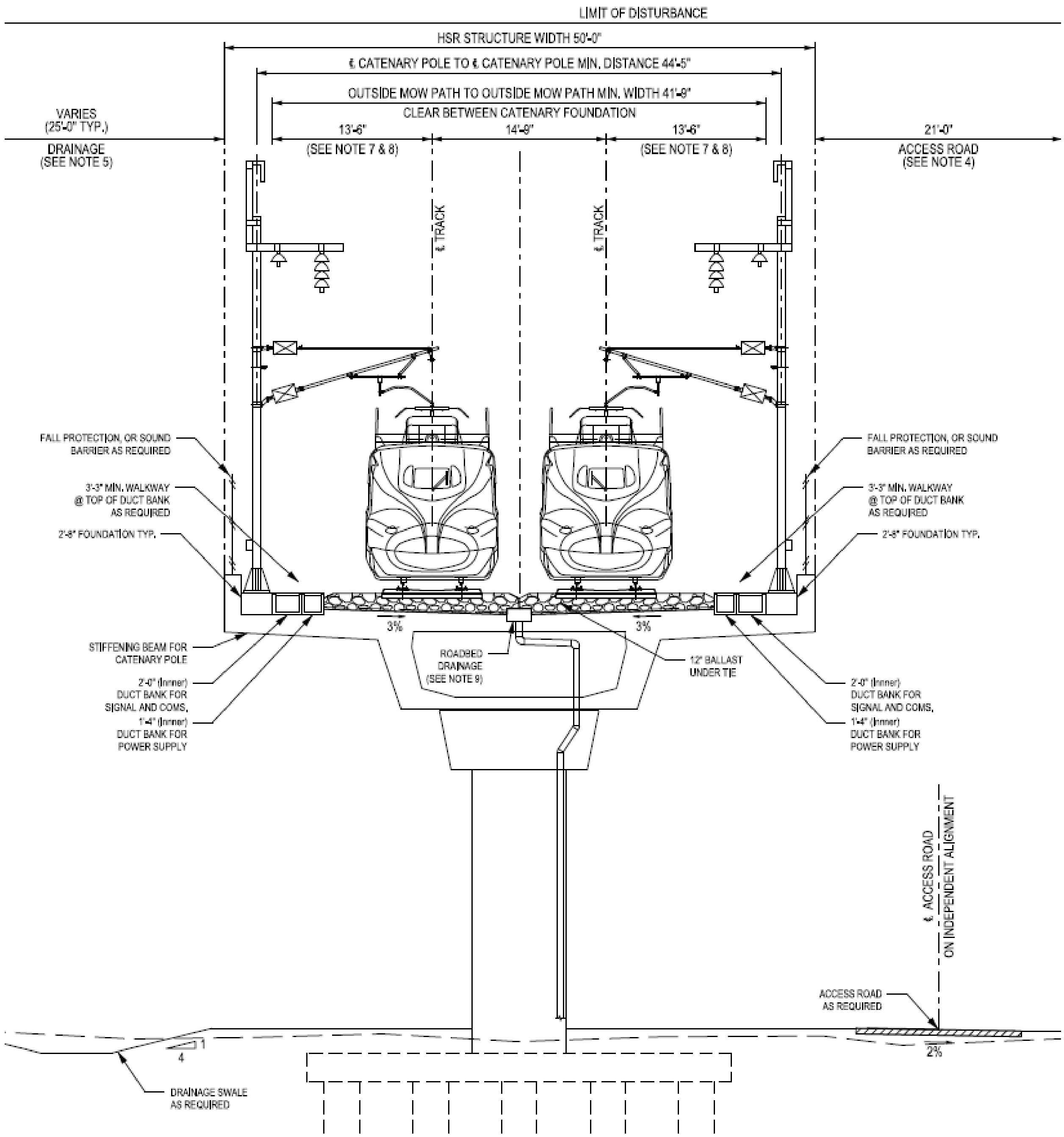
Source: TCR

Figure 3-3: Retained Fill Typical Section



Source: TCR

Figure 3-4: Viaduct Typical Section



Source: TCR

4.0 DESCRIPTION OF POTENTIAL ROUTE ALTERNATIVES

FRA's responsibility is to evaluate the alternatives that TCR developed and proposed. TCR proposed potential route alternatives in six geographic groups – Corsicana, Bardwell, IH-45, Middle, Hockley and downtown Houston – to help avoid known environmental or engineering constraints it identified along the Base Alignment. Figure 4-1 shows the 21 potential route alternatives. Note that some geographic groups overlap one another. The potential route alternatives were developed based on conceptual engineering completed as of June 25, 2015.

Common segments (CS) of the Base Alignment are located between several of the geographic groups: Dallas to the north end of the Bardwell geographic group; the south end of the IH-45 geographic group to the north end of the Hockley geographic group; and the south end of the Hockley geographic group to the north end of the downtown Houston geographic group. These common segments did not contain known environmental and/or engineering constraints. Therefore, TCR did not propose potential route alternatives in these areas. Given that there were no recommended potential route alternatives within these common segments, FRA collected data for purposes of identifying fatal flaws, but did not conduct an evaluation for the purpose of narrowing the range of alternatives. Descriptions of the common segments that will be carried forward in the Draft EIS are provided below.

North Terminus Common Segment (CS-1)

CS-1 begins on the south side of downtown Dallas and parallels the existing UPRR freight line towards IH-45. CS-1 crosses the Trinity River on the west side of IH-45 and parallels IH-45 until the Ellis County line.

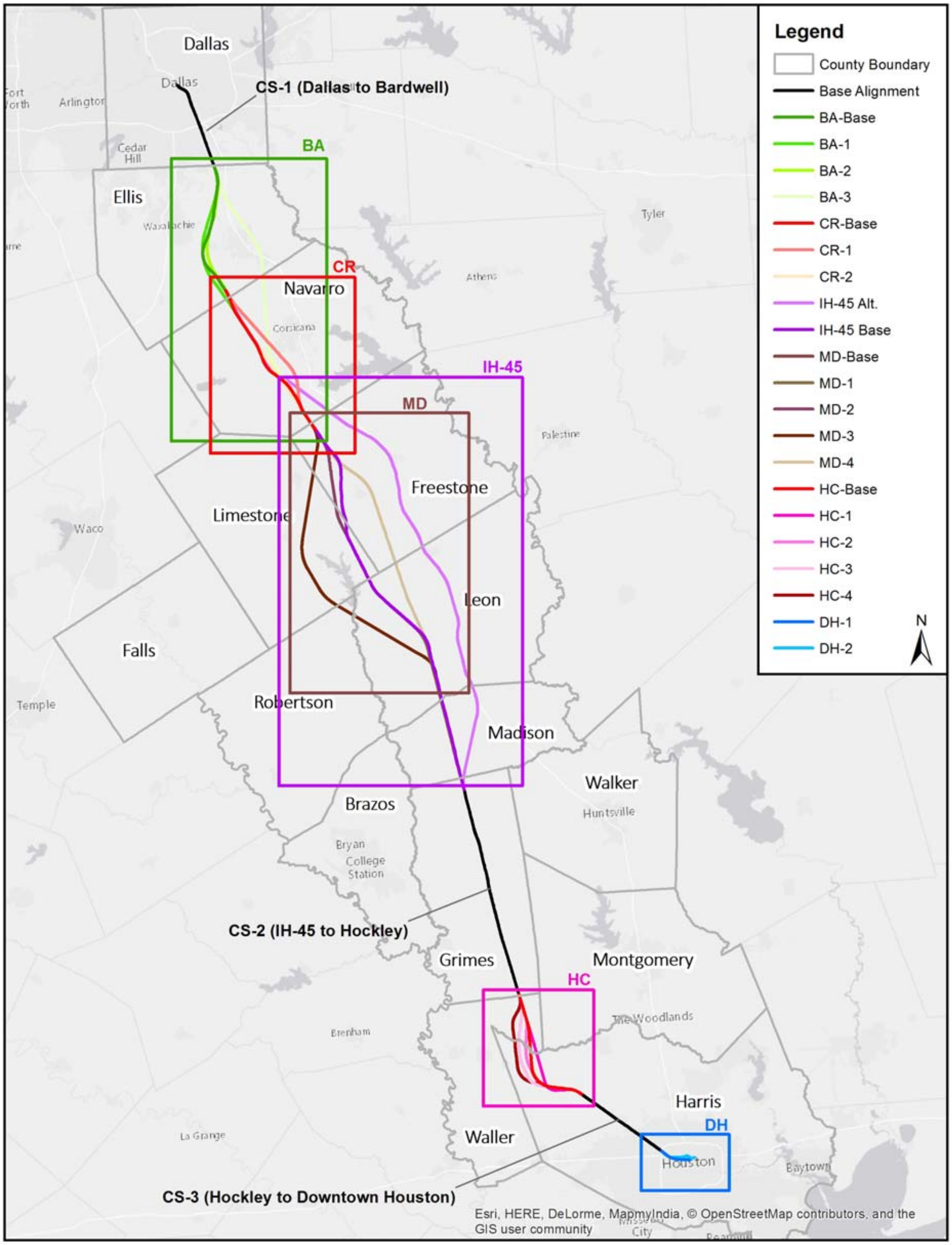
Grimes County Common Segment (CS-2)

CS-2 parallels the CenterPoint Energy utility easement and begins just south of the northern border of Grimes County. CS-2 parallels the utility easement through the entire county, passing west of Singleton, Roans Prairie and Plantersville and ends at the southern border of the county.

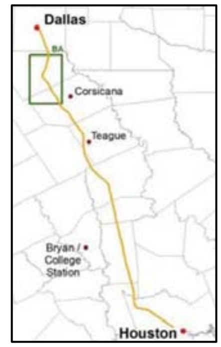
South Terminus Common Segment (CS-3)

CS-3 extends southeast from just south of Cypress along US 290. Just west of Beltway 8, CS-3 continues to IH-610 along the existing UPRR freight line and Hempstead Road.

Figure 4-1: Potential Route Alternatives



Descriptions of the potential route alternatives by geographic area are provided below.

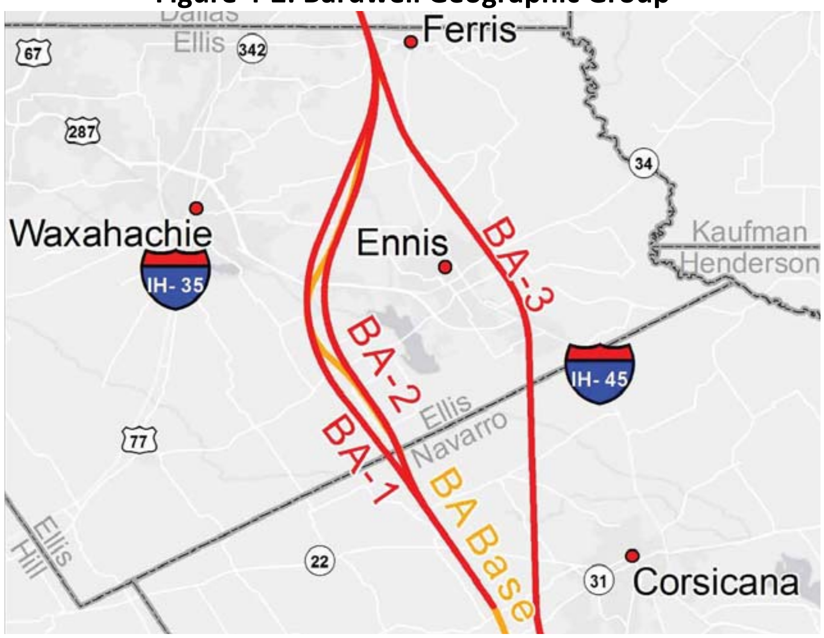


4.1 Bardwell Geographic Group

The Bardwell potential route alternatives (Figure 4-2) fall within Ellis, Navarro and Freestone counties between the cities of Ferris and Wortham. In addition to the Base Alignment, three potential route alternatives were proposed to improve geometric design and to avoid environmentally sensitive areas. Two of the potential route alternatives extend to the west of Bardwell Lake and one extends to the east.

Note: only one color is shown where potential route alternatives overlap one another to indicate that they share an alignment in this area.

Figure 4-2: Bardwell Geographic Group



Source: Texas Central High-Speed Railway *Step 2 Screening of Alignment Alternatives Report*

4.1.1 Bardwell Base (BA Base)

BA Base begins west of Ferris and joins the utility easement near Palmer. BA Base extends along the utility easement, curving southwest at Reagor Springs, staying west of Bardwell Lake. Extending southeast, it closely follows several utility easements east of Rankin and Barry, and west of Currie. BA Base ends near Wortham on the western side of the utility easement.

4.1.2 Bardwell 1 (BA-1)

BA-1 diverges from the Base Alignment (BA Base) north of Palmer where it employs a more direct route to curve west of Bardwell Lake, staying north and west of the utility easement. BA-1 rejoins BA Base at Barry.

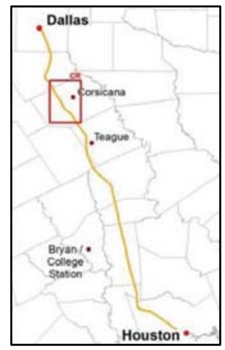
4.1.3 Bardwell 2 (BA-2)

BA-2 diverges from the Base Alignment (BA Base) west of Ferris and closely parallels BA Base near Palmer. It curves to the eastern side of the utility easement, closer to Bardwell Lake and rejoins BA Base just south of the Navarro County line.

4.1.4 Bardwell 3 (BA-3)

BA-3 diverges from the Base Alignment (BA Base) near Ferris and crosses over IH-45, extending east of Palmer. BA-3 continues east of IH-45 until it re-crosses IH-45 near Alma and passes east of Oak Grove. BA-3 crosses the utility easement and rejoins BA Base northeast of Pursley.

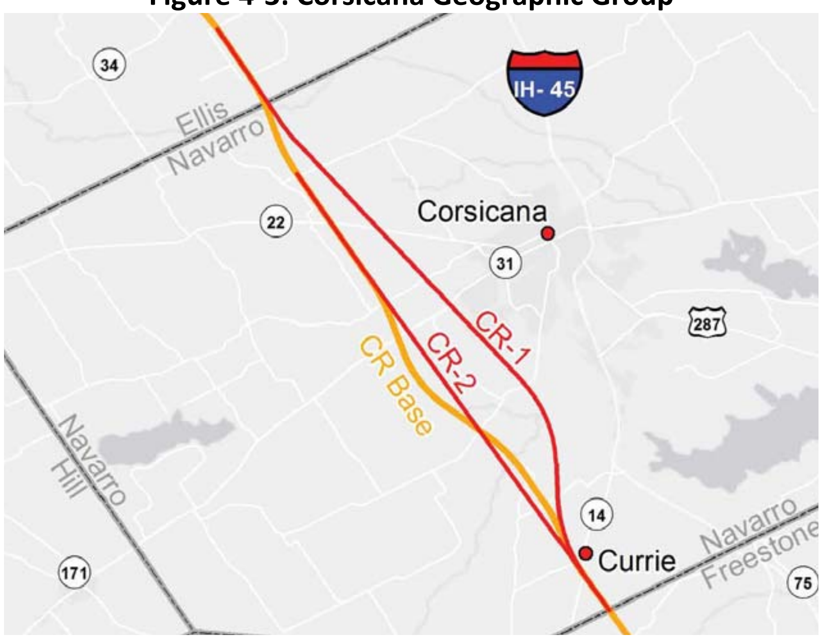
4.2 Corsicana Geographic Group



The Corsicana potential route alternatives are within Ellis, Navarro and Freestone counties and extend between approximately Rankin and Wortham. One base alignment and two potential route alternatives were proposed (Figure 4-3).

Note: only one color is shown where potential route alternatives overlap one another to indicate that they share an alignment in this area.

Figure 4-3: Corsicana Geographic Group



Source: Texas Central High-Speed Railway *Step 2 Screening of Alignment Alternatives Report*

4.2.1 Corsicana Base (CR Base)

CR Base parallels the utility easement. It starts just north of the Navarro County line and extends along the utility easement east of Barry to a point west of Currie. CR Base extends south following the utility easement on the western side, east of Wortham.

4.2.2 Corsicana 1 (CR-1)

CR-1 separates from the Base Alignment (CR Base) east of Rankin and extends in a southeasterly direction, staying west of Corsicana. CR-1 curves southeast and crosses a floodplain just north of Richland. CR-1 crosses the utility easement and curves southeast to rejoin CR Base near Currie.

4.2.3 Corsicana 2 (CR-2)

CR-2 follows the Base Alignment (CR-Base) until south of Barry, where it takes a straighter route. CR-2 crosses the utility easement north of Pursley and rejoins CR Base near Currie.

4.3 IH-45 Geographic Group

A potential route alternative on IH-45 was proposed to eliminate construction risks through dense gas well fields and former mining areas, and minimize private property impacts.

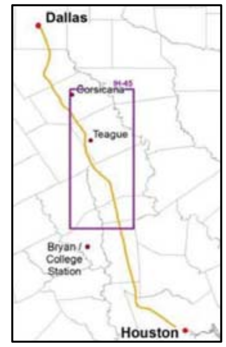
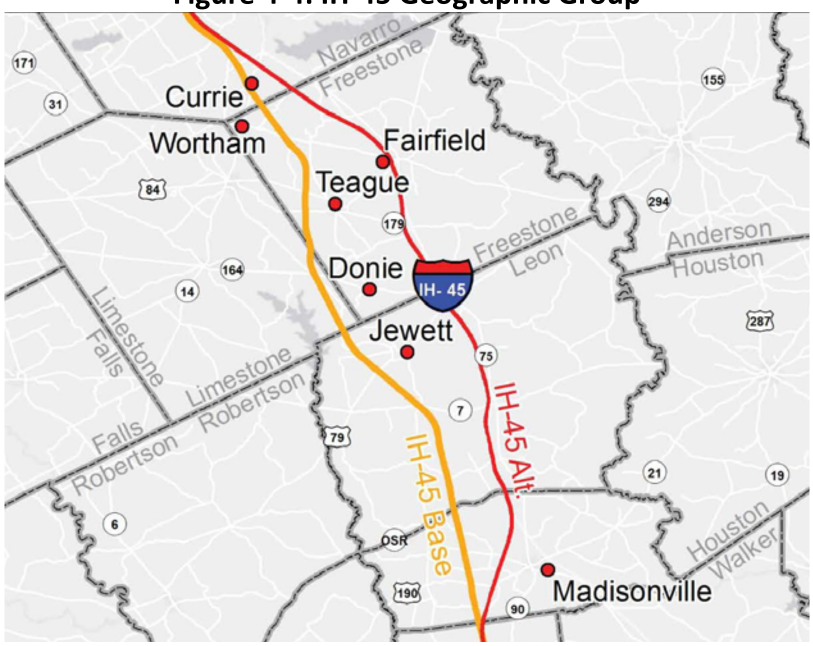


Figure 4-4: IH-45 Geographic Group



Source: Texas Central High-Speed Railway *Step 2 Screening of Alignment Alternatives Report*

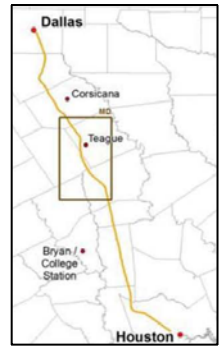
4.3.1 IH-45 Base

IH-45 Base aligns with the utility easement as it extends south from a point just north of Navarro County. IH-45 Base separates from the utility easement to pass through the oil and gas fields east of Lake Limestone and west of Teague and Donie. Just south of Concord, IH-45 Base rejoins the utility easement and ends at the southern edge of Madison County.

4.3.2 IH-45 Alternative (IH-45 Alt)

IH-45 Alt separates from the Base Alignment (IH-45 Base) and follows the IH-45 highway corridor for approximately 57 miles starting six miles north of Fairfield to north of Madisonville. IH-45 Alt runs southwest and realigns with the Base Alignment south of the Grimes County line until is separates just north of Bedias.

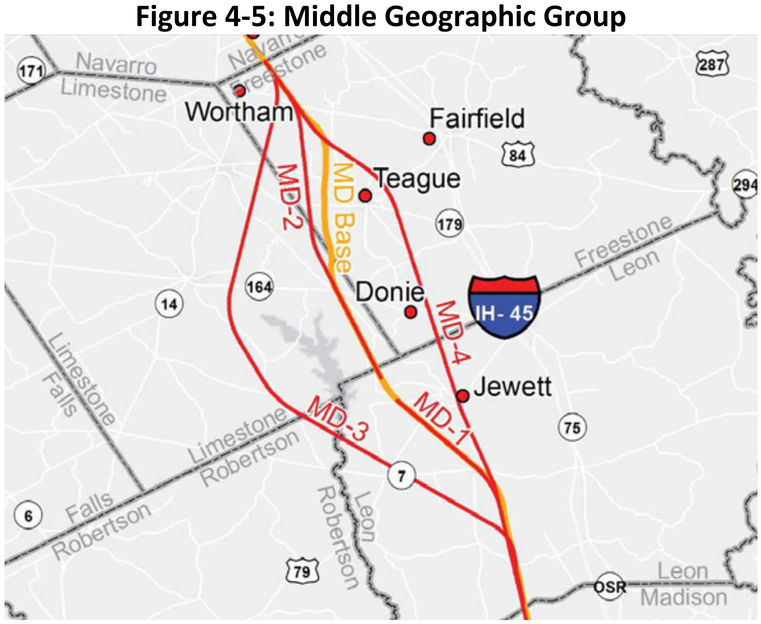
4.4 Middle Geographic Group



The Middle geographic group (Figure 4-5) begins at the Freestone/Navarro county line and continues south to the Grimes/Madison county line. Near Jewett where several electrical transmission lines converge, there are major electrical facilities at-grade, and several towns and developments. All of the potential route alternatives closely follow the utility easement along either the west or east side until the Grimes County line. The Base Alignment (MD Base) and four Middle potential route alternatives were proposed to provide options to avoid or minimize impacts to the above mentioned electrical facilities, towns and developments.

Note: only one color is shown where potential route alternatives overlap one another to indicate that they share an alignment in this area.

Figure 4-5: Middle Geographic Group



Source: Texas Central High-Speed Railway *Step 2 Screening of Alignment Alternatives Report*

4.4.1 Middle Base (MD Base)

MD Base begins at the Freestone/Navarro county line and continues south adjacent to the utility easement and curves along the east side of Browns Lake. MD-Base separates from the utility easement to pass through the dense oil and gas well fields west of Donie and east of Lake Limestone and realigns with the utility easement ten miles south of Jewett. MD Base extends south on the east side of the utility easement and ends at the Grimes/Madison county line.

4.4.2 Middle 1 (MD-1)

MD-1 follows the Base Alignment (MD Base), except at a point about ten miles south of Jewett, where it separates from MD Base and continues to parallel the utility easement on the west side.

4.4.3 Middle 2 (MD-2)

MD-2 separates from the Base Alignment (MD Base) east of Wortham. MD-2 extends west around Browns Lake and rejoins MD Base south of the oil and gas fields.

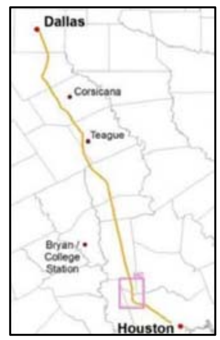
4.4.4 Middle 3 (MD-3)

MD-3 separates from the Base Alignment (MD Base) near Wortham and extends west of Lake Limestone and crosses the Navasota River. Approximately a half mile south of Simms Lake, MD-3 crosses the utility easement and rejoins MD Base.

4.4.5 Middle 4 (MD-4)

MD-4 separates from the Base Alignment (MD Base) north of Teague and curves around the north and east side of Teague to pass the oil and gas fields. MD-4 extends south through the oil and gas fields near Donie and passes west of Jewett. Just south of Concord, MD-4 crosses over to the east side of the utility easement and rejoins MD Base west of Cottonwood.

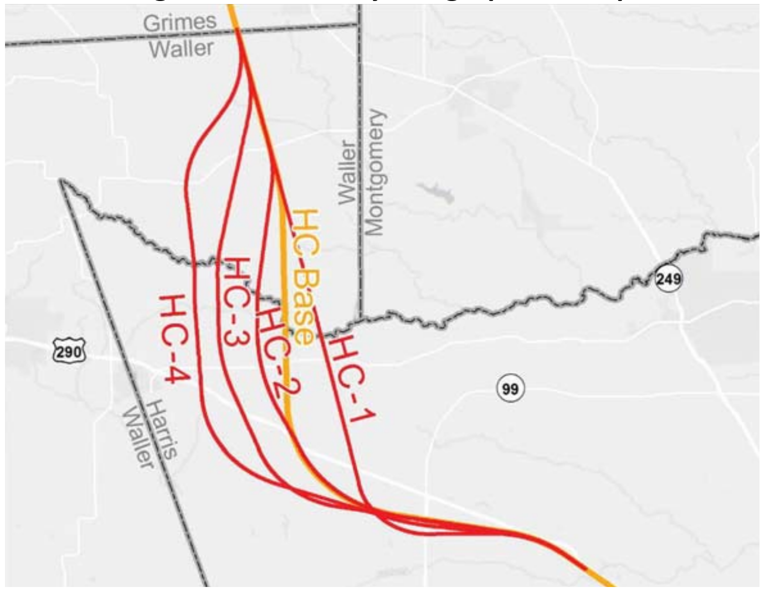
4.5 Hockley Geographic Group



The Hockley geographic group begins west of Todd Mission in Grimes County and ends west of Cypress in Harris County (Figure 3-6). The potential route alternatives all begin near Todd Mission. The three potential route alternatives were proposed to provide options to cross State Highway (SH 99) and extend through Harris and Waller counties before aligning along the east side of the utility easement. The potential route alternatives curve east to cross over SH 99 and generally follow the utility easement south towards Houston.

Note: only one color is shown where potential route alternatives overlap one another to indicate that they share an alignment in this area.

Figure 4-6: Hockley Geographic Group



Source: Texas Central High-Speed Railway *Step 2 Screening of Alignment Alternatives Report*

4.5.1 Hockley Base (HC Base)

HC Base begins west of Todd Mission and continues south following the east side of the utility easement. HC Base crosses to the west side of the utility easement and extends south along Hegar Road. To accommodate maximum operating speed, HC Base curves south, east of the City of Hockley, and crosses US 290 before extending east to cross both SH 99 and the utility easement and ends near the town of Cypress.

4.5.2 Hockley 1 (HC-1)

HC-1 begins west of Todd Mission and parallels the utility easement, crossing over US 290. West of SH 99, HC-1 sharply turns to the east. HC-1 maximizes the length adjacent to the utility easement through the Hockley area and requires two sharp horizontal curves to turn east towards Houston.

4.5.3 Hockley 2 (HC-2)

HC-2 follows the Base Alignment (HC Base) to a point south of Farm-to-Market 1488 (FM1488). From here, it curves to the west paralleling Hegar Road before curving east over US 290, east of Hockley, and rejoining HC Base.

4.5.4 Hockley 3 (HC-3)

HC-3 begins west of Todd Mission and extends south following the east side of the utility easement before crossing the utility easement. HC-3 then curves southwest towards Kickapoo Road and continues south parallel to Kickapoo Road. HC-3 crosses over US 290 and then curves south to the west of Hockley. HC-3 crosses both SH 99 and the existing utility easement as it curves east and ends near Cypress.

4.5.5 Hockley 4 (HC-4)

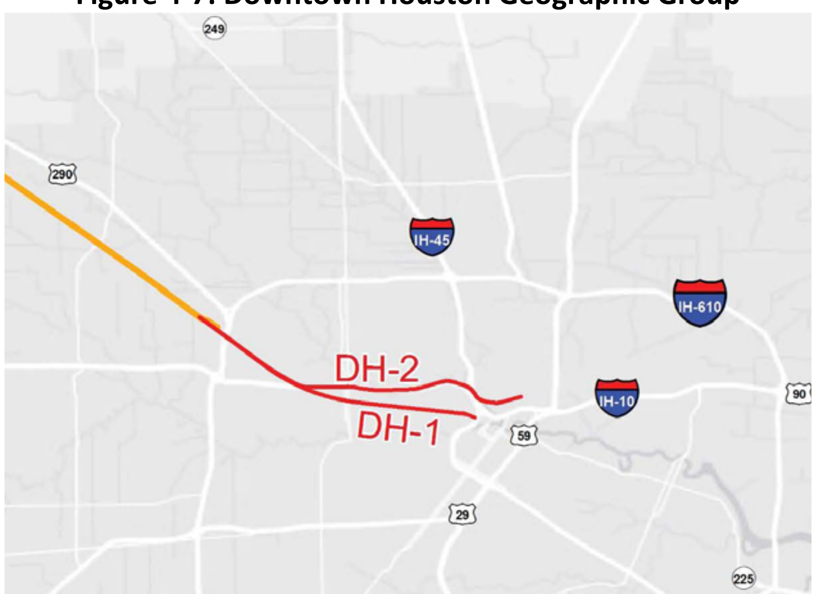
HC-4 begins west of Todd Mission and extends south following the east side of the utility easement. HC-4 crosses the easement and extends southwest and parallels an existing underground pipeline as it continues to the south. HC-4 crosses over US 290 and then approximately 3.3 miles west of Hockley and just after Binford Road, curves to the south and extends east. HC-4 crosses the utility easement and SH 99 and ends near the town of Cypress.

4.6 Downtown Houston Geographic Group

For the purpose of this Project, the downtown Houston area begins southwest of US 290 and IH-610 interchange near the Northwest Mall or the Northwest Transit Center. The Base Alignment is proposed to terminate near IH-610 at the Northwest Mall site. Two potential route alternatives were proposed to extend east to downtown Houston.

Note: only one color is shown where potential route alternatives overlap one another to indicate that they share an alignment in this area.

Figure 4-7: Downtown Houston Geographic Group



Source: Texas Central High-Speed Railway *Step 2 Screening of Alignment Alternatives Report*

4.6.1 Downtown Houston 1 (DH-1)

Extending from the Base Alignment, DH-1 continues southeast between the UPRR ROW and Hempstead Road and continues south of the Northwest Mall site. DH-1 crosses over IH-610 and the existing UPRR freight line. It then follows the freight line before crossing over Interstate Highway (IH-10) and curving east towards downtown Houston. DH-1 continues east along the south side of the UPRR ROW and terminates near Amtrak's Houston Station.

4.6.2 Downtown Houston 2 (DH-2)

Extending from the Base Alignment, DH-2 continues southeast between the UPRR ROW and Hempstead Road, crosses over IH-610, and extends along the north side of the existing freight line. DH-2 then curves east to align with the median of IH-10. At Studemont Street, DH-2 turns north from the median to follow the north side of IH-10 highway ROW. DH-2 crosses over IH-45 entrance and exit ramps before curving east to pass over the White Oak Bayou and terminate at UPRR's Hardy Yard.

5.0 ALTERNATIVES EVALUATION

The following section describes FRA's independent evaluation of the potential route alternatives by geographic group. This evaluation consists of a two-level process. The Level I Screening evaluates the potential route alternatives based on Project purpose and need, TCR's alignment objectives and TCR's design guidelines. The potential route alternatives that met the Level I Screening requirements moved on to the Level II Screening, in which potential route alternatives were evaluated based on environmental constraints defined by NEPA, and TCR's cost and construction factors.

5.1 Level I Screening

FRA's Level I Screening used the Project's purpose and need, alignment objectives and design guidelines as screening criteria.

5.1.1 Purpose and Need

Table 5-1 shows the evaluation of the potential route alternatives to the Project Purpose and Need as defined in Section 2.0 of this report.

5.1.2 Alignment Objectives

TCR developed alignment objectives that all potential route alternatives must meet to be considered feasible. These alignment objectives, used by FRA in its Level I Screening, include:

- Alignments must be configured as a dedicated, fully grade separated, two-track alignment to meet safety, service planning and travel time goals with no shared use of track or connections to existing railroad network
- Maximize co-location opportunities with transportation and utility corridors
- Minimize relocation of any existing roadways or freight railroad tracks
- Optimize the alignment to allow for the desired maximum operating speed and operational efficiency
- Minimize the number of times the high-speed rail tracks must cross existing freight tracks or major roadways
- Minimize expected impacts of construction to traffic and freight operations
- Minimize expected environmental impacts and constructability concerns
- Minimize expected ROW and construction costs associated with heavy infrastructure requirements
- Achieve both the travel time and economic objectives

The results of the FRA evaluation of the potential route alternatives to the alignment objectives are shown in Table 5-1.

5.1.2 Design Guidelines

TCR developed alignment design guidelines based on their engineering judgment and professional experience. The guidelines focused on alignment curvature, profile gradient, and constructability considerations. These are requirements all potential route alternatives must meet to be considered feasible. The general design guidelines, used by FRA in its Level I Screening, are:

- **Maximum Operating Speed**: a desired maximum operating speed of 205 mph (330 kilometers per hour (km/h)) was chosen to be consisted with N700-I Tokaido Shinkansen technology. The alignment was designed to provide for maximum operating speeds throughout to the extent practical, but in some locations alignment curvature to minimize property and environmental impacts would restrict speeds.
- **Separation from Existing Freight Rail Lines**: the proposed HSR system would not operate on any existing freight rail lines. It is expected that reconfiguration of existing freight lines in select locations may be required to support construction and operations of the HSR system.
- **Alignment Curvature**: a desired minimum radius of 17,000 feet (5,200 meters) was used for development of the preliminary alignments. This minimum radius curve would allow for operations at 205 mph (330 km/h) using the maximum permissible cant (actual superelevation) of 7 inches (175 millimeters).
- **Maximum Grade**: the desired maximum grade was set at 1.5 percent
- **Special Trackwork**: for the design of the trackwork at the approaches to stations, where all trains would stop, an assumption of 31 mph (50 km/h) special trackwork components was used to establish the footprint of the station approach limits
- **Recommended Minimum Offset between HSR and Utility ROW**: a 165-foot (50 meter) offset was established as the minimum separation distance from the centerline of the electrical transmission line corridor to the centerline of the HSR corridor. This was determined by taking approximately half of the minimum assumed transmission line ROW width of 215 feet (65 meters) for an electrical transmission line corridor and adding it to half of the assumed 100 feet (30 meters) minimum high-speed rail ROW width.

Table 5-1 shows the results of the FRA design guidelines evaluation.

Table 5-1: Level I Screening Results

Criteria	Potential Route Alternatives																				
	Corsicana Geographic Group			Bardwell Geographic Group				IH-45 Geographic Group		Middle Geographic Group					Hockley Geographic Group					Downtown Houston Geographic Group	
	CR-B	CR-1	CR-2	BA-B	BA-1	BA-2	BA-3	IH-45 B	IH-45 Alt	MD-B	MD-1	MD-2	MD-3	MD-4	HC-B	HC-1	HC-2	HC-3	HC-4	DH-1	DH-2
Purpose																					
Economic	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	**N**	**N**
Technological	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Operational	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Environmental	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	**N**	**N**
Need																					
Improve intercity mobility	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
improve passenger accessibility and connectivity	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
improve overall transportation system safety	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Alignment Objectives																					
Dedicated, fully grade separated, two-track alignment to meet safety, service planning, and travel time goals	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Maximize co-location opportunities	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Minimize relocation of exiting roadways or freight railroad tracks	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Optimize alignment to allow for desired maximum operating speed	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Minimize HSR tracks crossing existing freight tracks	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Minimize expected impacts of construction to traffic and freight operations	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Minimize expected environmental impacts and constructability concerns	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Minimize expected ROW and construction costs associated with heavy infrastructure requirements	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Achieve both the travel time and economic objectives	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Design Guidelines																					
Maximum Operating Speed - 330 km/h (205 mph)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	**N**	Y	Y	Y	Y	Y
Separation from Existing Freight Rail Lines	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Alignment Curvature - min of 17,000 feet (5,200 m)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	**N**	Y	Y	Y	Y	Y
Maximum Grade - max grade of 1.5%	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Special Trackwork	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Recommended Minimum Offset between HSR and Utility ROW - min 50 m (165 feet) offset	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Carried to Detailed Environmental Analysis	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	***N***	**Y**	**Y**	**Y**	***N***	***N***

5.2 Level I Screening Conclusion

FRA used the Level I Screening to eliminate those potential route alternatives that did not meet the Project's purpose and need, alignment objectives or design guidelines.

Two alternatives for the Downtown Houston geographic group, DH-1 and DH-2, have potential to create significant environmental impacts, thereby resulting in higher per mile costs (TCR's *Last Mile Analysis Report* 2015a). Given the cost to build the Downtown Houston potential route alternatives, they do not meet the economic viability of the Project purpose and need. Accordingly, FRA eliminated DH-1 and DH-2 from further consideration for this Project.

DH-1 has the potential to create significant environmental impacts to six areas of concerns – National Historic District Heights Boulevard Esplanade, the US Healthworks Hospital, Houston and Texas Central Railroad archeology site, and Cottage Grove Park. Additionally, DH-1 also has a potential to disproportionately impact minority populations. Due to these potential environmental impacts, as well as TCR's estimated high capital costs (TCR's *Last Mile Analysis Report* 2015a), FRA determined that DH-1 does not meet the stated purpose and need of the Project and FRA eliminated it from further consideration for this Project.

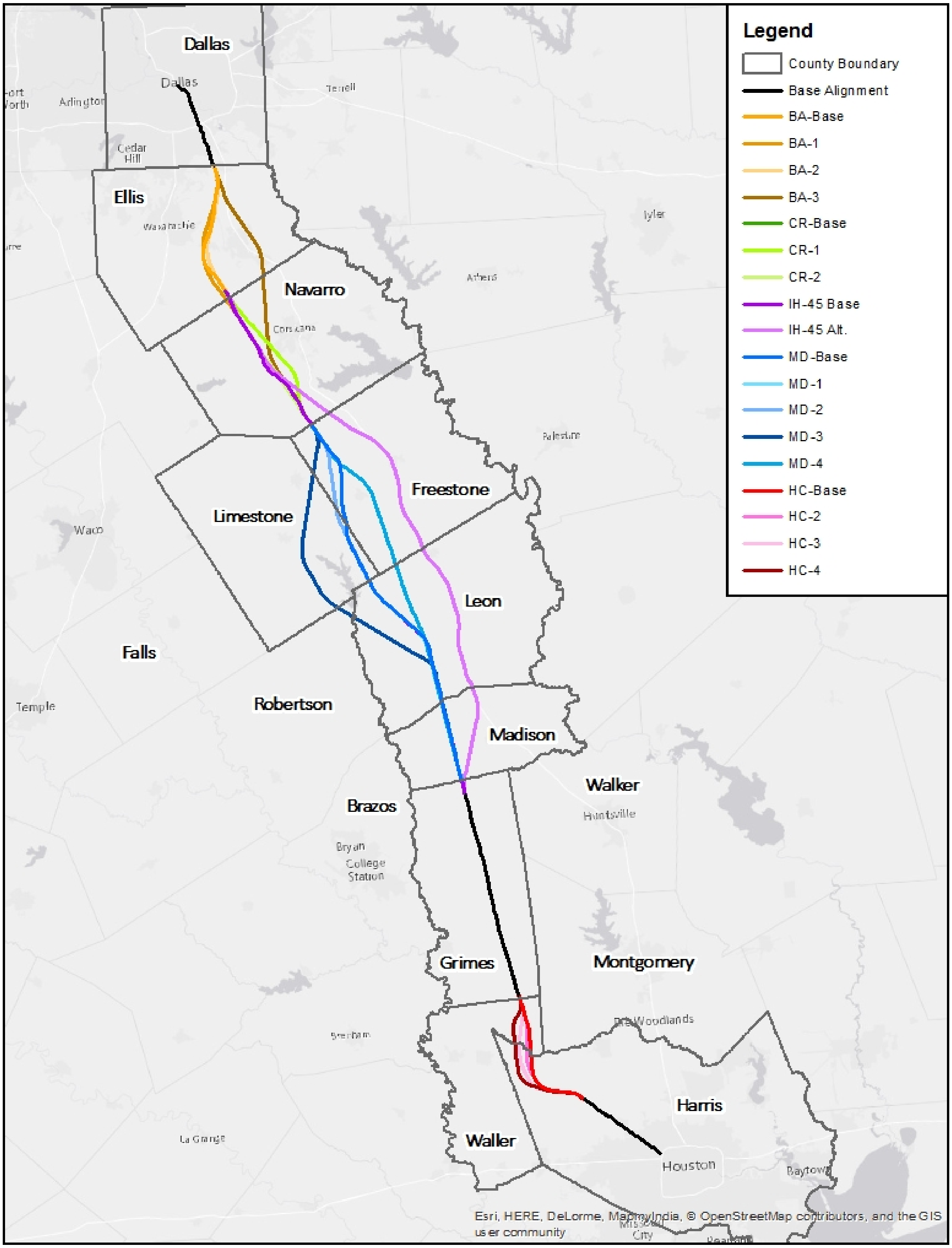
DH-2 has the potential to create significant environmental impacts to nine areas of concern – National Historic District Heights Boulevard Esplanade, U.S. Healthworks Hospital, Houston and Texas Central Railroad archeology site, Cottage Grove Park, Stude Park, White Oak Park, and Hogg Park. Due to these potential environmental impacts, as well as TCR's estimated high capital cost (TCR's *Last Mile Analysis Report* 2015a), FRA determined that DH-2 does not meet the stated purpose and need of the Project and FRA eliminated it from further consideration for this Project.

Additionally, FRA determined that HC-1 does not meet the design guidelines for the Project. Based on conceptual engineering as of June 25, 2015, HC-1 contains two curves that would require a speed restriction of 160 mph, which fails to meet the minimum alignment curvature necessary to achieve the intended travel time of 90 minutes (TCR's *Step 2 Screening of Alignment Alternatives Report* 2015b) . Therefore, FRA determined that HC-1 does not meet the stated purpose and need of the Project and FRA eliminated it from further consideration for this Project.

FRA carried the following potential route alternatives forward into the Level II Screening (Figure 5-1):

- Bardwell Geographic Group
  - BA-Base
  - BA-1
  - BA-2
  - BA-3
- Corsicana Geographic Group
  - CR-Base
  - CR-1
  - CR-2
- IH-45 Geographic Group
  - IH-45 Base
  - IH-45 Alt
- Middle Geographic Group
  - MD-Base
  - MD-1
  - MD-2
  - MD-3
  - MD-4
- Hockley Geographic Group
  - HC-Base
  - HC-2
  - HC-3
  - HC-4

Figure 5-1: Potential Route Alternatives FRA Carried Forward to Level II Screening



5.3 Level II Screening

FRA's Level II Screening consisted of two stages. The first stage looked at 16 environmental evaluation criteria (Table 5-3) to determine areas of potential environmental impact, as required by NEPA. These included prime farmland, wetlands and floodplains, community facilities, historical properties, threatened and endangered species, and road crossings. The second stage incorporated cost and construction factors into the screening analysis.

This analysis is based on desktop level research and data collection. No field surveys or site verification was conducted to complete this analysis. Fieldwork, modeling and detailed technical evaluation in accordance with NEPA and FRA's procedures will be completed as part of the Draft EIS on the feasible and practicable alternatives.

5.4 Level II, Stage I Environmental Constraints Screening

In the Level II, Stage I Environmental Constraints Screening, FRA quantitatively evaluated the potential route alternatives that were carried forward from Level I Screening using a Geographic Information Systems (GIS)-based analysis of environmental constraints pursuant to NEPA. FRA conducted the GIS analysis on 16 environmental evaluation criteria using readily available state and federal databases, as described in Appendix A. The methodology and criteria used to complete the Level II, Stage I Environmental Constraints Screening are explained below.

5.4.1 Methodology

Scoring for each of the environmental evaluation criteria was based on the lowest score having the least potential to create an environmental impact (best). A ratio method was used to distribute the scores among potential route alternatives within each geographic group. An example of how this is displayed is provided in Table 5-2, which contains four potential route alternatives within the Bardwell geographic group and their scoring for the wetlands criteria. Because there are four alternatives, the scores range from 1.0 to 4.0. For each criterion the lowest impact is scored a 1.0 (BA-2) and the greatest impact is scored a 4.0 (BA-3). (Note: If a geographic group contains two alternatives, the scores range from 1.0 to 2.0. And, if the geographic group contains three alternatives, the scores range from 1.0 to 3.0). The remaining potential route alternatives are scored relative to the minimum and maximum scores.

Table 5-2: Ratio Methodology

		Wetlands	
Scoring (Bardwell)		Acreage	Points
Bardwell Geographic Group	**BA-Base**	**5.243**	**1.300**
	BA-1	**6.357**	**1.496**
	BA-2	**3.542**	**1.000**
	BA-3	**20.560**	**4.000**

A different measurement is used for each environmental evaluation criterion. These measurements encompass the potential for "direct" or "indirect" impacts. For the purposes of this analysis, potential impacts due to the implementation and operation of a potential route alternative are considered direct impacts. For example, if a hospital sits within the alignment ROW (125 feet), it is considered a direct impact under Community Facilities. Potential indirect impacts represent those that may occur outside of the proposed ROW (up to 1,000 feet). For example, if a hospital is set back 250 feet from the alignment ROW, it is considered an indirect impact. A description of each environmental evaluation criterion and the measurement used is provided below in Table 5-3.

Table 5-3: Environmental Evaluation Criteria

Criterion	Data Source	From Centerline (feet)	Total Width (feet)	Direct/ Indirect	Description
Urban Land Cover	NLCD	500	1000	Indirect	Low-intensity, medium-intensity, high-intensity, and open space developed area
Structures	Aerial Photography	62.5	125	Direct	A count of rooftops as seen on aerial photography that are within the buffer
Parcel Takes	Appraisal Districts, in-house digitization	62.5	125	Direct	Parcels with affected structures + Parcels without affected structures where at least 40% of area is impacted
Parks	TPWD, MPOs	500	1000	Indirect	State and local parkland
Prime Farmland	NRCS	62.5	125	Direct	NRCS soil survey prime farmland impacted
Wetlands	NWI	62.5	125	Direct	NWI wetlands impacted
Waterways	NHD	0	0	Direct	Direct alignment crossings of waterways
Floodplains	FEMA	62.5	125	Direct	100- and 500-year floodplain impacted
Road Crossings	TxDOT	0	0	Direct	Direct alignment crossings of roads
Infrastructure Adjacency	TxDOT (roads), Platts (transmission lines), US National Transportation Atlas (railroads)	500	1000	Indirect	Percentage of the alignment that is paralleled by roads, transmission lines, or existing railroads
Minority Population	Census Bureau (Census 2010)	500	1000	Indirect	Estimated minority population affected (tract density times alignment-tract intersection area)
Cemeteries	THC	62.5	125	Direct	Cemetery acreage impacted
Ecology	TXNDD	62.5	125	Direct	Acreage of TXNDD Element occurrences impacted
Historic Properties	NRHP	500	1000	Indirect	NRHP properties and districts
Community Facilities	GNIS	500	1000	Indirect	Includes the following GNIS feature classes: Building (public facilities), Church, Hospital, Post Office, School
Hazardous Materials	TCEQ	62.5	125	Direct	Includes: municipal setting designations, municipal solid waste landfills, radioactive sites, Superfund sites, municipal water wells, and underground petroleum storage tanks.
Population below Poverty Line	Census Bureau (2013 5-year ACS)	500	1000	Indirect	Estimated population below poverty line affected (tract density times alignment-tract intersection area)

5.4.2 Urban Land Cover

The urban land cover criterion is an approximate quantification in acres of potential land use impacts. This criterion looks at the difference between low-intensity, medium-intensity, high-intensity and open space land uses. Generally, the more urbanized or complex the property use is, the greater the number of potential impacts.

Initially, the land use criteria considered residential, commercial and industrial land uses. When land use datasets were only partially available for the 1,000-foot buffer, and where available they had inconsistent classification/schema, Urban Land Cover from the National Land Cover Dataset (NLCD) was used due to its consistency over the entire screening buffer.

5.4.3 Parcel Takes

This criterion represents the number of potential parcels that could be acquired by implementing a potential route alternative.

This criterion combines structures (rooftops) identified by aerial photography with parcel data from county appraisal districts to calculate the number of properties potentially impacted. This criterion counts the impacted parcels as “takes” if:

- Any parcel with one or more structures on it that falls within 62.5 feet of the alignment centerline (125 feet total width)
- Parcels without structures within 62.5 feet of the alignment centerline where at least 40 percent of the parcel area falls within the alignment buffer (125 feet total width)

5.4.4 Parks

This criterion measures the potential acreage of impact to areas designated by state and local agencies for recreation and wildlife habitat are substantially forested, largely undisturbed, and used for recreational activities. Impacts to these lands may require avoidance under Section 4(f) of the Department of Transportation Act or may not be able to be considered if prudent or practical alternatives exist.

Parks data was available in GIS polygon form from the Metropolitan Planning Organizations (MPO) and the Texas Parks and Wildlife Department (TPWD) datasets.

5.4.5 Prime Farmland

This criterion measures the acreage of land designated by the Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) as prime farmland, which is defined as land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is available for these uses.

5.4.6 Wetlands

This criterion measures the acreage of impacts to wetlands within 62.5 feet of the alignment center line (125 feet total width). Increased impacts to wetlands would increase the complexity of Project permitting and also require a higher amount of wetland mitigation to offset Project impacts. Wetland data was obtained from the USFWS National Wetland Inventory (NWI) dataset.

5.4.7 Waterways

The total number of waterways (e.g., rivers and streams) a potential route alternative crosses was calculated using data obtained from the National Hydrography Dataset (NHD). Increased impacts to river and stream crossings would increase the complexity of permitting the Project and also require greater mitigation to offset Project impacts.

5.4.8 Floodplain

Acres of floodplain were tabulated based on the number of acres within 62.5 feet from the alignment centerline (125-foot buffer) of each potential route alternative. Floodplain data was obtained from FEMA and included both the 100- and 500-year floodplain classifications. Increased impacts to floodplains would increase the complexity of permitting the Project and also require higher mitigation to offset Project impacts. Construction through these areas would also result in higher potential implementation costs to design and maintain structures that would be resilient to potential flooding impacts.

5.4.9 Road Crossings

This criterion is a count of the number of roadway crossings, regardless of ownership or roadway classification (e.g., state, county and private). TxDOT was the data source for roadways.

5.4.10 Infrastructure Adjacency

One of TCR's alignment objectives is for potential route alternatives to "maximize co-location opportunities with transportation and utility corridors." Therefore, the infrastructure adjacency criterion estimates the percentage of the potential route alternative that parallels existing infrastructure. This analysis uses the roads dataset from TxDOT, railroads dataset from the U.S. National Transportation Atlas, and electrical transmission line dataset from Platts.

5.4.11 Minority Population

Environmental Justice (EJ) populations include low-income and minority populations. Minority population was analyzed to determine if a potential route alternative might disproportionately affect EJ populations. Minority population data was obtained at the U.S. Census Block level from the 2010 Decennial U.S. Census. For the purposes of this analysis, minority population is defined as the total population minus persons that reported themselves as White, Not Hispanic or Latino. This information was converted into a metric by counting the number of U.S. Census Bocks with a minority population over 50 percent intersecting a 1,000-foot buffer around each potential route alternative (500 feet from the alignment centerline).

5.4.12 Cemeteries

Cemetery data was obtained from the Texas Historical Commission (THC) to evaluate both the number of impacted cemeteries within the 125-foot buffer of the potential route alternative and total acreage within the cemetery that might be impacted. An impact to cemeteries could require mitigation including potential localized alignment modifications to avoid and/or minimize impacts. If alignment modifications could not be accommodated, additional coordination with THC and/or consultation under Section 106 of the National Historic Preservation Act would require investigation that could delay Project implementation.

5.4.13 Ecology

This criterion measures the potential impact to environmentally sensitive areas that could provide habitat for threatened and endangered species based on acreage of potential impacts to observed occurrences of the species. Impacts to individual species of plants and wildlife or the habitat of threatened and endangered wildlife species would require mitigation including potential localized alignment modifications to avoid and/or minimize impacts. If alignment modifications could not be accommodated, additional coordination with the USFWS and TPWD would be required, increasing the complexity of permitting the Project and also require higher mitigation to offset Project impacts.

The Texas Natural Diversity Database (TXNDD) element occurrence data from TPWD depicts areas where threatened and endangered species have been observed. This does not necessarily mean that these species are present, but it is an indicator that a species is or was present and has practical conservation value.

5.4.14 Additional Environmental Evaluation Criteria

There are four environmental evaluation criteria – community facilities, historic properties, hazardous materials and U.S. Census block groups with over 50 percent poverty population – for which data was collected. However, when evaluated, they did not create any differentiation between the scoring of the potential route alternatives at this level of analysis. For example, this desktop level analysis did not identify any historic properties within the 125-foot buffer (62.5 feet from the alignment centerline), although they are expected to be present. Therefore, for the purposes of this analysis, these four environmental evaluation criteria were not used in the Level II, Stage I Environmental Constraints Screening. Additional research and analysis will be conducted for these four environmental evaluation criteria, among resource topics as required by NEPA, as part of the Draft EIS.

5.5 Level II, Stage I Environmental Constraints Screening Results

Table 5-3 shows the results of the Level II, Stage I Environmental Constraints Screening for the 18 potential route alternatives that were carried forward from the Level I Screening.

Table 5-4: Level II, Stage I Environmental Constraints Screening Results

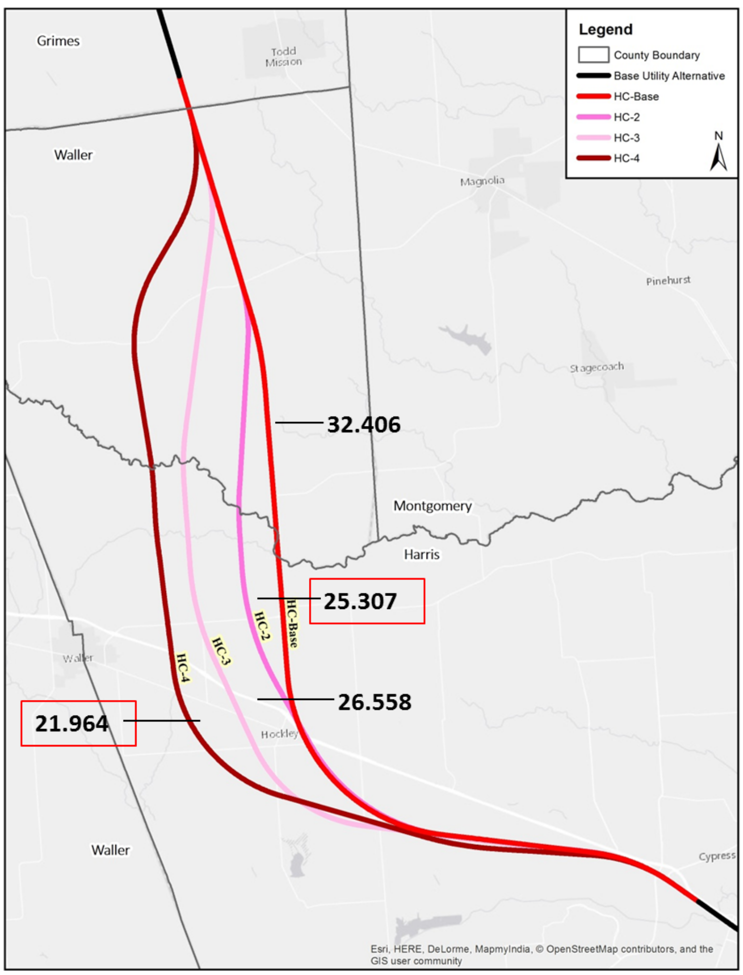
Potential Route Alternatives		Urban Land Cover		Parcel Takes (40%)		Parks		Prime Farmland		Wetlands		Waterways		Floodplains		Road Crossings		Infrastructure Adjacency		Minority Population		Cemeteries		Ecology (TXNDD)		Total Score
		Percent	Score	Number	Score	Acres	Score	Acres	Score	Acres	Score	Number	Score	Acres	Score	Number	Score	Percent	Score	Number	Score	Acres	Score	Acres	Score	
Corsicana Geographic Group	CR-Base	4.91%	3.000	7	1.333	0.00	1.000	198.79	1.659	2.39	1.000	47	1.833	93.92	2.504	37	1.000	56.79%	1.000	14	3.000	0.00	1.000	12.56	1.364	**19.69**
	CR-1	4.58%	2.566	17	3.000	0.00	1.000	187.26	1.000	4.83	1.571	42	1.000	41.09	1.000	47	3.000	20.54%	3.000	6	1.000	0.00	1.000	69.03	3.000	**22.14**
	CR-2	3.38%	1.000	5	1.000	0.00	1.000	222.22	3.000	10.94	3.000	54	3.000	111.34	3.000	40	1.600	40.90%	1.877	13	2.750	0.00	1.000	0.00	1.000	**23.23**
Bardwell Geographic Group	BA-Base	4.12%	1.726	14	1.000	0.00	1.000	455.41	3.734	5.24	1.300	83	1.000	141.10	1.000	68	1.167	51.24%	1.000	50	4.000	0.00	1.000	12.56	1.000	**18.93**
	BA-1	4.07%	1.481	20	1.720	0.00	1.000	470.53	4.000	6.36	1.496	91	4.000	144.23	1.720	68	1.167	33.74%	2.999	40	2.846	0.00	1.000	12.56	1.000	**24.43**
	BA-2	3.97%	1.000	18	1.480	0.00	1.000	436.10	3.393	3.54	1.000	85	1.750	150.29	3.114	66	1.000	50.81%	1.050	48	3.769	0.00	1.000	12.56	1.000	**20.56**
	BA-3	4.61%	4.000	39	4.000	0.00	1.000	300.25	1.000	20.56	4.000	85	1.750	154.14	4.000	102	4.000	24.98%	4.000	24	1.000	0.00	1.000	25.82	4.000	**33.75**
IH-45 Geographic Group	IH-45 Base	5.04%	1.000	47	1.000	0.00	1.000	423.30	2.000	25.83	1.000	185	2.000	189.49	2.000	115	1.000	52.23%	2.000	14	1.000	0.00	1.000	276.89	2.000	**17.00**
	IH-45 Alt.	27.19%	2.000	79	2.000	246.73	2.000	355.12	1.000	31.11	2.000	166	1.000	169.72	1.000	147	2.000	63.51%	1.000	20	2.000	0.00	1.000	172.62	1.000	**18.00**
Middle Geographic Group	MD-Base	5.15%	3.161	41	1.000	0.00	1.000	222.51	4.024	21.22	1.245	134	1.800	79.81	4.014	77	2.714	49.12%	1.000	0	1.000	0.00	1.000	264.33	5.000	**26.96**
	MD-1	4.99%	2.834	42	1.049	0.00	1.000	229.74	5.000	20.61	1.000	146	5.000	79.81	4.014	65	1.000	44.16%	1.939	0	1.000	0.00	1.000	264.33	5.000	**29.84**
	MD-2	4.97%	2.778	46	1.244	0.00	1.000	212.38	2.655	24.47	2.551	143	4.200	105.93	5.000	78	2.857	34.81%	3.707	1	3.000	0.00	1.000	264.33	5.000	**34.99**
	MD-3	4.15%	1.000	49	1.390	0.00	1.000	213.08	2.750	30.56	5.000	131	1.000	104.23	4.936	93	5.000	27.97%	5.000	2	5.000	0.27	5.000	169.54	1.000	**38.08**
	MD-4	5.99%	5.000	123	5.000	0.00	1.000	200.12	1.000	21.20	1.237	136	2.333	0.00	1.000	93	5.000	35.88%	3.504	1	3.000	0.00	1.000	228.41	3.484	**32.56**
Hockley Geographic Group	HC-Base	12.07%	4.000	28	3.250	0.00	1.000	191.97	1.000	50.64	1.370	34	3.786	69.10	4.000	41	4.000	62.19%	1.000	18	4.000	0.00	1.000	107.43	4.000	**32.41**
	HC-2	8.79%	1.669	25	1.000	0.00	1.000	209.35	1.549	56.33	4.000	35	4.000	57.34	2.339	33	1.000	36.83%	2.811	16	1.000	0.00	1.000	105.88	3.940	**25.31**
	HC-3	10.29%	2.737	29	4.000	0.00	1.000	252.77	2.920	51.80	1.906	21	1.000	54.71	1.966	35	1.750	32.66%	3.109	17	2.500	0.00	1.000	73.29	2.671	**26.56**
	HC-4	7.85%	1.000	26	1.750	0.00	1.000	286.99	4.000	49.83	1.000	29	2.714	47.87	1.000	33	1.000	20.18%	4.000	17	2.500	0.00	1.000	30.35	1.000	**21.96**

The scores for each criterion were totaled for each potential route alternative within its geographic group. FRA determined that the lowest scoring potential route alternative would move forward to Level II, Stage II Cost and Construction Screening for further evaluation. Additionally, FRA used a standard deviation[2] to quantify the variation of the data.

After the scores were totaled, the standard deviation was then calculated for each geographic group. The potential route alternatives that fell within one standard deviation of the lowest score were carried into the Level II, Stage II Cost and Construction Screening. Therefore, one standard deviation from the score was used to statistically capture those potential route alternatives closest to the lowest score, as well as the lowest score.

For example, as shown in Figure 5-2, the Hockley geographic group scores ranged from 21.964 to 32.406. One standard deviation from the lowest score is 3.77 or 25.73, so any scores less than 25.73 fall within one standard deviation of the lowest score. Using this methodology, HC-4 (21.964) and HC-2 (25.307) were carried forward to the Level II, Stage II Cost and Construction Screening.

Figure 5-2: Standard Deviation Example



2 Standard deviation is a statistic used to measure the dispersion or variation in a set of numbers. It is equal to the square root of the variance.

At the conclusion of the Level II, Stage I Environmental Constraints Screening, FRA carried ten potential routes alternatives forward for further consideration. Table 5-4 identifies all of the potential route alternatives that advanced to the Level II, Stage II Cost and Construction Screening.

Table 5-5: Level II, Stage I Environmental Constraints Screening Results and Standard Deviation

Potential Route Alternative		Total Score	Standard Deviation	Carried Forward
Corsicana Geographic Group	CR-Base	19.69	1.48	Yes
	CR-1	22.14		No
	CR-2	23.23		No
Bardwell Geographic Group	BA-Base	18.93	5.75	Yes
	BA-1	24.43		Yes
	BA-2	20.56		Yes
	BA-3	33.75		No
IH-45 Geographic Group	IH-45 Base	17.00	N/A	Yes
	IH-45 Alt.	18.00		Yes
Middle Geographic Group	MD-Base	26.96	3.88	Yes
	MD-1	29.84		Yes
	MD-2	34.99		No
	MD-3	38.08		No
	MD-4	32.56		No
Hockley Geographic Group	HC-Base	32.41	3.77	No
	HC-2	25.31		Yes
	HC-3	26.56		No
	HC-4	21.96		Yes

5.6 Level II, Stage II Cost and Construction Screening

FRA's Level II, Stage I Environmental Constraints Screening identified ten potential route alternatives for further consideration. As the Project Proponent, TCR identified several preferred alignments from the potential route alternatives in its *Step 2 Screening of Alignment Alternatives Report* (TCR 2015b) that best met its cost and construction goals. To include TCR's primary criteria of cost and constructability, FRA undertook a Level II, Stage II Cost and Construction Screening. Even though they were eliminated in the Level II, Stage I Environmental Constraints Screening, FRA carried three additional potential route alternatives (MD-4, BA-3 and CR-1) into the Level II, Stage II Cost and Construction Screening to further evaluate TCR's preferred alignments. These 13 remaining potential route alternatives were evaluated using a combination of environmental, cost, and construction factors.

FRA was not provided TCR's proprietary cost and construction data; instead, TCR provided cost and construction factors "normalized" against to the Base Alignment.[3] In order to use TCR's cost and construction factors as part of FRA's Level II, Stage II Cost and Construction Screening, FRA developed normalized environmental factors from the Level II, Stage I Environmental Constraints Screening Base Alignment scores. This allowed FRA to complete an independent evaluation using comparable factors.

[3] "Normalization" is used to bring different types of data into a common unit for the purposes of comparison

FRA calculated the environmental factor using the environmental evaluation criteria from the Level II, Stage I Environmental Constraints Screening. Each geographic group contained a Base Alignment (CR Base, BA Base, etc.). The Base Alignment from each geographic group was assigned a factor of 1.0. The difference between the base factor and the other geographically grouped potential route alternatives was calculated to assign a factor at, above or below 1.0. For example, BA Base has an environmental score of 18.926 (see Table 4-3 above). To create normalized factor, its environmental factor is 1.0. BA-2 has an environmental score of 20.556, which is 9 percent higher than the base factor, and creates a factor of 1.09.

TCR provided cost and construction factors for all 13 potential route alternatives in the Level II, Stage II Cost and Construction Screening (TCR 2015b). Similar to the environmental factors, within each geographic group, the Base Alignment was assigned a factor of 1.0 for cost and construction, and the other potential route alternatives factors were calculated from the base. TCR's cost factor was based on typical heavy infrastructure types (i.e., embankment vs. viaduct), trackwork, grade crossings, transmission line relocations, estimated environmental mitigation costs, and complexity factors associated with development and environmentally sensitive areas that are normalized to an average cost in order to compare potential route alternatives against each other within a geographic group. TCR's construction schedule factors were calculated based on type of infrastructure to be built and an estimated time to build each type of infrastructure (*Step 2 Screening of Alternative Alignments Report* 2015b).

In order to complete the Level II, Stage II Cost and Construction Screening, the cost and construction factors were averaged together to create a single factor that could be compared to the environmental factor, giving each an equal weight to environmental factors as the combined cost and construction factor. Table 5-5 shows the results of the Level II, Stage II Cost and Construction Screening.

Table 5-6: Level II, Stage II Cost and Construction Screening Results

Potential Route Alternative	Level 1 Score	Difference from Base	Level 2 ENV Factor	TCR Cost Factor	TCR Construction Factor	Average C/C Factor	Total
CR-Base	19.694	0.000	1.00	1.00	1.00	1.00	**2.00**
CR-1	22.137	-2.443	1.12	0.95	0.85	0.90	**2.02**
BA-Base	18.926	0.000	1.00	1.00	1.00	1.00	**2.00**
BA-1	24.429	-5.503	1.29	1.15	1.33	1.24	**2.53**
BA-2	20.556	-1.630	1.09	0.98	1.00	0.99	**2.08**
BA-3	33.750	-14.824	1.78	1.08	1.16	1.12	**2.90**
IH-45 Base	17.000	0.000	1.00	1.00	1.00	1.00	**2.00**
IH-45 Alt.	18.000	-1.000	1.06	1.04	0.92	0.98	**2.04**
MD-Base	26.959	0.000	1.00	1.00	1.00	1.00	**2.00**
MD-1	29.835	-2.877	1.11	1.13	1.22	1.17	**2.28**
MD-4	32.558	-5.599	1.21	0.96	0.95	0.96	**2.16**
HC-Base**	32.406	0.000	1.00	N/A	N/A	N/A	**N/A**
HC-2	25.307	7.099	0.78	0.83	0.60	0.71	**1.50**
HC-4	21.964	10.442	0.68	0.81	0.48	0.65	**1.32**

**** HC-Base was not carried forward to the Level II, Stage II Cost and Construction Screening, but the Level II, Stage I Environmental Constraints Screening score was used to generate environmental factors for the remaining HC potential route alternatives.

FRA carried forward the potential route alternatives with the lowest score in each geographic group. Additionally, FRA carried forward potential route alternatives within each geographic group that were very close to the lowest score in the geographic group such that there was no distinguishable difference between the scores using a natural break approach.[4]

FRA determined eight potential route alternatives moved forward through the Level II, Stage II Cost and Construction Screening for detailed consideration in the Draft EIS. The potential route alternatives that FRA will evaluate in the EIS are:

- Corsicana Base (CR-Base)
- Corsicana 1 (CR-1)
- Bardwell Base (BA-Base)
- Bardwell 2 (BA-2)
- IH-45 Base (IH-45 Base)
- IH-45 Alternative (IH-45 Alt.)
- Middle Base (MD-Base)
- Hockley 4 (HC-4)

As discussed in Section 4.0, no potential route alternatives were proposed for the common segments and FRA did not conduct an evaluation of the common segments for the purposes of narrowing the range of alternatives. Therefore, FRA will also evaluate CS-1, CS-2, and CS-3 in the EIS.

[4] The "natural break" point clusters data to determine the best arrangement of values into different classes. For this analysis, FRA identified classes of high and low scores, with low scores representing a lower potential for impact.

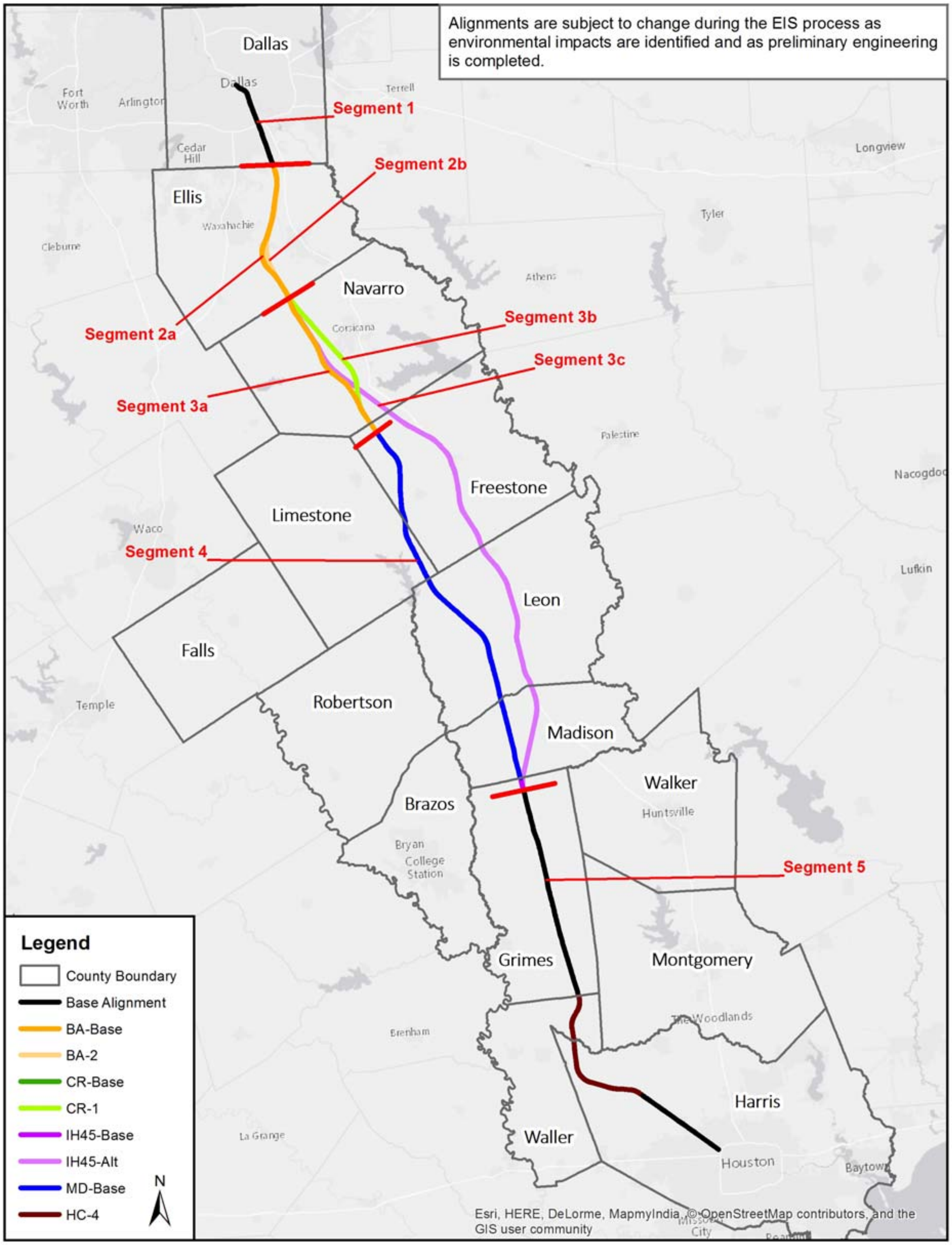
6.0 CONCLUSION

The eight potential route alternatives that FRA carried forward from the Level II, Stage II Cost and Construction Screening and the three common segments were then pieced together to create potential end-to-end alignment alternatives, or alignment alternatives from downtown Dallas to the Houston terminus at the intersection of US 290/IH-610. To create the end-to-end alignment alternatives, each draft alignment alternative was broken into five segments made up of the potential route alternatives and common segments. Table 6-1 and Figure 6-1 shows the potential route alternatives that make up each segment.

Table 6-1: Draft Alignment Alternative Development Segmentation

Segment	Potential Route Alternatives
Segment 1	Base Alignment (CS-1)
Segment 2a	BA-Base
Segment 2b	BA-2
Segment 3a	BA-Base, BA-2, CR-Base, IH-45 Base
Segment 3b	CR-1
Segment 3c	IH-45 Alt.
Segment 4	IH-45 Base, MD-Base
Segment 5	Base Alignment (CS-2 and CS-3) and HC-4

Figure 6-1 Draft Alignment Alternatives Carried Forward to the Draft EIS



The segments were then pieced together to create six end-to-end alignment alternatives. Table 6-2 shows the combination of segments that create draft Alignment Alternatives A-F. Because parts of the segments overlap, it is not possible to show all of the alternatives on one map; therefore, a series of six maps, one for each end-to-end alignment alternative, is included. Figures 6-2 through 6-7 show the maps of the six draft alignment alternatives that FRA will study in the Draft EIS.

Table 6-2: Draft EIS End-to-End Alignment Alternatives

Draft Alignment Alternative	Segments
Alternative A	1, 2a, 3a, 4, 5
Alternative B	1, 2a, 3b, 4, 5
Alternative C (IH-45A)	1, 2a, 3c, 5
Alternative D	1, 2b, 3a, 4, 5
Alternative E	1, 2b, 3b, 4, 5
Alternative F (IH-45B)	1, 2b, 3c, 5

This alternatives analysis provides a desktop-level review to compare potential route alternatives within specific geographic groups. The alignment alternatives presented in this document are preliminary and subject to change. The draft alignment alternatives will continue to be further refined and evaluated as per NEPA. For example, the Draft EIS will evaluate and document potential environmental impacts identified through modeling, field investigations and public input. These environmental impacts may dictate a modification to the alignment alternative to avoid and/or minimize an impact. Additionally, TCR's engineering team will refine the alignment alternatives during preliminary engineering, which will occur simultaneously with the preparation of the Draft and Final EIS. FRA will evaluate the modifications to the alignment alternatives through the EIS process.

Figure 6-2: Draft EIS End-to-End Alignment Alternative A

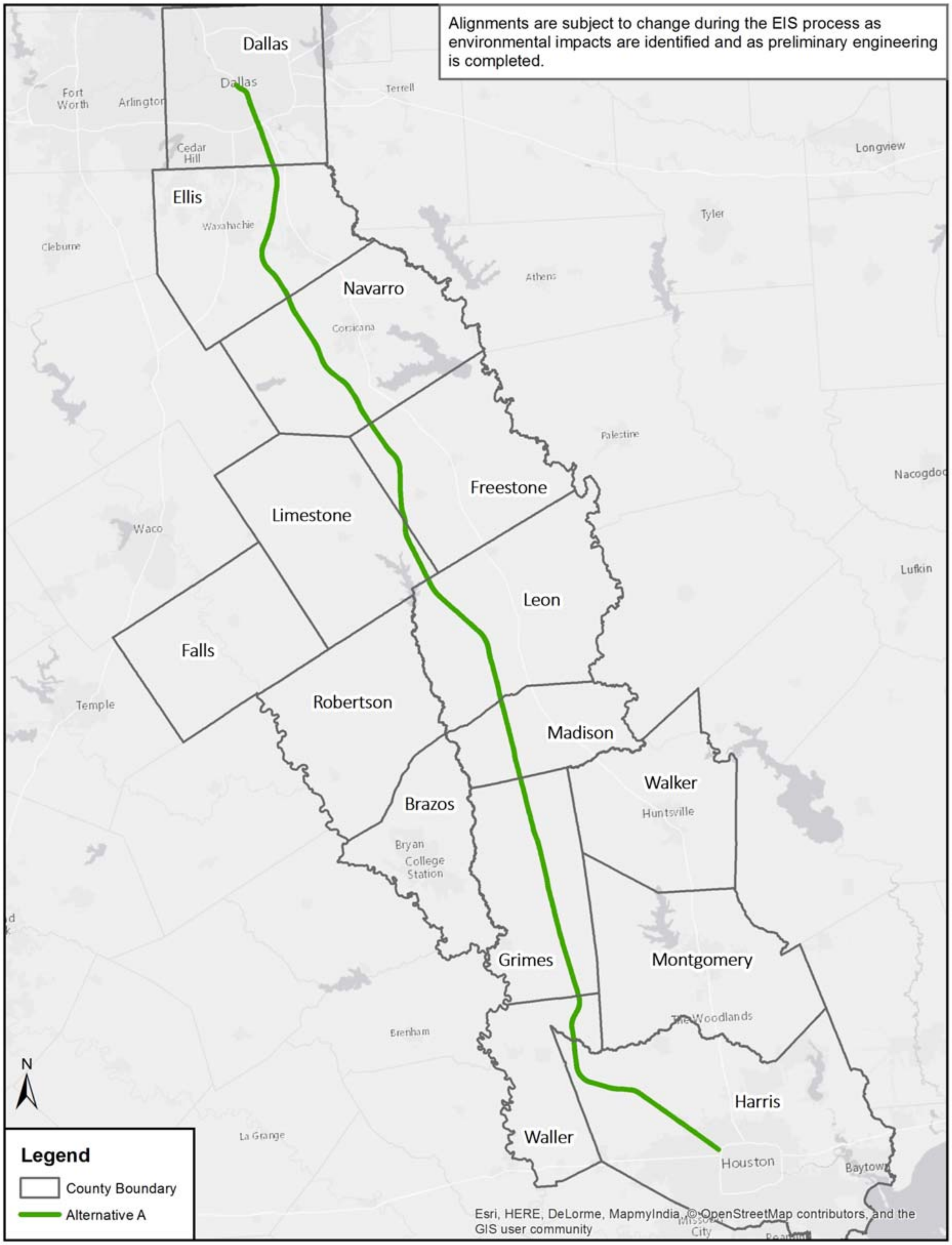


Figure 6-3: Draft EIS End-to-End Alignment Alternative B

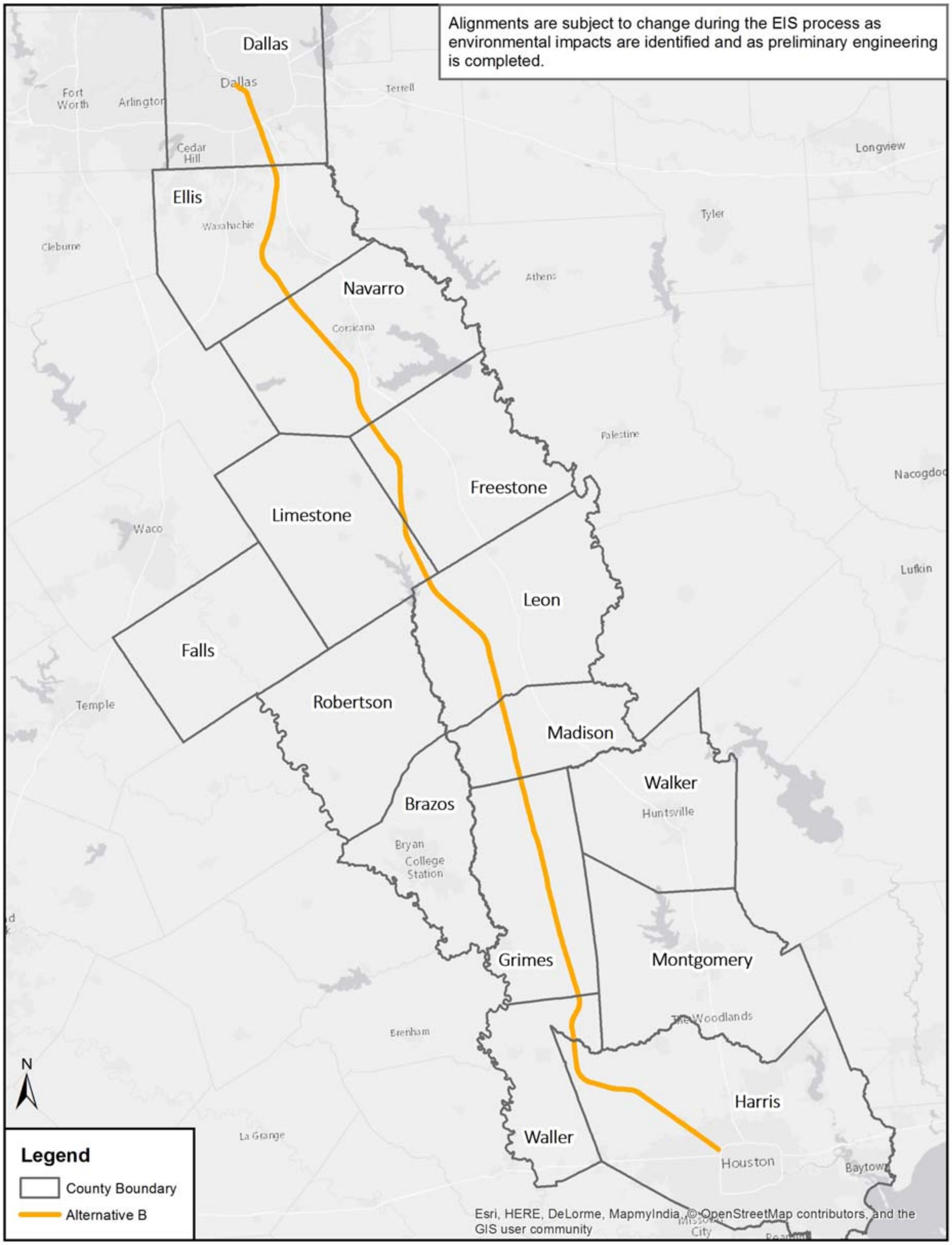


Figure 6-4: Draft EIS End-to-End Alignment Alternative C

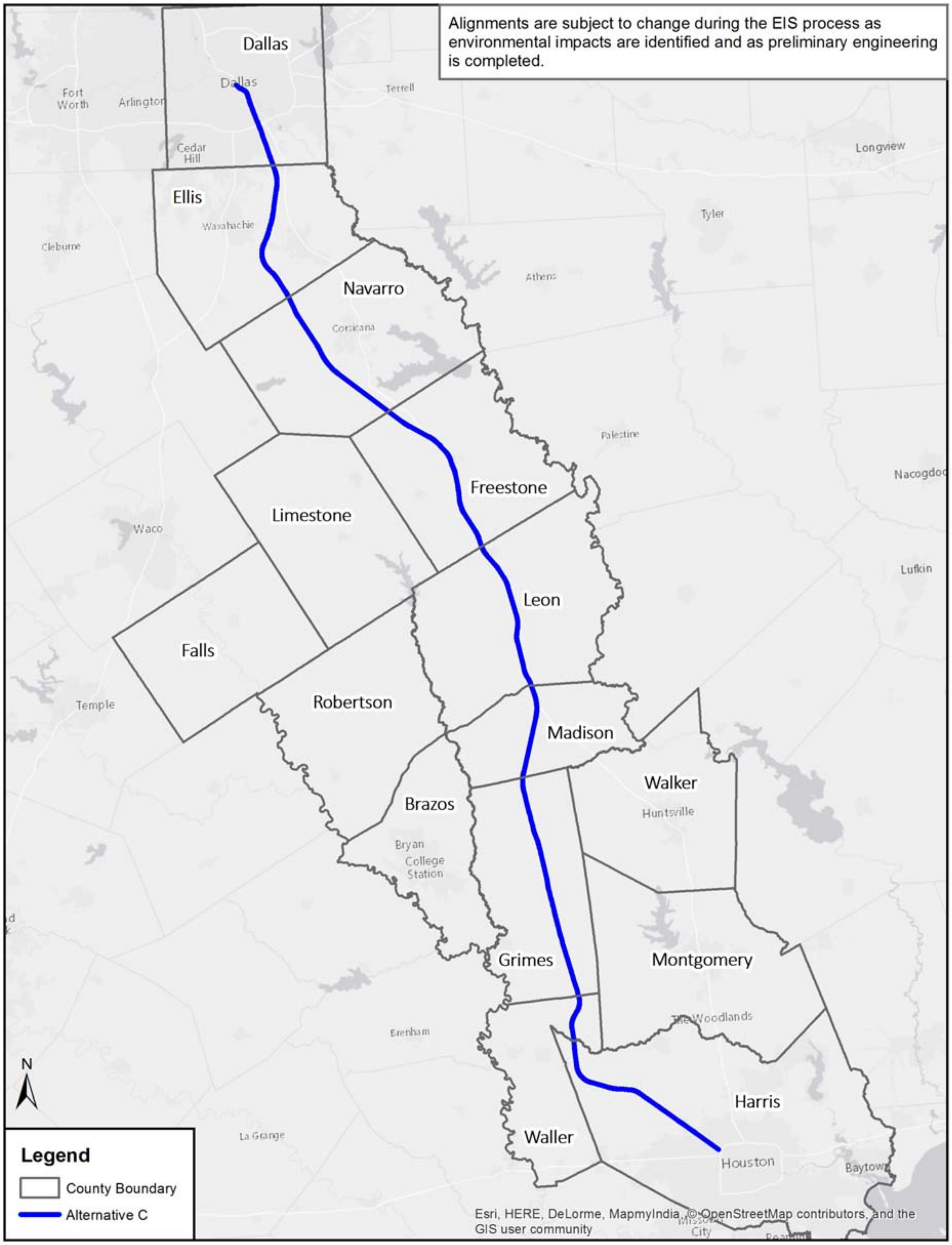


Figure 6-5: Draft EIS End-to-End Alignment Alternative D

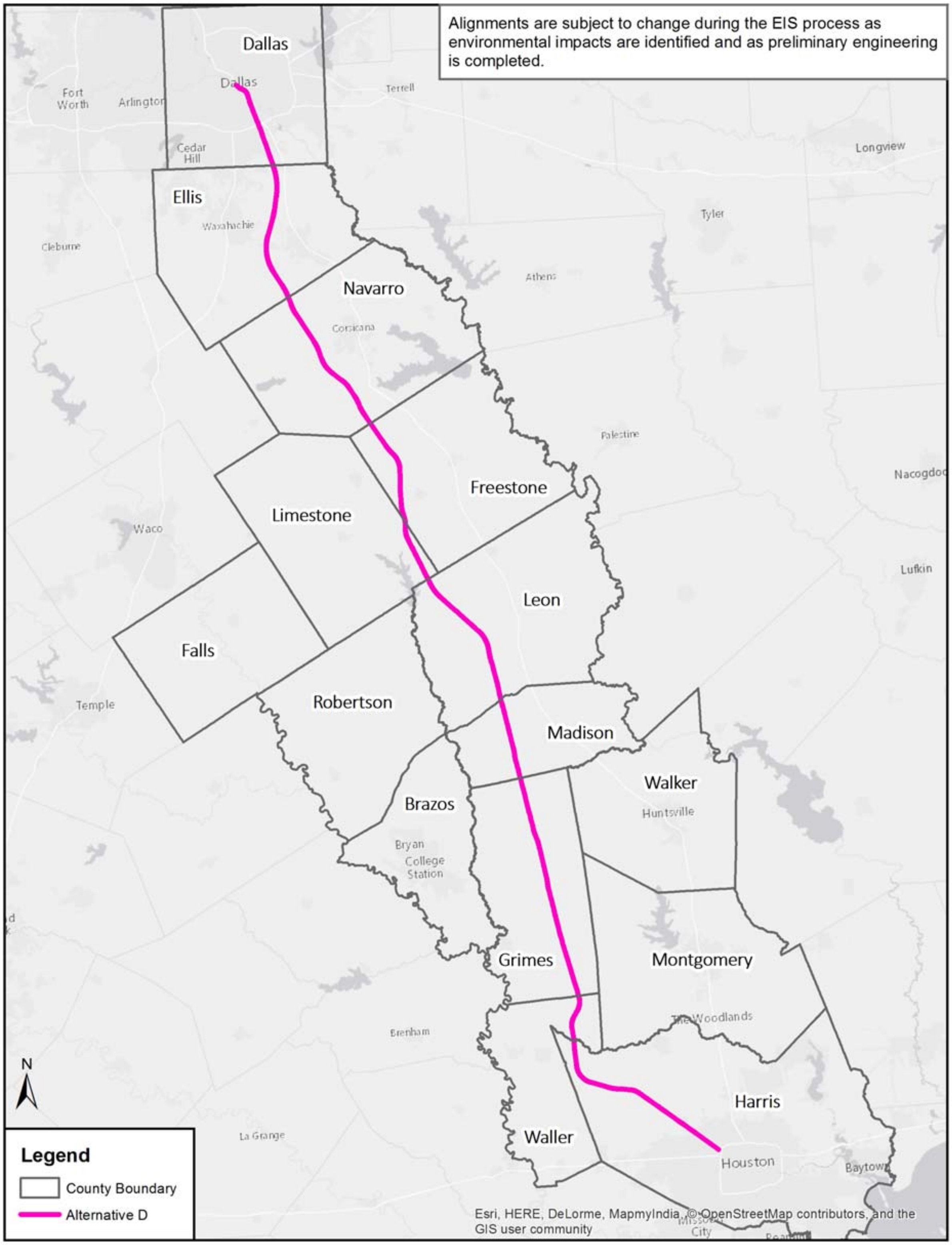


Figure 6-6: Draft EIS End-to-End Alignment Alternative E

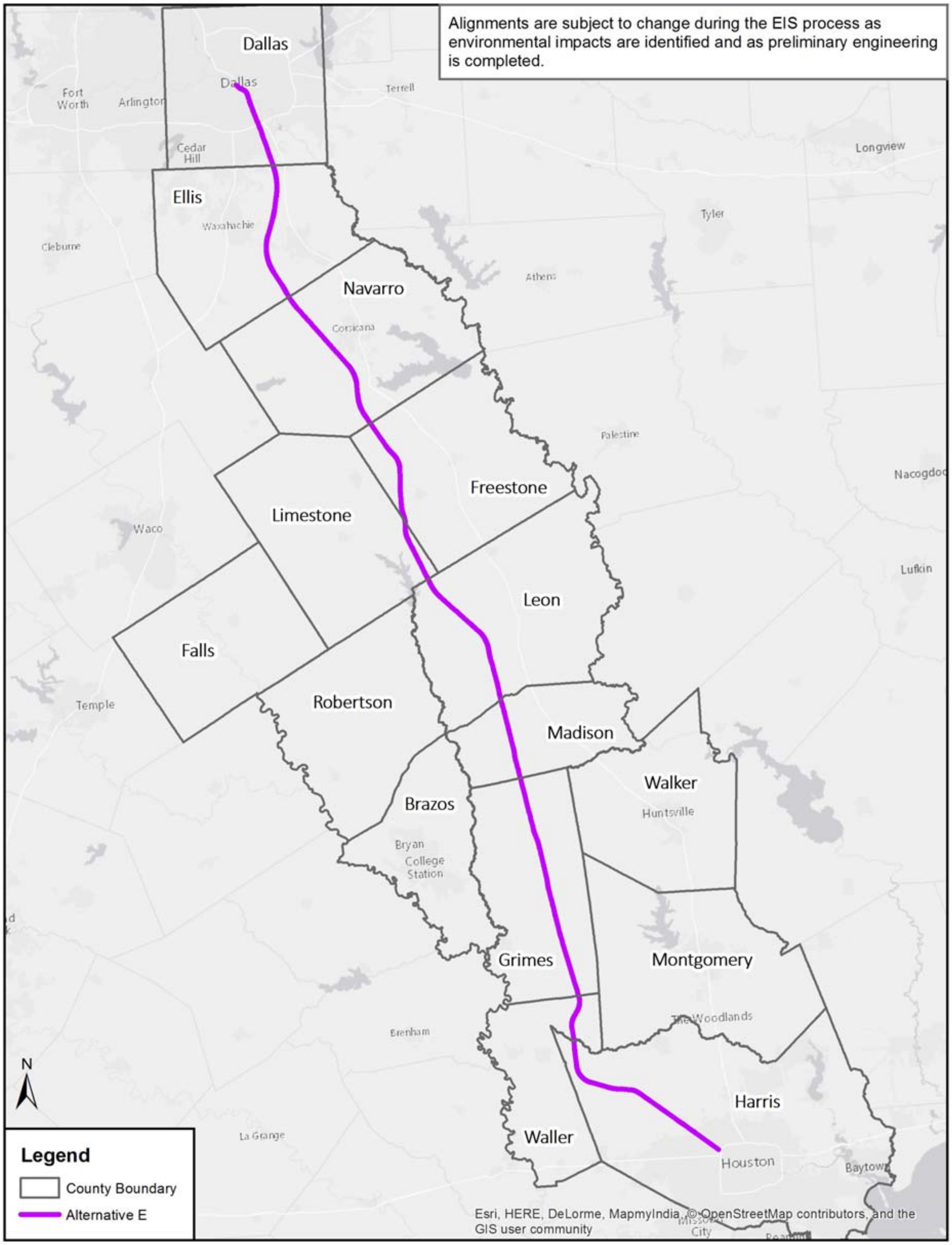
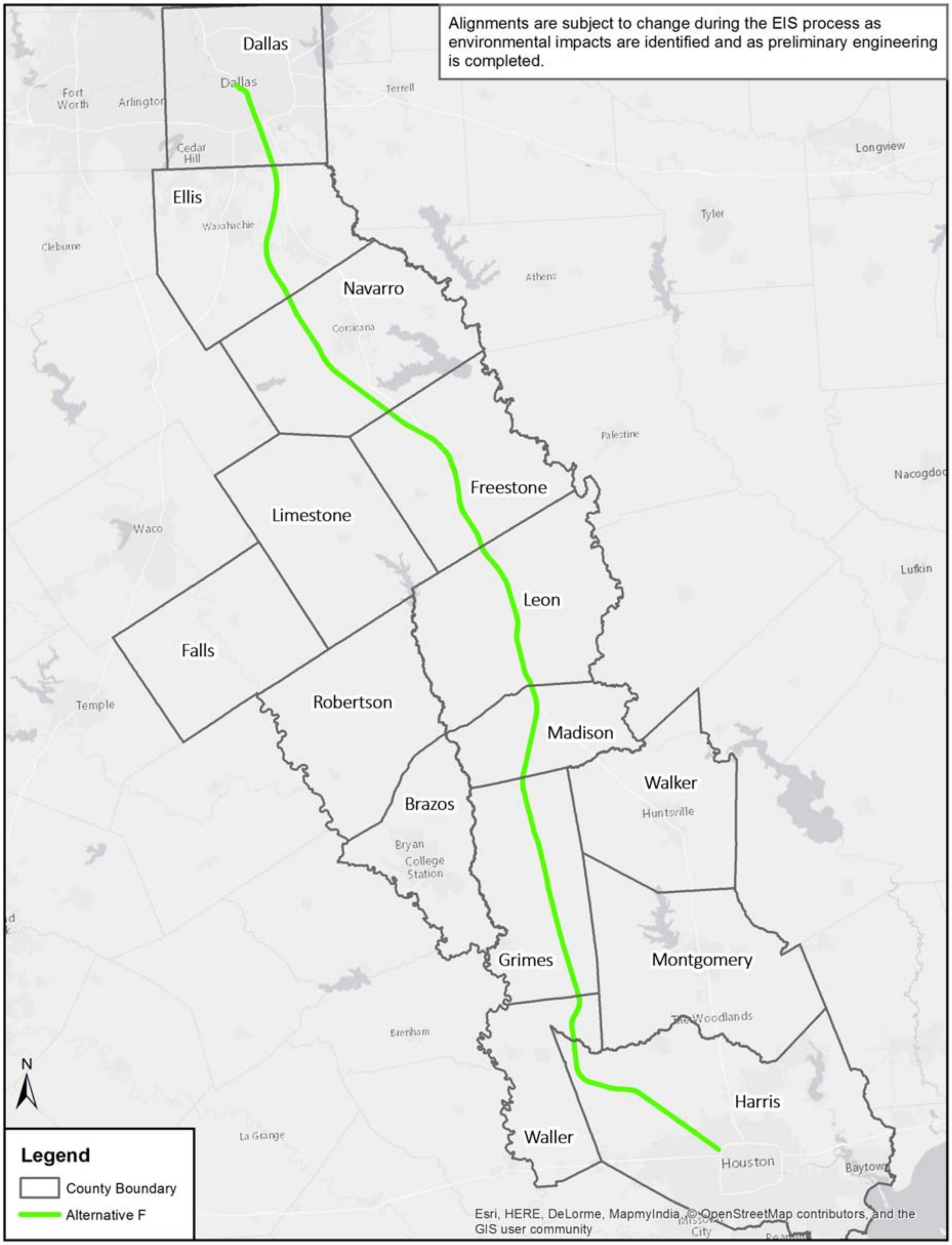


Figure 6-7: Draft EIS End-to-End Alignment Alternative F



Appendix A – GIS Methodology

GIS Methodology
The following is a detailed description of the methodology used for the GIS desktop analysis to evaluate the potential route alternatives for each of environmental criteria described in Section 4.0.

A.1 Urban Land Cover

Initially the land use criteria included residential, commercial and industrial land uses, but when it became apparent that the land use datasets are only partially available for the corridor, and where available, they have inconsistent classification/schema, Urban Land Cover from the NLCD was used. The NLCD is consistent throughout the entire corridor.
The following describes the GIS analysis used to identify the potential for impacts:

- Used Extract by Mask tool to clip the large NLCD dataset down to the area covered within 500 feet from the alignment centerline
- Per NLCD categories, grouped all developed/urban land cover classifications (low-, medium-, and high-intensity, and developed-open space) into one urban classification and grouped all other classifications into a rural classification
- Used ArcScan to create polygon (vector) features representing urban/developed land
- Used the intersect tool to determine which of these areas overlay 500 feet from the alignment centerline
- Calculated the area of these polygons in acres
- Dissolved the features to sum the total of potentially affected acreage for each buffer (1,000 feet total width)
- Exported total acreages of urban land cover from ArcGIS into Excel

A.2 Parcel Takes

This criterion combines structures (rooftops) identified by aerial photography with parcel data to arrive at an estimation of the potential impacts that the potential route alternatives could have on property owners. This criterion counts the identified parcel impacts as "takes:"

- Any parcel with one or more structure on it that falls within 62.5 feet of the alignment centerline (125-foot total width)
- Parcels without structures within 62.5 feet of the alignment centerline where at least 40 percent of the parcels area falls within the alignment buffer (125-foot total width)

The following steps were taken to conduct the GIS analysis:

- Collected preprocessed parcel data from the 13 intersecting counties and ensured that they are in the correct coordinate system. For Freestone and Leon counties, the parcel data was available in computer-aided design (CAD) line format, so the lines were converted into a shape to generate the parcel areas.
- Merged the clipped parcel data together
- Calculated the area of these parcels in acres
- Intersected the parcels within 62.5 feet of the alignment centerline, which clips the parcels to the alignment buffer and joins in alternative attributes
- Calculated the intersected area of these parcels in acres
- Divided the intersected area by the original whole area to arrive at a percent take
- Selected those features from this layer that contained structures and copied them into their own layer, then calculated summary statistics for this new layer, grouping by potential route alternative name and summing the number of affected parcels

- Reversed the selection in the original intersected parcels layer, thus selecting only those parcels without any structures within 62.5 feet of the alignment centerline. Selected from this selection only those with a take percentage greater than or equal to 40 percent, yielding only those parcels without structures where more than 40 percent of the parcel is within 62.5 feet of the alignment centerline. Copied these selected features into a new layer, and calculated summary statistics, grouping by potential route alternative name and summing the total number of affected parcels
- Exported both summary tables from ArcGIS and imported them into Excel. Added the number of parcels with affected structures and parcels without affected structures where more than 40 percent of its area is affected to arrive at the final "takes" number.

A.3 Parks

Parks data was available in polygon form from the MPOs and the TPWD. The data was merged together to form a single shapefile for the following analysis.

- Intersected the parks shapefile within 500 feet of the alignment centerline, which clips the parks to the corridor and joins them in the alternatives attributes
- Calculated acreage of intersected park features
- Calculated summary statistics for the resulting layer, grouping by potential route alternative name and summing the total affected park acreage
- Exported the summary table from ArcGIS and inserted it into the Excel table

A.4 Prime Farmland

Prime farmland was acquired from the NRCS SSURGO. The following analysis was conducted to determine the potential impacts.

- Merged together SSURGO data for the various drainage basins in the corridor
- Selected and exported only those polygon features from the SSURGO data that represent prime farmland
- Intersected the prime farmland polygons within 62.5 feet of the alignment centerline, which clips the data to the buffer and joins them to the alternatives attributes
- Calculated acreage of interested prime farmland features
- Calculated summary statistics for the resulting layer, grouping by potential route alternative name and summing the acreage to total affected prime farmland
- Exported this summary table from ArcGIS and placed into the Excel table

A.5 Wetlands

Wetland data was obtained from the USFWS NWI dataset. The analysis was conducted as follows:

- Intersected wetland polygon data within 62.5 feet of the alignment centerline, which clips the wetlands to the study area and joins in the alternatives attributes
- Calculated the acreage of intersected wetland features
- Calculated the summary statistics for the resulting layer, grouping by potential route alternative name and summing the total affected wetland acreage
- Exported the summary table from ArcGIS into Excel

A.6 Waterways

The number of waterways a potential route alternative crosses was calculated using the following analysis. The GIS data was obtained from the NHD.

- Intersected stream lines with the potential alignment alternatives, which generates a point at every crossing joined with attributes from both the streams and the potential route alternative
- Calculated summary statistics for this point layer, grouping by potential route alternative name and summing the number of crossings for each potential route alternative
- Exported the summary table from ArcGIS into Excel

A.7 Floodplain

Floodplain data was obtained from FEMA and included both the 100- and 500-year floodplain classifications. The following analysis was conducted to determine the acres of impacts for each potential route alternative.

- Intersected polygon floodplain data within 62.5 feet of the alignment centerline, which clips the floodplains to the study area and joins in the alternatives attributes
- Calculated acreage of the intersected floodplain features
- Calculated summary statistics for the resulting layer, grouping by potential route alternative name and summing the total affected floodplain acreage
- Exported the summary table from ArcGIS into the Excel table

A.8 Road Crossings

The TxDOT was the data source for the roadways within the corridor. The GIS data set included all public roads regardless of ownership or functional class. The number of roadway crossings was calculated for each potential route alternative by using the follow steps:

- Intersected roadway lines with the potential route alternatives, which generated a point at every crossing joined with attributes from both the roads and the potential route alternative
- Calculated summary statistics for the point layer, grouping by potential route alternative name and summing the number of road crossings for each potential route alternative
- Exported the summary table from ArcGIS into Excel

A.9 Infrastructure Adjacency

One of TCR's alignment objectives is for a potential route alternative to "maximize co-location opportunities with transportation and utility corridors." This criterion estimates the percentage of the potential route alternative that parallels existing infrastructure. This analysis uses the roads dataset from TxDOT, railroads dataset from the U.S. National Transportation Atlas, and electrical transmission line dataset from Platts.

To determine the percentage of the potential route alternative that parallels existing infrastructure, the following analysis occurred:

- Split the alternative lines at their vertices so that the bearing of individual segments could be computed
- Computed the bearing of these individual segments using Linear Direction Mean and created a non-dissolved flat-ended 1,000-foot buffer (500 feet from alignment centerline for each of these individual segments, which carries over alternative attributes and the bearing of the parent line segment

- Merged the infrastructure features into one feature class and clipped them to this new buffer area, primarily to cut down on processing time
- Intersected the infrastructure features with the new segment buffer, which breaks infrastructure features where the alternative changes direction and joins alternative attributes (including bearing)
- Split these intersected infrastructure features at their vertices and calculated the bearing of individual sections using Linear Direction Mean
- Selected only those infrastructure features that were within 5 degrees of the same bearing (substantially parallel) to move on in the analysis
- Split the original alternative lines into 500-foot segments for aggregation and created a non-dissolved 1,000-foot buffer (500 feet from alignment centerline) flat-ended buffer of the resulting features
- Selected only those 500 feet by 1,000 feet buffer features that contained parallel infrastructure
- Copied these selected features to a new layer and created summary statistics, grouping by potential route alternative name and summing their total length. This represents the total length of segments of the alignment that are paralleled by existing infrastructure
- Divided this parallel length by the potential route alternatives total length to arrive at a percentage paralleled by existing infrastructure
- Exported the summary table from ArcGIS into Excel

A.10 Minority Population

Minority population was looked at to determine which proposed route alternatives might disproportionately affect EJ populations, which are defined as minority and low-income populations. Minority population data was obtained at the U.S. Census Block level from the 2010 Decennial U.S. Census. For the purposes of this analysis, the minority population is defined as the total population minus persons that reported themselves as White, Not Hispanic or Latino. This information was converted into a metric by counting the number of U.S. Census Bocks with a minority population over 50 percent intersecting the potential route alternative 1,000-foot buffer (500 feet from alignment centerline).

A.11 Cemeteries

Polygon cemetery data was obtained from the THC. Both the number of impacted cemeteries and total impacted acreage was calculated. Only the impacted acreage was used for the evaluation scoring.

The following analysis was conducted to determine potential impacts:

- Cemetery polygon data was intersected within 62.5 feet of the alignment centerline
- The resulting impacted cemeteries were dissolved by both potential route alternative name and cemetery name to insure that there existed only one cemetery-alternative feature combination in the dataset to avoid double counting in areas where many potential route alternatives are close to each other
- Calculated the impacted area in acres
- Generated summary statistics, grouping by potential route alternative name and summing together both the number of impacted cemeteries and total impacted acreage
- Exported this summary table from ArcGIS and inserted it into the Excel table

A.12 Ecology

The TXNDD element occurrence data from TPWD depicts areas where threatened and endangered species have been observed. This does not necessarily mean that these species are present, but it is an indicator that an element is or was present and has practical conservation value. Impacts were determined from the following analysis:

- Intersected the TXNDD layer within 62.5 feet of the alignment centerline of the potential route alternative, which clipped the layer and joined in the alternatives attributes
- Calculated the area of the polygon features in this intersected element occurrence layer
- Generated summary statistics, grouping by potential route alternative name and summing the total potential impacted acreage
- Exported the summary table from ArcGIS and inserted it into the Excel table

A.13 Community Facilities

Community facility data is available from a number of different sources and covers a wide variety of facilities, but only the Geographic Names Information Service (GNIS) dataset covers the entire corridor consistently. GNIS data is delivered in a delimited text file for the entire state of Texas.
The analysis was conducted as follows:

- Imported the text file into Excel, cleaned it up, and saved it as a spreadsheet
- Imported the spreadsheet into ArcGIS using Excel to Table tool
- Used the Make XY Event Layer tool to project this tabular data into spatial points using NAD 83 coordinates provided in the dataset's attributes
- Used Select By Location to select features from this layer within the alignment counties
- Used Select By Attributes to select features from these selected features that are within the following GNIS feature classes: "Building" (public facilities included), "Church", "Hospital", "Post Office", "School"
- Exported this selection as its own layer, and then intersected this layer with the 1,000-foot buffer (500 feet from alignment centerline), which clips the GNIS points to the alternative buffer and joins in the alternative attributes
- Performed summary statistics on this intersected layer, grouping by potential route alternative name and summing the number of points intersected by each alignment buffer
- Extracted these total numbers from ArcGIS and inserted them into the Excel table

A.14 Historic Properties

The National Register of Historic Places (NRHP) was used to determine potential impacts to historic properties. Both individual properties (points) and districts (polygons) were looked at by using the methodology described below.

- Intersected both the point and polygon NRHP data with the 1,000-foot buffer (500 feet from alignment centerline), which clips these features to the buffer area and joins them in the alternatives attributes
- Calculated the summary statistics for both of these layers, grouping them by alternative name and summing the total number of NHRP districts and properties
- Exported both of these summary tables from ArcGIS and entered them into the Excel table

A.15 Hazardous Materials Sites

Hazardous material sites were obtained from the Texas Council on Environmental Quality (TCEQ), data included municipal setting designations; municipal solid waste landfills, radioactive sites, Superfund sites, municipal water wells, and underground petroleum storage tanks.

The following analysis was conducted to determine potential impacts:

- Intersected each set of features within 62.5 feet of the alignment centerline of the potential route alternatives, which clipped the sites and joined them in the alternative attributes
- Generated summary statistics for each set of features, grouping by potential route alternative name and summing the number of intersecting hazardous material sites
- Joined the resulting tables together, which yields a single table with a row for each potential route alternative and column for each type of hazardous material site
- Summed the total number of hazardous material sites for each potential route alternative, exported the table from ArcGIS and inserted it into the Excel table

A.16 Population below Poverty Line

Poverty data from the 2013 5-year American Community Survey (ACS) was obtained at the U.S. Census Block Group level to determine which proposed route alternatives might disproportionately affect EJ populations. The information was converted into a metric by counting the number of U.S. Census Block Groups that intersect the potential route alternatives' 1,000 -foot buffer (500 feet from alignment centerline) where 50 percent or more of the population is below the 2013 poverty line of $23,550 for a family of four (4).