

July 12, 2023

MEMORANDUM—

I-76 / Weld County Road 8 Interchange—Level 2 Screening Documentation

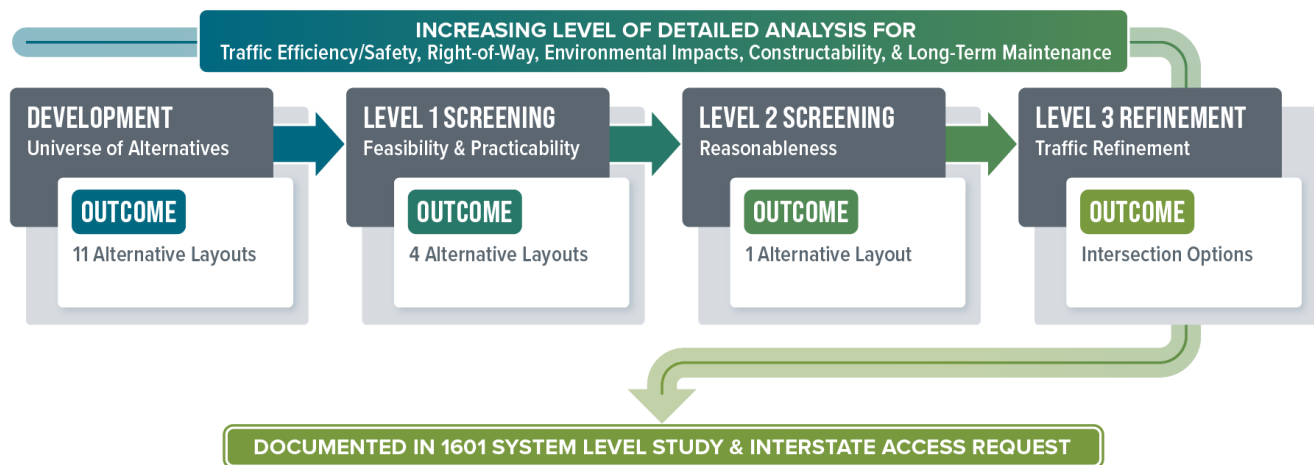
This memorandum discusses the Alternative Screening process and the results of the Level 2 Screening for the I-76 and Weld County Road 8 Interchange. This interchange is needed to adequately support a new BNSF Intermodal Facility (IMF) and construction of a new Logistics Park (LP) just east of I-76. This memorandum is intended to provide documentation of the overall alternative development and the results of Level 2 Screening. The subsequent phase (Level 3) of screening will also be documented in a memorandum. These will then be consolidated into a single report which will be incorporated in the I60I System Level Study and National Environmental Policy Act (NEPA) documents.

Each level of screening is being prepared in this format to gain approval from the Colorado Department of Transportation (CDOT) and the Federal Highway Administration (FHWA) on each step along the project development path.

Alternative Development and Screening

This section describes the process that the project team is using to develop, analyze, and select an alternative and intersection configuration. **Figure 1** presents the alternative development and screening process that is being used to identify the most favorable alternative configuration for Traffic Efficiency/Safety, Right-of-Way, Environmental Impacts, Constructability, and Long-term Maintenance.

Figure 1. Alternative Development and Screening Process



This process is intended to analyze various alternatives with an increasing level of detail. This is advantageous by efficiently applying resource efforts at the appropriate times, in other words, using the best available information at the time to inform decision-making.

Alternative Development and Level 1 Screening

The project team conducted an alternative workshop and identified eleven (11) unique interchange alternatives. These alternatives ranged in configurations that were identified as potential alternatives which may show promise as improvements needed to support the rail facility. These alternatives were subsequently evaluated and screened in Level 1 Screening.

Level 1 Screening Evaluation Summary

After the identification of the eleven (11) interchange alternatives, each alternative was evaluated in the Level 1 Screening. This initial level of screening was intended to identify substantial differences between the alternatives.

The Level 1 Screening evaluated the alternatives on various factors within the categories of traffic efficiency, safety, right of way, permitting, constructability, and long-term maintenance. Four alternatives—Standard Diamond, Partial Cloverleaf (ParClo), Diverging Diamond Interchange (DDI), and Single Point Urban Interchange (SPUI)—were selected to advance to the Level 2 Evaluation and Screening.

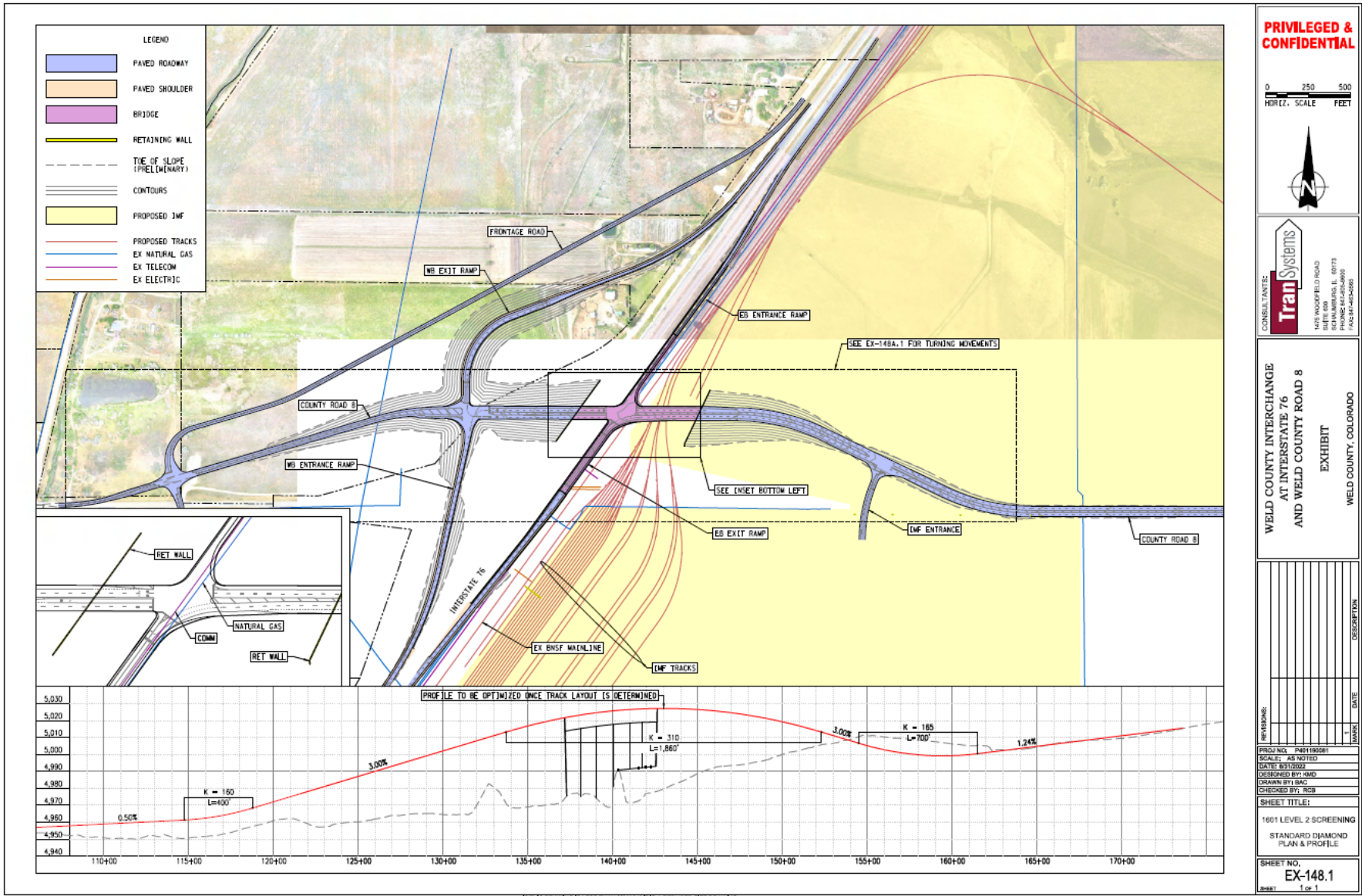
A Memorandum dated January 4, 2022 provides full detail regarding Level 1 Screening.

Level 2 Alternative Evaluation and Screening

The four remaining alternatives were advanced to conceptual design to understand the various elements, advantages, and challenges associated with each interchange type.

Figures 1 through 4 present the alternatives evaluated in Level 2. It should be noted that during the Level 2 process, the extension of the rail tracks associated with the IMF required shifting the interchange location to the north. An additional benefit to the northern shift is a reduction of wetland impacts directly associated with the interchange. This occurred at a point where the Standard Diamond and SPUI had been found to have critical disadvantages relative to the other two alternatives; therefore, only the ParClo and DDI alternatives were shifted north to accommodate the rail operations. The performance disadvantages associated with the Standard Diamond and SPUI would still be relevant in the northern configuration.

Figure 2. Standard Diamond Interchange



IF THIS DRAWING IS LESS THAN 22" X 34" IT IS A REDUCED SIZE DRAWING

Figure 3. Single Point Urban Interchange

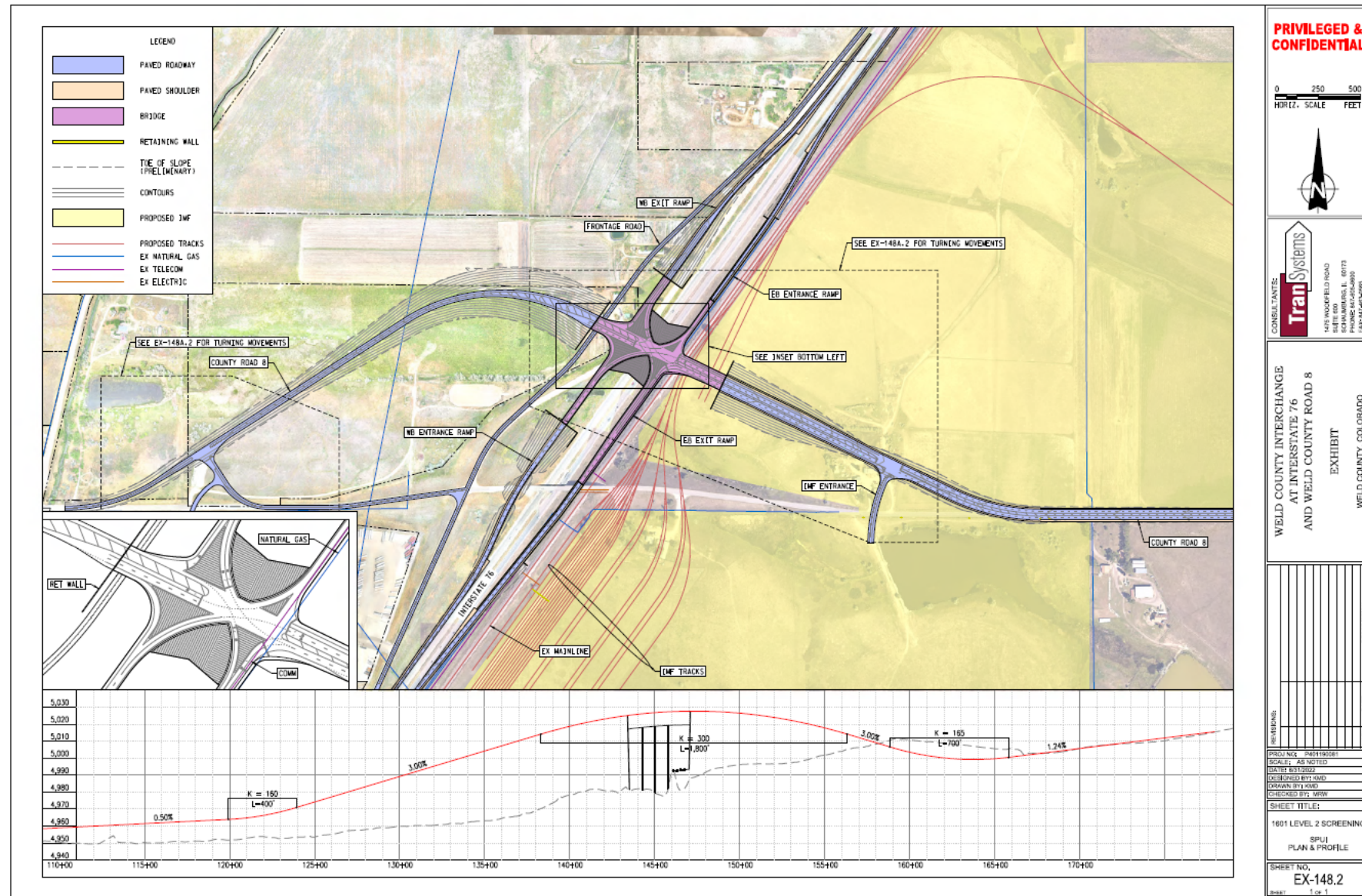


Figure 4. Partial Cloverleaf Interchange

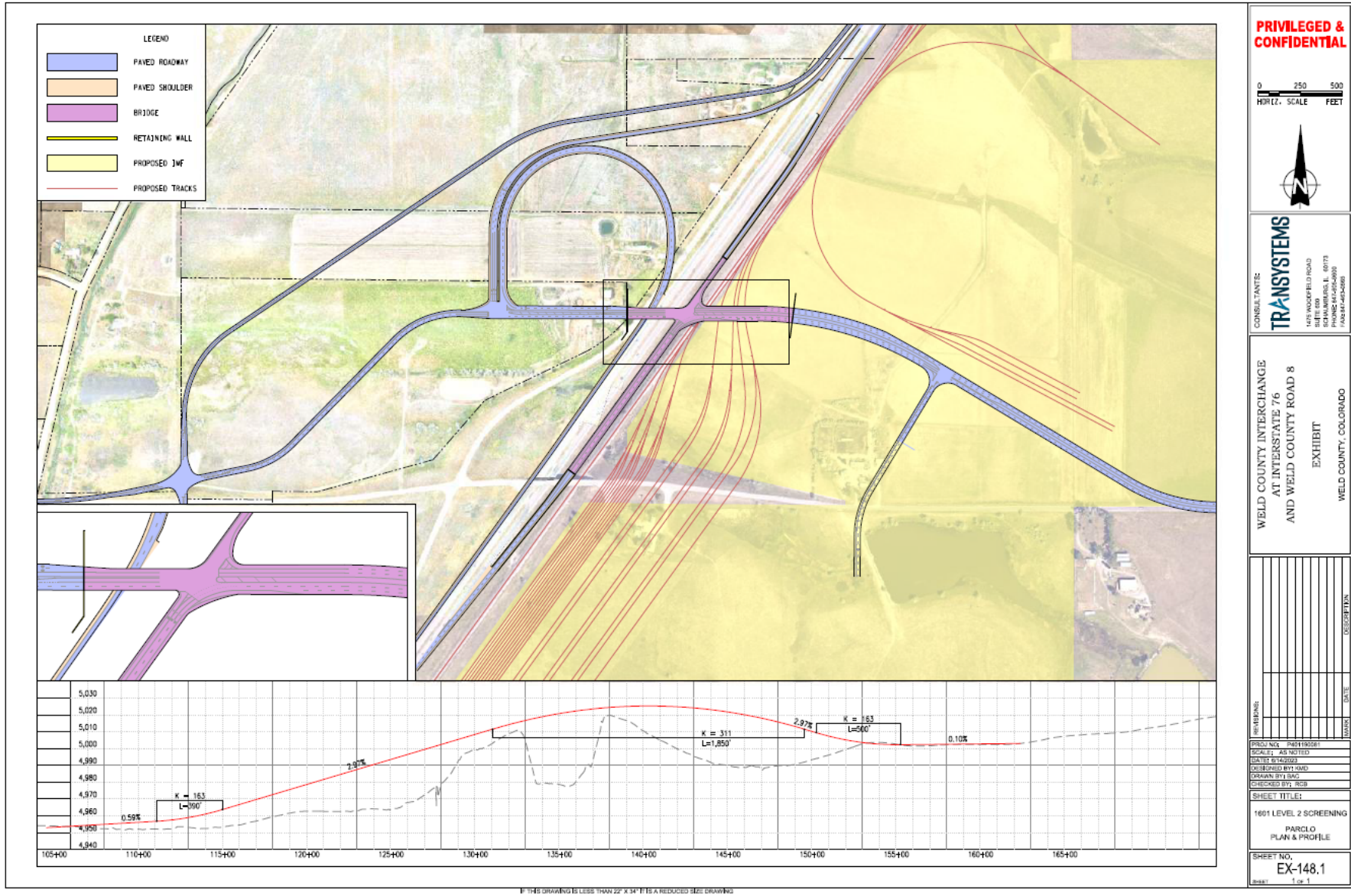
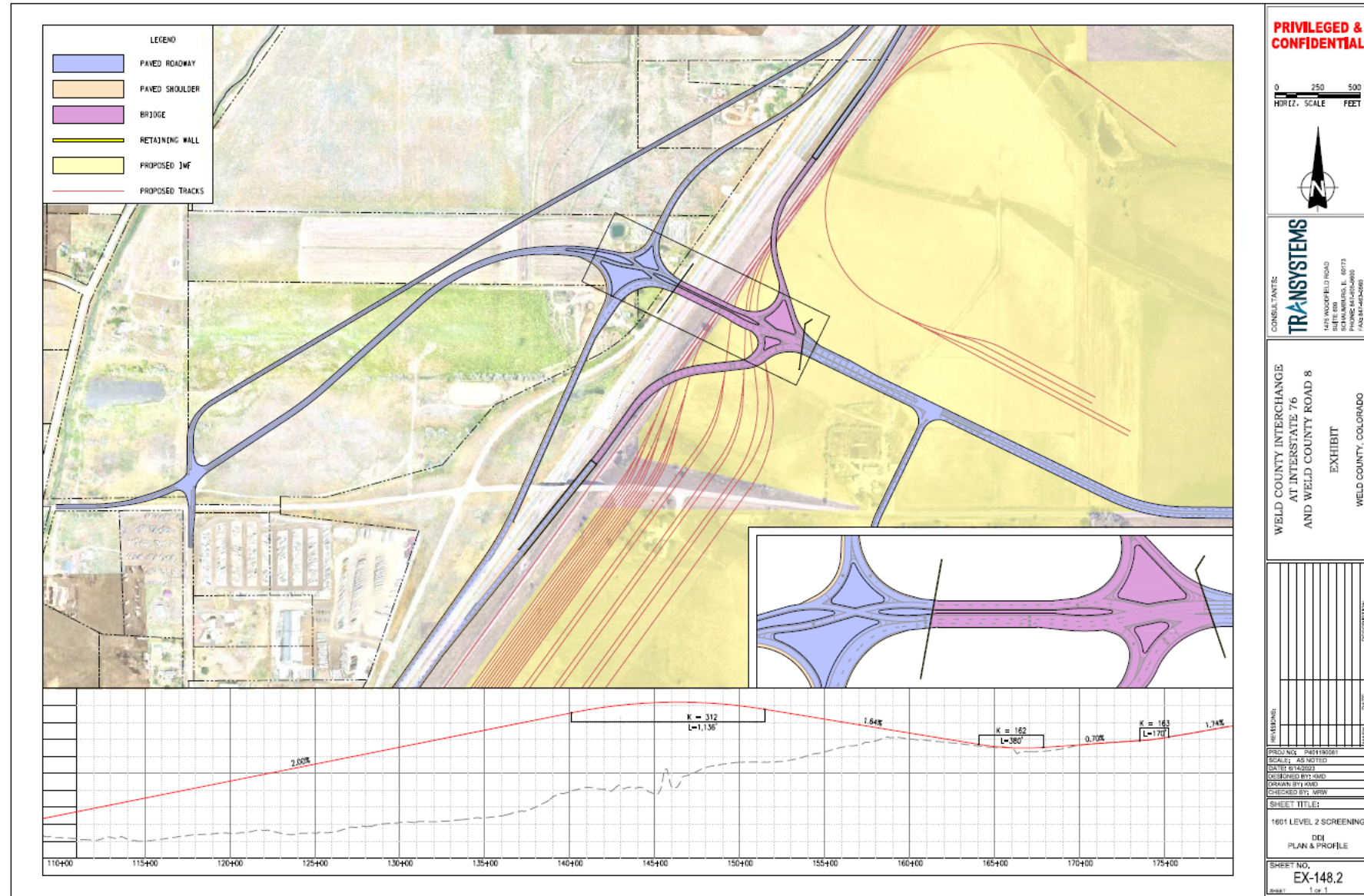


Figure 5. Diverging Diamond Interchange



Level 2 Alternative Evaluation & Results

To evaluate the Level 2 Alternatives, the project team developed Screening Criteria and Performance Measures to evaluate each alternative (Table I).

Table I. Level 2 Screening Criteria and Performance Measures

Category	Criteria	Performance Measure	
<i>Traffic Efficiency</i>	Can the Alternative provide the necessary vehicular capacity?	Aggregate ramp terminal intersection Volume to Capacity (V/C) ratio	
	Does the Alternative result in acceptable delay?	Aggregate Peak hour Level of Service (LOS) and delay for all surface street intersections and movements within and adjacent to the interchange alternative	
		Peak hour LOS for freeway mainline, merge, and diverge sections	
	Can the configuration accommodate large truck volumes?	Queue lengths into other intersections	
		Truck turning template analysis of all interchange movements	
		Northbound Right Ramp Vertical Grade	
	Does the Alternative create significant adverse effects to the operations of I-76?	I-76 Weighted Average Level of Service	No Action Alternative
		Off-ramp queue lengths	
<i>Primary Patterns</i>	Does the Alternative introduce significant delay for primary interchange travel patterns?	AM Peak Delay time in sec/veh (I-76 Northbound to WCR 8 Eastbound – Right Turn)	
		PM Peak Delay time in sec/veh (WCR 8 Westbound to I-76 Southbound – Left Turn)	
<i>Traffic Flexibility</i>	Does the Alternative have the ability to accommodate higher volumes and/or truck percentages?	Appraisal of extent of adjustments needed to provide additional capacity	
<i>Safety</i>	Does alternative create additional conflict points compared to other alternatives?	Number of conflict points (crossing/total)	
	Does alternative result in increased crashes relative to other options?	Crash modification factor associated with interchange type	
<i>Environmental Considerations</i>	What are the alternative's impacts on environmental and cultural resources within the built and natural environment	Impacts to Wetlands	
		Impacts to potential Section 4(f) Resources	
<i>Community Context</i>	What are the impacts on existing residential community?	Does the alternative adversely impact the existing residential community?	
	What are the impacts on existing business community?	Does the alternative adversely impact the existing business community?	

Category	Criteria	Performance Measure
<i>Railroad Operation Interactions</i>	Does the alternative affect the planned rail operations?	Does the alternative affect the planned rail operations?
	Does the alternative limit potential future expansion of rail operations?	Does the alternative limit potential future expansion of rail operations?
<i>Constructability</i>	Does the alternative allow for phasing?	Can the project be phased?
	Does the alternative have complicated construction elements when compared to other alternatives?	Does the alternative have complicated construction elements when compared to other alternatives?
<i>Long-Term Maintenance</i>	Does the alternative lower the long-term maintenance costs, associated with complicated structural elements, when compared with other alternatives?	Does the alternative lower the long-term maintenance costs, associated with complicated structural elements, when compared with other alternatives?
<i>Costs</i>	What is approximate cost of the alternative?	Includes 30% contingency and 26% CM

Level 2 Evaluation

The project team conducted the evaluation of the four Level 2 Alternatives using a variety of tools. The following briefly describes what tools were used for each Evaluation Category:

- **Traffic Efficiency and Primary Travel Patterns** criteria and measures were evaluated using the Highway Capacity Software (HCS), in accordance with the Methods and Assumptions document that was approved by CDOT and FHWA. Additionally, design review for various elements was used.
- **Traffic Flexibility** was determined by looking at the results of the HCS outputs and volume over capacity (V/C) ratios to determine the remaining capacity each alternative could absorb additional traffic associated with currently unplanned development. The focus on this measure was on the western side of the interchange.
- **Safety** was evaluated by identifying conflict points and crash modification factors associated with the basic design/layout of each alternative.
- **Environmental Consideration** was evaluated by overlaying the alternative design with field identified wetlands and potential historic (Section 4(f)) resources using Geographic Information Systems (GIS).
- **Community Context** was evaluated by identifying homes and businesses that would potentially be impacted by each alternative design.
- **Railroad Operation Interactions** was evaluated using planned rail configurations and necessary infrastructure associated with IMF and where potential interchange supports (i.e., piers, abutments, etc.) could limit future rail operations.

- **Constructability** was evaluated by identifying the likely necessary materials needed for the construction of the alternative. Additionally, associated construction techniques and skills required for construction were also evaluated.
- **Long-Term Maintenance** was qualitatively determined by identifying likely potential level of maintenance activities needed to ensure safe structural elements.
- **Costs** were determined by estimating the capital costs associated with each alternative, with the appropriate contingency for conceptual level of design.

The following table presents the results of the Level 2 Screening based upon the evaluation previously described (**Table 2**). Alternative performance was color-coded based upon the resultant evaluation within each category (favorable is highlighted green, a moderate is yellow, and negative is red).

Level 2 Screening Results

Table 2 presents the results of the Level 2 Screening Evaluation, and this section describes the rationale for the screening from four alternatives to one alternative to be carried forward to Level 3 Refinement.

Alternatives Removed

Based upon the results of the evaluation presented in **Table 2**, the following alternatives were removed from further evaluation:

Standard Diamond

While the Standard Diamond requires a relatively simple construction and maintenance schedule and has the lowest cost, it presents substantial challenges associated with some of the dominant travel patterns. Primarily, the heavy westbound to southbound movement in the PM peak hour consisting of roughly 50 percent large freight trucks has to move through the at-grade western intersection via a protected left turn indication. While signal timing can be adjusted to increase green time and capacity for this movement, the at-grade configuration leaves very little reserve intersection capacity as growth occurs. Additionally, the Standard Diamond has the greatest number of vehicular conflict points associated with the design. Because of these reasons and the presence of better performing alternatives, this configuration was removed from further consideration.

SPUI

The SPUI configuration was removed from consideration because of a number of insurmountable factors. The SPUI had the worst level of service (LOS) and most delay of all the interchanges. The delay associated with one of the dominant movements in the morning (northbound to eastbound) was over twice as high as the Standard Diamond and ParClo, and over three times as much as the DDI.

The constructability and long-term maintenance of the SPUI also creates a significant obstacle. The bridge deck for the SPUI would have to be exceedingly large to accommodate the intersection, which would result in large amounts of bridge structure that would be constructed and not used. Additionally, the SPUI requires complex steel framing where ramps tie-in County Road 8, which adds to the difficult construction and added maintenance efforts.

Table 2. Level 2 Screening Table

Category	Criteria	Performance Measure		Traditional Diamond	Diverging Diamond	ParClo	SPUI
Traffic Efficiency	Can the Alternative provide the necessary vehicular capacity?	Ramp terminal intersection Volume to capacity (v/c) ratio		0.77(0.71)	0.54(0.31)	0.74(0.64)	0.79(0.44)
	Does the Alternative result in acceptable delay?	Peak hour Level of Service (LOS) and delay for all surface street intersections and movements within and adjacent to the interchange alternative		AM: D (57 sec) PM: C (32 sec)	AM: C (33 sec) PM: B (22 sec)	AM: C (51 sec) PM: C (24 sec)	AM: D (77 sec) PM: B (27 sec)
		Peak hour LOS for freeway mainline, merge, and diverge sections		Worst LOS: D (South of WCR 8)	Worst LOS: D (South of WCR 8)	Worst LOS: D (South of WCR 8)	Worst LOS: D (South of WCR 8)
	Can the configuration accommodate large truck volumes?	Queue lengths into other intersections		NBL: Exceeds provided storage length, but does not spill back onto I-76	No queues are anticipated to exceed provided storage	NBL: Exceeds provided storage length, but does not spill back onto I-76	The EBT is anticipated to spill back past one-two lane diverge
		Truck turning template analysis of all interchange movements		Fits WB-67	Fits WB-67	Fits WB-67	Fits WB-67
		Northbound Right Ramp Elevation Grade		+3.37%	+3.25%	+2.90%	+2.79%
	Does the Alternative create significant adverse effects to the operations of I-76?	I-76 Weighted Average Level of Service	No Action	LOS B			
			Alternative	LOS C			
		Off-ramp queue lengths		NB: 1,253(620)/1900 SB: 361(200)/2,500	NB: 808(400)/2,500 SB: 285(185)/1,700	NB: 902(404)/1,850 SB: 315(173)/3,050	NB: 1,238(195)/2,300 SB: 247(162)/1,900
Primary Patterns	Does the Alternative introduce significant delay for primary interchange travel patterns?	AM Peak Delay time in sec/veh (I-76 Northbound to WCR 8 Eastbound – RT)		57 sec	34 sec	57 sec	116 sec
		PM Peak Delay time in sec/veh (WCR 8 Westbound to I-76 Southbound – LT)		40 sec	17 sec	18 sec	15 sec
Traffic Flexibility	Does the Alternative have the ability to accommodate higher volumes and/or truck percentages?	Appraisal of adjustments needed to provide additional capacity		NBRT can be adjusted to free flow (+) WBLT constrained (-)	NBRT can be adjusted to free flow (+)	WB loop movements (+) and NBRT (+) can be adjusted to free flow	NBRT can be adjusted to free flow (+)
Safety	Does alternative create additional conflict points compared to other alternatives?	Number of conflict points (crossing/total)		23/36	8/14	14/24	20/32
	Does alternative result in increased crashes relative to other options?	Crash modification factor associated with interchange type		1.0	0.85	0.92 (estimated from South Dakota data)	1.0 (Literature compares SPUI performance to tight diamond)
Environmental Considerations	What are the alternative’s impacts on environmental and cultural resources within the built and natural environment	Impacts to Wetlands		0.86 acres	3.2 acres	2.5 acres	1.21 acres
		Impacts to potential Section 4(f) Resources		No historic properties currently affected.	No historic properties currently affected.	No historic properties currently affected.	No historic properties currently affected.

Category	Criteria	Performance Measure	Traditional Diamond	Diverging Diamond	ParClo	SPUI
Community Context	What are the impacts on existing residential community?	<i>Does the alternative adversely impact the existing residential community?</i>	Moderate. Two residences displaced on west side of I-76	Higher. Three residences displaced on west side of I-76	Moderate. Two residences displaced on west side of I-76	Moderate. Two residences displaced on west side of I-76
	What are the impacts on existing business community?	<i>Does the alternative adversely impact the existing business community?</i>	No. Minimal to no impacts to business community	No. Minimal to no impacts to business community	No. Minimal to no impacts to business community	Moderate. Additional turns needed to access existing businesses
Railroad Operation Interactions	Does the alternative affect the planned rail operations?	<i>Does the alternative affect the planned rail operations?</i>	No. Pier locations and track alignments will be coordinated to minimize conflicts. No improvements are planned west of the existing mainline, so there will be no operational conflicts with the proposed structures there. The eastern wall & the two stub tracks north of CR-8 will need to be coordinated.			
	Does the alternative limit potential future expansion of rail operations?	<i>Does the alternative limit potential future expansion of rail operations?</i>	Moderate limitations. Alternative would require extension of bridge to the east.	Substantial limitation. Similar to other alternatives, but curved structures require more limitations via piers.	Moderate limitations. Alternative would require extension of bridge to the east.	Moderate limitations. Alternative would require extension of bridge to the east.
Constructability	Does the alternative allow for phasing?	<i>Can the project be phased?</i>	Yes. Straightforward. Minimal MOT.	Yes. Straightforward. Minimal MOT.	Yes. Straightforward. Minimal MOT.	Yes. Straightforward. Minimal MOT.
	Does the alternative have complicated construction elements when compared to other alternatives?	<i>Does the alternative have complicated construction elements when compared to other alternatives?</i>	This configuration requires complex steel framing where the ramps tie-in to County Road 8. The proposed bridge is offset from I-76, which will minimize traffic impacts to the expressway. May not be feasible with only straight structural members.	Long ramps with curved and tangent sections will have cross slope transitions on the bridge. Widened exit ramp required to avoid taper in the curved section. Singular material structure requirements (i.e., steel). Which requires highly specialized construction methods reliant on labor for framing versus straight mechanically placed girders. Requires multiple piers within rail operations. County Road 8 Bridge will have flared and curved girders, with potentially similar framing connections as the Traditional Diamond/SPUI although not as extensive.	Can connect independent simple structures via expansion joints, thus creating the main structure as WCR 8. The proposed bridge is offset from I-76, which will minimize traffic impacts to the expressway. May not be feasible with only straight structural members.	SPUI requires complex steel framing where ramps tie-in County Road 8. Temporary shoring may be necessary which would impact I-76 traffic. Complex framing also occurs over RR tracks, which may require more frequent and hands on inspection cycle (fracture critical) Likely for bridge to be wider than the roadway with unused deck space to facilitate construction.
Long-Term Maintenance	Does the alternative lower the long-term maintenance costs, associated with complicated structural elements, when compared with other alternatives?	<i>Does the alternative lower the long-term maintenance costs, associated with complicated structural elements, when compared with other alternatives?</i>	Yes. Structures relatively simple. No curvature. Limited area over I-76 & tracks.	No. Curved steel structures over tracks at both NB ramps. Very long retaining wall on east side.	Partially. Structures relatively simple. No curvature. Limited area over I-76. Significant length over tracks. Requires maintenance of expansion joints.	No. Large curved structures over I-76. Only alternative with significant structures on west side. More frequent & hands on inspection cycle. Has fewer signals.
Costs	<i>What is approximate cost of the alternative?</i>	<i>Includes 30% contingency and 26% CM</i>	\$143M	\$221M	\$185M	\$248M

The superior screening criteria performance of the DDI and ParClo caused these alternatives to emerge from the others for potential advancement to Level 3. Further evaluation of these alternatives relative to each other is described as follows:

DDI

The DDI was removed from additional consideration despite being the highest performing alternative in terms of vehicular capacity, delay, and number of conflict points. It is the only alternative with most interchange support structures showing the possibility of interfering with planned and future rail operations. This is a result of the curved structures associated with the ramps needed to gain the operational benefits of the DDI. Long ramps with curved and tangent sections will have cross slope transitions on the bridge, which is a more complicated construction than other alternatives. A widened exit ramp is required to avoid tapering in the curved section. Singular material structure requirements (i.e., steel) require highly specialized construction methods reliant on labor for framing versus straight mechanically placed girders.

Alternative Advanced

Partial Cloverleaf (ParClo)

As outlined in **Table 2**, the ParClo shows strong operational efficiency and traffic safety performance based on the Level 2 screening analyses. Because the ParClo performs very well from an operational and safety standpoint without the complicated construction materials/methods and associated maintenance of the materials associated with the DDI, the ParClo is advanced to Level 3.

Level 3 Refinement

As outlined in the overall screening process shown on **Figure 1**, Level 3 Screening will provide traffic operations refinement for the advanced alternative, the ParClo. Level 2 analyses have provided a high degree of confidence in its ability to perform acceptably from a traffic operations and safety perspective. Level 3 will further confirm this finding and address key operational questions related to the functionality of the preferred configuration. Level 3 is not anticipated to alter the basic configuration of the ParClo but may result in some refinements to geometric features to yield optimal operational performance. Completion of Level 3 screening will support final documentation of the alternative screening process within the System Level Study.

Particular aspects to be addressed during Level 3 include the following:

- Movement of tractor-trailer traffic through the interchange intersections, particularly related to the northbound off-ramp right-turn movement, where roadway grades will impact the ability of heavy vehicles to efficiently navigate the turn and negotiate downstream intersection movements east of the interchange.
- Confirmation of the ability of the west ramp terminal intersection to convey vehicles efficiently to the loop ramp to reach southbound I-76.

To address these items, the study team will develop a traffic microsimulation model of the advanced alternative, working with the following basic assumptions:

1. Only the ParClo will be analyzed; multiple basic interchange configuration alternatives will not be analyzed.
2. The study area will only include the proposed new interchange ramps, surface streets and adjacent surface street intersections. No interstate freeway segments will be included. As outlined in the study

Methods and Assumptions document, freeway facilities are analyzed using the Highway Capacity Software (HCS) tool.

3. Year 2050 traffic volume forecasts developed for Level 2 screening analyses will be carried forward for the Level 3 analysis.
4. Coordination with CDOT and FHWA traffic reviewers will occur to ensure agency support for the analysis scope, approach, tools and methods to be followed.

Additionally, efforts to minimize wetland impacts associated with the ParClo will be undertaken in Level 3. The majority of the wetland impacts associated with the ParClo are from the realigned frontage road, which a closer evaluation should reduce the wetland impacts considerably.

Summary

The I-76/WCR 8 Interchange study team has completed Levels 1 and 2 of alternative screening; resulting in the selection of the Partial Cloverleaf (ParClo) alternative to advance to Level 3 for final refinement. Within Level 3, the study team will introduce a focused microsimulation process to address key operational components and support any needed design refinements. Level 3 methods, tools and parameters will be coordinated with review agencies.

Please contact FHU at alex.pulley@fhueng.com with any questions.