



OHIO RIVER CROSSING

Interchange Concept Evaluation

I-69 Ohio River Crossing Project
Evansville, IN and Henderson, KY

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CHAPTER 1 - INTRODUCTION

The Draft Environmental Impact Statement (DEIS), published December 2018, identified two Preferred Alternatives – Central Alternative 1A and Central Alternative 1B. These alternatives are identical, except for the proposed toll scenario. Central Alternatives 1A and 1B would both construct a new roadway and Ohio River bridge to connect existing I-69 near Weinbach Avenue in Indiana to US 41 near Van Wyk Road in Kentucky. South of Van Wyk Road, modifications would be made to bring existing US 41 up to interstate standards.

As shown in Figure 1-1, construction of Central Alternative 1A or 1B would require the construction of three new interchanges and modifications to one existing interchange:

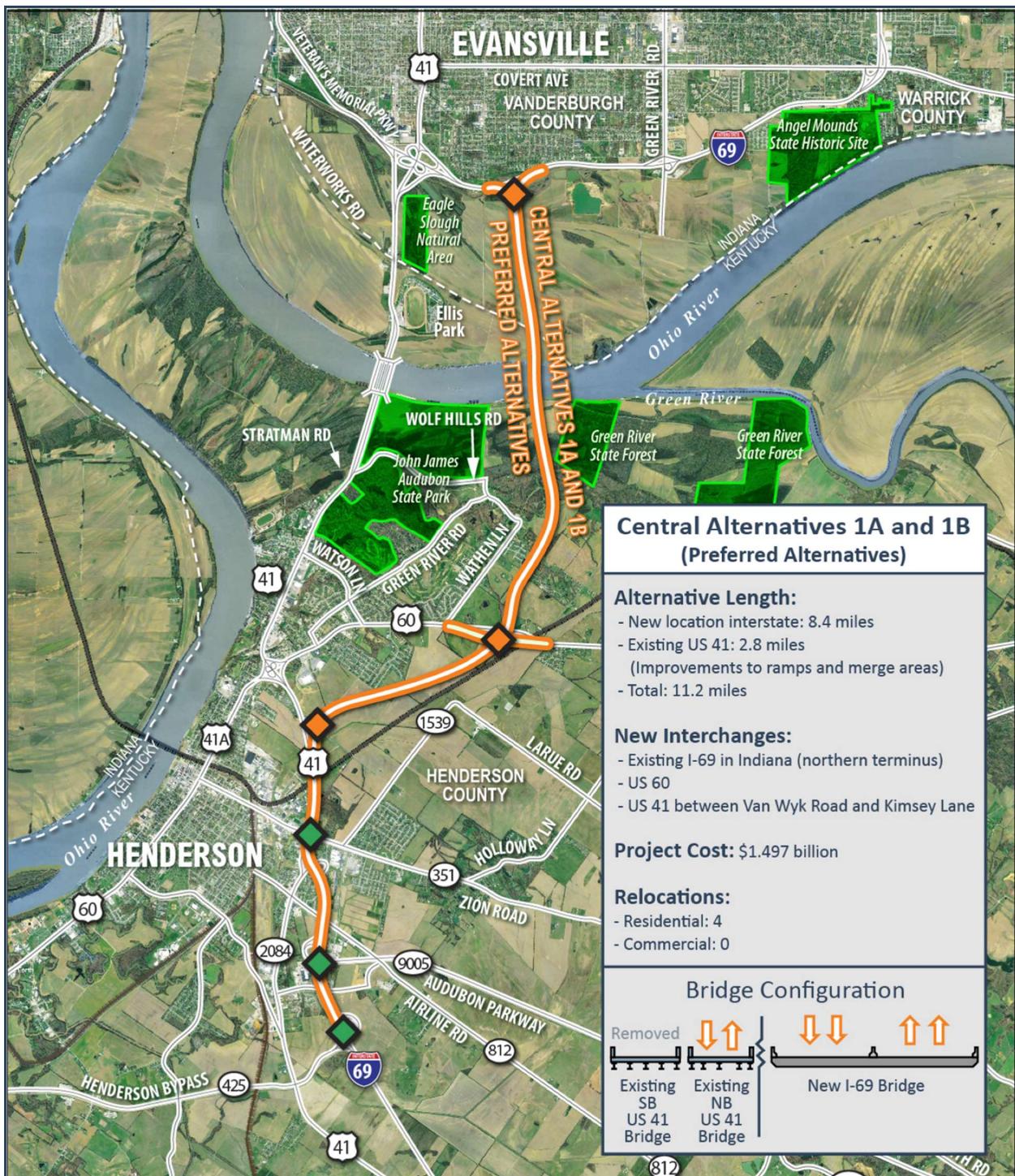
- Veterans Memorial Parkway – new interchange that would serve as the northern terminus of the new I-69 alignment
- US 60 – new interchange
- US 41 – new interchange that would serve as the southern terminus of the new I-69 alignment
- KY 351/KY 2084 – modifications to the existing interchange to meet interstate design standards.

The DEIS presented a conceptual design for each of these interchanges. Following publication of the DEIS, INDOT and KYTC held a Value Engineering (VE) Workshop March 12-14, 2019, with the goal of identifying opportunities to make improvements to the Preferred Alternatives. One of the recommendations of the VE Team was to revisit the interchange designs to improve operations and/or reduce costs. The project team also received comments during the DEIS public comment period with some specific suggestions to improve the interchanges. To this end, the project team held an interchange design workshop on July 25, 2019 where a range of concepts were developed at each interchange location. The most promising concepts at each interchange have been carried into this evaluation.

Each of the concepts has been compared on a range of criteria including traffic, safety, cost, and environmental factors. For each applicable criterion, the concepts were qualitatively or quantitatively evaluated and then compared to identify the highest performing concept(s). A high-moderate-low rating system was used, with a green rating given to the highest performing concept(s) for that criterion and an orange rating given to the lowest performing concept(s). A yellow rating was given to the concepts that performed between the highest and lowest performing concepts.

	Highest Performing Concept(s)
	Moderate Performing Concept(s)
	Lowest Performing Concept(s)

The sections that follow describe the evaluation for each interchange and identify the concept(s) recommended to be carried forward.



Existing Interchange to Remain
 Proposed Central Alternatives 1A and 1B Interchange



Preferred Alternatives
Central Alternatives 1A and 1B

0 0.5 1
Miles



December 2018

Figure 1-1. Preferred Alternative

CHAPTER 2 - VETERANS MEMORIAL PARKWAY INTERCHANGE

The Veteran’s Memorial Parkway (VMP) interchange is located at the project’s northern terminus where the new I-69 roadway would tie into existing I-69.¹ Because the I-69 / Veterans Memorial Parkway interchange would be a new access point on an existing interstate (I-69), it is subject to the requirements of the Federal Highway Administration’s *Policy on Access to the Interstate Highway System* and requires preparation and approval of an Interstate Access Document (IAD). While this evaluation will identify a preferred concept at this location, it will be subject to further evaluation in the IAD. The IAD, which will be completed prior to the FEIS, will include a full operational evaluation of interchange concepts and identify a single interchange concept to be incorporated into the Selected Alternative.

2.1 INTERCHANGE CONCEPTS

Five design concepts have been identified for this interchange location:

VMP CONCEPT A: DEIS DESIGN

This concept was included in the design of Central Alternatives 1A and 1B in the DEIS (Figure 2-1). A primary goal in the development of this interchange concept was the desire to provide a system interchange² with only traditional, right-hand exits and to minimize the number of roadway/ramp “levels” (i.e., roadways/ramps crossing over other roadways/ramps). These goals led to the inclusion of a long (1+ mile) loop ramp for eastbound VMP traffic continuing eastbound on I-69. Based on subsequent hydraulic analysis, it was determined that the majority of this ramp would be required to be built on structure, which would be costly. Following publication of the DEIS, the project team also received comments expressing disapproval of this concept due to the circuitous route required for drivers that, today, have a direct route.

VMP CONCEPT B: MODIFIED SYSTEM INTERCHANGE WITH RIGHT-HAND EXIT

This interchange concept modifies the DEIS Design by replacing the eastbound-to-eastbound loop ramp with a more direct connection (Figure 2-2). This new connection would, however, require three levels for the interchange, increasing construction costs associated with the taller structure.

VMP CONCEPT C: SYSTEM INTERCHANGE WITH LEFT-HAND EXIT

This interchange concept is similar to Concept B, but the northbound-to-westbound ramp is shifted to exit I-69 on the left side of the roadway, which allows the ramp to be shorter in length (Figure 2-3). This concept would still result in a three-level interchange.

¹ Today, the Veterans Memorial Parkway extends from downtown Evansville to US 41 where it becomes I-69. With the construction of the I-69 ORX project, the segment of existing I-69 between US 41 and the new I-69 alignment would be incorporated into the Veterans Memorial Parkway.

² System interchanges are typically provided where two interstate, or interstate-like, roadways intersect and provide stop-free movements for all traffic. In contrast, service interchanges are typically provided where interstate-like roadways connect to an arterial or local street and typically include one or more stop-controlled or signal-controlled intersections.



Figure 2-1. VMP Concept A: DEIS Design



Figure 2-2. VMP Concept B: Modified System Interchange with Right-Hand Exit



Figure 2-3. VMP Concept C: System Interchange with Left-Hand Exit

VMP CONCEPT D: SERVICE INTERCHANGE 1

This service interchange concept would include a single, signalized intersection for two movements – eastbound VMP to eastbound I-69 and northbound I-69 to westbound VMP (Figure 2-4). As in the DEIS Design Concept, I-69 traffic would be prioritized and provided with continuous interstate service.

VMP CONCEPT E: SERVICE INTERCHANGE 2

Similar to Concept D, this service interchange concept would include a single, signalized intersection (Figure 2-5). However, in this concept, except for eastbound VMP traffic connecting to southbound I-69, all other traffic connecting to or from VMP would be required to utilize a signalized intersection.

2.2 TRAFFIC PERFORMANCE

Each of the interchange concepts meets current design standards and is expected to accommodate forecasted traffic volumes at an acceptable level of service. As a result, the differences between concepts are expected in the form of travel time. Table 2-1 provides a comparison of predicted travel times through the interchange for each non-through movement (travel time for I-69 through traffic would be the same under all concepts). The concepts were compared based on a weighted average that takes into account the volume of vehicles making each movement. As shown, each of the system interchanges (Concepts A, B, and C) provided the shortest travel times, while the service interchanges (Concepts D and E), which required two movements to pass through a signalized intersection, resulted in longer travel times.

Table 2-1. Veterans Memorial Parkway Interchange Travel Time

MOVEMENT	VEHICLES PER DAY	VMP INTERCHANGE CONCEPTS TRAVEL TIME (SECONDS)				
		CONCEPT A	CONCEPT B	CONCEPT C	CONCEPT D	CONCEPT E
Eastbound VMP to Eastbound I-69	7,460	87	65	65	65	65
Eastbound VMP to Southbound I-69	5,170	55	55	55	39	39
Northbound I-69 to Westbound VMP	5,000	49	91	75	77	67
Westbound I-69 to Westbound VMP	13,470	66	66	66	103	103
Weighted Average		66	68	65	79	77

For Concepts D and E, Highway Capacity Software (HCS; version 7.8) was used to estimate the operational conditions at the signalized intersection. For each concept, HCS indicated the intersection would operate at Level of Service D, which is acceptable.



Figure 2-4. VMP Concept D: Service Interchange 1



Figure 2-5. VMP Concept E: Service Interchange 2

2.3 SAFETY PERFORMANCE

Conflict points occur where vehicle travel paths intersect and create opportunities for crashes. There are three categories of conflict points: crossing, merging, and diverging. In general, merging and diverging conflict points – where vehicles are moving in the same direction – are associated with less severe crash types than crossing conflict points where vehicles are moving in perpendicular directions. For the purposes of this analysis, each merge or diverge point was counted as a conflict point and each at-grade intersection was counted as a single crossing conflict.

Where ramps enter a roadway in a dedicated lane (i.e., no merge is required), it was not counted as a conflict point. Conflict points for each of the concepts are shown in Figures 2-1 through 2-5 and Table 2-2. As shown, Concepts A, B, and C would each have four conflict points and Concepts D and E would each have 5 conflict points.

Table 2-2. Veterans Memorial Parkway Interchange Conflict Points

CONFLICT CATEGORY	VMP INTERCHANGE CONCEPTS				
	CONCEPT A	CONCEPT B	CONCEPT C	CONCEPT D	CONCEPT E
Merge/Diverge Conflicts	4	4	4	4	4
Crossing Conflicts	0	0	0	1	1
Total	4	4	4	5	5

2.4 ACCESS

FHWA typically requires that interstate interchanges provide connections to each direction of the intersecting roadway. Likewise, the removal of existing connections is typically discouraged, except where safety concerns are unavoidable. Each of the concepts at this interchange would provide all movements and no existing movements would be removed. Therefore, this criterion was not applied to this interchange.

2.5 DRIVER EXPECTANCY

Driver expectancy relates to a driver's readiness to respond to situations, features, and information in predictable and successful ways. The more predictable the roadway, the less chance of errors. This criterion compares the number of left-hand exits and entrances for each interchange concept. While the concerns associated with left-hand exits/entrances can often be mitigated through advanced signage, they are still less preferable to traditional right-hand exits/entrances. As shown in Table 2-3 Concepts A, B, and D would have no left-hand exits, while Concept C and D would have one and two, respectively.

Table 2-3. Veterans Memorial Parkway Interchange Driver Expectancy Evaluation

CONFLICT CATEGORY	VMP INTERCHANGE CONCEPTS				
	CONCEPT A	CONCEPT B	CONCEPT C	CONCEPT D	CONCEPT E
Left Hand Exits/Entrances	0	0	1	0	2

As shown in the table, Concept C and Concept E would each have a left-hand exit from northbound I-69 to westbound VMP; Concept E would also have a left-hand entrance for eastbound VMP to eastbound I-69. The long distance between the Ohio River Bridge and this exit, more than 1.5 miles, provides sufficient distance for appropriate signage and weaving for northbound vehicles exiting to westbound VMP on this two-lane road. Similarly, for Concept E, the number of vehicles on I-69 in this location and the distance between this merge and the Green River Road exit, approximately 1.5 miles, should provide adequate distance for signage and safe weaving. Although there would be acceptable distances and signage to accommodate these left-hand exits and entrances, these movements are less desirable.

2.6 BRIDGE COST

Bridges are typically the most expensive element in construction of an interchange. This criterion used the total area of bridges (measured in square feet) for each interchange concept as an indicator of overall costs. Despite variations in cost for bridges with different design characteristics (e.g., curved bridges are typically more expensive than straight or tangent bridges), as shown in Table 2-4, concepts were compared based on the total square footage of bridge deck required. Concept A, with its long eastbound VMP to eastbound I-69 ramp, would require the most bridge deck (337,735 sf) and Concept E would require the least (252,576 sf). It's worth noting that, while Concept B reduces the quantity of bridge deck compared to the similarly designed Concept A, Concept B would be a "three level" interchange, likely increasing the cost due to the height of one ramp structure.

Table 2-4. Veterans Memorial Parkway Interchange Bridge Deck Area Comparison

	VMP INTERCHANGE CONCEPTS				
	CONCEPT A	CONCEPT B	CONCEPT C	CONCEPT D	CONCEPT E
Bridge Deck Area (ft ²)	337,735	307,851	302,614	286,048	252,576

2.7 ENVIRONMENTAL IMPACTS

Each of the interchange concepts was compared on their anticipated impacts to wetlands, streams, floodways/floodplains and forested habitat. The impact assessment was based on the estimated construction limits for each interchange concept and the most recent environmental data available for each resource. The values reported below may not match those reported in the DEIS or in the forthcoming FEIS due to design changes and/or ongoing coordination with agencies. The environmental resources are shown in Figures 2-6 to 2-10 and estimated impacts for each interchange concept and resource are presented in Table 2-5. Ratings for each resource were grouped based on a statistical comparison of the impact values for each concept with a goal of looking for natural "breaks" in the range of impacts.



Figure 2-6. VMP Concept A – Environmental and ROW Impacts



Figure 2-7. VMP Concept B – Environmental and ROW Impacts



Figure 2-8. VMP Concept C – Environmental and ROW Impacts

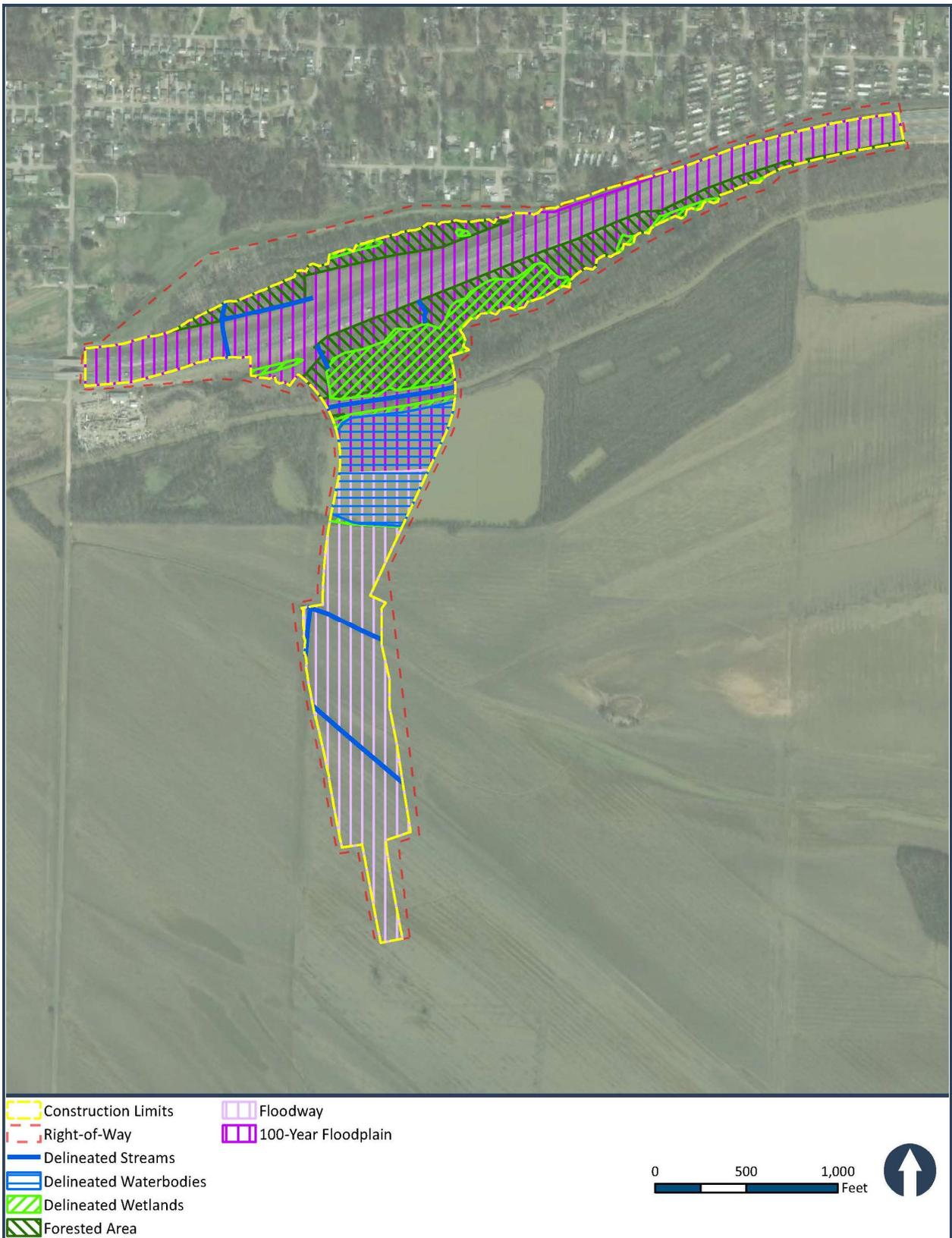


Figure 2-9. VMP Concept D – Environmental and ROW Impacts



Figure 2-10. VMP Concept E – Environmental and ROW Impacts

As shown in Table 2-5, there is limited variation in the impact to jurisdictional wetlands, but Concepts D and E would have the least impacts. Impacts to streams and floodway/floodplain areas vary between the concepts, but Concepts C and E would have the least impacts for both criteria. For forested habitat impacts, there was limited variability, but Concept A would have the least impacts.

Table 2-5. Veterans Memorial Parkway Interchange Environmental Impact Comparison

RESOURCE	VMP INTERCHANGE CONCEPTS				
	CONCEPT A	CONCEPT B	CONCEPT C	CONCEPT D	CONCEPT E
Wetland Impacts (acres)	9.0	9.4	8.8	8.3	8.4
Stream Impacts (linear feet)	3,578	3,365	2,823	3,189	2,820
Floodway/Floodplain Impacts (acres)	79.5	78.8	61.4	67.9	61.0
Forested Habitat Impacts (acres)	13.3	15.7	15.6	17.7	14.8

2.8 RIGHT-OF-WAY IMPACTS

Each of the interchange concepts were evaluated for right-of-way (ROW) impacts based on estimated ROW limits. As shown in Table 2-6, Concepts C and E would require the least ROW; Concepts A and B would require the most; and Concept D was in between. Concepts D and E would each require a very small amount of additional ROW to the north of existing I-69 in an area that would not be impacted by Concept A as it was presented in the DEIS; however, no relocations would be required in the area.

Table 2-6. Veterans Memorial Parkway Interchange Right-of-Way Impacts

	VMP INTERCHANGE CONCEPTS				
	CONCEPT A	CONCEPT B	CONCEPT C	CONCEPT D	CONCEPT E
Right-of Way-Impact (acres)	63.8	55.4	39.5	42.2	38.4

2.9 VMP INTERCHANGE CONCEPT COMPARISON AND SELECTION

As described at the beginning of this section, the goal of this analysis is to identify the highest performing concept, subject to additional evaluation in the IAD. Table 2-7 summarizes the evaluation of concepts at this interchange location. Based on the analysis, **VMP Concept D: Service Interchange 1** has been recommended to be carried forward. Left-hand exits and entrances at this location were a concern, leading to the dismissal of Concepts C and E, when comparably performing alternatives were available. While Concept D had a modest increase in weighted travel time and one additional conflict point, it performed better on almost all other criteria when compared to Concepts A and B.

Table 2-7. Veterans Memorial Parkway Interchange Evaluation Summary

EVALUATION CATEGORIES	VMP INTERCHANGE CONCEPTS				
	CONCEPT A	CONCEPT B	CONCEPT C	CONCEPT D	CONCEPT E
Weighted Travel Time (seconds)	66	68	65	79	77
Conflict Points	4	4	4	5	5
Access	N/A	N/A	N/A	N/A	N/A
Left Hand Exits/Entrances	0	0	1	0	2
Bridge Deck Area (ft ²)	337,735	307,851	302,614	286,048	252,576
Wetland Impacts (acres)	9.0	9.4	8.8	8.3	8.4
Stream Impacts (linear feet)	3,578	3,365	2,823	3,189	2,820
Floodway/Floodplain Impacts (acres)	79.5	78.8	61.4	67.9	61.0
Forested Habitat Impacts (acres)	13.3	15.7	15.6	17.7	14.8
Right-of Way-Impact (acres)	63.8	55.4	39.5	42.2	38.4
SELECTED CONCEPTS				✓	

CHAPTER 3 - US 60 INTERCHANGE

The US 60 Interchange would provide access for this east-west arterial to the new I-69 roadway. The north side of the interchange is flanked on either side by properties eligible for the National Register of Historic Places; land to the south of US 60 is agricultural. To minimize impacts to the historic properties, the US 60 roadway would be realigned to the south by approximately 400 feet. Because this interchange would be constructed with the new interstate roadway, an IAD is not required. The goal of the evaluation is to select the single best concept at this interchange location.

3.1 INTERCHANGE CONCEPTS

In addition to the DEIS Design Concept, one additional concept has been developed for this interchange location:

US 60 CONCEPT A: DEIS DESIGN

This concept was included in the design of Central Alternatives 1A and 1B in the DEIS (Figure 3-1) and utilizes a traditional diamond interchange with a single ramp in each quadrant. As previously mentioned, to minimize impacts to historic properties, the US 60 roadway would be realigned to the south by approximately 400 feet. Because of the proximity to the northbound I-69 entrance ramp, access to Tilman-Bethel Road would be via the existing US 60 roadway and bridge over the CSX railroad. This requires both a circuitous route for these users as well as the continued maintenance of the existing bridge over the railroad (in addition to the new bridge carrying the realigned US 60 over I-69).

US 60 CONCEPT B: SOUTHEAST QUADRANT LOOP

This concept would modify the DEIS Design by moving the northbound I-69 entrance ramp to the southeast quadrant where the connection would be provided via loop ramp (Figure 3-2). This modification allows a direct connection to Tilman-Bethel Road to be provided from the relocated US 60 and allows for the removal of the existing bridge over the CSX railroad. While the loop ramp would have a design speed of 30 mph, an extended acceleration lane would mitigate merging concerns where it enters I-69 northbound.

3.2 TRAFFIC PERFORMANCE

Traffic performance at the US 60 Interchange was compared based predicted Level of Service at the two ramp terminal intersections. Level of Service was determined using the Evansville Metropolitan Planning Organization's travel demand model. As shown in Table 3-1 each of the intersections would operate at Level of Service D or better for both concepts.



Figure 3-1. US 60 Concept A: DEIS Design



Figure 3-2. US 60 Concept B: Southeast Quadrant Loop

3.3 SAFETY PERFORMANCE

Categories of conflict points and the methodology used in this analysis are described above in Section 2.3. Conflict points for each of the concepts are shown in Figures 3-1 and 3-2 and Table 3-2. As shown, Concepts A and B would each have six conflict points and received the same rating.

Table 3-2. US 60 Interchange Conflict Points

CONFLICT CATEGORY	US 60 INTERCHANGE CONCEPTS	
	CONCEPT A	CONCEPT B
Merge/Diverge Conflicts	4	4
Crossing Conflicts	2	2
Total	6	6

3.4 ACCESS

Each of the concepts at this interchange would provide all movements and no existing movements would be removed. As shown in Table 3-3, access to Tillman-Bethel Road would differ between the two concepts. Under Concept A, vehicles traveling eastbound on US 60 would be required to pass through the interchange, cross over the CSX Railroad, turn left onto a remnant of existing US 60 (“Old US 60”) to travel back across the CSX Railroad and connect to Tillman-Bethel Road. Under Concept B, with the northbound entrance ramp relocated, a direct connection to Tillman-Bethel Road would be provided within the interchange area. For this reason, Concept B was rated higher than Concept A on this criterion.

Table 3-3. US 60 Interchange Access

CONFLICT CATEGORY	US 60 INTERCHANGE CONCEPTS	
	CONCEPT A	CONCEPT B
Direct Access to Tillman-Bethel Road	No	Yes

3.5 DRIVER EXPECTANCY

Driver expectancy is described above in Section 2.5. Because each of the interchange concepts at this location would provide only right-hand exits/entrances, both concepts would equally satisfy this criterion as shown in Table 3-4.

Table 3-4. US 60 Interchange Driver Expectancy Evaluation

	US 60 INTERCHANGE CONCEPTS	
	CONCEPT A	CONCEPT B
Left Hand Exits/Entrances	0	0

3.6 BRIDGE COST

In addition to estimating the area of new bridge deck, for this interchange location, the analysis also included the long-term maintenance cost associated with the existing US 60 bridge over the CSX Railroad. As shown in Table 3-5, the new bridge deck area for the realigned US 60 would be the same under both concepts. However, Concept A would have the added cost associated with maintaining the existing bridge over the railroad. As a result, Concept B would have the least overall bridge costs.

Table 3-5. US 60 Interchange Bridge Deck Area Comparison

	US 60 INTERCHANGE CONCEPTS	
	CONCEPT A	CONCEPT B
New Bridge Deck Area (ft ²)	48,705	48,705
Retained Bridge Deck Area (ft ²)	12,500	0

3.7 ENVIRONMENTAL IMPACTS

Each of the interchange concepts was compared on their anticipated impacts to wetlands, streams, floodways/floodplains and forested habitat. These environmental resources are shown in Figures 3-3 and 3-4 and estimated impacts for each interchange concept and resource are presented in Table 3-6. As shown in Table 3-6, the differences between the impacts of the two concepts are limited to negligible differences in impacts to streams and floodway/floodplains; therefore, the concepts were given the same rating.

Table 3-6. US 60 Interchange Environmental Impact Comparison

RESOURCE	US 60 INTERCHANGE CONCEPTS	
	CONCEPT A	CONCEPT B
Wetland Impacts (acres)	0	0
Stream Impacts (linear feet)	2,788	2,819
Floodway/Floodplain Impacts (acres)	65.6	63.3
Forested Habitat Impacts (acres)	2.4	2.4

3.8 RIGHT-OF-WAY IMPACTS

Each of the interchange concepts were evaluated for ROW impacts based on estimated ROW limits. As shown in Table 3-7, the differences between the concepts are small and both concepts were given the same rating.



Figure 3-3. US 60 Concept A – Environmental and ROW Impacts



Figure 3-4. US 60 Concept B – Environmental and ROW Impacts

Table 3-7. US 60 Interchange Right-of-Way Impacts

	US 60 INTERCHANGE CONCEPTS	
	CONCEPT A	CONCEPT B
Right-of-Way Impact (acres)	116.8	116.9

3.9 US 60 INTERCHANGE CONCEPT COMPARISON AND SELECTION

As discussed at the beginning of this section, the goal of this analysis is to identify the best interchange concept for this location. As shown in Table 3-8, **US 60 Concept B: Southeast Quadrant Loop**, performed equal to or better than Concept A on all criteria and is recommended to be carried forward.

Table 3-8. US 60 Interchange Evaluation Summary

EVALUATION CATEGORIES	US 60 INTERCHANGE CONCEPTS	
	CONCEPT A	CONCEPT B
Level of Service	D or better	D or better
Conflict Points	6	6
Direct Access to Tillman-Bethel Road	No	Yes
Left Hand Exits/Entrances	0	0
New Bridge Deck Area (ft ²)	48,705	48,705
Retained Bridge Deck Area (ft ²)	12,500	0
Wetland Impacts (acres)	0	0
Stream Impacts (linear feet)	2,788	2,819
Floodway/Floodplain Impacts (acres)	65.6	63.3
Forested Habitat Impacts (acres)	2.4	2.4
Right-of-Way Impact (acres)	116.8	116.9
SELECTED OPTION		✓

CHAPTER 4 - US 41 INTERCHANGE

The new I-69 roadway would tie into existing US 41 between Kimsey Lane and Van Wyk Road, prioritizing the connection between the new roadway and existing US 41 to the south, which would be redesignated as I-69. Two primary factors – access and cost – played a role in the alternative concepts developed for this location.

Existing US 41 to the north of this location is a fully access controlled, interstate-like facility until its interchange with US 60. North of US 60, US 41 becomes an arterial lined with commercial uses and numerous access points. With the construction of the new I-69 roadway, it is anticipated that I-69 would become the primary through route for north-south traffic. This change in function for US 41 opens the door to consider alternative access control options for the segment of US 41 between I-69 and US 60. If access restrictions were relaxed, in this segment, a service interchange design at I-69 and US 41 would be more appropriate. To facilitate consideration of such an approach, two service interchange concepts have been developed for this evaluation.

The DEIS concept included a long, curved ramp to connect southbound US 41 to northbound I-69. This ramp is forecast to carry a relatively low volume of traffic (approximately 400 vehicles per day in 2045) at a relatively high cost due to the need for a tall structure that would cross over both the new I-69 roadway and the northbound I-69 to northbound US 41 ramp. The VE Workshop and the interchange design workshop both identified this location as an opportunity to reduce construction costs while still meeting the traffic needs of the project. Since publication of the DEIS, the project team has also completed additional hydraulic analyses of North Fork Canoe Creek, which crosses existing US 41 in this area. The analysis showed that construction of a detention basin upstream of US 41 could substantially reduce the extent of bridges required at the interchange. This provides additional opportunity for cost savings at the interchange and all concepts have been designed with these reduced hydraulic requirements. The DEIS concept was modified based on these reduced hydraulic requirements and is referred to as Modified DEIS Design throughout this report for that reason.

The goal of the evaluation at this interchange was to identify two concepts – one system interchange concept and one service interchange concept. Once the best concept of each type is identified, the project team will coordinate with local officials regarding their long-term vision for the US 41 corridor and will incorporate that feedback into the final decision.

4.1 INTERCHANGE CONCEPTS

Five design concepts have been identified for this interchange location:

US 41 CONCEPT A: MODIFIED DEIS DESIGN (SYSTEM INTERCHANGE)

This concept was included in the design of Central Alternatives 1A and 1B in the DEIS (Figure 4-1). As noted above, it includes a long, 3rd-level ramp connecting southbound US 41 to northbound I-69 and provides relatively high-speed travel for all ramp movements. Southbound I-69 to northbound US 41 access would be provided via a ramp. Southbound US 41 to southbound I-69 access would be provided via the existing US 41 southbound lanes. Northbound I-69 to

northbound US 41 access would be provided via a flyover and the existing northbound US 41 lanes would be closed. For this evaluation, this concept has been modified from what was shown in the DEIS to reflect the inclusion of the detention basin and reduced structure requirements for North Fork Canoe Creek.

US 41 CONCEPT B: REMOVE SOUTHBOUND US 41-TO-NORTHBOUND I-69 FLYOVER (SYSTEM INTERCHANGE)

This interchange concept modifies the DEIS Design by removing the southbound US 41 connection to northbound I-69 (Figure 4-2). Vehicles making this connection would be required to utilize the existing interchange at US 41 and US 60, travel approximately 2.5 miles east on US 60 and enter I-69 northbound at the new I-69/US 60 interchange. This alternate route would be approximately 0.5-mile shorter than using US 41 and I-69 but would utilize an arterial with multiple signals rather than interstate and interstate-like roadways. All other movements would be the same as in Concept A.

US 41 CONCEPT C: DIAMOND INTERCHANGE 1 (SERVICE INTERCHANGE)

This interchange concept would construct a diamond interchange providing a connection to Kimsey Lane and a realigned US 41 (Figure 4-3). As a result of the US 41 realignment, direct access from southbound US 41 to southbound I-69 and northbound I-69 to northbound US 41 would not be provided and all access between the two highways would occur via the diamond interchange. In addition, a section of existing US 41 would be closed. The existing Kimsey Lane bridge over US 41 would be removed and an at-grade intersection would be provided at Kimsey Lane and US 41. This intersection would also provide access to the adjacent electric substation. Changes to access control on US 41 north of the interchange would be the responsibility of local governments.

US 41 CONCEPT D: DIAMOND INTERCHANGE 2 (SERVICE INTERCHANGE)

Similar to Concept C, this interchange concept would construct a diamond interchange at a realigned Kimsey Lane and realigned US 41 (Figure 4-4). In this concept, the interchange would be shifted approximately 300 feet to the northeast, requiring the realignment of both Kimsey Lane and US 41. As a result of the US 41 realignment, direct access from southbound US 41 to southbound I-69 and northbound I-69 to northbound US 41 would not be provided and all access between the two highways would occur via the diamond interchange. In addition, a section of existing US 41 would be closed. Similar to Concept C, the Kimsey Lane bridge over US 41 would be removed and a new connection to the electric substation would be provided.

US 41 CONCEPT E: LOOP RAMP (SYSTEM INTERCHANGE)

Similar to Concept B, this interchange concept would remove the US 41 southbound to I-69 northbound flyover ramp but would maintain that movement by constructing a loop ramp on the west side of US 41 (Figure 4-5). All other movements would be the same as in Concept A.

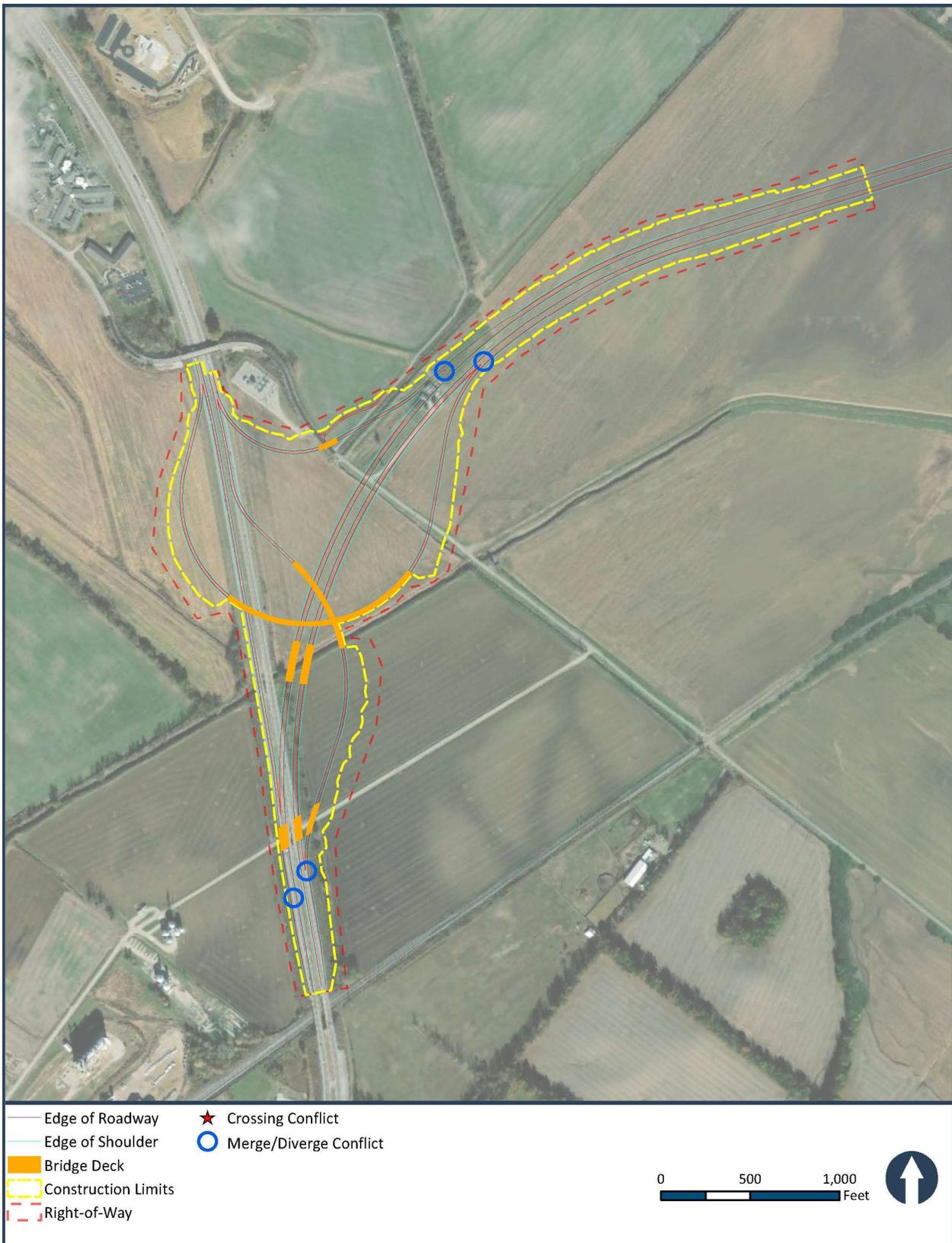


Figure 4-1. US 41 Concept A: Modified DEIS Design (System Interchange)

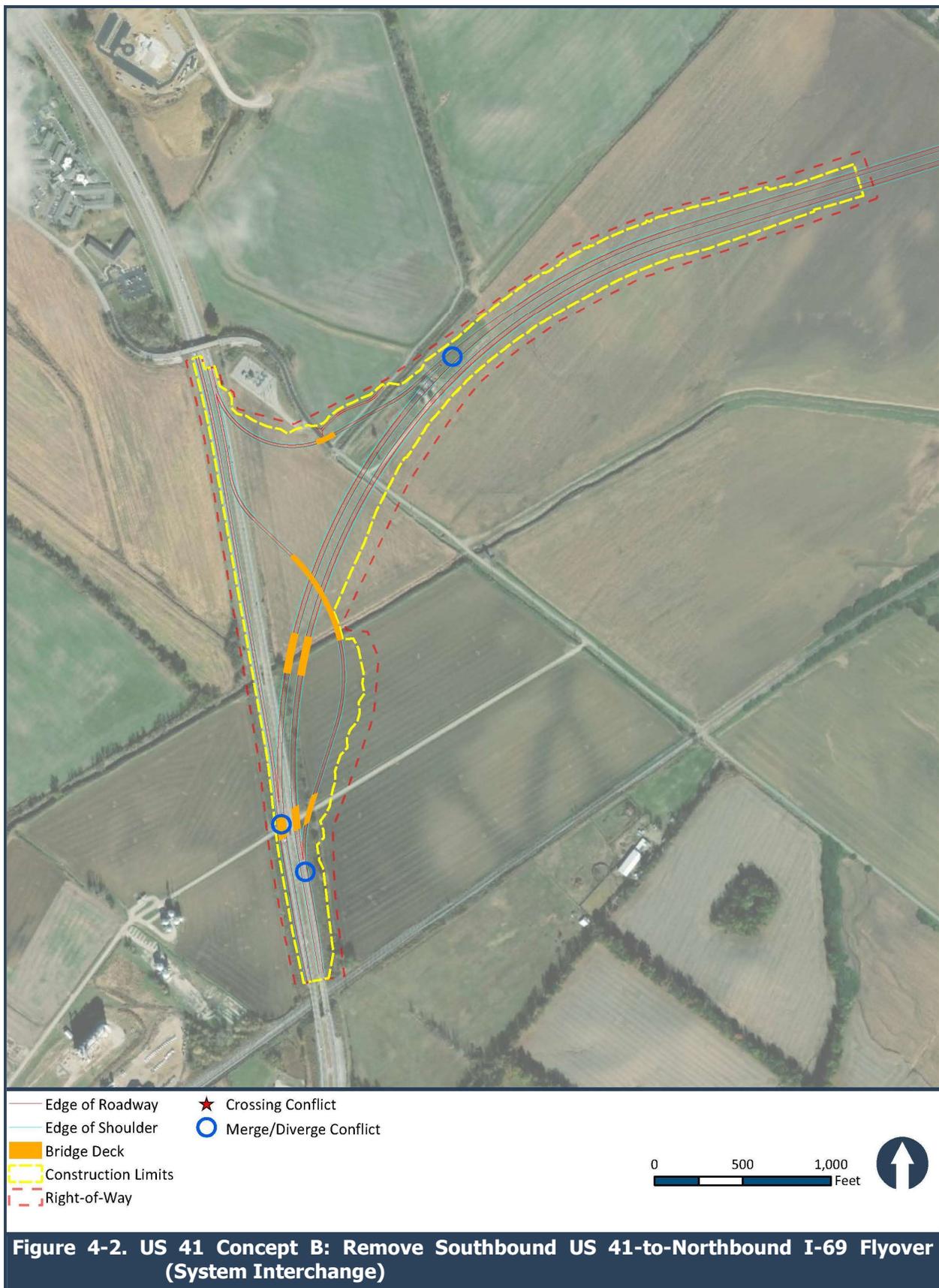




Figure 4-3. US 41 Concept C: Diamond Interchange 1 (Service Interchange)



Figure 4-4. US 41 Concept D: Diamond Interchange 2 (Service Interchange)

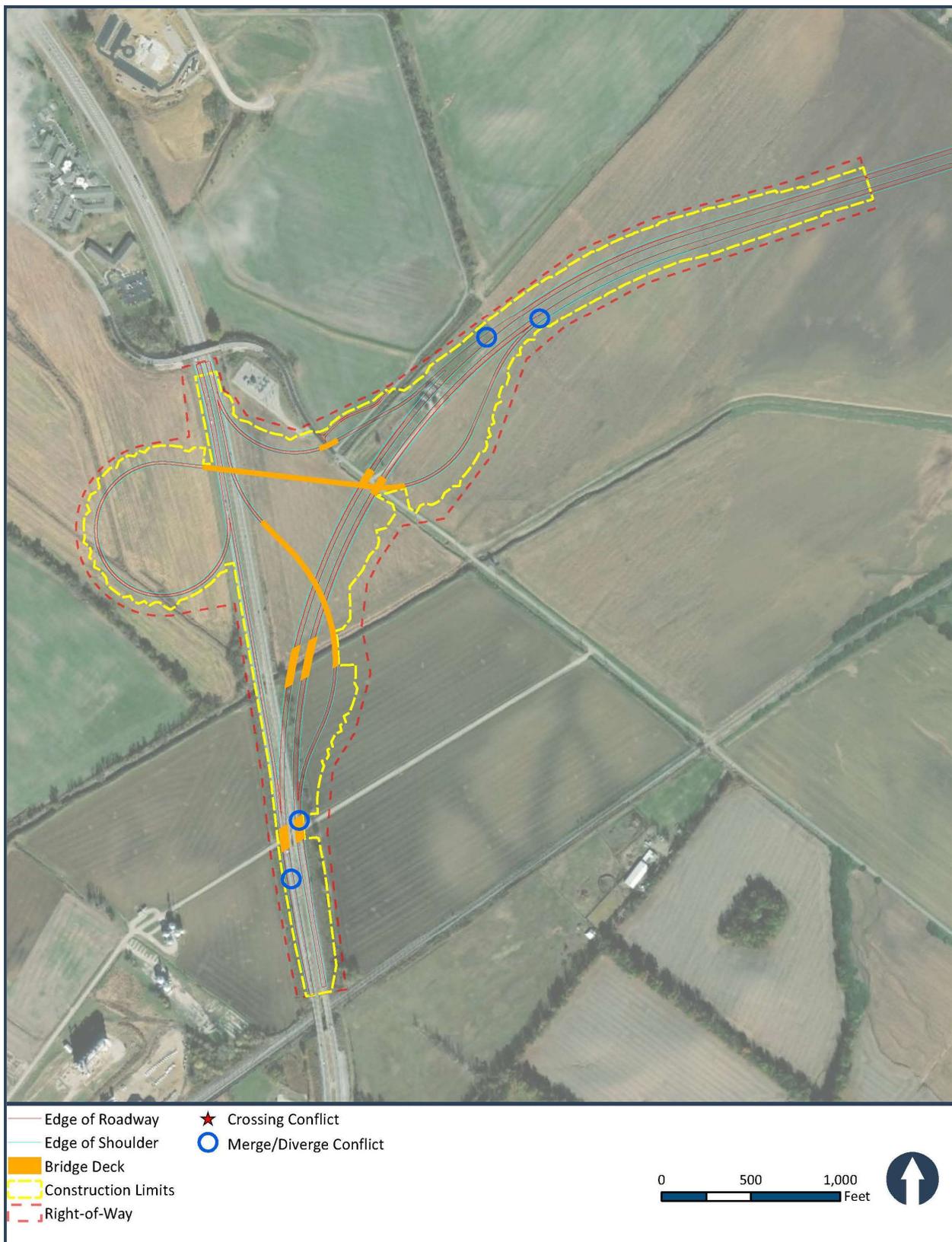


Figure 4-5. US 41 Concept E: Loop Ramp (System Interchange)

4.2 TRAFFIC PERFORMANCE

Each of the interchange concepts meets current design standards and is expected to accommodate forecasted traffic volumes at an acceptable level of service. As a result, the differences between concepts are expected in the form of travel time. Table 4-1 provides a comparison of predicted travel times through the interchange for each of non-through movements (travel time for I-69 through traffic would be the same under all concepts). The concepts were compared based on a weighted average that takes into account the volume of vehicles making each movement. As shown, each of the system interchanges (Concepts A, B, and E) provided the shortest travel times, while the service interchanges (Concepts C and D) resulted in longer travel times.

Table 4-1. US 41 Interchange Travel Time

MOVEMENT	VEHICLES PER DAY	US 41 INTERCHANGE CONCEPTS TRAVEL TIME (SECONDS)				
		CONCEPT A	CONCEPT B	CONCEPT C	CONCEPT D	CONCEPT E
Southbound US 41 to Northbound I-69	410	197	N/A ¹	175	175	217
Southbound US 41 to Southbound I-69	7,880	33	33	45	45	33
Northbound I-69 to Northbound US 41	8,050	39	39	59	59	39
Southbound I-69 to Northbound US 41	680	149	149	162	162	149
Weighted Average		44	40	59	59	45

¹ This movement is not available in this interchange concept and was, therefore, not included in the analysis.

4.3 SAFETY PERFORMANCE

Categories of conflict points and the methodology used in this analysis are described above in Section 2.3. Conflict points for each of the concepts are shown in Figures 4-1 through 4-5 and Table 4-2. As shown, Concept B would have the lowest number of conflict points (3), primarily based on the removal of the southbound US 41-to-northbound I-69 flyover ramp. Concepts A and E, both full access system interchanges, would each have four conflict points and Concepts C and D, both service interchanges, would each have 6 conflict points.

Table 4-2. US 41 Interchange Conflict Points

CONFLICT CATEGORY	US 41 INTERCHANGE CONCEPTS				
	CONCEPT A	CONCEPT B	CONCEPT C	CONCEPT D	CONCEPT E
Merge/Diverge Conflicts	4	3	4	4	4
Crossing Conflicts	0	0	2	2	0
Total	4	3	6	6	4

4.4 ACCESS

As described in Section 4.1, US 41 Concept B would not provide a direction connection from southbound US 41 to northbound I-69. Vehicles seeking that connection would use US 60, a shorter, but likely slower, route. Therefore, as shown in Table 4-3 below, Concepts A, C, D, and E would not be missing any movements while Concept B would be missing one movement.

Table 4-3. US 41 Interchange Access Comparison

CONFLICT CATEGORY	US 41 INTERCHANGE CONCEPTS				
	CONCEPT A	CONCEPT B	CONCEPT C	CONCEPT D	CONCEPT E
Missing Movements	0	1	0	0	0

4.5 DRIVER EXPECTANCY

Driver expectancy is described above in Section 2.5. Because each of the interchange concepts at this location would provide only right-hand exits/entrances, all concepts would equally satisfy this criterion as shown in Table 4-4.

Table 4-4. US 41 Interchange Driver Expectancy Evaluation

CONFLICT CATEGORY	US 41 INTERCHANGE CONCEPTS				
	CONCEPT A	CONCEPT B	CONCEPT C	CONCEPT D	CONCEPT E
Left Hand Exits/Entrances	0	0	0	0	0

4.6 BRIDGE COST

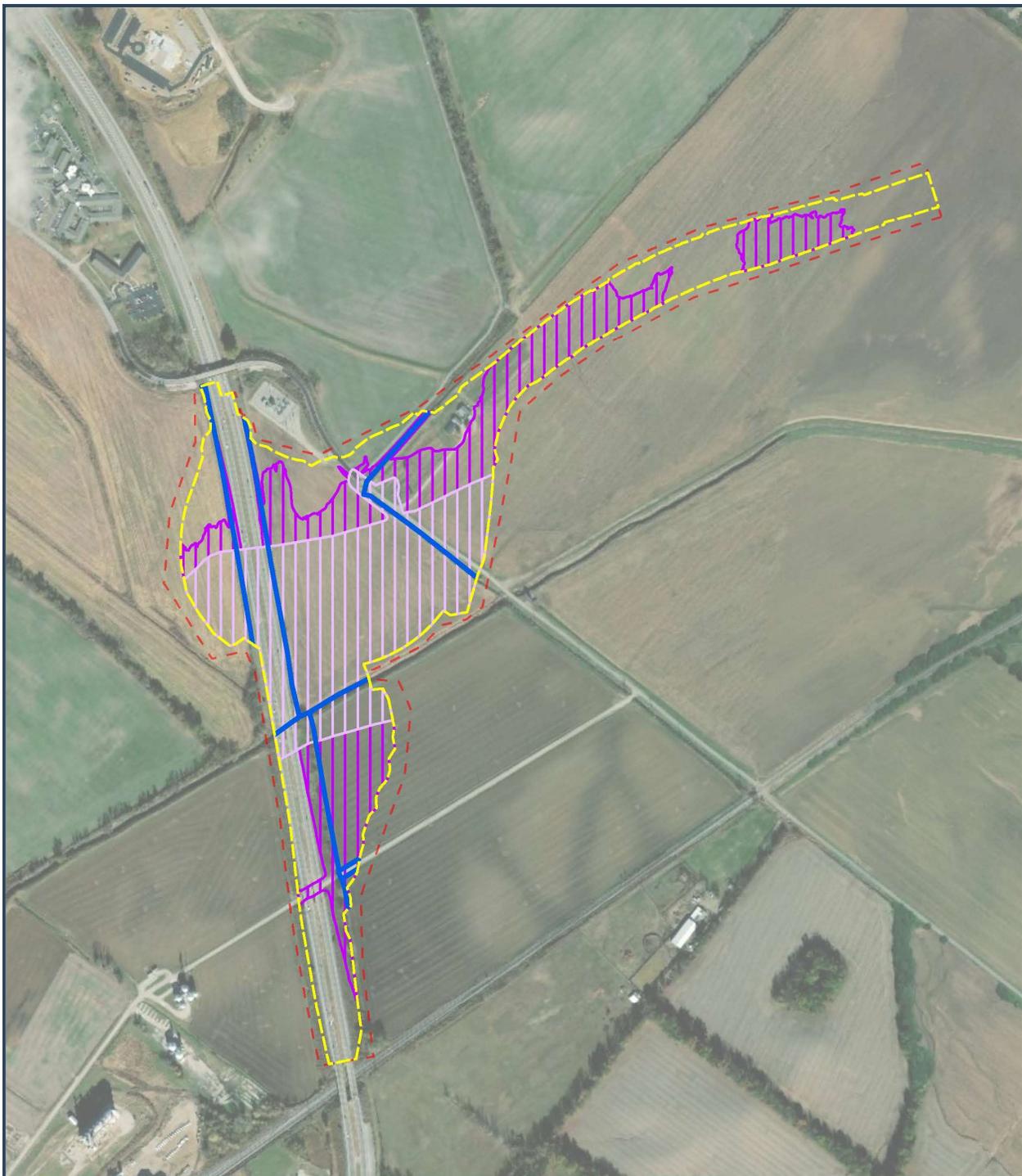
As shown in Table 4-5, the values for bridge deck area varied widely between the concepts. The removal of the southbound US 41 to northbound I-69 ramp substantially reduced the bridge deck area for US 41 Concept B compared to US 41 Concept A, while bridge deck area was even further reduced for the two service interchange concepts, US 41 Concept C and US 41 Concept D.

Table 4-5. US 41 Interchange Bridge Deck Area Comparison

CONFLICT CATEGORY	US 41 INTERCHANGE CONCEPTS				
	CONCEPT A	CONCEPT B	CONCEPT C	CONCEPT D	CONCEPT E
New Bridge Deck Area (ft ²)	85,172	54,042	79,200	60,631	99,650

4.7 ENVIRONMENTAL IMPACTS

Each of the interchange concepts was compared on their anticipated impacts to wetlands, streams, floodways/floodplains, and forested habitat. These environmental resources are shown in Figures 4-6 to 4-10 and estimated impacts for each interchange concept and resource are presented in Table 4-6. As shown in Table 4-6, none of the concepts would impact wetlands or forested habitat. Concepts B and D would have the least impact on streams, followed by Concepts



- Construction Limits
- Right-of-Way
- Delineated Streams
- Delineated Waterbodies
- Delineated Wetlands
- Forested Area
- Floodway
- 100-Year Floodplain

0 500 1,000
Feet



Figure 4-6. US 41 Concept A – Environmental and ROW Impacts

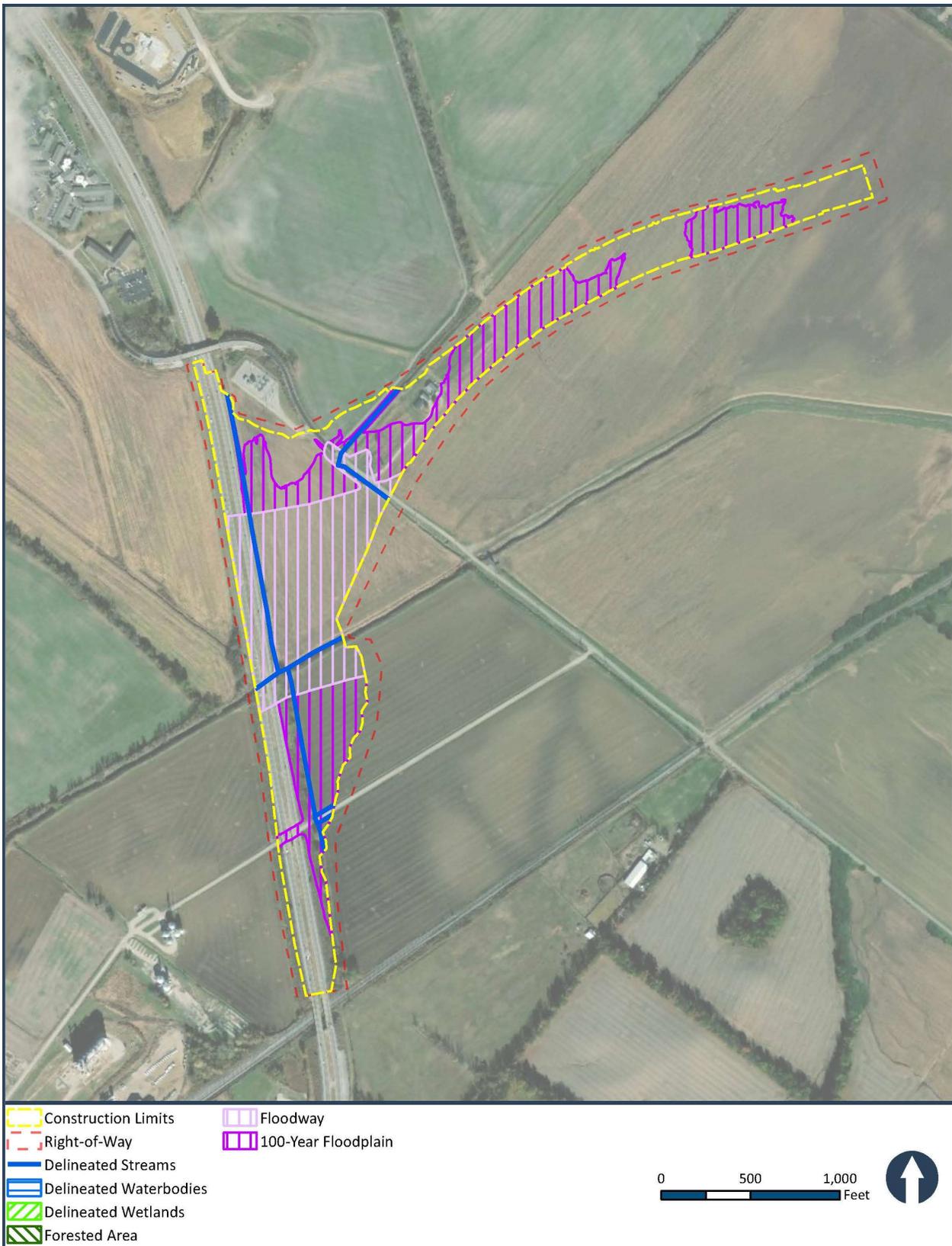


Figure 4-7. US 41 Concept B – Environmental and ROW Impacts

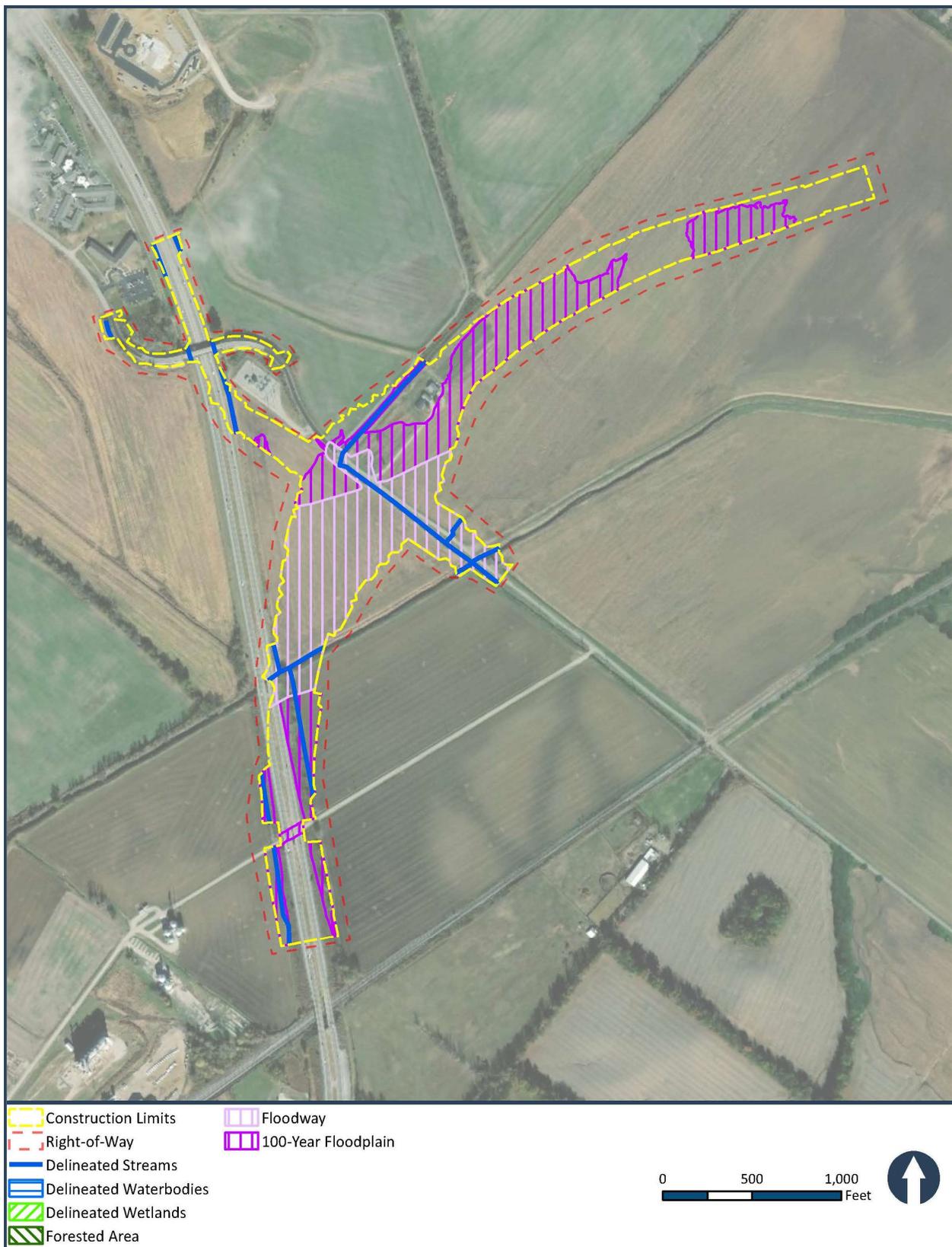


Figure 4-8. US 41 Concept C – Environmental and ROW Impacts

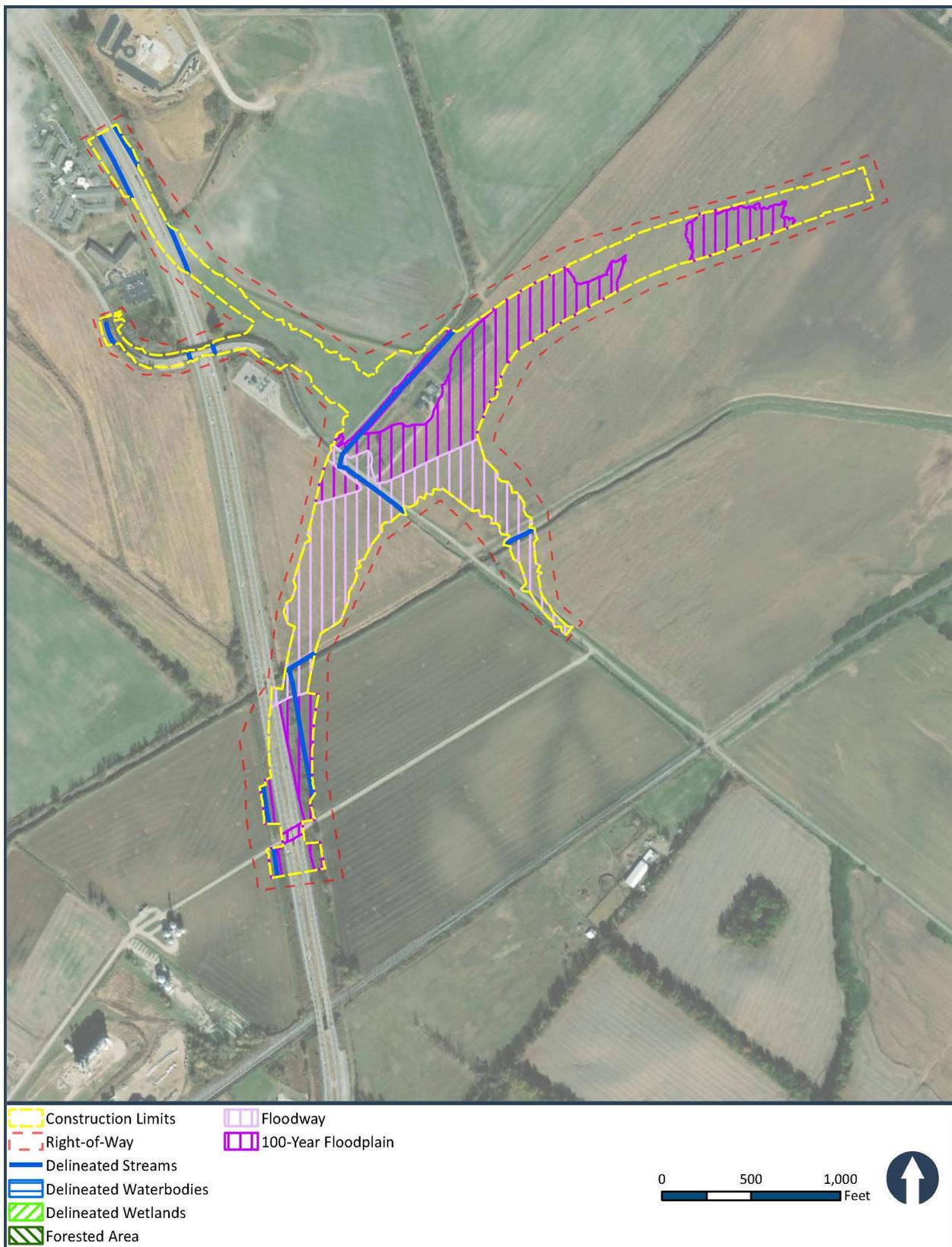


Figure 4-9. US 41 Concept D – Environmental and ROW Impacts

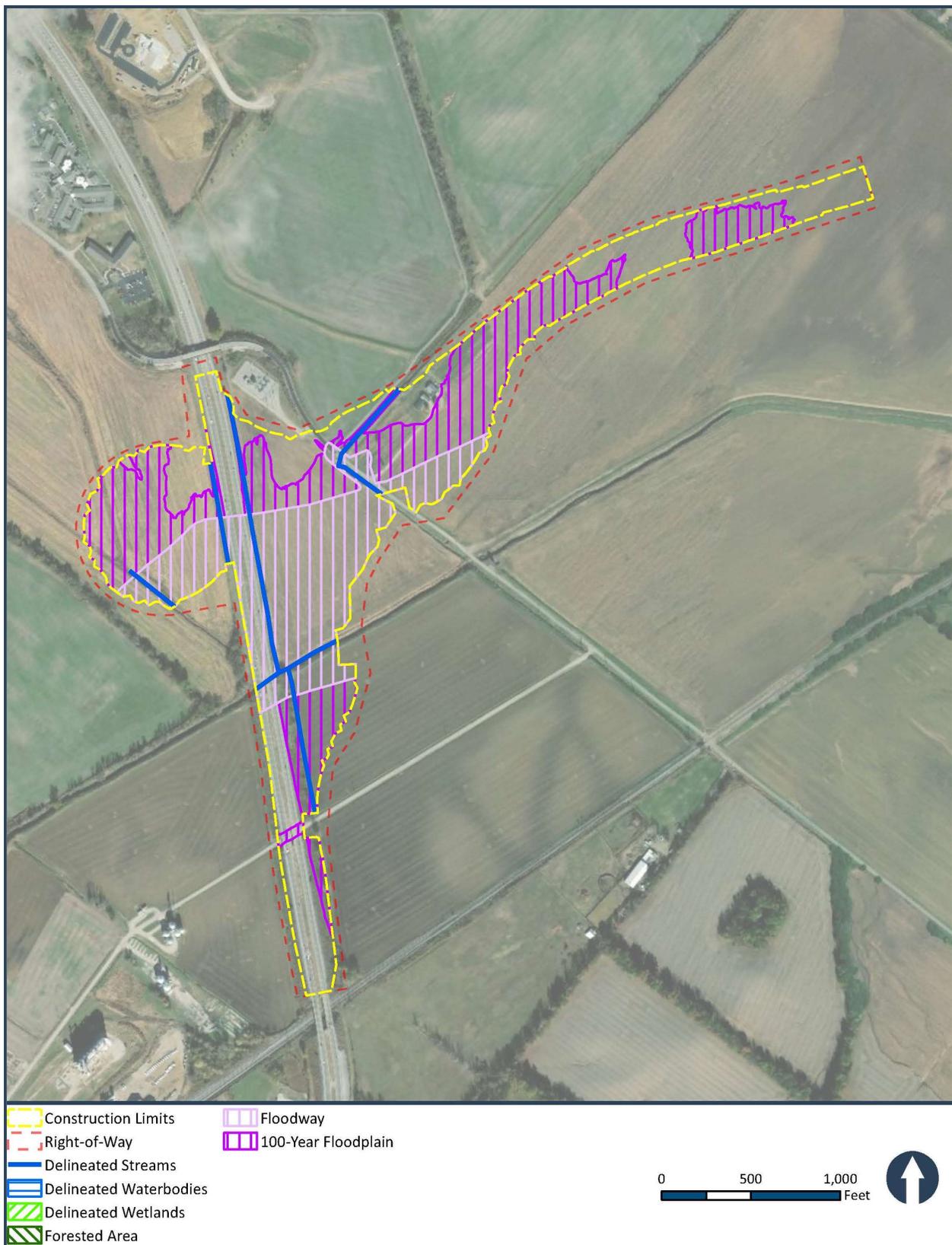


Figure 4-10. US 41 Concept E – Environmental and ROW Impacts

C and E; Concept A had the highest impacts to streams. Concept D would also have the least impact on floodway/floodplain areas; Concepts B and C each would have moderately higher impacts and Concepts A and E would have the highest impact.

Table 4-6. US 41 Interchange Environmental Impact Comparison

RESOURCE	US 41 INTERCHANGE CONCEPTS				
	CONCEPT A	CONCEPT B	CONCEPT C	CONCEPT D	CONCEPT E
Wetland Impacts (acres)	0	0	0	0	0
Stream Impacts (linear feet)	6,125	4,335	5,375	4,183	4,685
Floodway/Floodplain Impacts (acres)	50.5	38.2	35.3	31.9	52.3
Forested Habitat Impacts (acres)	0	0	0	0	0

4.8 RIGHT-OF-WAY IMPACTS

Each of the interchange concepts were evaluated for ROW impacts based on estimated ROW limits. As shown in Table 4-7, Concept B would require the least new ROW (46.7 acres); Concepts D and E would each require more than 67 acres of ROW; and Concepts A and C were in between.

Table 4-7. US 41 Interchange Right-of-Way Impacts

	US 41 INTERCHANGE CONCEPTS				
	CONCEPT A	CONCEPT B	CONCEPT C	CONCEPT D	CONCEPT E
Right-of-Way Impact (acres)	61.3	46.7	57.5	67.4	67.8

4.9 US 41 INTERCHANGE CONCEPT COMPARISON AND SELECTION

As described in Section 2.1, the goal of this analysis is to identify two concepts – one system interchange concept and one service interchange concept for use in coordination with local officials.

Table 4-8 summarizes the evaluation of concepts at this interchange location. Based on the analysis, the following concepts were carried forward:

- US 41 Concept A: Modified DEIS Design (System Interchange)
- US 41 Concept D: Diamond Interchange 2 (Service Interchange)

Among the system interchange concepts, the missing movement on Concept B was a concern and led to its dismissal. Concept E was originally designed in an effort to reduce the amount of bridge deck required. However, with the modifications made to Concept A based on the updated hydraulic analysis, Concept A would have lower bridge costs than Concept E, while performing similarly on other criteria. Between the service interchange concepts, Concept D performed similar or better on every criterion except ROW impacts.

Following this evaluation, the Project Team met with local officials in Henderson on February 3, 2020, to review the recommended concepts and solicit input. Officials from both Henderson County and the City of Henderson supported the selection of Concept D; therefore, it is recommended that Concept D be carried forward.

Table 4-8. US 41 Interchange Evaluation Summary

EVALUATION CATEGORIES	US 41 INTERCHANGE CONCEPTS				
	CONCEPT A	CONCEPT B	CONCEPT C	CONCEPT D	CONCEPT E
Weighted Average Travel Time (sec)	44	40	59	59	45
Conflict Points	4	3	6	6	4
Missing Movements	0	1	0	0	0
Left Hand Exits/Entrances	0	0	0	0	0
New Bridge Deck Area (ff ²)	85,172	54,042	79,200	60,631	99,650
Wetland Impacts (acres)	0	0	0	0	0
Stream Impacts (linear feet)	6,125	4,335	5,375	4,183	4,685
Floodway/Floodplain Impacts (acres)	50.5	38.2	35.3	31.9	52.3
Forested Habitat Impacts (acres)	0	0	0	0	0
Right-of-Way Impact (acres)	61.3	46.7	57.5	67.4	67.8
SELECTED CONCEPTS	✓			✓	

CHAPTER 5 - KY 351/KY 2084 INTERCHANGE

An existing interchange provides access between US 41, KY 351, and KY 2084. Full access to KY 351 from US 41 is provided via a modified flop diamond interchange; it is similar to a traditional diamond interchange except that a loop ramp is utilized to provide the US 41 northbound exit. From the KY 351/US 41 interchange, KY 351 provides a direct route into downtown Henderson. North Middle School is located west of the interchange and Henderson County High School is located east of the interchange.

The interchange between KY 2084 and US 41 is immediately to the south of KY 351 and provides access only from southbound US 41 to southbound KY 2084 and from northbound KY 2084 to northbound US 41. Vehicles traveling northbound on US 41 can only access KY 2084 via the KY 351 interchange and KY 2084 southbound traffic cannot access US 41. Currently, KY 2084 is bifurcated, with northbound KY 2084 crossing over the US 41 southbound exit ramp. FHWA does not typically approve the implementation of “partial” interchanges (those that do not provide all movements) on the Interstate Highway System.

The goal of the evaluation is to select the single best concept at this interchange location.

5.1 INTERCHANGE CONCEPTS

In addition to the DEIS Design Concept, one additional concept has been developed for this interchange location:

KY 351/KY 2084 CONCEPT A: DEIS DESIGN

This concept was included in the design of Central Alternatives 1A and 1B in the DEIS (Figure 5-1). In order to upgrade this section of US 41 to interstate standards, the DEIS Design Concept added a new northbound auxiliary lane and extended the southbound auxiliary lane between the KY 351 and KY 2084 interchanges. In addition, the bifurcation of KY 2084 would be removed and the southbound exit ramp would be realigned to create a T-intersection with KY 2084.

KY 351/KY 2084 CONCEPT B: KY 2084 RAMPS REMOVED

This concept would modify the DEIS Design by removing the two KY 2084 ramps entirely (Figure 5-2). This would eliminate the need to add a northbound auxiliary lane and eliminate the existing southbound auxiliary lane. Because the limits of work would be reduced, it is anticipated that the noise wall proposed for this area under the DEIS Design Concept would not be required. With the removal of access from 2084, it is anticipated that much of this traffic would be rerouted to the KY 351 interchange, requiring improvements at that location in the form of extended turn lanes.



Figure 5-1. KY 351/KY 2084 Concept A: DEIS Design

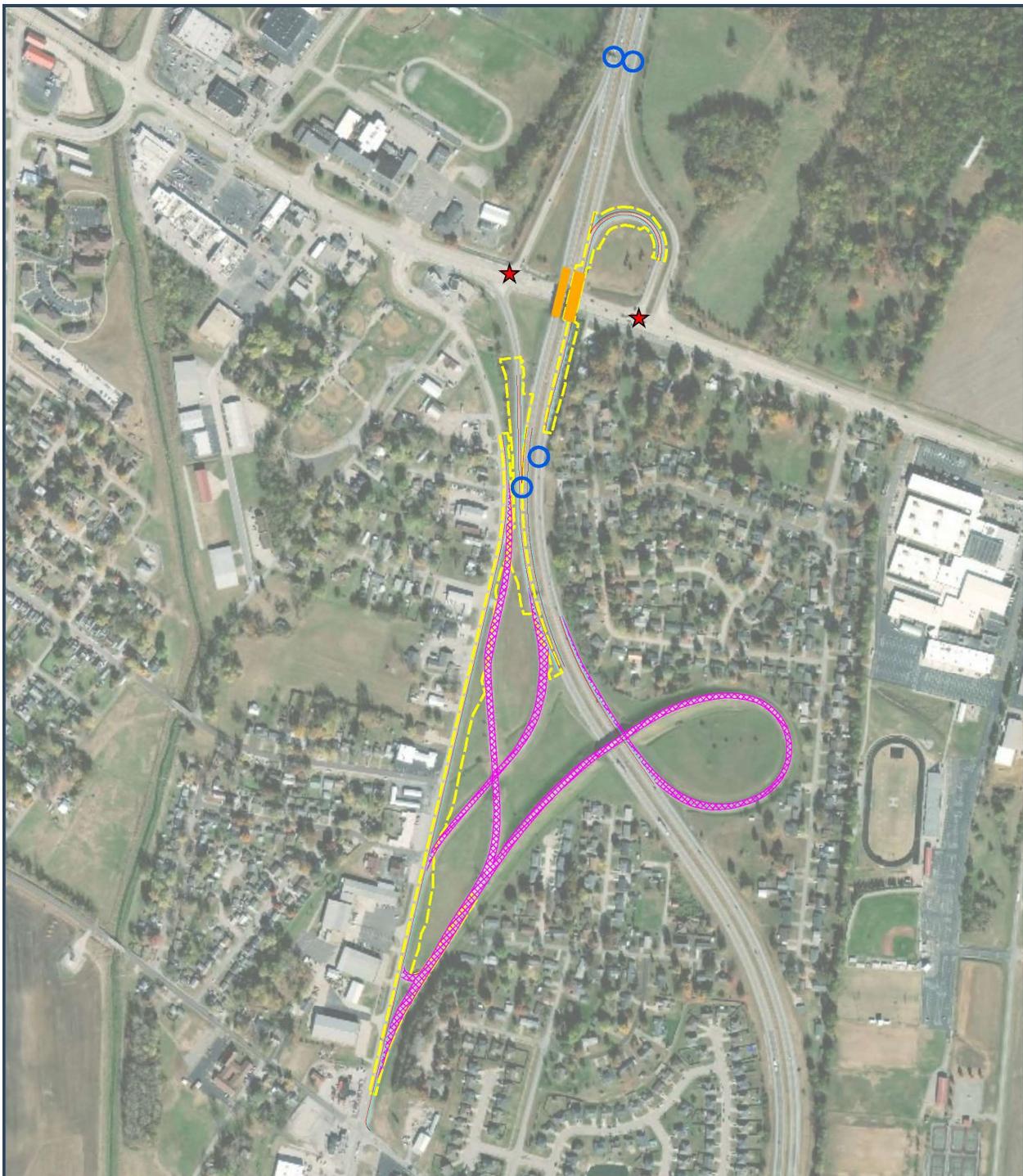


Figure 5-2. KY 351/KY 2084 Concept B: KY 2084 Ramps Removed

5.2 TRAFFIC PERFORMANCE

Traffic performance at the KY 351/KY 2084 Interchange was compared based on two factors: (1) predicted level of service at the interchange and (2) travel times for vehicles that currently use the KY 2084 ramps. Travel time was estimated for vehicles starting at the KY 2084/Clay Street intersection to north of KY 351 on I-69 as well as the reverse trip.

As shown in Table 5-1 each of the intersections would operate at Level of Service D or better for both concepts. With the removal of the KY 2084 ramps, travel times for both northbound and southbound traffic on KY 2084 would be longer under Concept B. As result, Concept A would have the shortest travel times.

Table 5-1. KY 351/KY 2084 Interchange Level of Service and Travel Time

	KY 351/KY 2084 INTERCHANGE CONCEPTS	
	CONCEPT A	CONCEPT B
Level of Service	D or better	D or better
Northbound Travel Time (seconds)	155	184
Southbound Travel Time (seconds)	107	198

5.3 SAFETY PERFORMANCE

Categories of conflict points and the methodology used in this analysis are described above in Section 2.3. Conflict points for each of the concepts are shown in Figures 5-1 and 5-2 and Table 5-2. As shown, Concept A would have 5 conflict points and Concept B would have 6 conflict points.

Table 5-2. KY 351/KY 2084 Interchange Conflict Points

CONFLICT CATEGORY	KY 351/KY 2084 INTERCHANGE CONCEPTS	
	CONCEPT A	CONCEPT B
Merge/Diverge Conflicts	2	4
Crossing Conflicts	3	2
Total	5	6

5.4 ACCESS

As described in Section 5.1, KY 351/KY 2084 Concept B would remove two existing connections to KY 2084. Vehicles seeking that connection would use the KY 351 interchange and KY 2084 to reach their destination. As a result, as shown in Table 5-3, Concept B would have two missing movements while Concept A would have no missing movement.

Table 5-3. KY 351/KY 2084 Interchange Access Comparison

CONFLICT CATEGORY	KY 351/KY 2084 INTERCHANGE CONCEPTS	
	CONCEPT A	CONCEPT B
Missing Movements	0	2

5.5 DRIVER EXPECTANCY

Driver expectancy is described above in Section 2.5. Because each of the interchange concepts at this location would provide only right-hand exits/entrances, all concepts would equally satisfy this criterion as shown in Table 5-4.

Table 5-4. KY 351/KY 2084 Driver Expectancy Evaluation

CONFLICT CATEGORY	KY 351/KY 2084 INTERCHANGE CONCEPTS	
	CONCEPT A	CONCEPT B
Left Hand Exits/Entrances	0	0

5.6 BRIDGE COST

KY 351/KY 2084 Concept A and KY 351/KY 2084 Concept B would both require reconstruction of the I-69 bridge over KY 351, neither would require the construction of any other new bridges, resulting in no difference in bridge construction cost. As shown in Table 5-5, there would be a cost savings associated with Concept B because it would remove the bridge carrying the KY 2084 northbound entrance ramp to I-69 over I-69, reducing long-term maintenance costs.

Table 5-5. KY 351/KY 2084 Interchange Bridge Deck Area Comparison

	KY 351/KY 2084 INTERCHANGE CONCEPTS	
	CONCEPT A	CONCEPT B
New Bridge Deck Area (ft ²)	19,522	19,522
Retained Bridge Deck Area (ft ²)	5,740	0

5.7 ENVIRONMENTAL IMPACTS

Each of the interchange concepts was compared on their anticipated impacts to wetlands, streams, floodways/floodplains and forested habitat. These environmental resources are shown in Figures 5-3 and 5-4 and estimated impacts for each interchange concept and resource are presented in Table 5-6. As shown in Table 5-6, neither concept would impact floodplains/floodways or forested habitat and each concept impacted a very small area of wetland (less than 0.1 acres). Impacts to streams differed between the two concepts with Concept A having a higher impact.

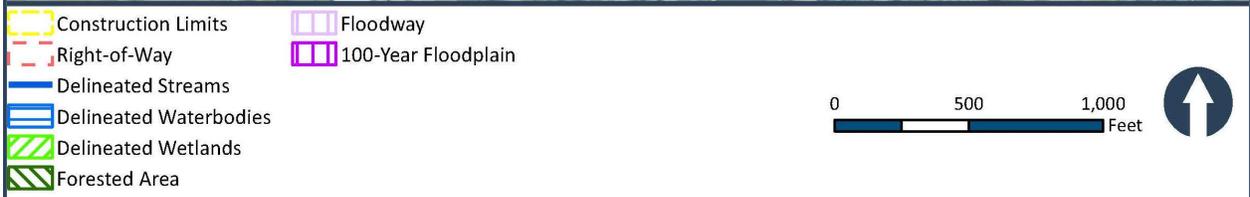


Figure 5-3. KY 351/KY 2084 Concept A – Environmental and ROW Impacts

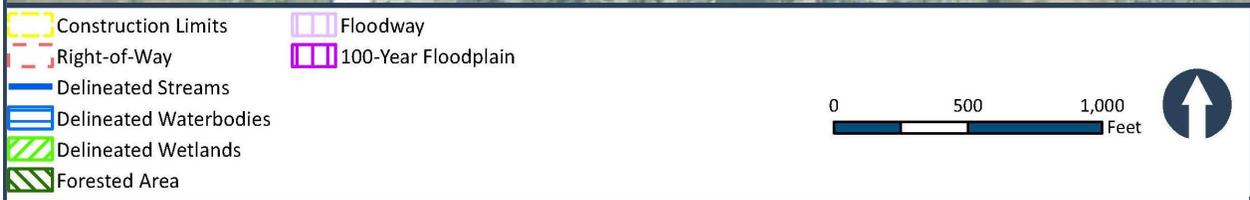


Figure 5-4. KY 351/KY 2084 Concept B – Environmental and ROW Impacts

Table 5-6. KY 351/KY 2084 Interchange Environmental Impact Comparison

RESOURCE	KY 351/KY 2084 INTERCHANGE CONCEPTS	
	CONCEPT A	CONCEPT B
Wetland Impacts (acres)	0.05	0.01
Stream Impacts (linear feet)	634	138
Floodway/Floodplain Impacts (acres)	0	0
Forested Habitat Impacts (acres)	0.0	0.0

5.8 RIGHT-OF-WAY IMPACTS

Each of the interchange concepts were evaluated for ROW impacts based on estimated ROW limits. As shown in Table 5-7, neither concept would require new ROW.

Table 5-7. KY 351/KY 2084 Interchange Right-of-Way Impacts

	KY 351/KY 2084 INTERCHANGE CONCEPTS	
	CONCEPT A	CONCEPT B
Right-of-Way Impact (acres)	0	0

5.9 KY 351/KY 2084 INTERCHANGE CONCEPT COMPARISON AND SELECTION

As discussed in Section 5.1, the goal of this analysis is to identify the best interchange concept for this location. As shown in Table 5-8, KY 351/KY 2084 Concept A performed better on most criteria. However, because it is anticipated that FHWA will determine that the existing partial interchange at KY 2084 is unacceptable, it is recommended that Concept B be carried forward.

Table 5-8. KY 351/KY 2084 Interchange Evaluation Summary

EVALUATION CATEGORIES	KY 351/KY 2084 INTERCHANGE CONCEPTS	
	CONCEPT A	CONCEPT B
Level of Service	D or better	D or better
Northbound Travel Time (seconds)	155	184
Southbound Travel Time (seconds)	107	198
Conflict Points	5	6
Missing Movements	0	2
Left Hand Exits/Entrances	0	0
New Bridge Deck Area (ft ²)	19,522	19,522
Retained Bridge Deck Area (ft ²)	5,740	0
Wetland Impacts (acres)	0.05	0.01
Stream Impacts (linear feet)	634	138
Floodway/Floodplain Impacts (acres)	0	0
Forested Habitat Impacts (acres)	0.0	0.0
Right-of-Way Impact (acres)	0	0
SELECTED OPTION		✓

CHAPTER 6 - SUMMARY

The purpose of this analysis was to qualitatively and quantitatively evaluate the design concepts identified during the interchange design workshop for incorporation into the project's Selected Alternative. Based on that evaluation, the following concepts will be carried forward:

Veterans Memorial Parkway Interchange: VMP Concept D: Service Interchange 1

US 60 Interchange: US 60 Concept B: Southeast Quadrant Loop

US 41 Interchange: the following interchange concepts will be discussed with local officials:

- US 41 Concept A: Modified DEIS Design (System Interchange)
- US 41 Concept D: Diamond Interchange 2 (Service Interchange)

KY 351/KY 2084 Interchange: KY 351/KY 2084 Concept B: KY 2084 Ramps Removed