US 14 EIS (New Ulm to N. Mankato) Interchange and Intersection Type Comparison

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This technical memorandum compares interchange and intersection types at two critical locations near New Ulm. The intersection of US 14, MN 15, and CR 21 and the intersection of US 14 and CR 37 currently experience the 1st and 3rd highest crash rates along the corridor, respectively. They also provide access from US 14 to New Ulm.

There are a number of complex tradeoffs to be considered at these sites and the comparison is presented in a table format where each interchange or intersection concept is compared on a number of criteria such as safety, traffic operations, environmental impacts, and others. Drawings of each concept are included to refer to as the comparative information in the tables is analyzed.

US 14/MN 15/CR 21 Location

Alignments W1 and W3

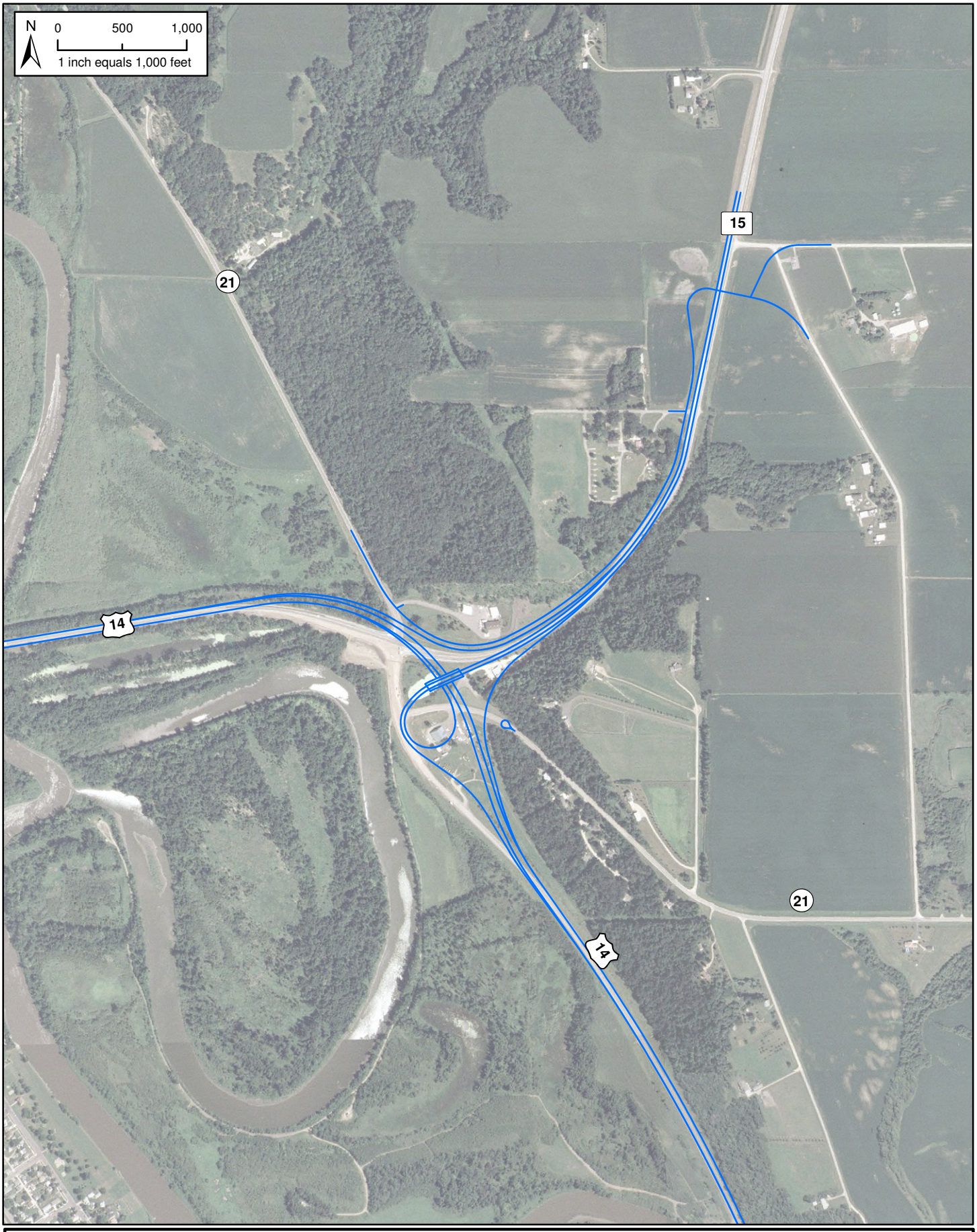
Three alternatives are under consideration for the US 14/MN15/CR 21 location.

- Concept A: trumpet interchange as illustrated in Exhibit 1.
- Concept B: compressed or tight diamond interchange as illustrated in Exhibit 2.
- Concept C: roundabout with bypass lane(s) as illustrated in Exhibit 3. See roundabout feasibility section later in this technical memorandum for more information.

A comparison of the three options is presented in Table 1.

Alignment W2

A diamond interchange on the top of the bluff is the only alternative under consideration for the US 14/MN15/CR 21 location.



US 14 EIS
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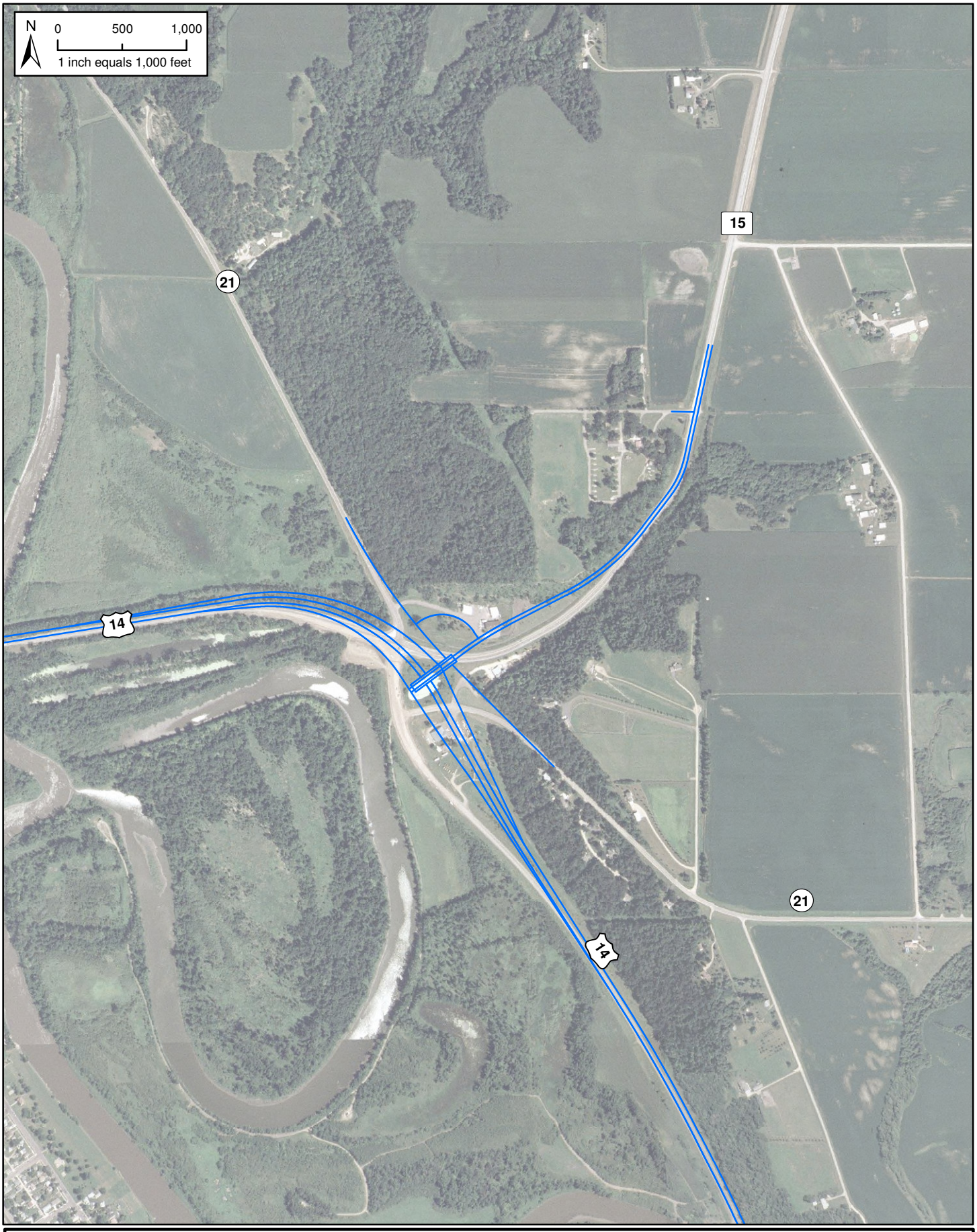
Exhibit 1
US 14/MN 15/CR 21 Alternative W1/W3
Concept A (Trumpet)
New Ulm



US 14 EIS
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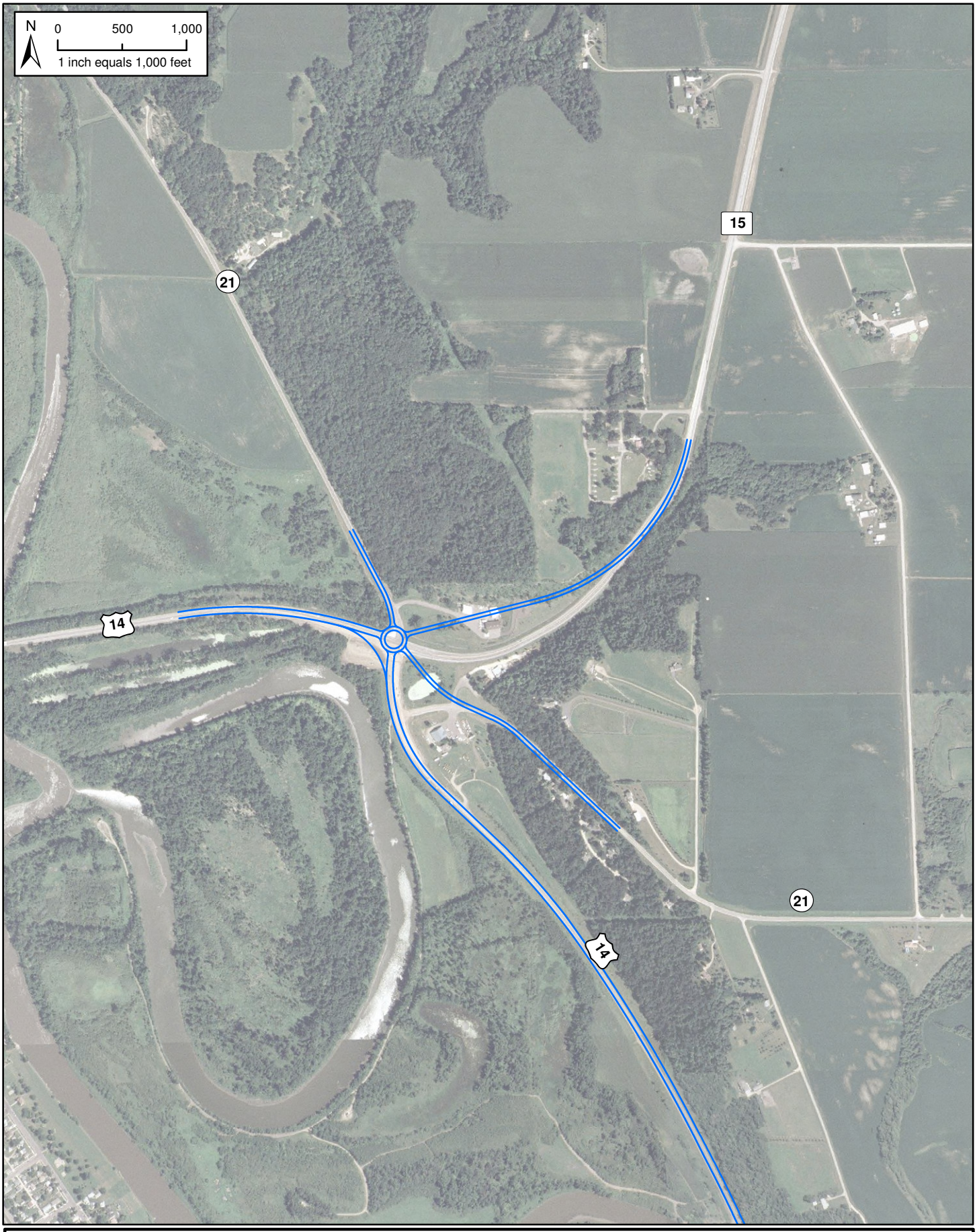
Exhibit 2
US 14/MN 15/CR 21 Alternative W1/W3
Concept B (Tight Diamond)
New Ulm



US 14 EIS
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Exhibit 3
US 14/MN 15/CR 21 Alternative W1/W3
Concept C (Roundabout)
New Ulm

Table 1: Comparison of interchange/intersection types at US 14/MN 15/CR 21 (Alignments W1 and W3)

	Safety
Concept A (trumpet, Ex. 1)	With free-flow, uncontrolled movements on all ramps and loops, there are no at-grade intersections, even at ramp terminals, which is a safety advantage. The overhead bridge would flatten the grade on MN 15 approaching the interchange. The intersection of MN 15 and CR 21 is relocated to a safer location at the top of the bluff, although this substantially impacts the continuity of CR 21, as well as the bluff.
Concept B (tight diamond, Ex. 2)	A safety disadvantage as compared to Concept A is the location of the T-intersection that provides a connection between MN 15 and CR 21. The intersection would be near the base of an approximately 4% grade on MN 15. The ramp terminals would be near the base of the steep grade as well, although the overhead bridge would flatten the grade on MN 15 approaching the interchange. Tangent ramps in the SW and SE quadrants provide some safety advantage as compared to the curved directional ramps and the exit loop of Concept A.
Concept C (roundabout, Ex. 3)	Probablility of severe intersection-related crashes is low. A larger number of low-severity crashes is likely as compared to the interchange options. Single vehicle, run-off-road crashes are more likely for motorists that may not be expecting a roundabout in a high-speed rural driving environment. Also, the 4% downgrade on MN 15 could increase speeds on that leg as drivers approach the roundabout and increase the number of single-vehicle run-off-road or rear-end type crashes.
	Operations
Concept A (trumpet, Ex. 1)	The free-flow, uncontrolled movements on all ramps and loops provide the most efficient operations of the three concepts.
Concept B (tight diamond, Ex. 2)	A diamond interchange would accommodate the traffic volumes at this location efficiently. An additional free flow ramp could be provided for the MN 15 to US 14 WB movement that ties into the ramp in the NE quadrant. However, the CR 21/MN 15 connection would need to be removed or relocated, affecting access to MN 15 and US 14 for drivers on CR 21. The ramp would also require an additional structure over CR 21.
Concept C (roundabout, Ex. 3)	A roundabout would operate efficiently at this location, even during peak hours. Because there is little pedestrian activity at this location, bypass lanes could be added to any quadrant with high right-turn volumes to further improve operations. A high-speed uncontrolled movement would not be provided for US 14 as it is with the interchange options.
	Driver Expectancy

Concept A (trumpet, Ex. 1)	Drivers generally expect exits to be in advance of the crossroad, which is not the case with the EB exit loop on US 14. Otherwise, a good option in terms of driver expectancy.
Concept B (tight diamond, Ex. 2)	A diamond interchange is a very good option in terms of driver expectancy. The configuration is simple and familiar to drivers. Exits are in advance of the crossroad. The overhead structure at the center of the interchange provides a visual cue for the location of the interchange for drivers on US 14.
Concept C (roundabout, Ex. 3)	A roundabout may not be expected by some drivers on high-speed rural highways—particularly unfamiliar drivers approaching from US 14 WB. Preceding the roundabout from this direction would be an interchange at CR 37 and prior to that, standard at-grade expressway intersections. Providing good visibility of the roundabout is important when located in a rural, high-speed driving environment.
	Route Continuity
Concept A (trumpet, Ex. 1)	Good route continuity is maintained for US 14 and MN 15. CR 21 would be significantly re-routed parallel to MN 15.
Concept B (tight diamond, Ex. 2)	Good route continuity is maintained for US 14, MN 15, and CR 21. A leg providing a connection to MN 15 and the interchange could be provided for CR 21 drivers as shown on Exhibit 2.
Concept C (roundabout, Ex. 3)	Assuming a five-leg roundabout as shown in Exhibit 3, good route continuity is maintained for US 14, MN 15, and CR 21.
	Cost
Concept A (trumpet, Ex. 1)	Highest cost of the 3 alternatives. Largest footprint, largest amount of earthwork, and largest realignment of CR 21 (up the bluff). One structure—minor road over.
Concept B (tight diamond, Ex. 2)	Lower cost than Concept A due to smaller footprint,less earthwork, and not realigning CR 21 up the bluff. Longer overhead structure needed to span CR 21.
Concept C (roundabout, Ex. 3)	Lowest cost of the 3 alternatives. Significant realignment of MN 15 would be required to accommodate the south leg of CR 21 and to provide a straighter alignment on the MN 15 approach. No structures.
	Right-of-Way
Concept A (trumpet, Ex. 1)	Largest footprint of the 3 concepts. The properties in the SE quadrant of the existing intersection would need to be acquired.
Concept B (tight diamond, Ex. 2)	Smaller footprint than Concept A, although the properties in the SE and NE quadrant of the existing intersection would need to be acquired.
Concept C (roundabout, Ex. 3)	Least right-of-way impact. Greatest right-of-way would be needed for realignment of MN 15. Existing intersection area is large and additional right-of-way needs for the roundabout itself would be minimal. Property in the NE quadrant would need to be acquired. Properties in SE quadrant could be maintained with access to CR 21.

	Environmental Impacts
Concept A (trumpet, Ex. 1)	Largest footprint of the 3 concepts. US 14 WB exit ramp to MN 15 and the relocation of CR 21 would impact the bluff. Some impact to floodplain from realigned US 14 and the MN 15 to US 14 WB entrance ramp.
Concept B (tight diamond, Ex. 2)	Smaller footprint than concept A. Some impact to floodplain from realigned US 14 and US 14 WB entrance ramp.
Concept C (roundabout, Ex. 3)	Significant impact to bluff due to realignment of MN 15. Only impact to the floodplain would be if any bypass lanes were used.

US 14/CR 37 Location

Alignment W1

Three alternatives are under consideration for the US 14/CR 37 location.

- Concept A: trumpet interchange as illustrated in Exhibit 4.
- Concept B: compressed or tight diamond interchange as illustrated in Exhibit 5.
- Concept C: folded diamond as illustrated in Exhibit 6.

A comparison of the three options is presented in Table 2.

Alignment W2

A diamond interchange on the top of the bluff is the only alternative under consideration for the US 14/CR 37 location.

Alignment W3

Three alternatives are under consideration for the US 14/CR 37 location.

- Concept A: compressed or tight diamond interchange as illustrated in Exhibit 7.
- Concept B: combination tight diamond/folded diamond interchange as illustrated in Exhibit 8.
- Concept C: combination folded diamond/buttonhook interchange as illustrated in Exhibit 9.

A comparison of the three options is presented in Table 3.

US 14 EIS
New Ulm to North Mankato

Exhibit 4
US 14/CR 37 Alternative W1
Concept A (Trumpet)
New Ulm

US 14 EIS
New Ulm to North Mankato

Exhibit 5
US 14/CR 37 Alternative W1
Concept B (Tight Diamond)
New Ulm

US 14 EIS
New Ulm to North Mankato

Exhibit 6
US 14/CR 37 Alternative W1
Concept C (Folded Diamond)
New Ulm

Table 2: Comparison of interchange types at US 14/CR 37 (Alignment W1)

	Safety
Concept A (trumpet, Ex. 4)	With free-flow, uncontrolled movements on all ramps and loops, there are no at-grade intersections, even at ramp terminals, which is a safety advantage.
Concept B (tight diamond, Ex. 5)	The only safety disadvantage as compared to Concept A is the at-grade intersections at the ramp terminals. Tangent ramps provide some safety advantage as compared to the curved directional ramps of Concept A and the loops (particularly the exit loop) of Concept C.
Concept C (folded diamond, Ex. 6)	Safety disadvantage as compared to Concept A is the at-grade intersections at the ramp terminals. Exit loop is a disadvantage as compared to Concepts A and B.
	Operations
Concept A (trumpet, Ex. 4)	The free-flow, uncontrolled movements on all ramps and loops provide the most efficient operations of the three concepts.
Concept B (tight diamond, Ex. 5)	A diamond interchange would accommodate the traffic volumes at this location efficiently.
Concept C (folded diamond, Ex. 6)	A folded diamond interchange would accommodate the traffic volumes at this location efficiently.
	Driver Expectancy
Concept A (trumpet, Ex. 4)	Unfamiliar drivers entering US 14 on a directional interchange may feel like they are entering a freeway with full access control. They may not expect the at-grade intersections just south of the interchange.
Concept B (tight diamond, Ex. 5)	A diamond interchange is a very good option in terms of driver expectancy. The configuration is simple and familiar to drivers. Exits are in advance of the crossroad. The overhead structure at the center of the interchange provides a visual cue for the location of the interchange for drivers on US 14.
Concept C (folded diamond, Ex. 6)	A folded diamond interchange is a fairly good option in terms of driver expectancy. Drivers generally expect exits to be in advance of the crossroad, which is not the case with the EB exit loop on US 14.
	Route Continuity
Concept A (trumpet, Ex. 4)	446th Street is severed and no longer has direct access to US 14, CR 37, or New Ulm.
Concept B (tight diamond, Ex. 5)	446th Street ties directly into CR 37, providing a route into New Ulm as well as access to US 14.
Concept C (folded diamond, Ex. 6)	446th Street ties directly into CR 37, providing a route into New Ulm as well as access to US 14.

	Cost
Concept A (trumpet, Ex. 4)	More detailed design is necessary to determine the relative cost of these 3 concepts. Concept A has a large footprint for the interchange and a large amount of earthwork where the interchange impacts the bluff. A wider structure is needed as the bridge(s) will be on the 4-lane US 14. The US 14 WB entrance loop will also widen the structure. However, there will be significant cost savings by not connecting 446th Street and CR 37 as this segment impacts the bluff.
Concept B (tight diamond, Ex. 5)	Lowest cost of the three alternatives for the interchange itself, due to smaller footprint, less earthwork, smallest structure. One structure—minor road over. Additional cost to connect 446th Street to CR 37 through the bluff.
Concept C (folded diamond, Ex. 6)	Large amount of earthwork, particularly in SE quadrant where the interchange impacts the bluff. Longer structure required to accommodate the loop tapers. Additional cost to connect 446th Street to CR 37 through the bluff.
	Right-of-Way
Concept A (trumpet, Ex. 4)	Larger footprint than Concept B for the interchange but right-of-way not needed to connect 446th Street to CR 37. Same as others in terms of residential impacts.
Concept B (tight diamond, Ex. 5)	Smallest footprint for the interchange but additional right-of-way needed to connect 446th Street to CR 37. Same as others in terms of residential impacts.
Concept C (folded diamond, Ex. 6)	Larger interchange footprint than Concept B. Additional right-of-way needed to connect 446th Street to CR 37. Same as others in terms of residential impacts.
	Environmental Impacts
Concept A (trumpet, Ex. 4)	Impacts to the floodplain due to the EB entrance and exit ramps. Impacts to the bluff due to the US 14 WB entrance loop and WB exit ramp and the alignment of US 14 shifted to the east. Impacts to the bluff avoided by not connecting 446th Street and CR 37.
Concept B (tight diamond, Ex. 5)	Least impact to the floodplain. Impacts to the bluff due to the alignment of US 14 shifted to the east and the realignment of 446th Street to connect with CR 37.
Concept C (folded diamond, Ex. 6)	Impact to the floodplain in the SW quadrant. Significant impacts to the bluff, particularly in the SE quadrant but also due to the alignment of US 14 shifted to the east and the realignment of 446th Street to connect with CR 37.

	Cultural/Archaeological/Recreational Impacts
Concept A (trumpet, Ex. 4)	EB exit ramp will impact the archaeological site. Access to boat landing on CR 37 will need to be closed or relocated due to proximity to the EB entrance ramp.
Concept B (tight diamond, Ex. 5)	Concepts B and C will have minimal impact to the archaeological site. Access to boat landing on CR 37 can be maintained.
Concept C (folded diamond, Ex. 6)	Concepts B and C will have minimal impact to the archaeological site. Access to boat landing on CR 37 can be maintained.

US 14 EIS
New Ulm to North Mankato

Exhibit 7
US 14/CR 37 Alternative W3
Concept A (Tight Diamond)
New Ulm

US 14 EIS
New Ulm to North Mankato

Exhibit 8
US 14/CR 37 Alternative W3
Concept B (Tight Diamond & Folded Diamond)
New Ulm

US 14 EIS
New Ulm to North Mankato

Exhibit 9
US 14/CR 37 Alternative W3
Concept C (Folded Diamond & Button Hook)
New Ulm

Table 3: Comparison of interchange types at US 14/CR 37 (Alignment W3)

	Safety
Concept A (tight diamond, Ex. 7)	Good alternative from a safety perspective. Near tangent ramps provide safety advantage.
Concept B (tight diamond/folded diamond, Ex. 8)	Curvature on US 14 WB entrance loop will be combined with significant downgrade.
Concept C (folded diamond/buttonhook, Ex. 9)	Curvature on US 14 WB entrance loop will be combined with significant downgrade. US 14 EB exit loop is a disadvantage as compared to Concepts A and B. An additional at-grade intersection is needed in the SW (buttonhook) quadrant.
	Operations
Concept A (tight diamond, Ex. 7)	A diamond interchange would accommodate the traffic volumes at this location efficiently. All alternatives would have stop control at the ramp terminals.
Concept B (tight diamond/folded diamond, Ex. 8)	Tight diamond/folded diamond interchange would accommodate the traffic volumes at this location efficiently.
Concept C (folded diamond/buttonhook, Ex. 9)	Least direct/continuous alternative from an operations standpoint. In the SW (buttonhook) quadrant, drivers are stopped at the intersection with old US 14 and then a short distance later at CR 37.
	Driver Expectancy
Concept A (tight diamond, Ex. 7)	A diamond interchange is a very good option in terms of driver expectancy. The configuration is simple and familiar to drivers. Exits are in advance of the crossroad. The overhead structure at the center of the interchange provides a visual cue for the location of the interchange for drivers on US 14.
Concept B (tight diamond/folded diamond, Ex. 8)	Good option in terms of driver expectancy. Exits are in advance of the crossroad. The overhead structure at the center of the interchange provides a visual cue for the location of the interchange for drivers on US 14.
Concept C (folded diamond/buttonhook, Ex. 9)	Drivers generally expect exits to be in advance of the crossroad, which is not the case with the EB exit loop. Buttonhook configuration may cause some confusion for unfamiliar drivers. This configuration is not common and most drivers expect the first intersection on a loop to be at the crossroad.

	Route Continuity
Concept A (tight diamond, Ex. 7)	No difference between the 3 alternatives. 446th Street is tied into CR 37. Old Hwy 14 is tied into CR 37.
Concept B (tight diamond/folded diamond, Ex. 8)	446th Street is tied into CR 37. Old Hwy 14 is tied into CR 37.
Concept C (folded diamond/buttonhook, Ex. 9)	446th Street is tied into CR 37. Old Hwy 14 is tied into CR 37.
	Cost
Concept A (tight diamond, Ex. 7)	Lowest cost alternative due to smaller footprint and less earthwork. One structure—minor road over.
Concept B (tight diamond/folded diamond, Ex. 8)	Higher cost than Concept A due to ramp and loop in SE quadrant. Significant earthwork in this area as this quadrant is in the bluff area. Longer structure to accommodate US 14 WB entrance loop taper.
Concept C (folded diamond/buttonhook, Ex. 9)	Highest cost alternative. Ramps and loops in both SE and SW quadrants. Significant earthwork in the SE quadrant which impacts the bluff. Longer realignment of old Hwy 14. Longer structure to accommodate US 14 WB entrance loop taper.
	Right-of-Way
Concept A (tight diamond, Ex. 7)	Smallest interchange footprint and therefore least amount of right-of-way needed. All concepts the same in terms of residential impacts.
Concept B (tight diamond/folded diamond, Ex. 8)	Larger interchange footprint than Concept A due to ramp and loop in SE quadrant. All concepts the same in terms of residential impacts.
Concept C (folded diamond/buttonhook, Ex. 9)	Largest interchange footprint and greatest right-of-way needs. All concepts the same in terms of residential impacts.
	Environmental Impacts
Concept A (tight diamond, Ex. 7)	Least environmental impact of the 3 alternatives. Some impact to the bluff due to shifting of US 14 to the east. Only significant impact to the floodplain would be realignment of old Hwy 14 to connect to CR 37.
Concept B (tight diamond/folded diamond, Ex. 8)	Larger impact to the bluff due to the ramp and loop in the SE quadrant. Some impact would be avoided by not having a ramp in the NE quadrant, which is a steeper area of the bluff. Same impact to the floodplain as Concept A due to the realignment of old Hwy 14 to connect to CR 37.
Concept C (folded diamond/buttonhook, Ex. 9)	Larger impact to the bluff due to the ramp and loop in the SE quadrant. Some impact would be avoided by not having a ramp in the NE quadrant, which is a steeper area of the bluff. Greater impact to the floodplain than Concepts A and B due to the ramp

	and loop in the SW quadrant and the longer realignment of old Hwy 14 within the floodplain.
	Cultural/Archaeological Impacts
Concept A (tight diamond, Ex. 7)	Minimal impact to the archaeological site, accomplished by shifting the US 14 alignment to the east.
Concept B (tight diamond/folded diamond, Ex. 8)	Minimal impact to the archaeological site, accomplished by shifting the US 14 alignment to the east.
Concept C (folded diamond/buttonhook, Ex. 9)	Minimal impact to the archaeological site, accomplished by placing all ramps and loops on the south side of the interchange.

Roundabout Feasibility

The feasibility of a roundabout was investigated at the US 14/MN 15/CR 21 location. This is the only intersection along the entire US 14 study corridor for which a roundabout is under consideration (although a roundabout could be considered at other intersections at some future point). This decision was made because:

1) The US 14/MN 15 intersection is a "gateway" to New Ulm, an urban area. A roundabout would be more contextually appropriate at this location than at other intersections where interchanges are being considered. The other intersections are located in a rural context, where people expect high speed, through movements on US 14.

2) Under Alternatives W1 and W3, the US 14 cross section would be constrained between US 14/MN 15/CR 21 and CR 37. The constrained cross section in combination with a roundabout could serve to transition drivers to the the reduced-speed environment as they enter New Ulm.

3) In addition to entering New Ulm, this intersection location is also the terminus of the rural 4-lane expressway section of US 14. Therefore, maintaining a high-speed, uncontrolled through movement for US 14 traffic is less critical than along US 14 to the east.

While a roundabout would be feasible at US 14/MN 15/CR 21, there would be some disadvantages and design challenges because: 1) all traffic would slow down and pass through the roundabout. A high-speed, uncontrolled movement could not be provided for US 14; 2) the 4% grade on the MN 15 leg approaching the roundabout is a safety concern. Although not severe enough to make a roundabout infeasible at this location, mitigation measures (discussed later in this technical memorandum) should be investigated to minimize the safety effects of the grade; 3) providing good visibility and advance warning of the roundabout is important as some drivers may not expect a roundabout in a rural, high-speed environment.

Capacity and Traffic Operations

The traffic volumes at the US 14/MN 15/CR 21 intersection are well within the range of what can be accommodated by a roundabout. Roundabouts, when properly designed, can handle peak volumes of up to 7000 vph and average daily traffic of 50,000 to 70,000 vpd. 2030 projected traffic for this area of US 14 is 10,500 vpd. The 2002 PM peak hour volume at the intersection was 833 vph. Approximately 32% of the traffic is left-turning, due primarily to the heavy left-turn movement on westbound US 14.

Exhibit 10 presents a planning-level model for determining roundabout feasibility in terms of capacity. It also provides a preliminary estimate of roundabout lane requirements. Based on this model, a single-lane roundabout could accommodate the traffic volumes at the intersection with no operational problems.

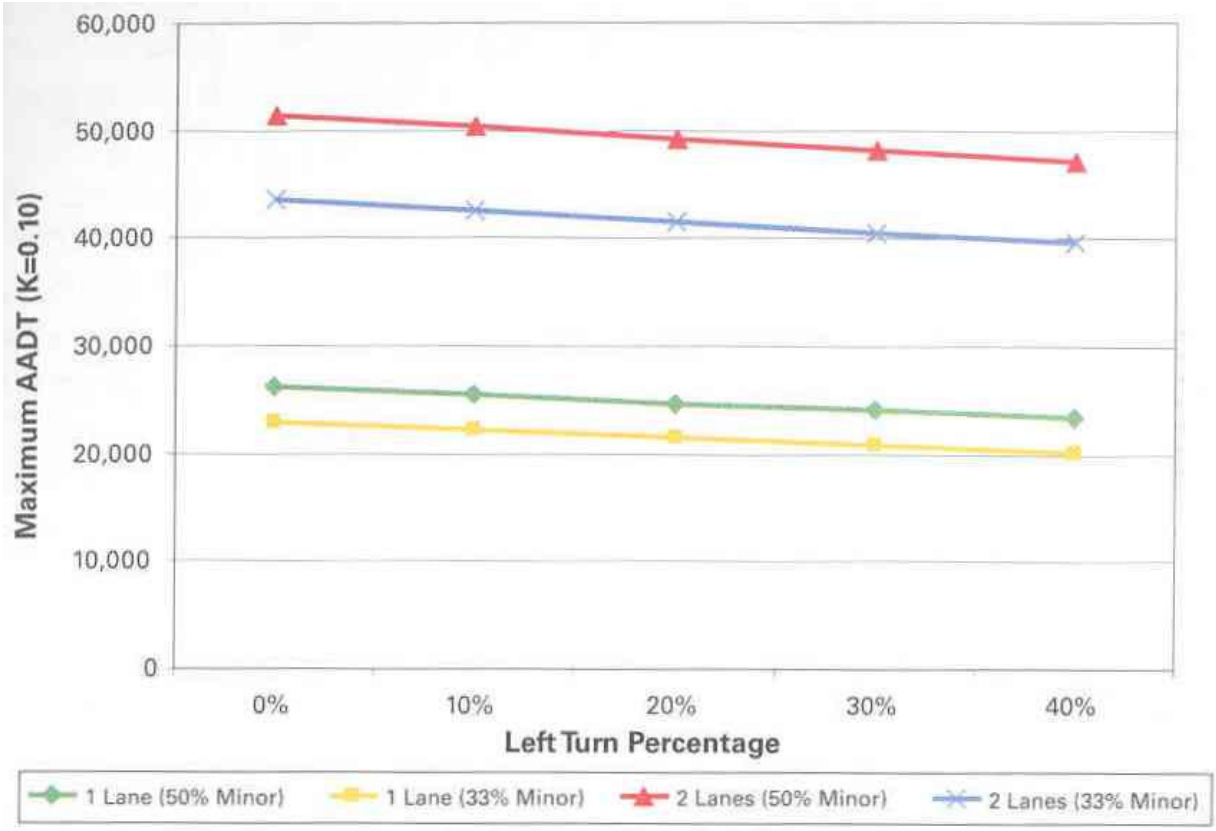

Exhibit 10: Capacity of single- and double-lane roundabouts. (source: Roundabouts: An Informational Guide, FHWA)

An additional site advantage that could further improve operations is the feasibility of bypass lanes to handle any large right-turn volumes, such as the heavy right-turn movement on eastbound US 14 at the intersection. Bypass lanes allow traffic to make right turns, typically at higher speeds, without entering the roundabout. Because of the higher speeds, bypass lanes are normally not used where there is heavy pedestrian activity, which is not the case at this location.

Driver Expectancy

A safety consideration on rural, high-speed roadways is that a roundabout may not be expected by some approaching drivers. This could be particularly true for unfamiliar drivers approaching the roundabout on US 14 from the east. Preceding the roundabout from this direction would be an interchange at CR 37 and prior to that, standard at-grade expressway intersections. Potential mitigation measures for this issue are lighting at the roundabout, advance signing, and introducing successive curves in advance of the roundabout (Exhibit 11). This strategy could be particularly useful on the south leg of the roundabout (US 14 westbound) to transition drivers from the rural high-speed driving environment to the roundabout.

Exhibit 11: Successive curves on the approach to roundabouts should be considered on rural, high-speed roadways.

MN 15 Grade

One particular safety concern for a roundabout or any at-grade intersection at this location is the grade of the MN 15 leg. There is an existing 4% grade, combined with a horizontal curve on the intersection approach. Grade affects vehicle speed and vehicle control, particularly for trucks and other large vehicles. Potential adverse safety impacts include:

- Vehicles approaching the intersection at higher speeds and losing control as they enter the intersection or running off the road.
- Vehicles having difficulty slowing down on the intersection approach during adverse weather or pavement conditions.
- Rear-end crashes due to trucks reducing speeds earlier than passenger vehicles.
- Speed differential on the upgrade as trucks will take more time to ascend the grade and reach highway speeds. This can lead to risky passing maneuvers.

Strategies to mitigate these potential safety impacts include:

- Realignment of the MN 15 leg as illustrated in Exhibit 3. This will provide greater visibility of the roundabout. Removing the horizontal curvature that is currently combined with the steep grade will also improve safety.
- Increase the elevation of the roundabout area to accommodate a flatter segment for the MN 15 approach. This would involve increasing the grade up to the roundabout on several of the other approaches, but a design that provides an optimal balance would be the goal. Maintaining good visibility of the roundabout on all high-speed approaches is important.

- Provide a full-width paved shoulder on the downgrade to provide an area for motorists to avoid rear-end crashes with slower moving vehicles.
- Provide a climbing lane on the upgrade to allow passenger vehicles to safely pass slower moving trucks.
- Provide good pavement surface friction and maintain it during winter driving conditions.

Connectivity of CR 21

To provide the best connectivity between all routes, a five-leg roundabout has been shown in Exhibit 3. Other concepts were explored that looked at a four-leg roundabout with alternate intersection locations for the south leg of CR 21. One potential location is along the MN 15 approach (Exhibit 12). This is not an optimal intersection location due to the steep grade and potential safety issues on the MN 15 leg, previously discussed. Another potential location is along the south leg (US 14). This location is also not optimal due to the heavier traffic along US 14 as well as the desire to maintain a greater degree of access control along US 14. If a roundabout is chosen for this location, it is recommended that a roundabout that accommodates all five legs be designed in more detail. If this is found to be infeasible, providing a connection to CR 21 on one of the approach legs is an option that can be further explored.

Exhibit 12: Four-leg roundabout with the connection to CR 21 provided along MN 15. This intersection location is not optimal due to the steep grade on MN 15.