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MEMORANDUM

TO: Tim Bray, Crow Wing County Engineer

FROM: Chris Hiniker, AICP

DATE: June 21, 2022

RE: TH 210/TH 371 Intersection Study - Improvement Concepts Definition and Assessment Memo
SEH No. CROWW-166235

PURPOSE

The purpose of this memorandum is to document analysis conducted to identify key issues associated with the Trunk Highway (TH) 210/TH 371 intersection in Baxter, Minnesota and determine whether they may be feasible options for addressing those needs. Is it noted that this is high-level feasibility assessment and that pending results of this process a decision will need to made whether to initiate more detailed design studies to comprehensively assess the study area issues, document the needs, define proposed improvement, engage the public and agencies, and conduct required environmental reviews.

PROJECT AREA

The study area incorporates the immediate intersection and extend west to Elder Drive, north to Excelsior Road, east to Golf Course Drive, and south across the at-grade railroad crossing.

BACKGROUND

The TH 210/TH 371 intersection has long been recognized as a significant traffic safety and operational issue. With over 31,000 ADT on TH 371 and over 24,000 ADT on TH 210, it is the busiest at-grade intersection in northern Minnesota and ranks 14th on MnDOT's most recent statewide list of highest crash cost intersections. The intersection is further complicated by the at-grade BNSF railroad crossing of TH 371 immediately south of TH 210. The intersection was assessed as part of the Corridors of Commerce program in 2018, however the grade-separated improvement concept was not advanced in the program.

The intersection has long history of a high number of crashes; the 2021 TH 210 Corridor Study showed a crash rate at the TH 210/TH 371 intersection that is over three times the critical crash rate; a crash rate equal to the critical rate indicates a safety concern.

Given the substantial operational concerns associated with the combination of very high traffic volumes, safety issues, and the existing at-grade railroad crossing, Crow Wing County partnered with MnDOT and the City of Baxter to conduct this feasibility study to determine if there are any potential concepts that merit pursuit of funding to conduct more detailed design and environmental impact studies.

Summary of Key Issues

The TH 210/TH 371 intersection serves as a critical crossroad for the Brainerd/Baxter region and north-central Minnesota. The intersection is particularly complex because of the combination of:

- Very high traffic volumes on both highways
- An active at-grade railroad crossing extending east-west immediately south of TH 210

- It serves a mix of local, regional, and interregional traffic
- It services a significant amount traffic intensive retail land use

POTENTIAL IMPROVEMENT CONCEPTS

A set of improvement concepts were developed using these basic guiding principles:

- Provide a set of options ranging from relatively lower cost to relatively higher cost concepts
- Investigate at-grade options
- Provide options that grade-separate the railroad crossing
- Limit closures or restrictions of existing access to the extent practical
- Provide accommodations for pedestrians and bicyclists
- Only develop options that will improve traffic operations and are deemed practical and viable

Building from these guiding principles a range of at-grade and grade-separated options were considered. The FHWA Cap-X, a planning level analysis tool, was used to determine both at-grade and grade separated designs that will serve the existing and future traffic volumes.

At-Grade Intersection Concepts

The following at-grade options were considered:

- Conventional Intersection – Adding existing capacity to the intersection to improve operations would require expanding TH 371 to a 6-lane roadway in addition to dual left turns on all four approaches. This was deemed not reasonable or practical.
- Roundabout - Given the very high traffic volumes and turning movements it was determined the roundabout would need to be a three-lane design which was deemed not reasonable or practical
- Quadrant Intersection – Also known as a “Jug Handle” this design provides a short connecting roadway in one quadrant to serve left turning traffic. Given the close proximity of the railroad and existing development as well as the traffic patterns of the intersection, this concept was deemed not reasonable or practical.
- Full Displaced Left Turn – With this concept, left turns occur at separate crossover intersections which allows for more efficient signal timings to be implemented. The design was determined to be potentially practical.

Grade-Separation Concepts

The Cap-X tool showed that most grade separated designs would work well; so, the focus was on considering a design(s) that would minimize costs and impacts. Given these considerations a diamond interchange configuration was deemed most appropriate. In reviewing the traffic volumes and patterns it was determined that any diamond interchange configuration would address the identified needs and issues. As a result, given the limited scope of this feasibility study, a diverging diamond interchange (DDI) was developed because it would best serve the particular traffic patterns of the intersection.

Description of Improvement Concepts

In total, four improvement concepts were developed, one at-grade option and three grade-separated options. They include:

- Concept 1 – Full Displaced Left Turn Intersection (Figure 1)
- Concept 2 – Quadrant Interchange (Figure 2)
- Concept 3 – East-West Diverging Diamond Interchange (Figure 3)
- Concept 4 – North-South Diverging Diamond Interchange (Figure 4)

Concept 1 – Full Displaced Left Turn Intersection

A full displaced left turn intersection is an at-grade design focused on managing large volumes of left turning traffic. Key attributes of the concept include:

- Construction and design cost is approximately $13-$16 million ($2021)

- No current applications in Minnesota, but exist in Colorado, Florida, and California
- Traffic operations benefits include improved safety and efficiency:
    - Left turns and through movements can cross the main intersection at the same time
    - While the number of signalized locations increases to five, the number of phases is reduced from eight at the existing signal down to four.
    - Each signalized intersection will operate at a LOS B; however, total delays passing through the entire intersection would be LOS D as some movements need to travel through three intersections.
    - Design would add complexity of maintaining signal coordination between TH 210 and TH 371.
- Does not provide grade-separation of the railroad tracks.
- Existing access conditions are retained at Excelsior Road and Golf Course Drive.
- Elder Drive access would be modified to redirect Elder Drive traffic south of TH 210 west to Forthun Road. Access to and from the north of TH 210 would be retained at Elder Drive.

Concept 2 – Quadrant Interchange

A grade-separated interchange that bridges TH 371 over the TH 210 and the railroad tracks. Two sets of access ramps to/from TH 210 and TH 371 would be added, one in the northwest quadrant and one on the northeast quadrant. These ramps would connect to TH 210 via two signalized intersections immediately west and east of TH 371. It is anticipated that a traffic signal would also be required on TH 371 at the northbound TH 210 access ramp given the very high traffic volumes. Key attributes of the design include:

- Construction and design cost is approximately $29-$33 million ($2021)
- Removes the at-grade railroad crossing
- Required TH 371 grade raise may have some limited right-of-way impacts in northwest quadrant and some easement needs in southwest quadrant
- Reduces conflict points from 32 with the existing down to 22.
- Signal phasing reduced from eight with existing conditions down to three at each signal.
- Each signalized intersection will operate at a LOS B or better.
- Overpass allows ability to break existing coordination of TH 371 and TH 210 to improve the coordination of the signal systems separately.
- Existing access conditions are retained at Excelsior Road and Golf Course Drive.
- Elder Drive access would be modified to redirect Elder Drive traffic south of TH 210 west to Forthun Road. Access to and from the north of TH 210 would be retained at Elder Drive

Concept 3 – East-West Diverging Diamond Interchange

A grade-separated interchange that bridges TH 371 over TH 210 and the railroad tracks. Two access ramp intersections with traffic signals would be added to TH 371. TH 210 would be free-flow traffic through the intersection area. Key attributes of the design include:

- Construction and design cost is approximately $35-$39 million.($2021)
- Removes at-grade railroad crossing
- Requires removal of access between TH 210 and Golf Course Drive.
- Elder Drive access would be shifted to Forthun Road/Flintwood Drive consistent with the recommendations from the recently completed TH 210 Baxter Corridor Study.
- Reduces conflict points from 32 points with existing intersect down to 18.
- Signal phasing reduced from eight at existing intersection to two at each intersection.
- Each signalized intersection will operate at a LOS C or better.
- Overpass allows ability to break existing coordination of TH 371 and TH 210 to improve the coordination of the signal systems separately.
- DDI’s design type is estimated to reduce crashes by 50% to 60%.

Concept 4 – North-South Diverging Diamond Interchange

A grade-separated interchange that includes raising TH 371 slightly along with lowering TH 210 and the railroad tracks. Key attributes of the design include:

- Construction and design cost is approximately $50-$54 million.($2021)
- Removes at-grade railroad crossing
- Lowers railroad, which would place it under the water table and likely require permanent dewatering.
- Requires removal of access between TH 371 and Excelsior Road
- Possibly need to close ¾ access at Design Road.
- Removal of access at Excelsior Road and potentially Design Road; would create large scale traffic diversions.
- Elder Drive access would be shifted to Forthun Road/Flintwood Drive consistent with the recommendations from the recently completed TH 210 Baxter Corridor Study.
- Reduces conflict points from 32 at existing intersection to 18.
- Signal phasing reduced from eight at existing intersection to two.
- Each signalized intersection would operate at a LOS B or better.
- Overpass allows ability to break existing coordination of TH 371 and TH 210 to improve the coordination of the signal systems separately.
- DDI's design type is estimated to reduce crashes by 50% to 60%.

ASSESSMENT OF CONCEPTS

SEH met with County, City and MnDOT staff on April 6, 2022, to review each concept and discuss the trade-offs between each. The following was highlighted:

Concept 1 – Full Displaced Left Turn Intersection

- Lowest cost ($13-$16 million - $2021).
- Does not provide grade-separation of the railroad tracks.
- Retains existing local road access conditions except for Elder Drive south of TH 210 which would be redirected west to Forthun Road consistent with the recommendations from the recently completed TH 210 Baxter Corridor Study.
- Improves traffic operations compared to existing conditions, however, provides the least traffic benefit of the four concepts.

Concept 2 – Quadrant Interchange

- Moderate construction and design cost compared to other concepts ($29-$33 million - $2021).
- Removes Hwy 371 at-grade railroad crossing and would provide the first grade-separated railroad crossing in Baxter.
- Retains existing local road access conditions except for Elder Drive south of TH 210 which would be redirected west to Forthun Road consistent with the recommendations from the recently completed TH 210 Baxter Corridor Study.
- Improves traffic operations compared to existing conditions with simplified signal phasing and southbound TH 371 always uncontrolled.
- Relative safety benefit includes simplified movements at T-intersections, which have reduced conflict points.

Concept 3 – East-West Diverging Diamond Interchange

- Moderate construction and design cost compared to other concepts ($35-$39 million - $2021).
- Removes Hwy 371 at-grade railroad crossing and would provide the first grade-separated railroad crossing in Baxter.
- Requires removal of access between TH 210 and Golf Course Drive and shifting Elder Drive access west to Forthun Road/Flintwood Drive

- Improves traffic operations compared to existing conditions with a high-capacity interchange design and simplified signal phasing.
- Relative safety benefit includes a substantial reduction in crashes of approximately 60% based on previous conversions of at-grade conditions to a DDI design.

Concept 4 – North-South Diverging Diamond Interchange

- Highest construction and design cost - $50-$54 million ($2021)
- Removes Hwy 371 at-grade railroad crossing and would provide the first grade-separated railroad crossing in Baxter.
- Most significant local access impacts including removal of access between TH 371 and Excelsior Road, possible removal of access at Design Road, and shifting Elder Drive access west to Forthun Road/Flintwood Drive.
- More significant ongoing maintenance costs associated with probable permanent dewatering of lowered railroad.
- Improves traffic operations compared to existing conditions with a high-capacity interchange design and simplified signal phasing.
- Relative safety benefit includes a substantial reduction in crashes of approximately 60% based on previous conversions of at-grade conditions to a DDI design.

Based on the assessment of the options; County, City, and MnDOT staff determined that Concepts 1 and 4 should be removed from consideration. Concept 1 because it does not address the at-grade railroad crossing and Concept 4 because of the high costs, significant local access impacts, and ongoing maintenance concerns associated with probable railroad corridor dewatering requirements. Concepts 2 and 3 were recommended to be carried forward for further consideration, the first step of which was to conduct a benefit-cost analysis to determine whether the safety and travel time benefits of each are greater than the associated costs.

Benefit-Cost Analysis

To better understand the relative cost benefit of the two remaining concepts a benefit-cost analysis (BCA) was conducted based on MnDOT Planning and Programming guidance. In general, a proposed projects monetary "benefit" is quantified in terms of reduced vehicle miles traveled (VMT), vehicle hours traveled (VHT), and estimated crash reductions between the no build and build options. The "costs" typically include construction, bridges and structures, right-of-way, and engineering/project delivery costs; remaining capital values of these roadway features at the end of the analysis period are subtracted from the total cost of the project. The results of the analysis provide input for evaluating the overall benefit of proposed improvements. Due to the planning level of detail in the calculations, the magnitude of the value is not as important as the value being greater or less than one.

The analysis for the two remaining TH 210/TH 371 intersection concepts assumed a 2021 existing year for the cost calculations, based on current MnDOT pricing information, and a 20-year benefit period between 2025 and 2045. Though weekend traffic can be high during summer months in the project area, only a typical weekday benefit was calculated assuming 260 working days per year. Preliminary costs were developed using current estimation methodology and operating and maintenance costs were calculated based on the proposed bridge structures and additional lane miles.

VMT and VHT data was calculated based on 2019 intersection count data and 2040 forecast data from the TH 210 Baxter Access Study (2021); Synchro/SimTraffic operations models were developed for four separate hourly volume scenarios for the No Build and Build conditions; this included the AM and PM peak hours as well as additional hours throughout the day including a mid-day and overnight hour. The results were spread across the 24-hour daily distribution based on hourly percentages of the existing daily traffic demands for the project area. Daily VMT and VHT for the 2025 and 2045 forecasts years was extrapolated based on the 2019 and 2040 analysis years.

It should be noted, given the limitations of the scope of this study, the existing at-grade rail crossing was not included in the existing and future no build calculations. The VHT for the existing and no build scenarios would be significantly higher than what was analyzed as part of this scope, which would result in a larger benefit for any build concepts that grade separates the crossing. During the next phase of study for the intersection, a more detailed traffic operations and benefit cost analysis should be considered.

Crash benefits were calculated assuming the existing crash rate would continue through 2045 in the no build condition; the existing intersection crash rates are significantly above the critical rates for multiple intersections. The proposed build conditions crashes were calculated based on the total volume shifting to the new intersections and traffic control changes for the proposed designs; MnDOT's average crash rates were used based on the intersection control changes.

The preliminary analysis indicates that both proposed build concepts have a benefit cost ratio greater than 1.0. Meaning, the VMT, VHT and crash reduction benefits of the project are estimated to be higher than the costs associated with the construction of the project. It should be noted that current cost estimates have seen significant fluctuations, for the purposes of this analysis any increase in costs would not be significant enough to change the positive benefit-cost ratio or the comparison between the two proposed build concepts.

Table 1 shows the results of the benefit cost analysis. The monetary values in the table are the difference between each concept and the do nothing (No Build) scenario. The No Build provides no user benefits and has no associated costs for improvements, resulting in a benefit-cost ratio of zero.

Table 1 Benefit Cost Analysis Results

Item	No Build	Concept 2	Concept 3
VMT & VHT Benefit	$0	$15,859,179	$40,692,056
Crash Benefit	$0	$83,196,672	$141,635,631
Total Benefit[1]	$0	**$98,667,720**	**$181,849,447**
Construction Costs	$0	$29,723,147	$35,779,865
Remaining Capital Value	$0	$8,992,075	$11,020,659
Total Project Costs	$0	**$20,731,073**	**$24,759,206**
Benefit Cost Ratio	**0**	**4.76**	**7.34**

Notes: 1-includes Operating and Maintenance Benefits/Costs not shown.

While both concepts have a significant benefit compared to the cost of each option, Concept 3 does have higher vehicle hours traveled savings and a larger safety benefit. Concept 3 is a full interchange design with less overall delay for all movements and the safety benefits of the DDI design are more substantial than the Concept 2 design with three separate signalized intersections remaining.

CONCLUSIONS AND NEXT STEPS

The study findings indicate there are options for improving the TH 210/TH 371 intersection that appear to be effective and technically feasible with Concepts 2 and 3 having the greatest merit for further consideration. Moving forward the partners involved in this feasibility study will need to determine whether to proceed with more detailed design studies to document the key needs, more comprehensively define and assess a full range of alternatives, address potential social, economic and environmental impacts, and engage the public and applicable agencies. In the short-term, the primary item to address is to determine who would lead the next phase of studies which are estimated to cost approximately $2.0 million.

Attachments:
Concepts 1, 2, 3, and 4 Figures

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Excelsior Rd.

Flintwood Dr.

Golf Course dr.

Cypress Dr.

MINNESOTA 371

MINNESOTA 210

Foley Rd.

Elder Dr.

College Rd.

Industrial Park Rd

XX INDICATES ACCESS CLOSURE

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200 0 500
scale feet

SEH PHONE: (651)490-2000 3535 VADNAIS CENTER DR. ST. PAUL, MN 55110	166235 DATE: 6/15/2022	TH 371/TH 210 STUDY CONCEPT 1 – FULL DISPLACED LEFT TURN INTERSECTION	FIGURE No. 1

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Excelsior Rd.

Flintwood Dr.

Golf Course dr.

Cypress Dr.

MINNESOTA 371

MINNESOTA 210

Foley Rd.

Elder Dr.

College Rd.

Industrial Park Rd

XX INDICATES ACCESS CLOSURE

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Quadrant Interchange

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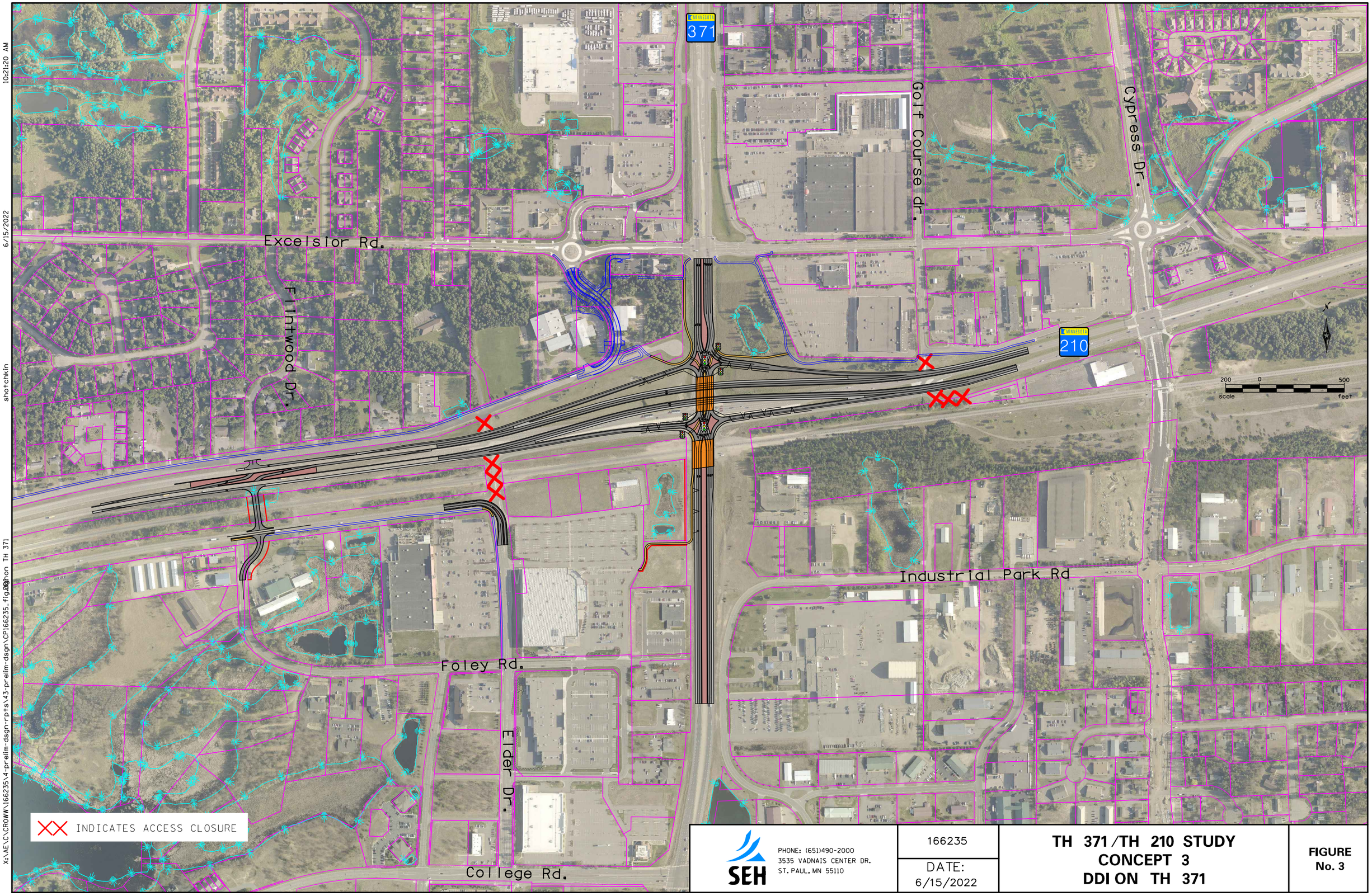
ST. PAUL, MN 55110

166235

DATE:
6/15/2022

TH 371/TH 210 STUDY
CONCEPT 2
QUADRANT INTERCHANGE

FIGURE
No. 2



SEH PHONE: (651)490-2000 3535 VADNAIS CENTER DR. ST. PAUL, MN 55110	166235 DATE: 6/15/2022	TH 371/TH 210 STUDY CONCEPT 3 DDI ON TH 371

FIGURE No. 3

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ACCESS BETWEEN HWY 371 AND DESIGN ROAD MAY NEED TO BE REMOVED

ACCESS BETWEEN HWY 371 AND EXCELSIOR ROAD IS REMOVED

MINNESOTA 371

MINNESOTA 210

Excelsior Rd.

Flintwood Dr.

Golf Course dr.

Cypress Dr.

Foley Rd.

College Rd.

Industrial Park Rd

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DATE: 6/15/2022

TH 371/TH 210 STUDY
CONCEPT 4
DDI ON TH 210

FIGURE No. 4

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