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East 18th Street Improvements

Traffic Study

City of Rolla, Missouri

Prepared for:

City of Rolla

Department of Public Works

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Executive Summary

Lochmueller Group has completed a traffic study to evaluate possible improvements near the intersection of E 18th Street and Bardsley Road/Old St. James Road in Rolla, Missouri. The offset nature of Bardsley Road and Old St. James Road at E 18th Street, channelization of vehicles on Bardsley Road, and close proximity to the railroad tracks increases conflict for vehicles traversing the intersection, resulting in undesired queueing and crashes. Three alternatives are proposed for improvements to the intersection of E 18th Street and Bardsley/Old St. James Road.

1. Re-align Old St. James Road to meet the existing Bardsley Road approach (North Alignment) and install traffic signal intersection control with railroad preemption;
2. Re-align Bardsley Road to meet the existing Old St. James approach (South Alignment) and install traffic signal intersection control with railroad preemption;
3. Install a single lane roundabout at E 18th Street and Bardsley Road/Old St. James Road.

Alternative A is not recommended for consideration as a viable intersection improvement alternative due to the eastbound approach queues greatly exceeding the available space between the eastbound stop bar and the railroad buffer. A comparison of Alternatives 2 and 3 is shown in **Table 11**. Either Alternative B or Alternative C are acceptable for implementation at the intersection of E 18th Street and Bardsley/Old St. James Road. Due to the sustained continuous vehicle flow and minimized eastbound approach queueing, Lochmueller Group recommends Alternative C for implementation at the intersection of E 18th Street and Bardsley/Old St. James Road.

Table 11. Alternative B and Alternative C Comparison

	Alternative B (South Alignment)	Alternative C (Roundabout)
Overall Intersection Delay	Non-continuous flow. All approaches must stop during each cycle. Inherently more delay.	Maintains continuous flow through the intersection, except when train present.
Eastbound Approach Queueing	Maximum forecasted queues slightly exceed provided spacing between intersection and railroad tracks during the 2045 Horizon Year PM peak. Interaction between queue and train possible during up to 5% of the 2045 PM peak hour.	Maximum forecasted queues within provided spacing between intersection and railroad tracks. No interaction anticipated between queues and trains.
Impacts by Train	Dedicated turn lanes allow some movements to maintain flow through the intersection even when a train is present.	Intersection may be blocked by waiting vehicles when a train is present.
Planning Level Opinion of Cost	Approx. $1.0 – 1.5M	Approx. $1.3 – 1.7M*
Required ROW Acquisition	Required ROW acquisition within the southeast quadrant of the intersection in addition to the acquisition of three buildings.	Required ROW acquisition in northwest and southeast quadrants of the intersection. No buildings require acquisition.

** Based on TRB annual meeting presentation "States' Practices on Roundabout Selection, Design, and Performance Analysis" (2016) cost for single-lane roundabout escalated to 2021*

Introduction

Lochmueller Group has completed a traffic study to evaluate possible improvement alternatives near the intersection of E 18th Street and Bardsley Road/Old St. James Road in Rolla, Missouri. The offset nature of Bardsley Road and Old St. James Road at E 18th Street, channelization of vehicles on Bardsley Road, and close proximity to the railroad tracks increases conflict for vehicles traversing the intersection, resulting in undesired queueing and crashes. The surrounding land is comprised of mainly residential neighborhoods to the west and south of the study area and industrial uses to the east and north. The study area includes four main intersections, as shown in **Exhibit 1**:

1. Highway 63 and North Walnut Street/I-44 Eastbound Exit Ramp (Signalized)
2. East 18th Street and Mainline North Walnut/East 18th Street (side-street stop)
3. North Walnut Street and East 18th Street (side-street stop)
4. East 18th Street and Bardsley Road/Old St. James Road (side-street stop)

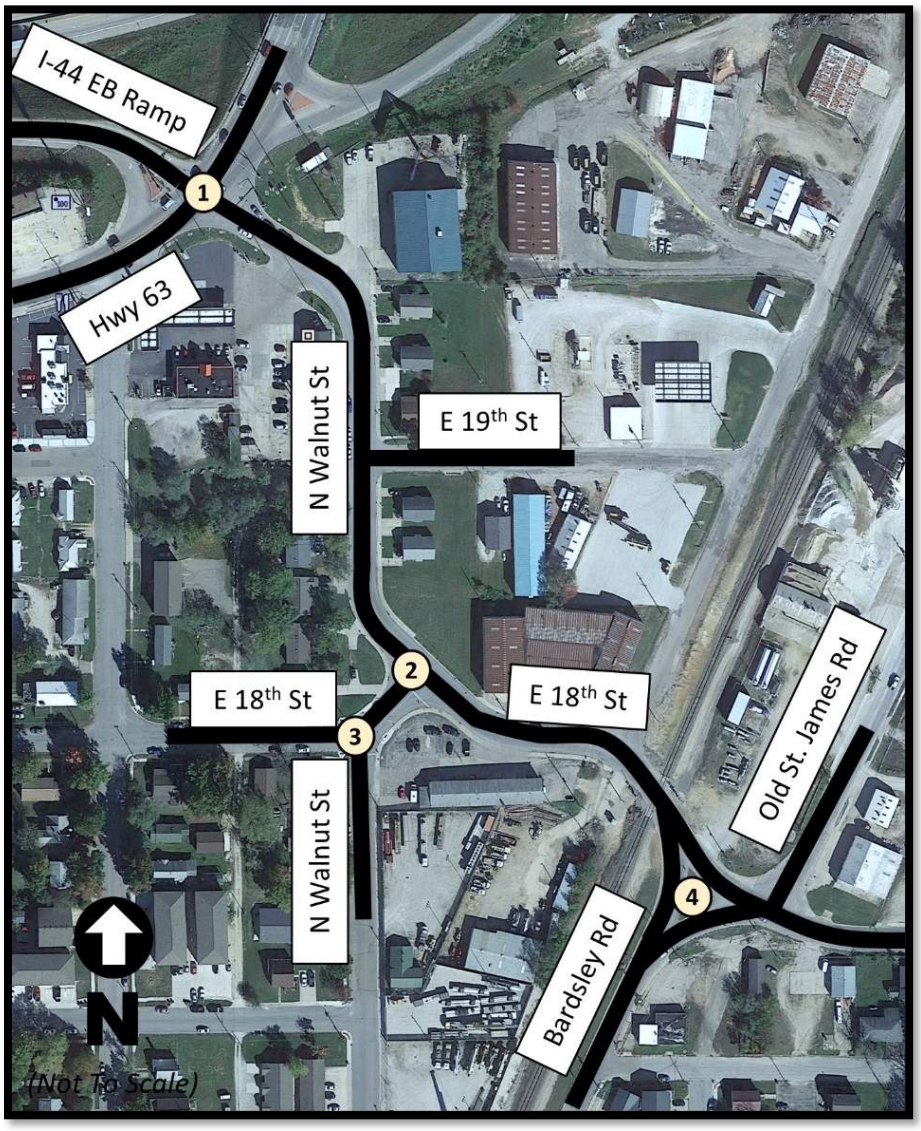


Exhibit 1. Study Area Map

Existing Conditions

Road Network

N Walnut Street/E 18th Street is classified as a minor arterial roadway throughout the study area. E 18th Street becomes N Walnut Street west of the railroad tracks. At N Walnut Street, E 18th Street continues to the west through the adjacent residential neighborhood. In general, N Walnut Street/E 18th Street is comprised of one travel lane in each direction, with an auxiliary left turn lane provided for the northbound left from E 18th Street onto the continuation of E 18th Street west of the railroad tracks, and for the eastbound left from E 18th Street onto Sharp Road. A two-way-left-turn lane (TWLTL) is provided along E 18th Street between these two auxiliary left turn lanes to serve businesses on either side of the road, one of which is the Phelps Health Ambulance EMT center. The posted speed limit along N Walnut Street/E 18th Street is 25 miles per hour (mph) throughout the study area, with the exception of a posted school zone speed limit of 20 mph near Harry S. Truman Elementary, east of the study area.

E 18th Street west of N Walnut Street is a local roadway with a posted speed limit of 25 mph. Its connection to N Walnut Street/E 18th Street is side-street stop controlled, with E 18th Street traffic required to stop while mainline N Walnut Street/E 18th Street remains free flow. Single dedicated left and right turn lanes are provided from E 18th Street onto mainline N Walnut Street/E 18th Street. The southern portion of N Walnut Street intersects the western portion of E 18th Street west of the connection to mainline N Walnut Street/E 18th Street as a side-street stop controlled intersection, with N Walnut Street required to stop while E 18th Street remains free flow. No auxiliary turn lanes are provided at this intersection. Phelps Health Ambulance EMT center is bounded by mainline E 18th Street to the north, railroad tracks to the east, and the southern portion of N Walnut Street to the west. The center has over 60 feet of curb cut access onto mainline E 18th Street, with a smaller access point onto the southern portion of N Walnut Street.

Bardsley Road is classified as a major collector with a posted speed limit of 30 mph within the study area. The intersection of Bardsley Road with E 18th Street is side-street stop controlled, with traffic on Bardsley Road required to stop, while E 18th Street traffic is free flow. No auxiliary turn lanes are provided at the intersection, however the northbound Bardsley Road approach is channelized such that left turning vehicles bear left of the grass island to complete their turn onto E 18th Street, while through and right turning vehicles bear right. Vehicles wishing to turn left onto Bardsley Road from westbound E 18th Street are intended to turn before the grass median, although vehicles were observed making this left turn after the grass median during field inspections. Westbound left turning vehicles that turn before the grass median are directed to yield via signage before entering Bardsley Road.

Old St. James Road is classified as a minor arterial roadway, with a posted speed limit of 30 mph throughout the study area. The intersection of Old St. James with E 18th Street is side-street stop controlled, with traffic on Old St. James required to stop while E 18th Street traffic is free flow. No auxiliary turn lanes are provided to or from Old St. James Road. The centerline of Old St. James Road is approximately 100 feet east of the Bardsley Road centerline. However, the channelization of the Bardsley Road approach at E 18th Street shifts Bardsley Road northbound through and right turning traffic to within 50 feet of Old St. James Road. The resulting configuration is such that vehicles are able to make northbound and southbound through movements to/from Old St. James Road and Bardsley Road via the Bardsley Road lanes east of the channelization island.

Highway (Hwy) 63 is a principal arterial with a posted speed limit of 35 mph throughout the study area. N Walnut Street connects to Highway 63 opposite the I-44 eastbound exit ramp, which has a speed limit of 40 mph. The intersection of Hwy 63 with N Walnut Street is signalized, with single dedicated westbound left and right turn lanes from N Walnut Street onto Hwy 63, a dedicated southbound left turn lane from Hwy 63 onto N Walnut Street, and single dedicated eastbound left and right turn lanes from the I-44 ramp onto Hwy 63.

Other Transportation Considerations

A railroad line runs parallel to Old St. James Road, and intersects East 18th Street between Sharp Road and Bardsley Road. A number of warning signs alert drivers of the railroad crossing, and level crossing signals are present on either side of the crossing to separate vehicular traffic when a train is present.

One train was observed on November 17th at approximately 7:45 AM during the morning peak hour. The train crossing took 3 minutes and 6 seconds from arm up to arm down. The resulting westbound queue at E 18th Street and Bardsley Road was at least 8 cars, or approximately 200 feet. The southbound queue on Old St. James Road was at least 3 cars, or approximately 75 feet. The eastbound E 18th Street queue west of the tracks was approximately 350 feet, extending past the Phelps Health Ambulance EMT center to the intersection of mainline E 18th Street and N Walnut Street. After the train cleared it took approximately 1 minute for the westbound queue on E 18th street to dissipate, 1 minute 45 seconds for the southbound queue on Old St. James Road to dissipate, and 1 minute 40 seconds for the eastbound E 18th Street queue west of the tracks to dissipate. Overall the network appeared back to pre-train operating conditions about 2 minutes and 30 seconds after the train cleared the crossing.

There are no dedicated bicycle facilities within the study area. Pedestrian facilities within the study area include newly constructed sidewalks and curb ramps along East 18th Street and North Walnut Street. The sidewalks are not continuous on both sides of the street throughout the length of the roadways and lack crosswalk markings at roadway crossings. The sidewalks do extend over the railroad tracks and provide adequate width for pedestrians to safely cross. The south side of the rail crossing is shown in **Exhibit 2**. A photo of a typical roadway crossing in the study area is displayed in **Exhibit 3.** The existing lane configurations and traffic control at study area intersections is shown in **Exhibit 4.**

Exhibit 2. Sidewalk Crossing at Railroad Tracks

Exhibit 3. Sidewalk and Crossing at Bardsley Road

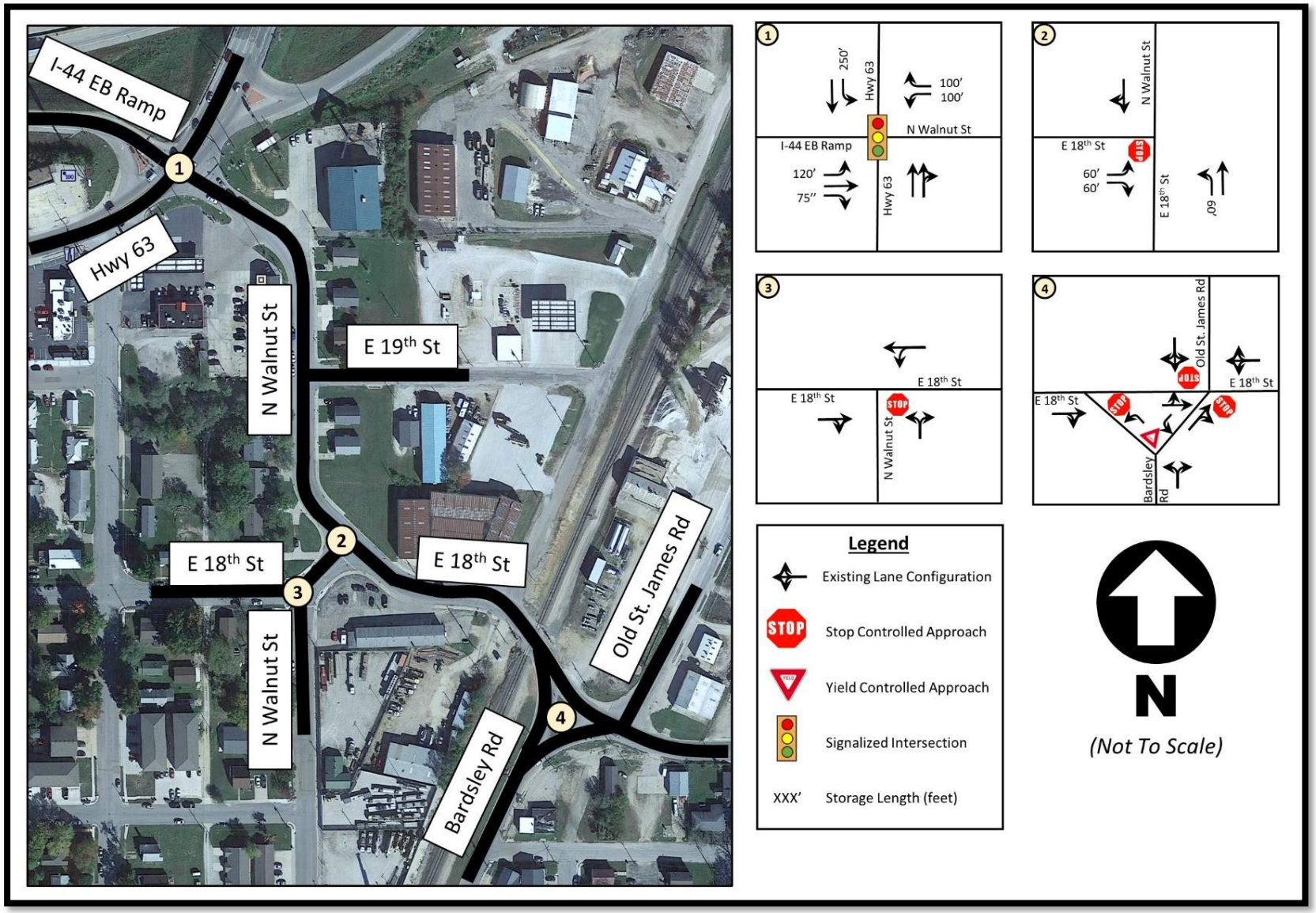


Exhibit 4. Existing Lane Configuration and Traffic Control

Safety Analysis

Crash data from 2015 to 2019 was pulled from Missouri Department of Transportation (MoDOT) crash records in order to assess current safety conditions. The data was analyzed from East 19th Street south to Holloway Street so as to focus on Bardsley Road, Old St. James Road, and the immediate surrounding area. **Exhibit 5** displays the location of crashes pulled for analysis. **Table 1** displays crash severity by year, while **Exhibit 6** displays the distribution of crash types.

Exhibit 5. Crash Locations near Bardsley Road and Old St. James Road

Table 1. Crash Severity from 2015 to 2019 near Bardsley Road and Old St. James Road

Year	Fatality	Disabling Injury	Minor Injury	Property Damage Only	Total
2015	0	0	1	5	6
2016	0	0	2	7	9
2017	0	0	1	8	9
2018	0	0	2	6	8
2019	0	0	0	3	3
Grand Total	**0**	**0**	**6**	**29**	**35**

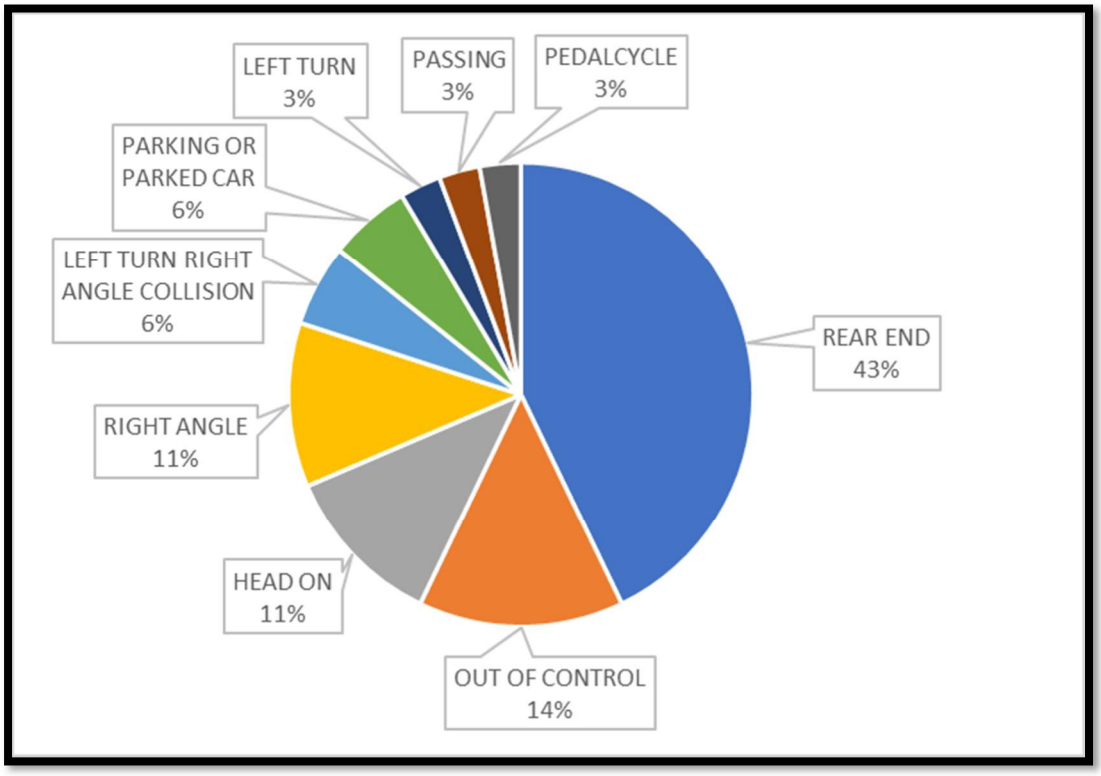


Exhibit 6. Crash Types from 2015 to 2019

The crashes at the intersection are largely property damage only, with only 6 minor injury crashes over the past 5 years. However, there is a relatively high number of head-on crashes (4), which are more likely to result in severe injuries than other crash types. All but one of the head-on crashes occurred on the Bardsley Road northbound approach to E 18th Street where southbound drivers yield to both eastbound right and northbound left drivers, indicating the unusual geometry and control of the intersection is contributing to these crashes. The high number of rear end crashes is also likely due to the unusual geometry and control of the E 18th Street and Bardsley Road/Old St. James intersection. A majority of the rear end crashes occurred within the southbound queue of vehicles exiting Old St. James Road. The offset of the intersection makes it difficult for drivers to discern who has the right-of-way. This confusion likely leads to drivers starting to go and abruptly stopping, resulting in a rear end collision.

Traffic Volumes

To quantify existing traffic volumes, turning movement counts were completed on November 17, 2020. It was determined the AM and PM peak hours occurred from 7:15-8:15 AM and 4:15-5:15 PM. School was in session at the time of the counts. However, it should be noted that counts were taken during the COVID-19 worldwide pandemic, which has generally affected traffic patterns everywhere. Historic counts were not available for comparison to determine if any adjustments needed to be made or if volumes reflected typical conditions. Therefore, no adjustments were made to the turning movement counts. Existing traffic volumes are shown below in **Exhibit 7.**

In order to properly assess future conditions of the study area, a growth rate was calculated for projecting future traffic volumes. Available historic MoDOT ADT information for nearby roadways was reviewed to understand the traffic growth in the surrounding area over the past 5 years. The potential development of available land east of the study area, specifically the plot served by the east leg of the Forum Street and E 18th Street roundabout, was also considered. A projected annual growth rate of 1.0% per year from 2020 to 2045 is appropriate to account for future development to the east and is in line with historic growth of surrounding roadways. Projected volumes for the 2025 construction year and 2045 horizon year are shown in **Exhibit 8** and **Exhibit 9.**

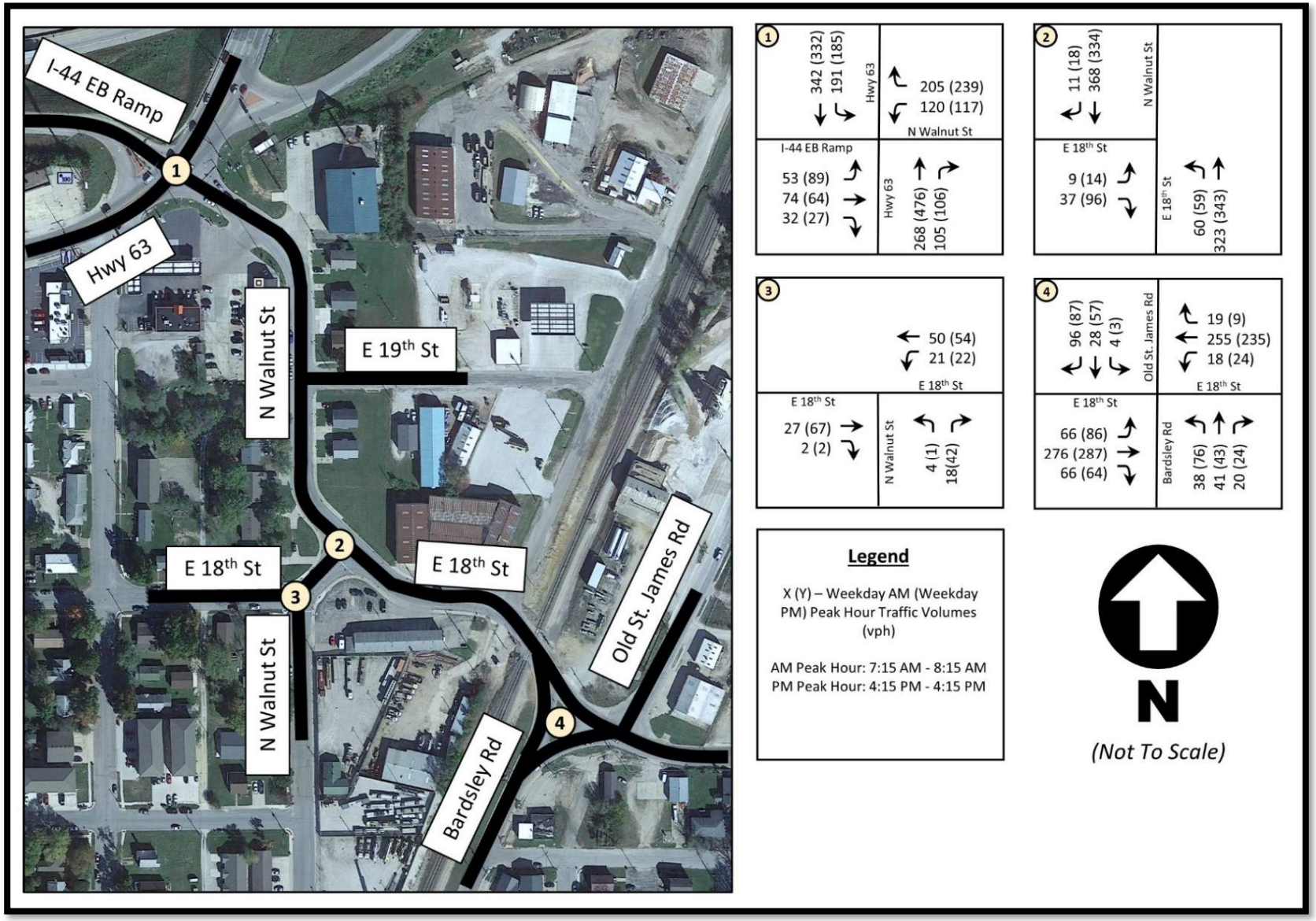


Exhibit 7. 2020 Existing Traffic Volumes

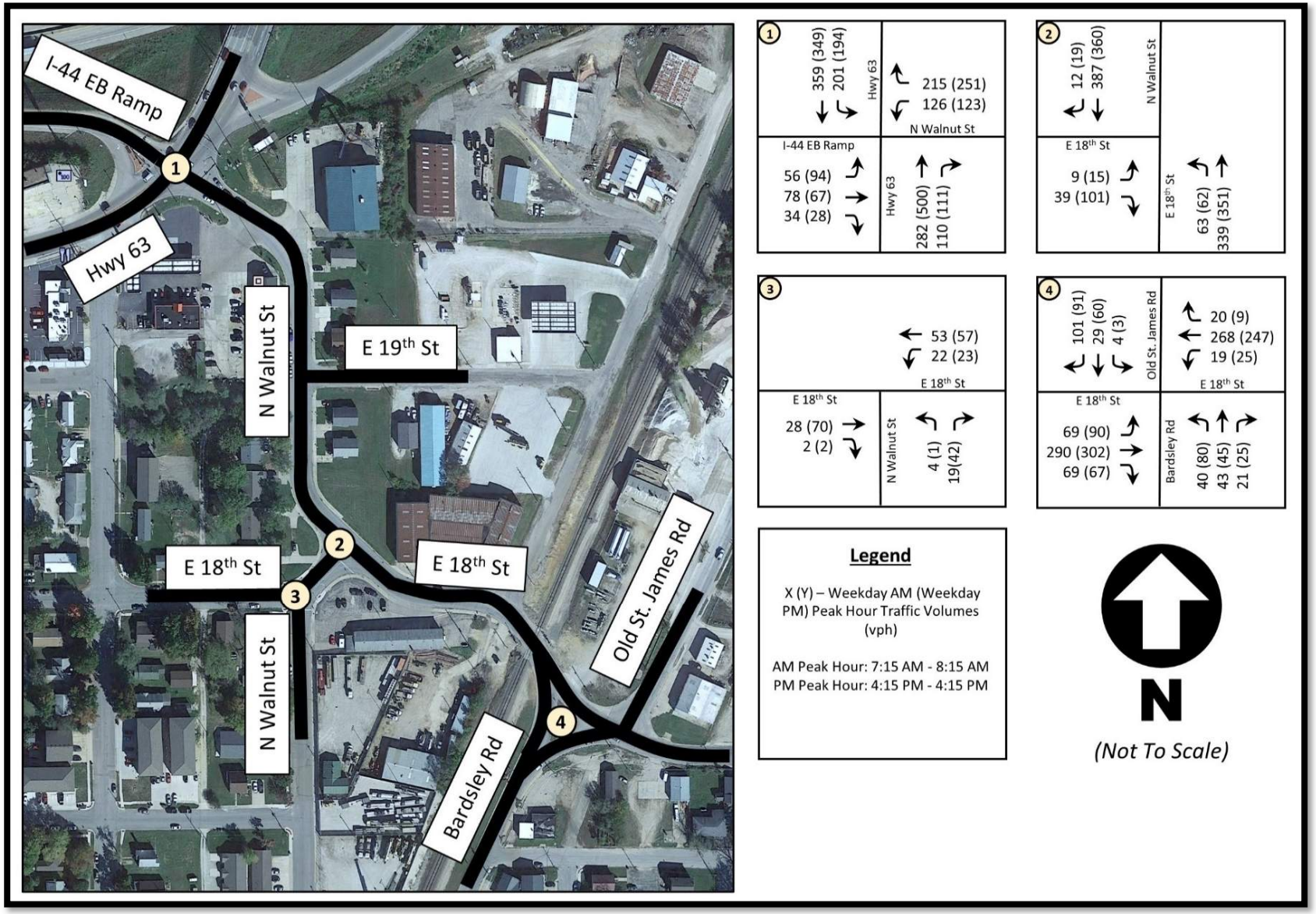


Exhibit 8. Forecasted 2025 Construction Year Volumes

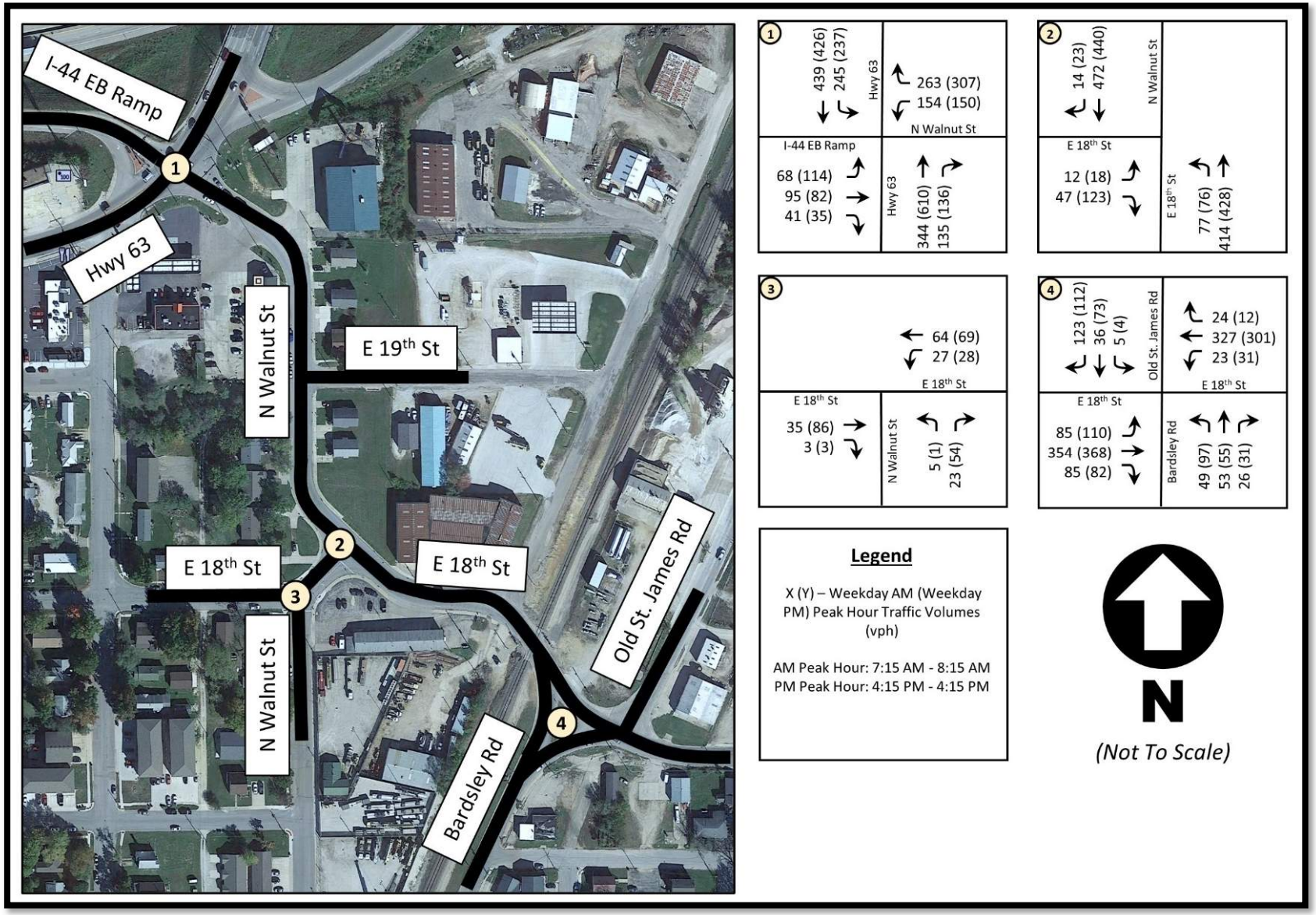


Exhibit 9. Forecasted 2045 Horizon Year Volumes

Existing Operating Conditions

Existing operating conditions were evaluated using Synchro 10, a traffic flow modeling software based on the Highway Capacity Manual (HCM) 6th Edition, last updated in 2016 by the Transportation Research Board. Intersection performance or traffic operations are quantified by six Levels of Service (LOS), which range from LOS A ("Free Flow") to LOS F ("Fully Saturated"). LOS C is normally used for design purposes and represents a roadway with volumes ranging from 70% to 80% of its capacity. LOS D is generally considered acceptable for peak period conditions in suburban areas and would be an appropriate benchmark of acceptable traffic for the study area road system.

Levels of service for intersections are determined based on the average delay experienced by motorists. For intersections with partial (side-street) stop control, the delay is calculated for the minor movements only (side-street approaches and major road left-turns) since thru and right turning traffic on the major road is not required to stop. The thresholds for each level of service vary based upon the type of control to reflect different driver expectations. Signalized intersections are designed to carry higher traffic volumes, and therefore motorists accept heavier delays as compared to unsignalized intersections. **Table 2** summarizes the criterion for both signalized and unsignalized intersections, as defined by the HCM.

While Synchro 10 is sufficient for evaluating the traffic flow of the network, the unusual layout of the intersection of East 18th Street and Bardsley Road/Old St. James Road requires a more sophisticated queueing analysis to accurately capture queue interaction, and to understand how queues interact with the railroad tracks to the west, if at all. Therefore, SimTraffic, a microsimulation software that tracks individual vehicles rather than overall traffic flow, was used to model queue lengths. **Table 3** summarizes the existing operating conditions of the study area intersections.

The study area intersections function at acceptable levels of service as all approaches operate at a LOS C or better excluding the eastbound approach of the intersection of Hwy 63 and North Walnut Street/I-44 EB Exit Ramp, which operates at a LOS D.

It is likely that the unconventional geometry of the off-set intersection at E 18th and Bardsley/Old St. James Road makes drivers feel like they experience more delay than is typical since they traverse the intersection with heightened awareness. Crashes are certainly prevalent due to the skewed geometry as well, solidifying negative driver perceptions. Therefore, future improvements should focus on the geometry of the intersection and alignment of Bardsley/Old St. James Road rather than only considering the traffic control at the intersections. If drivers feel safe and comfortable using the intersection, perceptions should improve.

Table 2. Intersection Level of Service Thresholds

Level of Service	Delay per Vehicle (sec/veh)	
	Signalized	Unsignalized/Roundabout
A	< 10	0-10
B	> 10-20	> 10-15
C	> 20-35	> 15-25
D	> 35-55	> 25-35
E	> 55-80	> 35-50
F	> 80	> 50

Table 3. Existing Operating Conditions

Intersection Approach/Movement	LOS (Delay in seconds per vehicle) [95th Queue]	
	AM	PM
1. Hwy 63 and N Walnut Street/I-44 EB Exit Ramp (Signalized)		
Northbound Approach	**C (24.2)**	**C (23.6)**
Northbound Through/Right	C (24.2) [142]	C (23.6) [189]
Eastbound Approach	**D (44.1)**	**D (45.7)**
Eastbound Left	E (55.4) [99]	E (55.1) [112]
Eastbound Through	D (54.6) [117]	D (51.5) [103]
Eastbound Right	A (0.7) [46]	A (0.7) [0]
Southbound Approach	**B (17.3)**	**B (14.3)**
Southbound Left	B (17.7) [217]	B (15.2) [203]
Southbound Through	B (17.1) [193]	B (13.7) [168]
Westbound Approach	**C (26.9)**	**C (27.4)**
Westbound Left	E (56.1) [130]	E (56.8) [126]
Westbound Right	A (9.8) [146]	B (13.0) [146]
Overall Intersection	***C (24.9)***	***C (24.0)***
2. E 18th Street and Mainline N Walnut/E 18th Street (side-street stop)		
Northbound Left	A (8.5) [43]	A (8.3) [45]
Eastbound Approach	**B (13.5)**	**B (12.9)**
Eastbound Left	C (22.3) [33]	C (19.9) [33]
Eastbound Right	B (11.3) [53]	B (11.9) [57]
3. N Walnut Street and E 18th Street (side-street stop)		
Northbound Left/Right	A (9.0) [50]	A (8.9) [44]
Westbound Left	A (2.2) [12]	A (2.2) [12]
4. E 18th Street and Bardsley Rd/Old St James Rd (side-street stop)		
Northbound Left	C (19.1) [51]	C (19.3) [68]
Northbound Through/Right	C (19.9) [45]	B (13.3) [37]
Eastbound Left	A (1.6) [64]	A (1.9) [67]
Southbound Left/Through/Right	B (17.9) [78]	C (20.5) [83]
Westbound Left	A (8.0) [38]	A (7.9) [43]

2045 No Build Conditions

The same operational analysis methodology used for the 2020 existing conditions was again used to evaluate the 2045 no build conditions, with the Forecasted 2045 Horizon Year traffic volumes, as shown in **Exhibit 9**, applied to the existing roadway network. **Table 4** summarizes the 2045 no build operating conditions.

As shown, most of the study area approaches operate similarly to existing conditions during the 2045 no-build scenario. However, the southbound approach at the intersection of E 18th Street and Bardsley/Old St. James Road will experience a sharp decline in operational efficiency, degrading from LOS B to LOS E during the AM peak period, and from LOS C to LOS F during the PM peak period. The southbound approach struggles to find acceptable gaps in opposing traffic with the forecasted increase in traffic along E 18th Street.

Therefore, proposed geometric improvements to the study area should focus on the intersection of E 18th Street and Bardsley/Old St. James Road. The remaining study area intersections are forecasted to function similarly to existing conditions under the future no build conditions. If delay, safety, and driver comfort issues are addressed through geometric improvements at E 18th Street and Bardsley/Old St. James Road, the remaining study area intersections should function acceptably through the future horizon year of 2045 without any geometric or intersection control improvements.

Table 4. 2045 No Build Operating Conditions

Intersection Approach/Movement	LOS (Delay in seconds per vehicle) [95th Queue]	
	AM	PM
1. Hwy 63 and N Walnut Street/I-44 EB Exit Ramp (Signalized)		
Northbound Approach	**C (29.7)**	**C (30.3)**
Northbound Through/Right	C (29.7) [188]	C (30.3) [255]
Eastbound Approach	**D (49.6)**	**D (50.1)**
Eastbound Left	E (58.9) [112]	E (64.6) [140]
Eastbound Through	E (64.0) [133]	D (51.0) [129]
Eastbound Right	A (0.9) [53]	A (0.8) [53]
Southbound Approach	**C (24.4)**	**C (21.1)**
Southbound Left	C (29.6) [181]	C (29.0) [172]
Southbound Through	C (21.5) [244]	B (16.7) [209]
Westbound Approach	**C (28.1)**	**C (34.2)**
Westbound Left	E (57.5) [139]	E (60.3) [148]
Westbound Right	B (10.8) [210]	C (21.5) [275]
Overall Intersection	***C (29.9)***	***C (30.5)***
2. E 18th Street and Mainline N Walnut/E 18th Street (side-street stop)		
Northbound Left	A (9.0) [53]	A (8.8) [53]
Eastbound Approach	**C (17.0)**	**C (15.9)**
Eastbound Left	D (33.7) [37]	D (29.2) [39]
Eastbound Right	B (12.7) [53]	B (14.0) [57]
3. N Walnut Street and E 18th Street (side-street stop)		
Northbound Left/Right	A (9.1) [46]	A (9.1) [46]
Westbound Left	A (7.5) [13]	A (7.5) [18]
4. E 18th Street and Bardsley Rd/Old St James Rd (side-street stop)		
Northbound Left	D (28.5) [58]	D (31.1) [81]
Northbound Through/Right	D (33.7) [54]	D (29.7) [50]
Eastbound Left	A (8.7) [82]	A (8.6) [84]
Southbound Left/Through/Right	E (36.2) [117]	F (51.2) [115]
Westbound Left	A (8.3) [41]	A (8.2) [55]

Proposed Alternatives

As stated previously, the proposed alternatives should focus on the geometry of the intersection and alignment of Bardsley/Old St. James Road to improve driver comfort and safety. Alignment of Bardsley Road and Old St. James Road is necessary to correct safety issues caused by the unusual and offset nature of these two approaches at E 18th Street. This alignment can be accomplished by: moving Old St. James Road north/west, closer to the railroad tracks; moving Bardsley Road to the south/east to meet Old St. James Road; or splitting the difference. All three options would require right-of-way (ROW) acquisition and relocation of utility poles.

However, re-aligning both Bardsley Road and Old St. James Road to meet in the middle would likely require ROW acquisition in both the northwest and southeast quadrants of the intersection, whereas

only realigning one of the roads to meet the existing location of the other would likely limit the required ROW acquisition to one quadrant. Therefore, re-aligning both Bardsley Road and Old St. James Road to meet in the middle was not pursued further at this time.

The option to align Bardsley/Old St. James Road while maintaining the existing side-street intersection stop control was briefly analyzed. However, the resulting analysis was similar to the 2045 no-build operating conditions. The northbound and southbound approaches at E 18th Street and Bardsley/Old St. James Road will struggle to find acceptable gaps in opposing traffic with the forecasted increase in traffic along E 18th Street if traffic along E 18th Street is free-flowing. Therefore, side-street stop intersection control was not considered as a viable solution for any of the proposed alternatives.

The feasibility of signalizing the existing roadway configuration, without re-alignment was also briefly considered. The proximity of the railroad tracks to Bardsley/Old St. James Road coupled with the unusual geometry of the roadway network would require the eastbound approach to stop west of the railroad tracks. This in turn would require abnormally long yellow and red clearance times in order to safely allow vehicles to exit the intersection before the opposing approaches move into the intersection. The resulting queue lengths would be undesirable for the east and westbound approaches during the 2045 horizon year, even when tested with multiple phase configurations. Therefore, signalizing the existing intersection configuration was not considered as a viable solution.

Any proposed alternative for improvements to the intersection of E 18th Street and Bardsley/Old St. James Road must also take care to ensure traffic exiting E 18th Street onto N Walnut/E18th Street (Intersection 2) can still find acceptable gaps in the opposing traffic stream. Adjustments to intersection control at E 18th Street and Bardsley/Old St. James Road as part could change the existing traffic flow pattern along N Walnut/E 18th Street.

Three alternatives are proposed for improvements to the intersection of E 18th Street and Bardsley/Old St. James Road. Schematics of each alternative are shown in the Appendix.

1. Re-align Old St. James Road to meet the existing Bardsley Road approach (North Alignment) and install traffic signal intersection control with railroad preemption;
2. Re-align Bardsley Road to meet the existing Old St. James approach (South Alignment) and install traffic signal intersection control with railroad preemption;
3. Install a single lane roundabout at E 18th Street and Bardsley Road/Old St. James Road.

Alternative A: North Alignment of Bardsley/Old St. James Road (Signalized)

Alternative A re-aligns Old St. James Road to the north/west to align with Bardsley Road in its current location. This alternative would require some ROW acquisition of the industrial parcel north of E 18th Street and immediately adjacent to the railroad tracks. The parcel currently looks to be used for industrial storage. This north alignment would provide less than 50 feet of queuing space for vehicles between the eastbound stop bar at the intersection and the railroad buffer. Due to the tight spacing of the proposed intersection and the railroad tracks, no turn lanes are provided at the intersection approaches with the north alignment. This could mean that certain movements would be blocked by waiting vehicles while a train is present.

Alternative B: South Alignment of Bardsley/Old St. James Road (Signalized)

Alternative B re-aligns Bardsley Road to the south/east to align with Old St. James Road in its current location. Re-aligning Bardsley Road to the south would require ROW acquisition within the southeast quadrant of the intersection in addition to the acquisition of three buildings. Two of the buildings appear to be vacant or used for storage, while the other appears to house a carpet cleaning business. Re-aligning Bardsley Road to the south to meet Old St. James has the added benefit of moving the intersection as far away from the railroad tracks as possible, lessening concerns about queues interacting with the tracks. The South Alignment would provide approximately 135 feet between the eastbound approach stop bar and the railroad buffer. Since the intersection would be further away from the railroad tracks, dedicated turn lanes can be provided at each intersection approach. The northbound, eastbound, and westbound approaches will each have a dedicated left turn lane, while the southbound approach will have a dedicated right turn lane. Under this configuration, traffic flow could still be maintained for certain movements while a train is present.

Alternative C: Roundabout

Various roundabout designs were considered for implementation at the intersection. “Dog bone” or “dumbbell” roundabouts were considered, but would require some vehicles to cross the tracks twice with the railroad bisecting the intersection. There are no readily available examples of this type of roundabout implemented in conjunction with a railroad crossing in other places within the United States. Additionally, the National Cooperative Highway Research Program (NCHRP) Report 672 advises against designing new roundabouts with railroad tracks passing through the center.

Therefore, Alternative C proposes a traditional single lane roundabout east of the railroad tracks. The existing railroad gates would prevent vehicles from crossing the tracks from the west when a train is present. However, flow would not be constrained from entering the roundabout from the east. Stopped flow within the roundabout would prevent traffic from moving between the north, south, and west legs of the intersection while a train is present. This configuration is listed as one of the three most common roundabouts near at-grade rail crossing designs in NCHRP Report 672, and there are several instances of similar designs implemented across the country. The following locations contain similar roundabout near rail crossing layouts:

- Intersection of 11th Street and Lindsey Street in Columbus, Indiana
- Intersection of East 4th Avenue and Channelside Drive in Tampa, Florida
- Intersection of East Connelly Blvd and South Dock Street in Sharon, Pennsylvania

Alternatives Analysis

The same operational analysis methodology used for the 2020 existing conditions and 2045 no build conditions was again used to evaluate the proposed alternatives, with one exception. The queueing analysis for each alternative was conducted using Synchro 10 instead of Sim Traffic, as was done for the existing and no-build analyses. Since each alternative proposes aligning Bardsley/Old St. James Road in some fashion, there is no longer a need for complex modeling to accurately capture forecasted conditions at the intersection of E 18th Street and Bardsley/Old St. James Road. Each alternative was analyzed for the 2025 construction year using traffic volumes shown in **Exhibit 8**, and for the 2045 horizon year using traffic volumes shown in **Exhibit 9**.

Alternative A: North Alignment of Bardsley/Old St. James Road (Signalized)

Table 5 and **Table 6** depict Alternative A (North Alignment) operating conditions for the 2025 construction year and 2045 horizon year, respectively. As shown, Alternative A would function with acceptable levels of service on all intersection approaches through both the construction and horizon years. Additionally, based on a brief Sim Traffic simulation, Alternative A would not prevent cars from exiting E 18th Street onto N Walnut/E18th Street (Intersection 2) due to the change in intersection control at E 18th Street and Bardsley/Old St. James Road. However, the North Alignment would provide less than 50 feet of queuing space for vehicles between the eastbound stop bar at the intersection and the railroad buffer. The eastbound approach queues greatly exceed this distance in both peak periods of the construction and horizon years, and would extend past the railroad crossing, creating a potentially hazardous condition for drivers when a train is present. Therefore, Alternative A is not recommended for consideration as a viable intersection improvement alternative.

Table 5. Alternative A 2025 Construction Year Operating Conditions

Intersection Approach/Movement	LOS (Delay in seconds per vehicle) [95th Queue]	
	AM	PM
E 18th Street and Bardsley Rd/Old St James Rd		
Northbound Approach	B (16.3) [65]	B (17.9) [95]
Eastbound Approach	B (15.5) [153]	B (16.0) [192]
Westbound Approach	B (10.4) [95]	B (10.7) [102]
Southbound Approach	A (8.3) [31]	B (10.8) [58]
Overall Intersection	**B (12.8)**	**B (13.8)**

Table 6. Alternative A 2045 Horizon Year Operating Conditions

Intersection Approach/Movement	LOS (Delay in seconds per vehicle) [95th Queue]	
	AM	PM
E 18th Street and Bardsley Rd/Old St James Rd		
Northbound Approach	C (22.0) [92]	C (25.6) [144]
Eastbound Approach	B (18.8) [237]	B (18.9) [258]
Westbound Approach	B (10.9) [135]	B (11.2) [125]
Southbound Approach	A (9.9) [37]	B (15.2) [90]
Overall Intersection	**B (15.1)**	**B (17.0)**

Alternative B: South Alignment of Bardsley/Old St. James Road (Signalized)

Table 7 and **Table 8** depict Alternative B (South Alignment) operating conditions for the 2025 construction year and 2045 horizon year, respectively. As shown, Alternative B would function with acceptable levels of service on all intersection approaches through both the construction and horizon years. Additionally, based on a brief Sim Traffic simulation, Alternative B would not prevent cars from exiting E 18th Street onto N Walnut/E18th Street (Intersection 2) due to the change in intersection control at E 18th Street and Bardsley/Old St. James Road. The South Alignment would provide approximately 135 feet between the eastbound approach stop bar and the railroad buffer. The eastbound approach queues are all less than 135 feet, with the exception of the 2045 PM peak maximum queue, which is 145 feet. The maximum eastbound approach queue is only forecasted to be present for up to 5% of the peak hour. However, if a train was present during this time, drivers could potentially be put in a hazardous situation.

Table 7. Alternative B 2025 Construction Year Operating Conditions

Intersection Approach/Movement	LOS (Delay in seconds per vehicle) [95th Queue]	
	AM	PM
E 18th Street and Bardsley Rd/Old St James Rd		
Northbound Approach	**B (11.1)**	**B (11.3)**
Northbound Left	B (13.0) [27]	B (13.2) [45]
Northbound Through/Right	A (10.0) [31]	A (9.0) [33]
Eastbound Approach	**B (11.5)**	**B (11.2)**
Eastbound Left	A (8.4) [25]	A (9.5) [33]
Eastbound Through/Right	B (12.1) [98]	B (11.6) [105]
Westbound Approach	**B (10.7)**	**B (10.3)**
Westbound Left	A (6.8) [9]	A (7.4) [12]
Westbound Through/Right	B (11.0) [77]	B (10.6) [74]
Southbound Approach	**A (6.9)**	**A (7.6)**
Southbound Left/Through	B (12.5) [21]	B (11.9) [34]
Southbound Right	A (5.0) [16]	A (4.6) [19]
Overall Intersection	**B (10.5)**	**B (10.4)**

Table 8. Alternative B 2045 Horizon Year Operating Conditions

Intersection Approach/Movement	LOS (Delay in seconds per vehicle) [95th Queue]	
	AM	PM
E 18th Street and Bardsley Rd/Old St James Rd		
Northbound Approach	**B (13.2)**	**B (13.6)**
Northbound Left	B (15.6) [36]	B (16.3) [62]
Northbound Through/Right	B (11.8) [42]	B (10.6) [43]
Eastbound Approach	**B (12.2)**	**B (11.9)**
Eastbound Left	A (9.1) [31]	A (10.0) [44]
Eastbound Through/Right	B (12.8) [124]	B (12.3) [145]
Westbound Approach	**B (10.9)**	**B (10.6)**
Westbound Left	A (6.7) [10]	A (7.6) [15]
Westbound Through/Right	B (11.1) [95]	B (10.9) [98]
Southbound Approach	**A (7.9)**	**A (8.9)**
Southbound Left/Through	B (14.9) [28]	B (14.3) [46]
Southbound Right	A (5.6) [17]	A (5.1) [23]
Overall Intersection	**B (11.2)**	**B (11.2)**

Alternative C: Roundabout

Table 9 and **Table 10** depict Alternative C (Roundabout) operating conditions for the 2025 construction year and 2045 horizon year, respectively. As shown, Alternative C would function with acceptable levels of service on all intersection approaches through both the construction and horizon years. Additionally, based on a brief Sim Traffic simulation, Alternative C would not prevent cars from exiting E 18th Street onto N Walnut/E18th Street (Intersection 2) due to the change in intersection control at E 18th Street and Bardsley/Old St. James Road. Alternative C would provide approximately 80 feet between the eastbound approach stop bar and the railroad buffer. The eastbound approach maximum queues are all less than 75 feet, which means the forecasted maximum queue values are not expected to interact with the upstream railroad crossing.

Table 9. Alternative C 2025 Construction Year Operating Conditions

Intersection Approach/Movement	LOS (Delay in seconds per vehicle) [95th Queue]	
	AM	PM
E 18th Street and Bardsley Rd/Old St James Rd		
Northbound Approach	A (5.9) [25]	A (6.1) [25]
Eastbound Approach	A (7.2) [50]	A (7.3) [50]
Westbound Approach	A (7.0) [50]	A (6.9) [50]
Southbound Approach	A (6.8) [25]	A (6.6) [25]
Overall Intersection	**A (7.0)**	**A (6.9)**

Table 10. Alternative C 2045 Horizon Year Operating Conditions

Intersection Approach/Movement	LOS (Delay in seconds per vehicle) [95th Queue]	
	AM	PM
E 18th Street and Bardsley Rd/Old St James Rd		
Northbound Approach	A (6.8) [25]	A (7.5) [25]
Eastbound Approach	A (8.6) [75]	A (9.0) [75]
Westbound Approach	A (8.5) [50]	A (8.6) [50]
Southbound Approach	A (8.1) [25]	A (8.3) [25]
Overall Intersection	**A (8.3)**	**A (8.5)**

Conclusions

Lochmueller Group has completed the preceding study to evaluate improvement alternatives near the intersection of E 18th Street and Bardsley/Old St. James Road in Rolla, Missouri. The traffic evaluation resulted in the following conclusions:

- Safety conditions are compromised by the unusual geometry of the roadway at the intersection of E 18th Street and Bardsley/Old St. James Road. Crashes are closely clustered at this intersection, and the prevailing rear end and head on crashes indicate the existing roadway configuration is a large contributing factor.
- Under existing conditions, the study area intersections function at acceptable levels of service with all approaches operating at a LOS C or better, excluding the eastbound approach of the intersection of Hwy 63 and North Walnut Street/I-44 EB Exit Ramp, which operates at a LOS D.
- It is likely that the unconventional geometry of the off-set intersection at E 18th and Bardsley/Old St. James Road makes drivers feel like they experience more delay than is typical since they traverse the intersection with heightened awareness.
- During the 2045 no-build conditions, most of the study area approaches operate similarly to existing conditions. However, the southbound approach at the intersection of E 18th Street and Bardsley/Old St. James Road will experience a sharp decline in operational efficiency, degrading from LOS B to LOS E during the AM peak period, and from LOS C to LOS F during the PM peak period. Therefore, proposed geometric improvements to the study area should focus on the intersection of E 18th Street and Bardsley/Old St. James Road.
- Three alternatives are proposed for improvements to the intersection of E 18th Street and Bardsley/Old St. James Road.
    1. Re-align Old St. James Road to meet the existing Bardsley Road approach (North Alignment) and install traffic signal intersection control with railroad preemption;
    2. Re-align Bardsley Road to meet the existing Old St. James approach (South Alignment) and install traffic signal intersection control with railroad preemption;
    3. Install a single lane roundabout at E 18th Street and Bardsley Road/Old St. James Road.
- Alternative A is not recommended for consideration as a viable intersection improvement alternative due to the eastbound approach queues greatly exceeding the available space between the eastbound stop bar and the railroad buffer.
- A comparison of Alternatives 2 and 3 is shown in **Table 11**.
- Either Alternative B or Alternative C are acceptable for implementation at the intersection of E 18th Street and Bardsley/Old St. James Road.

- Due to the sustained continuous vehicle flow and minimized eastbound approach queueing, Lochmueller Group recommends Alternative C for implementation at the intersection of E 18th Street and Bardsley/Old St. James Road.

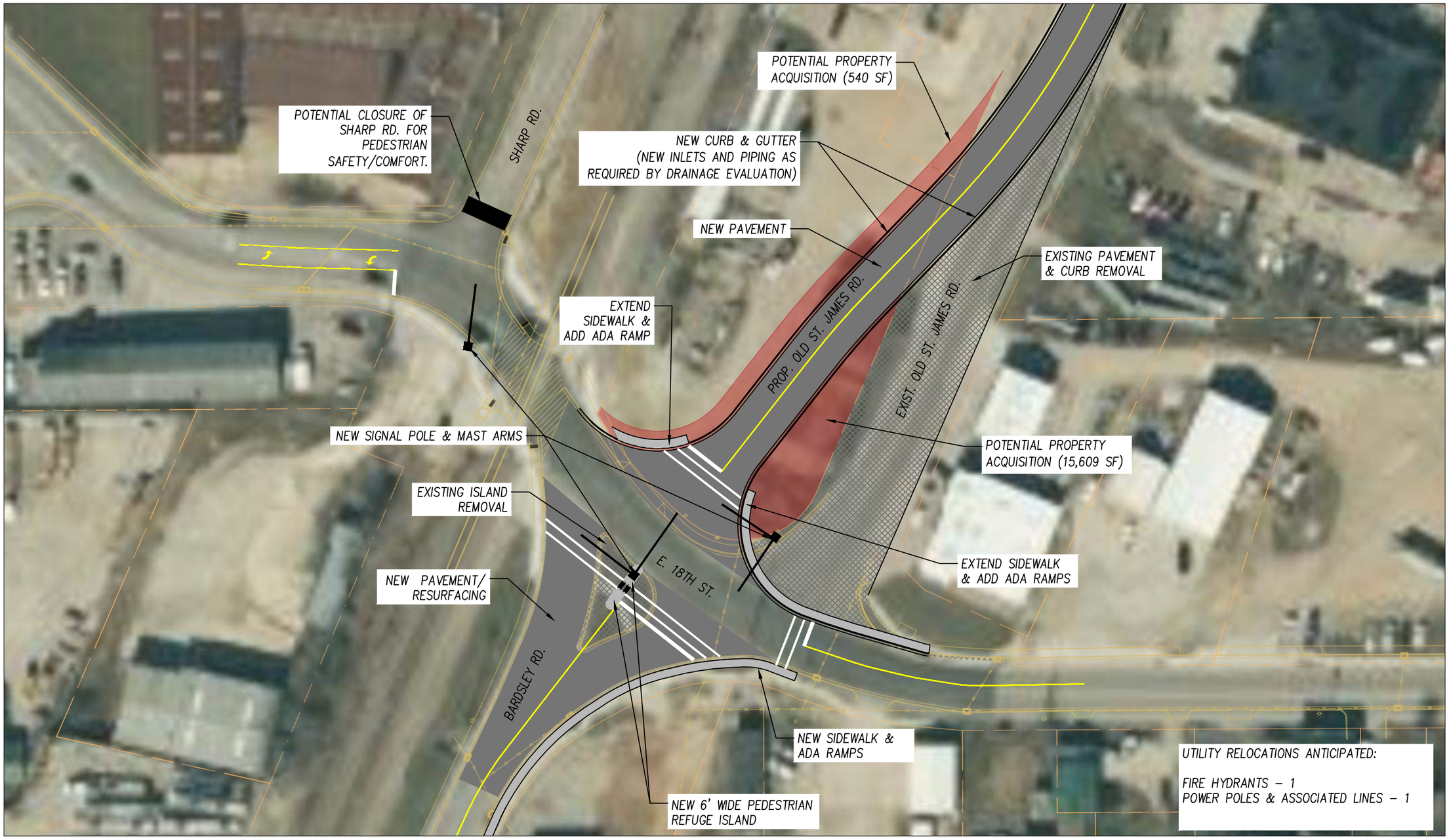
Table 11. Alternative B and Alternative C Comparison

	Alternative B (South Alignment)	Alternative C (Roundabout)
Overall Intersection Delay	Non-continuous flow. All approaches must stop during each cycle. Inherently more delay.	Maintains continuous flow through the intersection, except when train present.
Eastbound Approach Queueing	Maximum forecasted queues slightly exceed provided spacing between intersection and railroad tracks during the 2045 Horizon Year PM peak. Interaction between queue and train possible during up to 5% of the 2045 PM peak hour.	Maximum forecasted queues within provided spacing between intersection and railroad tracks. No interaction anticipated between queues and trains.
Impacts by Train	Dedicated turn lanes allow some movements to maintain flow through the intersection even when a train is present.	Intersection may be blocked by waiting vehicles when a train is present.
Planning Level Opinion of Cost	Approx. $1.0 – 1.5M	Approx. $1.3 – 1.7M*
Required ROW Acquisition	Required ROW acquisition within the southeast quadrant of the intersection in addition to the acquisition of three buildings.	Required ROW acquisition in northwest and southeast quadrants of the intersection. No buildings require acquisition.

** Based on TRB annual meeting presentation "States' Practices on Roundabout Selection, Design, and Performance Analysis" (2016) cost for single-lane roundabout escalated to 2021*

Appendix

Alternative A Schematic
Alternative B Schematic
Alternative C Schematic



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Rev.	Description	Date

Designed: KSD
Drawn: KSD
Checked: CS
Date: 6/02/2021
Scale: AS SHOWN
Proj. No.: 5200093

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Department of Public Works
901 North Elm Street
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18th Street & Bardsley Inter. Improv.
City of Rolla Public Works Department

18th Street Concept Plan A

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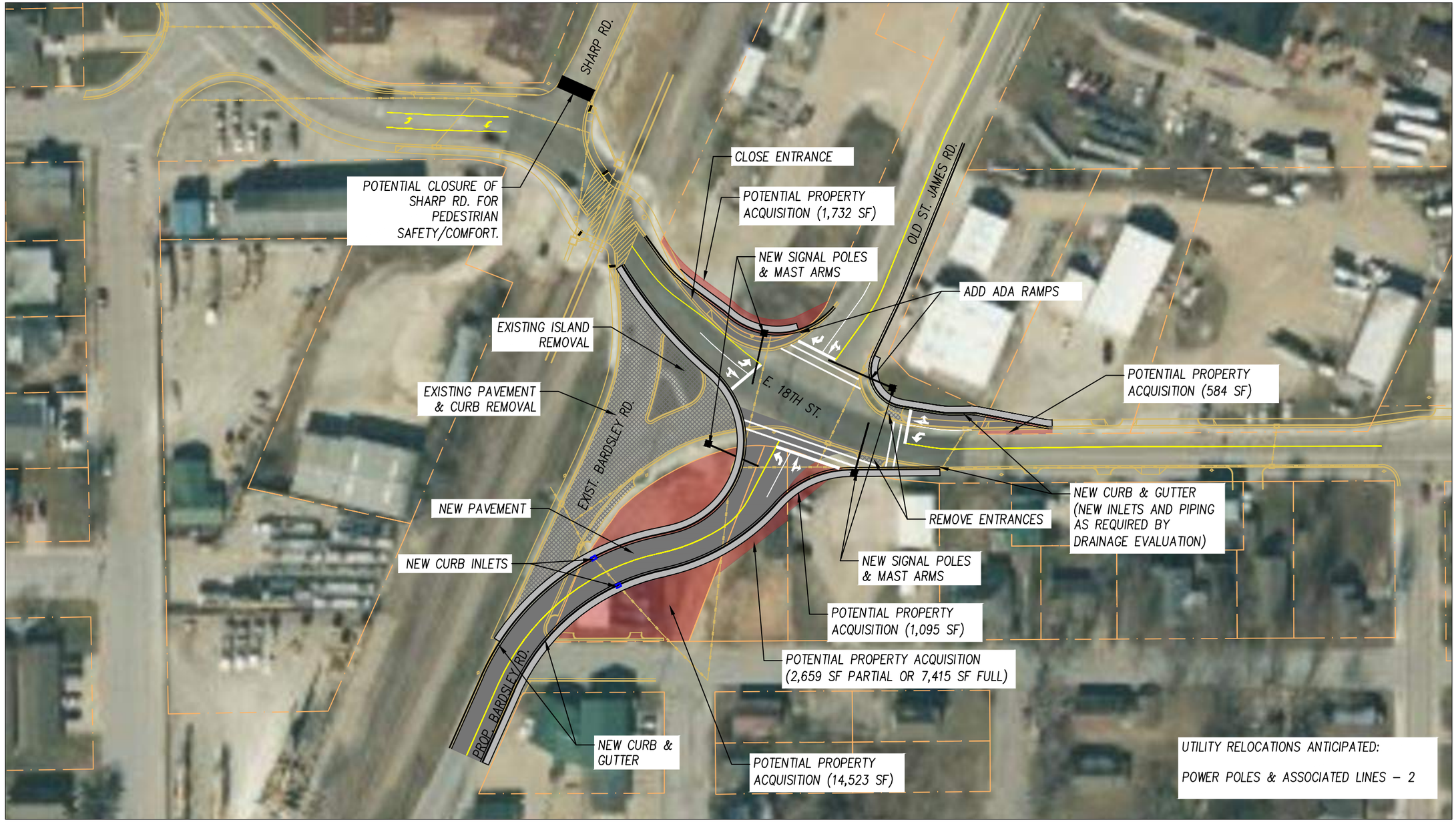

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18th Street Concept Plan B

Sheet No.: 2

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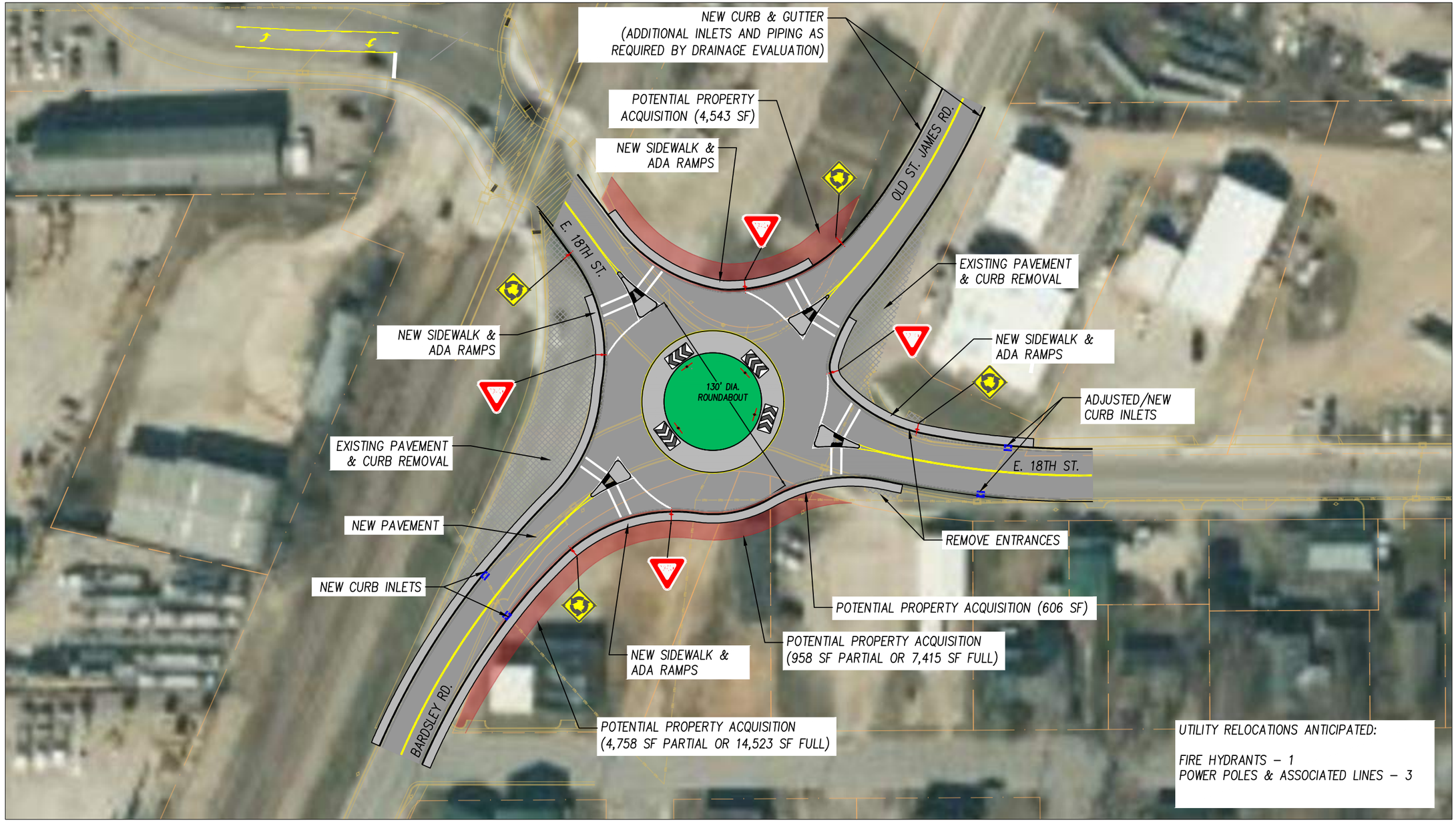

30' 0 30' 60'

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18th Street Concept Plan C

Sheet No.: 1

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