May 31, 2023

Mr. Tim Crockett. P.E.
Crockett Engineering
1000 West Nifong Boulevard, Building 1
Columbia, MO 65203

RE: Traffic Impact Study – Industrial/Warehouse Site
Boone County, Missouri
CBB Job No. 017-23

Dear Mr. Crockett:

As requested, CBB has completed a traffic impact study pertaining to a proposed warehouse building in Boone County, Missouri, just south of Hallsville. The proposed development is located along the east side of Route B just south of Parks Lane. The location of the site relative to the surrounding area is depicted in **Figure 1**.

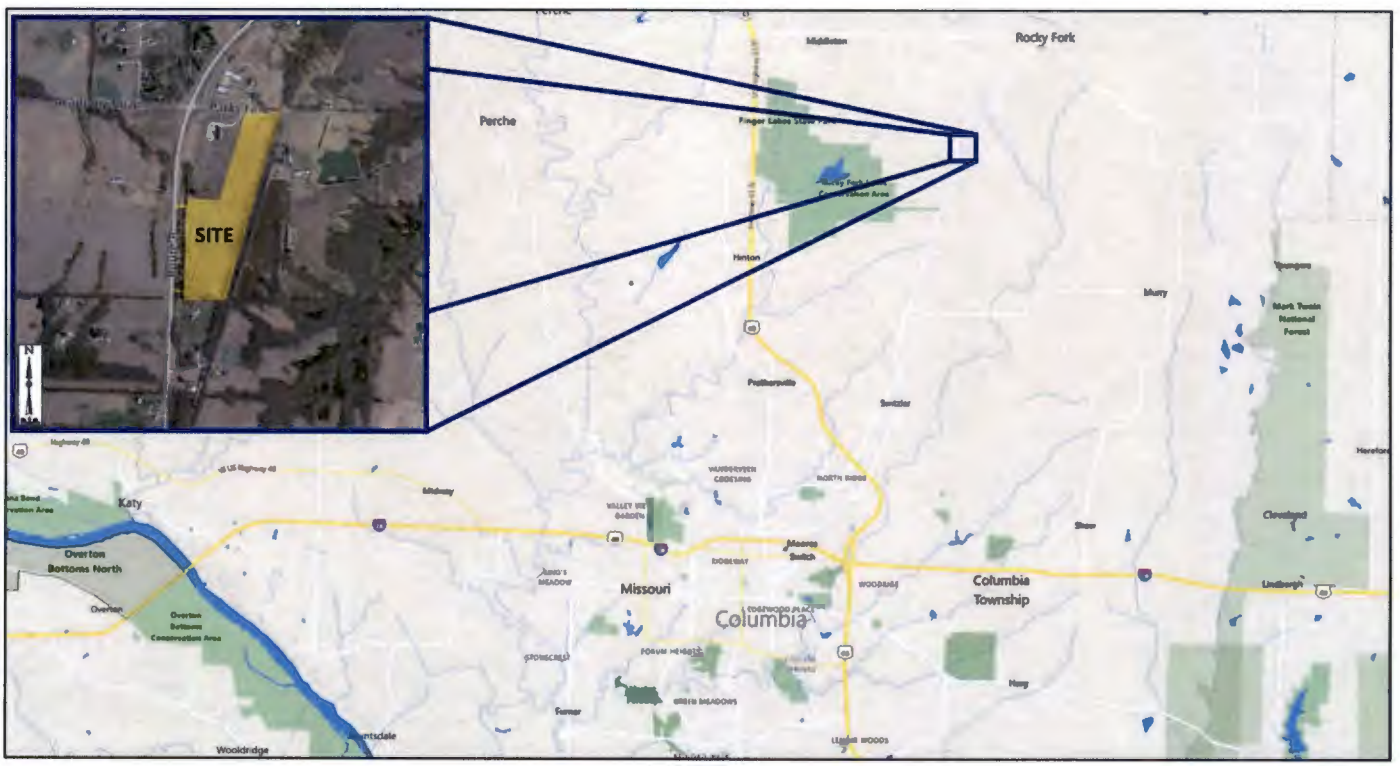

Figure 1: Project Location Map

Based on the latest site plan provided by Crockett Engineering, the proposed development will include an approximate 250,000 square feet (SF) industrial/warehouse building. Access is proposed via a single new access drive on Route B with an emergency access drive provided off Parks Lane. A schematic of the concept plan provided is shown in **Exhibit 1**.

It is important to note that Route B is "limited access" which means any new access drives are held to a higher examination including any benefit to the existing roadway network and a detailed safety analysis.

The purpose of this study was to determine the number of additional trips that would be generated by the proposed development, assign the trips to the adjoining roadways, evaluate the impact of the additional trips on the operating conditions for the adjacent roadways, and determine the ability of motorists to safely enter and exit the site. If necessary, roadway improvements (lane additions and/or traffic control modifications) would be recommended to mitigate the impact of the development and to accommodate the additional traffic. The focus of this study was the AM and PM peak hours of a typical weekday.

CBB discussed the scope of work for this traffic study with the Missouri Department of Transportation (MoDOT) and Boone County at the commencement of the traffic study process. CBB also provided MoDOT and Boone County a Technical Memo summarizing the proposed site trip generation and directional distribution estimates and gained their consensus on the assumptions prior to completing the traffic analyses.

As requested, the following intersections were included in the study:

- Route B and Academy Road/Parks Lane; and
- Route B and Proposed Site Drive.

As requested, the following analysis scenarios were evaluated for the weekday AM and PM peak hours:

- Existing Conditions (2022 Traffic Count); and
- Build Conditions (Existing plus proposed site trips).

The following report presents the methodology and findings relative to the Existing and Build conditions.

Exhibit 1: Preliminary Site Plan (provided by others)

Job# 017-23
05/31/2023

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EXISTING CONDITIONS

Area Roadway System: Route B is a north-south, minor arterial roadway owned by MoDOT. Within the study area, Route B provides two travel lanes, one lane in each direction, and connects the City of Columbia on the south to the City of Hallsville on the north. Route B has a posted speed limit of 60 miles per hour (mph). Shoulders are provided along Route B within the study area; however, sidewalks and marked bike lanes are not provided along the roadway.

Parks Lane is a local, two-lane roadway that runs east/west within the study area. Parks Lane consists of two travel lanes, one lane in each direction. It provides access from Route B to a few residential properties and a church to the east. There are no sidewalks, shoulders, or marked bike lanes on Parks Lane. There is a railroad crossing approximately one-fourth mile east of Route B where Parks Lane ends at a couple residential drives.

Academy Road is a local, east-west roadway owned by Boone County. Academy Road consists of two-lanes (one lane in each direction) within the study area. It provides access from Route B to nearby residential properties and eventually connects to Route 124 via Caldwell Road. Shoulders, sidewalks, and marked bike lanes are not provided along the roadway. Academy Road has a posted speed limit of 40 mph.

The intersection of Route B and Parks Lane/Academy Road is currently controlled as a side-street STOP with Route B having the right-of-way. Each approach provides one shard lane, with the westbound Parks Lane approach also providing a channelized right turn. **Figure 2** provides an aerial view of the Route B and Parks Lane/Academy Road intersection.

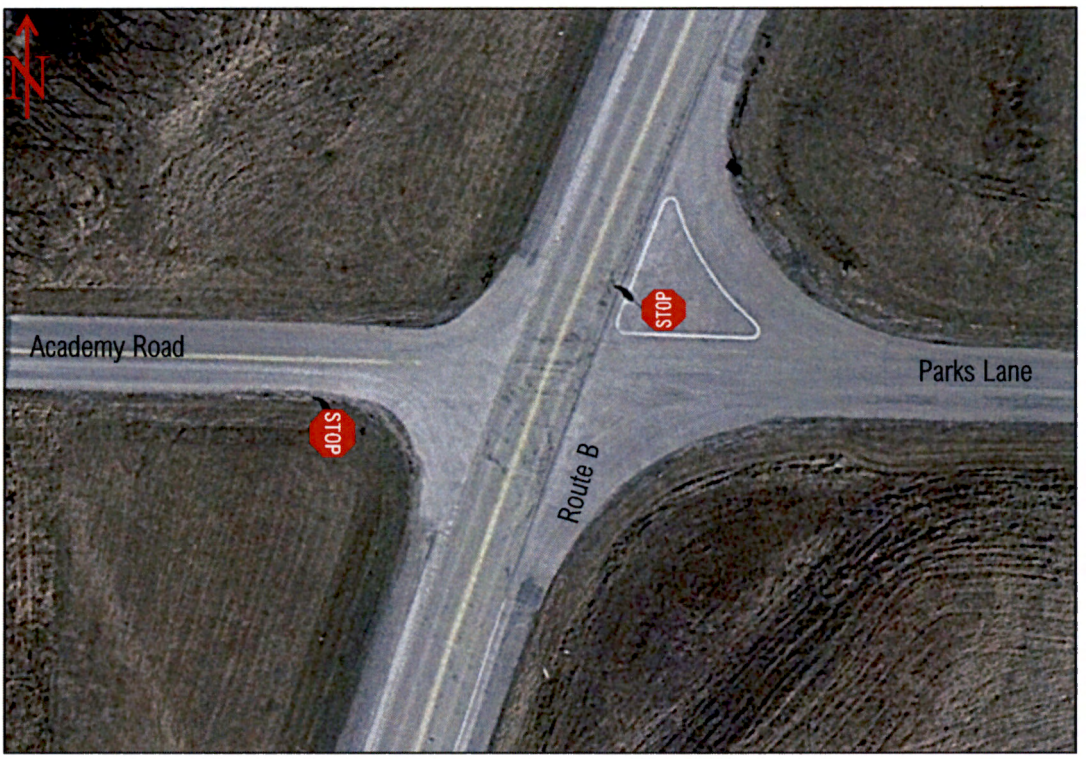

Figure 2: Route B and Parks Lane/Academy Road Intersection

Existing Traffic Volumes: To establish existing traffic conditions, video traffic counts were conducted at the intersection of Route B and Academy Road/Parks Lane during the weekday morning (6:00 - 9:00 a.m.) and afternoon (3:00 - 6:00 p.m.) peak periods on Thursday, October 27, 2022.

To better understand the existing truck traffic in the area, the number of heavy trucks, light trucks and buses was also counted at the intersection. The existing weekday AM and PM peak hour traffic volumes are summarized in **Exhibit 2**. The area schools were in session and there were no wet weather conditions.

Based on the traffic data collected, the morning peak hour occurred between 7:00 and 8:00 a.m. and the afternoon peak hour occurred between 4:45 and 5:45 p.m. Given the traffic characteristics in the area and the anticipated trip generation for the proposed development, the weekday AM and PM peak periods would likely represent a "worst-case scenario" with regards to the traffic impact. If traffic operations are acceptable during these peak periods, it can be reasoned that conditions would be acceptable throughout the remainder of the day.

Exhibit 2: Existing Traffic Volumes

Job# 017-23
05/31/2023

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PROPOSED SITE

Proposed Land Use: Based upon the concept plan provided by Crockett Engineering, previously shown in Exhibit 1, the proposed development would include an approximate 250,000 square foot (SF) industrial/warehouse building. Note that the site plan currently depicts a 210,000 SF building, but 250,000 SF was assumed as the actual building size is still in fluctuation.

Site Access: As shown on the concept plan, access is proposed via a single new access drive on Route B with an emergency access drive provided off Parks Lane.

Intersection Sight Distance: The sight distance for the proposed site drive on Route B was reviewed with respect to the guidelines found in MoDOT's Engineering Policy Guide, Section 941.7 which is based the guidelines found in *A Policy on Geometric Design of Highways and Streets* published by the American Association of State Highway and Transportation Officials (AASHTO), commonly referred to as the Green Book. Adequate sight distance is necessary at intersections to allow drivers to perceive potentially conflicting vehicles and allow those motorists sufficient time to adjust their speed to avoid a collision or make a choice of when to cross or enter the mainline traffic flow. All drivers approaching or stopped at the intersection should have an unobstructed view of the entire intersection so that potential collisions can be avoided.

The Green Book's guidelines for minimum safe sight distance for entrances reflect the design speed of the major road and the gap time required for a vehicle on the minor road to enter or cross the major road. The intersection sight distance is computed according to the following formula:

*ISD = 1.47*Design Speed (mph)*Design Gap (sec)*

A design speed of 65 mph (60 mph posted + 5 mph) was used for Route B. The minimum design gap time for a passenger car is typically assumed to be 7.5 seconds plus 0.5 seconds for each additional lane crossing with a design gap for a semi-truck assumed to be 11.5 seconds plus 0.7 seconds for each additional lane crossing. Based on these criteria, the recommended Intersection Sight Distance (ISD) for the proposed site drive on Route B is 765 feet for a passenger vehicle and 1,170 feet for a semi-truck.

Given the exact location of the proposed site drive is unknown at this time, the sight distance was not measured in the field. Due to the flat grade and lack of nearby foliage, the driveway should be able to be located to meet sight distance requirements. However, it is recommended the site design engineer verify adequate sight distance is provided at the proposed site drive.

Furthermore, careful consideration should be given to sight distance obstructions when planning any future aesthetic enhancements, such as berms, fencing and landscaping, at any of the subdivision entrances to ensure that these improvements do not obstruct the view of

entering and exiting traffic at the site intersections with the public roads. It is generally recommended that all improvements wider than two inches (posts, tree trunks, etc.) and higher than 3.5 feet above the elevation of the nearest pavement edge be held back at least 20 feet from the traveled roadway.

Trip Generation: Forecasts were prepared to estimate the amount of traffic the proposed industrial/warehouse use will generate during the weekday AM and PM peak periods. These forecasts were based upon information provided in the 11th Edition of the *Trip Generation Manual,* published by the Institute of Transportation Engineers (ITE). This manual, which is a standard resource for transportation engineers, is based on a compilation of nationwide studies documenting the characteristics of various land uses. The most appropriate ITE land use for the proposed development is Land Use: 150 – Warehouse which also provides truck trip rates.

Based upon the recommended procedure for estimating trip generation outlined in the *Trip Generation Handbook, 3rd Edition,* also published by ITE, the regression equation was used for the AM and PM peak hours. The peak hour of adjacent street traffic (one hour between 7 and 9 AM) was utilized for the AM peak hour and the peak hour of adjacent street traffic (one hour between 4 and 6 PM) was utilized for the PM peak hour trip generation.

It is important to note that our prior studies at industrial parks also correlates well with the truck trip estimates provided in the ITE *Trip Generation Manual* for the AM and PM commuter peak hours. However, the AM and PM peak hour of generator for Land Use 150 yields higher truck estimates which is expected since most of the truck activity occurs between 9 a.m. and 4 p.m. which is outside the traditional peak hours.

Table 1 summarizes the truck trip estimates for the traditional peak hours and the peak hour of generator. As shown, the truck trips are higher outside the traditional AM and PM commuter peak hours. Reviewing the traffic count data collected on Route B, the AM commuter peak hour traffic volumes (7:00-8:00 AM) are significantly higher than the off-peak morning hours, but the PM commuter peak hour traffic volumes are fairly consistent throughout the afternoon hours. As such, in an effort to be conservative and design the site entrances for the maximum trucks anticipated in an hour, the truck trip estimates based on the AM and PM peak hour of generator for Land Use 150 were used in the analysis.

Table 1: TRUCK Trip Estimate

Time Period	Size	Truck Trips		
		In	Out	Total
ITE Land Use 150 - Warehouse				
AM Peak (7-9 AM)	250,000 SF	3	2	5
AM Peak Hour of Generator	250,000 SF	6	10	16
PM Peak (4-6 AM)	250,000 SF	4	4	8
PM Peak Hour of Generator	250,000 SF	7	6	13

The trip generation forecast for the proposed warehouse/industrial building is shown in **Table 2**. As shown, the proposed development would be expected to generate 53 total trips during the weekday AM peak hour and 57 total trips during the weekday PM peak hour with 16 truck trips in the AM peak hour and 13 truck trips in the PM peak hour.

Table 2: Trip Estimate

Land Use	Size	Daily Trips	Weekday AM Peak Hour			Weekday PM Peak Hour		
			In	Out	Total	In	Out	Total
ITE Land Use 150 - Warehouse								
Warehouse Building	250,000 SF	433	41	12	53	16	41	57
	Auto Trips	283	35	2	37	9	35	44
	Truck Trips	150	6	10	16	7	6	13

Trip Distribution: Due to their varying characteristics (origins and destinations), truck and passenger vehicle trips were assigned to the road system differently. Given the site's proximity to the closest major highway (I-70) and various population centers, it was concluded that truck traffic would be more oriented to and from the south (I-70), while passenger vehicles would be slightly more equally distributed to the local roadway system, though still predominately to and from the south as Columbia would be the largest population center. The specific directional distribution assumptions are summarized in **Table 3**.

Table 3: Trip Distribution Assumptions

Direction of Travel	Passenger Cars	Trucks
To/from the south on Route B	75%	90%
To/from the north on Route B	25%	10%

The site-generated trips were assigned to the adjacent roadway for the weekday AM and PM peak hours and are shown in **Exhibit 3.**

Build Traffic Volumes (Existing plus Site Trips): The assigned traffic volumes resulting from the trip distribution for the proposed site (Exhibit 3) were added to the Existing traffic volumes (Exhibit 2) to determine the total volumes in the forecasted scenario. The forecasted, or Build, traffic volumes for the weekday AM and PM peak hours are shown in **Exhibit 4.**

Exhibit 3: Site-Generated Trips

Job# 017-23
05/31/2023

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Exhibit 4: Build Traffic Volumes

Job# 017-23
05/31/2023

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TRAFFIC ANALYSIS

Study Procedures: The Existing and Build operating conditions were analyzed using SYNCHRO 11, a macro-level analytical traffic flow model. SYNCHRO is based on study procedures outlined in the *Highway Capacity Manual*, published by the Transportation Research Board. This manual, which is used universally by traffic engineers to measure roadway capacity, establishes six levels of traffic service: Level A ("Free Flow"), to Level F ("Fully Saturated"). Levels of service (LOS) are measures of traffic flow, which consider such factors as speed, delay, traffic interruptions, safety, driver comfort, and convenience. Level C, which is normally used for highway design, represents a roadway with volumes ranging from 70% to 80% of its capacity. However, Level D is often considered acceptable for peak period conditions in urban and suburban areas.

The thresholds that define level of service at an intersection are based upon the type of control used (i.e., whether it is signalized or unsignalized) and the calculated delay. For signalized and all-way stop intersections, the average control delay per vehicle is estimated for each movement and aggregated for each approach and then the intersection as a whole. At intersections with partial (side-street) stop control, delay is calculated for the minor movements only since motorists on the main road are not required to stop.

Level of service is directly related to control delay. At signalized intersections, the level of service criteria differ from that at unsignalized intersections primarily because varying transportation facilities create different driver expectations. The expectation is that a signalized intersection is designed to carry higher traffic volumes, and consequently may experience greater delay than an unsignalized intersection. **Table 4** summarizes the thresholds used in the analysis for signalized and unsignalized intersections.

Table 4: Level of Service Thresholds

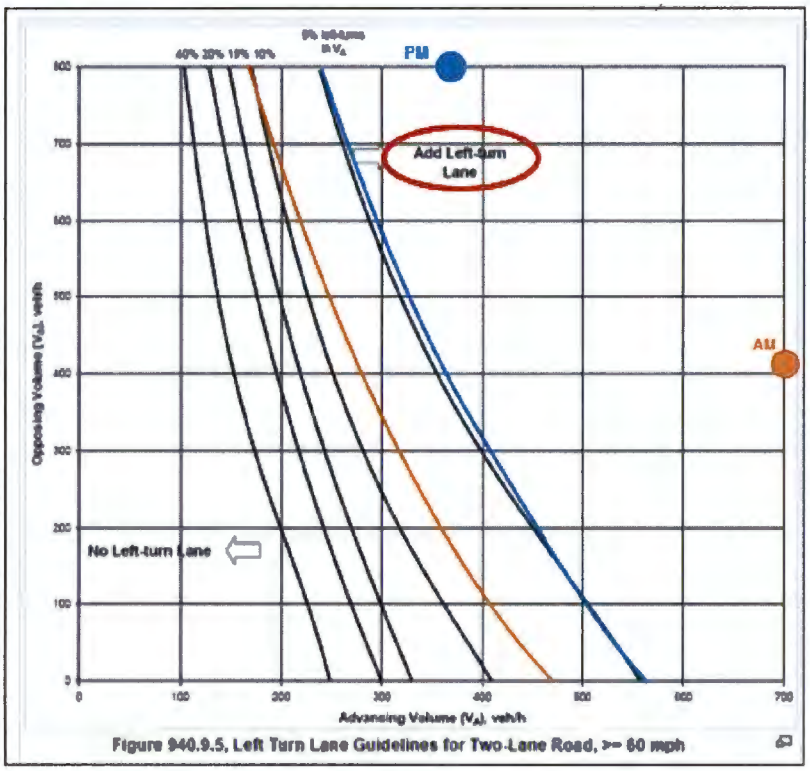
LEVEL OF SERVICE (LOS)	CONTROL DELAY PER VEHICLE (SEC/VEH)	
	SIGNALIZED INTERSECTIONS	UNSIGNALIZED INTERSECTIONS
A	≤ 10	0-10
B	> 10-20	> 10-15
C	> 20-35	> 15-25
D	> 35-55	> 25-35
E	> 55-80	> 35-50
F	> 80	> 50

Auxiliary Left-Turn Lane Warrant: The need for a southbound left-turn lane on Route B at the proposed site drive was evaluated using the *Left-Turn Guidelines for Two-lane Roadway* nomograph which is based on criteria using MoDOT's Access Management Guidelines (AMG). The MoDOT criteria provides guidelines for separate left-turn lanes on the through roadway by comparing the total advancing volume (which includes all turning traffic) to the total opposing volume (which includes opposing through and right-turn movements) during the design hour with respect to the number of mainline left-turns. Then, the percentage of left-turns is determined by dividing the number of left-turns by the total advancing volume. If the point lies to the right of the percentage line, then a left-turn lane should be considered. If the point is to the left of the line, then a left-turn lane is not necessary. Since the posted speed on Route B is 60 mph, the >=60 mph nomograph was used.

Figure 3 graphically illustrates the southbound left-turn evaluation on Route B at the proposed site drive assuming the Build traffic volumes during the weekday AM and PM peak hours. As can be seen in Figure 3, a separate southbound left-turn lane is warranted on Route B at the proposed site drive.

Auxiliary Right-Turn Lane Warrant: The need for northbound right-turn lane on Route B at the proposed site drive was evaluated using the *Right-Turn Guidelines for Two-Lane Roadway* nomograph which is based on criteria from MoDOT's AMG criteria. The MoDOT AMG provides guidelines for separate right-turn lanes on the through roadway by comparing the total advancing volume (which includes all turning traffic) to the number of mainline right-turns. The operating speed (posted speed limit) of the major roadway is used to determine if a right-turn lane is warranted. If the point lies to the right of the operating speed line, then a right-turn lane should be considered. Route B has a posted speed of 60 mph, so the >=60 mph graph line was used.

Figure 4 graphically illustrates the northbound right-turn evaluation on Route B at the proposed site drive assuming the Build traffic volumes. As can be seen in Figure 4, a separate northbound right-turn lane is warranted on Route B at the proposed site drive.



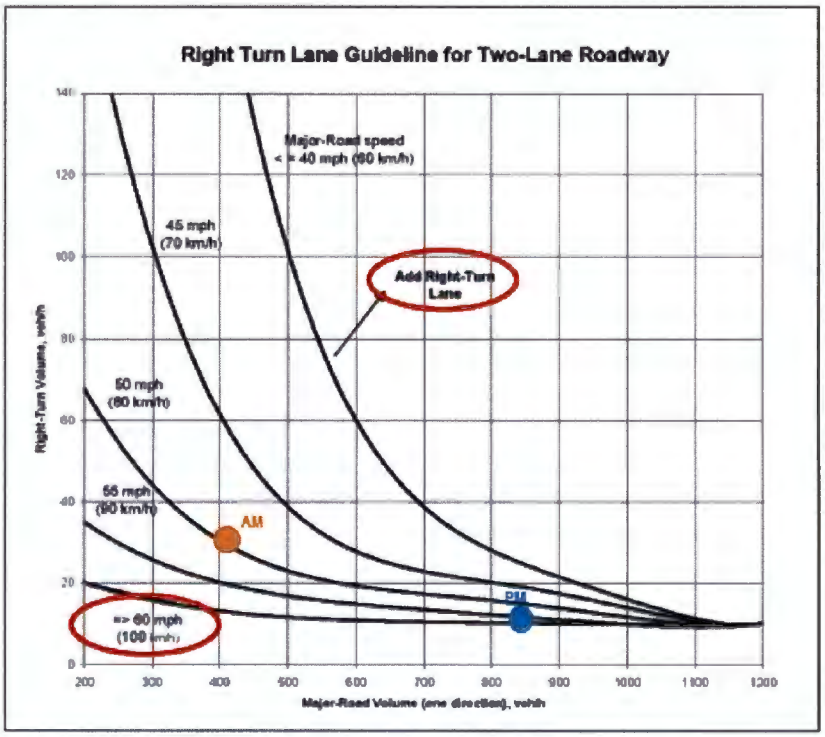
Posted Speed = 60 mph
Design Speed = 65 mph

Route B at
Proposed Site Drive

AM Peak Hour
Va = 895 vph
Vo = 402 vph
LT = <5%

PM Peak Hour
Va = 362 vph
Vo = 842 vph
LT = <5%

Figure 3: Southbound Route B Left-Turn Warrant at Site Drive – Build Conditions



Posted Speed = 60 mph
Design Speed = 65 mph

Route B at
Proposed Site Drive

AM Peak Hour
Va = 402 vph
RT = 31 vph

PM Peak Hour
Va = 842 vph
RT = 13 vph

Figure 4: Northbound Route B Right-Turn at Site Drive – Build

Operating Conditions: The study intersections were evaluated using the methodologies described previously. The existing lane configurations and traffic control were used in the analysis (i.e., no roadway or traffic control improvements) with the exception of the warranted turn lanes at the proposed site driveway described in the previous section. The proposed site drive was assumed to have one lane exiting and one lane entering.

Table 5 summarizes the results of these analyses, which reflect the Existing and Build operating conditions and average delay for each of the study intersections during the weekday AM and PM peak hours. Queue lengths were not included in the table since no estimated queues were greater than 25 feet.

Table 5: Capacity Analysis Summary

Intersection / Approach	AM Peak Hour		PM Peak Hour	
	Existing	Build	Existing	Build
Route B and Academy Road/Parks Lane (Side-Street STOP)				
Eastbound Academy Road Approach	C (23.1)	C (23.1)	C (15.2)	C (15.4)
Westbound Parks Lane Approach	D (27.6)	D (27.4)	C (15.6)	C (15.8)
Northbound Route B Approach	Free Flow	Free Flow	Free Flow	Free Flow
Southbound Route B Approach	Free Flow	Free Flow	Free Flow	Free Flow
Route B and Proposed Site Driveway (Side-Street STOP)				
Westbound Proposed Site Driveway Approach		E (39.8)		D (29.9)
Northbound Route B Approach		Free Flow		Free Flow
Southbound Route B Left-Turn		A (8.4)		B (10.7)

X (XX.X) - Level of Service (Vehicular delay in seconds per vehicle)

As shown, during the AM and PM peak hours, all the approaches of the Route B and Academy Road/Parks Lane intersection operate at overall favorable levels of service (i.e., LOS D or better) in the existing conditions and would continue to operate at overall favorable levels of service for the Build conditions.

This is also true for the Route B and Proposed Site Driveway intersection, with the exception of the westbound site driveway approach during the AM peak hour which is forecasted at LOS E with 39.8 seconds of delay on average per vehicle. This level of delay is attributable to the heavy through volumes on Route B resulting in vehicles having to wait a little longer to find a gap in traffic. Overall, this does not represent a notable capacity issue especially given there are only 12 vehicles exiting the site in the AM peak hour.

HIGHWAY SAFETY MANUAL ANALYSIS

As requested by MoDOT, a predictive safety analysis of the proposed access drive onto Route B was completed.

Existing Crash summary (2018-2022): As requested by MoDOT, the crash data from 2018 to 2022 was summarized for the Route B and Academy Road/Parks Lane intersection.

Based on crash data, 3 crashes occurred near the intersection of Route B and Academy Road/Parks Lane in the past five years. Two (2) of the crashes were property damage only with one minor injury. There were zero fatal or suspected serious injury crashes reported in the last five years. Two (2) property damage only crashes occurred in 2020 and 2021 and one minor injury crash in 2019.

One (1) of the three (3) crashes was a rear-end crash, one (1) was a left-turn crash and one (1) was a right angle crash. A summary of the crash data by year is provided in **Table 6.**

Table 6: Crash Summary (2018-2022) – Route B and Academy Road/Parks Lane (unsignalized)

Type / Severity	2018	2019	2020	2021	2022	Total
Rear End						
Property Damage Only	0	0	0	1	0	1
Left Turn						
Property Damage Only	0	0	1	0	0	1
Right Angle						
Minor Injury	0	1	0	0	0	1
Total	0	1	1	1	0	3

Predicted Safety Analysis: As requested by MoDOT, predictive safety analyses were performed at the existing and proposed intersections along Route B using methodologies from the Highway Safety Manual (HSM), published by the American Association of State Highway and Transportation Officials (AASHTO). The HSM provides guidance for quantifying potential effects on crash rates resulting from traffic volume and design decisions. Crash frequency is defined as the number of crashes occurring on a particular facility in a one-year period.

The proposed development will have primary via a new drive on Route B, south of Academy Road/Parks Lane. The site drive was assumed to be side-street stop controlled at the approach to Route B.

The safety analyses include the 2018 MoDOT Calibration Factors, which impact the baseline HSM crash frequency predictions to account for the historical crash trends in the state of Missouri at those types of intersections (3-leg/4 leg, rural, 2 lane unsignalized intersections). The relevant state of Missouri calibration factors are as follows:

- Unsignalized, 3-leg, rural, 2 lane intersection = 0.69
- Unsignalized, 4-leg, rural, 2 lane intersection = 0.41.

The Route B intersection with Academy Road/Parks Lane and the future intersection of Route B with the Proposed Drive were completed using the rural 2 lane HSM models. **Table 7** summarizes the predicted results of the HSM analysis for the No-Build, Build and Build Improved with the recommended auxiliary lanes. The Build improved scenario includes the recommended southbound left-turn lane and northbound right-turn lane at the proposed site drive.

As can be seen, there are negligible changes in the predicted crashes due to the increase in traffic volumes from the proposed development when comparing the No-Build to the Build conditions at Academy Road/Parks Lane. Additionally, the recommended auxiliary turn lanes at the proposed site drive will help to improve safety at the proposed site entrance on Route B.

Table 7: HSM Results – Predicted Crashes for No-Build and Build Conditions

Intersection	No-Build Volumes			Build Volumes			Build Volumes Improved [a]		
	F & I	PDO	Total	F & I	PDO	Total	F & I	PDO	Total
Route B at Academy Road/Parks Lane (Unsignalized; Rural)	0.1	0.4	0.5	0.1	0.4	0.5			
Route B at Proposed Site Entrance (Unsignalized; Rural)				0.3	0.8	1.0	0.1	0.4	0.5

[a] Improved conditions assumes auxiliary left and right turn lanes at proposed entrance as recommended in the traffic impact study

SUMMARY

CBB completed the preceding study to address the anticipated traffic impacts associated with the proposed industrial site development located in the southeast quadrant of the Route B and Parks Lane intersection near Hallsville, Missouri.

In summary, the following findings and improvements should be considered in conjunction with the proposed development:

- Careful consideration should be given to sight distance obstructions when planning any future aesthetic enhancements, such as berms, fencing and landscaping, at any of the subdivision entrances to ensure that these improvements do not obstruct the view of entering and exiting traffic at the site intersections with the public roads. It is generally recommended that all improvements wider than two inches (posts, tree trunks, etc.) and higher than 3.5 feet above the elevation of the nearest pavement edge be held back at least 20 feet from the traveled roadway.
- It is recommended the site design engineer verify adequate sight distance is provided at all proposed site drives.
- The proposed development is expected to add 53 trips during the weekday AM peak hour and 57 trips during the weekday PM peak hour to the adjacent roadways.
- Based on the Build traffic volumes, a separate northbound right-turn lane on Route B is warranted at the proposed site driveway. It is recommended this northbound right-turn lane be constructed with the proposed development.
- Based on the Build traffic volumes, a separate southbound left-turn lane on Route B at the proposed site driveway is warranted. It is recommended that this southbound left-turn lane be constructed with the proposed development.
- All of the study intersections operate at overall acceptable levels of service in the existing conditions and would continue to operate at overall favorable levels of service during the peak hours for the Build conditions.

We trust this traffic impact study adequately describes the forecasted traffic conditions that should be expected as a result of the proposed industrial/warehouse building. If additional information is desired, please feel free to contact me at 314-449-9572 or swhite@cbbtraffic.com.

Sincerely,

Shawn Lerai White, P.E., PTOE
Associate - Senior Traffic Engineer