Access Delaware

CARPENTER MARTY transportation

Northwest Arterial Corridor Analysis (NWACA)

Final Report

November 2, 2022

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Executive Summary

A. Purpose and Need

The purpose of this study is to review the impact of the proposed extension of Merrick Boulevard from Troy Road to US-23 on streets in the northwest quadrant of the City of Delaware under various roadway connection scenarios. The City of Delaware is the Delaware County seat and is the geographic center of the fastest growing county in Ohio. The City has completed and adopted a new Thoroughfare Plan and community Comprehensive Plan called Delaware Together which sets the goals and aspirations for who and what the City wants to become over the next 10-15 years. The Northwest Arterial Corridor Analysis (NWACA) explores existing and proposed transportation connection scenarios to the US-23 corridor for the growing northwest quadrant of the City.

B. Study Area Conditions

The NWACA study evaluates several area conditions including existing conditions, committed conditions, and five roadway scenarios. Committed conditions include extension of Merrick Boulevard to Troy Road and extension of Houk Road to Hills-Miller Road. The additional roadway scenarios include one or more combinations of the committed conditions plus extension of Merrick Boulevard to US-23, extension of Byxbe Parkway to Panhandle Road, and extension of Byxbe Parkway to Hills-Miller Road.

C. Analysis and Considerations

Horizon Year (2040) volumes were developed for each analysis scenario using collected count data, StreetLight data, Mid-Ohio Regional Planning Commission (MORPC) data, and background development trip generation data. Proper adjustments were made for each analysis scenario that incorporates traffic pattern changes associated with new roadway connections.

Analysis of each scenario includes turn lane warrants and lengths, signal warrants, capacity, and travel time. Existing crash data and at-grade train crossing impact on the travel times were assessed. A high-level overview of innovative intersection concepts is provided for consideration. Concept plans and cost estimates were provided for each scenario. Lastly, access management recommendations are provided for the extension of Merrick Boulevard to US-23.

One-page summaries for each scenario are provided in a separate attachment. Each summary includes a description of the scenario, recommended intersection control types/configurations, overall intersection LOS/delay, improvements added, and information of note.

D. Impact Summary

An impact summary assessment was developed which evaluates each analysis scenario based on travel time across the northwest area of the city, US-23 progression impacts, emergency response times, travel delay associated with rail traffic, estimated construction costs, right-of-way (R/W) and property impacts, and environmental impacts.

E. Conclusions & Recommendations

See section XI for details.

I. Project History

The City of Delaware is the Delaware County seat and is the geographic center of the fastest growing county in Ohio. The City has completed and adopted a new Thoroughfare Plan and community Comprehensive Plan called Delaware Together which sets the goals and aspirations for who and what the City wants to become over the next 10-15 years. Adequate roadway infrastructure to support the existing community, as well as future growth, is a critical element to the overall success of the community from a housing, business, and jobs producing perspective. Likewise, ensuring that traffic demands can be met without exceeding the capacity of the existing roadways, and accounting for future growth and development, will ensure a bright future for the City.

The NWACA study explores existing and proposed transportation connection scenarios to the US-23 corridor for the growing northwest quadrant of the City. This work, in combination with the City's Comprehensive Plan update, plays a role in planning for continued growth. The NWACA evaluates and determines optimal connections to US-23 from the northwest side of Delaware while considering other Thoroughfare Plan objectives and proposed network connections.

The network connections explored in this study are a result of 50+ years of planning for the City. Many of the network changes explored were included in past Thoroughfare plans, which were joint City and County studies. This study explores the feasibility and impact of those proposed connections and how they would impact connectivity for the City as a whole and as part of a long-term plan to continue improving the City of Delaware.

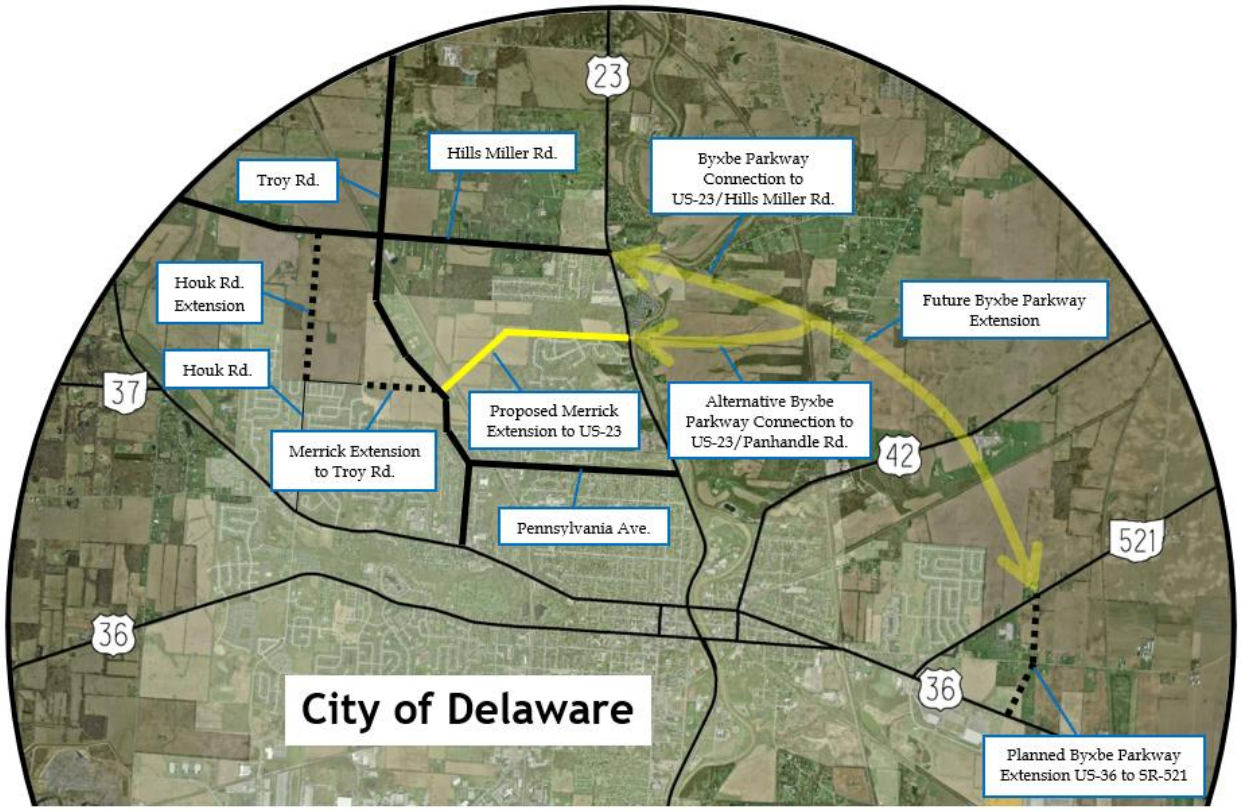
II. Purpose and Need

The purpose of this study is to review the impact of the proposed extension of Merrick Boulevard from Troy Road to US-23 on streets and intersections in the northwest quadrant of the City of Delaware under various roadway connection scenarios. Current existing conditions, committed conditions, and proposed scenarios being considered are listed below (refer to **Figure 1**). Committed conditions include roadway connections of Merrick Boulevard to Troy Road, Houk Road to Hills-Miller Road, US-36/SR-37 to SR-521 (planned Byxbe Parkway Extension), and assumed developments.

- **Scenario A** – Future Byxbe Parkway Extension to Panhandle Road/US-23 (Merrick Boulevard terminates at Troy Road)
- **Scenario B** – Future Byxbe Parkway Extension to Panhandle Road/US-23 + Hills-Miller Road Connection (Merrick Boulevard terminates at Troy Road)
- **Scenario C** – Merrick Boulevard extended to US-23 (no Future Byxbe Parkway Extension)
- **Scenario D** – Merrick Boulevard extended to US-23 + Future Byxbe Parkway Extension to Panhandle Road
- **Scenario E** – Merrick Boulevard extended to US-23 + Future Byxbe Parkway Extension to Panhandle Road + Hills-Miller Road Connection

Each scenario is described in further detail in the next section of this report. **Figure 1** illustrates all the proposed scenarios combined.

Figure 1 – Study Area and Scenarios Being Considered



III. Study Area Conditions

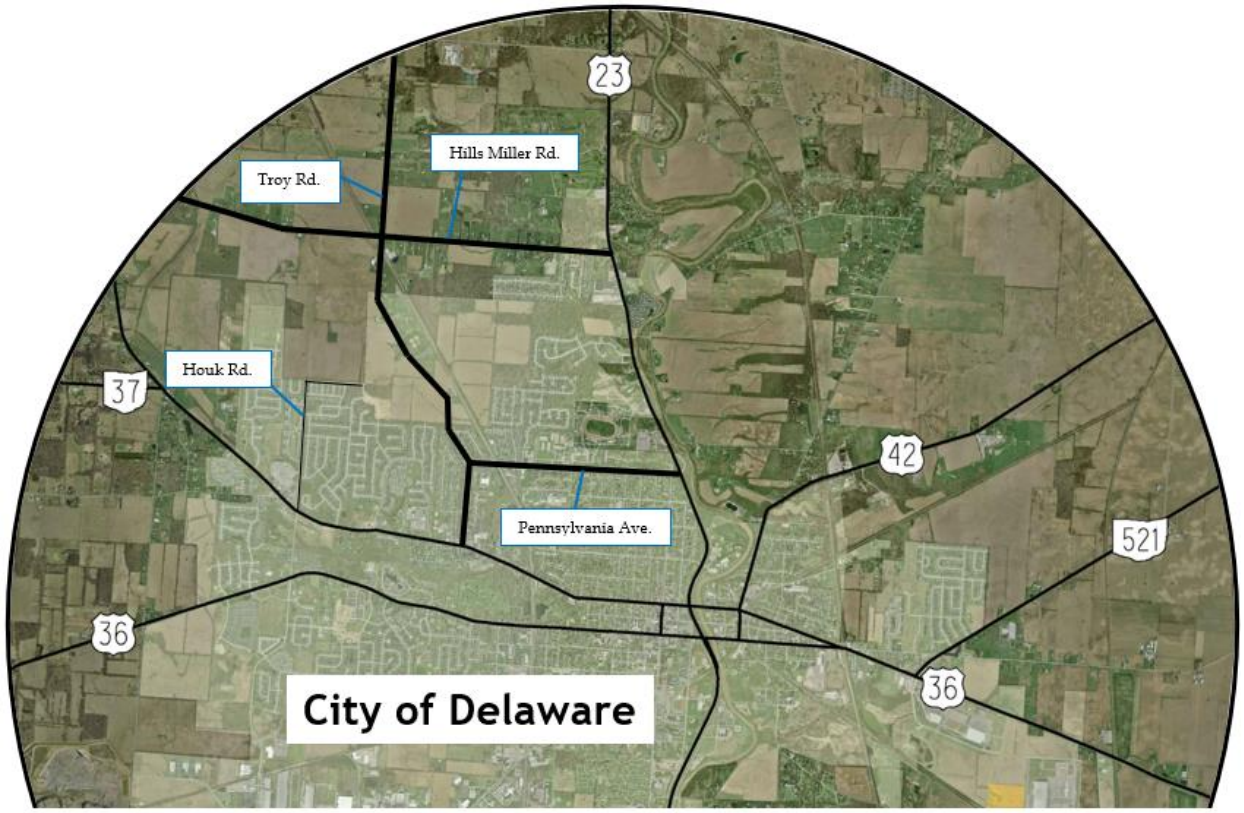
A. Scenario Descriptions

Below is a description of each scenario analyzed for this study.

Existing Conditions

This scenario assumes only the existing roadway network is in place as of January 2021. No planned, proposed, or future connections are included. See **Figure 2**.

Figure 2 – Existing Conditions Scenario



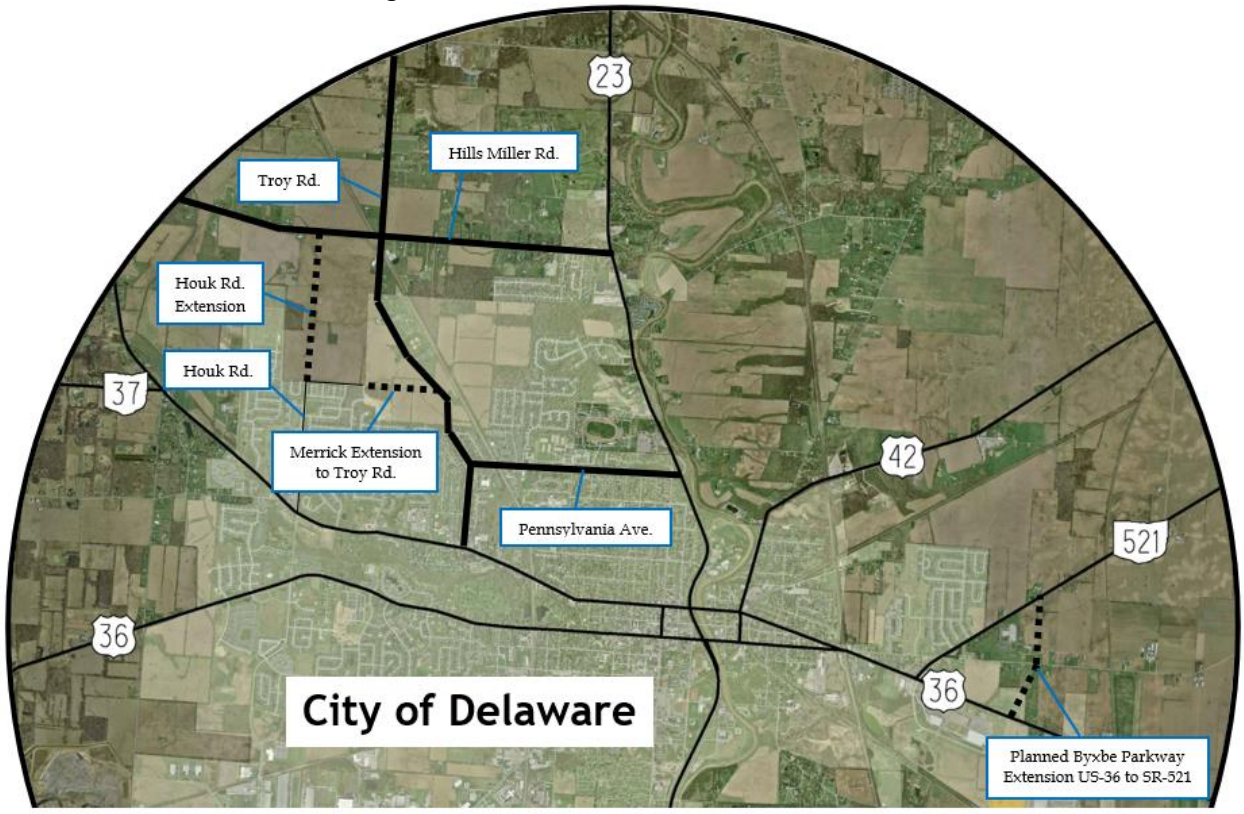
Committed Conditions

This scenario assumes the existing roadway network with the addition of three extensions/connections committed for construction:

- Extension of Merrick Boulevard, from its existing terminus in the residential neighborhood (stub at Cambridge Road), east to Troy Road
- Extension of Houk Road, from its current terminus at Merrick Boulevard, north to Hills-Miller Road
- Connection of US-36/SR-37 to SR-521, called the Byxbe Parkway Extension

Figure 3 illustrates the committed extensions/connections shown as black dotted lines.

Figure 3 – Committed Conditions Scenario

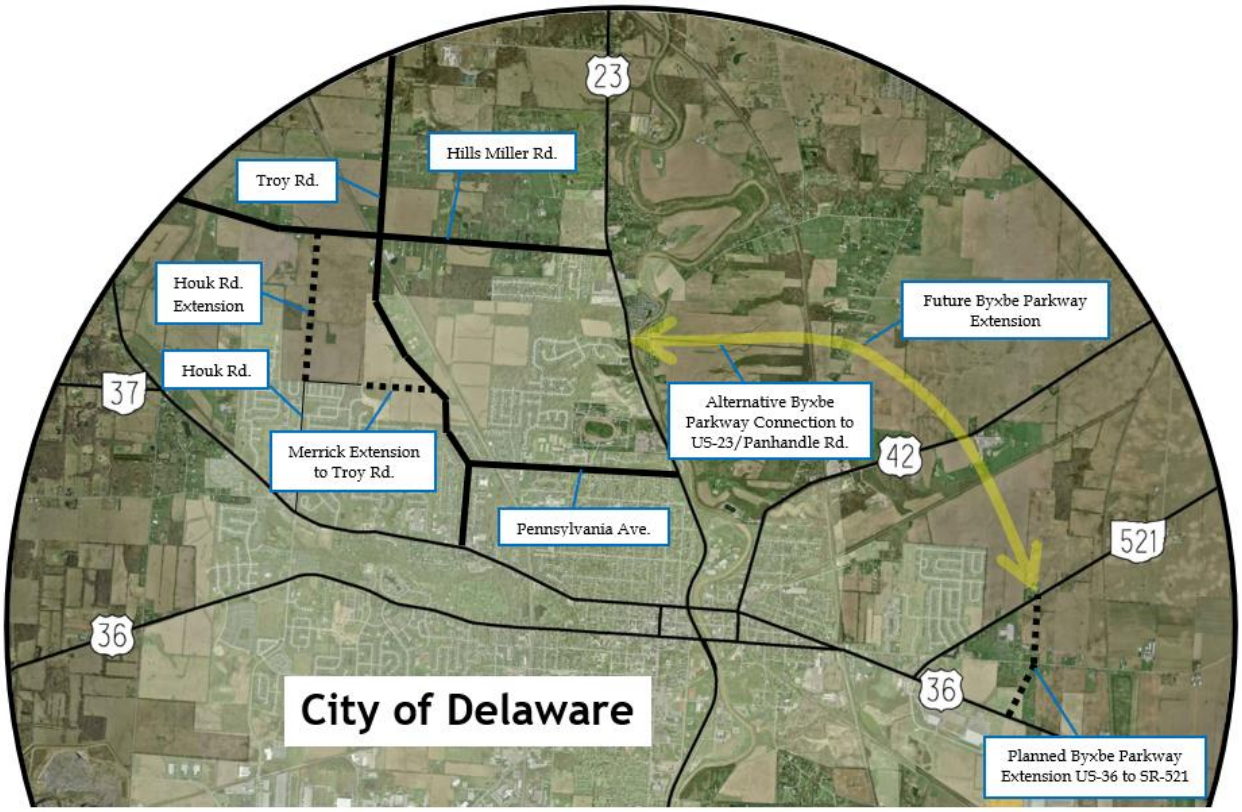


Note, all other scenarios evaluated assume committed conditions are in place with various additional roadway connections specific to each scenario.

Scenario A

This scenario assumes the committed conditions roadway network and the Planned Byxbe Parkway Extension further expanded. The Planned Byxbe Parkway Extension is currently committed to connect US-36/SR-37 to SR-521. In this scenario, the Byxbe Parkway Extension continues northwest from the planned terminus at SR-521 to US-42 and then to US-23. The extension is shown to terminate at the existing US-23 & Panhandle Road intersection. This scenario only includes the committed Merrick Boulevard extension from its existing terminus in the residential neighborhood to Troy Road. No additional extensions of Merrick Boulevard are included. **Figure 4** shows the proposed future Byxbe Parkway Extension with a semi-transparent yellow line.

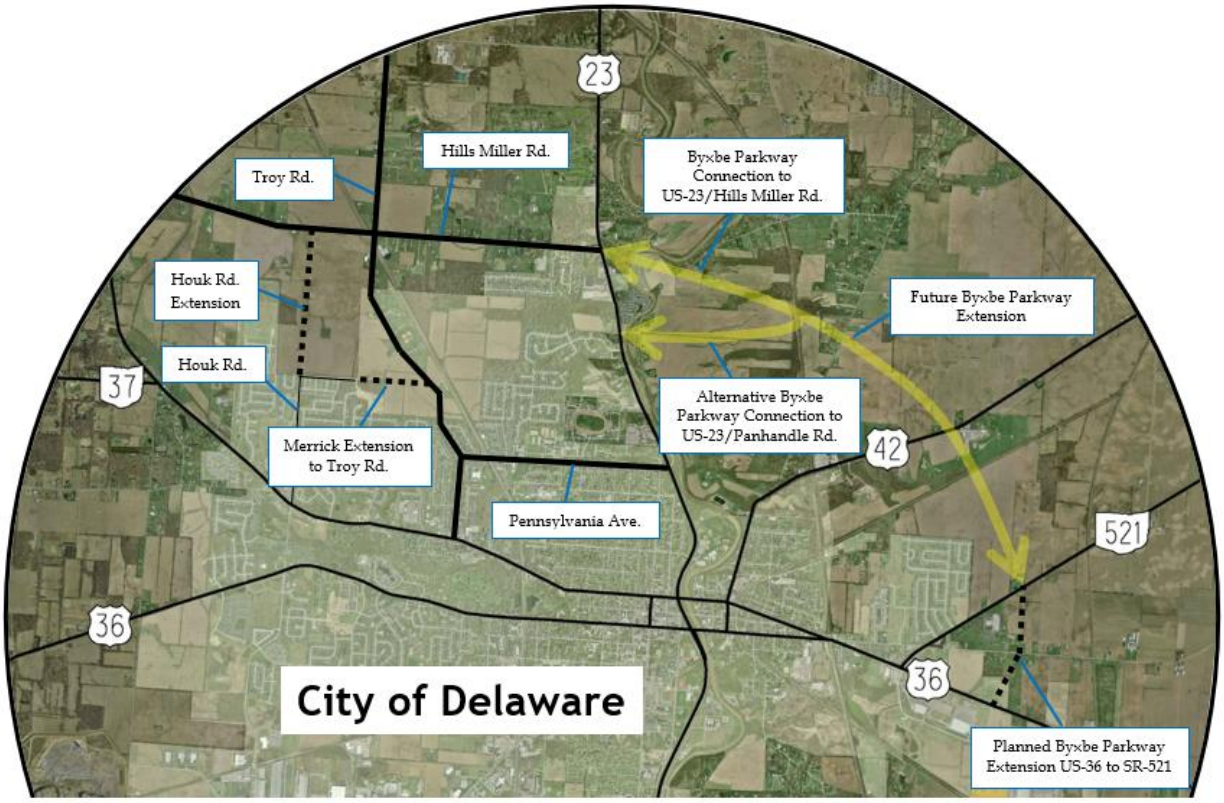
Figure 4 – Scenario A



Scenario B

This scenario assumes the committed conditions and Scenario A roadway network with an additional connection added to the Byxbe Parkway Extension. As shown in Scenario A, the Byxbe Parkway Extension continues northwest from the terminus at SR-521 to US-42 and then to US-23, terminating at the existing US-23 & Panhandle Road intersection. Another connection is added from the Byxbe Parkway Extension (between US-42 and US-23) and then terminates as an east leg to the existing US-23 & Hills-Miller Road intersection. This scenario assumes that the main Byxbe Parkway Extension will be the connection to the Hills-Miller Road intersection, and the connection to the Panhandle Road intersection will be used as a secondary connection. This scenario only includes the committed Merrick Boulevard extension from its existing terminus in the residential neighborhood to Troy Road. No additional extensions of Merrick Boulevard are included. **Figure 5** shows the proposed Byxbe Parkway Extension and additional connection shown with semi-transparent yellow lines.

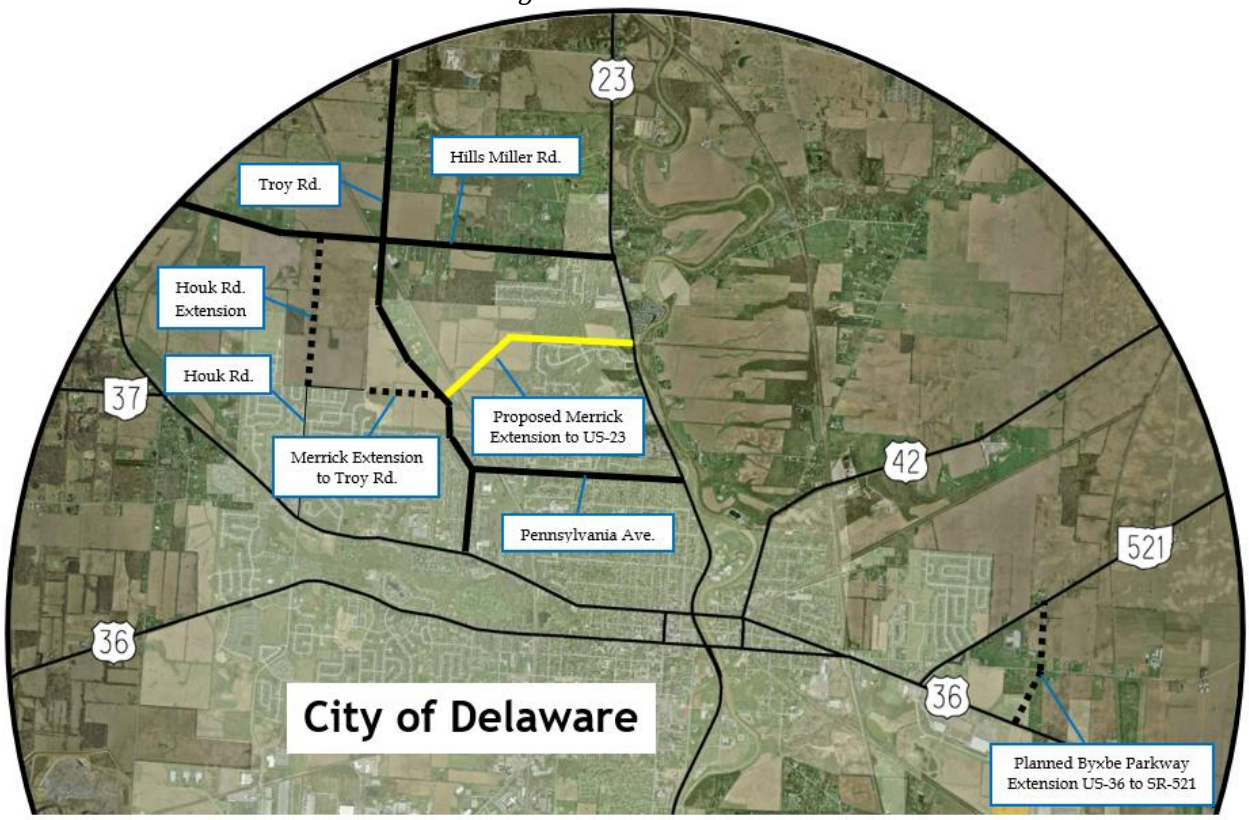
Figure 5 – Scenario B



Scenario C

This scenario assumes the committed conditions roadway network with the Merrick Boulevard Extension further expanded. Merrick Boulevard is currently committed to extend from its existing terminus at Cambridge Road to Troy Road. In this scenario, Merrick Boulevard is proposed to continue east from Troy Road to US-23. This scenario includes only the Planned Byxbe Parkway Extension from US-36/SR-37 to SR-521 and Houk Road Extension from Merrick Boulevard to Hills-Miller Road from the committed conditions. No additional extensions or connections are included. **Figure 6** shows the proposed Merrick Boulevard Extension with solid yellow lines.

Figure 6 – Scenario C



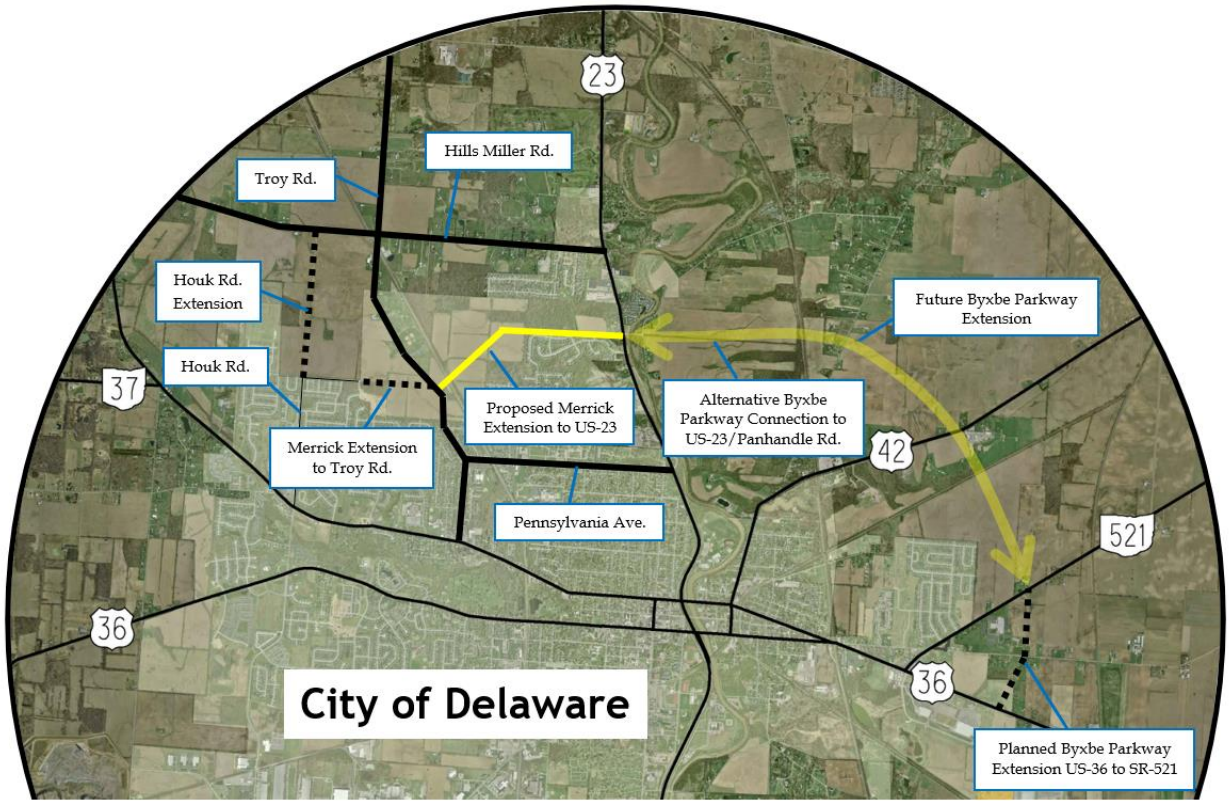
Scenario D

This scenario assumes the committed conditions roadway network with the following additional extensions:

- Byxbe Parkway extension continued from its committed terminus at SR-521 to US-23, terminating at the existing US-23 & Panhandle Road intersection (as described in Scenario A)
- Merrick Boulevard from Troy Road to US-23 (as described in Scenario C)

Both proposed extensions would terminate at the existing US-23 & Panhandle Road intersection. **Figure 7** shows the proposed extensions with solid and semi-transparent yellow lines.

Figure 7 – Scenario D



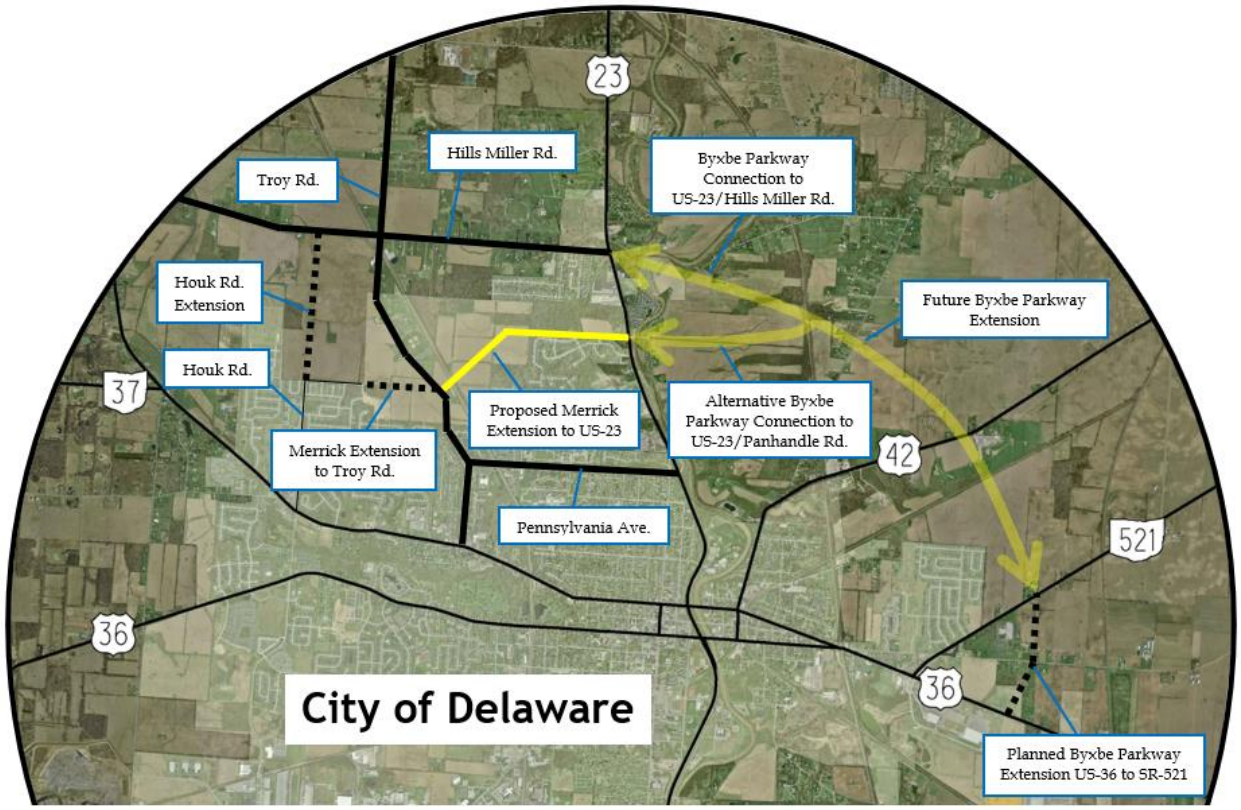
Scenario E

This scenario assumes the committed conditions roadway network with the following additional extensions:

- Byxbe Parkway continued from its committed terminus at SR-521 to US-23, terminating as an east leg to the existing US-23 & Hills-Miller Road intersection, with a Byxbe Parkway Alternative Connection added from the Future Byxbe Parkway Extension (between US-42 and US-23) terminating at the existing US-23 & Panhandle Road intersection (as described in Scenario B)
- Merrick Boulevard from Troy Road to US-23 (as described in Scenario C)

This scenario essentially incorporates all previously described scenarios. **Figure 8** shows the proposed extensions with solid and semi-transparent yellow lines.

Figure 8 – Scenario E

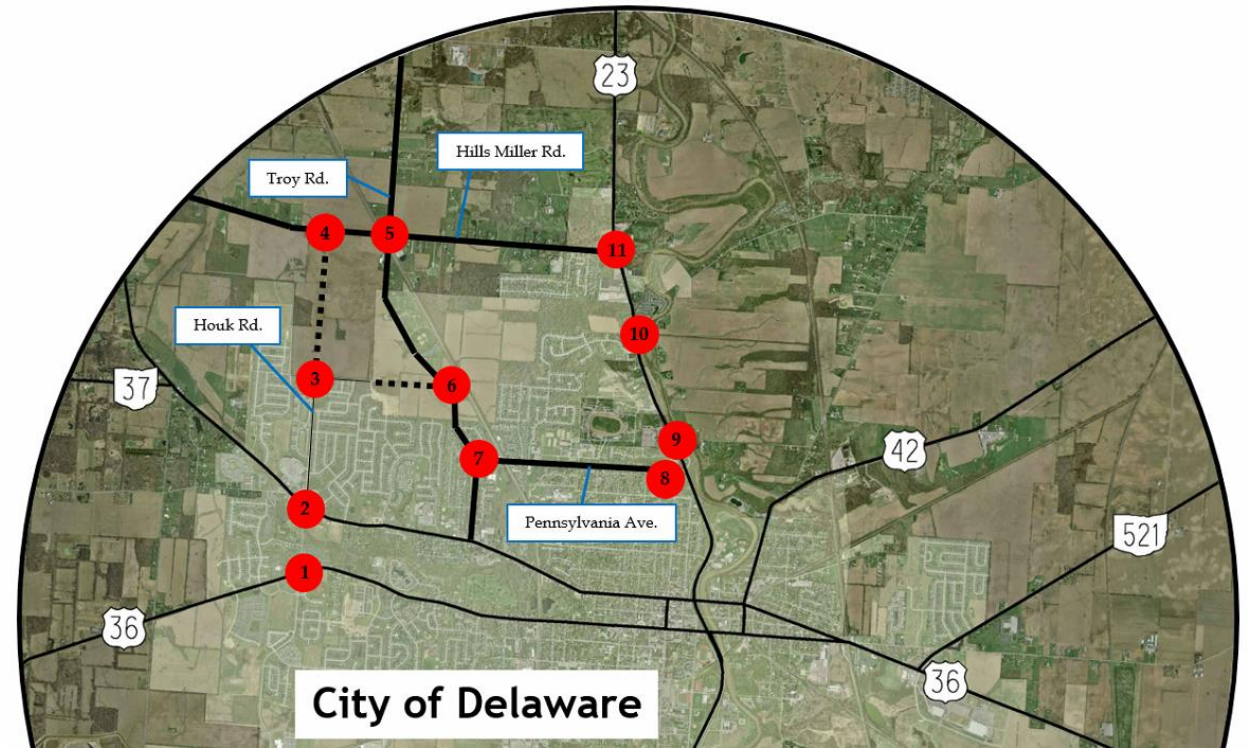


B. Intersection Conditions

A total of 11 intersections within the study limits were analyzed to determine the impacts of each scenario. Each intersection, and its existing traffic control (if applicable), is listed below with numbers corresponding to **Figure 9**.

1. Houk Road & US-36 *(signalized)*
2. Houk Road & SR-37 *(signalized)*
3. Houk Road & Merrick Boulevard *(all-way stop controlled)*
4. Committed Houk Road Extension & Hills-Miller Road
5. Troy Road & Hills-Miller Road *(east-west stop controlled)*
6. Troy Road & Committed Merrick Boulevard Extension
7. Troy Road & Pennsylvania Avenue *(signalized)*
8. N. Sandusky Street & Pennsylvania Avenue *(all-way stop controlled)*
9. US-23 & Sandusky Street *(signalized)*
10. US-23 & Panhandle Road *(signalized)*
11. US-23 & Hills-Miller Road *(signalized)*

Figure 9 – Study Intersections



C. Speed Limits & Functional Classification

Table 1 shows the speed limits and functional classifications for each approach of each study intersection used for analysis. For proposed roadway extensions, a speed limit of 35 MPH was assumed for analysis, unless otherwise stated.

Table 1 – Speed Limit & Functional Classification Summary

Intersection	Leg	Classification	Posted Speed Limit (MPH)
US-36 & Houk Road	West	Arterial	45
	South	Collector	35
	East	Arterial	45
	North	Collector	35
SR-37 & Houk Road	West	Arterial	35
	South	Collector	35
	East	Arterial	35
	North	Collector	35
Houk Road & Merrick Boulevard	West	Collector	25
	South	Collector	35
	East	Collector	25/35*
	North	Collector	35
Houk Road & Hills-Miller Road	West	Collector	55
	South	Collector	35
	East	Collector	55
Troy Road & Hills-Miller Road	West	Collector	55
	South	Collector	55
	East	Collector	55
	North	Collector	55
Troy Road & Merrick Boulevard	West	Collector	25/35*
	South	Collector	35
	East	Collector	25/35*
	North	Collector	35
Troy Road & Pennsylvania Avenue	West	Local Road	25
	South	Collector	35
	East	Collector	25
	North	Collector	35
N. Sandusky Street & Pennsylvania Avenue/ US-23 Entrance Ramp	West	Collector	25
	South	Arterial	35
	North	Arterial	35
US-23 & N. Sandusky Street	West	Arterial	35
	South	Expressway	45
	North	Expressway	45
US-23 & Panhandle Road	West	Collector	25/35*
	South	Arterial	45
	East	Collector	55
	North	Arterial	45
US-23 & Hills-Miller Road	West	Collector	35
	South	Arterial	45
	East	Collector	35
	North	Arterial	55

*Speed limit varies based on scenario

D. 2018 US-23 Safety Study

A safety study of US-23 from north of Shroyer Park to north of Hills-Miller Road was prepared by Ohio Department of Transportation (ODOT) in 2018. Recommended countermeasures included:

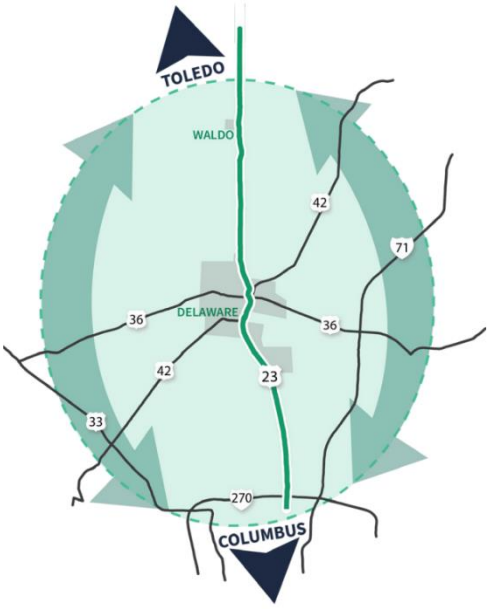
- Revise left turn signal phasing
- Reassign right turn overlap phase
- Install supplemental signal heads
- Add backplates to signal heads
- Remove "prepare to stop when flashing" signs
- Update clearance intervals
- Update coordinated signal timings
- Revise stop line locations
- Evaluate the benefit of dual left turn lanes
- Expand existing speed zone
- Revise existing lane and shoulder widths
- Access management
- Install right turn lanes as warranted

Safety improvements previously recommended by the 2018 Safety Study should be carried forward into future roadway improvements.

E. US-23 Centerline Corridor Study (PID 112768)

ODOT, along with regional partners at MORPC and Toledo Metropolitan Area Council of Governments (TMACOG), began project "Route 23 Connect" in Spring 2021 to study an improved transportation connection between the Columbus and Toledo regions. See **Figure 10**. The purpose of this project is to enhance regional connectivity and mobility by creating a free-flowing connection between Waldo, OH and I-270.

Figure 10 – US-23 Centerline Corridor Study



Project needs include:

- Reduce travel times between Waldo and I-270
- Improve travel time reliability so people can count on consistent travel times during particular periods of each day (i.e. morning commute)
- Improve safety and reduce congestion for local and regional trips
- Be consistent with local community goals and reduce diversion of traffic to local roads

An important piece of this initiative is the Delaware Regional Connection Study, which will evaluate different options for roadway improvements through Delaware County between Waldo in Marion

County and IR-270 in Franklin County. Seven concepts were developed and analyzed in Phase 1 of this study, including a no-build option, upgrading the existing US-23 corridor to free-flow, two new freeway connections to US-33 to the west, and three new freeway connections to I-71 to the east. Each concept was evaluated using a variety of metrics to analyze travel times, safety benefits, community impacts, environmental impacts, and cost.

After comparison of the expected benefits and costs for each Phase 1 concept, it was determined that none of the concepts can be reasonably implemented as presented. The concepts would cost at least three times more than the benefits they would provide and each of the proposed concepts would substantially impact community and natural resources.

Instead, ODOT is shifting its focus to planning and implementing a series of stand-alone improvement projects along the existing US-23 corridor between Waldo and I-270. The next phase of the study will inform an action plan that recommends and prioritizes specific projects along US-23 to provide safer and more efficient travel, including increased travel time reliability for through traffic. Phase 2 of this study is currently underway.

With US-23 being in the NWACA study area, the ODOT US-23 Centerline Corridor Study is inherently relevant and consequential. Since both studies are occurring simultaneously, the exact impacts of the recommended solutions that come from ODOT US-23 Centerline Corridor Study are unknown. The impacts to the US-23 intersections noted in this study have been coordinated with the ODOT US-23 Centerline Corridor Study team. Phase 2 of that study will further evaluate data, analyses, and recommendations from this NWACA study.

IV. Traffic Volume Development

Due to the complex nature of the volume development for this study, the technical explanation of the methods is provided in **Appendix A**. This section of the report provides high-level overviews of the methods utilized. For additional explanation and details, see **Appendix A**.

A. Data Collection

Turning movement count data was collected at the following intersections with data collection dates specified:

- Troy Road & Hills-Miller Road *(March 2021)*
- US-23 & Hills-Miller Road *(March 2021)*
- N. Sandusky Street & Pennsylvania Avenue *(March 2021)*
- US-23 & Sandusky Street Ramps *(March 2021)*
- Troy Road & Pennsylvania Avenue *(September 2020)*
- US-36 & Houk Road *(October 2019)*
- US-37 & Houk Road *(October 2020)*

2016 segment count data for Panhandle Road on the bridge directly east of US-23 was obtained from the MORPC Transportation Data Management System (TDMS). All count data can be found in **Appendix B**.

B. StreetLight Data

StreetLight data was utilized to supplement the data collection. StreetLight produces various datasets by utilizing cell phone location services which can be manipulated to track travel patterns using user-defined zones, or gates.

Gates were used to obtain volumes of vehicles that would likely choose to change their existing travel route in favor of a new roadway connection. These volumes were redistributed throughout the roadway network for the various scenarios. StreetLight data was also used to estimate the peak hour turning movement volumes for the intersection of Merrick Boulevard & Houk Road and to create a global distribution of traffic for planned and anticipated developments in the area.

C. Background Growth Rates

Traffic volumes were developed using a combination of count data, MORPC modeling, trip generation, previous traffic studies, StreetLight data, City input, and engineering judgement.

Background growth rates for the study area were calculated based on MORPC modeling, completed in 2016, and provided by the City. The MORPC model outputs titled "2015 Model Volumes" and "2040 Model Volumes: Scenario I (Alternatives 1, 4, 5, 7, 8, 10)" were utilized. The Scenario I 2040 model output used was chosen from a variety of alternatives because this model output most accurately depicted the expected development of the study area. The use of this model output was discussed with and approved by the City during the growth rate development process.

Once the appropriate MORPC model scenario was identified, it was determined individual background growth rates would be utilized for US-23, SR-37, US-36, and US-42 (north), and an overall background growth rate would be determined for all remaining roadways in the study area. An average of the respective values from the MORPC 2015 and 2040 models were then used to calculate the linear, annual background growth rates between the two models for each specified roadway and the overall remaining study area. The results of this analysis produced the background growth rates seen in **Table 2**, which were then used in the volume development process. The MORPC models used, and growth rate development calculations, can be seen in **Appendix C**.

Table 2 – Background Growth Rates

Roadway	Background Growth Rate
US-23	0.9%
SR-37	2.1%
US-36	2.9%
US-42 (north)	2.8%
Remaining Study Area	2.5%

D. Existing Conditions Volume Development

The background growth rates were applied to the count data to project all counts to a common year of 2040, which resulted in Existing Conditions volumes for the study area.

E. Committed Conditions Volume Development

Adjustments were made to the Existing Conditions volumes to account for several extensions and developments which are expected to have occurred by 2040. The resulting volumes were considered the Committed Conditions. These extensions and developments, as previously described, include:

- The extension of Merrick Boulevard (from the existing stub at Cambridge Road) to Troy Road
- The extension of Houk Road from Merrick Boulevard to Hills-Miller Road
- The construction of several background developments that are planned/anticipated to be developed by the year 2040

This section of the technical explanation details the information provided in **Appendices D-H**. For further information, see the additional information provided in **Appendix A**.

- **Appendix D** – Volume Development
- **Appendix E** – OD Visuals
- **Appendix F** – Trip Generation
- **Appendix G** – Troy/Rutherford Acres Study Excerpts
- **Appendix H** – Addison Mixed-Use Preliminary Information

F. Scenarios Volume Development

The final adjustments made to the Committed Conditions traffic volumes account for the changes in traffic associated with each of the five scenarios considered (Scenarios A-E). Adjustments were made to existing by-pass traffic, existing residential traffic, and to the Committed Conditions sheets (including the by-pass and residential adjustments already made, adjustments to the distribution of the background development traffic, and adjustments to the Existing Conditions traffic). These adjustments were made based on knowledge of the surrounding area, StreetLight OD data, engineering adjudgment, and City input.

The adjustments for each scenario were applied to the Final Committed Conditions traffic to produce Final traffic volumes for each scenario. Full volume development can be seen in **Appendix D**.

G. Average Daily Traffic (ADT) Development

ADT volumes were estimated for the following sections of roadways in the study area (depending on the scenario):

- Hills-Miller Road east and west of Troy Road
- Troy Road north and south of Merrick Boulevard
- Merrick Boulevard between Houk Road and US-23
- Houk Road between US-36 and Hills Miller Road
- Pennsylvania Avenue between Troy Road and N. Sandusky Street
- US-23 between N. Sandusky Street/Pennsylvania Avenue ramps and Hills Miller Road
- Panhandle Road east of US-23

ODOT Partial Count Factor forms were used to calculate the ADTs. Peak hour count data entering/exiting the adjacent intersections for each segment was averaged together to obtain the peak hour segment count in each direction. AM and PM segment counts were added together and then hourly percent by functional classification factors were applied to estimate ADTs for the above listed roadway links. These calculations were completed for each specified segment for the Final Existing Conditions, Committed Conditions, and each scenario Final traffic volumes. A summary of the ADT volumes for each scenario can be seen in **Appendix I**.

V. Analysis

A. Planning-Level Number of Through Lanes Evaluation

A planning-level evaluation of the number of through lanes needed for each roadway segment, for each Scenario, was evaluated based on 2040 volumes. The evaluation considered the ADT volume to capacity (V/C) ratio for each segment between study intersections. A V/C ratio of less than 0.80 represents a roadway that operates efficiently. The following ADT capacity thresholds were assumed (each may include turn lanes at intersections as necessary):

- 16,000 for a two-lane roadway (12,800 for a 0.8 V/C)
- 32,000 for a four-lane roadway (25,600 for a 0.8 V/C)
- 48,000 for a six-lane roadway (38,400 for a 0.8 V/C)

Note, the number of through lanes *calculated* for each segment are not necessarily *recommended*. This is a macro-level analysis which should be used as a planning tool for determining future roadway typical sections and R/W dedication needed for developments. The analyses described in the next sub-sections are more micro-level analyses which recommend intersection configurations anticipated for each scenario.

The results of the planning-level evaluation of the number of lanes can be found in **Appendix J.**

B. Planning-Level Signal Warrant Analysis

Planning-level signal warrant analyses were performed for intersections which were not able to meet acceptable capacity under stop control (described further in **Section V.D.**

Capacity Analysis). Planning-level signal warrants extrapolate peak hour, turning movement count data to the remaining hours of the day based on roadway classifications. Extrapolated volumes are then utilized to determine if an intersection meets Warrant #3 (eight-hour warrant) per the Ohio Manual of Uniform Traffic Control Devices (OMUTCD). This analysis was determined necessary for all scenarios for the following intersections:

- Troy Road & Hills-Miller Road
- Pennsylvania Avenue & Sandusky Street

It was determined planning-level signal warrants were met for both intersections for all scenarios. Therefore, the intersection control type was changed to a signal in the capacity analysis. Detailed planning-level signal warrant analysis can be found in **Appendix K.**

C. Turn Lane Analysis

Turn lane warrant analyses were conducted at all study intersections using standard ODOT turn lane warrant graphs. If a turn lane was warranted in any scenario, the length was calculated using methodologies in the ODOT Location and Design (L&D) Manual and it was represented as such in the capacity analysis for each scenario. Turn lane lengths were calculated assuming a design speed 5 mph greater than the posted speed limit.

Turn lane warrants were conducted for unsignalized intersections under the assumption that the intersection would be two-way stop controlled. The results of the turn lane warrant analysis are summarized in **Table 3**. Turn lane lengths were calculated for turn lanes considered at signalized intersections. Results of the turn lane length calculations can be seen in **Table 4.** Note, turn lanes listed in the tables are *calculated*, but are not necessarily *recommended*. Recommended turn lanes at intersections are described further in **Section VI.D. Capacity Analysis**. Detailed turn lane analysis can be found in **Appendix L.**

Table 3 – Turn Lane Warrant Analysis Summary for Unsignalized Intersections

Intersection	Movement	Scenario						
		Existing	Committed	A	B	C	D	E
Houk Road & Hills-Miller Road	EBR		Not Met	Not Met	Not Met	Not Met	Not Met	Not Met
	WBL		**Met – 345'**	**Met – 360'**	**Met – 360'**	**Met – 345'**	**Met – 345'**	**Met – 345'**
Troy Road & Hills-Miller Road	NBL	Not Met						
	NBR	Not Met						
	SBL	Not Met						
	SBR	Not Met						

Turn lane lengths listed include a 50' diverging taper

Table 4 – Turn Lane Length Summary for Signalized Intersections

Intersection	Movement	Existing Length*	Scenario						
			Existing w/ Improvements	Committed w/ Improvements	A	B	C	D	E
US-36 & Houk Road	EBL	160'	495'	458'/538'	470'/550	470'/550	458'/538'	470'/550	470'/550
	EBR	160'	320'	345'	345'	345'	345'	345'	345'
	WBL	230'	295'	320'	320'	320'	320'	320'	320'
	WBR	370'	520'	545'	545'	545'	545'	545'	545'
	NBL	430'	265'	290'	265'	265'	265'	265'	265'
	NBR	585'	315'	315'	315'	315'	315'	315'	315'
	SBL	260'	390'	440'	440'	440'	440'	440'	440'
	SBR	175'	440'	640'	640'	640'	615'	640'	640'
SR-37 & Houk Road	EBL	290'	165'	265'	265'	265'	265'	265'	265'
	EBR		315'	315'	315'				
	WBL	290'	440'	333'/383'	333'/383'	358'/408'	358'/408'	358'/408'	358'/408'
	WBR	310'	390'	565'			465'	465'	465'
	NBL	70'	365'	365'	365'	390'	390'	390'	390'
	NBR	265'	365'	565'	565'	590'	590'	590'	590'
	SBL	200'	315'	233'/283'	315'	365'	315'	315'	315'
Pennsylvania Avenue & Troy Road	NBR			465'	465'	465'			
US-23 & Sandusky Street	NBL	490'	245'	295'	395'	295'	395'	295'	395'
	SBR	365'	295'	320'	420'	395'	395'	345'	395'
US-23 & Panhandle Road	EBL				100'	100'	265'	265'	265'
	EBR			288'/338'	225'	225'	370'/420'	315'	315'
	WBL	525'	360'		360'	360'	385'	360'	385'
	WBR	525'	360'	360'/520'	585'/745'	435'	535'	548'/708'	345'
	NBL			420'/500'	345'	345'	470'/550'	395'	395'
	NBR		295'	345'	345'	320'	320'	345'	320'
	SBL	225'	320'	345'/425'	520'/600'	345'	520'	470'/550'	245'
	SBR			245'	245'	245'	295'	295'	295'
US-23 & Hills-Miller Road	EBL	325'	265'	440'	390'	390'	365'	390'	365'
	EBR	Drop Lane	440'	515'	615'	565'	515'	515'	
	WBL					165'			165'
	WBR					590'			615'
	NBL	220'	395'	595'	695'	345'/425'	545'	595'	470'
	NBR					225'			225'
	SBL					373'/533'			585'
	SBR	250'	345'	460'	460'	435'	435'	435'	435'

**Calculated turn lane lengths listed include a 50' diverging taper, existing turn lanes listed include storage only (as taper lengths vary)*
Turn lane length calculations were completed for turn lanes added, modified, and existing turn lanes to remain.
Values shown in red generally indicate calculated turn lane lengths show existing turn lanes must be lengthened (or added where no turn lanes exist). Again, note these are calculated values, not necessarily recommended. Recommended values are described later in this report.

D. Capacity Analysis

The Highway Capacity Manual, 6th Edition, module of Synchro 11 software was used to analyze capacity at all study intersections for each scenario. A minimum Level-of-Service (LOS) of D for the overall intersection and approaches and LOS E for each individual movement during peak traffic hours was considered acceptable for each intersection. Improvements (e.g., lanes, signal phasing, etc.) were added to each intersection so that acceptable capacity was achieved in the Horizon Year for each Scenario.

"Baseline" capacity analysis was provided for the Existing Conditions and Committed Conditions scenarios only. These analyses show the capacity results if no improvements were made to the study area (excluding improvements directly associated with the extension of Merrick Boulevard to Troy Road and Houk Road to Hills-Miller Road in the Committed Conditions scenario). All other scenario results show necessary improvements made to each intersection to achieve acceptable LOS.

All signal analyses, existing and new, assumed planning-level timings and clearance intervals. The City indicated the Merrick Boulevard intersections with Houk Road and Troy Road will likely be roundabouts. Therefore, these intersections were analyzed as roundabouts using Highway Capacity Software (HCS). Many of the study intersections shown as signalized in this analysis may also function acceptably as roundabouts. However, only intersections identified and selected by the City were analyzed as roundabouts.

Table 5 shows the intersection control type determined necessary and lane configurations needed in order to achieve acceptable LOS for each intersection in each scenario. If certain intersection improvements are not considered feasible, it was indicated as such in the table. **Tables 6-9** show a summary of the capacity analysis results assuming the lane configurations shown in **Table 5**. Detailed capacity analysis can be found in **Appendix M.**

Table 5 – Calculated Needed Intersection Control and Configuration

Intersection	Scenario						
	Existing w/ Improvements	Committed w/ Improvements	A	B	C	D	E
US-36 & Houk Road	*Signalized* EB: L, T, R WB: L, T, R NB: L, T, R SB: L, T, R	*Signalized* EB: L, L, T, R WB: L, T, R NB: L, T, R SB: L, T, R	*Signalized* EB: L, L, T, R WB: L, T, R NB: L, T, R SB: L, T, R	*Signalized* EB: L, L, T, R WB: L, T, R NB: L, T, R SB: L, T, R	*Signalized* EB: L, L, T, R WB: L, T, R NB: L, T, R SB: L, T, R	*Signalized* EB: L, L, T, R WB: L, T, R NB: L, T, R SB: L, T, R	*Signalized* EB: L, L, T, R WB: L, T, R NB: L, T, R SB: L, T, R
SR-37 & Houk Road	*Signalized* EB: L, T, R WB: L, T, R NB: L, T, R SB: L, T/R	*Signalized* EB: L, T, T, R WB: L, L, T, R NB: L, T, R SB: L, L, T/R	*Signalized* EB: L, T, T, R WB: L, L, T, T/R NB: L, T, R SB: L, T/R	*Signalized* EB: L, T, T/R WB: L, L, T, T/R NB: L, T, R SB: L, T/R	*Signalized* EB: L, T, T/R WB: L, L, T, R NB: L, T, R SB: L, T/R	*Signalized* EB: L, T, T/R WB: L, L, T, T/R NB: L, T, R SB: L, T/R	*Signalized* EB: L, T, T/R WB: L, L, T, T/R NB: L, T, R SB: L, T/R
Merrick Boulevard & Houk Road	*All-Way Stop Controlled* EB: T/R WB: L/T NB: L, R	*Roundabout* Single lane approaches and circulating	*Roundabout* Single lane approaches and circulating	*Roundabout* Single lane approaches and circulating	*Roundabout* Single lane approaches and circulating	*Roundabout* Single lane approaches and circulating	*Roundabout* Single lane approaches and circulating
Houk Road & Hills-Miller Road		*North-South Stop Controlled* EB: T/R WB: L, T NB: L/R	*North-South Stop Controlled* EB: T/R WB: L, T NB: L/R	*North-South Stop Controlled* EB: T/R WB: L, T NB: L/R	*North-South Stop Controlled* EB: T/R WB: L, T NB: L/R	*North-South Stop Controlled* EB: T/R WB: L, T NB: L/R	*North-South Stop Controlled* EB: T/R WB: L, T NB: L/R
Troy Road & Hills-Miller Road	*East-West Stop Controlled* EB: L/T/R WB: L/T/R NB: L/T/R SB: L/T/R	*Signalized* EB: L/T/R WB: L/T/R NB: L/T/R SB: L/T/R	*Signalized* EB: L/T/R WB: L/T/R NB: L/T/R SB: L/T/R	*Signalized* EB: L/T/R WB: L/T/R NB: L/T/R SB: L/T/R	*Signalized* EB: L/T/R WB: L/T/R NB: L/T/R SB: L/T/R	*Signalized* EB: L/T/R WB: L/T/R NB: L/T/R SB: L/T/R	*Signalized* EB: L/T/R WB: L/T/R NB: L/T/R SB: L/T/R
Troy Road & Merrick Boulevard		*Roundabout* Single lane approaches and circulating	*Roundabout* Single lane approaches and circulating	*Roundabout* Single lane approaches and circulating	*Roundabout* Single lane approaches and circulating	*Roundabout* Single lane approaches and circulating	*Roundabout* Single lane approaches and circulating
Pennsylvania Avenue & Troy Road	*Signalized* EB: L/T/R WB: L/T/R NB: L/T/R SB: L/T/R	*Signalized* EB: L/T/R WB: L/T/R NB: L/T, R SB: L/T/R	*Signalized* EB: L/T/R WB: L/T/R NB: L/T, R SB: L/T/R	*Signalized* EB: L/T/R WB: L/T/R NB: L/T, R SB: L/T/R	*Signalized* EB: L/T/R WB: L/T/R NB: L/T/R SB: L/T/R	*Signalized* EB: L/T/R WB: L/T/R NB: L/T/R SB: L/T/R	*Signalized* EB: L/T/R WB: L/T/R NB: L/T/R SB: L/T/R
N. Sandusky Street & Pennsylvania Avenue	*All-Way Stop Controlled* EB: L/T/R NB: L/T/R SB: L/T/R	*Signalized* EB: L/T/R NB: L/T/R SB: L/T/R	*Signalized* EB: L/T/R NB: L/T/R SB: L/T/R	*Signalized* EB: L/T/R NB: L/T/R SB: L/T/R	*Signalized* EB: L/T/R NB: L/T/R SB: L/T/R	*Signalized* EB: L/T/R NB: L/T/R SB: L/T/R	*Signalized* EB: L/T/R NB: L/T/R SB: L/T/R
US-23 & Sandusky Street	*Signalized* EB: R NB: L, T, T SB: T, T, R	*Signalized* EB: R NB: L, T, T SB: T, T, R	*Signalized* EB: R NB: L, T, T SB: T, T, R	*Signalized* EB: R NB: L, T, T SB: T, T, R	*Signalized* EB: R NB: L, T, T SB: T, T, R	*Signalized* EB: R NB: L, T, T SB: T, T, R	*Signalized* EB: R NB: L, T, T SB: T, T, R
US-23 & Panhandle Road	*Signalized* WB: L, R NB: T, T, R** SB: L, T, T	*Signalized* EB: L/T, R, R *WB: L/T, R, R NB: L, L, T, T, R** SB: L, L, T, T, R**	*Signalized* EB: L, T, R *WB: L, T, R, R NB: L, T, T, T, R** SB: L, L, T, T, R**	*Signalized* EB: L, T, R WB: L, T, R NB: L, T, T, R** SB: L, T, T, R**	*Signalized* EB: L, T, R, R WB: L, T, R NB: L, L, T, T, R** SB: L, T, T, R**	*Signalized* EB: L, T, T, R *WB: L, T, T, R, R NB: L, T, T, R SB: L, L, T, T, R**	*Signalized* EB: L, T, R WB: L, T, R NB: L, T, T, R SB: L, T, T, R**
US-23 & Hills-Miller Road	*Signalized* EB: L, R NB: L, T, T SB: T, T, R	*Signalized* EB: L, R NB: L, T, T SB: T, T, R	*Signalized* EB: L, R NB: L, T, T SB: T, T, R	*Signalized* EB: L, T, R WB: L, T, R NB: L, L, T, T, R** SB: L, L, T, T, R	*Signalized* EB: L, R NB: L, T, T SB: T, T, R	*Signalized* EB: L, R NB: L, T, T SB: T, T, R	*Signalized* EB: L, T/R WB: L, T, R NB: L, T, T, R** SB: L, T, T, R

L = left turn lane, T = through lane, R = right turn lane, / = shared lane
Green text: Improvements (e.g., lanes, control type, etc.) added so that acceptable capacity was achieved in 2040
Red text: Analysis shows that an additional through lane is needed on US-23. This is not recommended, as described later in this report.
**Panhandle Bridge requires widening. The number of additional lanes needed for each scenario is as follows: Committed Conditions – 1, Scenario A – 2, and Scenario D – 3.*
***Right turn lanes added along US-23 for safety (rather than capacity) as per City of Delaware comments*

Table 6 – AM Peak Horizon Year Capacity Analysis Summary – Existing and Committed Conditions

Intersection	Approach	Existing Conditions		Committed Conditions	
		Baseline	With Improvements	Baseline	With Improvements
Houk Road & US-36	Eastbound	C/24.2	C/24.2	C/25.0	C/29.9
	Westbound	C/21.4	C/21.4	C/29.0	C/26.5
	Northbound	C/23.7	C/23.7	C/24.3	C/23.4
	Southbound	C/22.8	C/22.8	D/42.1	D/47.8
	Total	**C/23.0**	**C/23.0**	**C/31.2**	**C/33.8**
Houk Road & SR-37	Eastbound	C/33.1	C/21.6	E/79.3	C/23.5
	Westbound	B/16.0	B/14.8	E/58.0	C/25.9
	Northbound	C/30.7	C/28.7	D/52.3	C/31.3
	Southbound	C/34.7	C/32.1	F/86.1	D/36.8
	Total	**C/27.0**	**C/22.6**	**E/66.9**	**C/28.6**
Houk Road & Merrick Boulevard	Eastbound	A/6.4	A/6.4	A/7.8	A/3.9
	Westbound	A/7.1	A/7.1	A/8.0	A/3.3
	Northbound	A/7.8	A/7.8	A/8.4	A/3.5
	Southbound			A/9.3	A/4.3
	Total	**A/7.8**	**A/7.8**	**A/9.3**	**A/3.9**
Houk Road & Hills-Miller Road	Eastbound			A/0.0	A/0.0
	Westbound			A/1.1	A/1.1
	Northbound			B/14.6	B/14.5
	Total			**B/14.6**	**B/14.5**
Troy Road & Hills-Miller Road	Eastbound	C/20.6	C/20.6	F/212.6	A/6.4
	Westbound	B/14.3	B/14.3	F/64.6	A/5.3
	Northbound	A/0.0	A/0.0	A/0.4	A/10.0
	Southbound	A/1.7	A/1.7	A/1.3	B/10.1
	Total	**C/20.6**	**C/20.6**	**F/212.6**	**A/7.2**
Troy Road & Merrick Boulevard	Eastbound			B/10.8	A/3.9
	Northbound			A/0.5	A/3.8
	Southbound			A/0.0	A/4.1
	Total			**B/10.8**	**A/4.0**
Troy Road & Pennsylvania Avenue	Eastbound	B/12.8	B/12.8	B/10.7	B/10.6
	Westbound	B/15.1	B/15.1	B/16.0	B/15.7
	Northbound	A/7.6	A/7.6	B/16.5	B/13.5
	Southbound	A/6.4	A/6.4	B/11.5	B/11.6
	Total	**A/9.7**	**A/9.7**	**B/14.9**	**B/13.6**
N. Sandusky Street & Pennsylvania Avenue	Eastbound	C/17.5	C/17.5	C/24.0	B/19.0
	Northbound	B/10.9	B/10.9	B/11.7	A/8.7
	Southbound	C/15.6	C/15.6	C/18.4	B/11.6
	Total	**C/17.5**	**C/17.5**	**C/24.0**	**B/14.3**
US-23 & Sandusky Street	Eastbound	C/26.5	C/26.5	D/39.8	D/47.1
	Northbound	A/0.5	A/0.5	A/1.0	A/1.4
	Southbound	A/8.6	A/8.6	A/7.8	A/4.2
	Total	**A/6.3**	**A/6.3**	**A/6.9**	**A/5.7**
US-23 & Panhandle Road/ Merrick Boulevard	Eastbound			F/289.6	D/39.9
	Westbound	D/39.8	D/39.8	F/113.4	D/48.8
	Northbound	B/10.4	A/9.1	C/34.5	C/32.4
	Southbound	A/0.8	A/0.8	C/26.1	D/50.0
	Total	**A/8.4**	**A/7.9**	**E/71.8**	**D/42.4**
US-23 & Hills-Miller Road	Eastbound	D/48.2	D/48.2	D/38.9	D/46.3
	Northbound	B/18.7	B/18.7	A/2.6	A/2.7
	Southbound	B/14.0	B/14.0	C/21.5	B/17.3
	Total	**C/21.4**	**C/21.4**	**B/17.2**	**B/17.1**

Level of service (LOS)/delay (sec)
Numbers in red indicate unacceptable LOS/delay
Baseline analysis utilizes existing lane configurations and control types
Unless noted, intersection control type corresponds to those listed for each intersection in Table 5 for the Improvements analysis

Table 7 – AM Peak Horizon Year Capacity Analysis Summary – Scenarios Analysis

Intersection	Approach	Scenario				
		A	B	C	D	E
Houk Road & US-36	Eastbound	C/33.1	C/33.1	C/30.7	D/35.9	C/33.1
	Westbound	C/28.6	C/28.6	C/27.5	C/30.2	C/28.6
	Northbound	C/23.7	C/23.7	C/23.3	C/23.2	C/23.7
	Southbound	D/46.7	D/46.7	D/48.8	D/40.2	D/46.7
	Total	**D/35.2**	**D/35.2**	**C/34.6**	**C/34.2**	**D/35.2**
Houk Road & SR-37	Eastbound	C/24.6	C/31.6	C/24.9	C/31.5	C/31.5
	Westbound	C/30.3	C/30.3	B/17.7	C/30.3	C/30.3
	Northbound	C/29.0	C/29.0	C/27.5	C/28.8	C/28.8
	Southbound	D/46.2	D/46.2	D/35.2	D/45.9	D/45.9
	Total	**C/31.1**	**C/32.9**	**C/24.6**	**C/32.8**	**C/32.8**
Houk Road & Merrick Boulevard	Eastbound	A/3.7	A/3.7	A/3.9	A/4.2	A/4.2
	Westbound	A/3.3	A/3.3	A/3.4	A/3.8	A/3.5
	Northbound	A/3.3	A/3.3	A/3.7	A/3.8	A/3.8
	Southbound	A/3.9	A/3.9	A/4.3	A/4.6	A/4.7
	Total	**A/3.6**	**A/3.6**	**A/3.9**	**A/4.2**	**A/4.3**
Houk Road & Hills-Miller Road	Eastbound	A/0.0	A/0.0	A/0.0	A/0.0	A/0.0
	Westbound	A/2.9	A/2.9	A/0.9	A/0.9	A/2.1
	Northbound	C/19.0	C/19.0	B/14.5	B/14.5	C/15.8
	Total	**C/19.0**	**C/19.0**	**B/14.5**	**B/14.5**	**C/15.8**
Troy Road & Hills-Miller Road	Eastbound	B/12.1	B/12.1	B/14.7	B/14.7	B/14.1
	Westbound	A/8.5	A/8.5	B/11.6	B/11.6	B/11.3
	Northbound	B/17.5	B/17.8	B/12.4	B/12.4	B/10.6
	Southbound	B/17.9	B/18.0	B/12.8	B/12.8	B/10.9
	Total	**B/12.5**	**B/12.6**	**B/13.2**	**B/13.2**	**B/12.3**
Troy Road & Merrick Boulevard	Eastbound	A/3.9	A/3.9	A/7.0	A/7.4	A/7.2
	Westbound			A/5.4	A/6.0	A/5.4
	Northbound	A/3.8	A/3.8	A/5.9	A/6.1	A/6.0
	Southbound	A/4.1	A/4.1	A/5.7	A/6.2	A/5.8
	Total	**A/4.0**	**A/4.0**	**A/6.0**	**A/6.4**	**A/6.1**
Troy Road & Pennsylvania Avenue	Eastbound	B/10.6	B/10.6	B/12.9	B/13.0	B/13.0
	Westbound	B/15.7	B/15.7	B/15.4	B/15.4	B/15.4
	Northbound	B/13.7	B/13.5	A/8.8	A/8.8	A/8.8
	Southbound	B/11.8	B/11.6	A/8.1	A/8.2	A/8.2
	Total	**B/13.8**	**B/13.6**	**B/10.1**	**B/10.1**	**B/10.1**
N. Sandusky Street & Pennsylvania Avenue	Eastbound	B/19.0	C/21.4	C/21.5	C/21.5	B/18.9
	Northbound	A/8.9	B/10.6	B/10.7	B/10.7	A/8.8
	Southbound	B/11.8	B/14.3	B/14.2	B/14.2	B/11.5
	Total	**B/14.5**	**B/16.8**	**B/16.8**	**B/16.8**	**B/14.3**
US-23 & Sandusky Street	Eastbound	D/41.4	D/41.6	D/49.1	D/41.5	D/47.2
	Northbound	A/0.5	A/0.5	A/1.8	A/0.5	A/0.5
	Southbound	A/2.8	A/2.5	B/12.0	A/2.9	A/2.3
	Total	**A/5.0**	**A/4.9**	**A/10.0**	**A/5.1**	**A/5.2**
US-23 & Panhandle Road/ Merrick Boulevard	Eastbound	D/43.6*	D/45.5	D/53.0	D/41.0	D/48.8
	Westbound	C/26.1*	C/31.6	D/52.2	C/32.0	D/35.1
	Northbound	C/34.8*	C/22.7	C/32.7	C/25.1	C/26.1
	Southbound	D/42.0*	B/12.3	D/45.2	D/39.8	D/37.4
	Total	**D/36.7***	**C/23.0**	**D/43.0**	**C/34.8**	**D/36.1**
US-23 & Hills-Miller Road	Eastbound	D/42.0	D/44.0	D/48.8	C/32.8	D/38.6
	Westbound		C/33.9			D/37.7
	Northbound	B/15.1	D/38.7	A/2.8	A/3.4	C/29.2
	Southbound	C/24.7	C/30.9	B/17.3	C/20.7	C/25.1
	Total	**C/24.6**	**D/36.4**	**B/17.1**	**B/15.7**	**C/30.9**

Level of service (LOS)/delay (sec)
Numbers in red indicate unacceptable LOS/delay
Unless noted, intersection control type corresponds to those listed for each scenario in Table 5
**Analysis conducted assuming additional through lanes shown to be needed on US-23 (in the PM peak) are not installed*

Table 8 – PM Peak Horizon Year Capacity Analysis Summary – Existing and Committed Conditions

Intersection	Approach	Existing Conditions		Committed Conditions	
		Baseline	With Improvements	Baseline	With Improvements
Houk Road & US-36	Eastbound	C/29.6	C/29.6	E/63.8	D/46.6
	Westbound	C/30.8	C/30.8	E/65.1	D/38.9
	Northbound	C/30.8	C/30.8	D/54.9	C/34.0
	Southbound	D/46.6	D/46.6	E/55.4	D/41.5
	Total	**C/33.8**	**C/33.8**	**E/61.0**	**D/41.8**
Houk Road & SR-37	Eastbound	E/69.3	D/54.4	F/136.4	C/31.6
	Westbound	D/47.3	D/38.3	F/92.7	D/43.7
	Northbound	F/81.2	D/50.5	F/119.1	D/53.7
	Southbound	F/95.7	D/54.2	F/177.9	D/53.8
	Total	**E/67.9**	**D/47.5**	**F/120.6**	**D/45.3**
Houk Road & Merrick Boulevard	Eastbound	A/6.6	A/6.6	A/8.3	A/3.7
	Westbound	A/0.0	A/0.0	A/8.3	A/4.1
	Northbound	A/7.9	A/7.9	A/10.0	A/5.0
	Southbound			A/9.2	A/4.2
	Total	**A/7.9**	**A/7.9**	**A/10.0**	**A/4.6**
Houk Road & Hills-Miller Road	Eastbound			A/0.0	A/0.0
	Westbound			A/1.6	A/1.6
	Northbound			B/14.0	B/13.9
	Total			**B/14.0**	**B/13.9**
Troy Road & Hills-Miller Road	Eastbound	B/14.4	B/14.4	F/129.0	A/5.9
	Westbound	C/16.4	C/16.4	F/270.4	A/6.6
	Northbound	A/0.0	A/0.0	A/0.4	B/10.0
	Southbound	A/0.5	A/0.5	A/0.4	A/9.8
	Total	**C/16.4**	**C/16.4**	**F/270.4**	**A/7.4**
Troy Road & Merrick Boulevard	Eastbound			B/12.8	A/3.9
	Northbound			A/0.8	A/5.3
	Southbound			A/0.0	A/4.7
	Total			**B/12.8**	**A/5.0**
Troy Road & Pennsylvania Avenue	Eastbound	B/11.3	B/11.3	B/15.8	A/9.2
	Westbound	B/15.8	B/15.8	D/42.0	C/21.1
	Northbound	B/12.7	B/12.7	E/61.9	D/38.5
	Southbound	A/9.2	A/9.2	D/35.9	B/18.8
	Total	**B/13.0**	**B/13.0**	**D/48.8**	**C/28.1**
N. Sandusky Street & Pennsylvania Avenue	Eastbound	B/14.6	B/14.6	C/18.0	C/22.6
	Northbound	B/13.9	B/13.9	C/16.3	A/7.9
	Southbound	C/21.4	C/21.4	D/32.5	A/9.3
	Total	**C/21.4**	**C/21.4**	**D/32.5**	**B/12.5**
US-23 & Sandusky Street	Eastbound	B/19.0	B/19.0	C/26.2	C/26.2
	Northbound	A/0.8	A/0.8	A/2.0	A/2.0
	Southbound	A/6.8	A/6.8	A/8.2	A/8.2
	Total	**A/3.8**	**A/3.8**	**A/5.2**	**A/5.2**
US-23 & Panhandle Road/ Merrick Boulevard	Eastbound			F/729.0	D/42.1
	Westbound	D/38.6	D/38.6	F/144.2	D/49.8
	Northbound	B/16.4	B/12.3	E/75.9	D/40.3
	Southbound	A/2.2	A/1.9	E/77.9	D/53.5
	Total	**B/11.5**	**B/9.3**	**F/141.1**	**D/45.8**
US-23 & Hills-Miller Road	Eastbound	D/35.6	D/35.6	D/46.2	D/44.9
	Northbound	A/2.6	A/2.6	A/5.3	A/7.6
	Southbound	B/13.0	B/13.0	C/25.0	C/25.0
	Total	**A/9.8**	**A/9.8**	**B/18.6**	**B/19.5**

Level of service (LOS)/delay (sec)
Numbers in red indicate unacceptable LOS/delay
Baseline analysis utilizes existing lane configurations and control types
Unless noted, intersection control type corresponds to those listed for each intersection in Table 5 for the Improvements analysis

Table 9 – PM Peak Horizon Year Capacity Analysis Summary – Scenarios Analysis

Intersection	Approach	Scenarios				
		A	B	C	D	E
Houk Road & US-36	Eastbound	D/46.9	D/46.9	D/46.6	D/46.9	D/46.9
	Westbound	D/39.9	D/39.9	D/38.9	D/39.9	D/39.9
	Northbound	C/34.1	C/34.1	C/34.0	C/34.1	C/34.1
	Southbound	D/41.4	D/41.4	D/41.5	D/41.4	D/41.4
	Total	**D/42.2**	**D/42.2**	**D/41.8**	**D/42.2**	**D/42.2**
Houk Road & SR-37	Eastbound	D/37.7	D/53.9	D/53.8	D/54.9	D/55.0
	Westbound	D/52.2	D/54.0	D/52.0	D/53.8	D/53.9
	Northbound	D/48.2	D/54.7	D/52.8	D/53.0	D/53.2
	Southbound	D/50.3	D/54.4	D/54.4	D/52.7	D/52.8
	Total	**D/47.6**	**D/54.2**	**D/52.9**	**D/53.7**	**D/53.8**
Houk Road & Merrick Boulevard	Eastbound	A/3.5	A/3.5	A/3.7	A/3.8	A/3.8
	Westbound	A/3.8	A/3.8	A/4.6	A/4.8	A/4.9
	Northbound	A/4.4	A/4.4	A/4.4	A/4.9	A/4.9
	Southbound	A/3.8	A/3.8	A/4.1	A/4.3	A/4.3
	Total	**A/4.1**	**A/4.1**	**A/4.3**	**A/4.6**	**A/4.6**
Houk Road & Hills-Miller Road	Eastbound	A/0.0	A/0.0	A/0.0	A/0.0	A/0.0
	Westbound	A/3.7	A/3.7	A/1.2	A/1.2	A/1.7
	Northbound	C/18.7	C/18.7	B/13.8	B/13.8	B/14.0
	Total	**C/18.7**	**C/18.7**	**B/13.8**	**B/13.8**	**B/14.0**
Troy Road & Hills-Miller Road	Eastbound	A/9.1	A/8.8	B/12.3	B/13.5	B/12.1
	Westbound	B/11.2	B/11.6	B/13.8	B/15.7	B/13.4
	Northbound	B/18.4	B/19.6	B/12.9	B/12.3	B/10.1
	Southbound	B/17.8	B/18.7	B/12.7	B/12.1	A/9.9
	Total	**B/12.2**	**B/12.5**	**B/13.0**	**B/13.9**	**B/11.9**
Troy Road & Merrick Boulevard	Eastbound	A/3.9	A/3.9	A/6.2	A/7.1	A/6.3
	Westbound			A/9.0	A/9.9	A/9.3
	Northbound	A/5.3	A/5.4	A/9.1	B/10.3	A/9.3
	Southbound	A/4.8	A/4.8	A/7.7	A/8.2	A/7.9
	Total	**A/5.0**	**A/5.1**	**A/8.4**	**A/9.3**	**A/8.7**
Troy Road & Pennsylvania Avenue	Eastbound	A/9.6	A/9.2	B/17.4	B/17.1	B/17.1
	Westbound	C/22.7	C/21.1	C/28.9	C/29.5	C/29.5
	Northbound	D/37.8	D/38.4	C/24.3	C/24.2	C/24.2
	Southbound	C/20.4	B/19.0	B/14.8	B/14.4	B/14.4
	Total	**C/28.5**	**C/28.0**	**C/22.6**	**C/22.6**	**C/22.6**
N. Sandusky Street & Pennsylvania Avenue	Eastbound	C/23.8	C/26.7	C/26.4	C/26.4	C/23.4
	Northbound	A/8.1	B/10.4	B/10.2	B/10.2	A/7.7
	Southbound	A/9.7	B/11.7	B/11.5	B/11.5	A/9.0
	Total	**B/13.0**	**B/15.3**	**B/15.1**	**B/15.1**	**B/12.5**
US-23 & Sandusky Street	Eastbound	D/53.9	C/21.2	E/57.0*	C/24.1	D/48.8
	Northbound	A/0.6	A/0.7	A/2.9	A/0.7	A/0.7
	Southbound	A/0.8	A/4.2	A/3.6	A/4.8	A/0.8
	Total	**A/2.8**	**A/3.0**	**A/4.7**	**A/3.3**	**A/2.7**
US-23 & Panhandle Road/ Merrick Boulevard	Eastbound	E/57.5**	D/48.3	D/39.1	D/49.1	C/34.8
	Westbound	D/51.4**	D/54.6	D/41.6	D/53.1	D/53.8
	Northbound	E/55.6**	C/25.6	D/52.7	D/50.7	D/44.5
	Southbound	D/38.6**	A/6.8	D/52.7	D/49.9	D/46.8
	Total	**D/48.6****	**C/27.0**	**D/50.5**	**D/50.8**	**D/45.3**
US-23 & Hills-Miller Road	Eastbound	D/39.0	D/35.4	D/45.5	D/48.2	D/47.9
	Westbound		D/49.5			D/54.2
	Northbound	C/23.5	D/48.8	A/7.3	A/7.4	B/14.4
	Southbound	D/52.3	D/37.6	C/23.3	C/22.0	C/30.1
	Total	**C/36.4**	**D/42.7**	**B/18.5**	**B/18.4**	**C/30.8**

Level of service (LOS)/delay (sec)
Numbers in red indicate unacceptable LOS/delay
Unless noted, intersection control type corresponds to those listed for each scenario in Table 5
**This was considered acceptable, as it is barely outside what is considered "acceptable"*
***Analysis conducted assuming additional through lanes shown to be needed on US-23 are not installed. Not shown in this table, specific movements WBT and SBL have LOS F.*

As previously described, the analysis shows that an additional northbound through lane is needed on US-23 at the Panhandle Road intersection in Scenario A. Adding a through lane at just one intersection is not effective on a high-volume through-route like US-23. The proposed three through lanes would have to be tapered back to the existing two lanes immediately after the intersection. Drivers would likely choose to not utilize the lane that has to merge after the intersection, reducing the effectiveness of the additional lane.

The intersection capacity analysis, planning-level number of lanes evaluation, and ODOT US-23 Centerline Corridor Study all indicate additional through lanes are needed on US-23. Since this is a large improvement which would have impacts well beyond the NWACA study area, the addition of through lanes on US-23 was not included with this study. Thus, analysis was completed for the US-23 & Panhandle Road intersection in Scenario A to show the capacity results with and without the necessary northbound through lane added on US-23. Analysis results with the necessary northbound through lane can be seen in **Appendix M**.

As shown in the capacity analysis results, unacceptable Horizon Year capacity is expected in Scenario A when the northbound through lane cannot be added to US-23. This exemplifies the need for additional capacity on US-23 and shows Scenario A could lead to future capacity issues at this intersection.

Also described in the previous tables, many scenarios include the need for additional lanes on the Panhandle Road bridge over the Olentangy River. The number of additional lanes needed for each scenario is as follows: Committed Conditions – 1, Scenario A – 2, and Scenario D – 3. This bridge is relatively new. Adding lanes is possible, but obviously not desirable. If lanes are not added to the bridge, significant capacity issues will be incurred. Therefore, widening the bridge was included in the analysis and considered "feasible".

E. Travel Time Analysis

Travel time analysis was conducted to quantify and compare general impacts the various scenarios would have on area travel times. Travel time analysis was conducted for local (bypass and residential) and emergency response traffic. The analysis represents the impact each scenario would have by providing alternate routes to utilize compared to existing routes.

For the residential traffic travel time analysis, three existing houses were selected in the residential areas on the north side of SR-37, west of US-23. For bypass traffic travel times, locations were selected on each of the outlying roadways: US-23 (north), SR-37 (west), US-36 (west), US-36/SR-37 (east), and US-42 (north). See **Figure 11** for a visual of locations utilized for the analysis. These locations were then used to determine the fastest travel route between various locations (bypass-to-bypass, bypass-to-residential, or residential-to-bypass) for each scenario. Route travel times were then calculated and compared between the various scenarios.

For the local (bypass and residential) analysis, travel times were calculated by adding the time to travel individual segments along the route used (assuming the vehicle is traveling at the posted speed limit) to the delays experienced at various intersections. For those intersections that were analyzed as a part of this project, the calculated delay for the applicable movement at the intersections was added to the total travel time. For intersections that were not included in the analysis for this project, base assumptions of 30 seconds of delay at signalized intersections, 10 seconds of delay for left turning movements on the stop-controlled approaches to unsignalized intersections, and 5 seconds of delay for right turning movements on the stop-controlled approaches to unsignalized intersections were utilized.

For the emergency response travel time analysis, the three existing houses used for the local travel time analysis were selected and response times from various emergency response locations were calculated. The City provided Delaware Fire Department (DFD) run cards for each house location. Travel times were calculated using the first responding Fire Station and Medic Station listed in the run card for each location. Also included in the travel time analysis is a planned future fire station, Station 305, which will be located at 680 Sunbury Road. See **Figure 12** for a visual of locations utilized for analysis. These locations were then used to determine the fastest travel route between the residential locations and each emergency location. Response times were calculated from the emergency locations to each residential location only.

Travel times for emergency response vehicles were calculated by adding the time to travel individual segments along the route used (assuming the vehicle is traveling at the posted speed limit) to each other for the entire length of the route. This was completed for each scenario and the results were then compared. A minimum time of two minutes was included in all travel times to account for dispatch processing and turn out.

Figure 11 – Locations Used to Calculate Local Travel Times

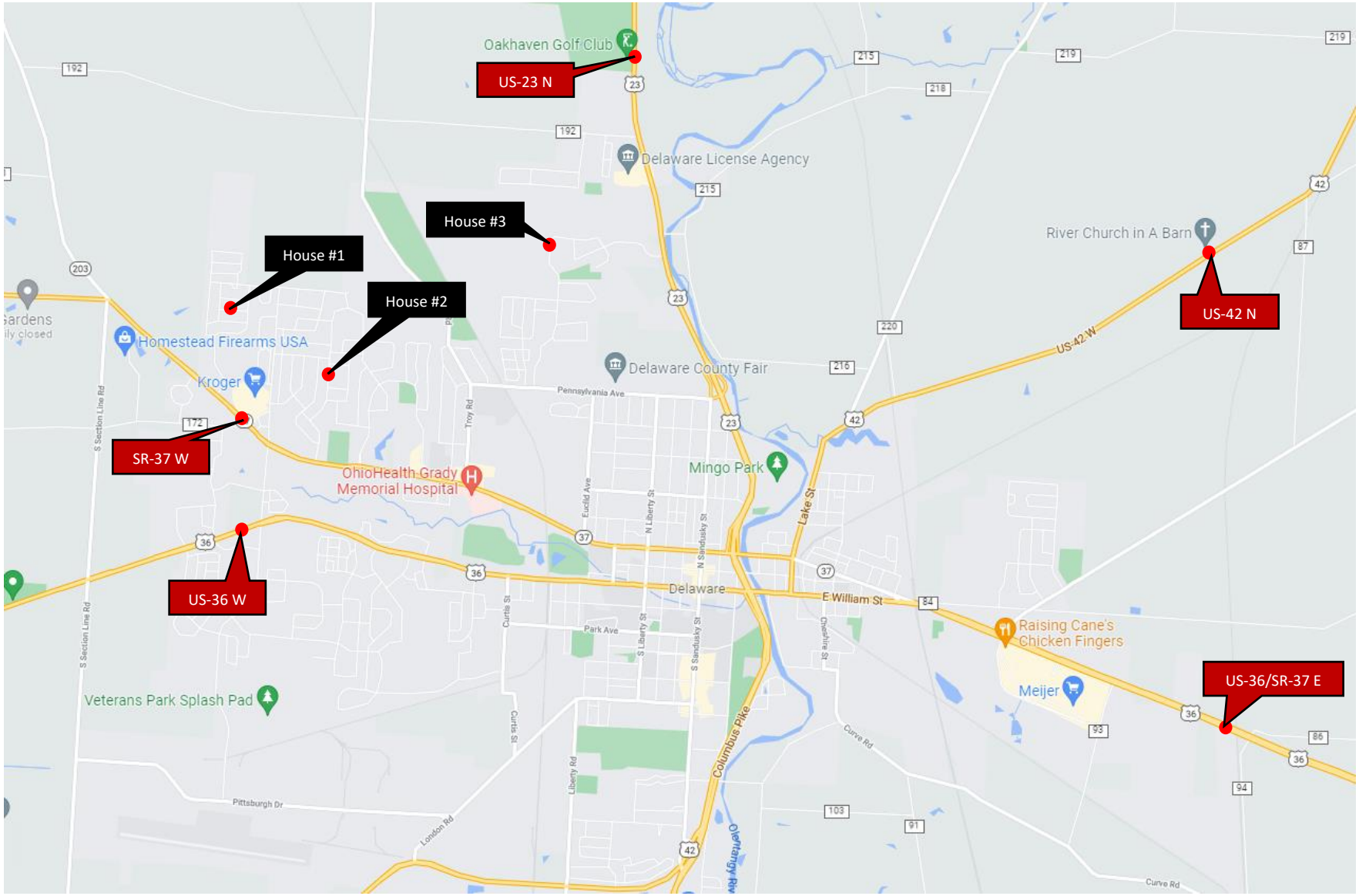
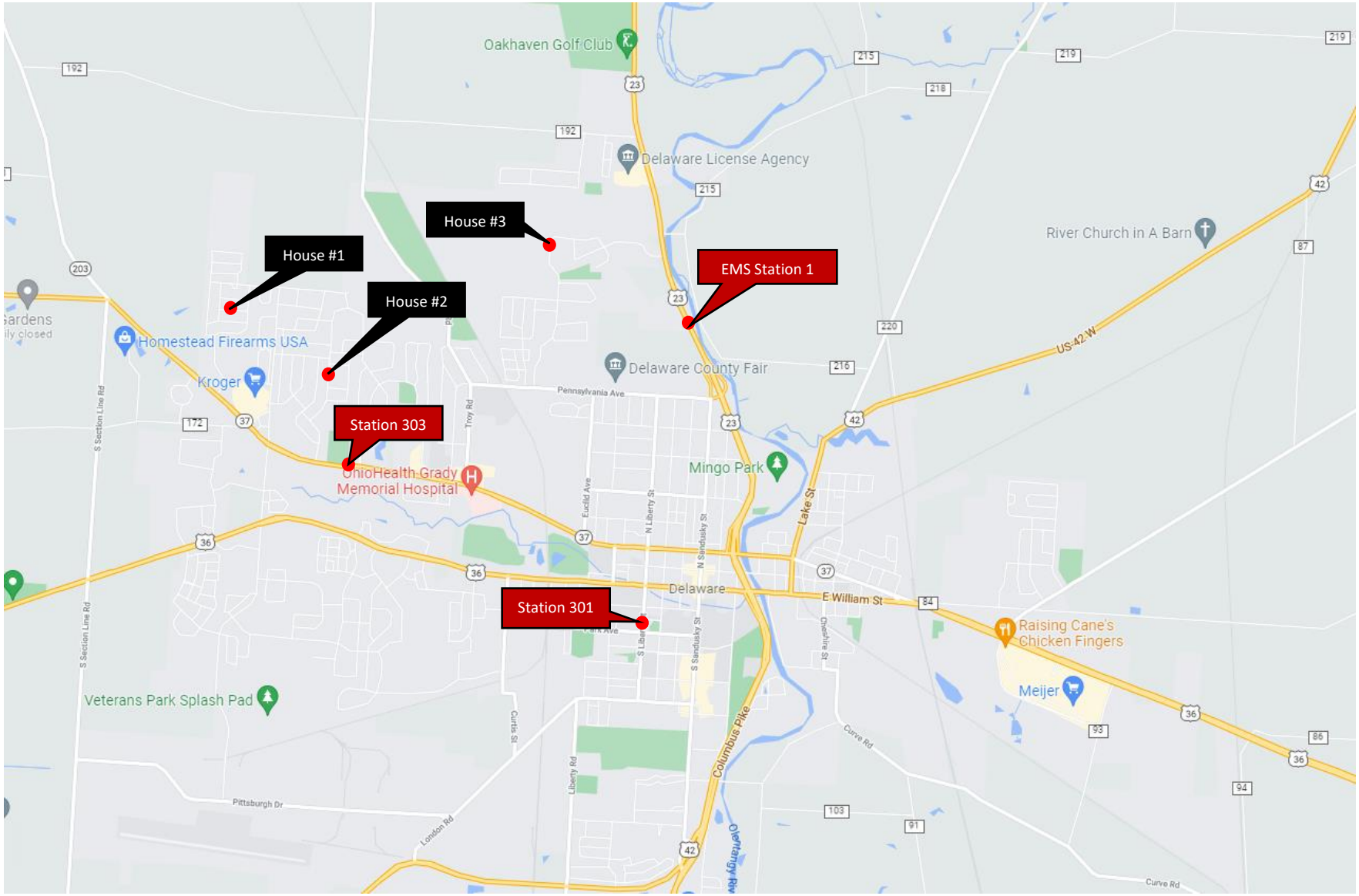


Figure 12 – Locations Used to Calculate Emergency Travel Times



Summaries of the travel times calculated are provided in **Tables 10 and 11**. Existing travel times and the calculated decrease (in seconds) for routes that are expected to take less travel time are listed. Calculated decreases in travel time are shown in shades of green. Routes that are expected to have the same travel time as the existing route, or are not expected to be more optimal than the existing route, are represented by asterisks. Detailed travel time calculations can be seen in the **Appendix N**.

Table 10 – AM Peak Local Travel Times

From	To	Existing Travel Time (sec)	Decrease in Travel Time compared to Existing (sec)					
			Commit.	A	B	C	D	E
SR-37 W	US-23 N	900	476	482	487	586	562	523
US-23 N	SR-37 W	780	351	361	362	397	373	365
US-36 W	US-23 N	780	*	146	133	127	128	102
US-23 N	US-36 W	780	77	135	136	80	72	52
SR-37 W	US-42 N	780	*	*	*	*	40	*
US-42 N	SR-37 W	750	*	*	*	*	*	*
US-36 W	US-42 N	780	*	*	*	*	*	*
US-42 N	US-36 W	750	*	*	*	*	*	*
US-23 N	US-42 N	600	*	145	139	*	147	163
US-42 N	US-23 N	600	*	176	155	*	189	152
US-23 N	US-36/SR-37 E	840	*	127	121	*	129	144
US-36/SR-37 E	US-23 N	1080	*	408	376	*	410	404
House #1	US-23 N	960	361	559	546	537	544	514
US-23 N	House #1	900	491	543	544	469	457	444
House #1	US-42 N	1020	*	225	651	*	333	316
US-42 N	House #1	960	*	231	369	*	292	295
House #2	US-23 N	780	339	326	312	408	414	386
US-23 N	House #2	780	324	377	378	409	401	390
House #2	US-42 N	840	*	*	29	*	203	187
US-42 N	House # 2	840	*	49	39	*	217	221
House #3	US-42 N	540	*	73	80	*	91	90
US-42 N	House #3	510	*	41	41	*	39	33
House #3	US-36 W	570	*	*	*	*	*	*
US-36 W	House #3	570	7	11	11	*	*	*
House #3	SR-37 W	600	*	*	*	180	164	167
SR-37 W	House #3	660	*	*	*	264	261	260
House #3	US-36/SR-37 E	840	*	*	*	128	136	121
US-36/SR-37 E	House #3	750	*	*	*	55	52	64

**New routes from this scenario are not more optimal compared to the existing route*

Table 11 – PM Peak Local Travel Times

From	To	Existing Travel Time (sec)	Decrease in Travel Time compared to Existing (sec)					
			Commit.	A	B	C	D	E
SR-37 W	US-23 N	900	449	462	453	530	533	526
US-23 N	SR-37 W	840	361	419	418	425	416	396
US-36 W	US-23 N	840	*	105	113	95	96	89
US-23 N	US-36 W	900	*	282	280	202	191	175
SR-37 W	US-42 N	960	*	105	135	*	191	118
US-42 N	SR-37 W	840	*	*	4	*	14	*
US-36 W	US-42 N	960	*	*	*	*	*	*
US-42 N	US-36 W	840	*	*	*	*	*	*
US-23 N	US-42 N	600	*	105	136	*	127	153
US-42 N	US-23 N	540	*	123	74	*	123	63
US-23 N	US-36/SR-37 E	780	*	27	58	*	108	76
US-36/SR-37 E	US-23 N	960	*	284	235	*	284	225
House #1	US-23 N	660	120	226	243	221	223	216
US-23 N	House #1	660	40	292	294	216	192	177
House #1	US-42 N	1080	*	289	318	*	378	386
US-42 N	House #1	1080	*	309	337	*	346	368
House #2	US-23 N	780	313	287	302	393	385	388
US-23 N	House #2	780	384	366	368	387	378	359
House #2	US-42 N	900	*	49	77	*8	245	258
US-42 N	House # 2	960	*	176	156	*	275	295
House #3	US-42 N	540	*	52	66	*	85	86
US-42 N	House #3	480	*	9	13	*	18	19
House #3	US-36 W	630	*	37	116	*	15	21
US-36 W	House #3	630	*	40	*	*	*	*
House #3	SR-37 W	630	*	*	*	180	177	183
SR-37 W	House #3	660	*	*	*	239	241	239
House #3	US-36/SR-37 E	1020	*	*	*	308	316	301
US-36/SR-37 E	House #3	900	*	*	*	181	160	175

**New routes from this scenario are not more optimal compared to the existing route*

Emergency response travel times were calculated but are not shown, as all route travel times were determined to be the same as the existing route. However, in the event that Delaware City services are not available, the County EMS response will be improved with the connection of Merrick Boulevard from Troy Road to US-23.

F. At-Grade Train Crossing Travel Time Impact Analysis

48-hour video footage of the at-grade CSX train crossing on Pennsylvania Avenue was obtained on March 11-12, 2021. This footage was analyzed to determine how many trains utilize the crossing in a day, and approximately how long the gates are down. The data could be further extrapolated to show the impacts on the proposed Merrick Boulevard extension if it had an at-grade train crossing as opposed to grade separated crossing.

A total of 22 trains were observed over the 48-hour period. The data shows an average of 11 trains are expected per day. Vehicle delays due to a train are expected to range from 0.5-2.75 minutes with an average of 1.75 minutes. This data is summarized in **Table 12** below.

Table 12 – Train Arrival Times

Train Number	Arrival Time	Traffic Delay (min)
1	Day 1, 12:27 AM	2.5
2	Day 1, 3:42 AM	2
3	Day 1, 4:25 AM	2
4	Day 1, 8:02 AM	0.75
5	Day 1, 9:10 AM	0.5
6	Day 1, 10:58 AM	1.5
7	Day 1, 12:26 PM	0.5
8	Day 1, 5:09 PM	2.75
9	Day 1, 8:44 PM	1.75
10	Day 1, 11:53 PM	2.5
11	Day 2, 1:00 AM	1.25
12	Day 2, 2:36 AM	1.25
13	Day 2, 3:31 AM	2.5
14	Day 2, 4:55 AM	1.25
15	Day 2, 7:16 AM	1.75
16	Day 2, 9:27 AM	0.5
17	Day 2, 9:39 AM	2.25
18	Day 2, 10:51 AM	1.5
19	Day 2, 5:22 PM	2.75
20	Day 2, 7:22 PM	2.25
21	Day 2, 8:19 PM	2.75
22	Day 2, 10:11 PM	2.25

G. Crash Analysis

Within the study area, several locations are identified by ODOT and MORPC as areas of concern regarding crash history:

- 2021 County Road High Crash Locations map for Delaware County
  - Troy Road from south of Hills-Miller Road to north of Hills-Miller Road
- Safety Integrated Project Maps
  - Hills-Miller Road from just east of SR-203 to US-23
  - Troy Road from SR-37 to just south of Hills-Miller Road
  - Pennsylvania Avenue from Troy Road to Euclid Avenue
  - US-23 between Panhandle Road and Hills-Miller Road
  - US-23 between SR-37 and N. Sandusky Street
  - SR-37, multiple segments from Brookwood Place to Campbell Street
  - US-36, multiple segments from Rockcreek Drive to Columbus Avenue
- Roadway Departure Systemic Priorities
  - US-23 between Hills-Miller Road and N. Sandusky Street
  - SR-37 from western to eastern study limits
  - US-36 from western to eastern study limits
- Pedestrian Systemic Priorities
  - SR-37 from western to eastern study limits
  - US-36 from western to eastern study limits
  - N. Sandusky Street from southern study limits to US-23
- MORPC 2019 High Injury Corridor
  - US-36 from western to eastern study limits
  - N. Sandusky Street from southern study limits to US-23
- MORPC 2015-2017 High Crash Intersections by Jurisdiction
  - US-36 & Sandusky Street
  - SR-37 & Sandusky Street

Crash data was obtained from ODOT TIMS for three years of available data (2017-2019). Although additional years of data are available, crash data was only obtained through 2019 to show a representation of the area prior to any impacts caused by the COVID-19 pandemic.

A total of 665 crashes were obtained. **Figure 13** shows a heat map of the raw data. **Figure 14** shows the crash severity details, with property damage only (PDO) crashes omitted. **Table 13** represents a breakdown of the crash data.

Figure 13 – Crash Frequency Heat Map

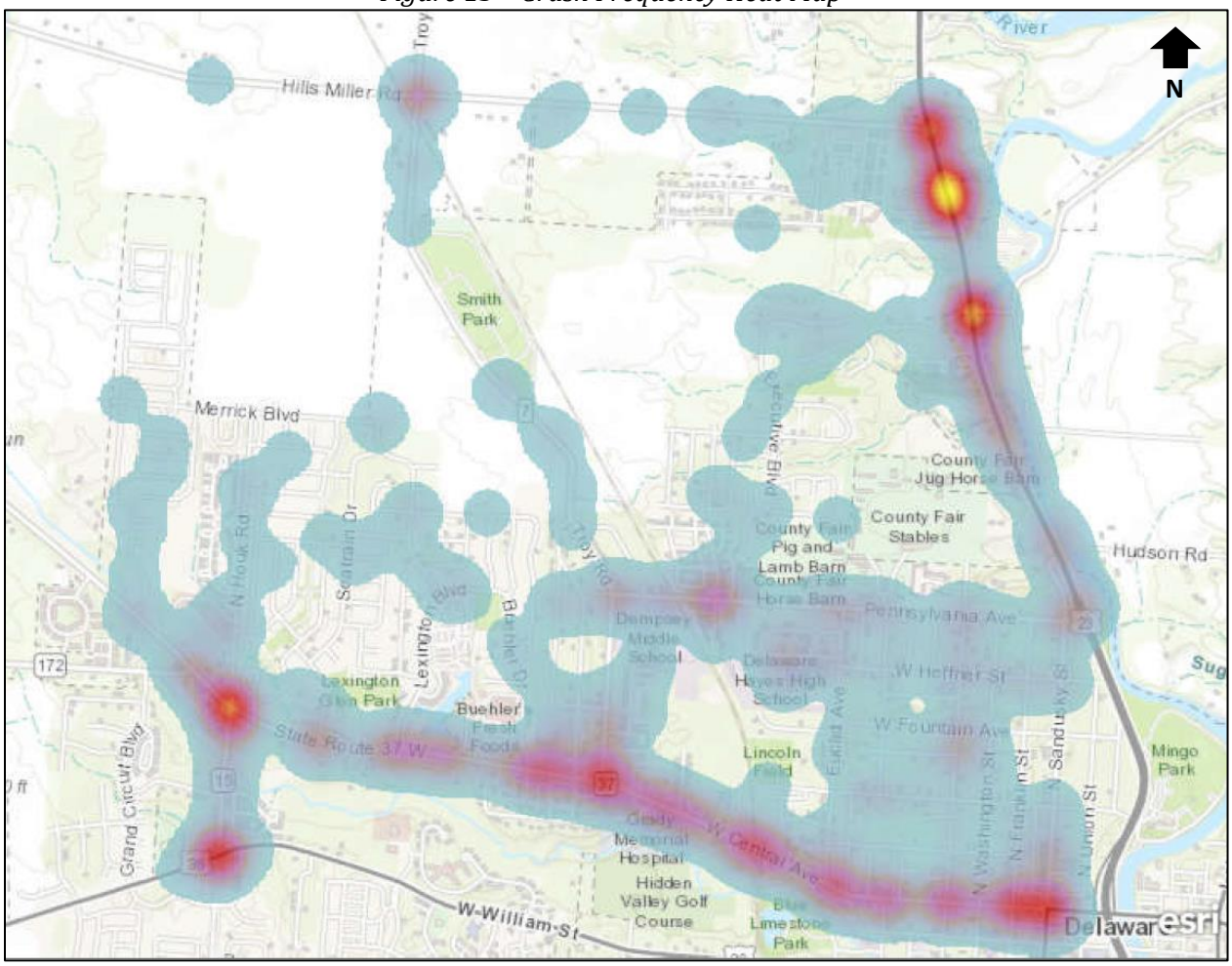


Figure 14 – Crash Severity Detail Map

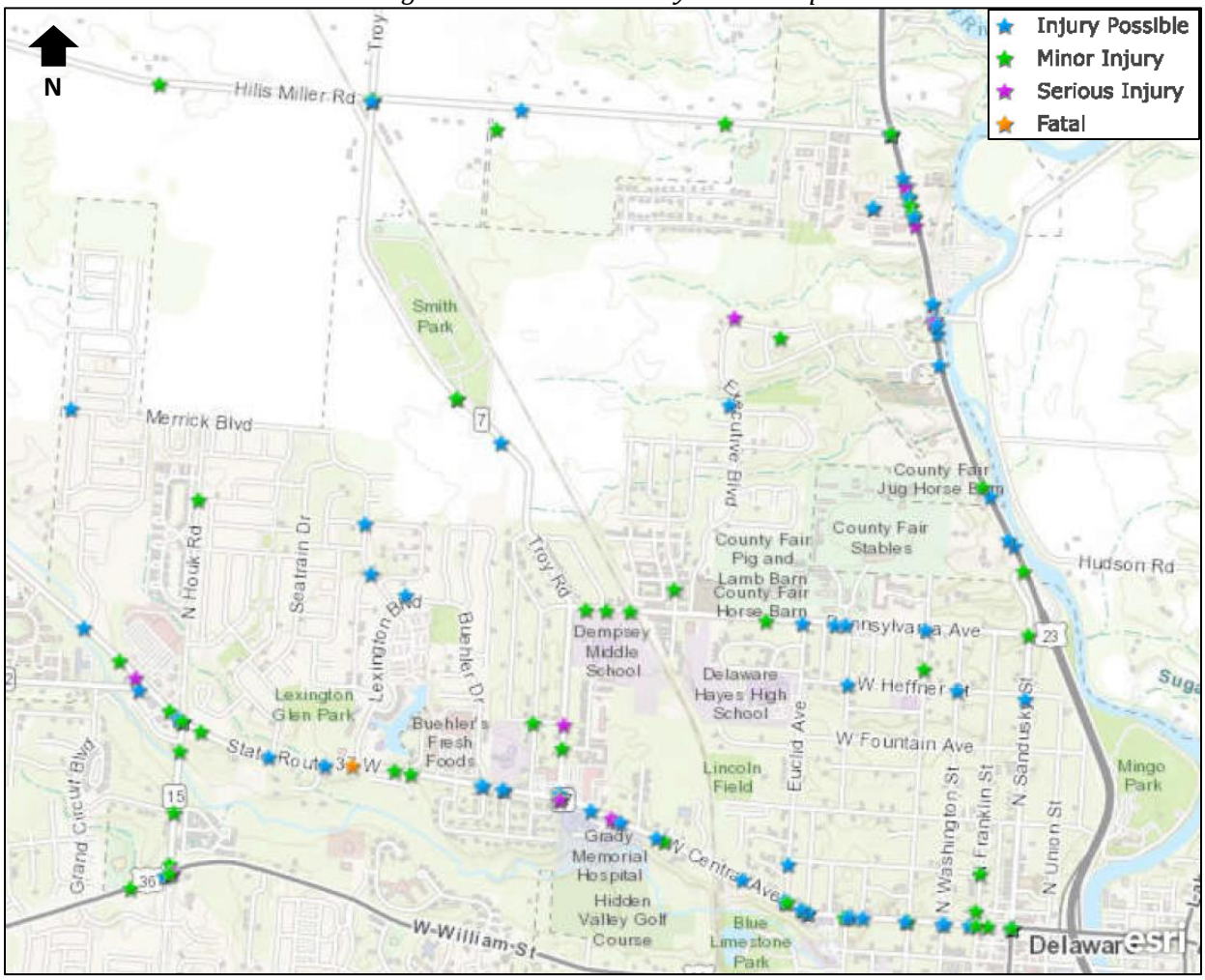


Table 13 - Crash Statistics

Crash Year	Number	Percent
2017	219	32.9%
2018	226	34.0%
2019	220	33.1%

Crash Severity	Number	Percent
Fatal Crash	1	0.2%
Injury Crash	136	20.4%
Property Damage Crash	528	79.4%

Crash Type	Number	Percent
Rear End	252	37.9%
Fixed Object	89	13.4%
Angle	70	10.5%
Parked Vehicle	58	8.7%
Sideswipe – Passing	45	6.8%
Left Turn	41	6.2%
Backing	29	4.4%
Animal	22	3.3%
Right Turn	21	3.2%
Pedalcycles	11	1.7%
Pedestrian	10	1.5%
Head On	7	1.1%
Other Non-Collision	4	0.6%
Unknown	2	0.3%
Other Object	2	0.3%
Sideswipe – Meeting	1	0.2%
Overturning	1	0.2%

Road Condition	Number	Percent
Dry	521	78.3%
Wet	110	16.5%
Snow	24	3.6%
Other/Unknown	7	1.1%
Ice	3	0.5%

Hour of Day	Number	Percent
12:00 AM	10	1.5%
1:00 AM	9	1.4%
2:00 AM	3	0.5%
3:00 AM	3	0.5%
4:00 AM	6	0.9%
5:00 AM	4	0.6%
6:00 AM	16	2.4%
7:00 AM	59	8.9%
8:00 AM	29	4.4%
9:00 AM	31	4.7%
10:00 AM	29	4.4%
11:00 AM	31	4.7%
12:00 PM	34	5.1%
1:00 PM	37	5.6%
2:00 PM	64	9.6%
3:00 PM	58	8.7%
4:00 PM	47	7.1%
5:00 PM	57	8.6%
6:00 PM	44	6.6%
7:00 PM	23	3.5%
8:00 PM	22	3.3%
9:00 PM	25	3.8%
10:00 PM	14	2.1%
11:00 PM	10	1.5%

Day of Week	Number	Percent
Monday	104	15.6%
Tuesday	107	16.1%
Wednesday	109	16.4%
Thursday	94	14.1%
Friday	120	18.0%
Saturday	71	10.7%
Sunday	60	9.0%

Overall, it is important to note safety issues exist in the study area. Many scenarios explored in this study will redirect traffic from many of these identified high-crash locations. Oftentimes, a high frequency of crashes at a location can be linked to congestion. By providing alternate routes, congestion can be reduced at other intersections, leading to a reduction in crashes. Capacity improvements at study intersections were evaluated for each scenario with the goal of reducing congestion and related crashes. Safety improvements previously recommended by the 2018 Safety Study should be carried forward into future roadway improvements.

VI. Innovative Intersection Considerations

As previously described, unacceptable Horizon Year capacity is expected at the US-23 & Panhandle Road intersection when through lanes cannot be added to US-23 for Scenario A. Furthermore, the planning-level number of lanes evaluation and ODOT US-23 Centerline Corridor Study all indicate additional through lanes are needed on US-23. Below is a high-level overview of the innovative intersection concepts which could be considered. Note, there are concerns regarding the space available for the concepts. Further evaluation would have to be completed to determine the feasibility of these concepts. It is understood that Phase 2 of the ODOT US-23 Centerline Corridor Study (which is currently underway) will be further investigating similar considerations.

Continuous Flow Intersection

A continuous flow intersection (CFI) design improves traffic flow and reduces delays by allowing left turns and through movements of one or both approaches to occur at the same time. A CFI design is meant for junctions which have heavy demand for left-turning traffic, similar to the US-23 & Panhandle Road intersection. Through and right turning movements generally operate the same as a conventional intersection. To make a left turn movement, drivers make the turn earlier, before reaching the main intersection. Drivers follow the signs and road markings to cross over the opposing through lanes at a traffic signal, which is typically 300-500 feet before the main intersection. The design slightly reduces the number of conflicts points where a crash can occur. CFI designs are present in Ohio south of Dayton and near Cincinnati. An example of a CFI application in Cincinnati, Ohio is shown in **Figure 15**.

Figure 15 – CFI Example in Cincinnati, Ohio

Crossbow

The Alum Creek Drive & Groveport Road "Crossbow" was the first of its kind in central Ohio. The design includes two roundabouts on Groveport Road, one east and one west of the Alum Creek Drive and Groveport Road intersection, which are connected by a flyover bridge or overpass (the "bow"). Minor street (Groveport Road) approach through and left

turn movements are prohibited, only right turn movements are allowed. The prohibited movements are redirected to the roundabouts and across the flyover. The changes allow traffic to move more efficiently and improve signal capacity and safety by reducing the number of conflicting movements. See **Figure 16** below.

Figure 16 – Alum Creek Drive & Groveport Road Crossbow Example

Signalized RCUT/Superstreet

A restricted crossing U-turn (RCUT) intersection is a four-approach intersection where minor street left-turn and through movements are rerouted to one-way downstream U-turn crossovers. The RCUT provides flexibility in traffic signal timing to accommodate unbalanced traffic flow which may result from commuter patterns or retail developments (similar to the NWACA study area). The RCUT design reduces the total number and overall severity of vehicle-to-vehicle conflict points. The RCUT design also improves overall roadway operations, even when the additional distance traffic entering from the minor road must travel is considered. A general example of a signalized RCUT/Superstreet is shown in **Figure 17**.

Figure 17 – Signalized RCUT/Superstreet Example in Hamilton, Ohio

VII. Access Management

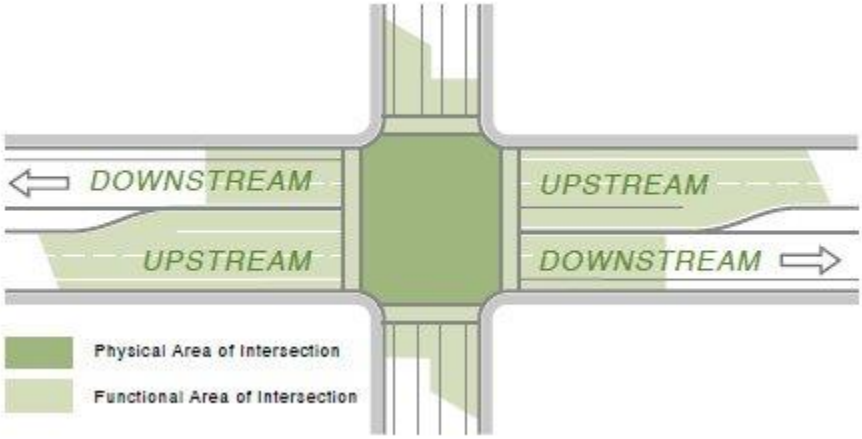
Access management is an important tool to increase roadway capacity, manage congestion, and reduce crashes in a roadway network. The NWACA project, in many scenarios, incorporates the extension of Merrick Boulevard from Troy Road east to US-23. Based on the anticipated traffic volumes along Merrick Boulevard, and the City's current thoroughfare plan, it is anticipated that Merrick Boulevard will be classified as a collector. From the hierarchy of roadway classifications, a collector should service numerous local, public roadways with a mixture of access points to private development. Private development access, however, should be minimized to an extent to reduce conflict points and ensure through traffic along Merrick Boulevard is not negatively impacted.

Chapter 9 of the City of Delaware's Design Manual provides recommendations for five categories of access management, each describing the degree of mobility for motor vehicle traffic versus access limitations for adjacent properties of a roadway. Merrick Boulevard, being a collector road, is expected to be a low to moderate speed (25-35 MPH) roadway that primarily provides access to residential areas with a mix of business uses. It is recommended that only one access point be provided for each parcel unless it is shown that additional access points are necessary, and the additional access is not detrimental to the safety and operations of the traveling roadway. Cross access between parcels/ developments is highly encouraged, and access points located within 150 feet of intersections with higher classified roads may be restricted.

The below, additional guidelines should be referenced and considered for new development and redevelopment along Merrick Boulevard:

- Access points should not be permitted within the functional and physical areas of an intersection. This will eliminate conflict points in areas where there are queued vehicles and turning movements that reduce perceived reaction time. **Figure 18** below shows the functional and physical areas of an intersection.

Figure 18 – Functional & Physical Areas of Intersection



Source: FHWA Access Management in the Vicinity of Intersections, 2010

- Reduce driveway density when possible. Reducing the number of driveways on any given stretch of road consistently shows reductions in crashes and more efficient travel. The number of access points permitted for development along Merrick Boulevard should be limited to an appropriate density and supported by a traffic impact study. If multiple access points are needed for a development, consider restricting access to right-in/right-out (RIRO)when possible. Also, cross-access between developments should be encouraged, to further reduce the driveway density.

Access management benefits cyclists and pedestrians in addition to vehicular traffic. Poorly managed access can result in hazardous conditions for pedestrians and cyclists due to an increase in conflict points. The Delaware Together Comprehensive Plan shows the community's desired enhancement of transportation alternatives via improvements to infrastructure. Pedestrian access and connectivity was a key component of the Access Delaware public survey. For these reasons, sidewalk and bicycle path connectivity should be implemented along Merrick Boulevard as it is developed.

VIII. Concept Plans

Concept plans for each scenario were created using available aerial imagery. The intersection configurations include those listed in **Table 5**. Concept plans are provided in **Appendix O**. A few items of consideration regarding the concept plans include:

- Many scenarios include the need for additional lanes on the Panhandle Road bridge over the Olentangy River. This bridge is relatively new. Adding lanes is possible, but the cost is substantial. This is shown in the cost estimates described further below. If lanes are not added to the bridge, significant capacity issues will be incurred.
- It is assumed Merrick Boulevard will include a grade-separated bridge over the existing CSX railroad. CSX typically requires a proposed bridge length to account for future tracks. To be conservative, a future track was assumed in both directions. CSX also requires a 25-foot minimum lateral clearance to the bridge abutment wall from the center of track. These factors produce a bridge length of approximately 120 feet. It is assumed the bridge will have two 15-foot lanes and a 14-foot shared-use path. Merrick Boulevard would have to have a maximum design speed of 30 MPH in order to get the roadway back to ground level for the Troy Road intersection.
- For all scenarios, US-23 & Pinecrest Drive is shown to be converted to a left-in/right-in/right-out (LIRIRO) only access.

IX. Cost Estimates

Cost estimates were prepared for each scenario assuming the lane configurations and intersection control outlined in **Table 5,** described previously. The construction cost estimates assume the following:

- 15 percent engineering design
- 10 percent construction administration
- 30 percent contingency
- 10 percent environmental, geotechnical, and federal requirements
- 9.3 percent inflation rate for an estimated 2024 construction year

- Estimated R/W costs
- Cost for utility relocation is not included

The City and American StructurePoint assisted with the cost estimates by providing general baseline assumptions, in line with previous efforts. Additionally, a cost per linear foot was developed, with assistance from the City, for the Houk Road and Merrick Boulevard extensions. The cost per linear foot assumptions do not include the costs for the roundabout installations. The Houk Road extension cost per linear foot is approximately $1100/foot of roadway, and the Merrick Boulevard extension cost per linear foot is approximately $1400/foot of roadway.

The estimated total cost for each scenario is summarized in **Table 14.** Detailed cost estimates are included in **Appendix P.**

Table 14 – Cost Estimates

Scenario	Total
Committed Conditions	$38.07 M
A	$38.91 M
B	$37.13 M
C	$53.94 M
D	$58.02 M
E	$54.24 M

X. Impact Summary

In order to summarize and assess the impacts of the scenarios analyzed herein, a Scenario Impact Summary was developed. Several criteria for the assessment were utilized to determine the merits and weaknesses of the roadway scenarios. The criteria for the Scenario Impact Summary include:

- Travel time across Northwest area of the City
- US-23 progression impacts
- Emergency response times
- Travel delay associated with rail traffic
- Estimated construction costs
- R/W costs and property impacts
- Environmental impacts

Table 15 shows the ratings of each Scenario for each of the evaluation criteria. A legend identifying the color code for high negative impact, some negative impact, minimal impact/no change, moderate benefit, and high benefit is provided below the table.

Table 15 – Scenario Impact Summary

	Committed Conditions	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
Travel Time Across Northwest Area of City						
US-23 Progression Impacts						
Emergency Response Times						
Travel Delay Associated with Rail Traffic						
Estimated Construction Costs	$22.61 M	$23.59 M	$21.82 M	$33.71 M	$37.29 M	$33.64 M
Right-of-Way Costs and Property Impacts	$4.30 M 35 properties	$3.75 M 34 properties	$4.51 M 37 properties	$3.84 M 37 properties	$2.75 M 37 properties	$4.20 M 35 properties
Environmental Impacts						

 **High Negative Impact**

 **Some Negative Impact**

 **Minimal Impact**

 **Moderate Benefit**

 **High Benefit**

XI. Conclusions & Recommendations

The following recommendations and conclusions have been developed with the City:

- Extension of Merrick Boulevard to US-23, as shown in the current City Thoroughfare Plan and prior plans dating back to 1968, remains a justified project. ADT of 12,000 in 2040 is expected to utilize the extension once area buildout has occurred.
- Construction of the Merrick Boulevard extension results in a notable reduction in current and future traffic volumes along the SR-37 and Hills-Miller Road corridors.
- The US-23 & Merrick Boulevard/Panhandle Road intersection can operate at an acceptable LOS with minor roadway improvements, and largely within existing R/W.
- The proposed Byxbe Parkway Extension results in the need to modify the Panhandle bridge over the Olentangy River. However, if Byxbe Parkway is extended to Hills-Miller Road, the existing Panhandle bridge will have sufficient capacity to manage future traffic volumes without modification.
- The US-23 & Pinecrest Drive intersection must be modified to improve safety, especially once the Merrick Boulevard extension is in place. The improvements will limit access to a RIRO or LIRIRO configuration. This change is in conformance with an agreement between the City and ODOT when the US-23 & Panhandle Road traffic signal was initially installed.
- Scenario E has been identified as the basis for design for the current Addison Farms development.
- Additional future intersection improvements were identified in the report so that acceptable capacity is achieved by the 2040 Design Year. For Scenario E, these improvements include but are not limited to:
  - US-36 & Houk Road – add an additional eastbound left turn lane
  - SR-37 & Houk Road – add an additional eastbound through lane, a westbound left turn lane, and a modified westbound shared through/right lane
  - Merrick Boulevard & Houk Road – modify intersection to be a roundabout
  - Houk Road & Hills-Miller Road – add new intersection including northbound shared left/right turn lane, eastbound shared through/right turn lane, westbound left turn lane and a through lane
  - Troy Road & Hills-Miller Road – install traffic signal
  - Troy Road & Merrick Boulevard – add new intersection as a roundabout
  - N. Sandusky Street & Pennsylvania Avenue – install traffic signal
  - US-23 & Panhandle Road – add an eastbound leg with a through lane, left turn lane, and right turn lane; add a westbound through lane; add a northbound right turn lane and left turn lane; add a southbound right turn lane
  - US-23 & Hills-Miller Road – add a westbound leg with a through lane, left turn lane, and right turn lane; modify eastbound right turn lane to be a shared through/right turn lane; add a northbound right turn lane; add a southbound left turn lane
- Note, all identified improvements may be modified depending upon future study or analysis, which may be completed either by development or city-led initiatives and are subject to review/approval by the City Engineer.