pennsylvania
DEPARTMENT OF TRANSPORTATION

Traffic Design Report
Route 228 Mars RR Bridge West Expansion

ECMS Project #E03625

02.13.2018

PennDOT Engineering District 10, Butler County

Cranberry Township, Adams Township, and Seven Fields Borough

WRA

OS-2 (10-08)

pennsylvania
DEPARTMENT OF TRANSPORTATION
www.dot.state.pa.us

DATE: February 13, 2018

SUBJECT: Butler County
Cranberry Township, Seven Field Borough, Adams Township
Route 228 Mars RR Bridge West Expansion
Traffic Design Report
ECMS Project #E03625

TO: Mark Rozich, PE
District Project Manager
Engineering District 10-0

FROM: Adam Marshall, PE
Assistant Traffic Engineer
Engineering District 10-0

The ITS / Congestion Management Section has completed its review of Whitman, Requardt & Associates, LLP's Traffic Design Report for the Route 228 Mars RR Bridge West Expansion project in Cranberry Township, Seven Fields Borough and Adams Township, Butler County and agree with its findings.

If you have any questions, please call me at 724.357.2844.

Contents

List of Exhibits

List of Appendices

Introduction

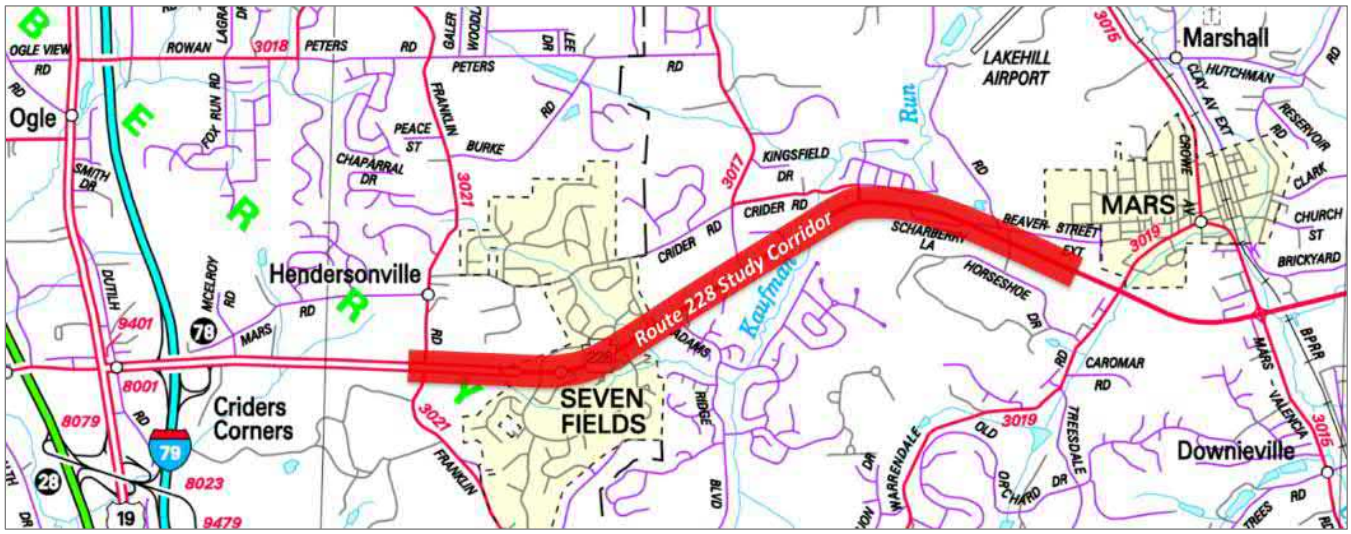
Project Summary

The Route 228 Mars Railroad (RR) Bridge West Expansion project is a design effort for Pennsylvania Department of Transportation (PennDOT) District 10-0 to implement widening, capacity, and safety improvements along the SR 228 corridor from Franklin Road in Cranberry Township, to just east of Beaver Street Extension in Adams Township, Butler County, Pennsylvania. As part of this effort, this Traffic Design Report documents a comprehensive evaluation of existing and projected traffic operations, capacity, mobility, and safety conditions; and develops/compiles applicable traffic details to support the project's overall infrastructure design effort.

Location and Study Limits

The project corridor is located in Butler County, Pennsylvania, and crosses three municipalities: Cranberry Township to the west, Seven Fields Borough in the center, and Adams Township to the east (**Exhibit 1**). Mars Borough is also less than one mile northeast of the corridor's eastern limit with direct access via Beaver Street Extension. SR 228 within the study limits is predominately oriented in the east-west direction; all roadways approaching SR 228 generally have north-south orientations.

Exhibit 1: Project Location Map



Document Organization

This Traffic Design Report summarizes the following study and analysis efforts for the project:

1. Traffic Data Collection
2. Traffic Volume Summaries and Projections
3. Baseline and No-Build Traffic Operations
4. Build Traffic Operations
5. Summary Design Implications

Supporting data and analysis details, where applicable, are referenced to the report's technical appendices. Additionally, a Confidential Safety Study has been prepared (under separate cover) as a companion document to this overall Traffic Design Report and provides additional details regarding existing and projected safety conditions, corridor-specific crash histories, and a safety assessment of the proposed project improvements.

Data Collection and Analysis

Data collection and related analysis efforts included reviewing various background information, collecting traffic counts, conducting traffic engineering studies, and evaluating highway safety data.

Background Information

Corridor Overview

Aerial reviews and site visits were conducted to establish or verify existing field conditions throughout the SR 228 corridor. Data gathered included lane configurations, lane widths, turn lane storage lengths, approach grades, speed limits, and signal timings. Focal points along the approximately three-mile study corridor included six signalized and four side-street stop-controlled intersections as displayed in **Exhibit 2**.

Exhibit 2: SR 228 Study Intersections

Functional classification along the SR 228 study corridor is defined as Other Principal Arterial. The route primarily consists of a two-lane undivided roadway with the exception of a four-lane section that runs from west of the study area to approximately 300' east of Franklin Road. Additional storage lanes for all mainline left-turn movements and some right-turn movements are provided at the signalized intersections; no turn lanes are available at the stop-controlled intersections. Existing posted speed limits vary from 40 miles per hour (mph) near the western project limits and through Seven Fields Borough, to 50 mph beginning approximately east of Adam Ridge Boulevard and through most of Adams Township.

Though much of the study corridor is generally level or slightly rolling, approach grades vary considerably at the western limits with eastbound downgrades from Franklin Road toward Castle Creek Drive, and again at the eastern limits from Beaver Street Extension toward Pittsburgh Street. Several intersections also have skewed geometry that creates sight distance constraints. Existing grades near Franklin Road, superelevation and horizontal curvature at Heritage Creek Drive, and slightly skewed intersection geometry at Scharberry Lane and Beaver Street Extension may also affect the efficiency of traffic flows or intersection turning movements.

Land Use and Development

Land use throughout the study area generally consists of mixed-use commercial and office developments along both sides of the roadway. Side-street connections also directly tie the corridor to substantial residential areas in Seven Fields Borough and Adams Township, as well as linkages to hubs of activity in Cranberry Township to the west, and Mars Borough to the east.

Ongoing and future development expansion is anticipated near Franklin Road and Heritage Creek Drive; and several large vacant parcels may also be poised for future development near High Pointe Drive, Adams Ridge Boulevard, and Myoma Road. Traffic influences due to general background growth and specific active, planned, or anticipated development areas were accounted for, as applicable, in the future traffic assumptions utilized in this Traffic Design Report (see subsequent discussions in the section on Traffic Volumes and Projections).

Adjacent Project Coordination (SR 228 and Pittsburgh Street Improvements)

PennDOT District 10-0 is actively pursuing implementation of the SR 228 Pittsburgh Street Intersection segment (**Exhibit 3**) located just east of the project limits addressed in this Traffic Design Report. The Pittsburgh Street project is slated for construction in Years 2018-2019 and will widen the SR 228 corridor to a four-lane section that links with previously-widened segments farther east (i.e. the SR 228 Section 251 Mars Railroad Bridge Replacement segment completed in 2014). The Mars RR Bridge West segment covered in this Traffic Design Report will subsequently tie into the ongoing Pittsburgh Street project.

Adjacent Project Coordination (SR 228 and UPMC Enhancements)

Additional SR 228 improvements are proposed under a UPMC Enhancements project (**Exhibit 3**) that would add a third eastbound travel lane along SR 228 from just east of the I-79 interchange area to Franklin Road. It is assumed that if installed prior to the improvements addressed in this Traffic Design Report, the third lane would likely drop as an eastbound right-turn lane at the Franklin Road intersection. The Mars RR Bridge West improvements would subsequently tie into the UPMC Enhancements improvements. As the status of the UPMC Enhancements project may currently be slated through design only, eastbound turn-lane needs and storage requirements at the intersection of SR 228 and Franklin Road will be fully/independently assessed as part of this Traffic Design Report.

Exhibit 3: Adjacent Project Coordination Sites

Source: PennDOT District 10-0

Past Project Insights (SPC Regional Traffic Signal Program)

The SR 228 study corridor has been included in multiple cycles of a broader program under the Southwestern Pennsylvania Commission (SPC) Regional Traffic Signal Program. Program efforts have included traffic signal equipment upgrades and timing/phasing optimization efforts in 2010, 2012, and 2017. Updates have been accounted for, as applicable, to help inform the development and calibration/validation of traffic models utilized in this Traffic Design Report.

Past Project Insights (US 19 Corridor Study)

Completed in December 2013, The US 19 Corridor Study was a comprehensive land use and transportation study of a multi-jurisdictional planning area that included the SR 228 study corridor. The study assessed traffic growth and operations, and developed a series recommendations through future year 2035. Highlights relevant to this Traffic Design Report include the following:

- Peak hour traffic signal warrants and criteria for the installation of left-turn lanes (eastbound) were satisfied at SR 228 and Myoma Road, as well as SR 228 and Beaver Street Extension.
- Criteria for the installation of right-turn lanes (eastbound and westbound) were satisfied at SR 228 and Franklin Road.
- 2035 No-Build committed project improvements were reported as follows:
  - Myoma Road: install a new traffic signal, eastbound left-turn lane, westbound right-turn lane, and southbound right-turn lane.
  - Seven Fields Boulevard to Myoma Road: install a new connecting road between existing and new development.
  - Adams Ridge Boulevard: install a new fourth leg in the intersection, linking with the connecting road above.
  - Beaver Street Extension: install a new traffic signal.
  - Pittsburgh Street: install a new southbound left-turn lane.
- Additional long-term recommendations were reported as follows:
  - Widen SR 228 between Franklin Road and east of Heritage Creek to provide two through-lanes in each direction.
  - Improve the intersection of SR 228 at Franklin Road to provide three through-lanes eastbound plus dual left-turn lanes on each approach.
  - Improve the intersection of SR 228 at Adams Ridge Boulevard to provide dual left-turn lanes on the northbound approach.

Traffic Count Data

New traffic volume counts were collected throughout the SR 228 study corridor in mid-October 2016 using Miovision video data recorders. Data included multi-day average daily traffic (ADT) counts and peak-period intersection turning movement counts (TMC). Detailed data is included in **Appendix A** and summarized below.

Average Daily Traffic Counts

Midblock ADT data recorded hourly volumes for seven consecutive days (October 6-12, 2016) along the SR 228 roadway segment between Castle Creek Drive (East) and Seven Fields Boulevard. Results were summarized for typical weekday and weekend ADT volumes to yield an adjusted Average Annual Daily Traffic (AADT) estimate of approximately 27,000 vehicles per day (**Exhibit 4**). This estimate reflects a 20% traffic increase compared to a Year 2009 AADT of 22,500 vehicles per day that was reported in the 2013 *US 19 Corridor Study*. Increases are likely attributable to substantial new development in the area since 2009 including, for example, the Westinghouse complex and other major new developments in Cranberry Township just west of the study corridor.

Exhibit 4: SR 228 Year 2016 ADT Summary

SR 228 ADT Estimate	Vehicles per Day
Tuesday-Thursday (Average)	28,100
Friday	29,300
Saturday	25,900
Sunday	20,500
Adjusted AADT	**27,000**

Hourly and directional volume trends from the ADT data were also evaluated. (**Exhibit 5** through **Exhibit 7**). Results indicate traditional weekday commuter and weekend midday traffic patterns with peak periods including 6:00 AM to 9:00 AM and 3:00 PM to 6:00 PM on weekdays, and 11:00 AM to 2:00 PM on Saturday.

Exhibit 5: SR 228 Two-Way Hourly Volumes

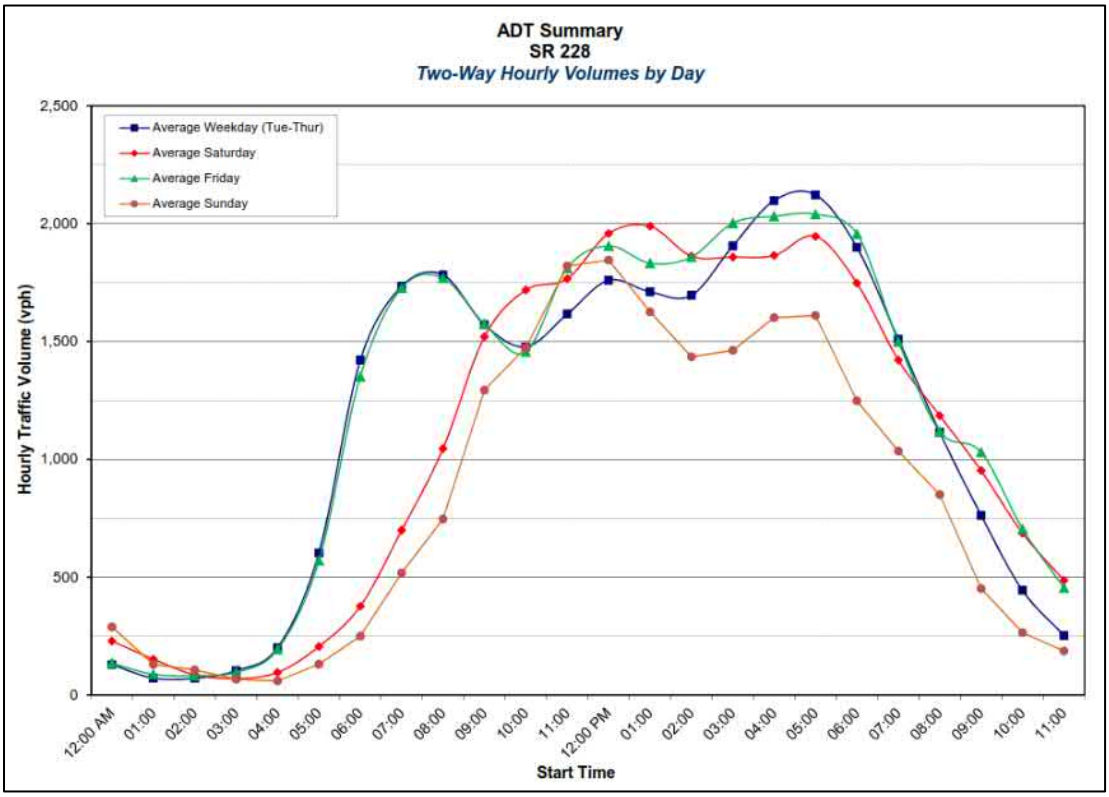


Exhibit 6: SR 228 Average Weekday Directional Traffic

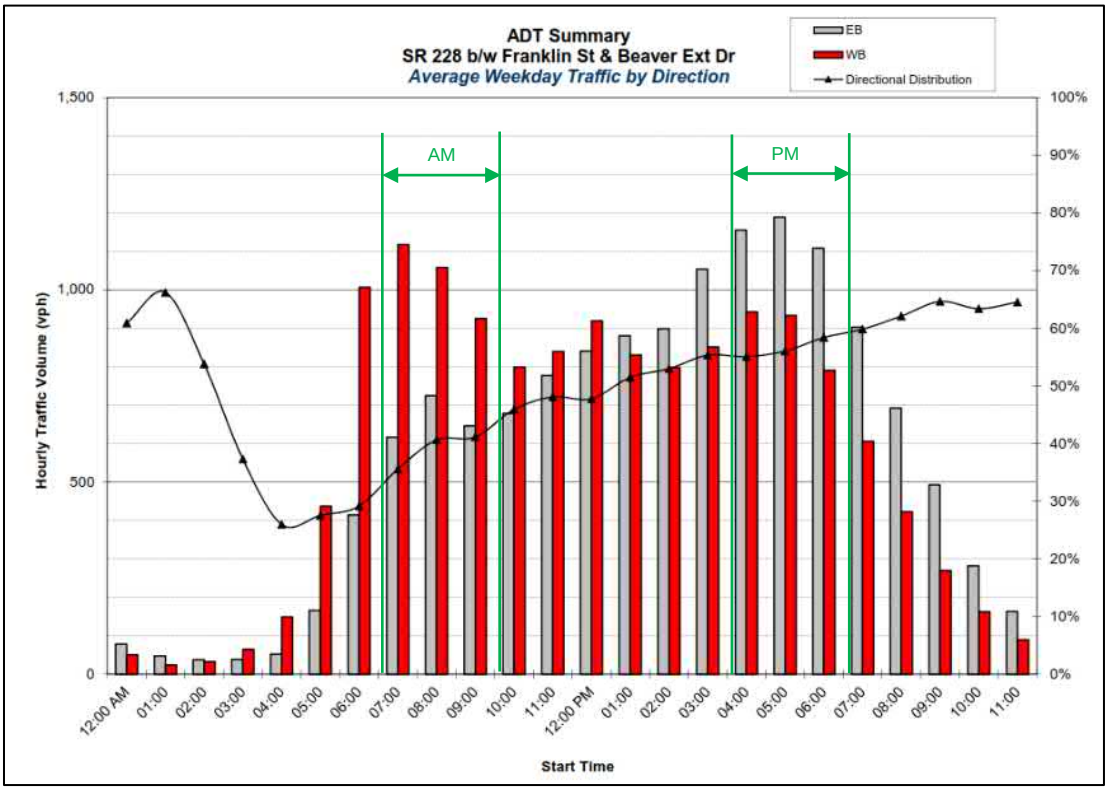
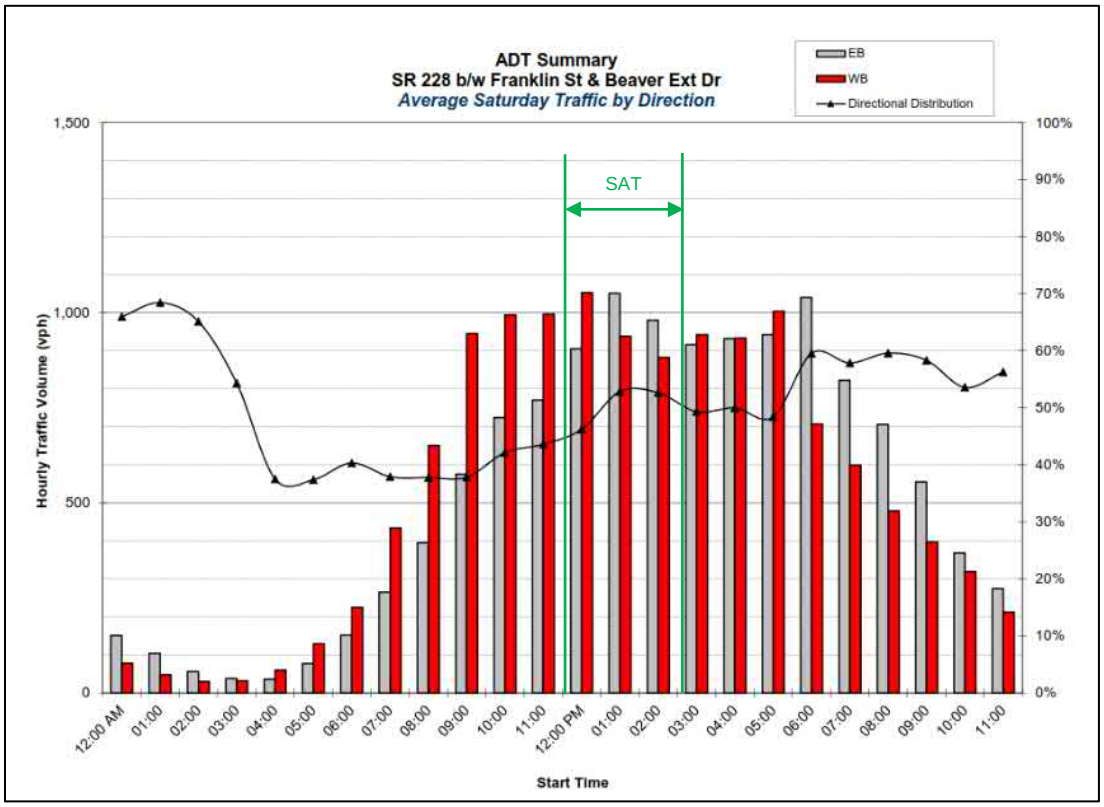


Exhibit 7: SR 228 Average Saturday Directional Traffic



Intersection Turning Movement Counts

Intersection TMC data – including car volumes, truck/bus volumes, and pedestrian volumes – was collected at nine locations (see previous **Exhibit 2**) including SR 228 at:

- Franklin Road (SR 3021)
- Castle Creek Drive (West) and High Pointe Drive (West)
- Castle Creek Drive (East) and High Pointe Drive (East)
- Seven Fields Boulevard and Adams Ridge Shoppes
- Adams Ridge Boulevard
- Myoma Road
- Heritage Creek Drive (SR 3017)
- Scharberry Lane
- Beaver Street Extension

Data collection periods included two hours per peak during typical weekday (October 11, 2016) and Saturday (October 8, 2016) travel conditions. Localized peak hour trends were evaluated to identify the dominant peak hour for volume balancing and traffic modeling purposes (**Exhibit 8**). Data was also mined to provide truck/bus percentages, pedestrian estimates, and overall intersection Peak Hour Factor (PHF) assumptions to support traffic modeling efforts per PennDOT Publication 46.

Exhibit 8: Intersection Peak Hour Summary

Peak	Count Period	Peak Hour
Weekday AM	7:00 AM to 9:00 AM	7:15 AM to 8:15 AM
Weekday PM	4:00 PM to 6:00 PM	4:45 PM to 5:45 PM
Saturday	11:00 AM to 1:00 PM	11:45 PM to 12:45 PM

Summary traffic volume preparations included balancing/adjusting volumes throughout the overall study corridor to account for any potential data anomalies and reflect local source/sink influences (e.g. driveways, minor streets, etc.) where applicable. Given the existing access conditions and several closely-spaced intersections along this stretch of SR 228, source/sink locations were limited; so volumes were generally hard-balanced to reflect minimal difference, if any, between adjacent intersections. Summary balancing efforts are documented in **Appendix B**. Final peak hour volumes are mapped in subsequent sections of this report (see discussions in the section on Traffic Volume Summaries and Projections, including **Exhibit 14**).

Traffic Engineering Studies

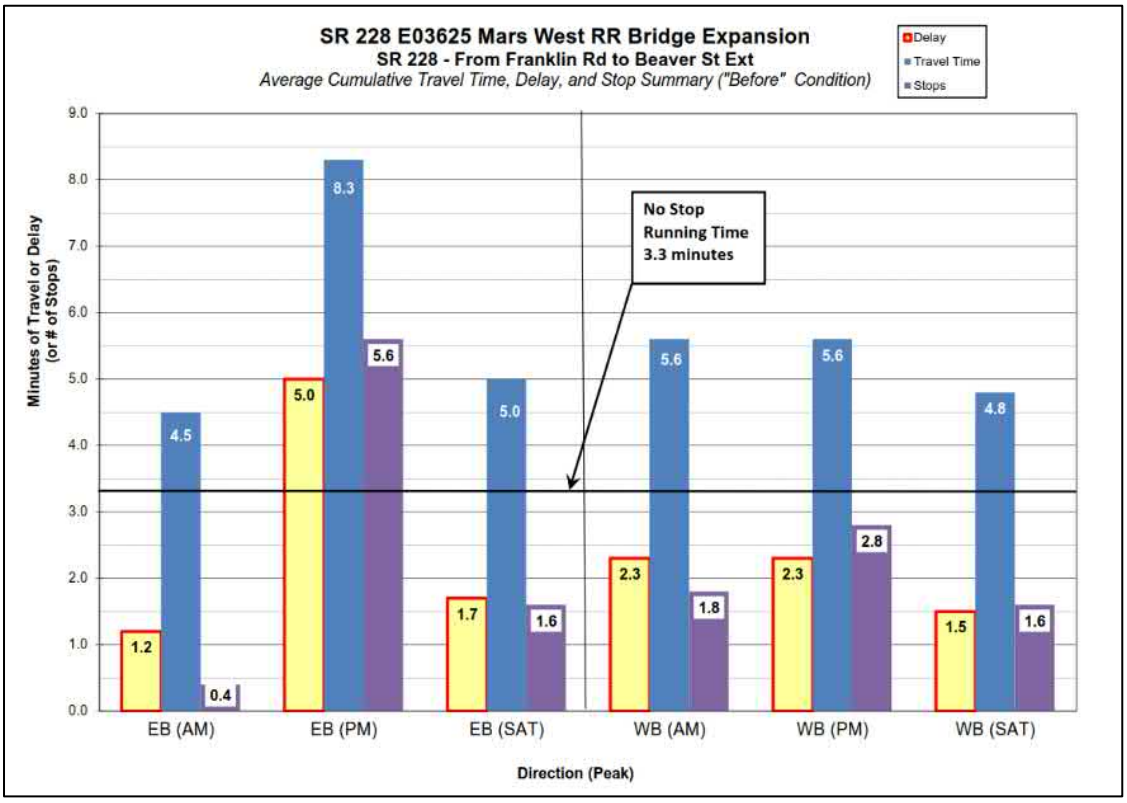
In addition to general field observations and qualitative insights, specific traffic engineering studies were conducted to obtain quantitative field measurements that accurately reflect the unique features of the local driving environment. Detailed data is included in **Appendix C** and summarized below for the following types of engineering studies: travel time and delay, intersection stopped delay, queuing, saturation flow rates, and lane utilization.

Travel Time and Delay Studies

Travel time and delay data – two principle measures of highway system performance – were collected along SR 228 between Franklin Road and Beaver Street Extensions using Tru-Traffic software and a global positioning system (GPS) receiver. A minimum of five travel time runs were completed in the eastbound and westbound direction during the AM, PM, and Saturday midday peak periods. Overall travel time along SR 228 varies from 4.5 to 8.3 minutes for eastbound traffic, and 4.8 to 5.6 minutes for westbound traffic (**Exhibit 9**).

Results illustrate that through-traffic along SR 228 typically experiences low to moderate levels of congestion during the AM and Saturday peak periods, reflected as 1.2 to 2.3 minutes of delay with less than 2 stops. Traffic during the PM peak period, however, typically experiences moderate to high levels of congestion, reflected as 2.3 to 5.0 minutes of delay and more than 5 stops. Congestion is highest in the eastbound direction during the PM peak period, attributable in part to the eastbound lane drop east of Franklin Road, congestion through closely-spaced traffic signals in Seven Fields Borough, unsignalized eastbound left-turn friction at Myoma Road and Beaver Street Extension, and queue spillback east of the study corridor emanating from delays at the SR 228 and Pittsburgh Street intersection.

Exhibit 9: Corridor Travel Time, Delay and Stops Summary



Intersection Stopped Delay Studies

Intersection delay studies were conducted at Myoma Road and Beaver Street Extension to evaluate potential delays for unsignalized turning movements to/from SR 228 at each location (**Exhibit 10**). At both locations, side-street delays were found to periodically approach one minute during the PM peak period, and notable side-street queuing was observed along Beaver Street Extension. Significant eastbound left-turn delays from the SR 228 mainline were also recorded, particularly at Beaver Street Extension during the PM peak period with an average measured delay of just under 38 seconds, and a maximum observed delay of almost two minutes.

Left-turn vehicles experiencing these delays while awaiting a gap in traffic can effectively block mainline SR 228 travel as there are no existing left-turn lanes at these locations. However, through-traffic was also periodically observed using the shoulder to bypass left-turning vehicles. The shoulder usage helps to decrease overall delay and queuing, but may also negatively impact safety due to an increase in potentially unexpected or inconsistent driver maneuvers and related vehicular conflicts.

Exhibit 10: Intersection Stopped Delay Studies

Measurement	Myoma Road at SR 228				Beaver St Ext at SR 228			
	EB Left		SB Left/Right		EB Left		SB Left/Right	
	AM	PM	AM	PM	AM	PM	AM	PM
Average Delay (Sec)	4	15	26	26	17	38	14	23
Maximum Delay (Sec)	7	32	42	50	60	109	21	51
Maximum Queue (Veh)	2	2	3	1	3	6	4	10

Queuing Studies

Queuing throughout the SR 228 corridor was qualitatively observed during initial field view efforts to identify locations for quantitative follow-up studies. Subsequent queuing studies targeted four signalized intersections and identified substantial queuing at each location (**Exhibit 11**).

Exhibit 11: Intersection Queueing Studies

Intersection	Peak	Max Queue (vehicles)			
		NB Side-Street	SB Side-Street	EB SR 228	WB SR 228
SR 228 @ Franklin Road	AM	7	17	9	> 20
	PM	> 20	11	> 20	> 20
SR 228 @ Seven Fields Blvd	AM	4	5	12	> 20
	PM	4	11	14	16
SR 228 @ Adams Ridge Blvd	AM	12	-	6	16
	PM	12	-	10	> 20
SR 228 @ Heritage Creek Dr	AM	1	7	9	10
	PM	2	13	15	> 20

Table Note: *> 20 implies queue length that exceeds 20 vehicles and is beyond visual limits for measuring precisely.*

During queue observations, cycle failures were also noted at key signalized intersections, particularly for eastbound SR 228 at Franklin Road during the PM peak period. A cycle failure occurs when a vehicle arrives during a red indication and waits through an entire green phase without passing through the intersection. Cycle failures and queue measurements were each generally referenced during subsequent traffic model calibration and validation efforts to ensure that model-generated queuing data reasonably matched field-observed data.

Saturation Flow Rate Studies

Saturation flow rate represents the maximum number of vehicles per hour per lane (vphpl) that can pass through a signalized intersection if there were a constant green indication with an infinite queue to supply a flow of vehicles that never stops. Saturation flow rate studies were performed in accordance with PennDOT Publication 46 (Chapter 10) and HCM 2010 methodologies for six movements and lane groups along SR 228 (**Exhibit 12**). Observed saturation flow rate data was converted (using standard HCM methodologies) to equivalent ideal saturation flow rates. The calculated average findings aligned with and validated the Pennsylvania default ideal saturation flow rate value of 1,800 vphpl for suburban areas (per PennDOT Publication 46, Exhibit 10-9). This rate assumption was used within all traffic models for the study area and for all traffic movements.

Exhibit 12: Saturation Flow Rate Studies

Intersection	Movement (Peak)	Observed Saturation Flow Rate (vphpl)	Ideal Saturation Flow Rate (vphpl)
		All Vehicles	All Vehicles
SR 228 @ Castle Creek Dr (West)	WB Thru (AM)	1723	1784
	WB Thru (PM)	1656	1714
	EB Thru (PM)	1812	1830
SR 228 @ Castle Creek Dr (East)	WB Thru (AM)	1981	2040
	WB Thru (PM)	1852	1908
SR 228 @ Seven Fields Blvd	WB Thru (AM)	1825	1825
	WB Thru (PM)	1794	1794
SR 228 @ Heritage Creek Dr	EB Thru (AM)	1483	1551
	WB Thru (AM)	1817	1808
	EB Thru (PM)	1589	1662
	WB Thru (PM)	1923	1914
AVERAGE		**1769**	**1803**

Lane Utilization Studies

To further support traffic model calibration and validation efforts, lane utilization studies were conducted for the eastbound SR 228 approach to Franklin Road to evaluate the influence of the downstream lane drop located approximately 300' east of the intersection. Study results were used to establish a lane utilization factor ranging from 0.64 to 0.71 (**Exhibit 13**), confirming general observations that most eastbound vehicles tend to position themselves in the eastbound left through-lane in advance of the lane drop to avoid the downstream merge in heavily-congested conditions. Such imbalances effectively reduce the capacity of the intersection approach, often referred to as a false capacity situation.

Exhibit 13: Lane Utilization Studies

Intersection	Movement	Peak	Average Lane Utilization Factor (f_{LU})
SR 228 @ Franklin Road	EB Thru	AM	0.64
		PM	0.71
		Saturday	0.64

Highway Safety Data

A Confidential Safety Study has been prepared (under separate cover) as a companion document to this Traffic Design Report and provides details regarding existing and projected safety conditions with a focus on crash characteristics, crash cluster identification, and safety assessments based on *Highway Safety Manual* (HSM) methodologies. Highlights based on a review of corridor-specific crash histories include the following:

- 203 reportable crashes occurred along the corridor from 2011-2015 with 68% at intersections and 32% along corridor segments.
- Annual crash totals during the study period ranged from 29 to 54 crashes per year, or the equivalent of approximately 1 to 2 crashes every other week.
- The majority of crashes involve property damage only (54%) with the remainder as injuries or possible injuries. There were zero fatalities along the corridor during the study period.
- Most crashes by type are Rear-End (70%, which is much higher than the 22% statewide average) followed by Angle (12%), and are likely attributable to substantial traffic volumes, queuing, and congestion along the corridor.
- Most crashes occur during the day with dry pavement and no adverse weather condition.

The above crash characteristics indicate that most crashes along the SR 228 corridor likely involve aggressive driving behavior and driver error during congested/oversaturated conditions. The most commonly reported driver actions include: sudden slowing/stopping, tailgating, driving too fast for conditions, red-light running, and being distracted, all of which contribute to the high proportion of rear-end crashes.

Traffic Volume Summaries and Projections

Traffic assessments for this project focus on the scenarios listed below, with peak hour traffic volumes and related growth/development assumptions summarized in the sub-sections that follow:

- **2016 Base Year** – reflects existing traffic volumes at the time that initial project data was collected
- **2025 Opening Year** – reflects future traffic volume projections and ongoing/imminent development for an approximate timeframe to when SR 228 widening under this project may be completed
- **2045 Design Year** – reflects future traffic volume projections and approved/planned development 20 years beyond the assumed Opening Year
- **2045 Design Year with Supplemental Growth** – reflects 2045 Design Year traffic volumes plus additional development traffic assumptions for major existing vacant parcels within the study corridor.

Base Year Volumes

As a compilation of previously-discussed traffic count data (**Appendix A**) and related traffic volume balancing/adjustments (**Appendix B**), final peak hour traffic volume assumptions for 2016 Base Year conditions are mapped on **Exhibit 14**.

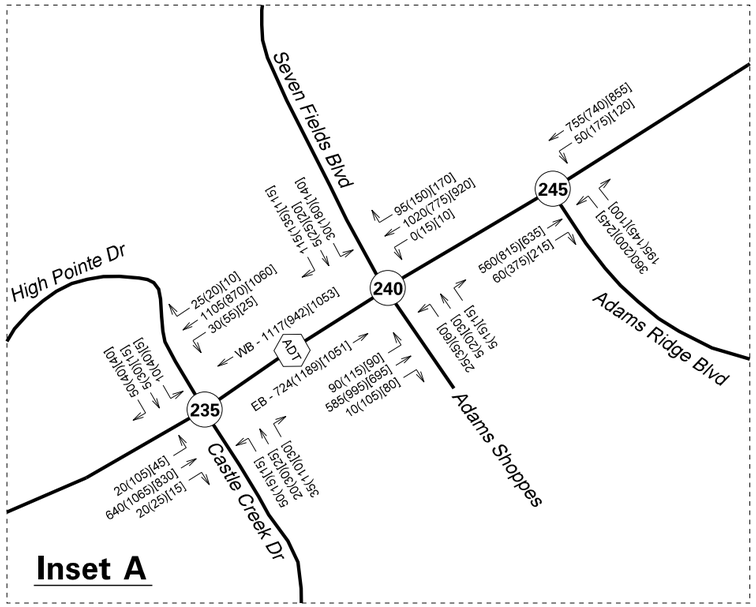
Growth and Development Assumptions

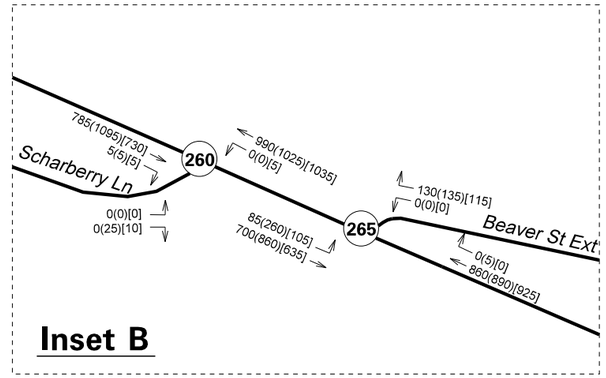
Background Growth Rates

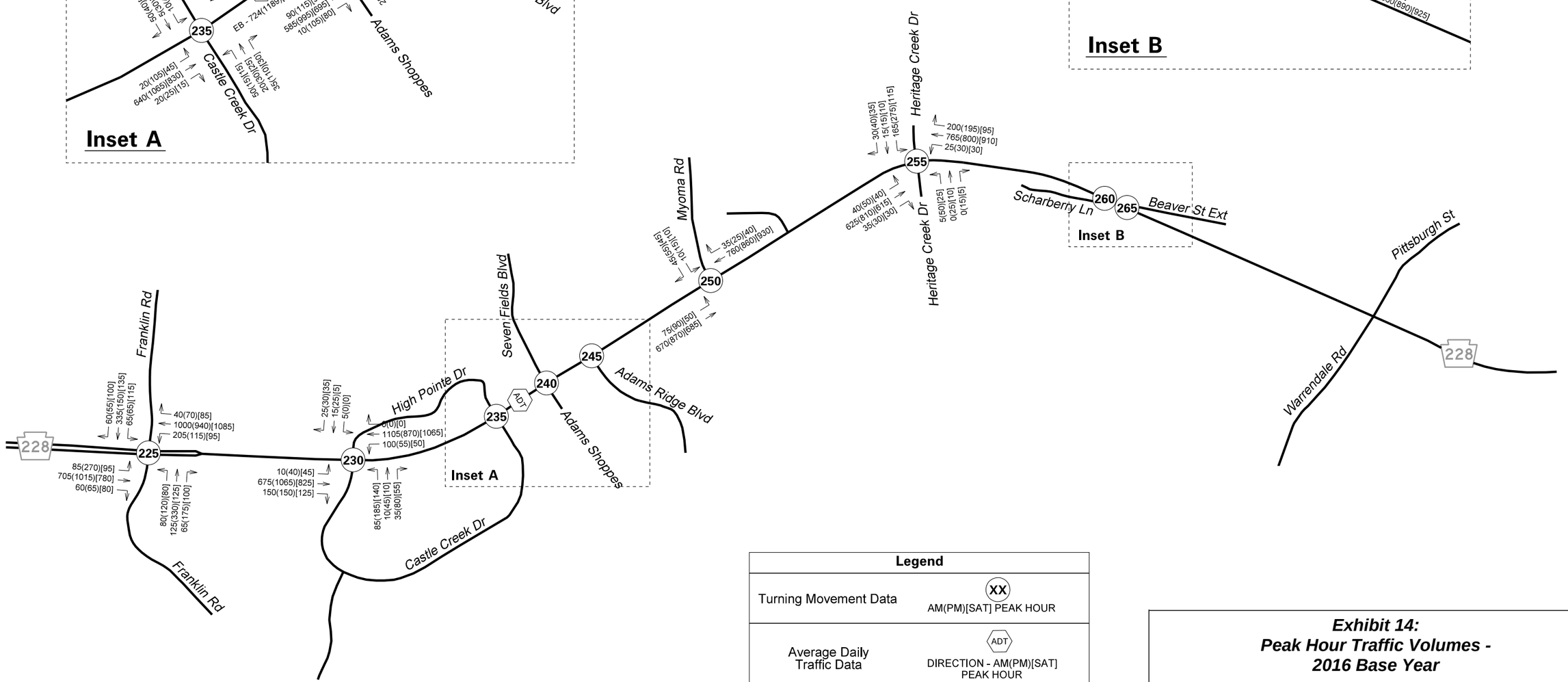
General background traffic growth assumptions were based on the latest official forecast data available from the Southwestern Pennsylvania Commission (SPC) as the formal Metropolitan Planning Organization (MPO) for the overall region, including Butler County. Specifically, linear annual growth rates were provided from SPC's Long Range Planning (LRP) Cycle 10 Forecast (Years 2015 to 2040) by municipal area as follows:

- Cranberry Township: 0.87% per year
- Adams Township: 0.81% per year
- Seven Fields Borough: 0.52% per year
- Mars Borough: 0.50% per year

Collectively, these rates yield an overall increase of 5-8% from 2016 to 2025 Opening Day, or 15-25% from 2016 to 2045 Design Year. While this growth may appear to be low compared to the aggressive rate of development perceived in the vicinity of the project corridor, it should be noted that it may also simply reflect a "less rapid" expansion than what has occurred in recent years. As noted previously, a comparison of 2016 AADT estimates (27,000 vpd) to 2009 historical data from the US 19 Corridor Study (22,500 vpd) reflects a 20% traffic increase in just 7 years, which is likely attributable to substantial recent development such as the Westinghouse complex and surrounding commercial activities in Cranberry Township. Other comprehensive land use and growth evaluations from the US 19 Corridor Study noted that growth from 2000 to 2035 was expected to increase by 50% over a much broader area. Summing the 20% AADT growth from 2009 to 2016, and the current projected growth of up to 25% from 2016 to 2045, yields a total growth of approximately 45% within a similar timeframe, which would be on par with the previous US 19 Corridor Study estimates.







Legend	
Turning Movement Data	XX — AM(PM)[SAT] PEAK HOUR
Average Daily Traffic Data	ADT — DIRECTION - AM(PM)[SAT] PEAK HOUR

SOURCE: WRA October 2016 count data with balancing adjustments/refinements

Exhibit 14:
Peak Hour Traffic Volumes -
2016 Base Year

NOT TO SCALE

Site-Specific Development Traffic

In addition to general background traffic growth, ten site-specific developments were also accounted for in the traffic volume projections for this project (**Exhibit 15**). Development details and related traffic volume assumptions were based on a combination of municipal coordination discussions with Cranberry Township and Adams Township officials, subsequent traffic impact study (TIS) data provided by the townships (if/where available), and supplemental aerial reviews of vacant parcels to approximate land use assumptions that could generate rough order-of-magnitude traffic volume estimates in-line with ITE Trip Generation methods.

Based on these efforts, site-specific developments were grouped into three categories as follows:

- **Imminent Development** – reflects active construction (at the time that traffic data was collected for this project) and/or anticipated short-term completion of new development sites. Sites A, B, and F (**Exhibit 15**) were assumed in this category, and related site-specific traffic volumes were added to all future traffic projections for Years 2025 and 2045.

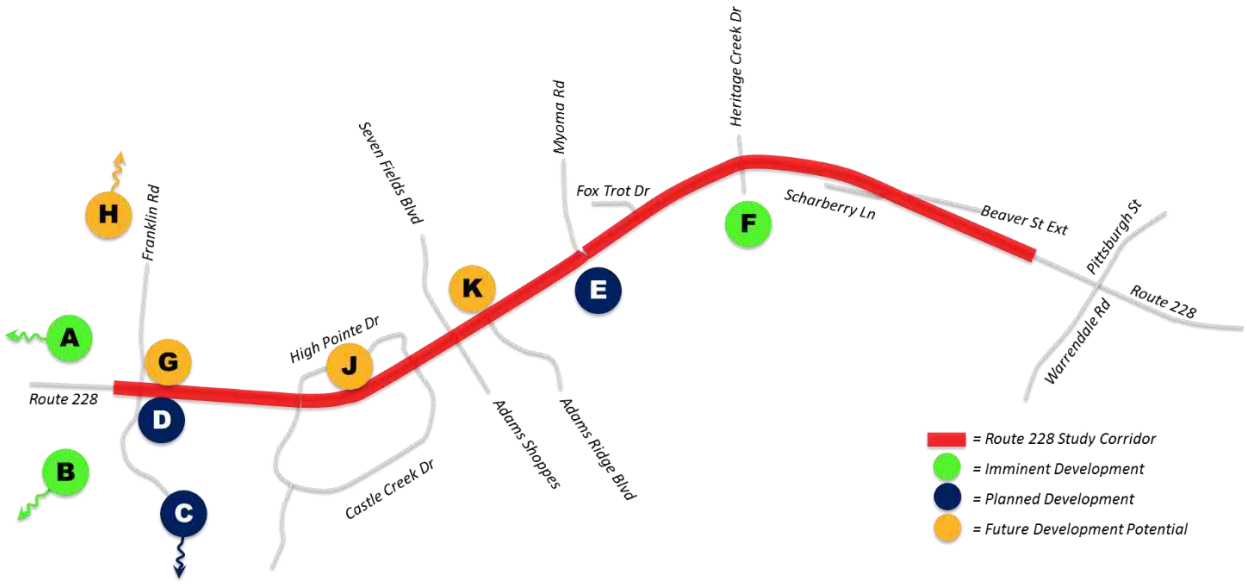
- **Planned Development** – reflects future development for which some degree of planning has been completed, but with approval status or completion timeframe not necessarily finalized. Sites C, D, and E (**Exhibit 15**) were assumed in this category, and related site-specific traffic volumes were assumed to be supplemental to future traffic projections in Year 2045 only.

- **Future Development Potential** – reflects future development for which minimal or unknown degrees of planning have been completed, but with long-term potential based on anticipated redevelopment interests or vacant parcel availability. Sites G, H, J, and K (**Exhibit 15**) were assumed in this category, and related site-specific traffic volumes were assumed to be supplemental to future traffic projections in Year 2045 only.

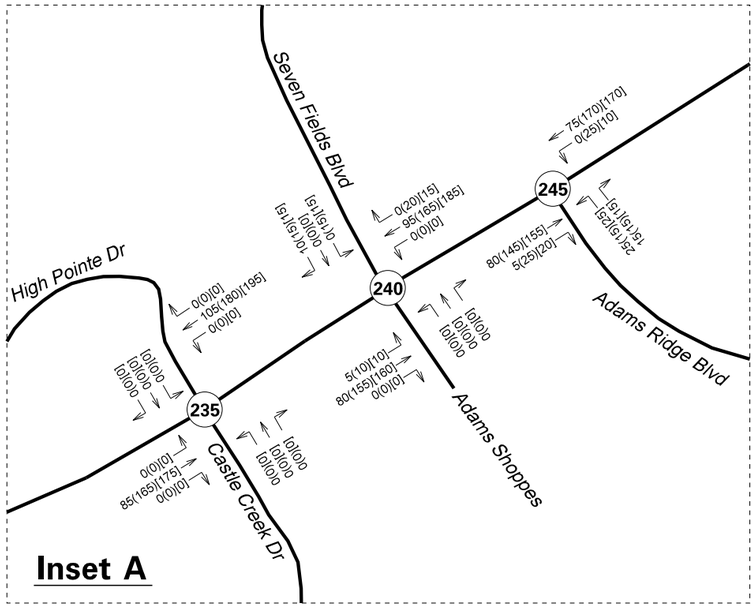
Of the assumed development sites, two locations are anticipated to add a new fourth leg to existing intersections including SR 228 at Adams Ridge Boulevard (Site K) and SR 228 at Myoma Road (Site E). All locations were reviewed to develop reasonable assumptions for manually distributing traffic throughout the project corridor based on simplified existing traffic pattern assumptions at the site-specific access point, and with a heavy emphasis on through-travel along the remainder of the study corridor.

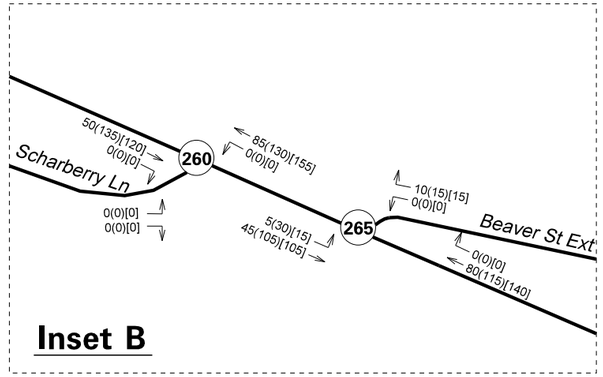
Resulting traffic volume assumptions were compiled separately for Imminent Development traffic (**Exhibit 16**) reflecting Sites A, B, and F; and for Supplemental Development traffic (**Exhibit 17**) reflecting a combination of Planned Development Sites C, D, and E, as well as Future Development Potential Sites G, H, J, and K.

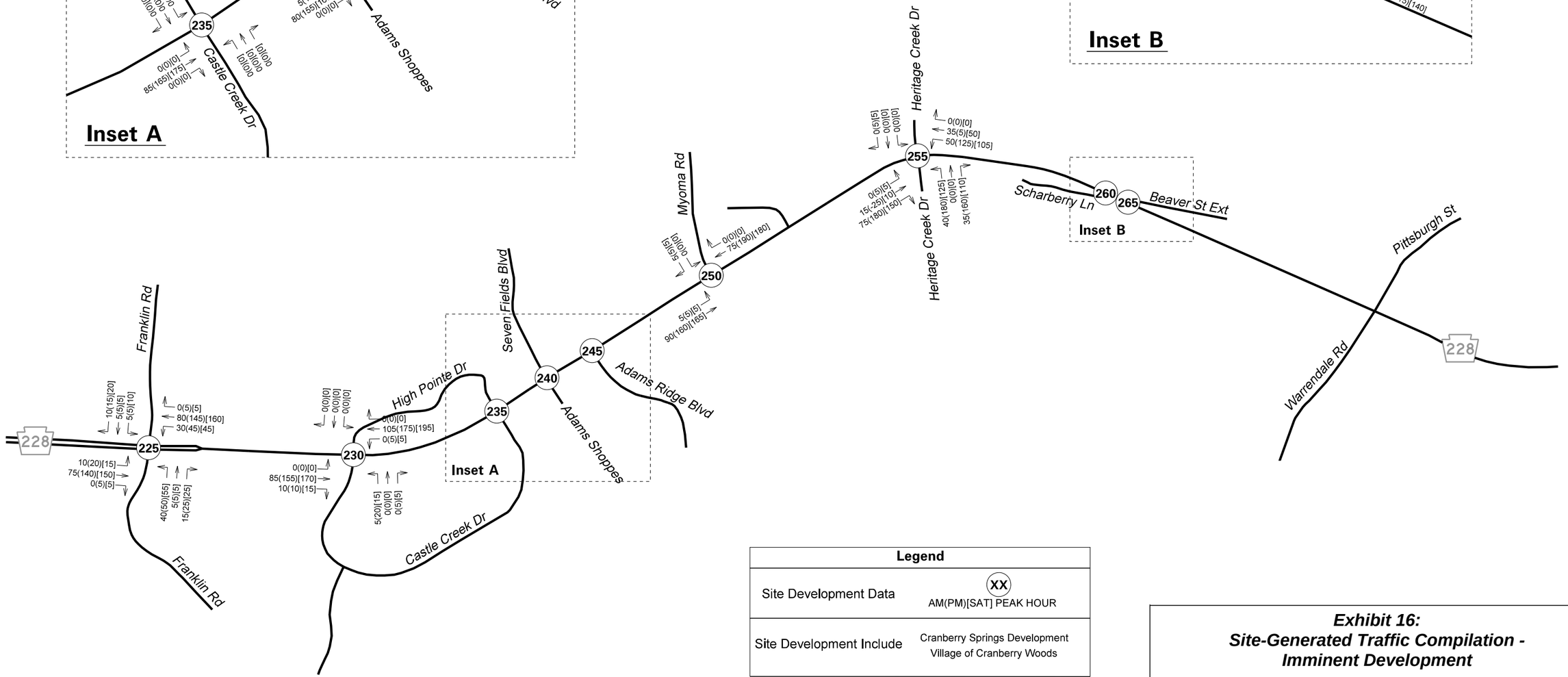
Exhibit 15: Site Specific Future Development Assumptions



Site	Imminent Development
A	**Cranberry Springs:** Multiple restaurants, retail space, and hotel less than one mile west of the project corridor along Cranberry Springs Drive *Traffic derived from 12/16/2015 TIS data from Cranberry Twp*
B	**Village of Cranberry Woods (Phase 2):** Multiple restaurants, office space, retail, hotels, and townhomes/apartments just southwest of SR 228 @ Franklin Rd *Traffic derived from 3/1/2017 TIS data from Cranberry Twp plus Trip Gen adjustments for previously-completed elements*
F	**Heritage Creek (Expansion):** Active and future planned expansion of approved site plans within the remainder of the existing Heritage Creek development *Traffic derived from 9/2012 TIS data from Cranberry Twp to estimate remaining 60% of ongoing site activity*
Site	**Planned Development**
C	**Family Resource/Laurel Pointe PRD:** Zoned R1; proposed 157 single family residential lot development located south along Franklin Rd *Traffic derived from 10/10/2016 TIS data from Cranberry Twp*
D	**Franklin Square:** Zoned S1 w/ CCD Corridor Overlay; proposed retail on 1-acre site on SE corner of Franklin Rd @ 228 *Traffic derived from 2/9/2017 TIS data from Cranberry Twp*
E	**Hespenheide Master Plan (Whitetail Meadows):** Zoned RAM w/ Transition Overlay; proposed development S of 228 *Traffic derived from 9/2012 TIS data from Cranberry Twp*
Site	**Future Development Potential**
G	**Franklin Rd @ SR 228 (NE Parcels):** Zoned C2 and R1 w/ CCD Corridor Overlay; assumed 12-acre site *Traffic assumed from Trip Gen estimate for 102 apartments, 30k SF specialty retail, 4k SF convenience market*
H	**Franklin Rd @ Mars Rd (SW Parcels):** Zoned R3 w/ CCD Corridor Overlay; assumed 5-acre site *Traffic assumed from Trip Gen estimate for 68 apartments*
J	**High Pointe Drive @ SR 228 (NE and NW Parcels):** Zoned as Planned Econ. Dev. Dist. (S of High Pointe Dr) and Industrial District (N of High Pointe Dr); assumed 6-14 acre site *Traffic assumed from Trip Gen estimate for 50k SF general office, 5k SF specialty retail, 5k SF high-turnover restaurant*
K	**Adams Ridge @ SR 228 (NE Parcels):** Zoned R1 w/ Transition Overlay; assumed 30-acre site *Traffic assumed from Trip Gen estimate for 100k SF general office, 20k SF specialty retail, 5k restaurant x 2*





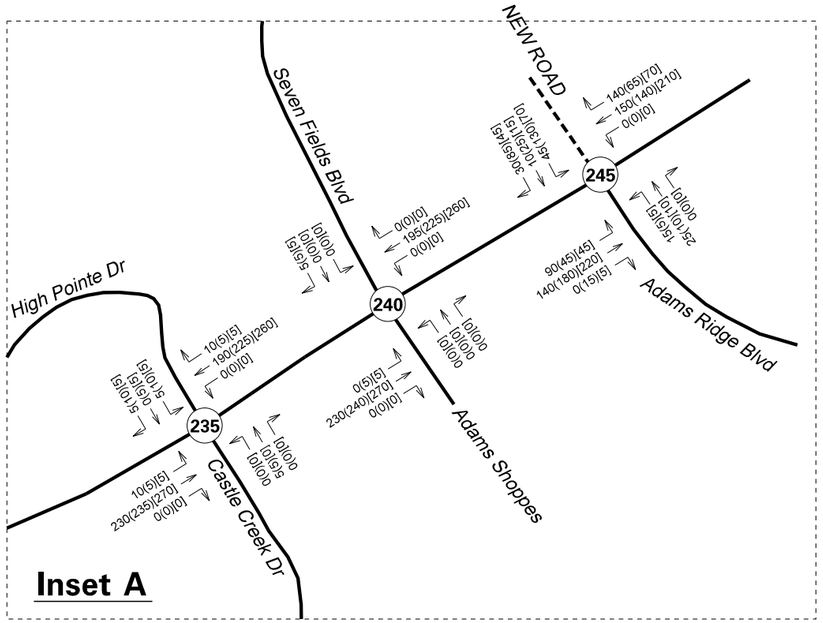


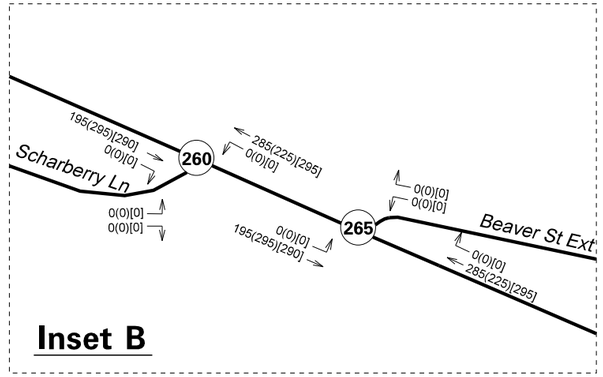
Legend	
Site Development Data	(XX) AM(PM)[SAT] PEAK HOUR
Site Development Include	Cranberry Springs Development Village of Cranberry Woods

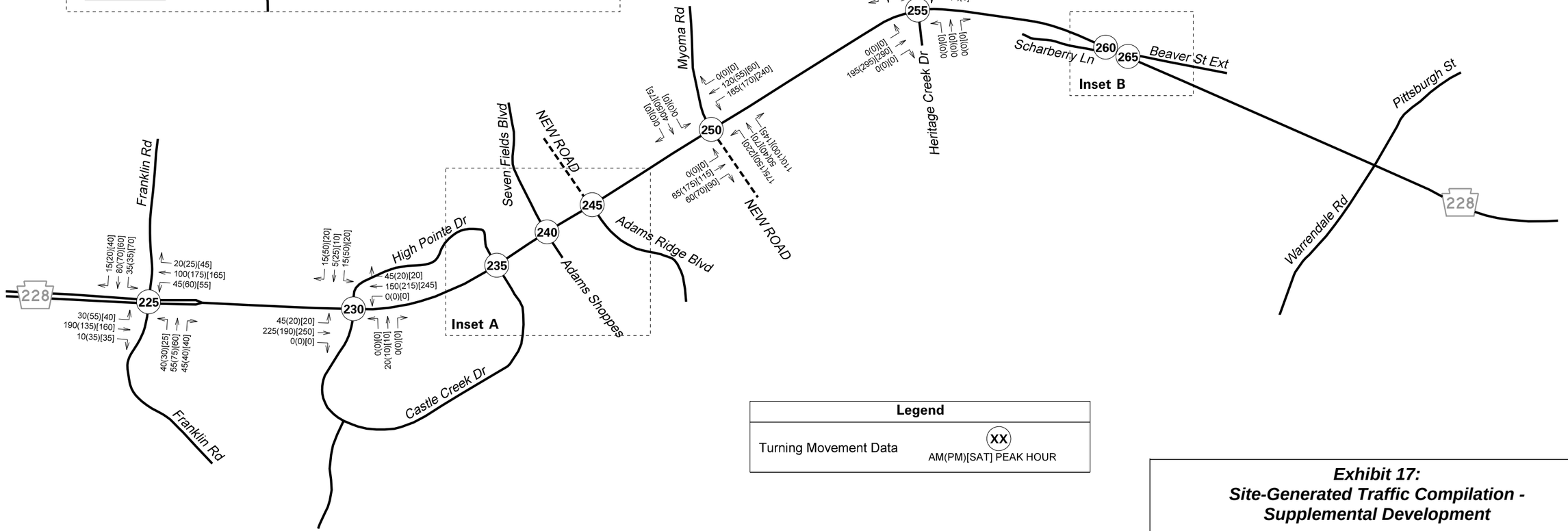
Exhibit 16:
Site-Generated Traffic Compilation - Imminent Development

NOT TO SCALE

SOURCE: WRA review and compilation of miscellaneous traffic impact study records (where available), plus site-specific development assumptions







Legend	
Turning Movement Data	XX AM(PM)[SAT] PEAK HOUR

SOURCE: WRA review and compilation of miscellaneous traffic impact study records (where available), plus site-specific development assumptions

Exhibit 17:
Site-Generated Traffic Compilation - Supplemental Development

NOT TO SCALE

Opening Year Volumes

Opening Year traffic volumes were developed by (1) applying background growth rates to the 2016 Base Year volumes to linearly grow traffic through Year 2025, and (2) adding the additional Imminent Development traffic before final rounding/balancing adjustments. Note that municipal-specific growth rates were applied to all side-street traffic and turning movements according to municipality; whereas SR 228 mainline through-traffic was consistently grown using the Cranberry Township rate from the western project limits to Seven Fields Boulevard, and then the Adams Township rate from Adams Ridge Boulevard to the eastern project limits.

Calculation data is included in **Appendix B**; final peak hour traffic volume assumptions for 2025 Opening Year conditions are mapped on **Exhibit 18**.

Design Year Volumes

Design Year traffic volumes were developed by (1) applying background growth rates to the 2016 Base Year volumes to linearly grow traffic through Year 2045, and (2) adding the additional Imminent Development traffic before final rounding/balancing adjustments. Growth rates were applied by municipality and for the SR 228 mainline through-traffic using the same assumptions as for the Opening Year.

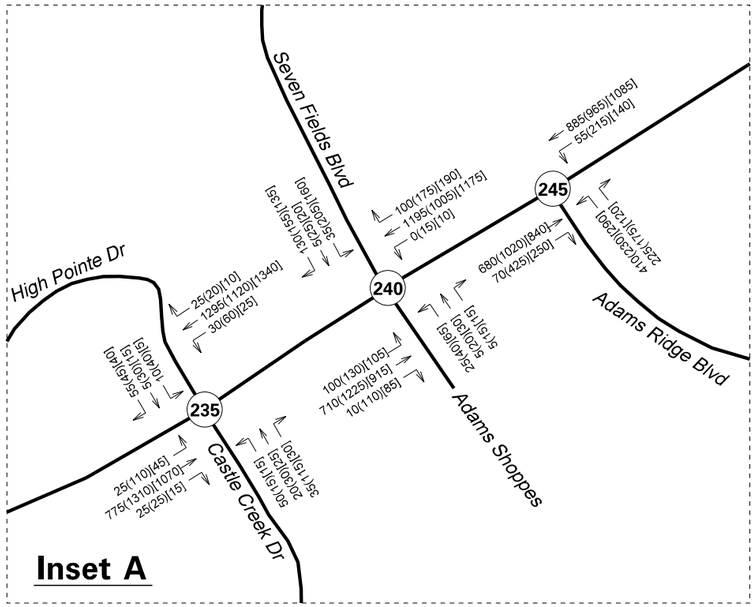
Calculation data is included in **Appendix B**; final peak hour traffic volume assumptions for 2045 Design Year conditions are mapped on **Exhibit 19**.

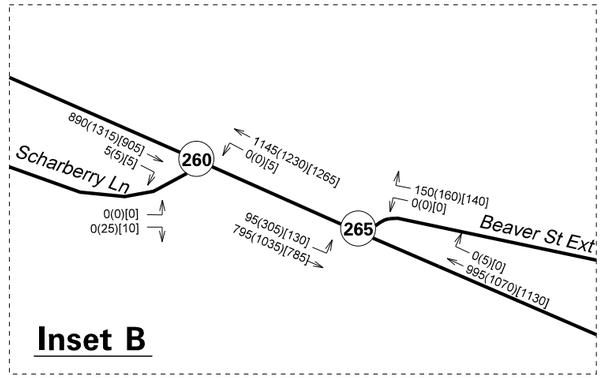
Design Year Volumes with Supplemental Growth

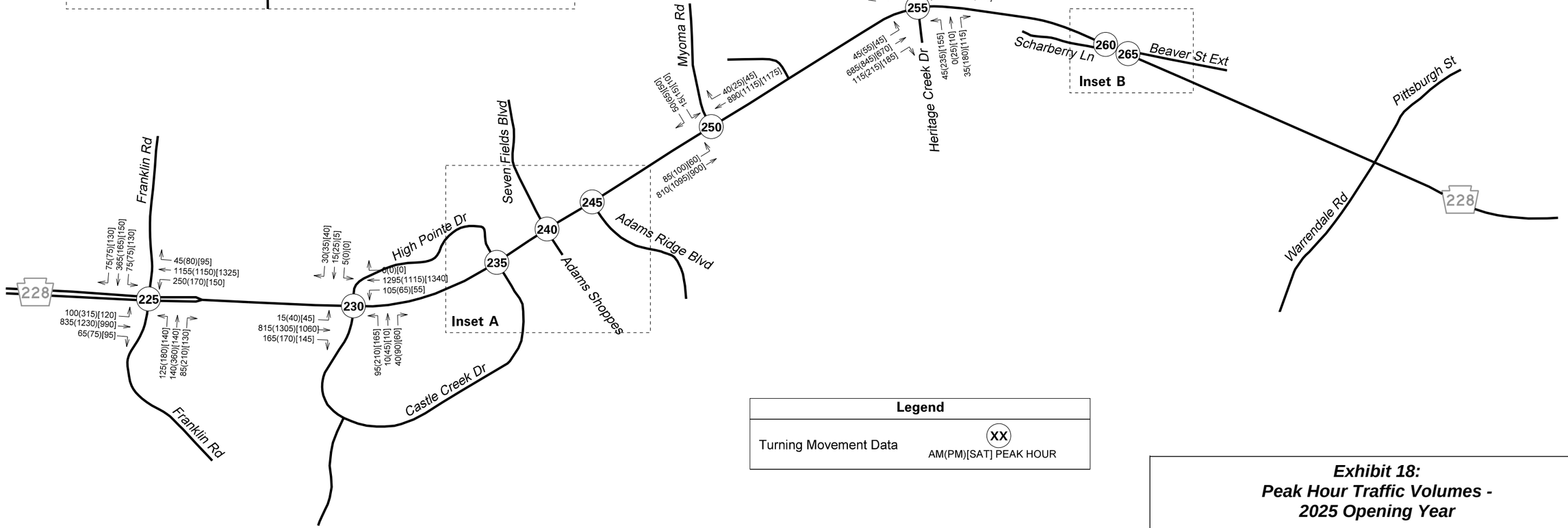
Though the previously-established supplemental growth assumptions account for future development that may not be formally/officially planned or approved, it is anticipated that the likelihood of experiencing such growth will only increase as the corridor becomes more attractive following the widening project and related congestion, operations, and safety improvements. It was therefore deemed a prudent exercise to review the potential influence of the supplemental growth to conduct a sensitivity check of any proposed improvements covered by this Traffic Design Report. To that end, Supplemental Development traffic was directly added to the 2045 Design Year volume set to yield a final peak hour traffic volume assumption for 2045 Design Year conditions with Supplemental Growth as mapped on **Exhibit 20**.

A simplified comparison of traffic variations under the future year scenarios shows the following:

	2016	2045	2045 Supplemental
• Peak Hour Through-Traffic (one-way):	1,100	1,500	1,800
• Peak Hour Roadway Volume (two-way)	2,500	3,500	4,000
• Estimated AADT:	27,000	36,000	41,000





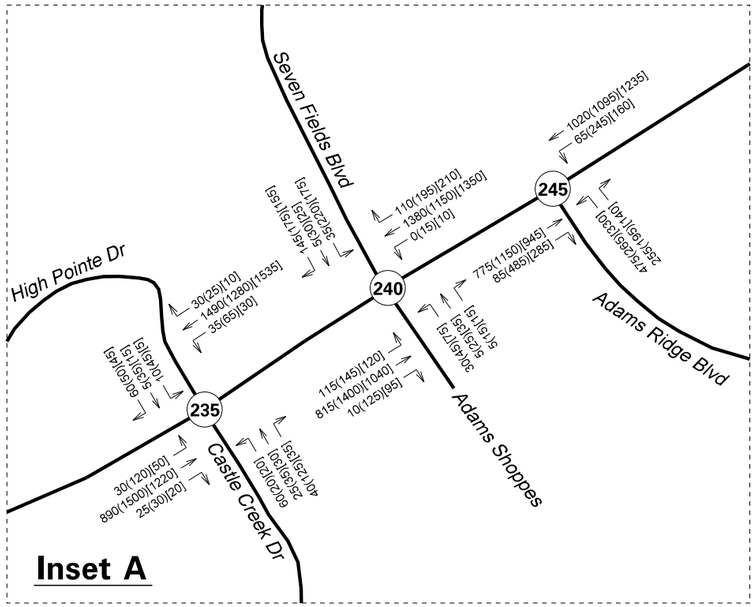


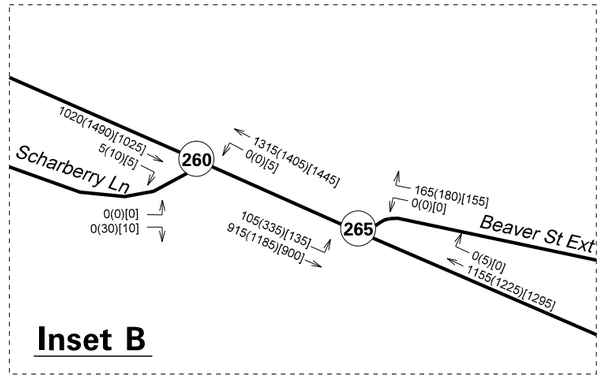
Legend	
Turning Movement Data	(XX) AM(PM)[SAT] PEAK HOUR

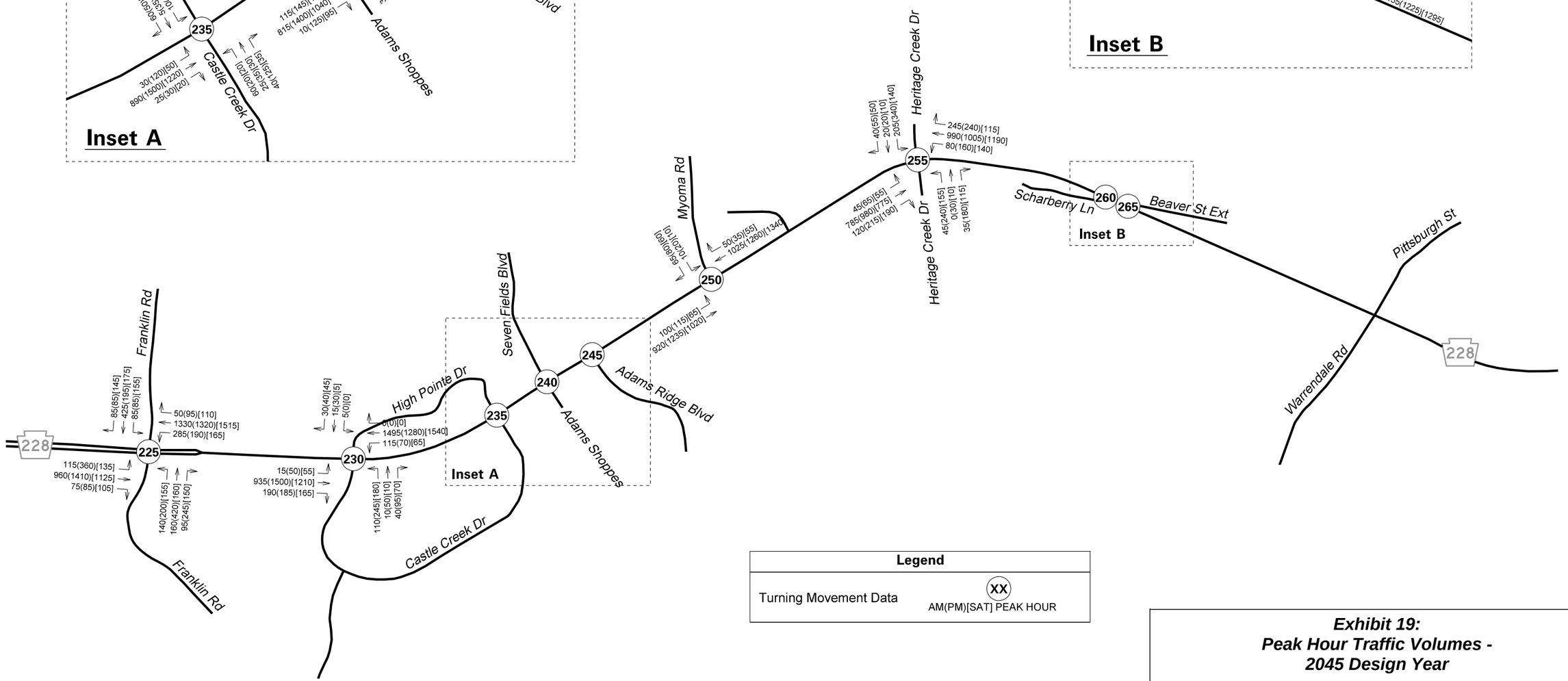
Exhibit 18:
Peak Hour Traffic Volumes -
2025 Opening Year

NOT TO SCALE

SOURCE: 2016 Base Year volumes plus background traffic increases per regional growth rates, plus imminent development traffic





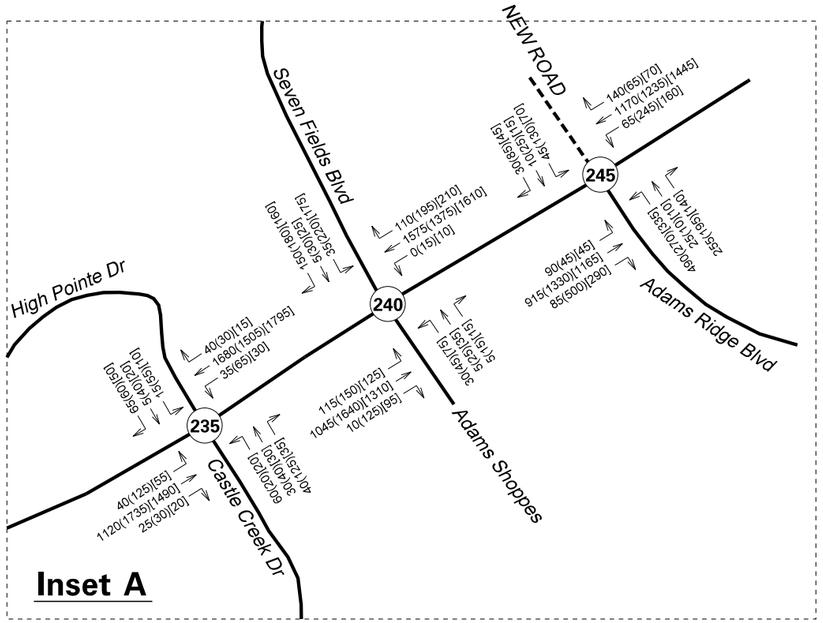


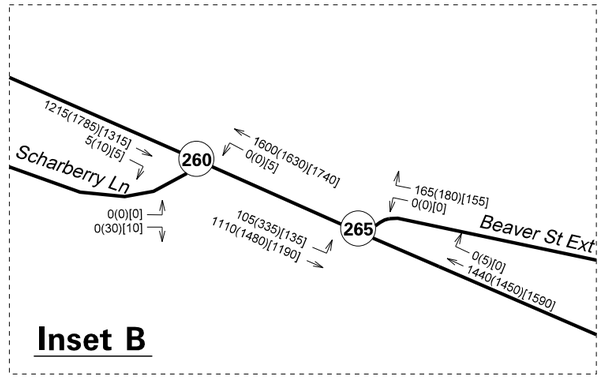
Legend	
Turning Movement Data	(XX) AM(PM)[SAT] PEAK HOUR

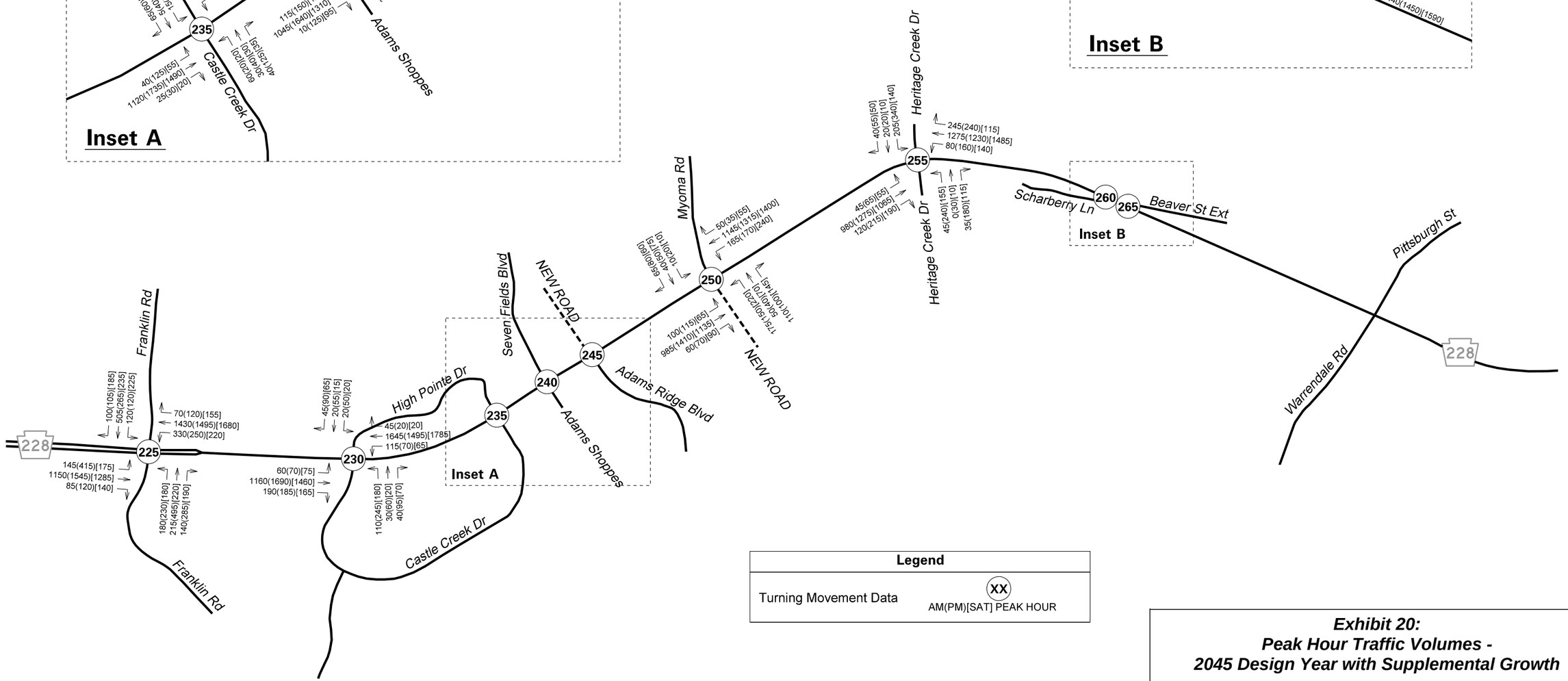
Exhibit 19:
Peak Hour Traffic Volumes -
2045 Design Year

NOT TO SCALE

SOURCE: 2016 Base Year volumes plus background traffic increases per regional growth rates, plus imminent development traffic







Legend	
Turning Movement Data	(XX) AM(PM)[SAT] PEAK HOUR

SOURCE: 2045 Design Year volumes plus supplemental development traffic

Exhibit 20:
Peak Hour Traffic Volumes -
2045 Design Year with Supplemental Growth

NOT TO SCALE

Baseline and No-Build Traffic Operations

Synchro traffic analysis software (a macroscopic capacity analysis and signal optimization computer program) was used to analyze traffic operations along the project corridor. Initial efforts focused on establishing a Baseline model to match 2016 Base Year conditions, and then evaluating future No-Build operations to assess the impact of future traffic growth without any of the proposed project improvements being constructed.

Traffic Model Development

The study area was modeled using Synchro software to replicate 2016 conditions and calibrated for the weekday AM, PM, and Saturday midday peak periods. Levels of Service (LOS) for the study intersections were evaluated to identify current problem areas and develop a basis for opening year and future year comparisons. LOS is a measure of effectiveness based on Highway Capacity Manual (HCM) methodologies that considers delay due to the traffic control in place at intersections and assigns a letter-grade from LOS A, representing the best operating conditions, to LOS F, representing the worst operating conditions.

The baseline transportation network was developed using traffic signal permit plans provided by PennDOT (including lane widths, auxiliary lane storage lengths, approach grades, traffic signal timings, etc.) coupled with project-specific data collection and field view details. Additional information such as traffic volumes, traffic demand, saturation flow rates, and traffic composition was entered based on project-specific traffic counts, engineering studies, and related data. Synchro models were calibrated/validated using the field data insights, including comparisons to queuing and travel time details (**Appendix D**).

Traffic Operations Summary

Using the calibrated Synchro models, traffic operations were evaluated for the Baseline and future No-Build scenarios including 2016 Base Year, 2025 Opening Year, and 2045 Design Year. Roadway and intersection geometry was assumed to remain constant throughout all scenarios. Model changes including increasing traffic demands (per previous **Exhibit 14**, **Exhibit 18**, and **Exhibit 19**) and optimizing traffic signal timings for each peak period given the increased demands. Analysis documentation included in the appendices to this Traffic Design Report include:

- **Appendix D** – all applicable Synchro output reports
- **Appendix E** – detailed delay and LOS summary tables (by intersection/approach/movement)
- **Appendix F** – queuing summary tables

An overall intersection LOS summary is compiled in **Exhibit 21**. Based on these results and an evaluation of the overall analysis efforts, key findings include the following:

- Notable congestion occurs during each peak period today and is expected to worsen into the future without improvements.
- Though most intersections operate at overall LOS D or better through year 2025, every signalized intersection along the study corridor experiences one or more approach failures (LOS E/F) in every peak, even under 2016 Base Year conditions.
- By 2045, the majority of signalized intersections are anticipated to experience overall failures, and all stop-controlled approaches (Myoma, Scharberry, and Beaver) are projected to fail.

Exhibit 21: LOS Summary for Baseline and No-Build Conditions

#	SR 228 at:	Overall Intersection LOS (AM / PM / SAT)		
		2016 Base Year Conditions	2025 Opening Year No-Build	2045 Design Year No-Build
225	Franklin Rd	D** E** C**	D** E** D**	E** F** D**
230	Castle Creek Dr (West)	C** C** B**	C** E** C**	E** F** D**
235	Castle Creek Dr (East)	A** B** A**	B** B** B**	D** D** C**
240	Seven Fields Blvd	B** C** B**	C** C** C**	D** E** D**
245	Adams Ridge Blvd	C** C** C**	C** C** C**	D** D** D**
250	Myoma Rd	D^ F^ D^	F^ F^ F^	F^ F^ F^
255	Heritage Creek Dr	C** C** B**	C** D** C**	C** E** C**
260	Scharberry Ln	A^ C^ B^	A^ D^ C^	A^ E^ C^
265	Beaver St Ext	C^ C^ C^	D^ E^ E^	F^ F^ F^

Table Notes:

***** *Single asterisk denotes that one or more individual movements fail (LOS E/F); see detail tables in Appendix E.*

****** *Double asterisk denotes that one or more overall approaches fail (LOS E/F); see detail tables in Appendix E.*

^ *Caret denotes that LOS represents stop-controlled side-street movement only.*

- Substantial queuing is also problematic and results in additional delays, blocked auxiliary lanes, and queue spillback that affects mainline travel, upstream intersections, and various side-street connections.
- By 2045, queuing concerns are anticipated corridor-wide and include notable queues affecting SR 228 from Franklin Road to Castle Creek Drive (West), through closely-spaced intersections in Seven Fields Borough, and through Heritage Creek Drive.
- By 2045, queueing concerns are also expected to result in upstream driveway or side-street blockages along most of the busier side-street approaches throughout the corridor, particularly along Franklin Road, Castle Creek Drive (West), Seven Fields Boulevard, Adams Ridge Boulevard, and Heritage Creek Drive.
- Considering existing crash patterns, including 70% rear-end crashes by type and noted aggressive driving behaviors, future congestion and queuing problems would also exacerbate safety concerns throughout the project corridor.

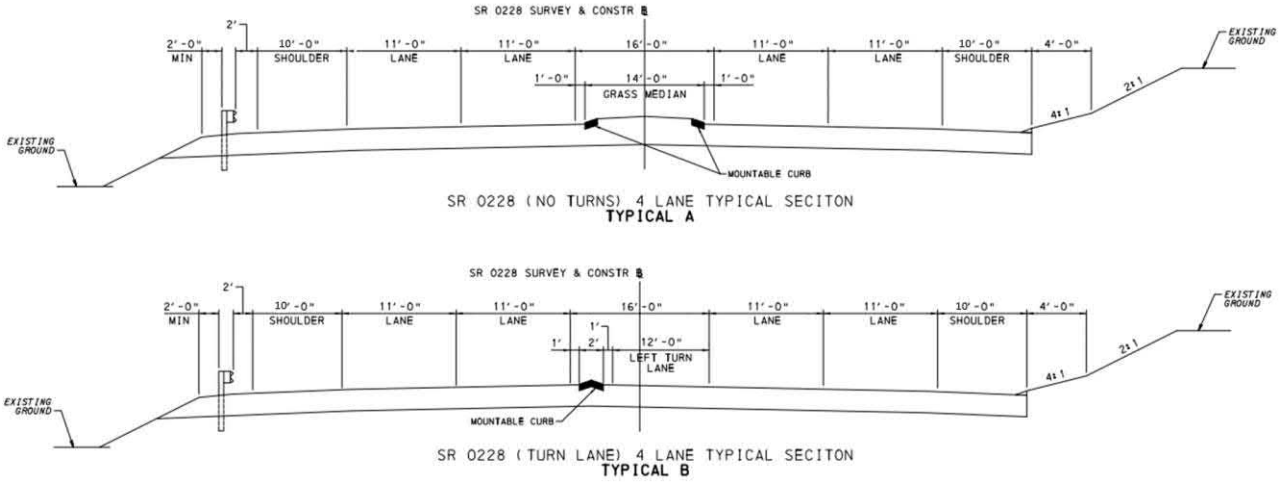
Basic Build Configuration

Considering the deficiencies identified by the Baseline and No-Build analyses, project design concepts and roadway/intersection improvement opportunities were evaluated to establish a set of Build conditions and their collective influence on accommodating future traffic growth and operations.

Corridor Typical Section and Design Requirements

Based on coordination with PennDOT District 10-0 and Safety Audit considerations for the broader SR 228 corridor, the proposed typical section for the Mars RR Bridge West segment consists of four 11' lanes, 10' shoulders, and a 16' median area that will also accommodate offset left-turns where applicable (**Exhibit 22**).

Exhibit 22: SR 228 Proposed 4-Lane Typical Section



Source: PennDOT District 10-0

Safety Audit details also suggest 40 mph for the posted and design speeds through Seven Fields Borough, and 45 mph for the posted and design speeds through Adams Township. Suggested access control includes limiting stop-controlled movements to right-in/right-out (RIRO) only, prohibiting U-turns, and providing jughandle accommodations where applicable (e.g. Beaver Street Extension). All turns should otherwise be made at signalized intersections.

To commence an evaluation of the Build conditions, the 2045 Design Year (No-Build) Synchro models for the weekday AM, PM, and Saturday midday peak periods were modified to reflect the corridor-wide geometric and speed changes summarized above.

Turn Lane Warrants

As further preparation for establishing the required geometry for the Build conditions and related Build Synchro models, turn lane warrants and storage lengths were evaluated throughout the study corridor based on PennDOT Publication 46 methodologies using PennDOT's Turn Lane Warrant and Length Analysis Workbook. Results are summarized in **Appendix G** and generally indicate that left/right turn lanes are warranted for most mainline intersection approaches along the study corridor, with the exception of right-turn lanes westbound at Castle Creek Drive (West), eastbound and westbound at Castle Creek Drive (East), and westbound at Beaver Street Extension. It is anticipated that future site-specific development may impact the need for certain turn lanes including, for example, the development-related potential for new approach legs at Adams Ridge Boulevard or Myoma Road. Such additions, however, were generally deferred to future development plans, and the summary lane, auxiliary lane, and storage length assumptions that make up the basic Build configuration coded into the Build Synchro models for this Traffic Design Report are illustrated in **Exhibit 23**.

Traffic Signal Warrants

As part of establishing the basic Build configuration for the project corridor, existing stop-controlled intersections along SR 228 at Myoma Road and at Beaver Street Extension were also evaluated to determine if either site satisfied warrants for the installation of a new traffic signal. Warrants were evaluated based on Manual on Uniform Traffic Control Devices (MUTCD) and PennDOT Publication 46 (Section 4.3) methodologies using PennDOT's Traffic Signal Warrant Analysis Workbook. Analyses were based on Opening Year 2025 traffic volume projections and assume the proposed posted speed limit of 45 mph at both locations. Results are summarized in Appendix G and as follows:

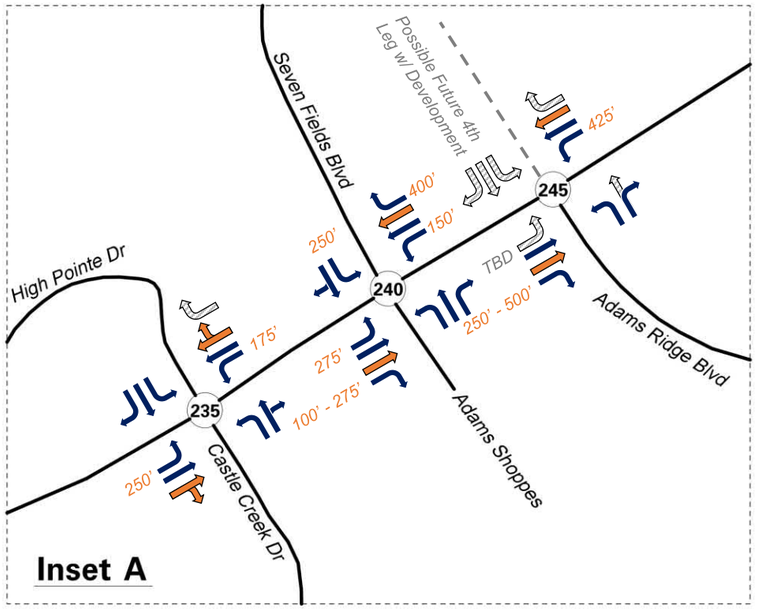
- **SR 228 at Myoma Road –** Barring future site-specific development by 2025, this intersection does not fully satisfy criteria under Warrant 2 (Four-Hour Vehicular Volume), Warrant 3 (Peak Hour), or Warrant 7 (Crash Experience). The location does, however, meet criteria under Warrant 8 (Roadway Network), but primarily based on mainline SR 228 traffic volumes during weekend (non-normal business day) conditions. It also meets Warrant PA-1 (ADT Volume), but this set of criteria is generally reserved as a secondary/supporting condition that would require a reevaluation of warrants (and potential signal removal if not fully satisfied) within two years of project construction.

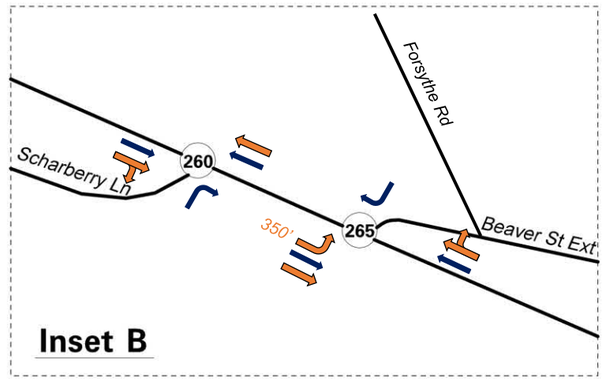
  As such, a new traffic signal is not proposed as part of the SR 228 basic Build configuration at this time, but Myoma Road should continue to be monitored for changes that may influence future traffic signal needs. It is anticipated that a signal will eventually be justified at this intersection based on longer-term growth beyond the 2025 Opening Year conditions and/or as a result of site-specific development activity (Site E on **Exhibit 15**) that potentially adds a fourth (northbound) approach leg with two to three times the traffic demand of existing Myoma Road (per **Exhibit 20** volumes).

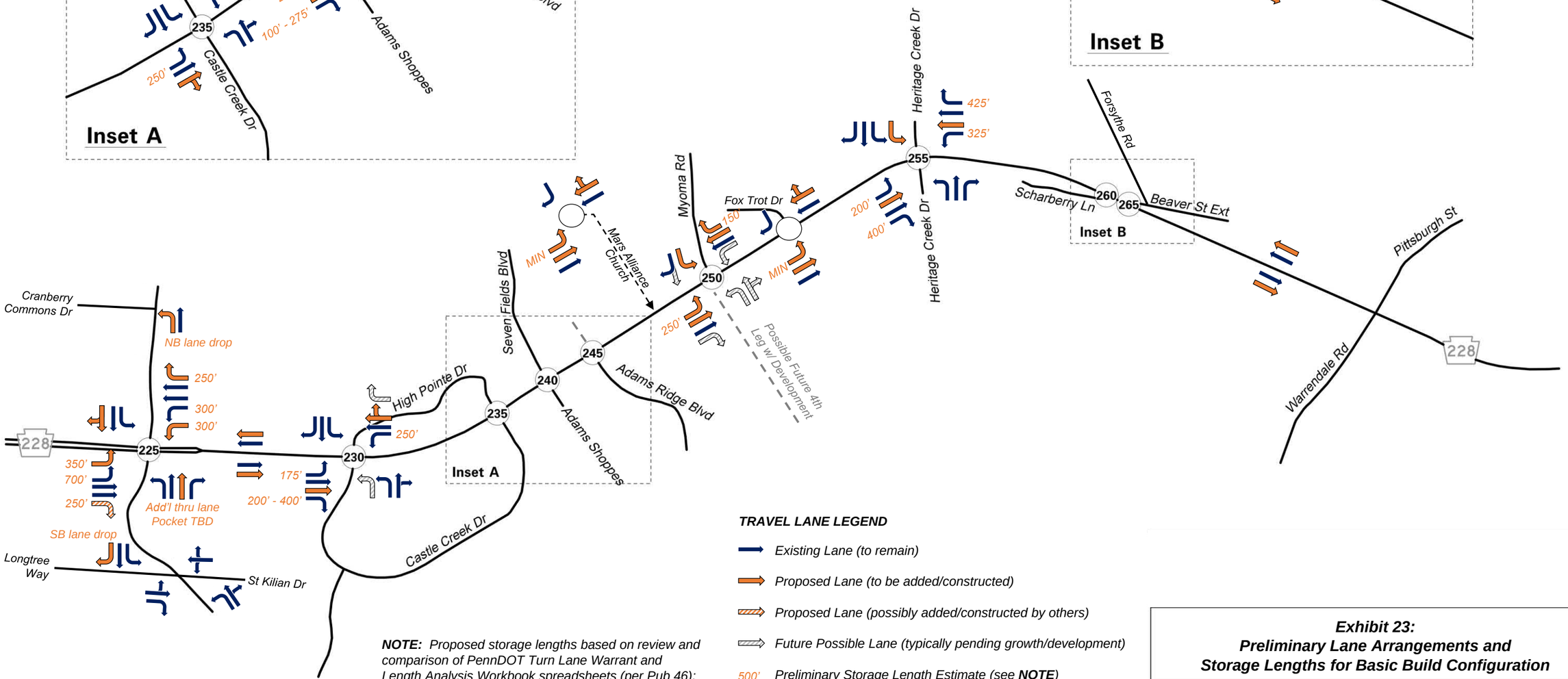
- **SR 228 at Beaver Street Extension –** This intersection satisfies Warrant 2 (Four-Hour Vehicular Volume), and supporting criteria under Warrant 8 (Roadway Network) and Warrant PA-1 (ADT Volume). As such, a new traffic signal is proposed as part of the SR 228 basic Build configuration.

Other Pre-Design Checks

In addition to the above traffic details, the SR 228 corridor was also evaluated to assess general bicycle/pedestrian needs per PennDOT Publication DM-1X, as well as intersection-specific needs via PennDOT Form TE-672 (**Appendix H**). Existing lane, speed, and related traffic insights were also noted as part of an existing sign inventory (**Appendix I**). Collectively, insights from these types of pre-design checks were also used to support development of the Build conditions, and related details have been included in the appendices of this Traffic Design Report for ongoing reference.







NOTE: *Proposed storage lengths based on review and comparison of PennDOT Turn Lane Warrant and Length Analysis Workbook spreadsheets (per Pub 46); Synchro-based queuing estimates; and potential site-specific characteristics or constraints.*

TRAVEL LANE LEGEND

- *Existing Lane (to remain)*
- *Proposed Lane (to be added/constructed)*
- *Proposed Lane (possibly added/constructed by others)*
- *Future Possible Lane (typically pending growth/development)*
- *500' Preliminary Storage Length Estimate (see **NOTE**)*
- *Possible Future Roadway/Development Connection*

Exhibit 23:
Preliminary Lane Arrangements and Storage Lengths for Basic Build Configuration

NOT TO SCALE

Design Year Traffic Operations

Assuming the basic Build configuration summarized above, the proposed geometric, auxiliary lane, speed, and traffic control changes were coded into the previously-established No-Build Synchro files to evaluate and compare future Build traffic operations. Separate analyses were conducted for each of two traffic growth scenarios including 2045 Design Year (previous **Exhibit 19**) and 2045 Design Year with Supplemental Growth (previous **Exhibit 20**). Build network and traffic control assumptions under both scenarios are similar, except as follows:

- **SR 228 at Adams Ridge Boulevard** – assumes a three-leg signalized intersection under 2045 Build, but adds a fourth (southbound) approach leg and related turn lanes associated with site-specific development (Site K per **Exhibit 15**) under 2045 Build with Supplemental Growth.

- **SR 228 at Myoma Road** – assumes a three-leg stop-controlled intersection under 2045 Build, but adds a new traffic signal and a fourth (northbound) approach leg associated with site-specific development (Site E per **Exhibit 15**) under 2045 Build with Supplemental Growth.

- **SR 228 at Beaver Street Extension** – assumes a new traffic signal at this intersection under both the 2045 Build and 2045 Build with Supplemental Growth.

Analysis documentation included in the appendices to this Traffic Design Report is listed below, and an overall intersection LOS summary is compiled in **Exhibit 24**.

- **Appendix D** – all applicable Synchro output reports
- **Appendix E** – detailed delay and LOS summary tables (by intersection/approach/movement)
- **Appendix F** – queuing summary tables

Exhibit 24: LOS Summary for Build Conditions

#	SR 228 at:	Overall Intersection LOS (AM / PM / SAT)								
		2045 No-Build			2045 Build			2045 Build w/ Supplemental Growth		
225	Franklin Rd	E**	F**	D**	D**	D**	C**	E**	D**	D**
230	Castle Creek Dr (West)	E**	F**	D**	B	C	B	B	D**	C*
235	Castle Creek Dr (East)	D**	D**	C**	A	A**	A	B	B**	B
240	Seven Fields Blvd	D**	E**	D**	B	B	B	A	C*	B
245	Adams Ridge Blvd	D**	D**	D**	B	B	B	D**	C**	C**
250	Myoma Rd (w/o WB RT)	F^	F^	F^	C^	F^	E^	B*	C**	C**
255	Heritage Creek Dr	C**	E**	C**	B	B	B	B	D**	B
260	Scharberry Ln	A^	E^	C^	A^	B^	B^	A^	C^	C^
265	Beaver St Ext	F^	F^	F^	B*	C	B	B*	C	B

Table Notes:

***** *Single asterisk denotes that one or more individual movements fail (LOS E/F); see detail tables in Appendix E.*

****** *Double asterisk denotes that one or more overall approaches fail (LOS E/F); see detail tables in Appendix E.*

^ *Caret denotes that LOS represents stop-controlled side-street movement only.*

Based on these results and an evaluation of the overall analysis efforts, key findings include the following:

- Compared to 2045 No-Build conditions, congestion is substantially reduced under the future Build scenarios with most intersections projected to operate at an acceptable LOS D or better overall.
- Individual approach and/or movement failures are mostly eliminated under 2045 Build conditions, with the exception of Franklin Road, and with minor exceptions at Castle Creek Drive (East) and Beaver Street (Extension). Though approach failures increase with additional development traffic under the 2045 Build with Supplemental Growth scenario, particularly during the weekday PM peak period, these conditions still reflect an improvement over No-Build conditions.
- Queuing, queue spillback, and related auxiliary lane, upstream, or side-street blockages are largely mitigated under the Build conditions.
- Improved operations and substantial reductions in queuing are anticipated to reduce aggressive driving behaviors and enhance safety conditions throughout the corridor. Additional safety benefits are detailed under separate cover in the project's Confidential Safety Study.

Optional Intersection Design Concepts

Details above summarize the basic Build configuration assuming consistent four-lane widening with appropriate turn lane installations and traffic signal improvements throughout the overall SR 228 project corridor. Beyond this basic configuration, site-specific intersection design enhancements were also explored at select locations to assess their potential for providing other benefits or opportunities related, for example, to congestion, safety, right-of-way, or development impacts. These options were introduced for possible consideration at a November 30, 2017, coordination meeting with PennDOT District 10-0. Though not currently assumed as part of the basic Build configuration detailed by this Traffic Study, potential design enhancements are summarized below for reference. If pursued, additional analysis and design consideration may be required to confirm the feasibility/viability of any given option and/or to integrate it into the proposed design and related project/segment phasing for the overall SR 228 corridor.

Franklin Road Quadrant Roadway (QR) Intersection

Due to the surrounding development, anticipated traffic demand, and substantial turning movement volumes on all four approaches, the basic Build configuration at the intersection of SR 228 and Franklin Road warrants substantial widening and multiple turn lanes (**Exhibit 25**). While these geometric changes improve operations versus No-Build conditions (as evidenced by LOS comparisons in **Exhibit 24**), they do not fully mitigate projected operational failures. Changes also introduce substantial pavement widths at the crossroads location and – barring additional widening along Franklin Road – require a northbound lane-drop that introduces a false capacity situation and likely results in inefficient/imbalanced use of the proposed eastbound dual left-turn lanes.

Multiple intersection design concepts were, therefore, explored to potentially enhance the conditions at Franklin Road versus the basic Build configuration. Preliminary concepts included incorporating a loop ramp in the southeast quadrant to divert the eastbound left-turn traffic; installing an innovative displaced left-turn (DLT) intersection to divert eastbound and westbound left-turn traffic; or installing a similar DLT concept to divert northbound and southbound left-turn traffic. All of these preliminary concepts were not found to reasonably improve operations, safety, or ROW impacts. One additional concept, however, may provide an opportunity for improvement by installing a new quadrant roadway (QR) intersection design with a new connection through areas northeast of the existing intersection (**Exhibit 26**). Operational comparisons for LOS and movement delays are summarized in **Exhibit 27** and **Exhibit 28**; details are included in **Appendix D** and **Appendix E**.

The QR intersection would move the eastbound and westbound left-turn traffic away from the main intersection of SR 228 at Franklin Road via new signalized connections at either end of a new quadrant roadway. The concept as currently evaluated would continue to accommodate northbound and southbound left-turn traffic from Franklin Road at the main intersection. Guidance from FHWA notes that this type of spot-treatment may be most applicable where (1) a roadway in the road network can be used as a connection roadway; (2) there are heavy left turns and through volumes on the major and minor roads; and (3) the minor road total volume to total intersection volume ratio is typically less than or equal to 0.35.[1] The existing Franklin Road intersection satisfies the second and third conditions; and while a new roadway connection would need to be constructed in this case, it is anticipated that the proposed design along SR 228 could tap into existing Rebecca Lane and implement a modified connection to the Cardinal Wuerl North Catholic School Campus.

[1] *Tech Brief: Quadrant Roadway Intersection.* (FHWA-HRT-09-058). Federal Highway Administration. October 2009. https://www.fhwa.dot.gov/publications/research/safety/09058/09058.pdf.

Exhibit 25: SR 228 at Franklin Road – Basic Build Concept

Exhibit 26: SR 228 at Franklin Road – Quadrant Roadway Concept

Exhibit 27: LOS Summary for Franklin Road QR Intersection Concept

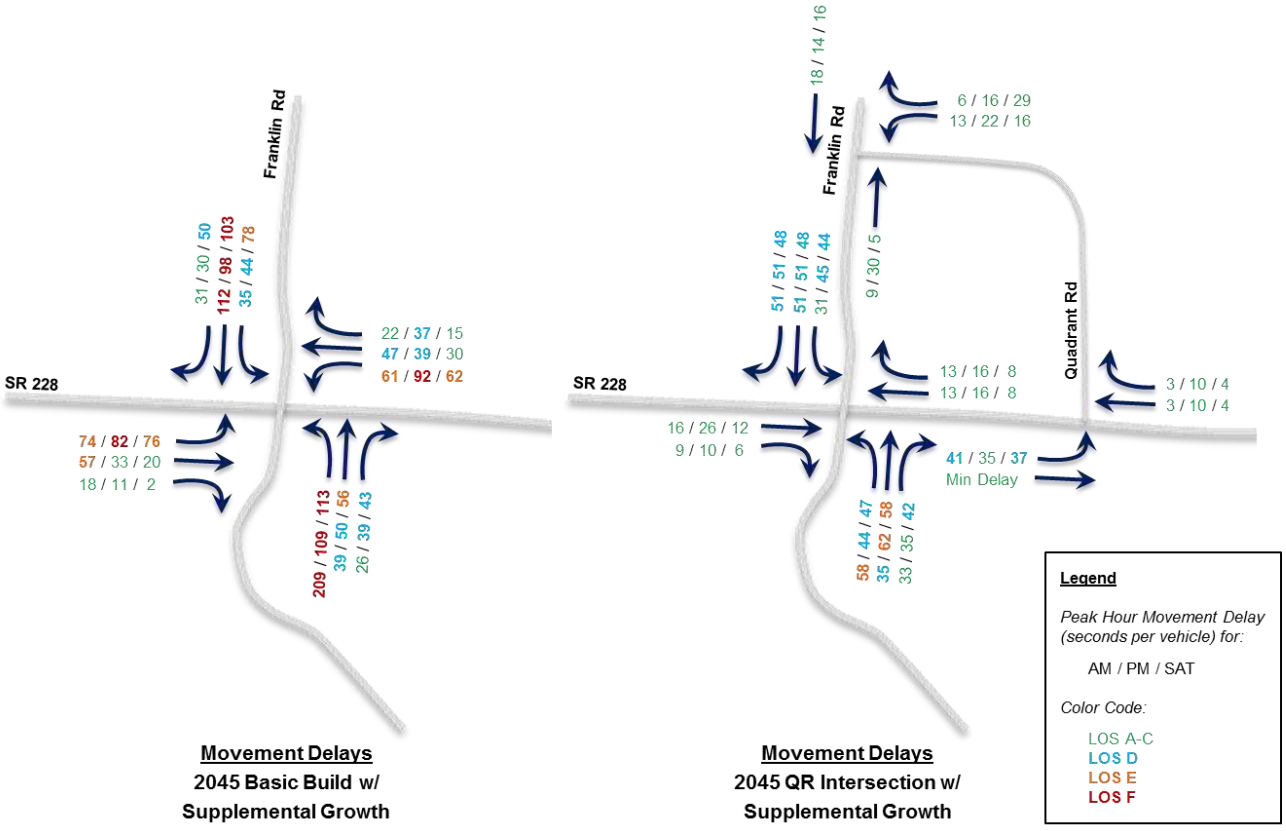
#	Intersection	Overall Intersection LOS (AM / PM / SAT)		
		2045 Basic Build w/ Approved Growth	2045 Basic Build w/ Supplemental Growth	2045 QR Intersection w/ Supplemental Growth
225	Franklin Rd @ SR 228	D** D** C**	E** D** D**	D* C* C*
---	Quad Rd @ Franklin Rd	-- -- --	-- -- --	B C B
---	Quad Rd @ SR 228	-- -- --	-- -- --	C A A

Table Notes:

* *Single asterisk denotes that one or more individual movements fail (LOS E/F); see detail tables in Appendix E.*

** *Double asterisk denotes that one or more overall approaches fail (LOS E/F); see detail tables in Appendix E.*

Exhibit 28: Movement Delay Comparison for Franklin Road QR Intersection Concept



Potential advantages of the QR intersection include improved operations and safety, a reduction in the number of vehicular conflict points, a more widely-spread series of maneuver/decision-making points, a narrower pavement area at the main intersection, and possibly a higher level of resilience toward accommodating additional future growth. Potential disadvantages of the QR intersection include left-turn diversion distance and possible related driver confusion, impacts to Cardinal Wuerl North Catholic School access, cost/availability of required ROW for the quadrant roadway, and influence on future development parcels or related opportunities through areas impacted by the quadrant roadway. If pursued, additional design evaluation/analysis and agency, municipal, and stakeholder coordination will likely be required.

High Pointe Drive Development Influence

The basic Build configuration with four-lane widening (previous **Exhibit 23**) is proposed at the SR 228 intersections with Castle Creek Drive and High Pointe Drive, at both the (West) and (East) locations. Future traffic impacts in these areas may, however, be influenced by development potential related to the vacant parcels adjacent to High Pointe Drive on the north side of SR 228 (Site J in previous **Exhibit 15**). Depending on the specific development activity, future evaluations may need to consider an additional northbound left-turn lane and/or westbound right-turn lane at the Castle Creek Drive / High Pointe Drive (West) intersection, and an additional westbound right-turn lane at the Castle Creek Drive / High Pointe Drive (East) location. While current traffic projections do not anticipate an immediate need for the additional lanes, ongoing design efforts for the SR 228 project corridor may wish to consider their potential relative to specific design elements if/where feasible (e.g. ROW considerations, drainage design, signal pole/foundation placement).

Seven Fields to Adams Ridge Boulevard Improvements

The basic Build configuration with four-lane widening (previous **Exhibit 23**) is proposed at the SR 228 intersections with Castle Creek Drive and High Pointe Drive (East), Seven Fields Boulevard and Adams Shoppes, and Adams Ridge Boulevard. While these geometric changes improve operations versus No-Build conditions (as evidenced by LOS comparisons in **Exhibit 24**), this configuration also maintains three closely-spaced traffic signals with less than approximately 700' between each intersection. Such close spacing inherently yields a potential to negatively influence congestion and delay, stop and go traffic, queue spillback, turn lane storage capacity, aggressive driving tendencies, and safety. This potential may also increase in the future with notable development opportunities (Site K in previous **Exhibit 15**) and a possible fourth (southbound) approach leg opposite existing Adams Ridge Boulevard.

Multiple intersection design concepts were, therefore, explored to potentially enhance the conditions along this stretch of SR 228. Three potential options include the following:

1. **Adams Ridge Turn Lanes** – Northbound dual left-turn lanes could be considered along Adams Ridge Boulevard. This concept, however, may provide limited benefits despite heavy traffic demands from/to residential areas to the south. A primary unknown is the potential trade-off and related operational impact that dual left-turn lanes may have if they also require splitting northbound/southbound signal phasing in light of a development-driven fourth intersection leg.

2. **Roundabout Trio** – A trio of roundabouts could be considered to replace existing traffic signals at Castle Creek Drive and High Pointe Drive (East), Seven Fields Boulevard, and Adams Ridge Boulevard. To balance driver expectations and avoid intermixing closely-spaced signals with roundabouts, it was assumed that this concept would require all three locations to simultaneously convert to roundabouts (i.e. not just one or two of the three locations).

   Conceptual analyses using SIDRA software indicated that with 2045 Design Year traffic with Supplemental Growth, multilane roundabouts and various slip-lane combinations would be required, in most cases yielding volume-to-capacity (v/c) ratios of 0.80 to 0.85, or very near a presumed "breaking point" for typical operations. Roundabouts could provide an important traffic calming and safety benefit through this particular segment of SR 228. However, with the heavy traffic demands to/from Adams Ridge Boulevard and the relative unknown growth potential of the vacant parcel opposite Adams Ridge Boulevard, additional detailed analysis, simulation, and design consideration would be required to fully/confidently assess the viability of this concept.

3. **Network Reconfiguration** – A third option includes locally reconfiguring the side-street network to eliminate one of the three closely-spaced traffic signals, thereby improving congestion, queuing, and safety. This reconfiguration could be accomplished by establishing a fourth (southbound) leg of the intersection at Adams Ridge Boulevard prior to future development-driven activities that anticipate a similar connection. The southbound leg could provide alternate access to/from Seven Fields Boulevard via a direct linkage to Roxsan Drive, or as a fully parallel route between Crider Road and SR 228. This new connectivity would then allow for removal of the existing traffic signal at SR 228 and Seven Field Boulevards, which would simultaneously be converted to accommodate right-in/right-out (RIRO) traffic only; all other access would shift to either of the adjacent traffic signals.

   Operationally, this concept would simplify travel along SR 228 through Seven Fields Borough by eliminating much of the stop & go or queue spillback potential, decreasing the overall number of conflict points along the roadway, and providing more resiliency in terms of accommodating future development traffic. Geometrically, it would also more easily accommodate appropriate storage lengths for future eastbound left-turns at Adams Ridge Boulevard. While it would also generally eliminate the vehicular traffic signal at Seven Fields Boulevard, further design coordination is required to determine if a pedestrian-actuated signal should be retained at that location to accommodate pedestrian movements across SR 228 between Seven Fields Boulevard and Adams Shoppes. Operational results are summarized below (**Exhibit 29**) and detailed in **Appendix D** and **Appendix E**, while concept schematics for the basic Build configuration and the reconfigured network are compared in **Exhibit 30** and **Exhibit 31**, respectively.

Exhibit 29: LOS Summary for Adams Ridge and Seven Fields Reconfiguration

#	SR 228 at:	Overall Intersection LOS (AM / PM / SAT)		
		2045 Basic Build w/ Approved Growth	2045 Basic Build w/ Supplemental Growth	2045 Reconfiguration w/ Supplemental Growth
240	Seven Fields Blvd	B B B	A C* B	A^ A^ A^
245	Adams Ridge Blvd	B B B	D** C** C**	C C** C

Table Notes:

*	*Single asterisk denotes that one or more individual movements fail (LOS E/F); see detail tables in Appendix E.*
**	*Double asterisk denotes that one or more overall approaches fail (LOS E/F); see detail tables in Appendix E.*
^	*Caret denotes that LOS represents stop-controlled side-street movement only.*

Exhibit 30: SR 228 at Seven Fields and Adams Ridge Boulevard – Basic Build Concept

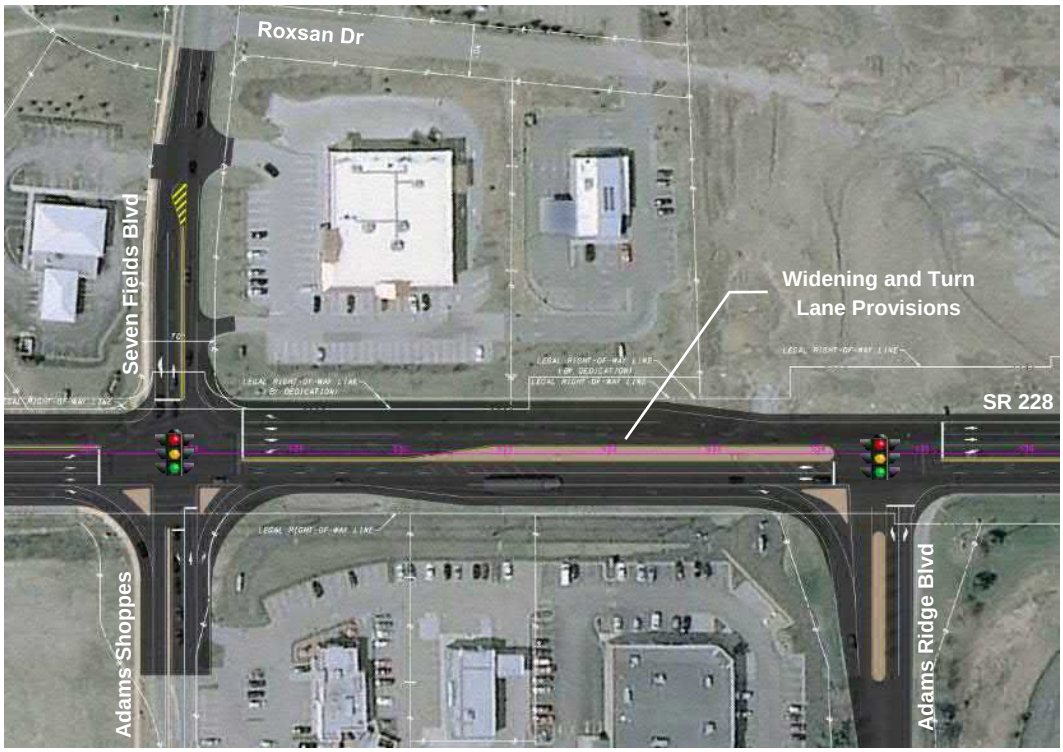
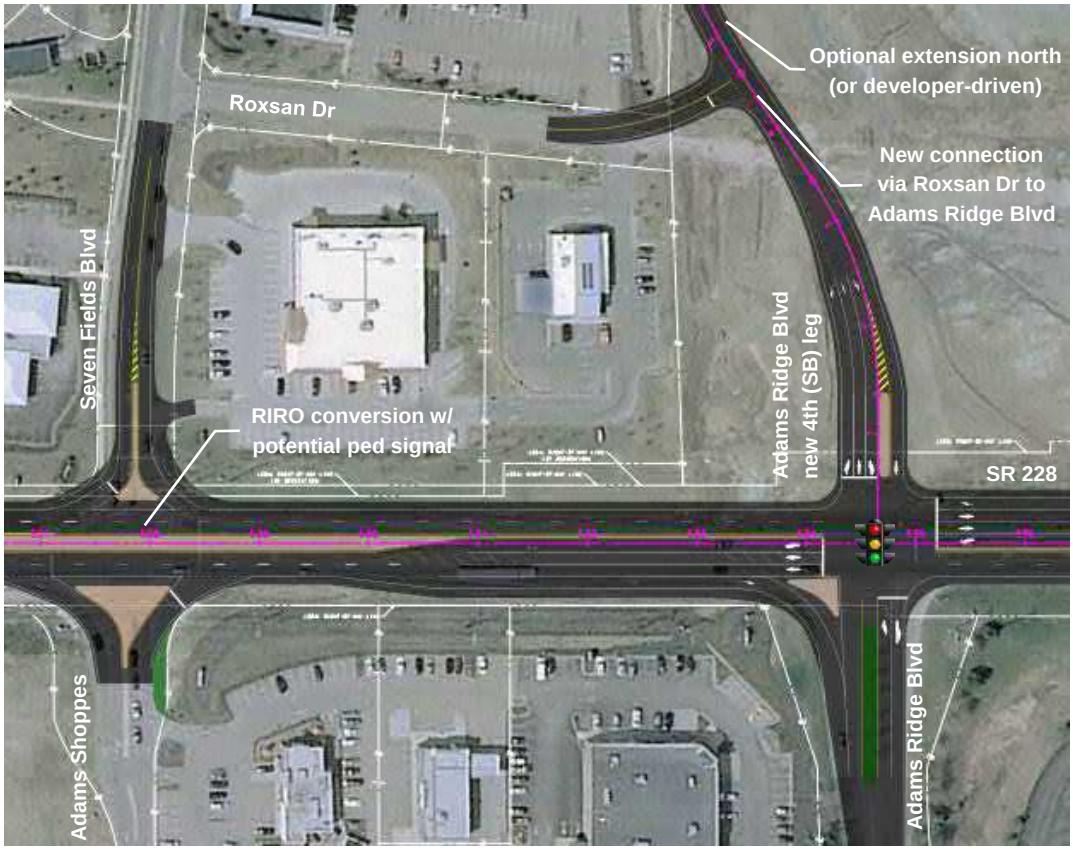


Exhibit 31: SR 228 at Seven Fields and Adams Ridge Boulevard – Reconfigured Network Concept



Myoma Road Options

The basic Build configuration with four-lane widening (previous **Exhibit 23**) is proposed at the SR 228 intersection with Myoma Road. As previously-discussed and barring future development, traffic signal warrants through 2025 Opening Year are not fully satisfied, and the proposed basic Build concept anticipates side-street stop-control operations with the addition of an eastbound left-turn lane and separate southbound left/right-turn lanes (**Exhibit 32**). Longer-term growth or modifications and a possible fourth (northbound) leg related to future development may add a new traffic signal to this intersection.

In addition, the segment of SR 228 between approximately Adams Ridge Boulevard and Heritage Creek Drive is essentially the only segment along the project corridor where there are minor stop-controlled side-street and driveway connections with direct access to the mainline (e.g. Fox Trot Drive, located just east of Myoma Road). Myoma Road, therefore, may provide an appropriate location to accommodate turnaround access for upstream/downstream locations along SR 228 that will otherwise be access-restricted with the proposed median along the corridor. Three potential options to accommodate such turnarounds include the following:

1. **Crider Road Loop** – In lieu of additional intersection treatments (and presuming U-turn access along SR 228 will be prohibited for geometric or safety reasons), local access along SR 228 could circulate via adjacent intersections by diverting in a loop-fashion via Myoma Road to Crider Road to Heritage Creek Drive. For example, left-turns into or out of Fox Trot Drive would turn via Myoma Road, right onto Crider Road, right onto Heritage Creek Drive, and then right or left back onto SR 228, as applicable

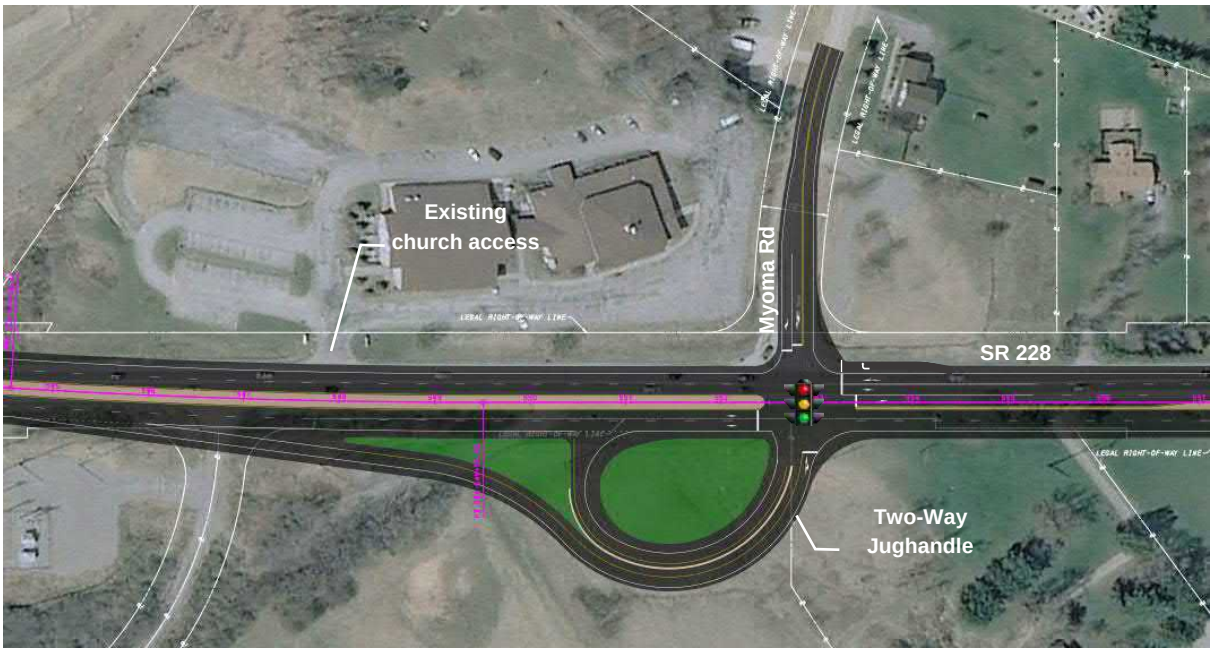
2. **Myoma Road Jughandle** – To directly accommodate turnaround traffic at Myoma Road, a signalized jughandle concept could be installed as depicted in **Exhibit 33**. The final design/geometry could vary depending on the design vehicle accommodated, and there may be impacts to future planned access points related to future development, including the previously-approved Hespenheide Master Plan (Site E per previous **Exhibit 15**), despite its unknown development timeframe.

3. **Myoma Road Roundabout** – In lieu of a jughandle concept to accommodate turnaround traffic, a new multilane roundabout could be considered at the SR 228 and Myoma Road intersection, which would effectively serve the same purpose while also providing typical speed, traffic calming, and safety benefits of a roundabout versus a traffic signal, and while still potentially accommodating future development access. Conceptual analyses using SIDRA software indicated that with the 2045 Design Year traffic, v/c ratios for a three-leg roundabout during the leading (weekday PM) peak period were less than 0.53 (LOS A/B), while v/c ratios for a four-leg roundabout with supplemental growth and future redevelopment in-place were just over 0.73 (LOS B/C). As such, a roundabout at Myoma Road could be a viable option, though additional detailed analysis, simulation, and design consideration would be required to fully/confidently assess its impacts.

Regardless of which option is pursued at the Myoma Road intersection, ongoing design development and agency/stakeholder coordination will also be needed to appropriately account for existing and/or modified access to the adjacent church property located on the northwest quadrant of the intersection.

Exhibit 32: SR 228 at Myoma Road – Basic Build Concept

Exhibit 33: SR 228 at Myoma Road – Jughandle Concept



Heritage Creek Drive Considerations

The basic Build configuration with four-lane widening (previous **Exhibit 23**) is proposed at the SR 228 intersection with Heritage Creek Drive. The basic widening concept includes the addition of dual southbound left-turn lanes along Heritage Creek Drive. Other relevant considerations at this intersection include the following:

- Based on Roadway Safety Audit findings, the existing roadway geometry along the SR 228 curve through Heritage Creek Drive may contribute to side-street traffic inefficiencies given the steep superelevation encountered by northbound/southbound approach traffic. As such, ongoing design development will explore flattening the existing curve to lessen superelevation if/where applicable.

- Based on municipal/stakeholder insights, broader bicycle route interests focus on parallel routes off of SR 228 in lieu of the mainline corridor directly. Such routes may include Crider Road (with parallel route access ending at Heritage Creek Drive) and Beaver Street Extension (located farther east), though these roadways are not directly connected. The approximately ½-mile segment of SR 228 between Heritage Creek Drive and Beaver Street Extension essentially provides this connection and, therefore, could be more likely to experience limited bicycle traffic as compared to other areas throughout the project corridor. Ongoing design development and coordination is needed to determine if or how this linkage influences the SR 228 project.

- Based on municipal/stakeholder insights, Mars Borough noted interest in a future extension/connection of Crider Road from east of Heritage Creek Drive to Forsyth Road. No known plans or timeline commitments are in place at this time, but such a connection could provide an alternate linkage for the bicycle traffic segment noted above.

Beaver Street Extension Options

The basic Build configuration at SR 228 and Beaver Street Extension assumes four-lane widening plus the installation of a new eastbound left-turn lane and a new traffic signal. This option would address existing operational deficiencies (as evidenced by previous **Exhibit 24**) and would maintain Scharberry Lane (to the west) in its existing RIRO configuration. Discussions with PennDOT have noted, however, that much of the traffic to/from Beaver Street Extension is essentially cut-through traffic destined to/through Mars Borough, including access to Pittsburgh Street, Mars-Evans City Road, and/or other points north or east. It is anticipated that future completion of the SR 228 Pittsburgh Street Intersection Project (by others) to the east could influence traffic patterns at Beaver Street Extension (i.e. portions of the existing cut-through traffic may shift their route over to Pittsburgh Street once the intersection and related congestion improves). If future traffic shifts are extensive, there is a possibility that it will influence traffic signal warrant outcomes at Beaver Street Extension.

With or without the future traffic shift, two additional concepts were explored at Beaver Street Extension to enhance turnaround opportunities throughout the project corridor. These concepts include a potential jughandle (**Exhibit 35**) and a multilane roundabout (**Exhibit 36**). Operationally, it is anticipated that both concepts would provide acceptable LOS and enhanced safety through this segment of the corridor. Geometrically, the jughandle (depending on design vehicle) may be more impactful and require a cul-de-sac modification at Scharberry Lane, whereas the roundabout may fit better within the adjacent hillside area. Both options would require design treatments to account for local access connections in the northwest quadrant of the intersection. Additional analysis and design coordination would be required to confirm the most viable or efficient option.

Exhibit 34: SR 228 at Beaver St Ext – Basic Build Concept

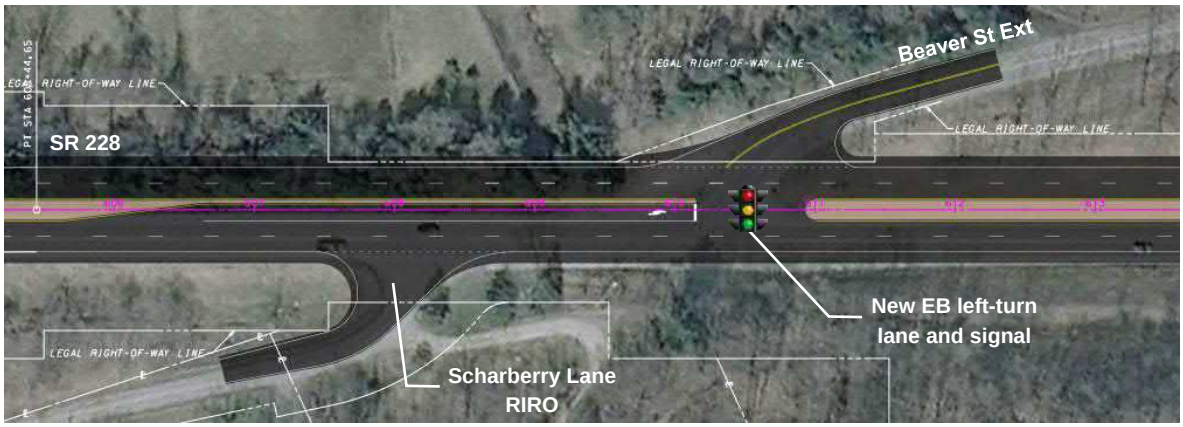


Exhibit 35: SR 228 at Beaver St Ext – Jughandle Concept

Exhibit 36: SR 228 at Beaver St Ext – Roundabout Concept

Summary Design Implications

Design Traffic Volume Summary

Based on data compilation throughout this report, classification and design traffic volume data for the SR 228 Mars RR Bridge West project corridor are summarized in **Exhibit 37**. Peak hour intersection turning movement volumes were also summarized in previous exhibits for the 2016 Base Year (**Exhibit 14**), 2025 Opening Year (**Exhibit 18**), 2045 Design Year (**Exhibit 19**), and 2045 Design Year with Supplemental Growth (**Exhibit 20**).

Exhibit 37: SR 228 Classification and Design Traffic Volume Summary

SR 228 Classification Details	Detail
Federal Functional Classification	Other Principal Arterial
Highway Classification	Regional Arterial
Roadway Typology	Suburban Corridor
SR 228 Design Traffic Volumes	**Detail**
2016 AADT (Base Year**)**	27,000 vpd
2025 AADT (Opening Year**)**	30,000 vpd
2045 AADT (Design Year**) ***	36,000-41,000 vpd
K (DHV / AADT**)**	9.8%
DHV (Two-Way Design Hourly Volume**) ***	3,500-4,000 vph
Truck % **	8.5%
Directional Distribution	55/45

Table Notes:

- ***** *2045 AADT and DHV ranges reflect Design Year Volumes with imminent/approved development versus additional supplemental growth.*
- ****** *Truck % based on 2009 data from US 19 Corridor Study including 0.9% bus, 5.0% single-unit trucks, and 2.6% tractor trailers.*

Basic Build Configuration

The basic Build configuration outlined by this report includes widening the overall project corridor to include four 11' lanes, 10' shoulders, and a 16' median area that will also accommodate offset left-turns where applicable as illustrated in previous **Exhibit 22**. Posted and design speeds are suggested as 40 mph through Seven Fields Borough, and 45 mph through Adams Township. One new traffic signal is proposed at the intersection of SR 228 and Beaver Street Extension. Specific turn lane arrangements and related storage length suggestions are as detailed in previous **Exhibit 23**.

Optional Intersection Design Concepts

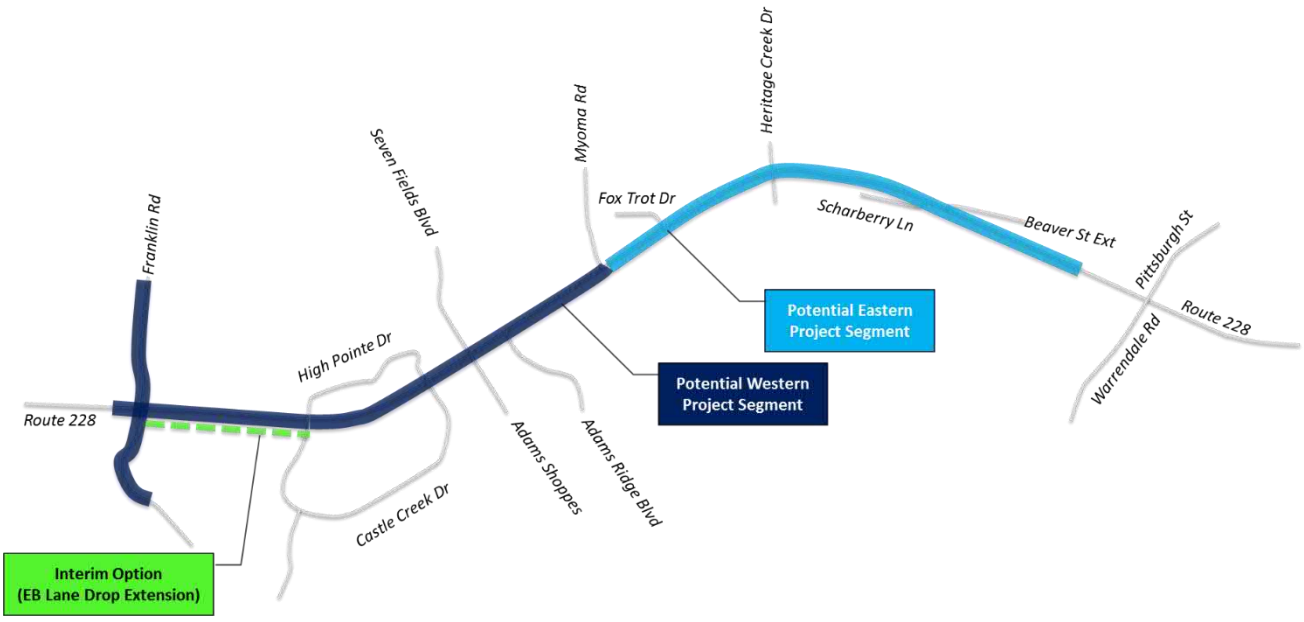
Beyond the basic Build configuration, this report also explored site-specific intersection design enhancements at select locations to assess their potential for providing other benefits or opportunities related, for example, to congestion, safety, right-of-way, or development impacts. Ongoing analysis/design coordination with PennDOT District 10-0 is anticipated to determine the interest or feasibility of potentially integrating any given option into the proposed design and related project/segment phasing for the overall SR 228 corridor. Specific options/locations included the following:

- **Franklin Road** Quadrant Roadway (QR) Intersection (per previous **Exhibit 26**).
- **High Pointe Drive** considerations related to future additional turn lanes (per previous **Exhibit 23**).
- **Seven Fields to Adams Ridge Boulevard** Improvements, including a potential network reconfiguration option (per previous **Exhibit 31**).
- **Myoma Road** options, including traffic circulation options via local roadways, a Myoma Road jughandle, or a Myoma Road roundabout.
- **Heritage Creek Drive** considerations, including superelevation adjustments, bicycle traffic considerations, and future interest in a Crider Road connection to Forsythe Road.
- **Beaver Street Extension** options, including signal, jughandle, or roundabout configurations.

Corridor/Project Segmentation

For planning/funding purposes, general assumptions to-date have presumed that the SR 228 Mars RR Bridge West Expansion corridor could be constructed in two separate segments: a western segment from approximately Franklin Road to Myoma Road, and an eastern segment from approximately Myoma Road to Beaver Street Extension (**Exhibit 38**). Discussions have also explored the idea of a shorter-term interim enhancement to shift the eastbound lane drop located east of Franklin Road by extending the second eastbound lane to the bottom of the hill, where it would then drop as a dedicated right-turn lane to Castle Creek Drive (West). Additional project segmentation concepts may also be possible – for example, prioritizing completion of the full build-out from Franklin Road to Castle Creek Drive (West) as a third element, separate from the overall western project segment. It is anticipated, however, that implementation of many of the optional intersection design concepts, such as the Franklin Road QR intersection or the Seven Fields to Adams Ridge network reconfiguration, may not be suitable as standalone projects without the widening and capacity improvements along mainline SR 228 first being constructed. Ongoing coordination with the District will continue to discuss and refine corridor/project segmentation options as the design progresses.

Exhibit 38: SR 228 Corridor/Project Segmentation Options



References

- *A Policy on Geometric Design of Highways and Streets* (Green Book), 6th Edition, AASHTO, 2011.
- *Manual of Transportation Engineering Studies*, Institute of Transportation Engineers (ITE), 2010.
- *Manual on Uniform Traffic Control Devices* (MUTCD), 2009 Edition with Revisions 1 and 2, USDOT/FHWA, May 2012.
- *PennDOT Internet Traffic Monitoring System* (iTMS), http://www.dot7.state.pa.us/iTMS/, accessed October-December 2016.
- *PennDOT Publication 46: Traffic Engineering Manual*, Pennsylvania Department of Transportation, 2011.
- *PennDOT Video Log*, http://www.dot7.state.pa.us/VideoLog/Index.html, accessed October-December 2016.
- *Tech Brief: Quadrant Roadway Intersection.* (FHWA-HRT-09-058). Federal Highway Administration. October, 2009. https://www.fhwa.dot.gov/publications/research/safety/09058/09058.pdf. Accessed January 4, 2018.
- *US 19 Corridor Study – Technical Report;* Whitman, Requardt & Associates, LLP, et al. for Pennsylvania Department of Transportation, District 10-0, December 2013.
- *US 19 & Freedom Rd / SR 228 SINC-UP Project*, Southwestern Pennsylvania Commission (SPC) Regional Traffic Signal Program, Cycle 1, January 2012.