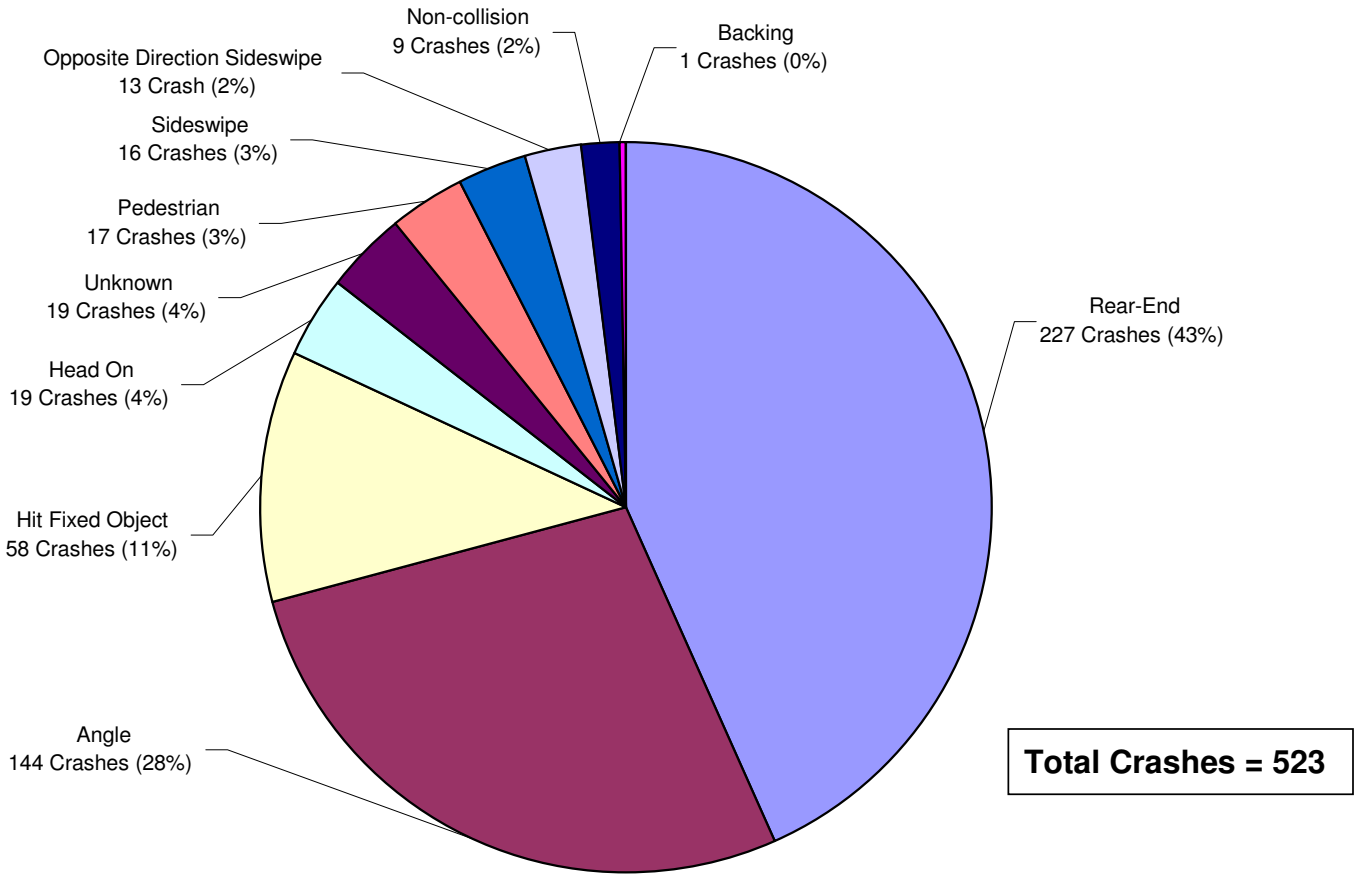
Figure 9: US 422 Crash Summary
1999-2004



III. Future "No-Build" Conditions

A. Traffic Projections

A 10-year design year was established for the CCIP projects; therefore, traffic volumes were projected to the year 2016. To determine the rate at which traffic will grow, the Lebanon County Planning Department was consulted. On March 20, 2006, McCormick Taylor met with representatives from the Lebanon County Planning Department to discuss the planned and potential future developments in the project area.

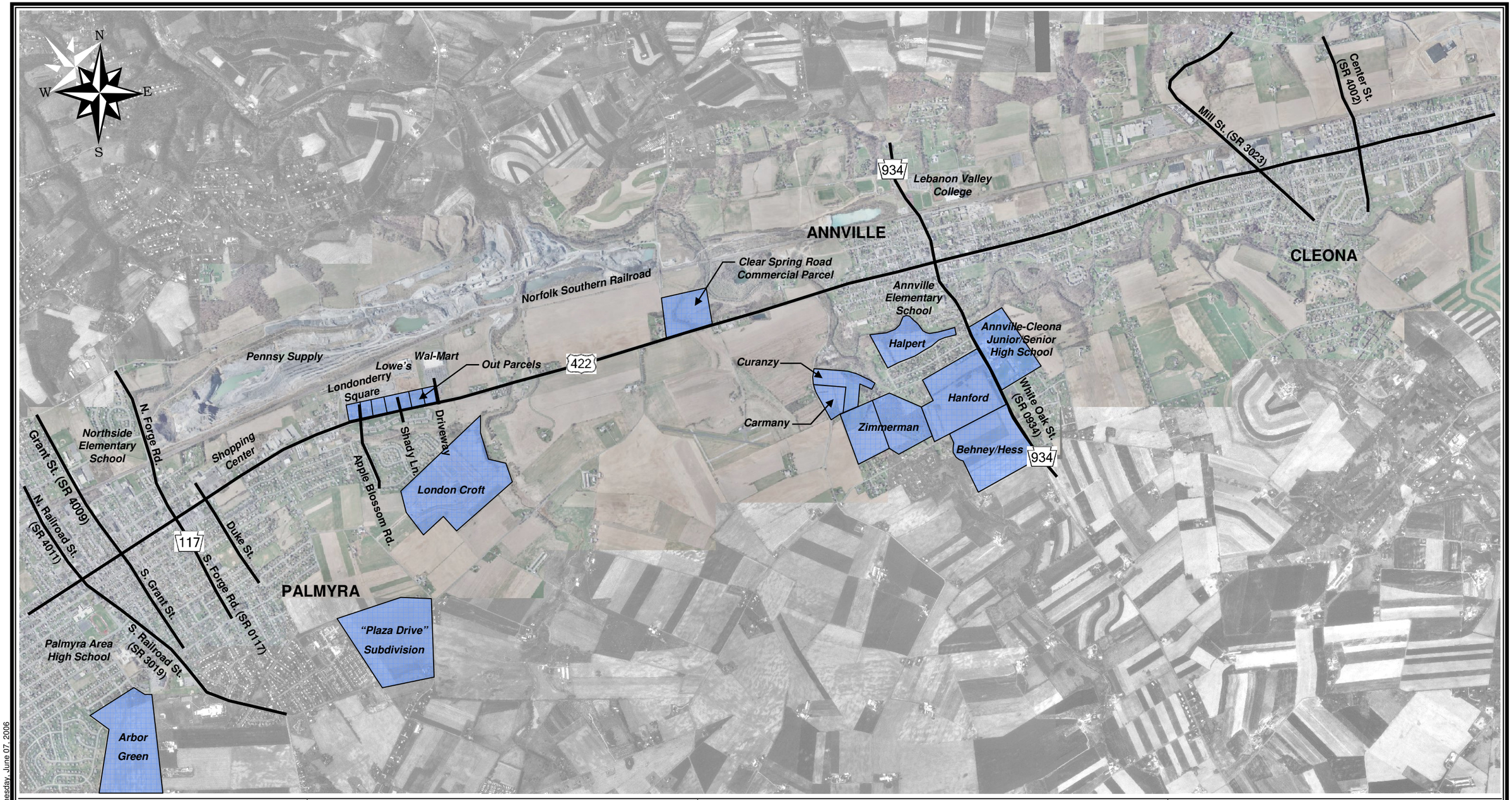
Based on that meeting and the understanding of growth in the area, the amount of traffic growth associated with regional land development and non-specific development growth was estimated to be two percent per year. The same growth rate was used in the recent Traffic Impact Study for the Annville-Cleona High School, and the rate is consistent with PennDOT's research of recent traffic growth on similar roadways in Pennsylvania and Lebanon County found in the *2004 Traffic Data Report*. Compounding the two percent per year over 10 years results in growth of 21.90 percent, which was applied to the existing 2006 traffic volumes by turning movement to estimate the background traffic growth. Background traffic growth was calculated for all turning movements except those that accessed specific land developments, including Wal-Mart and the Londonderry Square Shopping Center.

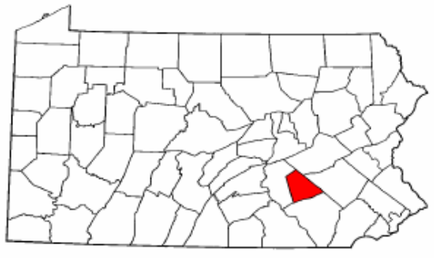
The amount of traffic growth associated with specific land development activity along the US 422 Corridor was estimated according to *Institute of Transportation Engineers Trip Generation* rates. The Lebanon County Planning Department and North Londonderry Township provided information about approved and preliminary land development activity along the US 422 Corridor. Traffic for the following subdivisions and commercial properties, highlighted in **Figure 10**, was generated explicitly and assigned to the study area roadway network:

- Arbor Green – Approved and partially built 226-unit residential subdivision (50% built) located south of Palmyra.
- London Croft – Approved and partially built 170-unit residential subdivision (10% built) located southeast of Palmyra.
- Londonderry Square – Partially occupied commercial buildings (25% occupied) and un-built out parcels (4 out parcels) located east of Palmyra; pass-by trips and internalization associated with the commercial development was considered.
- Clear Spring Road parcel – Un-built, 10-acre commercial parcel with development interest (grocery store) located on the northeast corner of Clear Spring Road and US 422.
- South Annville parcels – High School renovation/expansion and multiple conditionally approved residential subdivisions located immediately south of Annville. The High School traffic impact study included these developments in its future traffic projections.

Future 2016 traffic volumes were calculated by adding the existing 2006 volumes, background traffic growth, and the specific land development traffic growth. The 2016 traffic volumes are depicted in **Figures 11A-B, 12A-B, and 13A-B**. Volume projections and calculations are included in the **Technical Files, Section G**.

Based on the future roadway growth, the future Average Daily Traffic (ADT) volume was estimated for the design year 2016. **Figure 14** illustrates the anticipated future ADT at the four locations along the corridor where daily traffic information was collected. Future ADT calculations are included in **Appendix C**.





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US 422
Lebanon County, Pennsylvania

Lebanon County Planning Department
Annville Township
Cleona Borough
North Londonderry Township
Palmyra Borough

FIGURE 10

Future Development

Future Developments Included

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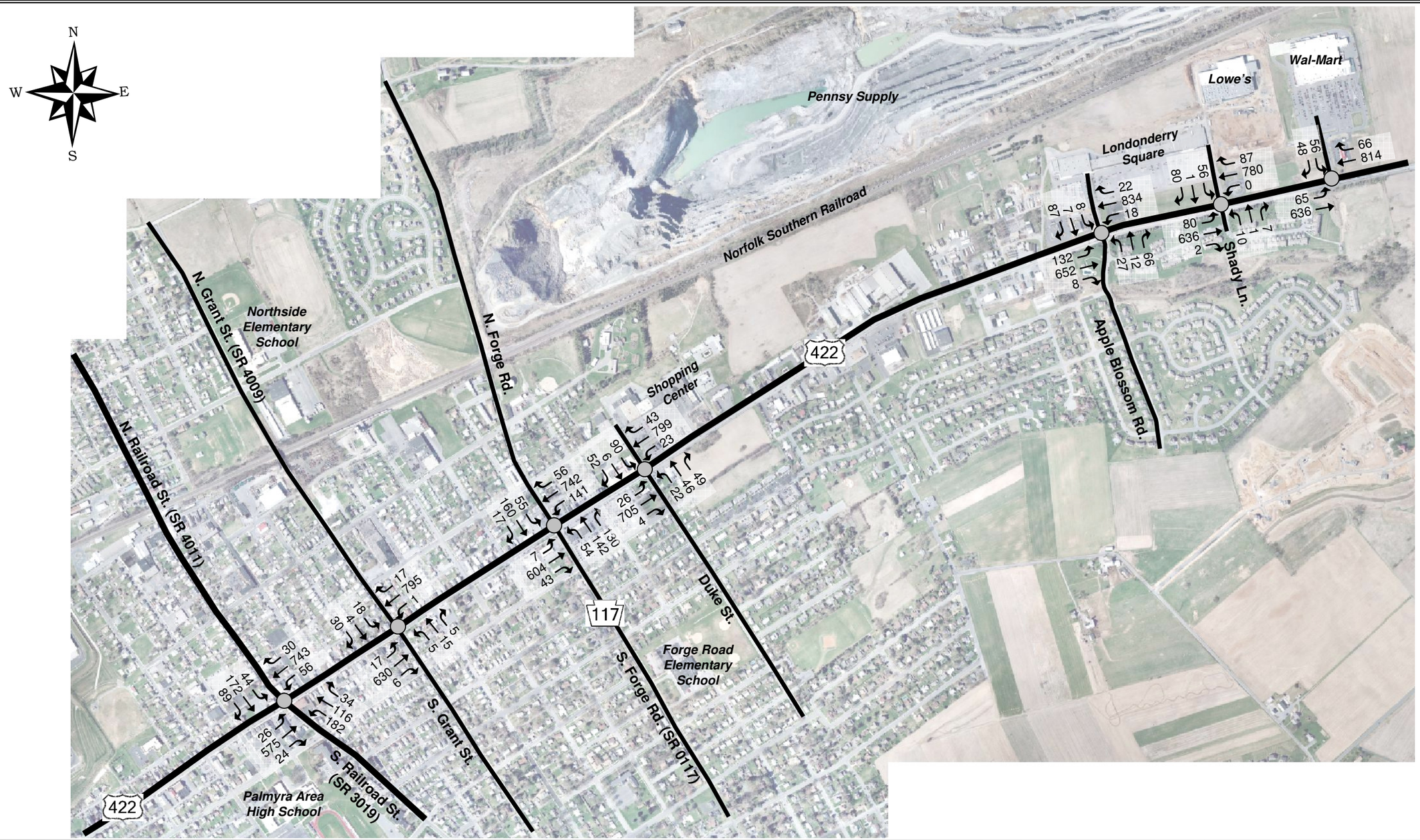

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Palmyra Borough

FIGURE 11A - PALMYRA

2016 AM Peak Hour Traffic Volumes

KEY:

23
112
15 — Peak Hour Turning Movement Volumes

Signalized Intersections

Created: Thursday, March 16, 2006; Printed: Wednesday, June 07, 2006

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FIGURE 11B - ANNVILLE-CLEONA

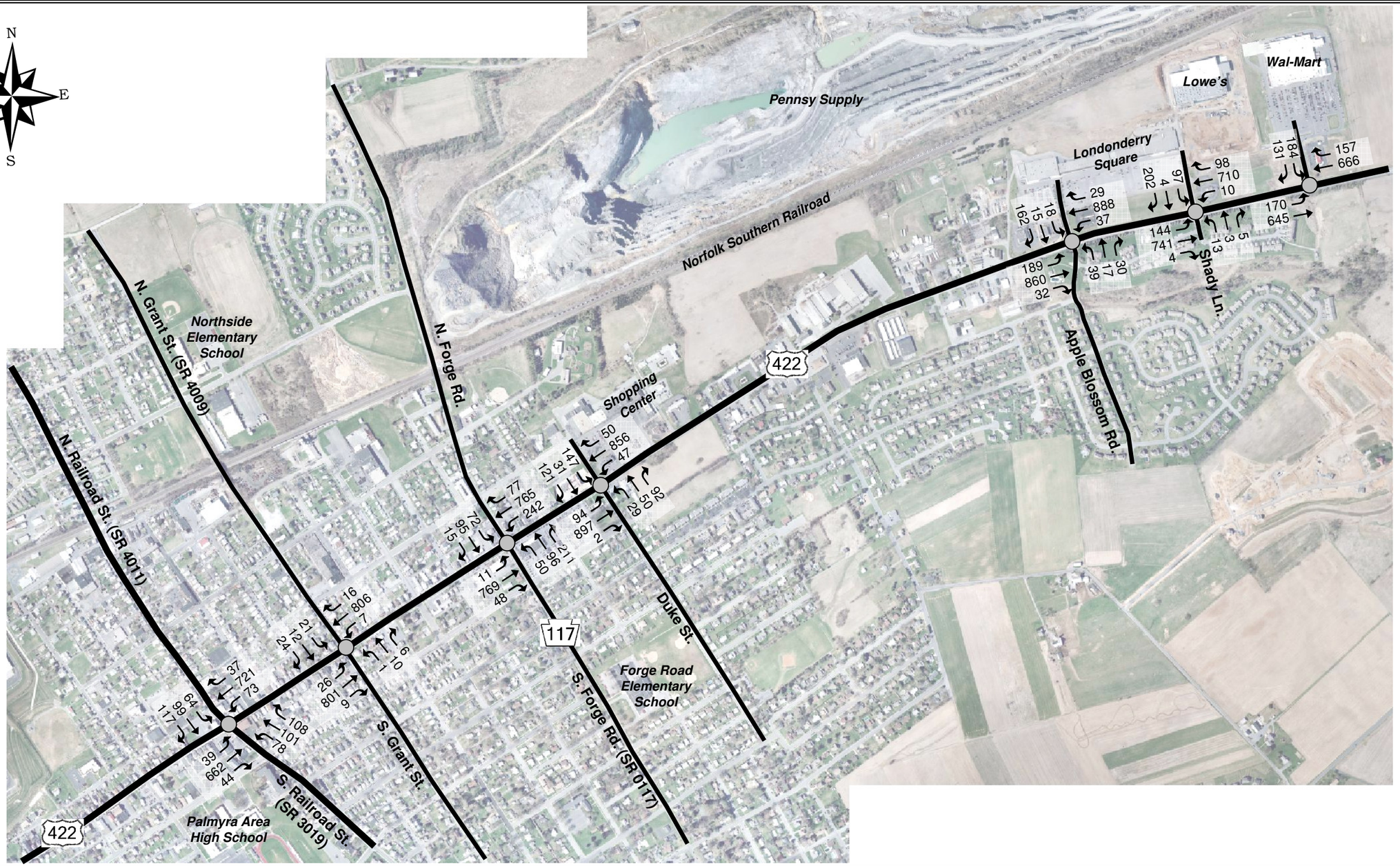
2016 AM Peak Hour Traffic Volumes

KEY:

23 / 112 / 15 — Peak Hour Turning Movement Volumes

Signalized Intersections

Created: Thursday, March 16, 2006; Printed: Wednesday, June 07, 2006



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Lebanon County Planning Department
Annville Township
Cleona Borough
North Londonderry Township
Palmyra Borough

FIGURE 12A - PALMYRA

2016 MIDDAY Peak Hour Traffic Volumes

KEY:

23
112
15 — Peak Hour Turning Movement Volumes

Signalized Intersections

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Palmyra Borough

FIGURE 12B - ANNVILLE-CLEONA

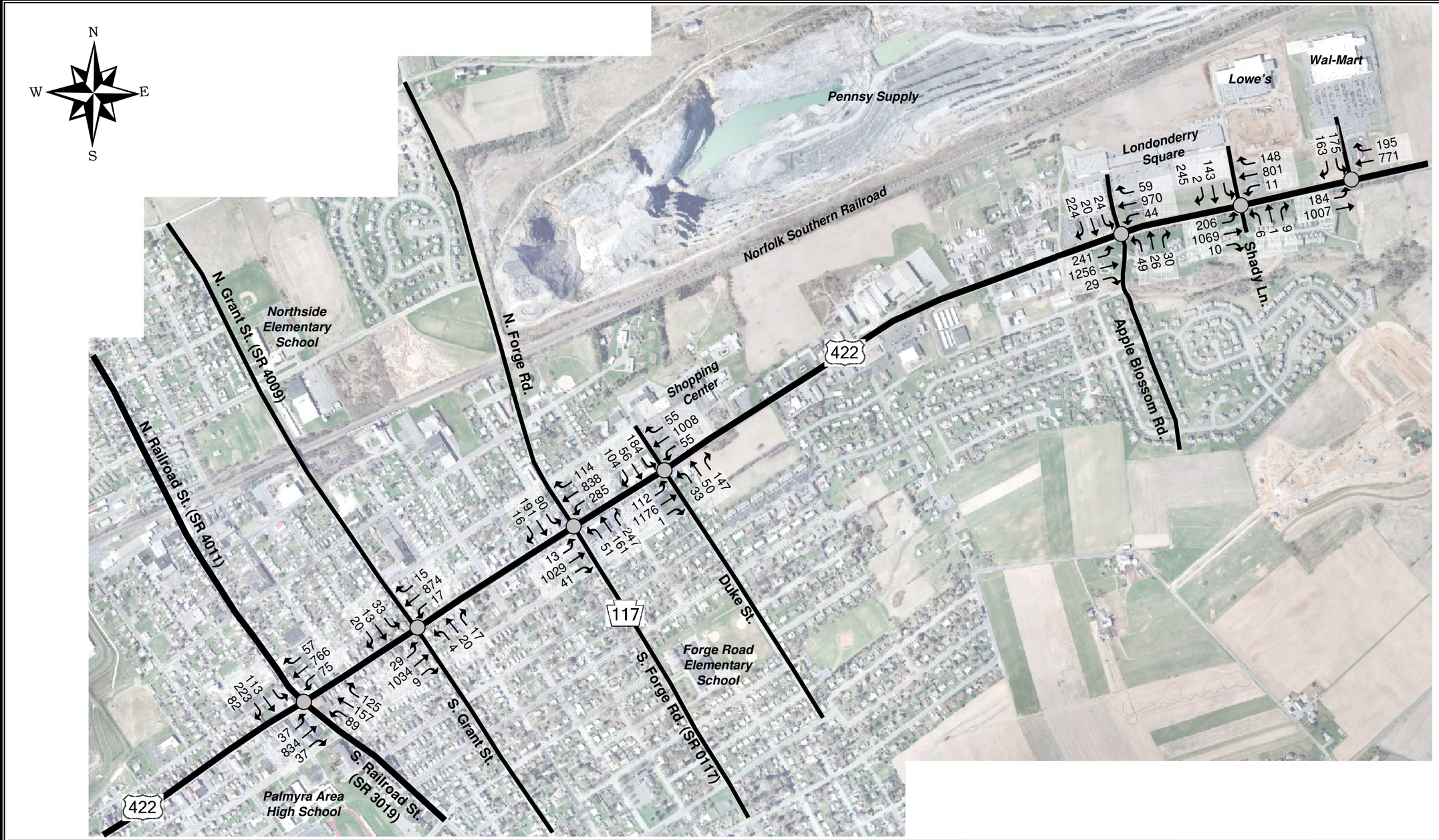
2016 MIDDAY Peak Hour Traffic Volumes

KEY:

23 / 112 / 15 — Peak Hour Turning Movement Volumes

Signalized Intersections

Created: Thursday, March 16, 2006; Printed: Wednesday, June 07, 2006



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Lebanon County, Pennsylvania

Lebanon County Planning Department
Annville Township
Cleona Borough
North Londonderry Township
Palmyra Borough

FIGURE 13A - PALMYRA

2016 PM Peak Hour Traffic Volumes

KEY:

23
112
15 — Peak Hour Turning Movement Volumes

Signalized Intersections

Created: Thursday, March 16, 2006; Printed: Wednesday, June 07, 2006

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Lebanon County, Pennsylvania

Lebanon County Planning Department
Annville Township
Cleona Borough
North Londonderry Township
Palmyra Borough

FIGURE 13B - ANNVILLE-CLEONA

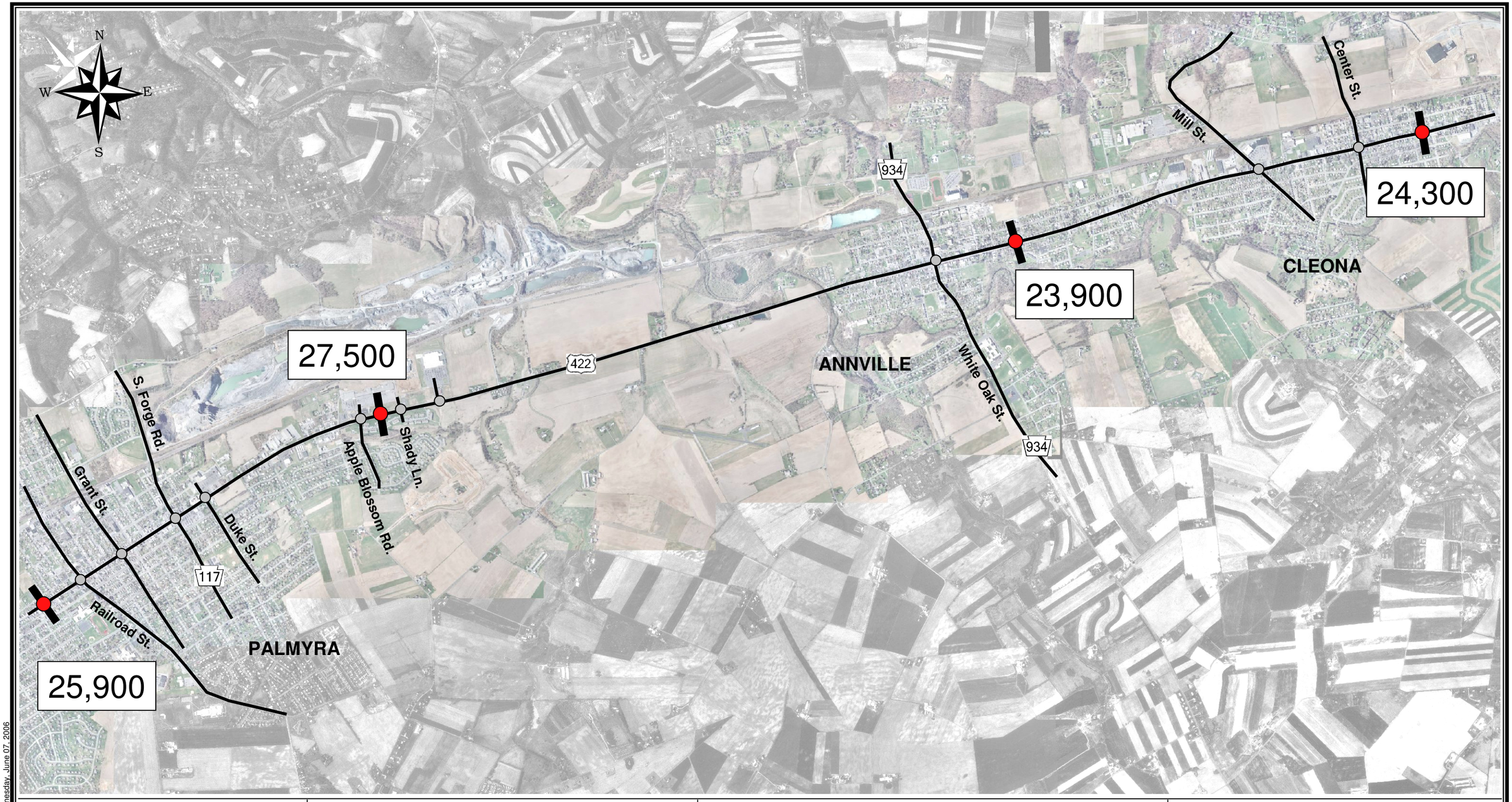
2016 PM Peak Hour Traffic Volumes

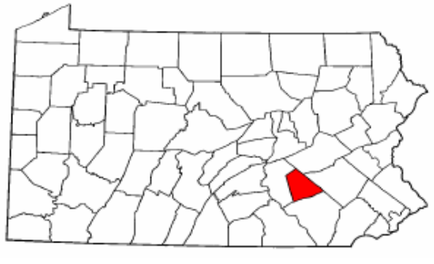
KEY:

23 / 112 / 15 — Peak Hour Turning Movement Volumes

Signalized Intersections

Created: Thursday, March 16, 2006; Printed: Wednesday, June 07, 2006





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Lebanon County, Pennsylvania

Lebanon County Planning Department
Annville Township
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North Londonderry Township
Palmyra Borough

FIGURE 14

Future 2016 Average Daily Traffic (ADT) Volumes

KEY:

ATR Location & Volumes

Signalized Intersections

Created: Thursday, March 16, 2006; Printed: Wednesday, June 07, 2006

B. Future "No-Build" Capacity Analysis

Capacity analyses were completed for Future 2016 No-Build conditions using the same methodology that was discussed in the Existing Conditions, Capacity Analysis and Methodology; Section II, Part D. With the increase in traffic volumes, congestion and delays will become more noticeable and lengthy along the corridor. Based on the capacity analysis, two intersections in the AM peak hour, three intersections in the Midday peak hour, and six intersections in the PM peak hour would operate below a LOS D. **Table 6** summarizes the overall intersection results.

Table 6: Summary of Existing and Future No-Build LOS

Intersection	AM		Midday		PM	
	Existing	Future No-Build	Existing	Future No-Build	Existing	Future No-Build
Railroad St & US 422	D	F*	D	F*	E*	F*
Grant St & US 422	A	A	A	A	A	B
Forge Rd & US 422	C*	D*	D*	E*	D*	F*
Duke St & US 422	B	D	C	C	C	F*
Apple Blossom Rd & US 422	B	C	B	C	B	E*
Shady Ln & US 422	A	B	B	B	B	D*
Wal-Mart Drway & US 422	A	B	B	C	B	C
White Oak St & US 422	C	F*	C	F*	E*	F*
Mill St & US 422	B	C	C	D*	C	E*
Center Street & US 422	B	B	B	C	B	D

* Notes where movements and/or approaches are operating with LOS F.

As expected, it will take longer to traverse the corridor in 2016 than it does today due to increased volumes. **Table 7** shows the travel time comparison and the percent change in travel time. Note the existing travel times from the calibrated models are slightly different than those shown in **Table 3**, which were collected during the field runs. A detailed LOS and travel time summary and analysis output is included in **Appendix E** and the **Technical Files, Section D**, respectively.

Table 7: Existing Calibrated vs. Future No-Build Travel Times

Roadway Links	AM			Midday			PM		
	Existing Calibrated	Future No-Build	Change	Existing Calibrated	Future No-Build	Change	Existing Calibrated	Future No-Build	Change
EB – Palmyra/North Londonderry Corridor	05:13	06:24	23%	05:32	08:20	51%	07:40	21:58	186%
WB – Palmyra/North Londonderry Corridor	05:02	10:43	113%	06:01	29:54	398%	06:41	42:31	537%
EB – Annville/Cleona Corridor	07:17	07:58	9%	07:12	08:37	20%	07:36	21:28	182%
WB –Annville/Cleona Corridor	05:13	06:54	32%	05:52	08:50	51%	06:05	13:08	116%

As part of the review and analysis for the study intersections, an evaluation of the left turn phasing operations was completed. There are three types of phasing that can be provided to left turning vehicles: permissive, protected/permissive, and protected/prohibited. For permissive phasing, a left turning vehicle receives a green ball and yields to opposing traffic. When a left turning vehicle receives a green arrow the movement is protected. If the protected movement is followed by a green ball this movement is called protected/permissive. If the protected movement is followed by a red indication, meaning the left turning vehicle can only turn when the green arrow is present, this movement is called protected/prohibited. The *Traffic Signal Design Handbook, PennDOT Publication 149*, establishes guidelines for the design and operation of traffic signals. A left turn movement should be considered to have protected phasing if the conflict factor is above an established threshold for two one-hour periods of a normal weekday. The conflict factor is the product of the left turning volume and the opposing conflicting traffic volume. The threshold value is established by the number of opposing lanes and whether or not a separate left turn lane is present. Each of the peak hour volumes for the study intersections were reviewed. **Technical Files, Section H**, includes the calculations for the conflict factors along with queue length calculations. For the future conditions, protected left turn phasing was included if all three peak periods satisfied the threshold value for the conflict factor or if future intersection operations were improved by including protected left turn phasing. Left turn phasing operations were adjusted for future traffic conditions at the following intersections:

- Forge Road and US 422 – The westbound left turn phase was adjusted from protected/permissive to protected/prohibited.
- Apple Blossom Road and US 422 – The eastbound left turn phase was adjusted from protected/permissive to protected/prohibited.
- Shady Lane and US 422 – The eastbound left turn phase was adjusted from protected/permissive to protected/prohibited.
- White Oak Street and US 422 – The northbound and southbound left turn phase was adjusted from permissive to protected/permissive.

The inclusion of protected/permissive or protected/prohibited phasing is a safety improvement; however, it generally affects the travel time negatively. When the protected phase is provided, the through vehicles must wait for their green indication (typically after the green arrow). When a protected/prohibited phase is provided, through vehicles generally have a longer wait for their green indication as the left turn phase is given adequate green time to clear the turn lane. A Future No-Build with Left Turn Phasing Adjustments scenario was analyzed. This scenario provides a base comparison for all of the future improvement scenarios as the adjusted left turn phasing will be included at the noted intersections. **Table 8** summarizes the overall intersection results compared to Future No-Build.

Table 8: Summary of Future No-Build and Future No-Build with Phasing Adjustments LOS

Intersection	AM		Midday		PM	
	Future No-Build	Future No-Build w/Phasing	Future No-Build	Future No-Build w/Phasing	Future No-Build	Future No-Build w/Phasing
Railroad St & US 422	F*	F*	F*	F*	F*	F*
Grant St & US 422	A	A	A	A	B	B
Forge Rd & US 422	D*	D*	E*	E*	F*	F*
Duke St & US 422	D	D	C	D*	F*	F*
Apple Blossom Rd & US 422	C	C*	C	D*	E*	E*
Shady Ln & US 422	B	C	B	C	D*	E*
Wal-Mart Drway & US 422	B	B	C	C	C	C
White Oak St & US 422	F*	F*	F*	F*	F*	F*
Mill St & US 422	C	C	D*	D*	E*	E*
Center Street & US 422	B	B	C	C	D	D

* Notes where movements and/or approaches are operating with LOS F.

As discussed above, including the protected/permissive and protected/prohibited left turn phasing generally negatively impacts the travel times. As shown in **Table 9**, the travel time increases with phasing changes. There are two locations where the travel time decreased due to the benefits of the adjusted left turn phasing (i.e. reduced delay for the left turn movement).

**Table 9: Existing Calibrated vs.
Future No-Build with Phasing Adjustments Travel Times**

Roadway Links	AM			Midday			PM		
	Existing Calibrated	Future No-Build w/Phasing	Change	Existing Calibrated	Future No-Build w/Phasing	Change	Existing Calibrated	Future No-Build w/Phasing	Change
EB – Palmyra/North Londonderry Corridor	05:13	06:49	31%	05:32	08:53	61%	07:40	20:40	169%
WB – Palmyra/North Londonderry Corridor	05:02	11:54	136%	06:01	32:17	437%	06:41	62:58	843%
EB – Annville/Cleona Corridor	07:17	10:53	49%	07:12	09:16	29%	07:36	23:44	212%
WB –Annville/Cleona Corridor	05:13	12:44	144%	05:52	08:05	38%	06:05	21:52	260%

IV. SUMMARY OF ADVERSE CONDITIONS

On May 3rd, 2006, a field view of the traffic signal equipment along the US 422 Corridor was completed. The review included a visual investigation of the controller assembly and the traffic signal installation. The inventory of the controller assemblies included documenting the type of controller, conflict monitor, and detector amplifiers and the number of positions available on the back panel. The review of the traffic signal installation included documenting the traffic signal head sizes, general condition of the mast arms, pedestrian accommodations, and pavement marking condition. A good/fair/poor rating was applied to both the traffic signal installation and the controller assembly. Summary sheets from the field view are included in **Appendix F**. Based on field views, meeting discussions, and existing and future analysis, several adverse conditions were noted.

Level of Service

In the AM, Midday, and PM peak periods some of the intersections are operating with an overall LOS worse than D. In addition to the overall intersection results, several of the intersections' movements and approaches are operating with a LOS F. In the Future No-Build scenario, the additional traffic volume causes even more of the intersections to deteriorate to LOS E and F. **Appendix E** provides detailed LOS information.

Travel Time

Based on analysis, it is expected that in the year 2016 it will take three times as long to travel the corridor in the eastbound direction during the PM peak hour if no improvements are made along the corridor (see **Table 9**).

Queuing at Intersections

Currently the intersections of Railroad Street and US 442 and White Oak Street and US 422 have significant queuing present. Vehicles stack up as they wait to be processed though the intersection. As volumes increase in the future, so will the length of the queue. See photos below of the existing queuing observed.

US 422 eastbound queue at Railroad Street looking west.

US 422 eastbound queue at White Oak Street looking east.

Cycle Failure

A cycle failure occurs when a vehicle waits through more than one signal cycle to traverse the intersection. It is caused by the cycle length, the green split, and or the geometry not being adequate to properly serve the vehicles at the intersection. Cycle failure was observed to occur at Railroad Street and White Oak Street. This appeared to occur frequently in the eastbound direction during the PM peak period at Railroad Street; it was observed to take up to three cycles to traverse the intersection. If improvements are not implemented the cycle failures will persist in the future.

Crashes

From January 1999 to December 2004, there were a total of 523 reportable crashes within the study area. Refer to Existing Conditions, Crash Summary; Section II, Part F for more information.

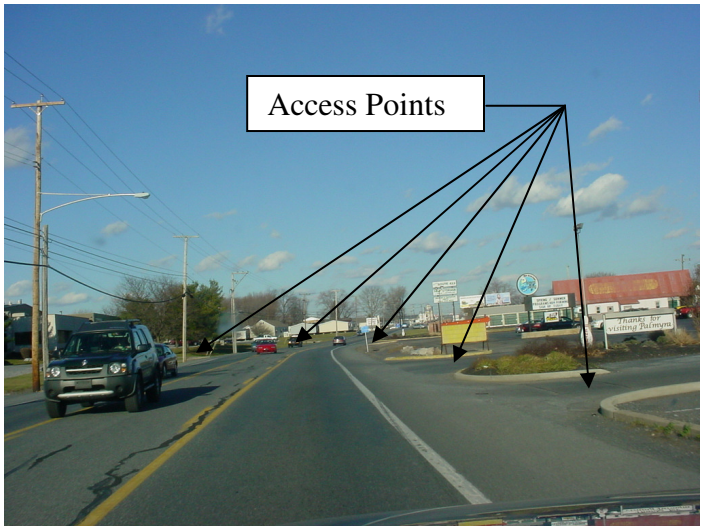
Parking

On-street parking is present in several locations throughout the corridor. Generally, parking adds additional conflict to the through traffic as vehicles entering and exiting the parking spaces slow to complete their parking maneuvers. Most of the on-street parking provided along the corridor is parallel parking. Head-in angle parking is present in Annville on the south side of US 422, west of the White Oak Street intersection. Head-in angle parking maneuvers create additional conflicts when drivers are backing out of the parking spot to exit. When backing, drivers have difficulty seeing on-coming traffic which can cause the driver to hesitate or slow and not complete the parking maneuver quickly.

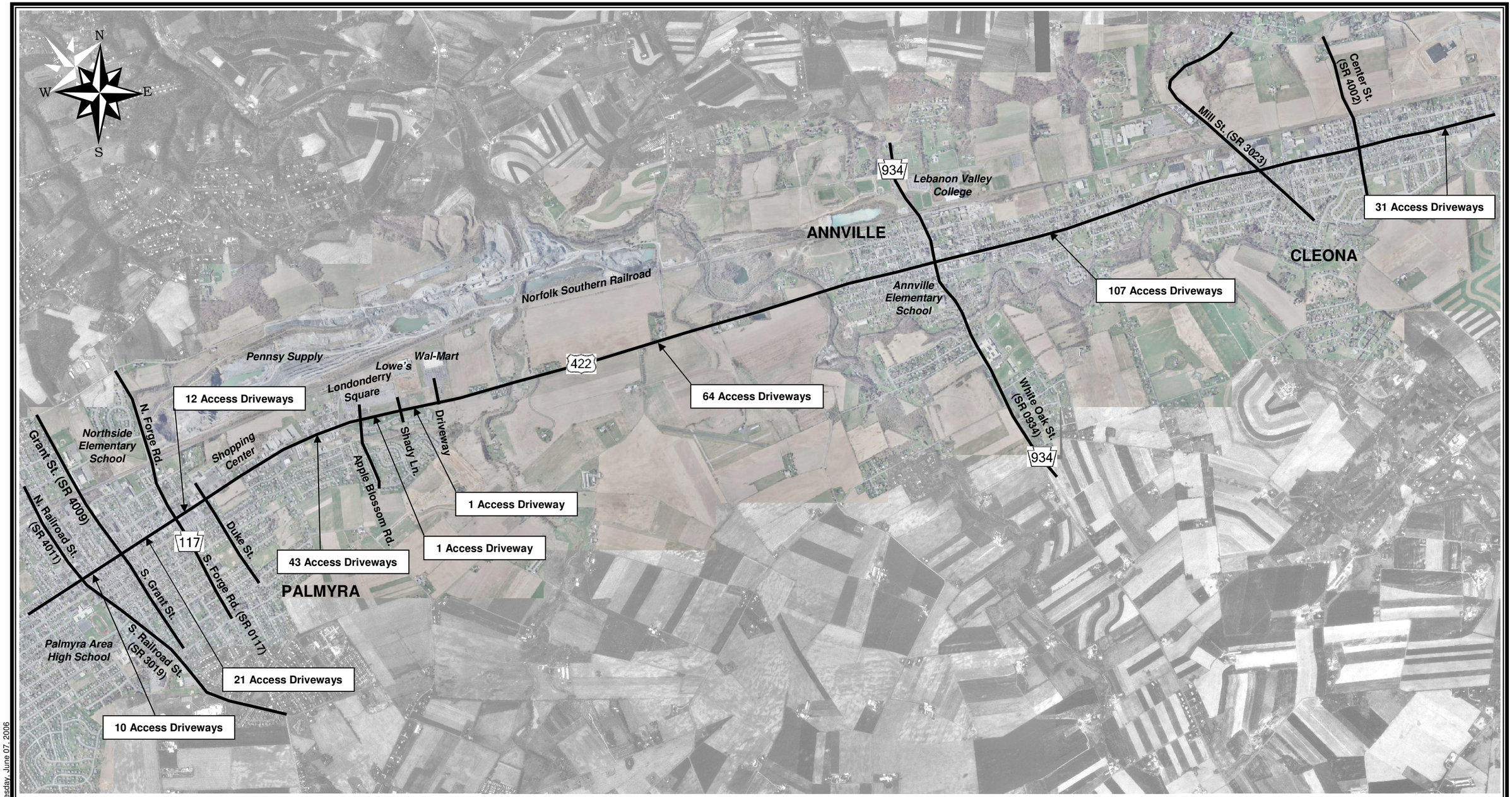
Along White Oak Street, north of the US 422 intersection, parallel parking is present on the east side of the roadway. The parking in this area prevents vehicles from passing left turning vehicles that are turning on to the cross street.

Access Management

Several unsignalized access streets and commercial and residential driveways are present throughout the corridor. These access points generate additional conflicts and delays when vehicles maneuver in and out of them. **Figure 15** shows the approximate number of access points located between each intersection. The adjacent photo gives an example of poor access management.



US 422 eastbound between Forge Street and Duke Street.



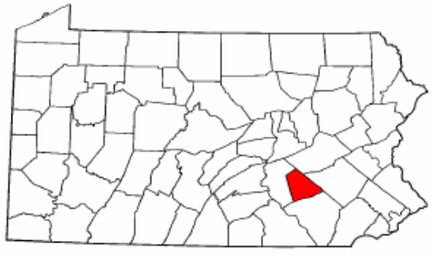


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FIGURE 15

Approximate Number of Access Points

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Emergency Vehicle Access

Within the area of the US 422 Corridor, there are three emergency service providers; fire and ambulance services in Palmyra, fire and ambulance services in Annville, and fire services in Cleona. Each station frequently assists or responds to emergency calls outside of their area. Last year, the Annville station received over 950 calls. The Palmyra and Annville stations are located along US 422 and queuing on the roadway occasionally blocks emergency vehicle access. Once on the US 422 corridor, the emergency vehicles must navigate through the signalized intersections. Currently, emergency vehicle pre-emption is only located at one intersection, Shady Lane and US 422. Emergency vehicle pre-emption allows responders to utilize an emitter to activate the pre-emption phase which provides a green indication to the activated approach. Currently, not all of the emergency responders within the area have the equipment for emergency vehicle pre-emption.

Traffic Signal Coordination

Currently there are two coordinated traffic signal systems within the US 422 Corridor, one in the Borough of Palmyra and one in North Londonderry Township. The Borough of Palmyra system includes the intersections of Railroad Street, Grant Street, Forge Road, and Duke Street. The North Londonderry Township system includes Apple Blossom Road, Shady Lane, and Wal-Mart Driveway. The North Londonderry Township system is interconnected with fiber optic cable. The Borough of Palmyra system is a time based coordinated system. Time based coordination has a greater potential for the coordination system to "slip" out of sync. The intersections of Mill Street and Center Street are located approximately 2,650-ft apart. Currently the intersections operate un-coordinated; if the signals were coordinated, improved east/west flow may be achieved.

Traffic Signal Operations

The following specific conditions related to the traffic signal operations were noted:

Delayed Detection

At the intersections of Grant Street, Apple Blossom Road, Shady Lane, and Wal-Mart Driveway, the southbound right turning volume is greater than or equal to the left turning volume. When a right turning vehicle approaches the intersection, it activates the loop detector which places a call into controller and a green indication is given to the vehicle. In some instances, the right turning vehicle has already stopped and turned right on red by the time the green indication is received. Including a delayed detection for the southbound right turning movement would allow the traffic at the intersection to be served more efficiently.

Malfunctioning Loop Detector

Based on a field review of the signal equipment conducted on May 3, 2006, the Center Street and US 422 intersection is operating with a constant call on the side street. With the constant indication, the maximum amount of green time (25 seconds) is given to the side street even when vehicles are not present.

Flashing Operation

According to the traffic signal permit plans, the four signalized intersections in the Borough of Palmyra (Railroad Street, Grant Street, Forge Road, and Duke Street) operate with the signals flashing from 12:00AM to 5:00AM. During this off-peak time, the intersections essentially operate as two-way stopped controlled intersections with the northbound and southbound approaches having to stop. When the traffic signals are in the flash mode, sometimes the driver is confused on how to respond to a flashing yellow light (i.e. proceed with caution or stop). With a functioning semi-actuated system, which is currently present at each of the intersections, the traffic signal can quickly and efficiently give the side street the green indication when actuated thus eliminating the need for the signals to flash.

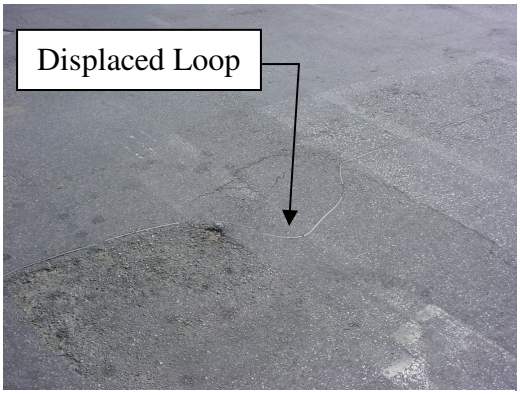
Pavement Condition

The surface of the US 422 roadway is asphalt pavement. Rutting in the pavement was visible at the following intersections:

- Railroad Street and US 422 on the eastbound and westbound approaches.
- Duke Street and US 422 on the eastbound and westbound approaches.
- Forge Road and US 422 on all approaches (see photo to the right).
- Wal-Mart Driveway and US 422 on the eastbound approach.

Rutting at US 422 eastbound at White Oak Street.

A rut is a surface depression in the wheel paths. Rutting is usually caused by the consolidation or lateral movement of the pavement due to traffic loads (generally heavy vehicle traffic, i.e. trucks). Rutting in pavement can cause uncomfortable travel, pooling of water, and traffic signal loop detectors to become displaced. The adjacent photo shows pavement rutting and the displacement of the traffic signal loop detector.



Rutting at White Oak Street southbound at US 422.

At the intersection of Railroad Street and US 422, (see adjacent photo) the pavement in the southwest quadrant of the intersection is rutted and distressed. The damage in the pavement causes vehicles to slow or adjust their path to avoid the area.

Damaged pavement in the southwest quadrant at Railroad Street and US 422.

Truck Traffic

Approximately 8 percent of the daily US 422 traffic volume is truck traffic. Trucks are larger than passenger cars and occupy more roadway space. Since trucks are larger, they require a larger turning radius than passenger cars. Due to the truck's size and weight, they create additional stress on the roadway surface. Operating characteristics of trucks are also less desirable than passenger cars, particularly with respect to acceleration and deceleration.

Intersection Turning Radii

Right turning vehicles follow the curved path provided by the corner radius at an intersection. The majority of the intersections within the corridor have limited turning radii. Trucks require larger turning radii due to their size and the off-tracking path of their trailers. The limited turning radii coupled with a significant amount of truck traffic can lead to additional traffic conflicts when trucks slow, encroach on adjacent lanes, or force opposing vehicles to back-up to complete the turning maneuver. If the intersection does not have a large enough turning radius, the trailer can travel outside the available area and jump the curb and/or hit adjacent roadside objects. Evidence of the impacts of limited turning radii was seen at the following locations:

- Forge Road and US 422 – Traffic signal poles in the southeast and southwest quadrants have dents and rub marks.
- Grant Street and US 422 – Traffic signal pole in northeast quadrant has dents and rub marks.
- Apple Blossom Road and US 422 – Traffic signal pole in northeast quadrant has dent, rub marks, and the pedestrian push button mounting has been disconnected (see accompanying photo). Tire tracks are present in the northeast quadrant where vehicles have jumped the curb (see accompanying photo).

Pole in NE quadrant of Apple Blossom Road and US 422

Tire tracks in NE quadrant of Apple Blossom Road and US 422

- Wal-Mart Driveway and US 422 – The pedestrian pedestal pole in the northwest quadrant has a crack at the base. Tire tracks are present in the northwest quadrant where vehicles have jumped the curb.
- White Oak Street and US 422 – All quadrants have limited turning radii. Bollards are installed along the sidewalks in each quadrant. Several of the bollards have been scratched, displaced, or completed removed by vehicles that have jumped the curb due to the limited radii (see photo to the right).
- Mill Street – The traffic signal pole in the northwest quadrant has dents and rub marks.

Bollard at White Oak Street and US 422

<u>Pavement Markings</u>

Pavement markings provide positive delineation to drivers and pedestrians. The pavement markings at each of the intersections were visually inspected and given a rating of good, fair, or poor. The areas that were classified as having fair or poor pavement marking conditions are as follows:

- Grant Street and US 422 – Overall fair rating, centerline on northbound approach not present.
- Forge Road and US 422 – Poor rating overall, crosswalks barely visible.
- Duke Street and US 422 – Pavement markings on the eastbound and westbound approaches in fair condition.

- Apple Blossom Road and US 422 – Good rating overall, but the northbound approach exclusive left turn lane pavement markings were missing.
- Wal-Mart Driveway and US 422 – Overall fair rating.
- Mill Street and US 422 – Poor rating overall, markings are not visible on the southbound approach.
- Center Street and US 422 – Overall poor rating.

Traffic Signal Installation

A field view of the traffic signal equipment including a visual investigation of the traffic signal installation was completed on May 3, 2006. The following specific conditions related to the traffic signal installations were noted:

Missing Lane Control Sign

- Grant Street and US 422 – A lane control sign is missing on the eastbound approach.

Traffic Signal Head Location

- Grant Street and US 422 – The nearest traffic signal head on the eastbound approach is located approximately 25-ft from the stop bar, there should be 40-ft between the nearest signal head and stop bar.

Wiring Exposed

- Forge Road and US 422 – Wiring to the mast arms are exposed at the base of the poles in the northeast and southeast quadrants (see photos below).

Wiring exposed in the NE quadrant at Forge Road and US 422

Wiring exposed in the SE quadrant at Forge Road and US 422

Tether Wire Missing

- Mill Street and US 422 – The tether wire, which prevents the traffic signals and signs installed on the span wire from aggressively swaying, is not present.