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**PENNDOT DISTRICT 8-0
Congested Corridor Improvement Program**

US 422
Lebanon County, Pennsylvania

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

**FIGURE 3B - ANNVILLE-CLEONA
Existing Intersection Lane Configurations**

KEY:

-  Lane Movements
-  Signalized Intersections



CONGESTED CORRIDOR IMPROVEMENT PROGRAM

US 422 Corridor – Palmyra/North Londonderry/Annville/Cleona

(PennDOT Bureau of Highway Safety & Traffic Engineering and PennDOT Engineering District 8-0)

B. Transit Service

Within the study area, the local transit service is provided by County of Lebanon Transit (COLT). COLT operates approximately 20 routes throughout Lebanon County, which provide weekday, late evening, and Saturday services. COLT also offers a daytime on-demand mini-bus/van service for all of Lebanon County Monday through Sunday, but with a limited service area in the afternoon and on Sundays. Mini-buses are available for all age groups and are handicapped accessible.

On the study corridor, there are two COLT bus routes, Routes 8 East and West. The routes provide service Monday through Friday from about 6:00AM to 6:00PM and Saturdays from about 7:30AM to 6:00PM. Twilight services are also offered along Route 8 from 6:00PM - 12:00AM Monday through Saturday. While buses operate on a fixed route with scheduled stops, riders can also board at any safe location. Adult fare on Route 8 is \$1.40 or \$0.40 for county transfers.

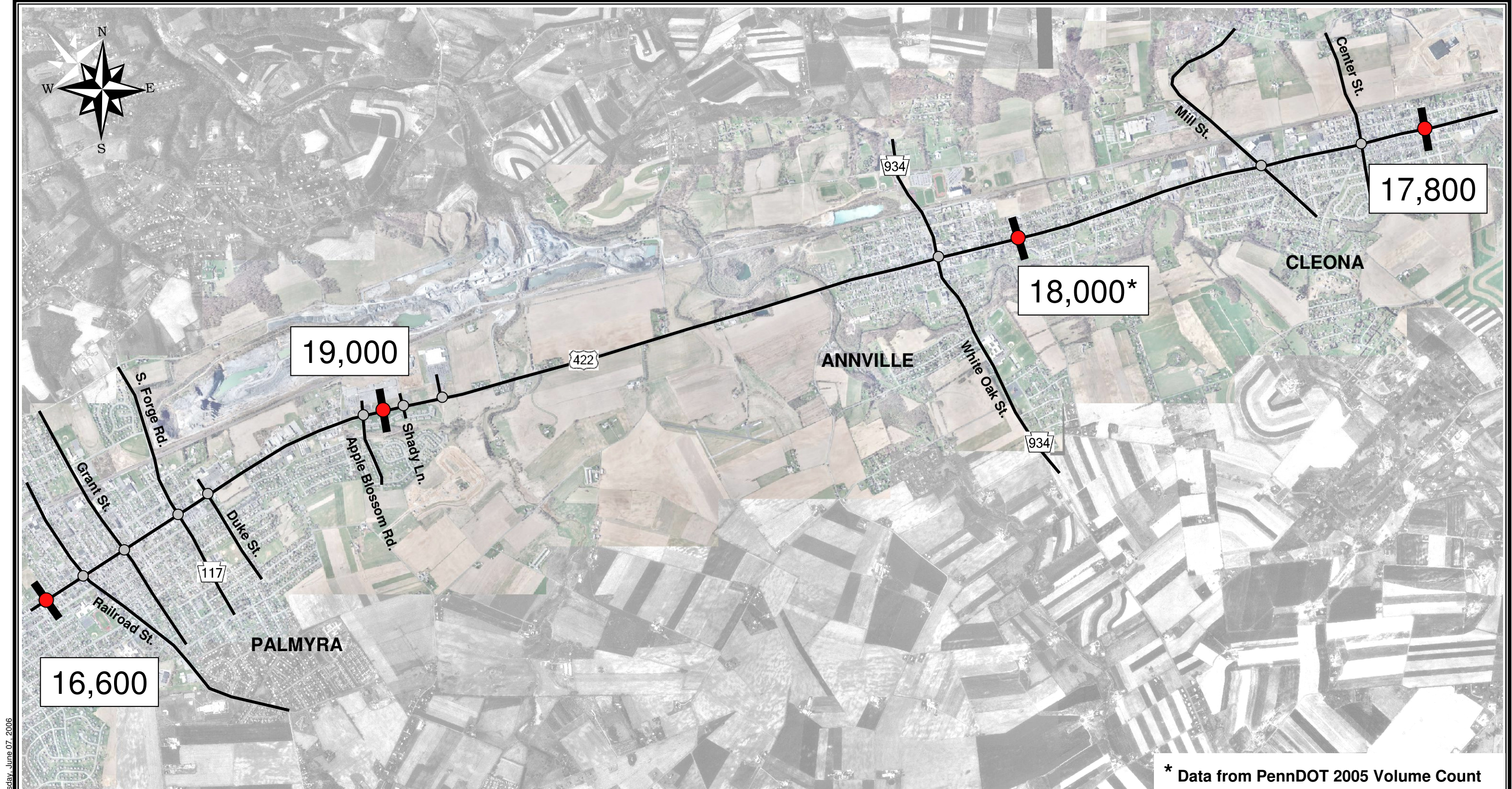
C. Traffic Data

In order to determine the overall quality of current traffic operations, traffic data was collected including automatic traffic recorder (ATR) counts, intersection counts, and travel time measurements.

1. ATR Data

ATRs were placed along the US 422 Corridor from February 27 to March 7, 2006. Four sets of ATRs were placed to collect vehicle classification data at the following locations: west of Railroad Street, between Apple Blossom Road and Shady Lane, east of White Oak Street, and east of Center Street. The ATR located east of White Oak Street was damaged during the data collection process. Therefore, data at this location was incomplete and was obtained from PennDOT.

From the ATR data, the average annual daily traffic (AADT) was determined. The *2004 Pennsylvania Traffic Data Report* was utilized to determine the appropriate adjustment factors to calculate the AADT. The adjustment factors account for the fluctuations in traffic that occur during different months in the year. The AADT volumes at the respective locations are shown in **Figure 4**. The AADT calculations are included in **Appendix C**; complete volume data is included in the **Technical Files, Section A**.



* Data from PennDOT 2005 Volume Count

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FIGURE 4
2006 Average Annual Daily Traffic (AADT) Volumes
Volumes collected March 2006

KEY:

- ATR Location & Volumes
- Signalized Intersections



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2. *Intersection Counts*

Turning movement counts were collected at each of the 10 signalized intersections within the US 422 Corridor. Count data for the three intersections in Annville/Cleona were collected on March 1, 2006 between 7:00-9:00AM, 11:00AM-1:00PM, and 3:00-6:00PM. Count data for the seven intersections in Palmyra/North Londonderry were collected on March 7, 2006 between 6:30-9:00AM, 11:00AM-1:00PM, and 3:00-6:00PM. A review of the traffic count data revealed the morning, midday, and evening peak hours in the corridor to be:

Peak AM Hour: 7:00AM – 8:00AM
Peak Midday Hour: 11:45AM – 12:45PM
Peak PM Hour: 4:30PM – 5:30PM

The existing volumes for AM, Midday, and PM peak hour are depicted on **Figures 5A-B, 6A-B, and 7A-B**. The intersection count sheets are included in **Technical Files, Section B**.

3. *Travel Time Measurements*

The travel time and delay study provides information on how long it takes to travel the 6.7 mile corridor and the significant causes of delay. The study was completed in accordance with the Travel Time and Delay Study guidelines developed in the *ITE Manual of Transportation Engineering Studies*. The study was conducted Wednesday March 1, 2006 in Annville/Cleona and Tuesday March 7, 2006 in Palmyra/North Londonderry during the AM, Midday, and PM peak periods, utilizing the average vehicle method. The average vehicle method requires the driver to perform several runs of the corridor while traveling the average speed of the traffic stream. An observer in the vehicle records causes of delay, stopping points, and the running time between checkpoints. Due to the length of the corridor, the travel time and delay study was divided into two sections. The first section was the Palmyra/North Londonderry area and began west of Railroad Street and ended at Clear Spring Road. The second section was the Annville/Cleona area and began at Clear Spring Road and ended east of Center Street.

The US 422 Corridor experiences the heaviest congestion during the PM peak hours, especially in the eastbound direction in the Palmyra/North Londonderry section. A summary of the travel time is shown in **Table 1** and the speeds throughout the corridor are shown on **Figures 8A-F**. Data from the travel time and delay study is included in the **Technical Files, Section C**.



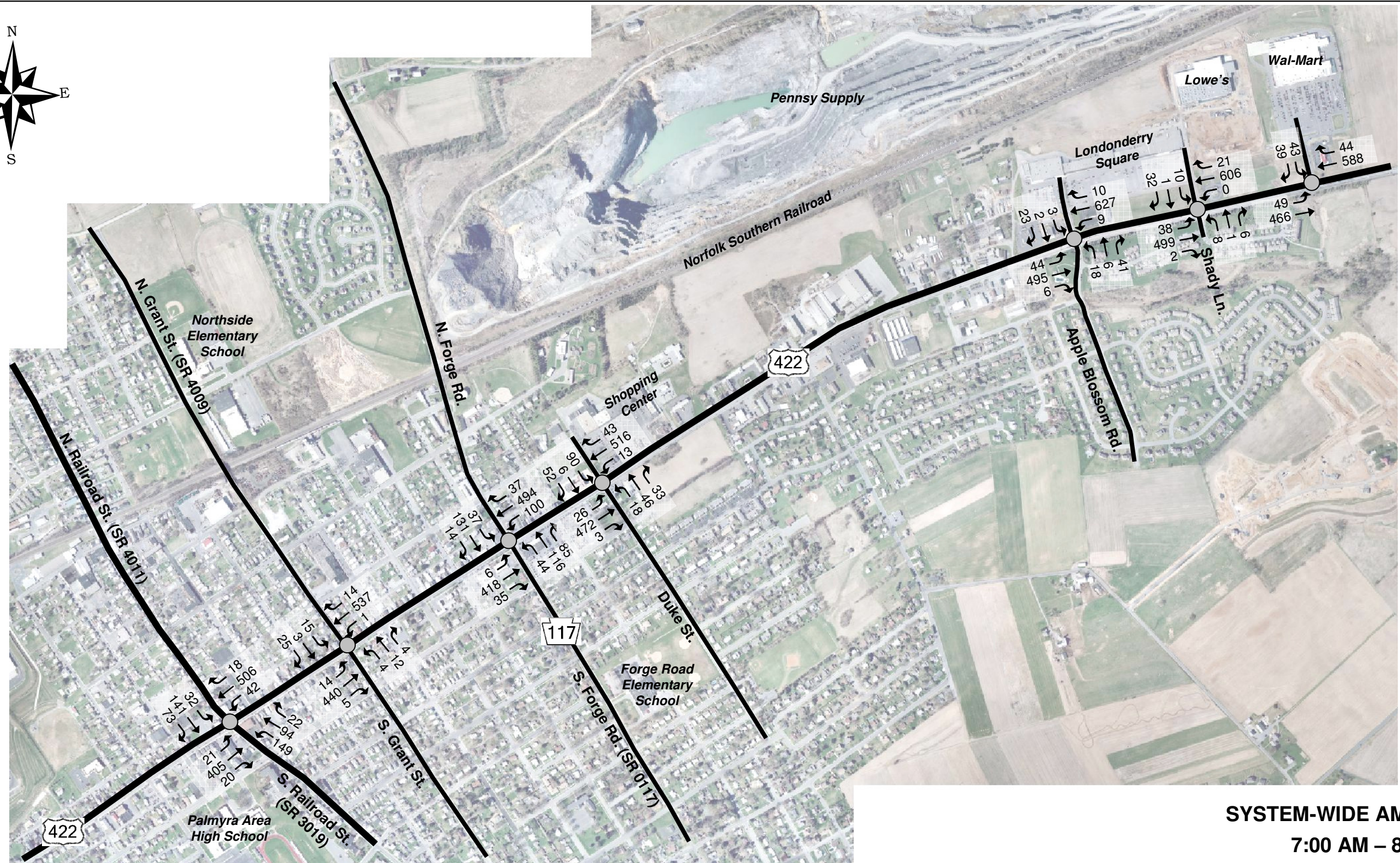
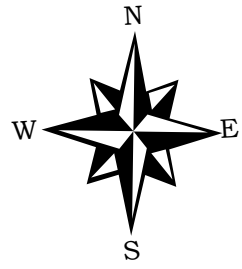
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Table 1: Summary of Average Field Travel Times

| Time Period | Eastbound | | Total | Westbound | | Total |
|-------------|---------------------------|-----------------|-------|---------------------------|-----------------|-------|
| | Palmyra/North Londonderry | Annville/Cleona | | Palmyra/North Londonderry | Annville/Cleona | |
| AM | 06:20 | 07:20 | 13:40 | 05:44 | 06:52 | 12:36 |
| Midday | 06:39 | 07:16 | 13:55 | 07:34 | 07:43 | 15:17 |
| PM | 08:09 | 08:20 | 16:29 | 06:59 | 08:53 | 15:52 |



SYSTEM-WIDE AM PEAK HOUR
7:00 AM – 8:00 AM



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FIGURE 5A - PALMYRA
2006 AM Peak Hour Traffic Volumes
Volumes collected March 2006

KEY:

| | | |
|--|-----|--------------------------|
| | 23 | Peak Hour Turning |
| | 112 | Movement Volumes |
| | 15 | |
| | | Signalized Intersections |



**SYSTEM-WIDE AM PEAK HOUR
7:00 AM – 8:00 AM**



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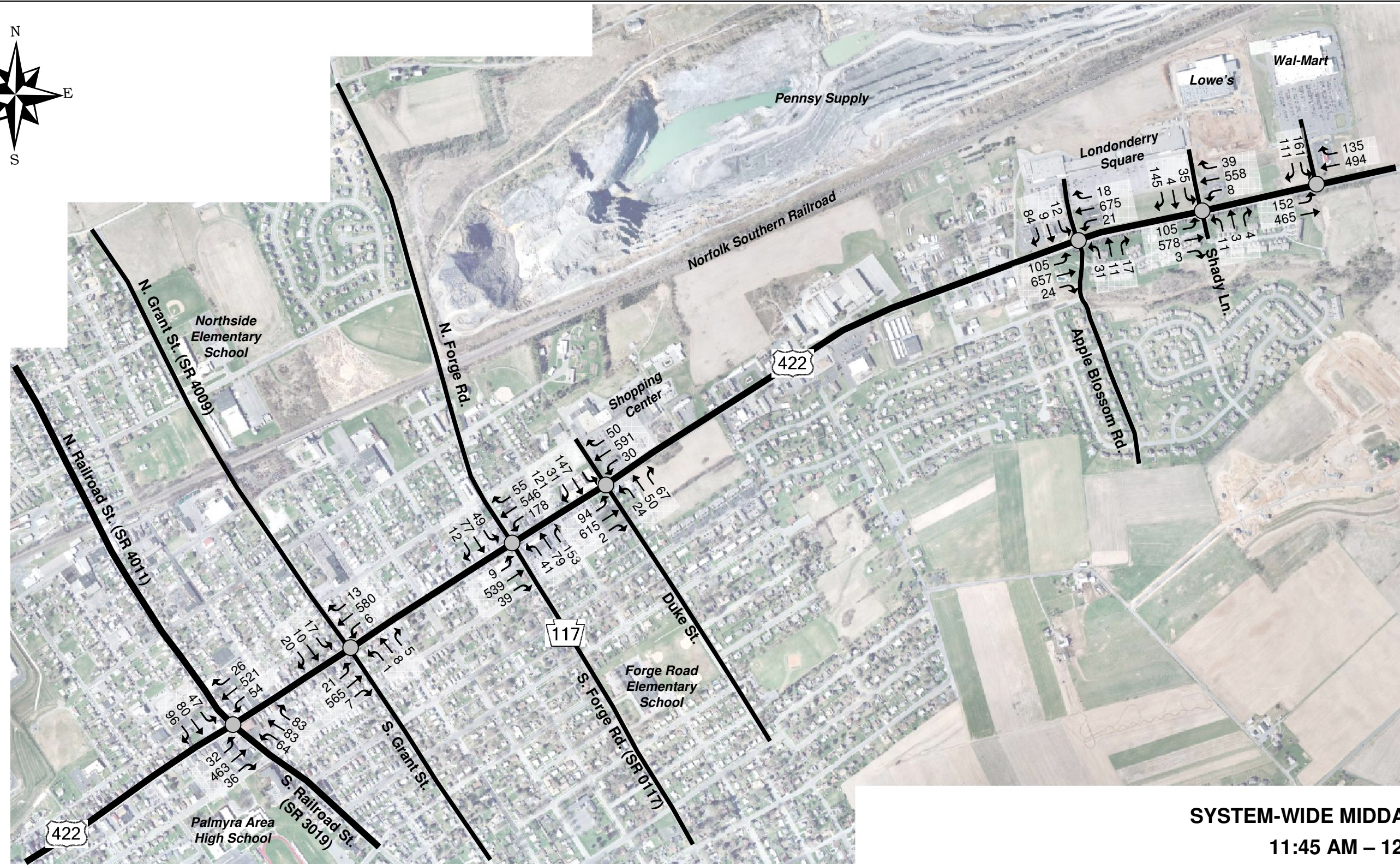
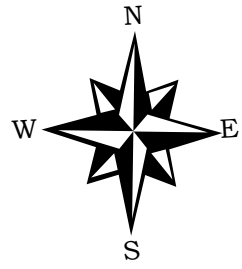
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**FIGURE 5B - ANNVILLE-CLEONA
2006 AM Peak Hour Traffic Volumes**
Volumes collected March 2006

KEY:

| | | |
|---|-----|--------------------------|
| ↖ | 23 | Peak Hour Turning |
| ↗ | 112 | Peak Hour Turning |
| ↔ | 15 | Movement Volumes |
| ○ | | Signalized Intersections |



SYSTEM-WIDE MIDDAY PEAK HOUR
11:45 AM – 12:45 PM



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FIGURE 6A - PALMYRA
2006 MIDDAY Peak Hour Traffic Volumes
 Volumes collected March 2006

KEY:

| | | |
|--|-----|--------------------------|
| | 23 | Peak Hour Turning |
| | 112 | Movement Volumes |
| | 15 | |
| | | Signalized Intersections |



SYSTEM-WIDE MIDDAY PEAK HOUR
11:45 AM – 12:45 PM



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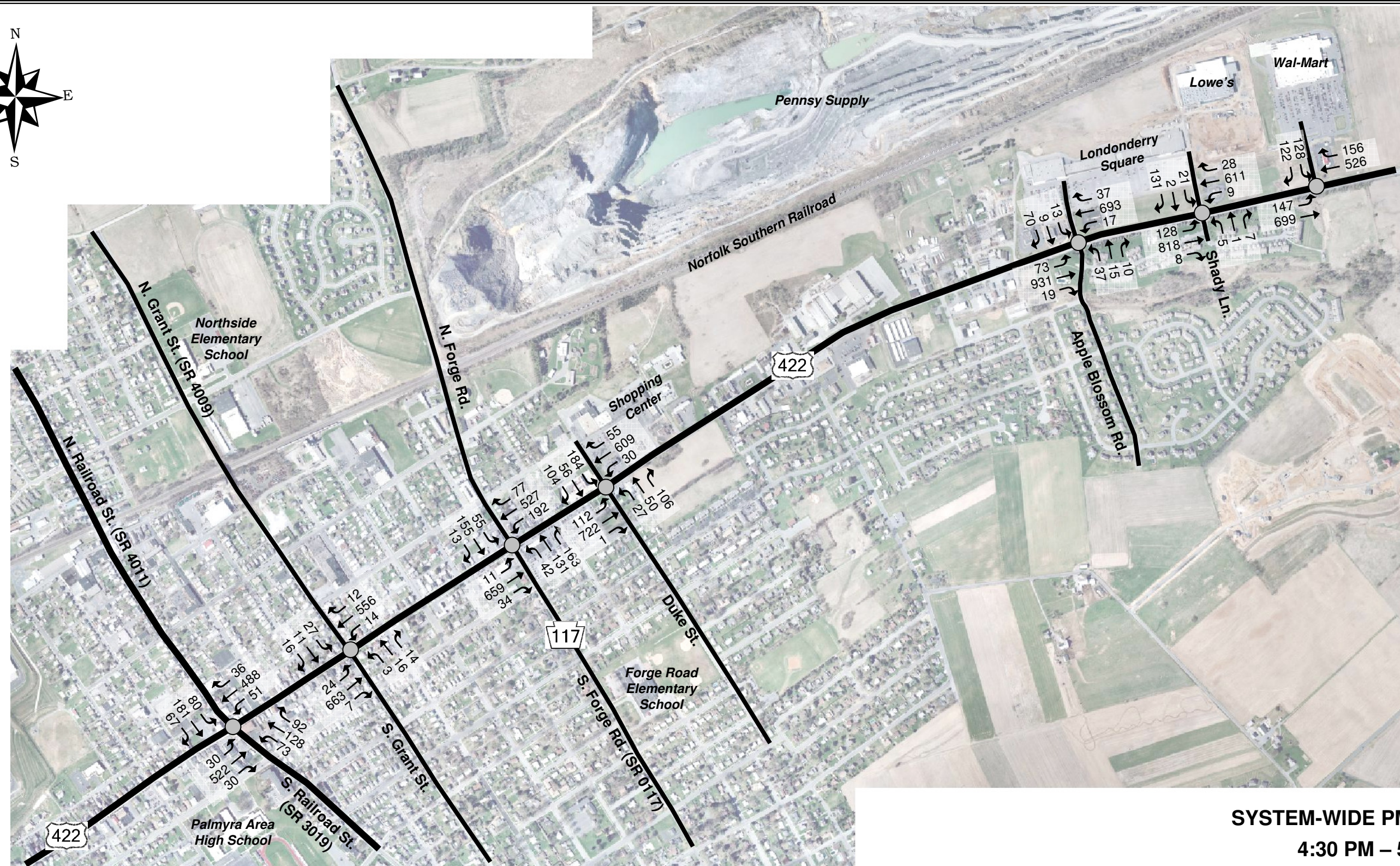
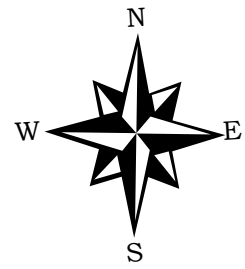
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FIGURE 6B - ANNVILLE-CLEONA
2006 MIDDAY Peak Hour Traffic Volumes
 Volumes collected March 2006

KEY:

| | | |
|--|-----|--------------------------|
| | 23 | Peak Hour Turning |
| | 112 | Peak Hour Turning |
| | 15 | Movement Volumes |
| | | Signalized Intersections |



SYSTEM-WIDE PM PEAK HOUR
4:30 PM – 5:30 PM



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FIGURE 7A - PALMYRA
2006 PM Peak Hour Traffic Volumes
Volumes collected March 2006

- KEY:**
- 23 Peak Hour Turning
 - 112 Peak Hour Turning
 - 15 Movement Volumes
 - Signalized Intersections



**SYSTEM-WIDE PM PEAK HOUR
4:30 PM – 5:30 PM**



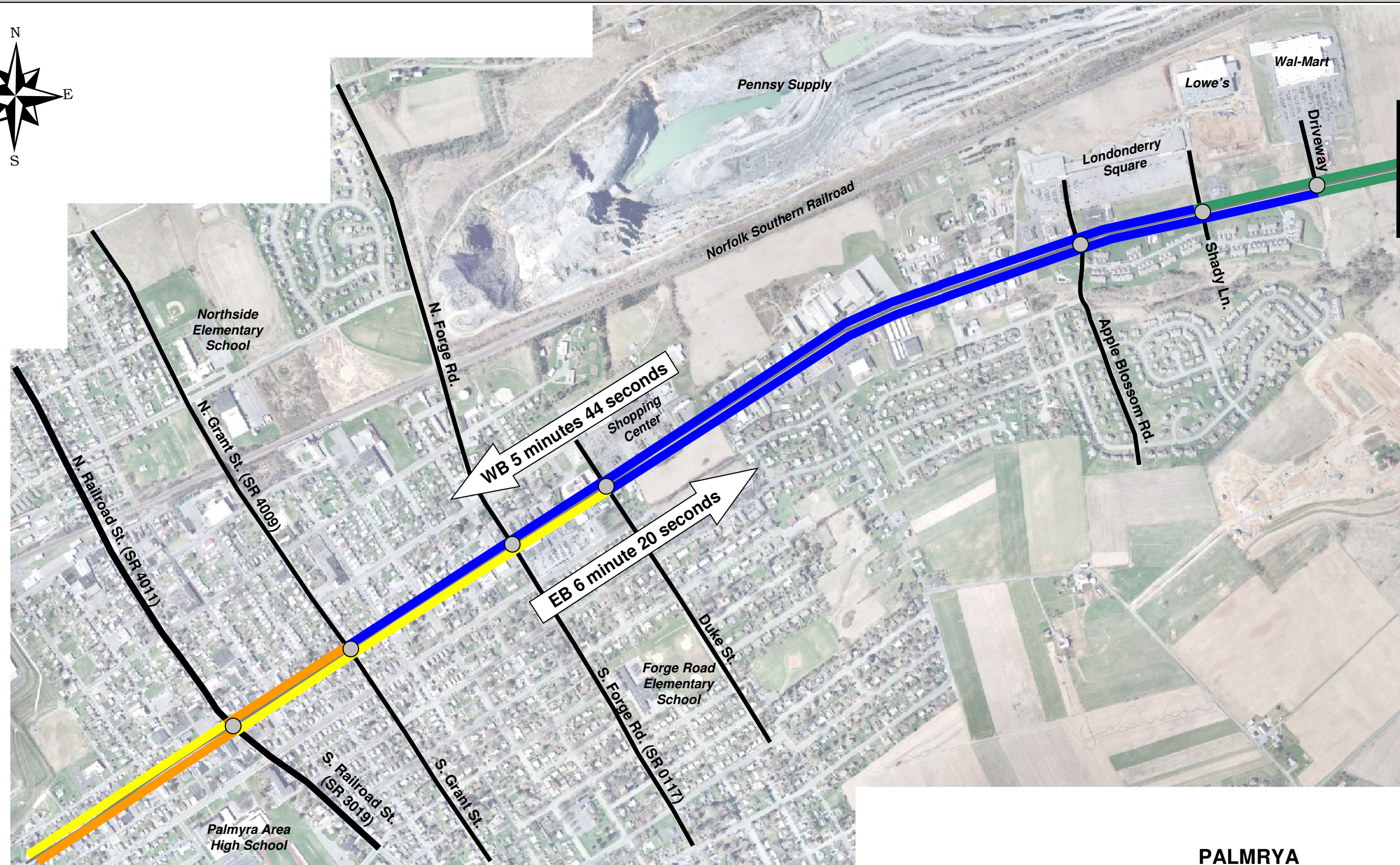
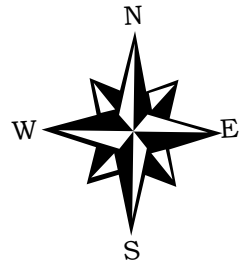
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**FIGURE 7B - ANNVILLE-CLEONA
2006 PM Peak Hour Traffic Volumes**
Volumes collected March 2006

- KEY:**
- 23 Peak Hour Turning
 - 112 Peak Hour Turning
 - 15 Movement Volumes
 - Signalized Intersections



To Clear Spring Rd
→

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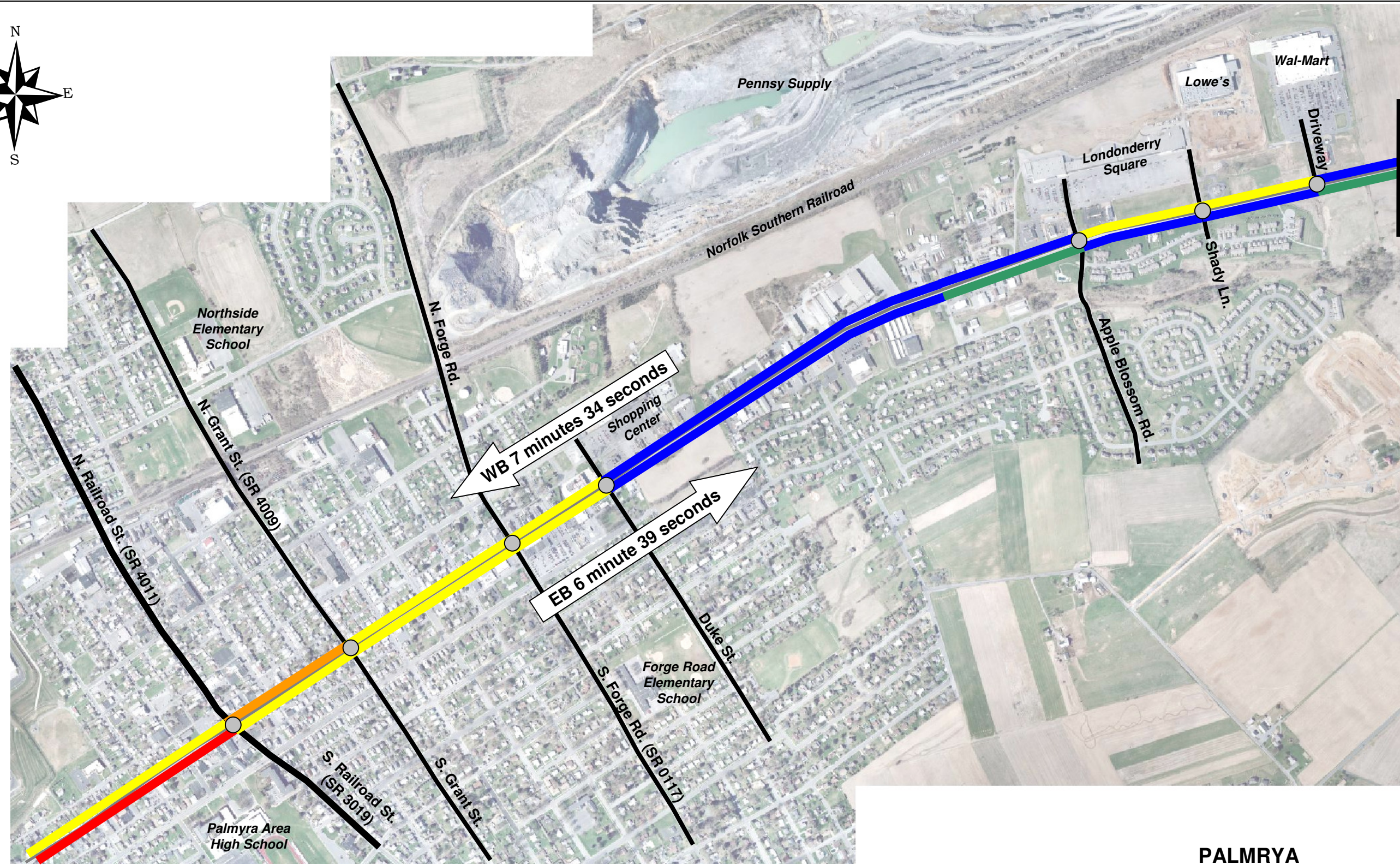
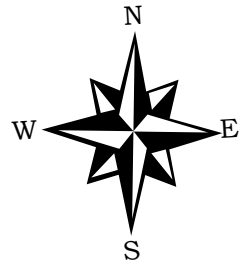
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PALMYRA
FIGURE 8A - AM Corridor Travel Times

KEY:

| AVERAGE TRAVEL SPEEDS | |
|---------------------------------------|--------------------------|
| █ | 0-10 mph |
| █ | 10 - 20 |
| █ | 20 - 30 |
| █ | 30 - 40 |
| █ | 40 + |
| ○ | Signalized Intersections |



To Clear Spring Rd
→

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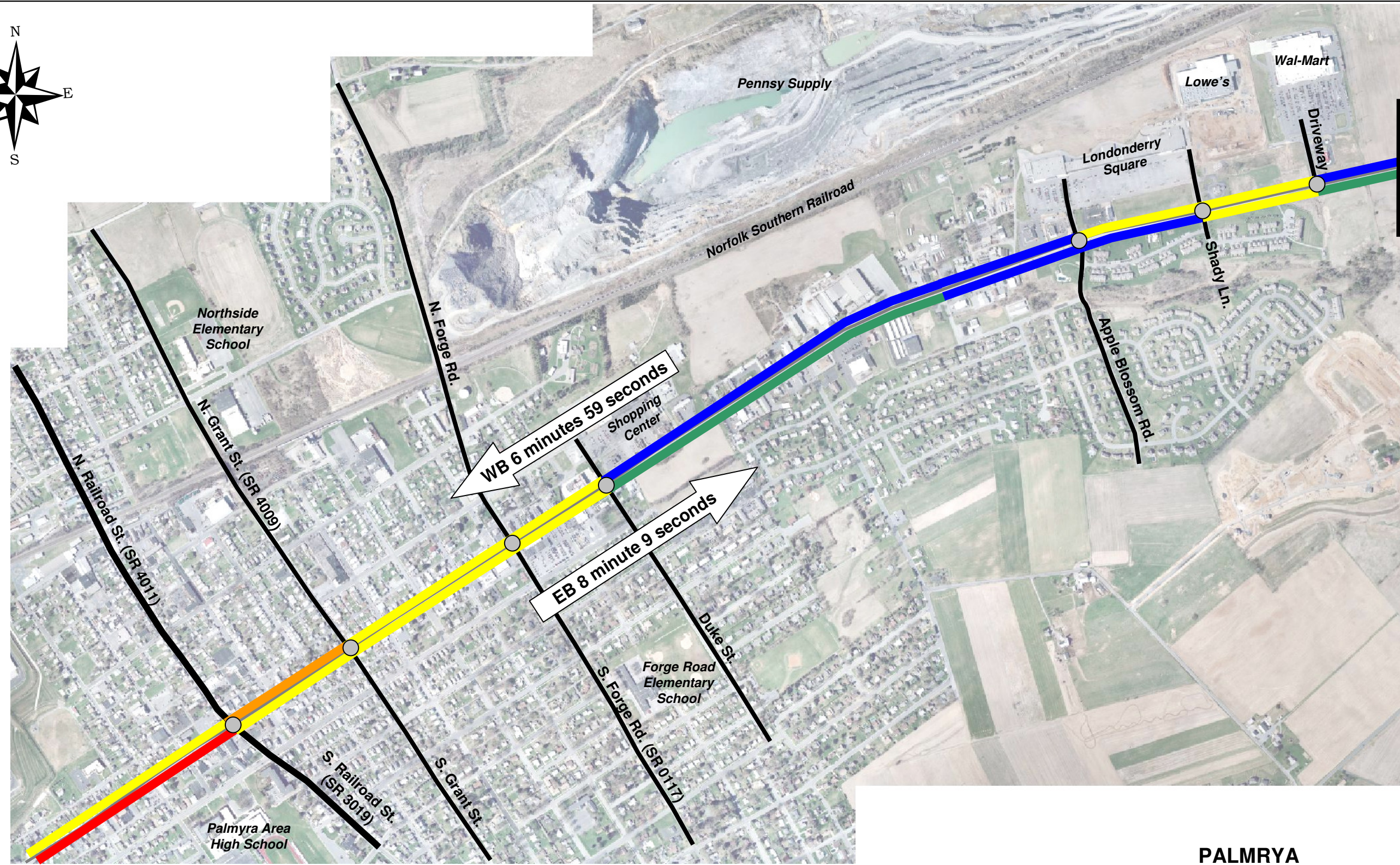
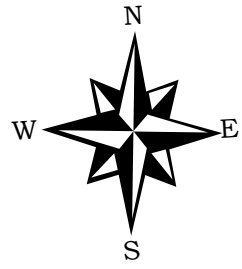
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PALMYRA
FIGURE 8B - MD Corridor Travel Times

KEY:

| AVERAGE TRAVEL SPEEDS | |
|---------------------------------------|--------------------------|
| █ | 0-10 mph |
| █ | 10 - 20 |
| █ | 20 - 30 |
| █ | 30 - 40 |
| █ | 40 + |
| ○ | Signalized Intersections |



To Clear Spring Rd
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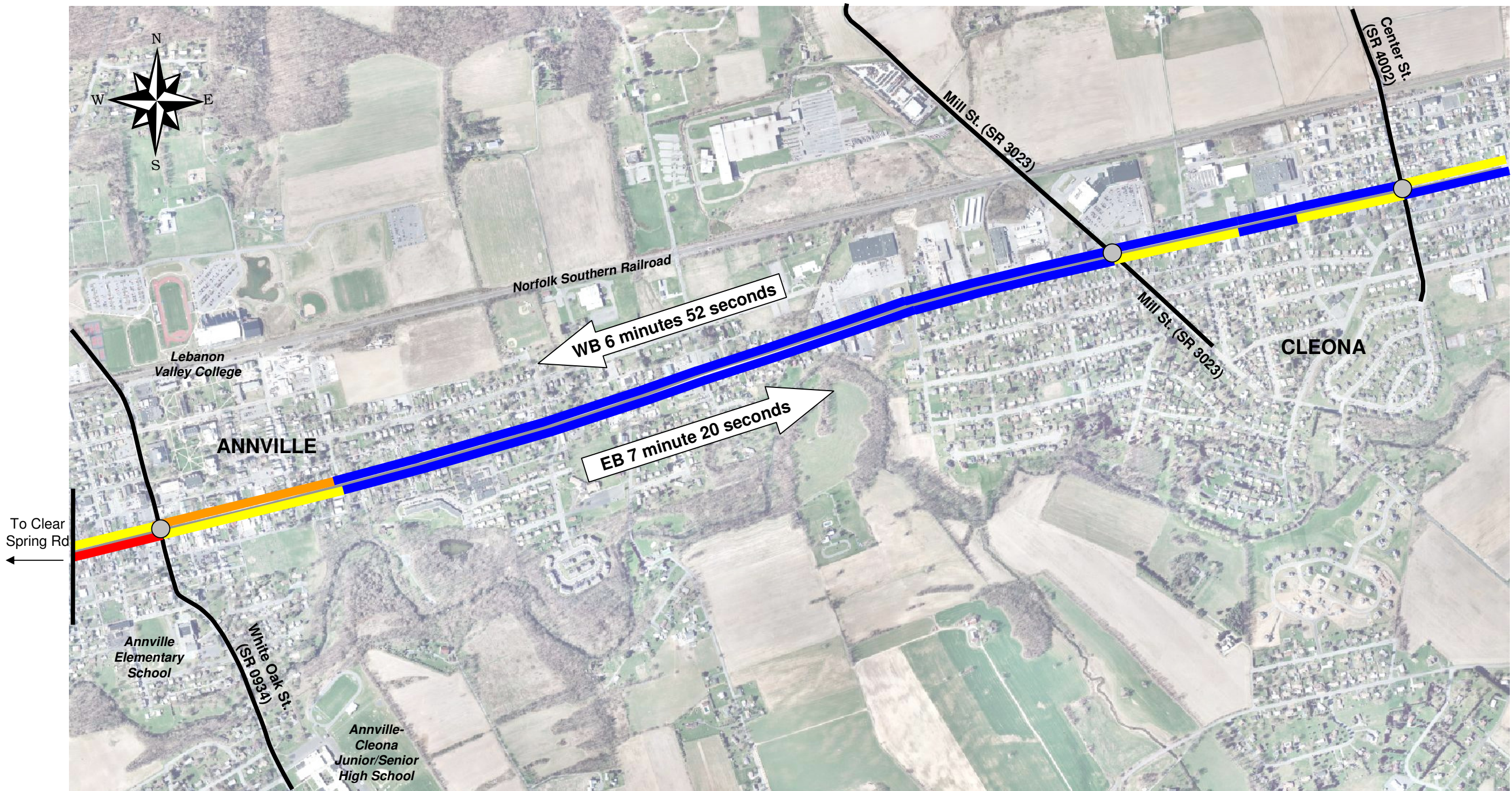
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PALMYRA
FIGURE 8C - PM Corridor Travel Times

KEY:

| AVERAGE TRAVEL SPEEDS | |
|---------------------------------------|--------------------------|
| █ | 0-10 mph |
| █ | 10 - 20 |
| █ | 20 - 30 |
| █ | 30 - 40 |
| █ | 40 + |
| ○ | Signalized Intersections |



Note: Travel time calculated between control points at Clear Spring Rd. and at Garfield St.

ANNVILLE-CLEONA

FIGURE 8D - AM Corridor Travel Times

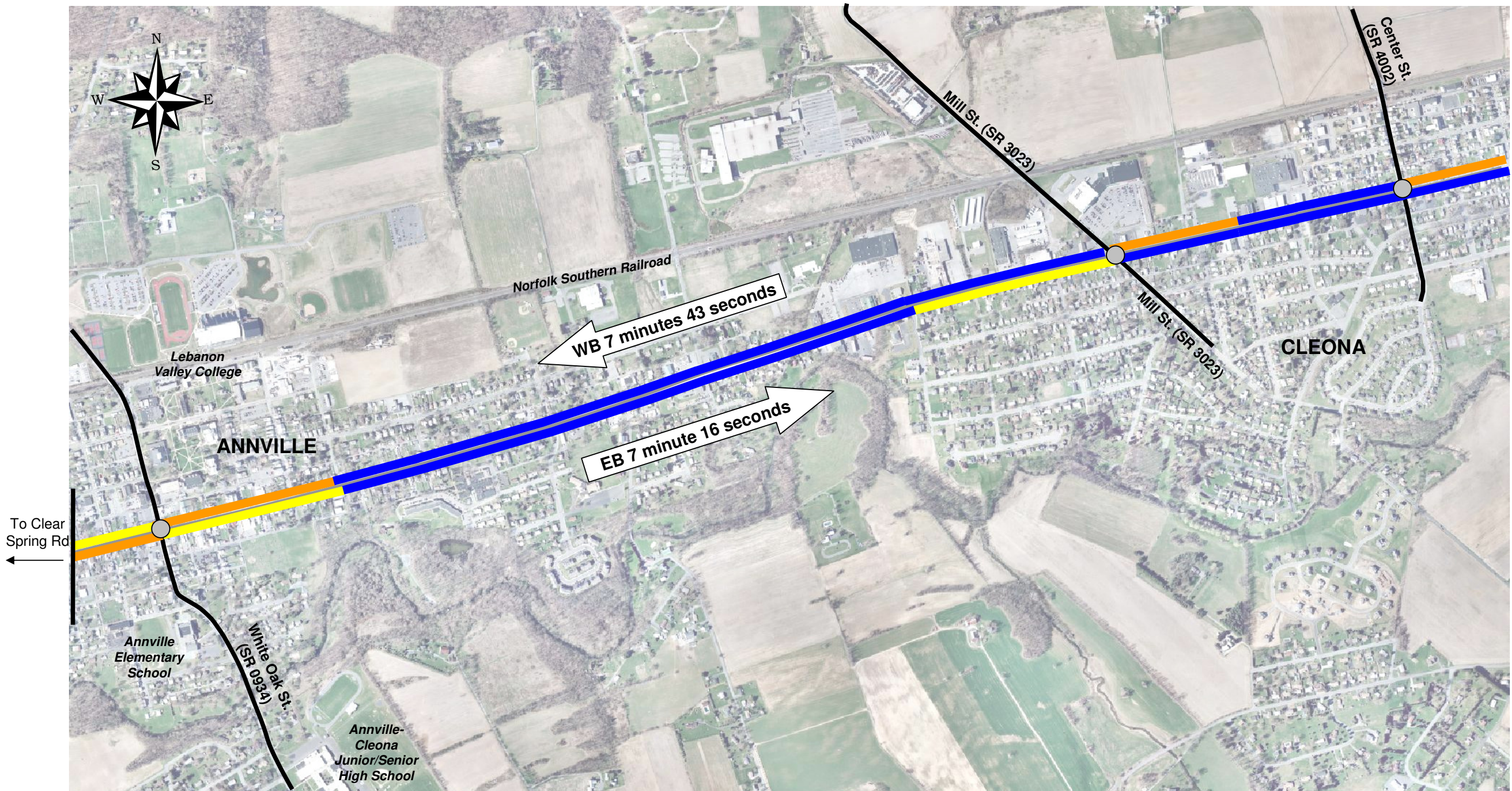
KEY:

| AVERAGE TRAVEL SPEEDS | |
|---------------------------------------|--------------------------|
| █ | 0-10 mph |
| █ | 10 - 20 |
| █ | 20 - 30 |
| █ | 30 - 40 |
| █ | 40 + |
| ○ | Signalized Intersections |

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Note: Travel time calculated between control points at Clear Spring Rd. and at Garfield St.

ANNVILLE-CLEONA

FIGURE 8E - MD Corridor Travel Times

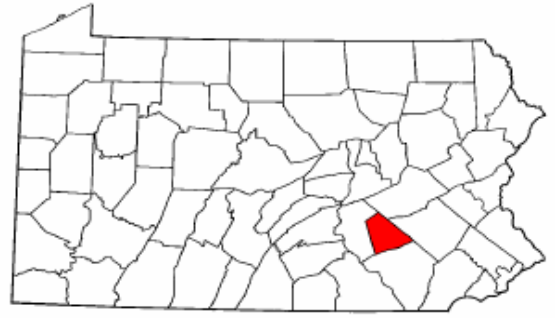
KEY:

| AVERAGE TRAVEL SPEEDS | |
|---------------------------------------|--------------------------|
| █ | 0-10 mph |
| █ | 10 - 20 |
| █ | 20 - 30 |
| █ | 30 - 40 |
| █ | 40 + |
| ○ | Signalized Intersections |

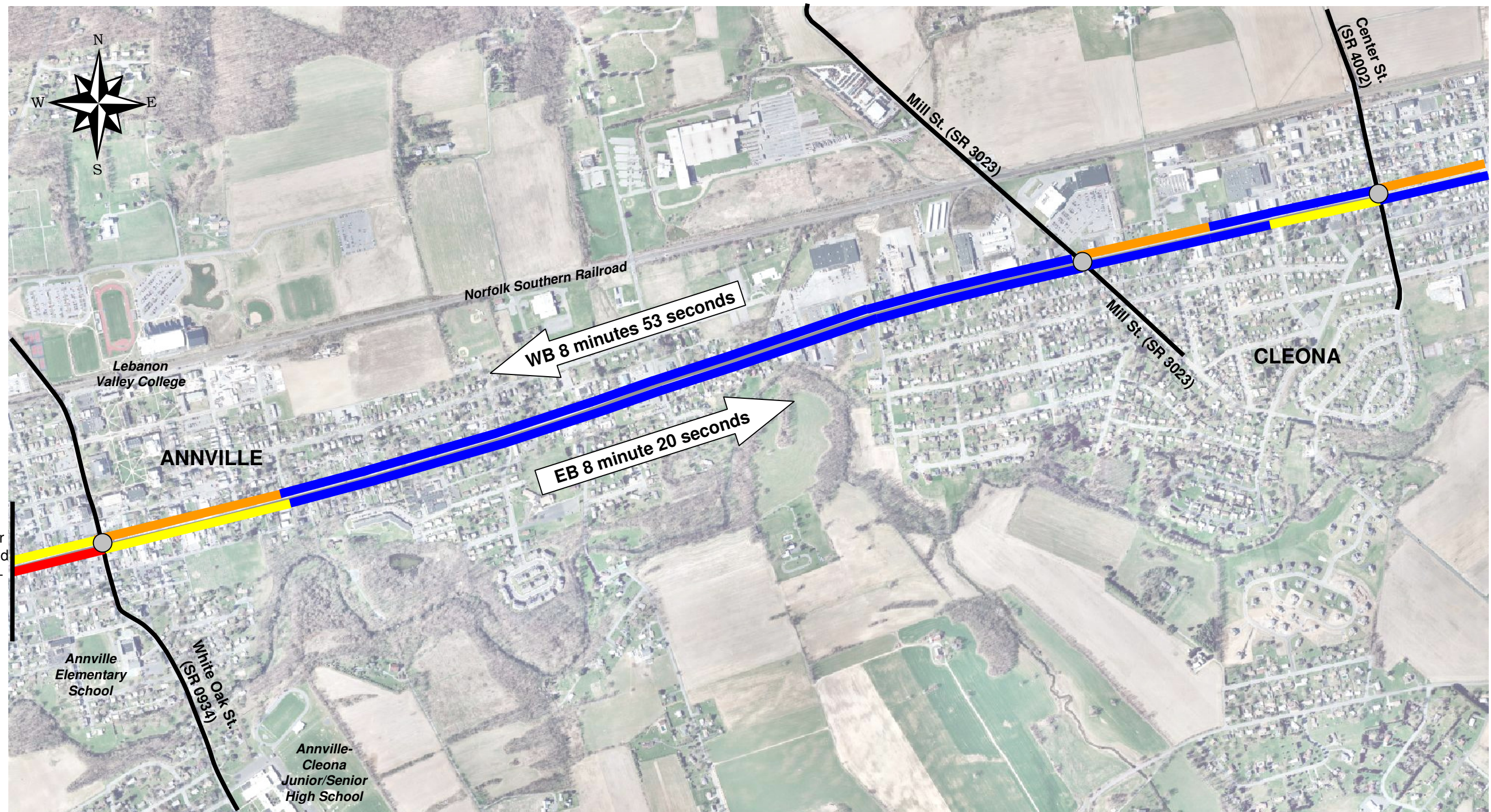
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Note: Travel time calculated between control points at Clear Spring Rd. and at Garfield St.

ANNVILLE-CLEONA

FIGURE 8F - PM Corridor Travel Times

KEY:

| AVERAGE TRAVEL SPEEDS | |
|---------------------------------------|--------------------------|
| █ | 0-10 mph |
| █ | 10 - 20 |
| █ | 20 - 30 |
| █ | 30 - 40 |
| █ | 40 + |
| ○ | Signalized Intersections |

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D. Capacity Analysis and Methodology

The intersection analysis utilized the methodology established in the 2000 Highway Capacity Manual (HCM) that describes the operation of intersections controlled by traffic signals. Synchro 6.0 (Build 614) software was used to apply the general HCM methodology and to derive the Level of Service (LOS) and intersection delay that is provided to traffic at the intersection. As per PennDOT Strike-Off Letter 470-04-02, Synchro software is recognized and supported by the Department. The study team discussed the use of this analytical tool and agreed that the software was appropriate to analyze the corridor as Synchro can effectively analyze and model (through SimTraffic) the affects of vehicles queuing, the interaction between closely spaced intersections, and traffic signals operating in coordination.

The LOS at signalized intersections is defined in terms of delay. Delay is a measure of the drivers’ discomfort and frustration, fuel consumption, and lost travel time. LOS criteria are stated in terms of delay per vehicle for the peak 15-minute analysis period.

The LOS at signalized intersections ranges from A to F. An overall intersection LOS of D or better is generally desirable for a signalized intersection in an urban area. Although LOS of D is desirable, a LOS of E is acceptable for areas that experience heavily congested peak periods. Intersections with an overall LOS below D indicate that during the peak 15-minute travel period at the intersection, the average stopped delay per vehicle will exceed 55 seconds. Descriptions of various LOS ranges are in **Appendix D** as contained in the HCM.

The 10 signalized intersections in the corridor were analyzed. Based on the capacity analysis, two intersections in the PM peak hour are operating with an overall LOS E. **Table 2** summarizes the overall intersection results.

Table 2: Existing Overall Intersection LOS Summary

| Intersection | AM | Midday | PM |
|----------------------------|----|--------|----|
| Railroad St & US 422 | D | D | E* |
| Grant St & US 422 | A | A | A |
| Forge Rd & US 422 | C* | D* | D* |
| Duke St & US 422 | B | C | C |
| Apple Blossom Rd & US 422 | B | B | B |
| Shady Ln & US 422 | A | B | B |
| Wal-Mart Driveway & US 422 | A | B | B |
| White Oak St & US 422 | C | C | E* |
| Mill St & US 422 | B | C | C |
| Center Street & US 422 | B | B | B |

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



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In addition to the overall intersection results, Railroad Street, Forge Road, and White Oak Street have movements and approaches that are operating with a LOS F. An asterisk (*) is placed beside those intersections. A detailed LOS summary is included in **Appendix E** and summary printouts of the capacity analysis are in the **Technical Files, Section D**.

In order to evaluate the peak hour travel time – one of the main goals of the CCIP is a 20 percent reduction in peak hour travel time – *SimTraffic 6.0 (Build 614)* software was utilized. SimTraffic is the microscopic simulation modeling component of Synchro. SimTraffic was used to generate a simulation model so the travel time changes associated with improvement strategies could be determined. Five one hour runs were completed and averaged for each time period under analysis. To assure that the base simulation model was representing actual/realistic conditions along the corridor, the model was calibrated with the goal to model the travel times within 10 percent of the field travel times. With approximately 2.5 miles between the Palmyra/North Londonderry corridor and the Annville/Cleona corridor, the model was divided into two corridors for calibration. Calibration was achieved by making minor adjustments to parameters including the link speed, turning speed, the affects of on-street parking, and the affects of mid-block traffic. The **Technical Files, Section E**, includes the calibration data.

E. Existing Condition Scenarios

After analyzing the network under existing conditions, it was determined that changes could be made immediately to the corridor to improve existing conditions. In order to have minimal impact and cost, the improvements were limited to adjusting cycle lengths, signal splits and offsets and addressing some of the easily amended adverse conditions discussed in Section IV, Summary of Adverse Conditions. These minimal impact and cost improvements were labeled “immediate term improvements.” **Table 3** summarizes the immediate term improvements at each of the intersections.



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Table 3: Summary of Immediate Term Improvements

| Intersection | Description of Improvements |
|---|---|
| | <i>Adjusted signal cycle length, splits, and offsets and included full clearance times for left turns.</i> |
| Railroad Street and US 422 | Adjusted signal cycle length, splits, and offsets. |
| Grant Street and US 422 | Adjusted signal cycle length, splits, and offsets. |
| Forge Street (PA 117) and US 422 | Adjusted signal cycle length, splits, and offsets. |
| Duke Street and US 422 | Adjusted signal cycle length, splits, and offsets. EB left turn phase included full yellow and all red clearance. |
| Apple Blossom Road and US 422 | Adjusted signal cycle length, splits, and offsets. |
| Shady Lane and US 422 | Adjusted signal cycle length, splits, and offsets. |
| Wal-Mart and US 422 | Adjusted signal cycle length, splits and offsets. |
| White Oak Street (PA 934) and US 422 | Adjusted signal cycle length and splits. |
| Mill Street (SR 3023) and US 422 | Adjusted signal cycle length and splits. |
| Center Street (SR 4002) and US 422 | Adjusted signal cycle length and splits. EB left turn phase included full yellow and all red clearance. |



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The 10 signalized intersections in each scenario were analyzed. **Table 4** summarizes the overall intersection LOS results and **Table 5** summarizes the travel time results. A detailed LOS and travel time summary is included in **Appendix E** and summary printouts of the capacity analysis are in the **Technical Files, Section D**. The summary tables illustrate the improved operation of the signals due to the optimized timings compared to the existing conditions.

A review of **Table 4 and 5** show an overall decrease in delay and travel times along the corridors. Adjusting the traffic signal operations does provide an improvement in the travel time; an approximate 22 percent reduction in travel time is estimated during the PM peak period travel eastbound through the Palmyra/North Londonderry corridor. On other sections of the corridor, the travel time changes were more negligible. In most cases, the travel time decreases, however in some cases negligible increases were noted. These increases were less than 30 seconds and can be attributed to the fluctuations in the simulation model and improvement in operations on the side street which are not reflected in the US 422 travel times.

Table 4: Summary of Existing and Immediate Term LOS

| Intersection | AM | | Midday | | PM | |
|---------------------------|----------|--------------------|----------|--------------------|----------|--------------------|
| | Existing | Existing Optimized | Existing | Existing Optimized | Existing | Existing Optimized |
| Railroad St & US 422 | D | D | D | C | E* | D |
| Grant St & US 422 | A | A | A | A | A | A |
| Forge Rd & US 422 | C* | C* | D* | C* | D* | C* |
| Duke St & US 422 | B | B | C | B | C | B |
| Apple Blossom Rd & US 422 | B | A | B | A | B | A |
| Shady Ln & US 422 | A | A | B | A | B | A |
| Wal-Mart Drway & US 422 | A | B | B | B | B | B |
| White Oak St & US 422 | C | C | C | C | E* | D* |
| Mill St & US 422 | B | B | C | C | C | C |
| Center Street & US 422 | B | B | B | B | B | B |

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



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Table 5: Summary of Existing and Immediate Term Travel Times

| Roadway Links | AM | | | Midday | | | PM | | |
|---|----------|--------------------|--------|----------|--------------------|--------|----------|--------------------|--------|
| | Existing | Existing Optimized | Change | Existing | Existing Optimized | Change | Existing | Existing Optimized | Change |
| EB – Palmyra/North Londonderry Corridor | 05:13 | 04:58 | -5% | 05:32 | 05:11 | -7% | 07:40 | 06:00 | -22% |
| WB – Palmyra/North Londonderry Corridor | 05:02 | 05:21 | 6% | 06:01 | 05:34 | -7% | 06:41 | 05:54 | -12% |
| EB – Annville/Cleona Corridor | 07:17 | 07:08 | -2% | 07:12 | 07:11 | 0% | 07:36 | 08:05 | 6% |
| WB – Annville/Cleona Corridor | 05:13 | 05:10 | -1% | 05:52 | 05:46 | -2% | 06:05 | 06:08 | 1% |



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(PennDOT Bureau of Highway Safety & Traffic Engineering and PennDOT Engineering District 8-0)

F. Crash Summary

Crash records along the US 422 Corridor for the five years from January 1999 to December 2004 were obtained from PennDOT's Bureau of Highway Safety and Traffic Engineering. The records did not include complete crash data for the year 2002, since complete data from this year has not been included in PennDOT's Accident Record System. The crash data obtained included information on "reportable" crashes. Reportable crashes are crashes involving fatalities, injuries, or where a vehicle must be towed. Based on the data provided, a total of 523 reportable crashes occurred within the corridor. These crashes were categorized by their collision type, as shown in **Figure 9**. Rear-end crashes were the most common type of crash accounting for 43 percent of the 523 crashes. The next most common crash type was angle crashes, which involve a turning vehicle. There were 144 angle crashes, 28 percent of the total crashes. Both of these crash types are typical for congested and signalized arterial routes with numerous access points. Additional crash data is included in the **Technical Files, Section F**.