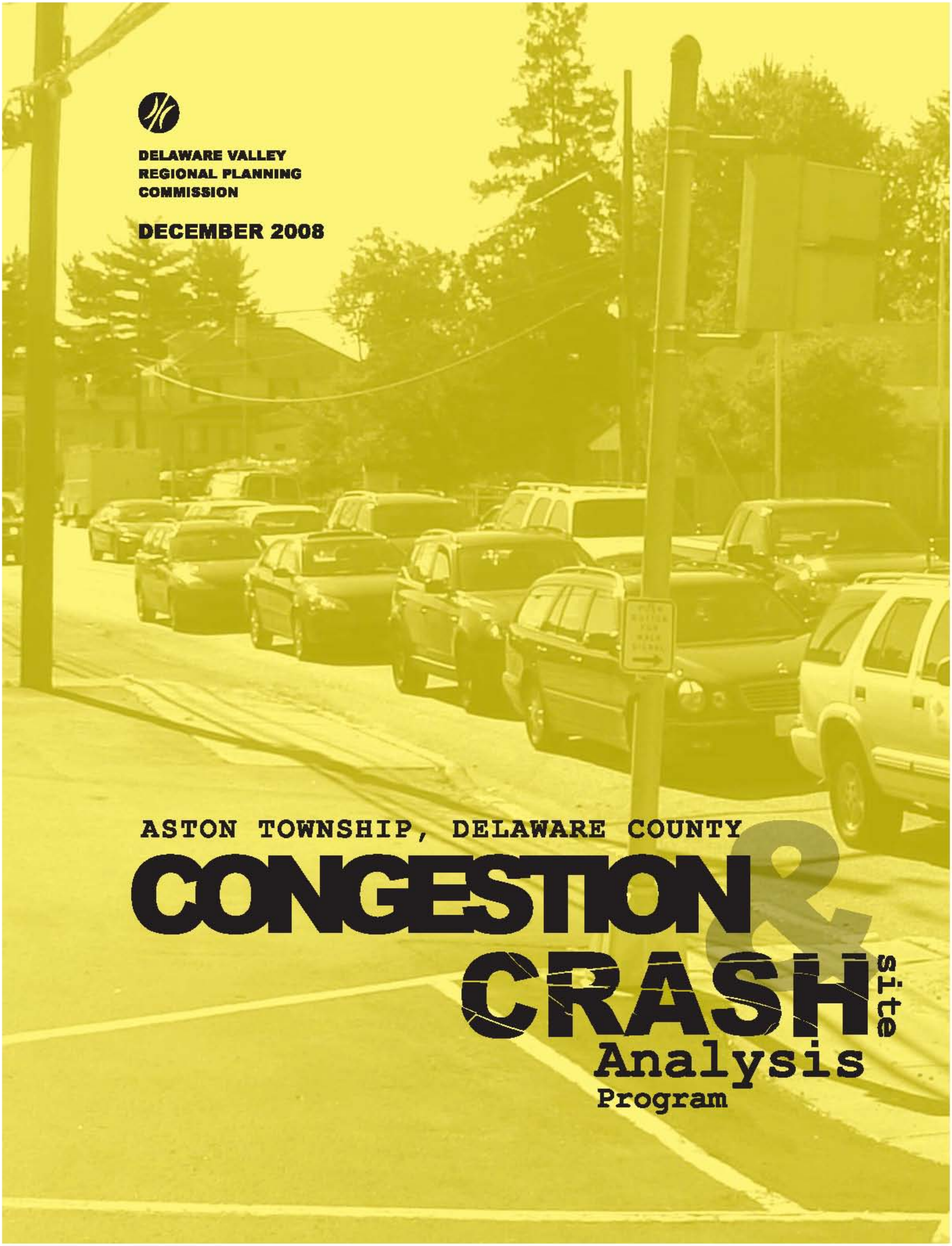


DELAWARE VALLEY
REGIONAL PLANNING
COMMISSION

DECEMBER 2008

ASTON TOWNSHIP, DELAWARE COUNTY

CONGESTION & CRASH site Analysis Program

The Delaware Valley Regional Planning Commission is dedicated to uniting the region's elected officials, planning professionals and the public with a common vision of making a great region even greater. Shaping the way we live, work and play, DVRPC builds consensus on improving transportation, promoting smart growth, protecting the environment and enhancing the economy. We serve a diverse region of nine counties: Bucks, Chester, Delaware, Montgomery and Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester and Mercer in New Jersey. DVRPC is the federally designated Metropolitan Planning Organization for the Greater Philadelphia Region - leading the way to a better future.

Our logo is adapted from the official DVRPC seal, and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole, while the diagonal bar signifies the Delaware River. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.

DVRPC is funded by a variety of funding sources including federal grants from the U.S. Department of Transportation's Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), the Pennsylvania and New Jersey departments of transportation, as well as by DVRPC's state and local member governments. The authors, however, are solely responsible for its findings and conclusions, which may not represent the official views or policies of the funding agencies.

TABLE OF CONTENTS

FIGURES

Delaware County, Aston Township

TABLES

The crash data used in this report was provided by the Pennsylvania Department of Transportation for the Delaware Valley Regional Planning Commission's traffic safety related transportation planning and programming purposes only. The raw data remains the property of the Pennsylvania Department of Transportation and its release to third parties is expressly prohibited without the written consent of the Department.

INTRODUCTION

The goals of the Congestion and Crash Site Analysis Program are improving access to and efficiency of the region's transportation system, improving safety and air quality, and reducing congestion through analyses for specific highway locations with demonstrated problems in both New Jersey and Pennsylvania. Unlike a typical corridor study, which examines a larger geographic area, the intent of this program is to examine individual intersections or specific problem sites. Although this program precedes the DVRPC's Regional Safety Action Plan, it also addresses one of our established emphasis areas: "improving the design and operations of intersections."

Due to their many conflict points, intersections experience more crashes than midblock locations. In addition, the geometry of an intersection can present many issues for the road user. Assuring the efficient operation of intersections is an increasingly important issue as municipalities attempt to maximize vehicle roadway capacity to serve the growing demand for travel. The objective is to identify cost-effective improvements that will reduce crashes and congestion created by limited capacity and design deficiencies.

These selected locations may experience high levels of congestion and/or have a high number of crashes. Crashes not only result in fatalities, injuries, and property damage, but they also add to the congestion and deficiency in the operation of the intersection. This report examines the intersection of Pennell Road, Concord Road, and Knowlton Road in Aston Township, and its surroundings in Delaware County, and identifies potential improvement strategies that would increase the safety and mobility of all road users.

There are three other locations in New Jersey currently being evaluated in this program—one each in Mercer, Camden, and Burlington counties. Their results have been presented in separate documents.

DVRPC solicited input from each of the counties in the region to identify potential problem locations. Working with the counties, DVRPC selected the four locations to study. Each of the locations is distinct and has its own particular set of issues and problems. Since each location is unique, there is no one cure-all solution. In fact, each location may need to implement a combination of strategies in order to have an impact on improving safety and reducing congestion.

Methodology

The Delaware County Planning Department was asked to submit two locations for further study. This selection was to be based on the following criteria: a location demonstrating high levels of congestion and/or crashes and one not already programmed for improvement. Selection for the program was also determined by whether the location provides a regional function. Several locations were submitted by Delaware County, and the study team, in cooperation with the county, decided on this location for study.

The study team conducted field views for the location to observe the issues. Data was then compiled and analyzed. This included crash records data, Average Annual Daily Traffic (AADT), turning movement counts, and traffic signal timings. Stakeholder meetings were held with the appropriate state, county, and municipal officials. These meetings assisted in the identification of problems, with discussion of the study team observations and local stakeholder feedback.

The study team conducted follow-up field views to better define the existing conditions, observe the operating conditions, and refine the identification of problems. Subsequently, a technical analysis was performed to quantify the identified transportation problem areas. This included the preparation of collision diagrams displaying crash patterns and conducting of level of service (LOS) analyses for existing conditions.

Based on these analyses, a set of improvements was developed that addresses the identified problems. LOS analyses were then conducted for the recommended improvements.

Findings and preliminary recommendations were presented to stakeholders at a follow-up meeting. The purpose of the meeting was to discuss the recommendations and get the local officials' perspectives of the practicality on the recommendations.

Report Structure

This report is organized into separate sections that consist of: Location Description, Existing Conditions, Opportunities and Constraints, Potential Improvement Scenarios, and Recommendations.

The *location description* section provides an account of the location and examines the study area in terms of regional setting. This includes a general depiction of the local area surroundings, lane configurations, and adjacent land uses.

The *existing conditions* section presents additional background information for the site. Turning movement counts were collected during the peak periods in 15-minute increments to determine the peak-hour traffic volumes. Traffic signal timing and operation plans for the intersection were collected from the county. A crash analysis and an LOS analysis were conducted for the intersection and adjacent area for current conditions.

The crash analysis was performed to substantiate problems presented during the municipal field views and to identify any probable causes and potential improvements. Reportable crash records for a four-year period were collected from the Pennsylvania Department of Transportation (PennDOT). Reportable crashes typically involve an injury, fatality, and/or significant property damage that renders the vehicle undrivable. Although a nonreportable crash is one where there is no injury to the occupant(s) of the vehicle(s) and the vehicles involved do not have considerable damage, the crash may have negative effects on the operation of the intersection.

The *opportunities and constraints* section discusses specific issues or problems that may affect any potential improvements that have been identified. A typical constraint may be the restriction of right-of-way expansion to increase capacity. Expansion may be cost prohibitive due to encroaching land uses or nearby bridge widths.

The *potential improvement scenarios* section addresses operational and safety problems. Typical improvement scenarios range from optimizing signal timing and signal coordination to adding turning lanes and intersection redesign/reconstruction. A LOS analysis was conducted for each scenario and compared to the existing LOS analysis. This process helps to determine the level of improvement of the efficiency and operation of the intersection if the scenario is implemented.

The *recommendations* in the final section are based on the ability to correct existing or potential problems or deficiencies. The potential improvement scenario concepts presented in this document have been categorized as short-term, mid-range, or long-term. Short-term improvement recommendations typically consisted of lower cost operational/safety improvements that can be completed with little lead time and no additional major studies. Long-range improvement concepts should only be pursued if the implemented set of short-term and mid-range improvements is evaluated and determined to be ineffective. These improvements, such as additional signing and resurfacing or enhancing pavement markings, may be completed primarily through maintenance activities. A mid-range improvement may require additional costs with regard to signal coordination and pedestrian enhancements. A long-term improvement may have a higher capital cost and require the acquisition of right-of-way and construction of new infrastructure.

There is a corresponding Appendix that contains the detailed technical data documentation for turning movement counts and LOS analysis.

Level of Service Analysis

The level of service analysis (LOS) is a common tool for assessment of transportation facilities and is used extensively in this report. The LOS for existing conditions and potential improvement scenarios is evaluated for the study intersection. When applied as a measure of performance for an entire or a particular component of an intersection, LOS has a precise meaning: the average delay experienced by a vehicle traveling through the intersection or a specific component of it. In other words, LOS is a reflection of the average delay experienced by vehicles traversing an intersection. The exact parameters of delay that determine the various LOS categories for a signalized and an unsignalized intersection are displayed in ***Table 1***.

A review of the existing conditions and of the various improvement scenarios was conducted using SYNCHRO traffic signal software for the project intersection. Necessary information for determining delay and LOS measures include turning movement counts, roadway geometry, signal timing, and actuation plans. The turning movement counts were mostly gathered by DVRPC staff; the signal timing, actuation data, and roadway geometrics were supplied by the county.

Table 1 **– Level of Service (LOS) Designations and Associated Delays**

Level of Service	Signalized Intersection	Unsignalized Intersection
	Total Delay per Vehicle (seconds/vehicle)	Control Delay per Vehicle (seconds/vehicle)
A (Desirable)	≤ 10	≤ 10
B (Desirable)	> 10 and ≤ 20	> 10 and ≤ 15
C (Desirable)	> 20 and ≤ 35	> 15 and ≤ 25
D (Acceptable)	> 35 and ≤ 55	> 25 and ≤ 35
E (Undesirable)	> 55 and ≤ 80	> 35 and ≤ 55
F (Unsatisfactory)	> 80	> 50

Source: Highway Capacity Manual

For signalized intersections, SYNCHRO calculates a control delay and a queue delay. The control delay is calculated by a percentile delay method; this approach uses formulas from the Highway Capacity Manual (HCM) to calculate delay; however, the final delay measure is taken from an average of the 10^{th}, 30^{th}, 50^{th}, 70^{th}, and 90^{th} percentile volume levels. As a result, the calculated delay is a product of the various operating conditions that a signal may actually encounter. The queue delay is utilized whenever two signalized intersections are located within a critical distance of one another. If the intersections are within that distance, then calculations are made to determine the extent to which queue interactions (such as queue spillback and queue blocking) reduce capacity and, consequently, increase delay.

For an unsignalized intersection, SYNCHRO only utilizes control delay, for which it relies exclusively upon HCM methods.

For the revision of timing plans, SYNCHRO is capable of optimizing intersection splits, cycle lengths, and offsets. These efforts seek to establish a timing plan that provides the most efficient performance that serves a critical volume of vehicles.

LOCATION DESCRIPTION

The study location is the five-point signalized intersection of Pennell Road (PA 0452), Concord Road (SR 3007), and Knowlton Road in Aston Township, Delaware County, as shown on ***Figure 1***. This intersection is centrally located in the township and the crossing point of these major roadways, serve all points in the municipality.

Pennell Road is functionally classified as an urban principal arterial and it runs in a north-south direction from US 13 in Marcus Hook to PA 352 in Middletown Township for a distance of approximately seven miles. Pennell Road connects with several key roads, including Ridge Avenue (SR 3006), Chichester Avenue (SR 3009), Interstate 95, Meeting House Road (SR 3012), Duttons Mill Road (SR 3020), Parkmount Road/Glen Riddle Road (SR 3030), Lenni Road (SR 3032), and North Pennell Road/Baltimore Pike (US 1).

Concord Road is functionally classified as a minor arterial and it runs in an east-west direction from Interstate 95 in Chester Township to Baltimore Pike (US 1) in Concord Township for a distance of 8.26 miles. Concord Avenue connects with several key roads, including Bethel Avenue (SR 3010), Engel Street (SR 3033), Bridgewater Road (SR 3018), Duttons Mill Road (SR 3020), Aston Mills Road (3023), Chichester Avenue (SR 3009), Chelsea Road (SR 3031), Foulk Road (SR 3029), Smithbridge Road (SR 3045), Ivy Mill Road (SR 3036), Cheney Road (SR 4015), Station Road (3025), and Thornton Road (SR 4019).

Knowlton Road is functionally classified as an urban collector and it runs in a southeast-northwest direction from the study intersection to New Middletown Road (PA 352) in Middletown Township for a distance of 2.12 miles.

The width of Pennell Road varies throughout its length. It carries between two and five lanes, with additional turning lanes at some intersections. As depicted in ***Figure 2***, the study intersection at both legs of Pennell Road carries two approach lanes, an exclusive left-turn lane, and a shared through/right-turn lane. Both legs carry a single receiving lane. The lane configuration for both legs of Concord Road at the approaches shows exclusive left-turn, exclusive through, and exclusive right-turn lanes. Both legs carry a single receiving lane. At the Knowlton Road leg of the intersection, there are an exclusive left-turn lane and a shared through/right-turn lane with a single receiving lane.

The land use surrounding the study intersection is retail and commercial. Commercial land use is located along Pennell Road and Concord Road, as shown in ***Figure 3***. Businesses around the intersection consist of a gas station, a pharmacy, a food establishment, and several small businesses, including insurance sales and bail bonds. In the area adjacent to the study intersection, the land use is mainly residential. Residential land uses, though predominantly single-family homes, include several multifamily structures located in the area. Neumann College is located northwest of the study intersection on Concord Road.

Figure 1
Congestion and Crash Site Analysis
Study Area
Pennell Rd. (PA 452), Concord Rd. & W. Knowlton Rd.
Aston Twp., Delaware Co., PA

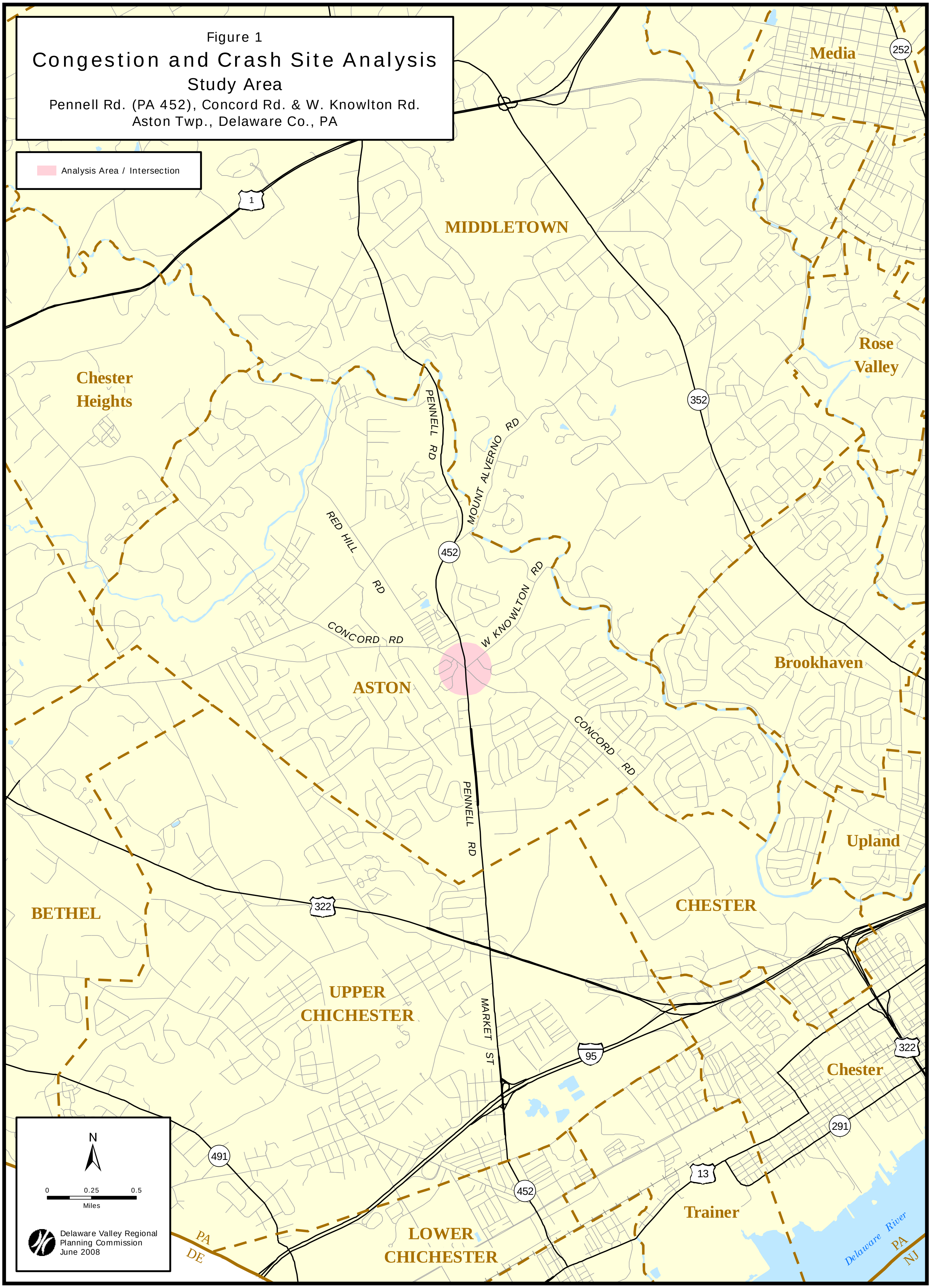


Figure 2

Congestion and Crash Site Analysis

Existing Lane Configuration

Pennell Rd. (PA 452), Concord Rd. & W. Knowlton Rd.
Aston Twp., Delaware Co., PA

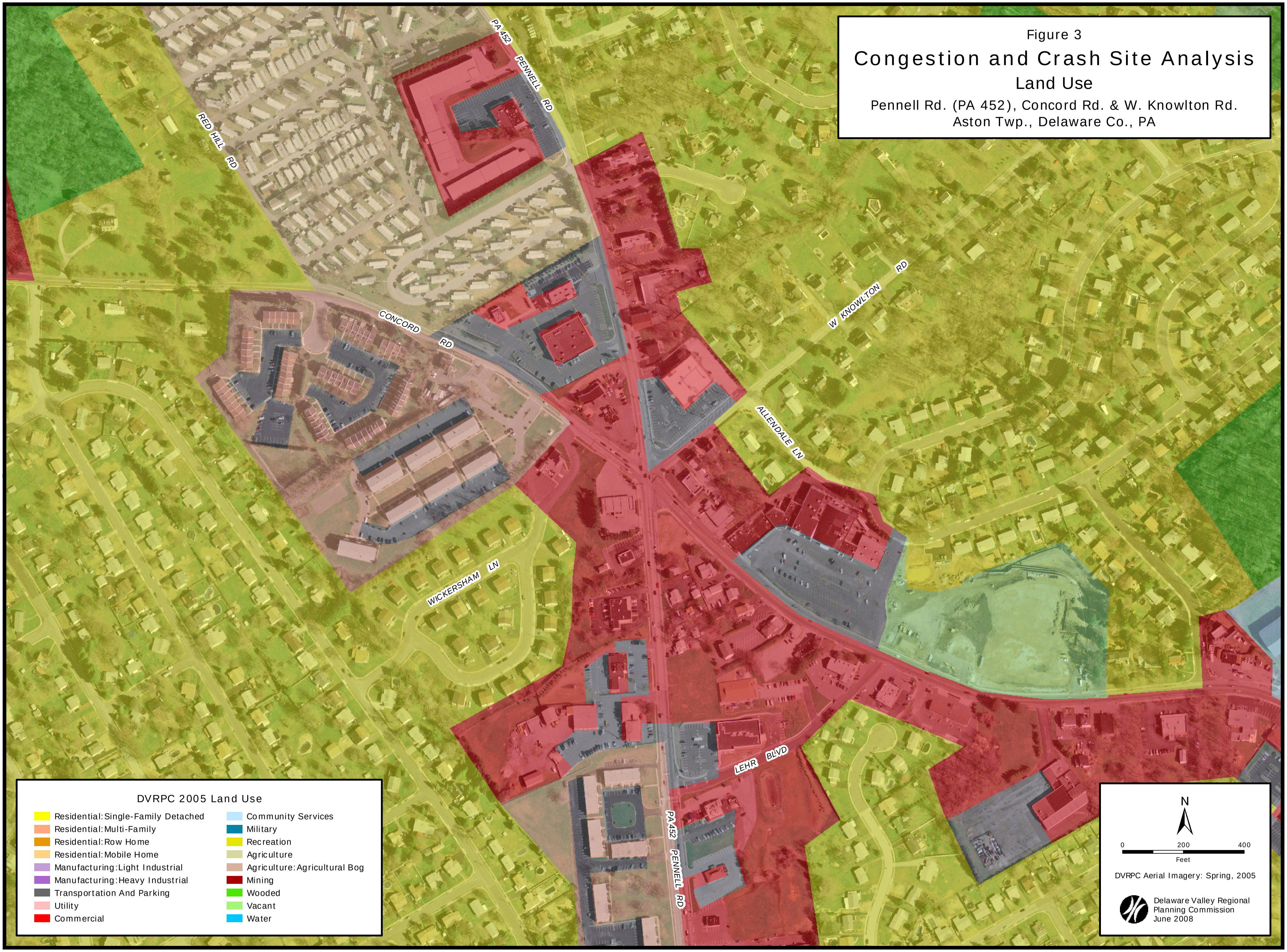


Figure 3
Congestion and Crash Site Analysis
Land Use
Pennell Rd. (PA 452), Concord Rd. & W. Knowlton Rd.
Aston Twp., Delaware Co., PA
PA 452 PENNELL RD
RED HILL RD
CONCORD RD
W KNOWLTON RD
ALLENDALE LN
WICKERSHAM LN
LEHR BLVD
PA 452 PENNELL RD
DVRPC 2005 Land Use
Residential:Single-Family Detached
Residential:Multi-Family
Residential:Row Home
Residential:Mobile Home
Manufacturing:Light Industrial
Manufacturing:Heavy Industrial
Transportation And Parking
Utility
Commercial
Community Services
Military
Recreation
Agriculture
Agriculture:Agricultural Bog
Mining
Wooded
Vacant
Water
N
0
200
400
Feet
DVRPC Aerial Imagery: Spring, 2005
Delaware Valley Regional
Planning Commission
June 2008

The SEPTA Bus Route 114 from Darby to Lima serves the study intersection. The eastbound bus makes a left turn from Pennell Road to Concord Road, circles Neumann College, and then makes a left turn from Concord Road to Pennell Road. The westbound bus makes a right turn from Pennell Road to Concord Road, circles Neumann College, and then makes a right turn from Concord Road to Pennell Road. This route provides connecting services at the Darby and Chester transportation centers and to several SEPTA Regional Rail R2 stations that connect Center City, Philadelphia to Wilmington, Delaware. Access to Taylor Hospital, Eddystone Shopping Center, I-95 Industrial Park, Bridgewater Industrial Park, Aston Industrial Park, Neumann College, Riddle Memorial Hospital, and Granite Run Mall is provided by this bus route. The 114 Bus Route provides 33 eastbound and 32 westbound trips per weekday, with an average daily boarding of 2,035.

EXISTING CONDITIONS

The five-leg intersection of Pennell Road, Concord Road, and Knowlton Road is located approximately 1.5 miles north of US 322, and approximately two miles from I-95, in Delaware County. This intersection experiences heavy commuter through movements to and from adjacent major roadways, as well as the surrounding residential areas. Concord and Pennell roads serve areas in which there are a limited number of options from major north-south or east-west roadways for the motoring public. As such these roads are utilized as relief roadways for traffic from the north and west, which would normally use US 322 to access points to the south and east, and vice versa.

Congestion

Daily Traffic Counts

Traffic counts taken in 2007 on Concord Road showed an average annual daily traffic (AADT) volume of 6,983 vehicles westbound between Pennell Road and Lehr Boulevard and 10,689 eastbound between Shubrook Lane and Village Drive. As depicted in ***Figure 4***, Pennell Road experiences higher daily volumes than Concord Road. AADT volumes recorded on Pennell Road north of the study area, between Jessica Way and Concord Road, in 2007 were 8,351 vehicles in the southbound direction, and 9,913 vehicles in the northbound direction between Lehr Boulevard and Concord Road. The AADT volumes recorded on Pennell Road north of Weir Road/Marianville Road, also in 2007, were 18,576 vehicles for both directions. A total of 17, 487 vehicles were recorded in the same location in 2002. Knowlton Road had an AADT of 3,426 vehicles in the southbound direction in 2007.

Turning Movement Counts

Manual turning movement counts were taken at the intersection of Pennell Road, Concord Road, and Knowlton Road in July 2008 between the hours of 6:00 AM and 9:00 AM and between 3:00 PM and 6:00 PM. A peak-hour turning movement diagram is shown in ***Figure 5***. The morning peak hour is 7:30 AM to 8:30 AM and the afternoon peak hour is 4:45 PM to 5:45 PM.

During the morning peak hour, 2,310 vehicles traveled through the intersection. The dominant approach movement during this time is the northbound Pennell Road approach, with 646 vehicles, representing 28 percent of the intersection total. This approach has 55 percent of its morning peak-hour traffic making through movements to continue northbound on Pennell Road and 30 percent making a left turn for westbound Concord Road. For the southbound Pennell Road approach, 62 percent of the total morning peak hour volume (540 vehicles) continues on Pennell Road and 25 percent makes left turns for eastbound Concord Road. Both Concord Road approaches experience heavy right turns onto Pennell Road. For the westbound Concord Road approach, 35 percent of the total (520) during the morning peak hour makes right turns onto northbound Pennell Road and 34 percent of the eastbound approach total (419) makes right turns onto Pennell Road southbound. The dominant movement for the Concord Road approaches is the through movements. The Knowlton Road approach has 55 percent of its traffic headed for westbound Concord Road and 34 percent for

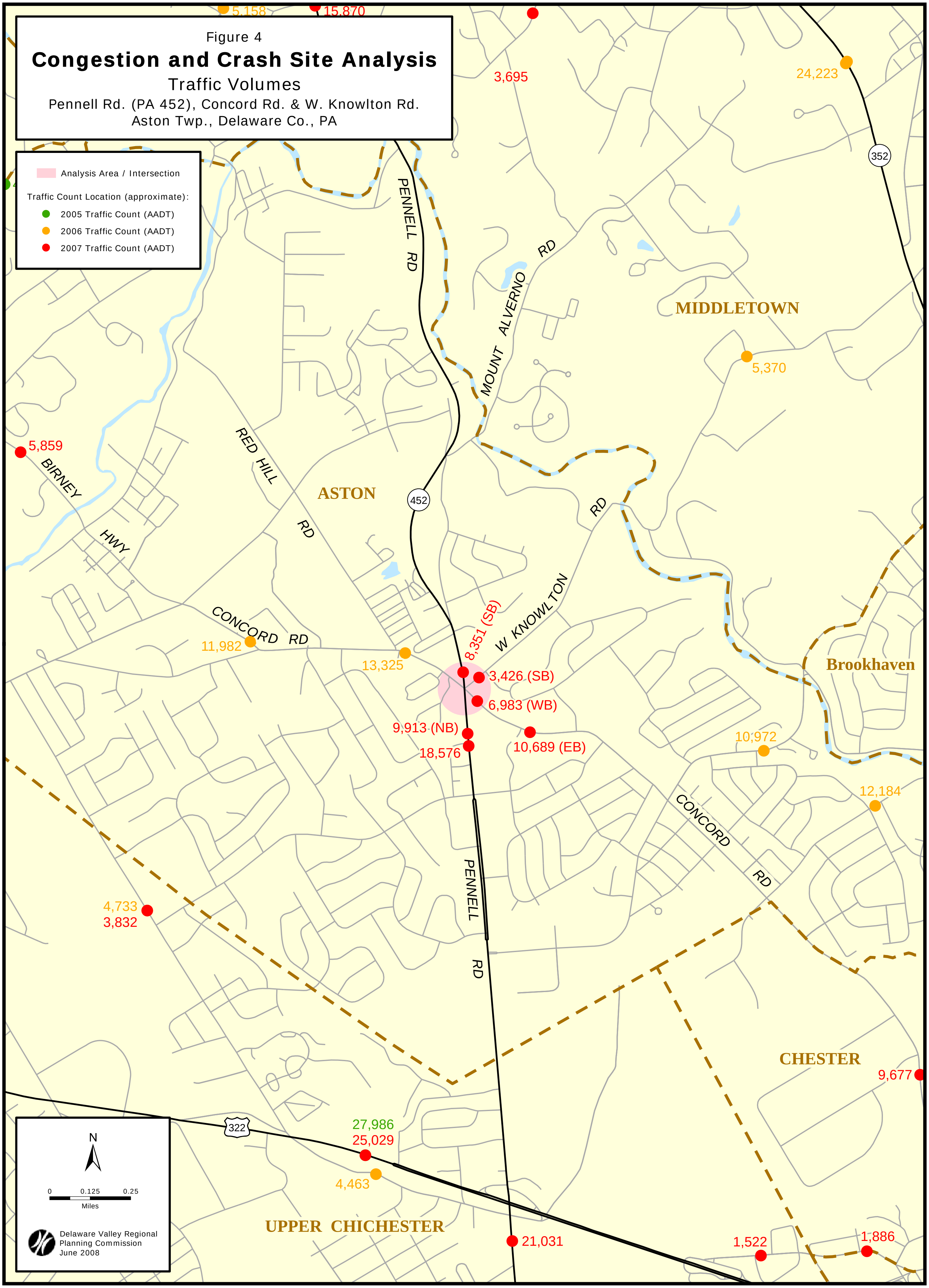
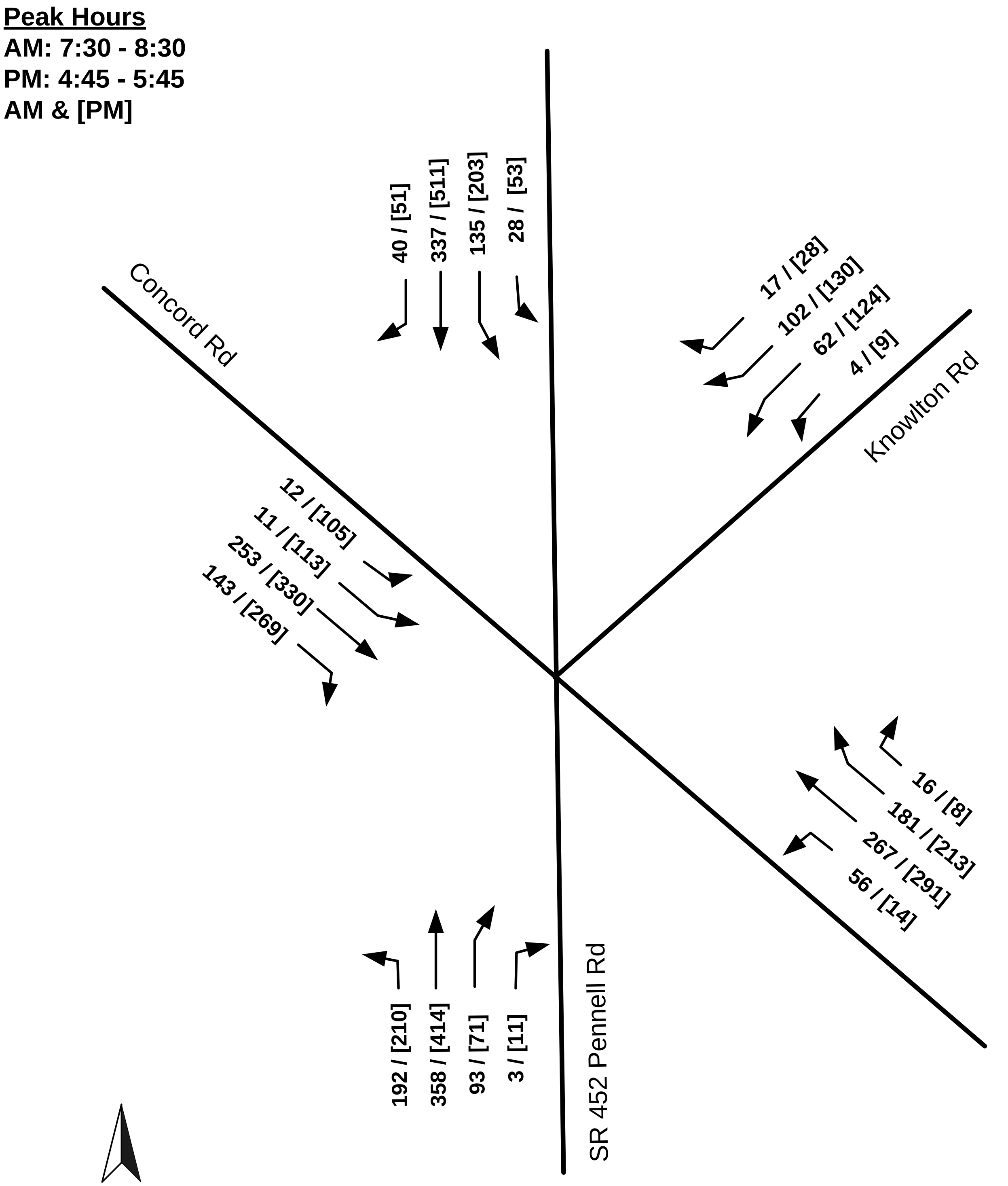


Figure 4
Congestion and Crash Site Analysis
Traffic Volumes
Pennell Rd. (PA 452), Concord Rd. & W. Knowlton Rd.
Aston Twp., Delaware Co., PA
Analysis Area / Intersection
Traffic Count Location (approximate):
2005 Traffic Count (AADT)
2006 Traffic Count (AADT)
2007 Traffic Count (AADT)
5,158
15,870
3,695
24,223
352
PENNELL RD
MOUNT ALVERNO RD
MIDDLETOWN
5,370
5,859
BIRNEY HWY
RED HILL RD
ASTON
452
RD
W KNOWLTON
CONCORD RD
11,982
13,325
8,351 (SB)
3,426 (SB)
6,983 (WB)
9,913 (NB)
18,576
10,689 (EB)
10,972
Brookhaven
12,184
CONCORD RD
PENNELL RD
4,733
3,832
CHESTER
9,677
322
27,986
25,029
4,463
UPPER CHICHESTER
21,031
1,522
1,886
N
0 0.125 0.25
Miles
Delaware Valley Regional Planning Commission
June 2008

Figure 5
Congestion and Crash Site Analysis
Existing Peak Hour Turning Movement Counts



SCHEMATIC NOT TO SCALE

Delaware Valley Regional Planning Commission
September 2008

southbound Pennell Road.

The afternoon peak-hour volumes are 37 percent higher than the morning peak-hour volumes. 3,158 vehicles traveled through the intersection during the afternoon peak hour, with the dominant approaches being southbound Pennell Road (818) and eastbound Concord Road (817). The dominant movement for these approaches is the through movements, but there are heavy left-turn movements (203) from southbound Pennell Road for eastbound Concord Road and heavy right-turn movements (269) from eastbound Concord Road for southbound Pennell Road. Northbound Pennell Road carries 22 percent of the afternoon peak-hour volume, and although the through movement is the dominant movement, 30 percent of the approach's total vehicles make left turns for westbound Concord Road. For the westbound Concord Road approach, 55 percent of the traffic continues through the intersection for points west and 41 percent make right turns onto northbound Pennell Road. Like the morning peak hour, the Knowlton Road approach's afternoon peak hour is dominated by right-turning traffic (45 %) for westbound Concord Road and traffic for Pennell Road southbound (43%). For Concord Road, heavy through movements are potential conflicts for the heavy left-turn movements eastbound. Likewise, for Pennell Road the heavy left-turn movements conflict with the heavy through movements in both directions.

Level of Service

SYNCHRO Traffic Analysis Software was utilized to evaluate the intersection's current performance levels and to compare the effectiveness of potential improvements. In its evaluations of intersection performance, SYNCHRO considers several factors, including, but not limited to, vehicular volume, intersection geometry, and signal timing. From this data, SYNCHRO is capable of providing a Level of Service (LOS) and the average delay-per-vehicle, as well as other measures of effectiveness. These measures are detailed for each movement and approach for the entire intersection.

***TABLE 2* – Existing Peak Hour Level of Service (LOS) Analysis**

Pennell Road, Concord Road, and Knowlton Road

Scenario	**Direction of Travel**	**2008 Peak AM Hour and Peak PM Hour LOS with Average Delay/Vehicle**			
Existing Conditions		AM Peak (121 sec)		PM Peak (121 sec)	
		LOS	Delay (sec)	LOS	Delay (sec)
	Pennell Road northbound	D	53	F	117
	Pennell Road southbound	D	46	F	226
	Concord Road eastbound	C	32	E	57
	Concord Road westbound	F	92	F	153
	Knowlton Road southbound	F	107	F	351
	Intersection	E	61	F	161

Source: DVRPC, 2008

As shown in ***Table 2,*** the intersection LOS is E in the morning peak period and F in afternoon peak period, with 61 and 161 seconds of delay, respectively. Westbound Concord Road and Knowlton Road southbound are the only intersection approaches that fail in both the morning and afternoon peak hours. The Pennell Road approaches have LOS D in the morning peak hour, with 53 seconds of delay northbound and 46 seconds southbound. Although both Pennell Road approaches have failing LOS in the afternoon peak, the delay for the southbound approach is 226 seconds, which is almost twice the length of the northbound delay of 117 seconds. Concord Road eastbound operates at a desirable LOS C during the morning peak hour and an undesirable LOS E for the afternoon peak period.

Safety

The crash analysis for this location focused on crashes occurring on all three routes within the intersection box and approximately 250 feet of the intersection along the five intersection approach legs.

Crash Data

The crash data used in this analysis was obtained from Police Crash Investigation Reports for years 2003 to 2006, provided by the Pennsylvania Department of Transportation (PennDOT) District 6 Office. For this study reportable crash reports were utilized. Reportable crashes are incidents that result in a fatality, an injury, and/or property damage that requires a vehicle to be towed from the scene.

The main goals of the crash analysis are to identify problematic areas, highlight crash trends, and determine causal factors. A collision diagram and a crash summary are utilized to aid in the analysis. The collision diagram is a graphic representation of the location, collision type, and frequency of vehicular crashes within the study area. The crash summary is the synopsis of various crash conditions obtained from the police reports. These are planning tools to assist in the identification of crash trends, which may be addressed through any combination of engineering improvements, increased enforcement, and/or educational campaigns.

Analysis

A total of 26 crashes occurred within the study limits between 2003 and 2006. Five crashes occurred in 2003, eight in 2004, four in 2005, and nine in 2006; this averages to approximately six per year. As shown in the crash summary provided in ***Table 3***, there were no recorded fatal crashes, two moderate crashes, 11 minor injury crashes, five crashes of unknown severity or injury, and eight property-damage-only crashes during the study period.

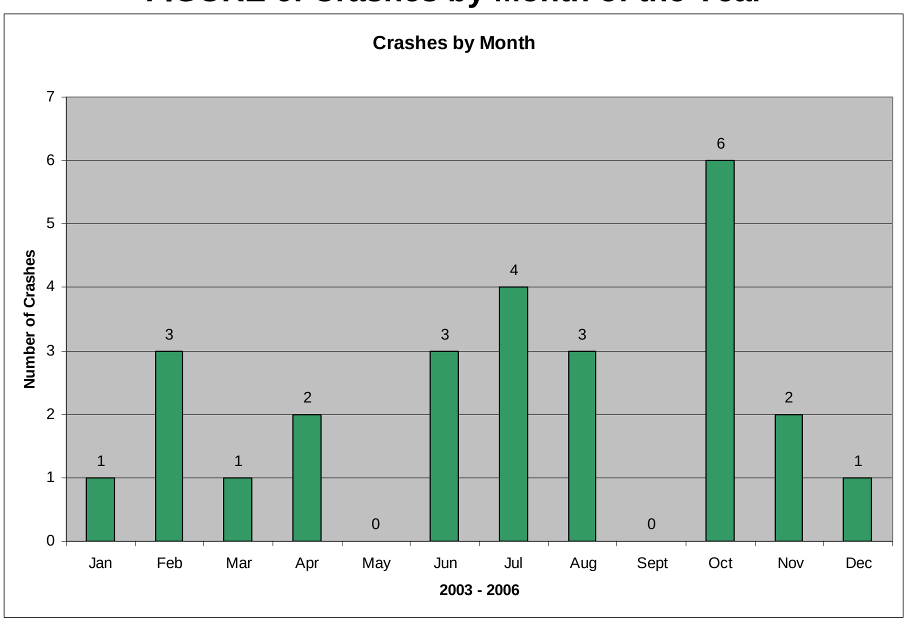
The highest percentage of crashes was coded as angle crashes, representing 53 percent, or 14 of the 26 total crashes. Due to the fact that the Pennsylvania crash reporting form relies on the point of impact between vehicles rather than precrash movements to characterize collision types, angle crashes can include a variety of precrash movements (e.g., left turns, entering and exiting driveways, and vehicles traveling in angular directions and opposing directions). Angle crashes are common at intersections and often result when drivers proceed into the intersection without proper clearance, as in red-light running or rushing to turn left at the beginning or ending of a signal cycle. This correlates positively with the heavy left-turn volume at this intersection.

Rear-end crashes were the second most frequent type, representing 34 percent. Rear-end accidents often correlate strongly with traffic congestion. Even though congestion is an issue at this intersection, nine rear-end crashes over a four-year period does not establish a significant trend. Two opposite-direction-sideswipe crashes and one hit-fixed-object crash constitute the remainder of the crash total.

Table 3 also shows crash percentages according to light and road surface conditions. Eighteen (69%) crashes occurred during daylight hours, seven (26%) crashes occurred at night under street lights, and one crash occurred at dusk. The majority of the crashes occurred when the road surface was dry (84%) and none of the crashes occurred under snowy or icy road surface conditions. Only one crash was recorded while it was raining. The other 25 occurred under clear skies.

Figures 6, 7, and 8 depict crashes by month of the year, day of the week, and time of the day, respectively. Crashes analyzed by month of the year showed no clear trend. There were six crashes in October, making it the busiest crash month of the year; no crashes were recorded in September or May. July had the next highest number of crashes at four. February, June, and August all had three crashes each. The remaining months had one or two crashes each over the study period.

FIGURE 6: Crashes by Month of the Year



Source: PennDOT

Table 3 - Intersection Crash Summary

DELAWARE CO INTERSECTION STUDY

Date Range: 1/1/2003 to 12/31/2006

USER ID/QUERY ID: lkubli/ 0620071207001

Area of Interest: (In County 23 On State Route 0452(P) Between Segment 0080 Offset 1550 and Segment 0080 Offset 1850) or (In County 23 On State Route 0452(S) Between Segment 0081 Offset 1550 and Segment 0081 Offset 1850) or (In County 23 On State Route 3007(P) Between Segment 0054 Offset 1890 and Segment 0054 Offset 2245) or (In County 23 On

MONTH OF YEAR

	JAN	FEB	MAR	APR	JUN	JUL	AUG	OCT	NOV	DEC	
CRASHES	1	3	1	2	3	4	3	6	2	1	26
PCT	3%	11%	3%	7%	11%	15%	11%	23%	7%	3%	100%

DAY OF WEEK

	MON	TUE	WED	THR	FRI	SAT	
CRASHES	2	3	3	7	5	6	26
PCT	7%	11%	11%	26%	19%	23%	100%

HOUR OF DAY

	06	09	12	13	14	15	16	17	18	20	21	22	99	
CRASHES	1	3	2	2	1	1	1	6	3	1	2	1	2	26
PCT	3%	11%	7%	7%	3%	3%	3%	23%	11%	3%	7%	3%	7%	100%

YEAR

	CRASHES	PCT
2003	5	19%
2004	8	30%
2005	4	15%
2006	9	34%
TOTAL	26	100%

COLLISION TYPE

	CRASHES	PCT
ANGLE	14	53%
REAR END	9	34%
OPP DIR SS	2	7%
HIT FIX OBJ	1	3%
TOTAL	26	100%

CRASH SEVERITY LEVEL

	CRASHES	PCT
MODERATE	2	7%
MINOR	11	42%
UNK SEVERITY	4	15%
UNK IF INJURED	1	3%
PDO	8	30%
TOTAL	26	100%

SEVERITY COUNT

	PERSONS
FATALITIES	0
MAJOR	0
MODERATE	2
MINOR	13
UNK SEVERITY	6
UNK IF INJURED	2

DRIVER ACTIONS

	ACTIONS	PCT
NO CONTRIBUTING ACTION	52	41%
IMPROPER/CARELESS TURN	20	16%
OTHER IMPROPER DRIVING	12	9%
DRIVER WAS DISTRACTED	11	8%
IMPROPER ENTRANCE HWY	8	6%
UNKNOWN	4	3%
SUDDEN SLOWING/STOP	3	2%
TOO FAST FOR CONDITION	3	2%
CARELESS PASS/LN CHNG	2	1%
FAILR MAINT PROP SPEED	2	1%
PROCEED W/O CLEARANCE	2	1%
RUNNING RED LIGHT	2	1%
OTHERS	4	3%
TOTAL	125	100%

VEHICLE TYPE

	VEHICLES	PCT
AUTOMOBILE	35	66%
SUV	8	15%
SMALL TRUCK	6	11%
LARGE TRUCK	2	3%
MOTORCYCLE	1	1%
VAN	1	1%
PEDALCYCLE	1	1%
TOTAL	53	100%

ROAD CONDITION

	CRASHES	PCT
DRY	22	84%
WET	4	15%
TOTAL	26	100%

ILLUMINATION

	CRASHES	PCT
DAYLIGHT	18	69%
STREET LIGHTS	7	26%
DUSK	1	3%
TOTAL	26	100%

WEATHER

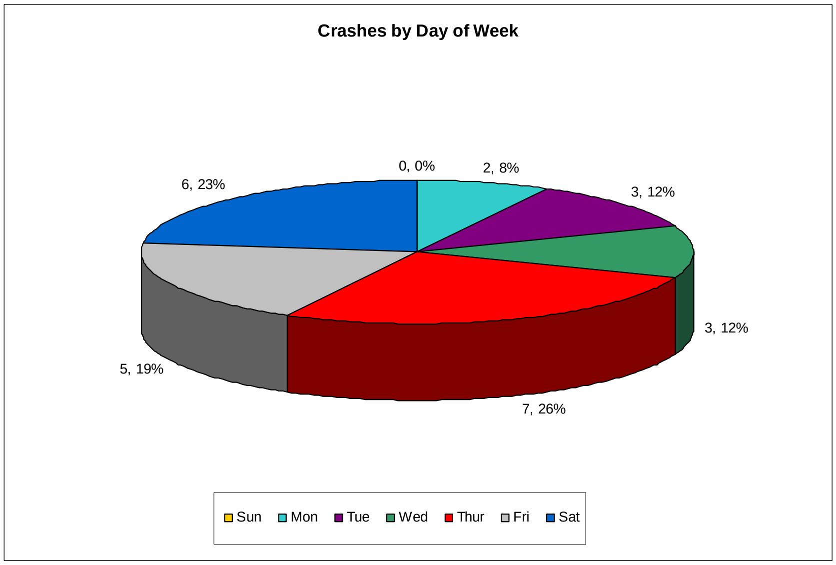
	CRASHES	PCT
CLEAR	25	96%
RAIN	1	3%
TOTAL	26	100%

ENVIR/ROADWAY FACTORS

	FACTORS	PCT
NONE	35	100%
TOTAL	35	100%

Crash totals by day of week reveals that the end of the week Thursday, Friday, and Saturday was when most of the crashes occurred. These three days accounted for 68 percent of the total crashes for the study period. Sunday was the only day which did not have crashes recorded. Monday, Tuesday, and Wednesday had between two and three crashes occurring during the study period.

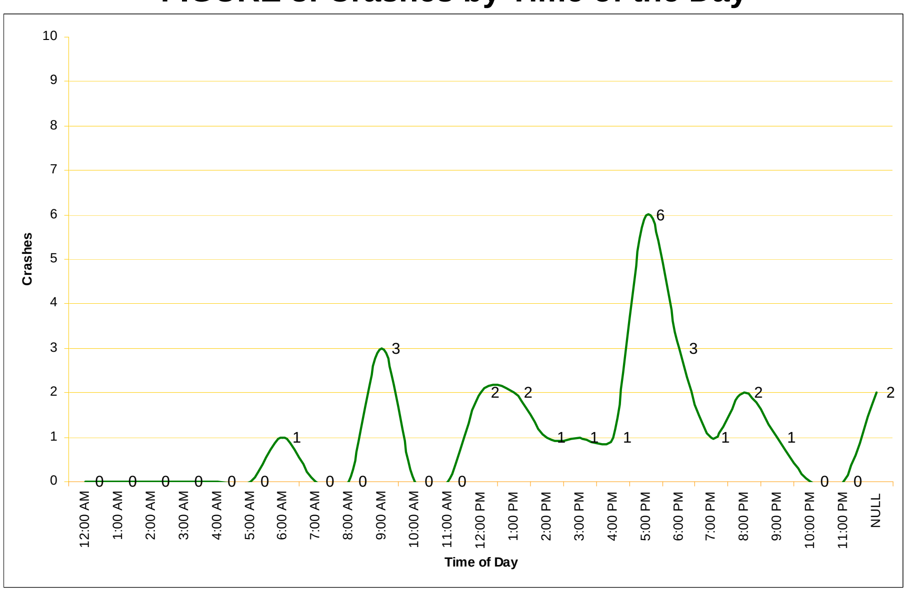
FIGURE 7: Crashes by Day of the Week



Source: PennDOT

Forty-four percent of the crashes occurred during the afternoon peak period, between 4:00 PM and 7:00 PM. As shown in ***Figure 8,*** there was a spike in crash occurrences during the morning peak and around midday.

FIGURE 8: Crashes by Time of the Day



Source: PennDOT

As depicted in ***Figure 9***, three of the intersection's five legs standout with higher crash frequencies. The Concord Road westbound approach leg and the Pennell Road northbound approach leg each experienced five crashes, accounting for 38.5 percent of the total when combined. The Pennell Road southbound approach leg was second with four crashes, accounting for approximately 15 percent. The Knowlton Road southbound and Concord Road eastbound legs experienced one and two crashes, respectively.

Approximately 35 percent of the crashes occurred within the intersection box. Eight of the nine crashes occurring within the intersection box were angle crashes. Given the congestion and heavy left-turn movements at the intersection, the abundance of angle crashes can be attributed to aggressive driving brought on by impatient motorists waiting too long to clear the intersection.

Of note is the angle crashes associated with the driveways of businesses located around the intersection. Six of the 14 total angle crashes for the study period occurred at driveways.

Pedestrian and Bicycle Amenities

Currently, there are no bicycle amenities in the study area. The roadways do not have shoulders; therefore, bicyclists are forced to share the travel lanes or, in some cases, utilize the sidewalks. There are no "share the road" signs to alert motorists of these road users. There was one crash involving a bicyclist on Pennell Road.

The status of sidewalks in the study area is mixed. The sidewalk around the Rite-Aid Pharmacy is in good condition and is wide enough to accommodate mobility devices of the physically challenged. On the opposite side on Knowlton Road, a sidewalk is also available, but it is not in good condition and it ends abruptly north of the study intersection. On the west side of Pennell Road there are no sidewalks, and this condition extends on to Concord Road on the westbound side. On the eastbound side of Concord Road adjacent to the gas station, narrow sidewalks are available. Due to wide open driveways on the westbound side of Concord Road east of the intersection, sidewalks are not present and can prove unsafe for pedestrians traveling in this area.

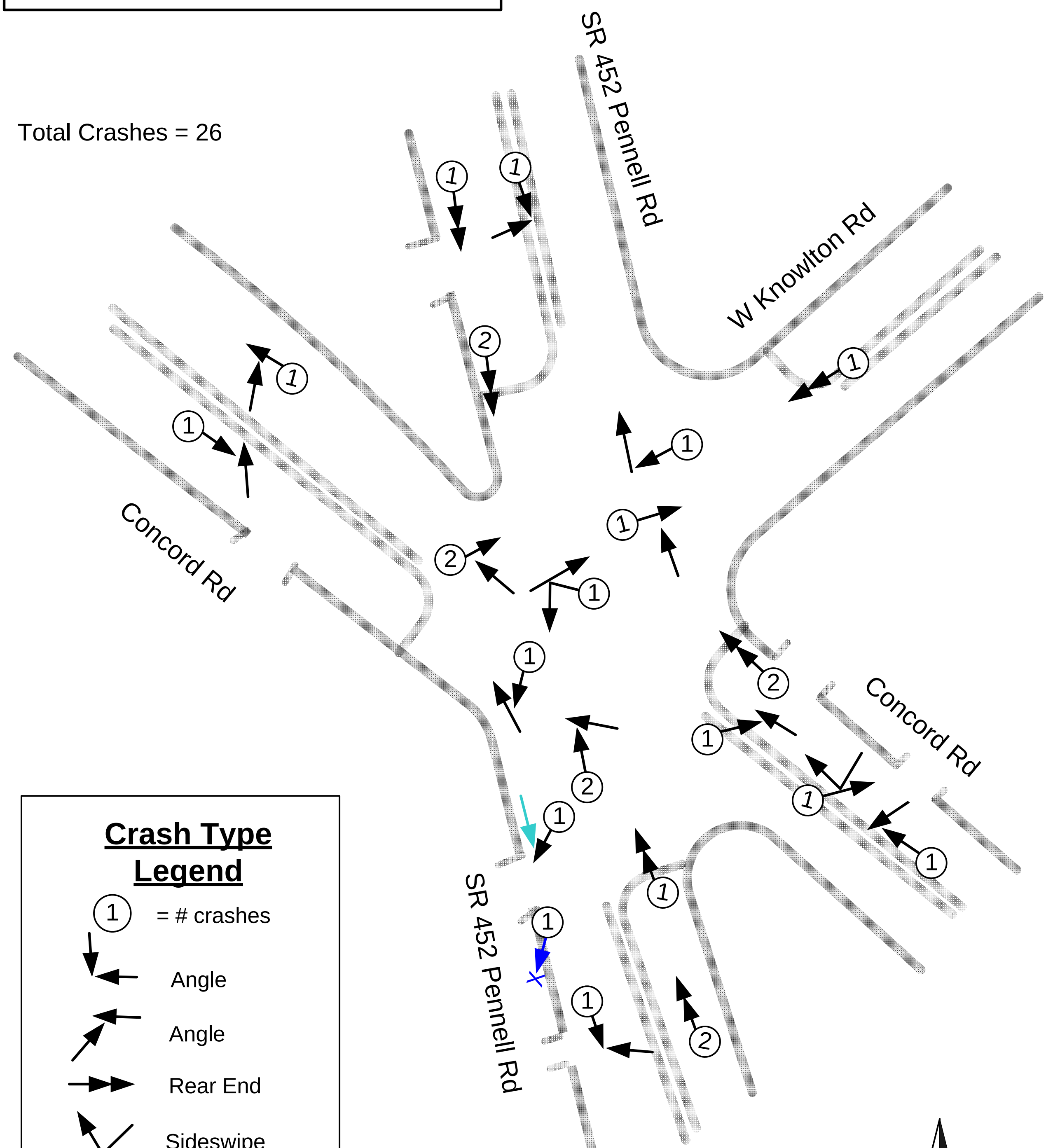
In addition, throughout the study area, curb ramps are missing or are not ADA (American with Disabilities Act) compliant. The traffic signals at the intersection have no pedestrian indication.

Access Management

The access issue at the study location is the proximity of driveways to the intersection. In addition to the close proximity of driveways, motorists are allowed to make left turns from these driveways across multiple lanes during congested traffic conditions. The business just east of the study intersection on Concord Road has open access/egress, which can result in confusion for road users.

Figure 9
Congestion and Crash Site Analysis
Collision Diagram
Crash Data Years 2003 - 2006

Total Crashes = 26



Crash Type Legend

- ① = # crashes
- Angle
- Angle
- Rear End
- Sideswipe
- Bicycle

Possible Miscoding

- Hit Fixed Object "Angle"

SCHEMATIC NOT TO SCALE

Delaware Valley Regional Planning Commission
May 2008

Pavement Markings
Pavement markings in the study area are faded in some areas. Crosswalks are the minimum required by Manual of Uniform Traffic Control Devices guidelines and are fading.

Transit
Due to the acute angle, SEPTA buses making the right turn from southbound Pennell Road to westbound Concord Road have major problems accomplishing that maneuver. This has resulted in traffic tie-up at and in the intersection.

Existing Signal Timing
The existing signal timing has two separate programs: one operates during the weekday afternoon peak period and the other is responsible for all other times. However, their timings are nearly identical, each with maximum cycle lengths of 121 seconds. Both programs provide signal protection for left turns from either Pennell Road approach, with the allowance of concurrent through and right-turn movements if no opposing and thus conflicting movements are detected. This phase provides up to 10 seconds of green time. During Pennell Road's through movement phase, its left turns are permitted; the green time for this phase is a maximum of 34 seconds. Both timing programs also provide a lead phase for the eastbound Concord Road approach. As a result, all of the movements for this approach are signal protected for up to 16 seconds of green time. Afterwards, both Concord Road approaches are provided up to 18 seconds of green time, during which eastbound left turns are prohibited. Lastly, both programs provide an exclusive phase for the Knowlton Road approach; this is the only opportunity for these vehicles to enter the intersection. All of the movements from this approach are protected for up to nine seconds of green time.

OPPORTUNITIES AND CONSTRAINTS

Pennell and Concord roads are important commuter routes in Delaware County and other important destinations. Knowlton Road serves both through traffic and destination traffic for residential developments located in and around the area. As a result there are heavy traffic movements within the study area.

High or increasing traffic volumes in the past usually led to widening of the right-of-way to accommodate additional lanes. The study intersection vehicular capacity is limited. The intersection currently occupies all the existing right-of-way, and all areas of the intersection are developed. Therefore, any required lane increase would require right-of-way acquisition.

Signal upgrade and retiming to provide for improved safety, efficiency, and operation of the intersection will have to be considered, but there are limitations to the level of improvement that these measures can provide within the existing parameters. Given the high number of angle crashes at the intersection, improvement strategies will examine the addition or extension of the “all red” phase/s. Modification of the “all red” phase may also be beneficial to the overall operation of the intersection. Although the addition of the “all red” phase will not necessarily reduce red-light running, it will provide additional clearance time that can help to prevent crashes if red-light running occurs in the first few seconds of the red intervals.

The intersection is extremely wide. As a result, vehicles have to travel longer distances to clear the intersection. Given its geometry (width and configuration), a roundabout was considered but dismissed because of the traffic volume and the right-of-way restrictions.

According to *DVRPC Publication No. 00002, US 322 Traffic Study I-95 to US 1, Supplement No.1*, it is projected that with the completion of the US 322 widening project, traffic volumes at the intersection will be affected. Vehicular volumes are projected to decrease along US 322 parallel routes such as Concord Road and increase for feeder routes like Pennell Road with the widening. The current Transportation Improvement Program shows construction on the US 322 widening slated to begin in 2012.

POTENTIAL IMPROVEMENT SCENARIOS

Intersection of Pennell Road, Concord Road, and Knowlton Road

Several alternatives were evaluated for the study intersection. Five are considered short term, as they involve changes to the signal timing only. Two medium-term alternatives incorporate geometric changes that can be implemented mainly within the existing right-of-way while including revisions to the timing plan. The remaining alternatives are regarded as long term, as they involve either geometric alterations or the rerouting of traffic that would occur beyond the existing right-of-way. For the development of the alternative strategies, there is a focus upon safely accommodating particularly heavy turning movements.

Short-Term Scenarios:

Scenario 1
Characteristics

- Optimize the existing signal's splits and cycle lengths.
- Retain the existing signal protection for Pennell Road, Knowlton Road, and eastbound Concord Road left turns.

Advantages

- Timing revisions may be implemented in the short term.
- Implementation costs are minimal.
- Optimization provides splits and cycle lengths that are more appropriate for current peak-hour traffic patterns and volumes.

Disadvantages

- Some approaches may experience longer delays than existing conditions.
- Longer cycle lengths may require greater storage lengths for left- and right-turn lanes.

Level of Service Analysis
As shown in ***Table 4***, the morning peak hour overall delay is 59 seconds (LOS E). This represents a two-second improvement from existing conditions. Cycle length is reduced to 100 seconds. LOS for all approaches remains the same as existing conditions, but only eastbound Concord Road does not have a change in delay. Westbound Concord Road experiences the largest decrease in delay at nine seconds, while southbound Pennell Road has the highest increase at six seconds.

For the afternoon peak hour, LOS for the intersection remains at F, but there has been a 30-second reduction in delay. Cycle length is increased from the existing 121 seconds to 150 seconds. All approaches operate at a failing LOS, with Knowlton Road continuing to experience the highest delay measures of almost three minutes, but this approach also shows the greatest improvement over the existing conditions, with 2 minutes and

53 seconds reduction in delay. Of the other four approaches, only southbound Pennell Road has a reduction in delay of 92 seconds.

TABLE 4 - Proposed Scenario 1 Peak-Hour Level of Service (LOS) Analysis				
2008 Peak AM Hour and Peak PM Hour LOS with Average Delay				
Existing Geometry with Revised Timing; Optimized Signal Plan				
Existing Volumes	**100 sec CL**		**150 sec CL**	
	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
Pennell Road-Northbound	D	48	F	132
Pennell Road-Southbound	D	52	F	134
Concord Road-Eastbound	C	32	F	84
Concord Road-Westbound	F	83	F	168
Knowlton Road	F	109	F	178
Intersection	E	59	F	131

Source: DVRPC, 2008

Scenario 2

Characteristics

- Optimize the existing signal's splits and cycle lengths.
- Retain the existing signal protection for Pennell Road, Knowlton Road, and eastbound Concord Road left turns.
- Add an additional second of "all red" time after the Pennell Road and Concord Road phases, resulting in three-second "all red" time
- Add signal protection for left turns from the westbound Concord Road approach to operate in conjunction with eastbound Concord Road left turns and continue to permit left turns at other times.

Advantages

- Timing revisions may be implemented in the short term.
- Implementation costs are minimal.
- Reduction of potential conflicts for westbound Concord Road left-turn movements.
- The additional second of "all red" phase will provide an increased buffer of clearance for vehicles in the intersection, especially those seeking to complete a left turn.
- Optimization provides splits and cycle lengths that are more appropriate for current peak-hour traffic patterns and volumes.

Disadvantages

- Some approaches may experience longer delays than existing conditions.
- Additional "all red" time contributes additional delay for all approaches.
- Opportunities for eastbound Concord Road through movements are reduced.

- Longer cycle lengths may require greater storage lengths for left- and right-turn lanes.

Level of Service Analysis

As shown in ***Table 5***, the morning peak hour overall delay is 64 seconds with LOS E. This represents a three-second improvement from existing conditions. Cycle length is reduced to 110 seconds. The delay for both the Pennell Road and eastbound Concord Road approaches increases over *Scenario 1*. LOS improvements are experienced by westbound Concord Road, which goes from LOS F to E. The northbound Pennell Road approach deteriorates from LOS D to E and the eastbound Concord Road approach from LOS C to E.

For the afternoon peak hour, LOS for the intersection remains at F, but there has been an eight-second increase in overall delay. All approaches operate at a failing LOS, with Knowlton Road continuing to experience the highest delay measures of almost three minutes. Both Pennell Road approaches and the eastbound Concord Road approach experiences increases in delay ranging between three and 19 seconds over *Scenario 1*.

TABLE 5 - Proposed Scenario 2 Peak-Hour Level of Service (LOS) Analysis

2008 Peak AM Hour and Peak PM Hour LOS with Average Delay

Existing Geometry with Revised Timing; Optimized Signal Plan with Increased "All Red" time and WB Concord Road Left Turns Protected/Permissive

Existing Volumes	**100 sec CL**		**150 sec CL**	
	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
Pennell Road-Northbound	E	67	F	135
Pennell Road-Southbound	D	53	F	153
Concord Road-Eastbound	E	57	F	90
Concord Road-Westbound	E	60	F	167
Knowlton Road	F	108	F	178
Intersection	E	64	F	139

Source: DVRPC, 2008

Scenario 3

Characteristics

- Retain the existing signal protection for Pennell Road, Knowlton Road, and eastbound Concord Road left turns.
- Add signal protection for left turns from the westbound Concord Road approach to operate in conjunction with eastbound Concord Road left turns and continue to permit left turns.
- Optimize the existing signal's splits and cycle lengths.

Advantages

- Reduction of potential conflicts for westbound Concord Road left-turn movements.
- Timing revisions may be implemented in the short term.
- Implementation costs are minimal.
- Optimization provides splits and cycle lengths that are more appropriate for current peak-hour traffic patterns and volumes.

Disadvantages

- Opportunities for eastbound Concord Road through movements are reduced.
- Some approaches may experience longer delays than existing conditions.
- Longer cycle lengths may require greater storage lengths for left- and right-turn lanes.

TABLE 6 - Proposed Scenario 3 Peak-Hour Level of Service (LOS) Analysis

2008 Peak AM Hour and Peak PM Hour LOS with Average Delay

Existing Geometry with Revised Timing
WB Concord Road Left Turns Protected/Permissive

Existing Volumes	**100 sec CL**		**150 sec CL**	
	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
Pennell Road-Northbound	D	52	F	132
Pennell Road-Southbound	D	55	F	134
Concord Road-Eastbound	E	70	F	90
Concord Road-Westbound	E	67	F	167
Knowlton Road	F	114	F	178
Intersection	E	65	F	133

Source: DVRPC, 2008

Level of Service Analysis

As shown in ***Table 6***, overall LOS for the morning peak hour remains at E, with an average delay of 65 seconds. This represents a four-second increase in delay over the existing conditions and a six-second increase over *Scenario 1*. In terms of delay, eastbound Concord Road is affected the most, with a 38-second increase and its LOS deteriorating from C in existing conditions and *Scenario 1* to E. Concord Road westbound had the best improvement of all the approaches, with a 25-second reduction in delay and an improved LOS from F to E.

For the afternoon peak hour, LOS remains at F, with 133 seconds of overall delay for the intersection. All of the intersection approaches operate in the same way as *Scenario 1*, with the exception of eastbound Concord Road, which has an increase in delay of six seconds.

Scenario 4
Characteristics

- Retain the existing signal protection for Pennell Road, Knowlton Road, and eastbound Concord Road left turns.
- Add signal protection for left turns from the westbound Concord Road approach to operate in conjunction with eastbound Concord Road left turns.
- Optimize the existing signal's splits and cycle lengths.

Advantages

- Reduces potential conflicts for westbound Concord Road left-turn movements.
- Timing revisions may be implemented in the short term.
- Implementation costs are minimal.
- Optimization provides splits and cycle lengths that are more appropriate for current peak-hour traffic patterns and volumes.

Disadvantages

- Opportunities for eastbound Concord Road through movements are reduced.
- Permissive westbound Concord Road left turns are prohibited.
- Some approaches may experience longer delays than existing conditions.
- Longer cycle lengths may require greater storage lengths for left- and right-turn lanes.
-

TABLE 7 - Proposed Scenario 4 Peak-Hour Level of Service (LOS) Analysis

2008 Peak AM Hour and Peak PM Hour LOS with Average Delay

Existing Geometry with Revised Timing
WB Concord Road Left Turns Protected ONLY

Existing Volumes	**100 sec CL**		**150 sec CL**	
	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
Pennell Road-Northbound	E	55	F	132
Pennell Road-Southbound	E	62	F	134
Concord Road-Eastbound	E	68	F	90
Concord Road-Westbound	E	66	F	169
Knowlton Road	F	125	F	178
Intersection	E	67	F	133

Source: DVRPC, 2008

Level of Service Analysis
As shown in ***Table 7***, overall LOS for the morning peak hour remains at E, with an average overall delay of 67 seconds. This represents a six-second increase in delay over the existing conditions and a two-second increase over *Scenario 3*. In terms of approach delay, eastbound Concord Road is affected the most, with a 36 second increase over existing conditions and LOS deteriorating from C to E. Of all the

approaches, Concord Road westbound had the most improvement, with a 26-second reduction in delay and improvement from a failing LOS to E. Compared to *Scenario 3,* all approaches except the Concord Road approaches experience an increase in delay, with Knowlton Road experiencing the highest increase. Both Pennell Road approaches went from LOS D to LOS E. Overall, the afternoon LOS and delay for the intersection as well as the individual approaches remains the same as *Scenario 3.*

Scenario 5

Characteristics

- Provide each approach leg of Pennell Road with its own signal phase, thus making all movements, including through and right turns, signal protected.
- Eliminate all permissive turning movements, excluding currently allowed right-turn-on-reds.
- Optimize the signal timing splits and cycle lengths.

Advantages

- The potential for conflicts between opposing movements on Pennell Road is virtually eliminated.
- Timing revisions may be implemented in the short term.
- Implementation costs are minimal.
- Optimization provides splits and cycle lengths that are more appropriate for current peak-hour traffic patterns and volumes.

Disadvantages

- Some approaches may experience longer delays than existing conditions.
- Longer cycle lengths and longer dwell times for each approach leg may require greater storage lengths.

Level of Service Analysis

As shown in ***Table 8***, during the morning peak hour, the intersection operates at LOS F, with 88 seconds of overall delay. The cycle length increases to 150 seconds and all approaches are failing except eastbound Concord Road. Southbound Pennell Road experiences the greatest increase in delay when compared to the existing conditions, with an additional 47 seconds. For the other approaches, increases in delay range from 15 to 29 seconds.

For the afternoon peak hour, the overall average delay increases by 26 seconds over the existing conditions for the intersection. The southbound Pennell Road and Knowlton Road approaches experience a reduction in delay of 17 seconds and 107 seconds, respectively, over the existing conditions. The increase in delay of the other approaches over the existing conditions ranges from 55 seconds for northbound Pennell Road to 83 seconds for westbound Concord Road. The southbound Pennell Road, the westbound Concord Road, and the Knowlton Road approaches have delays of over 200 seconds.

TABLE 8 - Proposed Scenario 5 Peak-Hour Level of Service (LOS) Analysis				
2008 Peak AM Hour and Peak PM Hour LOS with Average Delay				
Existing Geometry with Revised Timing Split phase for Northbound and Southbound Pennell Road				
Existing Volumes	150 sec CL		150 sec CL	
	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
Pennell Road-Northbound	F	82	F	172
Pennell Road-Southbound	F	93	F	209
Concord Road-Eastbound	D	50	F	120
Concord Road-Westbound	F	107	F	236
Knowlton Road	F	129	F	244
Intersection	F	88	F	187

Source: DVRPC, 2008

Medium-Term Scenarios

Scenario 6

Characteristics

- Introduce a yield-controlled channelized right-turn lane for the southbound Pennell Road approach.
- Optimize the existing signal timing splits and cycle lengths.
- Retain the existing signal protection for Pennell Road, Knowlton Road, and eastbound Concord Road left turns.

Advantages

- The channelized right turn may provide a greater turning radius, thus improving operations for this movement.
- Optimization provides splits and cycle lengths that are more appropriate for current peak-hour traffic patterns and volumes.

Disadvantages

- The introduction of the channelized right-turn lane may require minor right-of-way acquisition in the vicinity of the triangular property currently occupied by Zac's Hamburgers.
- Longer cycle lengths may require greater storage lengths for left- and right-turn lanes.
- Some approaches may experience longer delays than existing conditions.

Level of Service Analysis

As shown in ***Table 9***, the overall intersection operates at LOS E, with 59 seconds of delay for the morning peak hour. This is a two-second improvement from existing conditions and is the same as *Scenario 1*, which entails an optimization of the existing signal timings. The geometrically improved southbound Pennell Road approach operates with a delay that is only one second less than it is in *Scenario 1*. Similar to previous alternatives, the most congested approaches are westbound Concord Road and Knowlton Road. The LOS for all approaches is the same as existing conditions.

TABLE 9 - Proposed Scenario 6 Peak-Hour Level of Service (LOS) Analysis				
2008 Peak AM Hour and Peak PM Hour LOS with Average Delay				
Existing Geometry with Revised Timing Southbound Pennell Road Channelized Right Turn				
Existing Volumes	**100 sec CL**		**150 sec CL**	
	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
Pennell Road-Northbound	D	48	F	132
Pennell Road-Southbound	D	51	F	133
Concord Road-Eastbound	C	32	F	84
Concord Road-Westbound	F	83	F	168
Knowlton Road	F	109	F	178
Intersection	E	59	F	131

Source: DVRPC, 2008

For the afternoon peak hour, the overall intersection experiences 131 seconds of delay, for a failing LOS; but there is an improvement in delay over the existing conditions, and this is the same as in *Scenario 1*. Westbound Concord Road and Knowlton Road remain the worst performing of all the approaches during the afternoon peak. Both Pennell Road approaches experience more than two minutes of delay during the afternoon peak hour.

Scenario 7

Characteristics

- Introduce a yield-controlled channelized right-turn lane for the southbound Pennell Road approach.
- Optimize the existing signal timing splits and cycle lengths.
- Introduce a signal protected left-turn phase for westbound Concord Road.
- Retain the existing signal protection for Pennell Road, Knowlton Road, and eastbound Concord Road left turns.

Advantages

- The channelized right turn may provide a greater turning radius, thus improving operations for this heavy turn movement.
- Reduces potential conflicts for westbound Concord Road left-turn movements.
- Optimization provides splits and cycle lengths that are more appropriate for current peak-hour traffic patterns and volumes.

Disadvantages

- The introduction of the channelized right-turn lane may require minor right-of-way acquisition in the vicinity of the triangular property currently occupied by Zac's Hamburgers.
- Longer cycle lengths may require greater storage lengths for left- and right-turn lanes.
- Some approaches may experience longer delays than existing conditions.
- Opportunities for eastbound Concord Road through movements are reduced.

Level of Service Analysis

As shown in ***Table 10***, the morning peak hour operates at LOS E, with 64 seconds of delay for the intersection. This is a three-second delay increase over existing conditions, and a delay of five seconds more than in *Scenario 6.* All approaches show an increase in delay over *Scenario 6* except westbound Concord Road, which improves from LOS F to E. Eastbound Concord Road declines from LOS C to E when compared with *Scenario 6*. Similar to previous alternatives, the most congested approach is Knowlton Road.

For the afternoon peak hour, the intersection experiences 133 seconds of overall delay, for a failing LOS, though it is an improvement in overall delay over the existing conditions. The westbound Concord Road and Knowlton Road approaches remain the worst performing of all the approaches during the afternoon peak. Both Pennell Road approaches experience more than two minutes of delay during this peak hour.

TABLE 10 - Proposed Scenario 7 Peak-Hour Level of Service (LOS) Analysis

2008 Peak AM Hour and Peak PM Hour LOS with Average Delay

Existing Geometry with Revised Timing
Southbound Pennell Road Channelized Right Turn and Protected/Permissive Westbound Concord Road Left Turns

Existing Volumes	**100 sec CL**		**150 sec CL**	
	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
Pennell Road-Northbound	D	52	F	132
Pennell Road-Southbound	D	54	F	133
Concord Road-Eastbound	E	70	F	90
Concord Road-Westbound	E	67	F	167
Knowlton Road	F	114	F	178
Intersection	E	64	F	133

Source: DVRPC, 2008

Long-Term Scenarios:

Scenario 8

Characteristics

- Convert Knowlton Road into a one-way approach, where vehicles are prohibited from entering the intersection.
- Utilize none of the current entering volume from the Knowlton Road approach into the rerouting.
- Optimize the signal’s splits and cycle lengths after removing the Knowlton Road phase.
- Retain the existing signal protection for Pennell Road and eastbound Concord Road left turns.

Advantages

- The removal of a timing phase from the signal plan, since no accommodation must be made for vehicles entering the intersection via Knowlton Road.
- Optimization provides splits and cycle lengths that are more appropriate for current peak-hour traffic patterns and volumes.

Disadvantages

- The diversion of vehicles onto, and higher volumes upon, residential connector roads.
- Increased travel time and distance for vehicles currently entering the intersection via the Knowlton Road approach.
- Increased turning movements and complexity at the intersection of Knowlton Road and Allan Dale Lane.
- Necessity to add a road connection between Robin Hood Lane and the shopping center entrance opposite Lehr Boulevard.
- Longer cycle lengths may require greater storage lengths for left- and right-turn lanes.

Level of Service Analysis

As shown in ***Table 11***, the intersection operates at LOS C, with an average overall delay of 34 seconds during the morning peak hour. This represents a 27-second improvement from existing conditions and a 25-second improvement from the exclusively timing-optimized *Scenario 1*. All approaches operate at LOS C, with 24 seconds of delay, except westbound Concord Road, which operates at LOS E, with 65 seconds of delay.

The afternoon peak hour shows improvement over all previous scenarios and the existing conditions. With this scenario the LOS is E, with 74 seconds of overall delay. All approaches show a reduction in delay, while only westbound Concord Road retains a failing LOS.

TABLE 11 - Proposed Scenario 8 Peak-Hour Level of Service (LOS) Analysis				
2008 Peak AM Hour and Peak PM Hour LOS with Average Delay				
Existing Geometry with Revised Timing Knowlton Road – One Way Northbound, 0% Rerouted				
Existing Volumes	**80 sec CL**		**140 sec CL**	
	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
Pennell Road-Northbound	C	24	E	75
Pennell Road-Southbound	C	24	E	77
Concord Road-Eastbound	C	24	D	51
Concord Road-Westbound	E	65	F	101
Knowlton Road	N/A	N/A	N/A	N/A
Intersection	C	34	E	74

Source: DVRPC, 2008

Scenario 9

Characteristics

- Convert Knowlton Road into a one-way approach, where vehicles are prohibited from entering the intersection.
- Reroute Knowlton Road's traffic onto the westbound Concord Road approach via Allan Dale Lane, Robin Hood Lane, and the shopping center entrance opposite Lehr Boulevard.
- Utilize 50 percent of the current entering volume from the Knowlton Road approach into the rerouting.
- Optimize the existing signal's splits and cycle lengths.
- Retain the existing signal protection for Pennell Road and eastbound Concord Road left turns.

Advantages

- The removal of a signal phase from the signal plan, since no accommodation must be made for vehicles entering the intersection via Knowlton Road.
- Optimization provides splits and cycle lengths that are more appropriate for current peak-hour traffic patterns and volumes.

Disadvantages

- The diversion of vehicles onto, and higher volumes upon, residential connector roads.
- Increased travel time and distance for vehicles currently entering the intersection via the Knowlton Road approach.
- Increased turning movements and complexity at the intersection of Knowlton Road and Allan Dale Lane.
- Necessity to add a road connection between Robin Hood Lane and the shopping center entrance opposite Lehr Boulevard.

- Longer cycle lengths may require greater storage lengths for left- and right-turn lanes.

Level of Service Analysis

As shown in ***Table 12***, the intersection operates at LOS C, with an average overall delay of 34 seconds during the morning peak hour. This represents a 27-second improvement from existing conditions, a 25-second improvement from the exclusively timing-optimized *Scenario 1*, and the same overall delay as *Scenario 8*. All approaches operate at LOS C, except westbound Concord Road, which operates at LOS D, with 51 seconds of delay. The Pennell Road approaches show an increase in delay from the previous *Scenario 8*.

The afternoon peak hour shows improvement over all previous scenarios and the existing conditions, except *Scenario 8*. With this scenario the LOS is E, with 83 seconds of delay. All approaches show a reduction in delay over the existing conditions and *Scenario 1,* though all approaches except westbound Concord Road show a delay increase over *Scenario 8*. However, only the eastbound Concord Road approach does not experience a failing LOS.

TABLE 12 - Proposed Scenario 9 Peak-Hour Level of Service (LOS) Analysis

2008 Peak AM Hour and Peak PM Hour LOS with Average Delay

Existing Geometry with Revised Timing
Knowlton Road – One Way Northbound, 50% of Traffic Rerouted

Existing Volumes	**90 sec CL**		**150 sec CL**	
	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
Pennell Road-Northbound	C	32	F	93
Pennell Road-Southbound	C	28	F	87
Concord Road-Eastbound	C	22	E	58
Concord Road-Westbound	D	51	F	96
Knowlton Road	N/A	N/A	N/A	N/A
Intersection	C	34	F	83

Source: DVRPC, 2008

Scenario 10

Characteristics

- Convert Knowlton Road into a one-way approach, where vehicles are prohibited from entering the intersection.
- Reroute Knowlton Road's traffic onto the westbound Concord Road approach via Allan Dale Lane, Robin Hood Lane, and the shopping center entrance opposite Lehr Boulevard.
- Utilize 100 percent of the current entering volume from the Knowlton Road approach into the rerouting.

- Optimize the existing signal's splits and cycle lengths.
- Retain the existing signal protection for Pennell Road, and eastbound Concord Road left turns.

Advantages

- The removal of a timing phase from the signal plan, since no accommodation must be made for vehicles entering the intersection via Knowlton Road.
- Optimization provides splits and cycle lengths that are more appropriate for current peak-hour traffic patterns and volumes.

Disadvantages

- The diversion of vehicles onto, and higher volumes upon, residential connector roads.
- Increased travel time and distance for vehicles currently entering the intersection via the Knowlton Road approach.
- Increased turning movements and complexity at the intersection of Knowlton Road and Allan Dale Lane.
- Necessity to add a road connection between Robin Hood Lane and the shopping center entrance opposite Lehr Boulevard.
- Longer cycle lengths may require greater storage lengths for left- and right-turn lanes.

TABLE 13 - Proposed Scenario 10 Peak-Hour Level of Service (LOS) Analysis

2008 Peak AM Hour and Peak PM Hour LOS with Average Delay

Existing Geometry with Revised Timing
Knowlton Road – One Way Northbound, 100% of Traffic Rerouted

Existing Volumes	**90 sec CL**		**150 sec CL**	
	AM Peak		PM Peak	
	LOS	Delay (sec)	LOS	Delay (sec)
Pennell Road-Northbound	C	34	F	109
Pennell Road-Southbound	C	32	F	101
Concord Road-Eastbound	C	21	E	61
Concord Road-Westbound	D	55	F	103
Knowlton Road	N/A	N/A	N/A	N/A
Intersection	D	38	F	94

Source: DVRPC, 2008

Level of Service Analysis

As shown in ***Table 13***, the intersection operates at LOS D, with an average overall delay of 38 seconds during the morning peak hour. This represents a 23-second improvement from existing conditions and a four-second increase in delay over *Scenarios 8 and 9*. All approaches operate at LOS C except westbound Concord Road, which operates at LOS D, with 55 seconds of delay. The Pennell Road and westbound Concord Road approaches show an increase in delay over *Scenario 9*.

The afternoon peak hour shows improvement over the existing conditions and all previous scenarios, except *Scenarios 8 and 9*. With this scenario the intersection LOS is F, with 94 seconds of overall delay. All approaches show an increase in delay over *Scenario 9* and all approaches except eastbound Concord Road are failing.

SUMMARY OF FINDINGS

- The intersection currently operates at an undesirable LOS E in the morning peak hour and a failing LOS F for the afternoon peak hours.
- The Knowlton Road and the westbound Concord Road approaches are the poorest performing in all the improvement scenarios except those with protected/permissive left turns for westbound Concord Road. This is mainly a result of an increased proportion of the cycle's green time allocation for westbound Concord Road.
- There are significant turning volumes at the intersection, as well as conflicting through movement.
- Turning radii at the intersection are minimal, resulting in awkward turning movements, especially for larger vehicles.
- More than half of the crashes occurring at this intersection are angle crashes.
- All corners of the intersection are already built out to the existing right-of-way limits.
- For the short-term alternatives, exclusively optimizing the signal timing *(Scenario 1)* provides the greatest reduction in overall delay, but it does not address the identified intersection safety issues.
- For the medium-term alternatives, *Scenario 6* displays the same LOS as *Scenario 1*, but it requires right-of-way acquisition.
- The long-term alternatives demonstrate overall and approach-specific delay reductions greater than those provided by all other alternatives analyzed.
- Converting Knowlton Road in the study area into one-way traffic northbound will greatly improve operations at the study intersection, but it will have adverse effects on the neighborhoods in the area.
- Access management is poor in the study area. Numerous driveways are close to the intersection, many with open access from which left turns are made in a congested area.
- There are no bike amenities. There are no shoulders or “share the road” signs.
- Pavement marking in the study area is faded.
- Pedestrian facilities are inconsistent.

RECOMMENDATIONS

All alternatives examined present shortcomings. A longer cycle length will create longer vehicle queues, and the rerouting of traffic will increase the volume along potential residential connector routes. These may be mitigated via longer storage bays for turn lanes and traffic calming measures, respectively.

Smart Transportation encourages looking beyond level of service exclusively. It is a collaborative approach to provide transportation solutions that strengthen and support communities. The Pennsylvania Department of Transportation has embraced the concepts and policies of *Smart Transportation*. At times, operational sacrifices are necessary to improve safety. The local road network in the area is sparse and disconnected this has resulted in heavy travel along these major road that connect at the study intersection. Enhancing the local road networks can provide viable travel alternatives which can potentially relieve some congestion and improve safety at the intersection.

For the short term, it is recommended that *Scenario 3* be employed; the introduction of a presence-actuated, protected left-turn phase for the westbound Concord Road approach operating in conjunction with the current eastbound protected left-turn phase. As mentioned earlier in the report, this will improve the operations of the intersection and reduce conflicts between the heavy eastbound through movements and westbound left turns along Concord Road. For this reason, *Scenario 7* is recommended for the medium term. This also improves the turning radius for right turns from southbound Pennell Road, which results in greater efficiency of movement through the intersection.

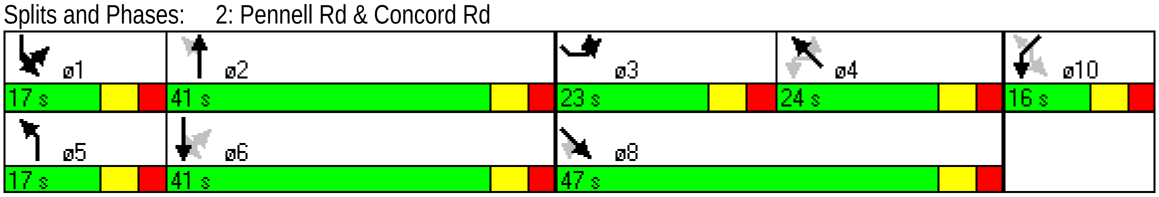
Central to the long-term alternatives is the rerouting of intersection-entering Knowlton Road traffic. Through the elimination of a phase during the signal cycle, overall delays are significantly reduced. Given the negative impacts of the long-term alternatives to the immediate residential neighborhood around the study area, this study does not recommend pursuing these alternatives unless there is another rerouting, other than those suggested in this report, which has less impact upon the neighboring residential land use.

There was one crash involving a bicyclist on Pennell Road. Install “share the road” signs to alert motorists of these road users. Install consistent sidewalks in the study area and add or replace curb ramps with ramps that are ADA compliant. Evaluate the study area for access issues and develop a plan for access management, and consider defining driveways and prohibiting left turns from driveways located in close proximity to the intersection. Restripe pavement markings in the area to make them more conspicuous, and consider using “continental” style striping for crosswalks.

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	192	358	93	3	28	135	337	40	12	11	253	143
Satd. Flow (prot)	1770	1859	0	0	0	1702	1937	0	0	1719	1810	1644
Flt Permitted	0.259					0.117				0.950		
Satd. Flow (perm)	482	1859	0	0	0	210	1937	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										183
Lane Group Flow (vph)	204	550	0	0	0	192	430	0	0	36	301	183
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	17.0	41.0	0.0	0.0	17.0	17.0	41.0	0.0	23.0	23.0	47.0	47.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	44.1	34.2				44.3	34.3			7.8	26.6	26.6
Actuated g/C Ratio	0.41	0.32				0.41	0.32			0.07	0.25	0.25
v/c Ratio	0.65	0.93				0.85	0.70			0.29	0.67	0.34
Control Delay	30.4	61.8				58.0	41.0			55.3	44.4	6.2
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	30.4	61.8				58.0	41.0			55.3	44.4	6.2
LOS	C	E				E	D			E	D	A
Approach Delay		53.3					46.2				31.7	
Approach LOS		D					D				C	

Intersection Summary	
Cycle Length: 121	
Actuated Cycle Length: 108	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.06	
Intersection Signal Delay: 60.6	Intersection LOS: E
Intersection Capacity Utilization 88.5%	ICU Level of Service E
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



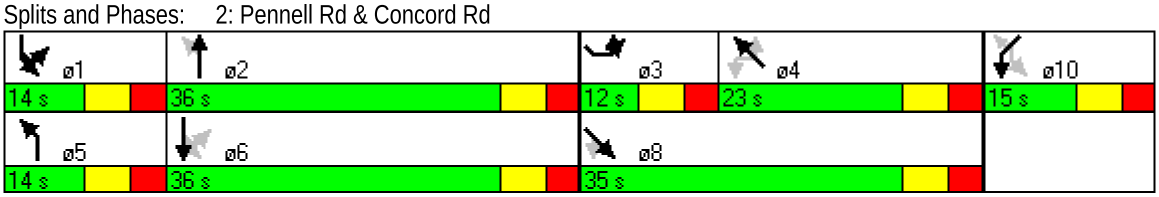
Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	56	267	181	16	4	62	102	17
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.577					0.950		
Satd. Flow (perm)	1044	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	76	310	229	0	0	84	136	0
Turn Type	Perm		Perm		Perm		Perm	
Protected Phases		4				10		
Permitted Phases	4		4		10		10	
Total Split (s)	24.0	24.0	24.0	0.0	16.0	16.0	16.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	17.5	17.5	17.5			9.0	9.0	
Actuated g/C Ratio	0.16	0.16	0.16			0.08	0.08	
v/c Ratio	0.45	1.06	0.86			0.60	1.01	
Control Delay	53.0	113.8	75.2			67.8	131.2	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	53.0	113.8	75.2			67.8	131.2	
LOS	D	F	E			E	F	
Approach Delay		91.9				107.0		
Approach LOS		F				F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	192	358	93	3	28	135	337	40	12	11	253	143
Satd. Flow (prot)	1770	1859	0	0	0	1702	1937	0	0	1719	1810	1644
Flt Permitted	0.277					0.125				0.950		
Satd. Flow (perm)	516	1859	0	0	0	224	1937	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										183
Lane Group Flow (vph)	204	550	0	0	0	192	430	0	0	36	301	183
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	14.0	36.0	0.0	0.0	14.0	14.0	36.0	0.0	12.0	12.0	35.0	35.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	39.1	32.1				39.1	32.1			5.0	23.3	23.3
Actuated g/C Ratio	0.40	0.33				0.40	0.33			0.05	0.24	0.24
v/c Ratio	0.69	0.91				0.99	0.68			0.41	0.70	0.35
Control Delay	33.3	53.6				86.7	36.3			61.6	43.8	6.4
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	33.3	53.6				86.7	36.3			61.6	43.8	6.4
LOS	C	D				F	D			E	D	A
Approach Delay		48.1					51.8				31.9	
Approach LOS		D					D				C	

Intersection Summary	
Cycle Length: 100	
Actuated Cycle Length: 98.5	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.04	
Intersection Signal Delay: 58.6	Intersection LOS: E
Intersection Capacity Utilization 88.5%	ICU Level of Service E
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



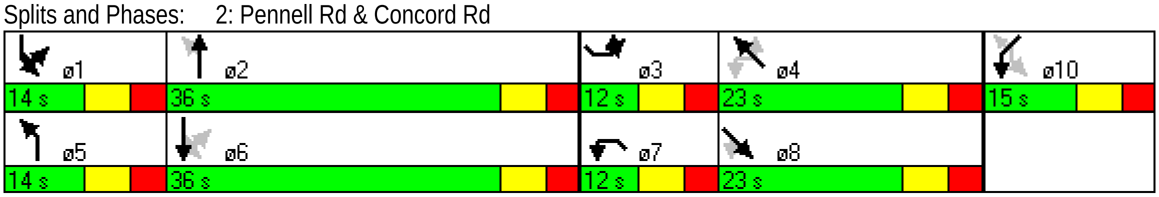
Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	56	267	181	16	4	62	102	17
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.577					0.950		
Satd. Flow (perm)	1044	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	76	310	229	0	0	84	136	0
Turn Type	Perm		Perm		Perm		Perm	
Protected Phases		4				10		
Permitted Phases	4		4		10		10	
Total Split (s)	23.0	23.0	23.0	0.0	15.0	15.0	15.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	16.4	16.4	16.4			8.0	8.0	
Actuated g/C Ratio	0.17	0.17	0.17			0.08	0.08	
v/c Ratio	0.44	1.03	0.84			0.61	1.04	
Control Delay	47.7	102.6	67.8			65.1	135.8	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	47.7	102.6	67.8			65.1	135.8	
LOS	D	F	E			E	F	
Approach Delay		82.8				108.8		
Approach LOS		F				F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	192	358	93	3	28	135	337	40	12	11	253	143
Satd. Flow (prot)	1770	1859	0	0	0	1702	1937	0	0	1719	1810	1644
Flt Permitted	0.267					0.125				0.950		
Satd. Flow (perm)	497	1859	0	0	0	224	1937	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										183
Lane Group Flow (vph)	204	550	0	0	0	192	430	0	0	36	301	183
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	14.0	36.0	0.0	0.0	14.0	14.0	36.0	0.0	12.0	12.0	23.0	23.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	39.1	32.1				39.1	32.1			5.0	16.0	16.0
Actuated g/C Ratio	0.39	0.32				0.39	0.32			0.05	0.16	0.16
v/c Ratio	0.72	0.93				1.01	0.70			0.42	1.05	0.44
Control Delay	36.4	57.8				93.4	37.8			62.9	108.0	9.6
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	36.4	57.8				93.4	37.8			62.9	108.0	9.6
LOS	D	E				F	D			E	F	A
Approach Delay		52.0					55.0				70.2	
Approach LOS		D					D				E	

Intersection Summary	
Cycle Length: 100	
Actuated Cycle Length: 100.6	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.06	
Intersection Signal Delay: 64.5	Intersection LOS: E
Intersection Capacity Utilization 88.5%	ICU Level of Service E
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



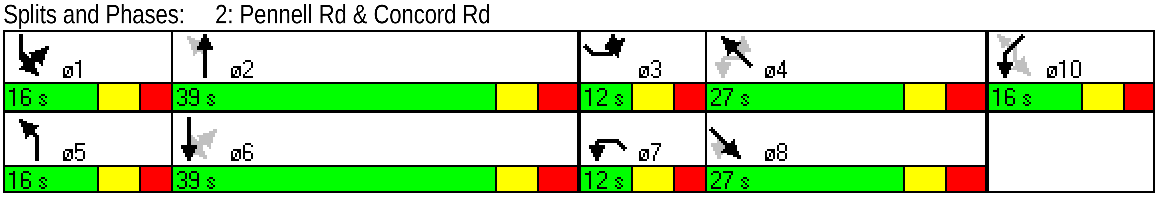
Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	56	267	181	16	4	62	102	17
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.223					0.950		
Satd. Flow (perm)	404	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	76	310	229	0	0	84	136	0
Turn Type	pm+pt		Perm		Perm		Perm	
Protected Phases	7	4				10		
Permitted Phases	4		4		10		10	
Total Split (s)	12.0	23.0	23.0	0.0	15.0	15.0	15.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	21.3	18.4	18.4			8.0	8.0	
Actuated g/C Ratio	0.21	0.18	0.18			0.08	0.08	
v/c Ratio	0.50	0.94	0.76			0.63	1.06	
Control Delay	42.0	79.4	58.6			67.2	143.1	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	42.0	79.4	58.6			67.2	143.1	
LOS	D	E	E			E	F	
Approach Delay		67.0				114.1		
Approach LOS		E				F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	192	358	93	3	28	135	337	40	12	11	253	143
Satd. Flow (prot)	1770	1859	0	0	0	1702	1937	0	0	1719	1810	1644
Flt Permitted	0.243					0.125				0.950		
Satd. Flow (perm)	453	1859	0	0	0	224	1937	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										183
Lane Group Flow (vph)	204	550	0	0	0	192	430	0	0	36	301	183
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	16.0	39.0	0.0	0.0	16.0	16.0	39.0	0.0	12.0	12.0	27.0	27.0
Total Lost Time (s)	7.0	8.0	4.0	4.0	7.0	7.0	8.0	4.0	7.0	7.0	8.0	8.0
Act Effct Green (s)	42.1	32.1				42.1	32.1			5.0	19.0	19.0
Actuated g/C Ratio	0.39	0.30				0.39	0.30			0.05	0.17	0.17
v/c Ratio	0.72	1.00				0.91	0.75			0.46	0.95	0.42
Control Delay	36.5	78.1				69.7	45.0			70.2	84.9	9.1
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	36.5	78.1				69.7	45.0			70.2	84.9	9.1
LOS	D	E				E	D			E	F	A
Approach Delay		66.8					52.6				57.2	
Approach LOS		E					D				E	

Intersection Summary	
Cycle Length: 110	
Actuated Cycle Length: 108.6	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.01	
Intersection Signal Delay: 63.5	Intersection LOS: E
Intersection Capacity Utilization 90.1%	ICU Level of Service E
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



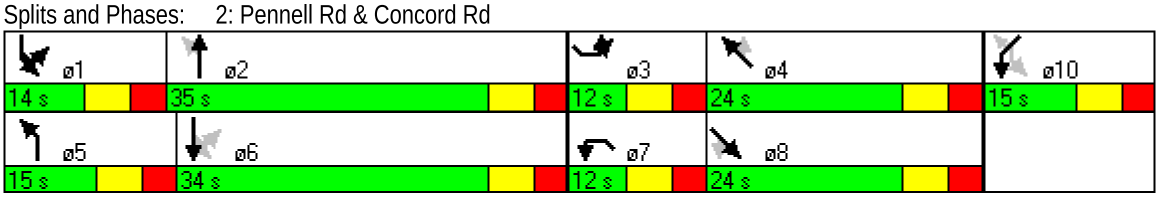
Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	56	267	181	16	4	62	102	17
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.273					0.950		
Satd. Flow (perm)	494	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	76	310	229	0	0	84	136	0
Turn Type	pm+pt		Perm		Perm		Perm	
Protected Phases	7	4				10		
Permitted Phases	4		4		10		10	
Total Split (s)	12.0	27.0	27.0	0.0	16.0	16.0	16.0	0.0
Total Lost Time (s)	7.0	8.0	8.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	25.3	21.4	21.4			9.0	9.0	
Actuated g/C Ratio	0.23	0.20	0.20			0.08	0.08	
v/c Ratio	0.44	0.87	0.71			0.60	1.01	
Control Delay	39.3	68.4	55.3			67.6	132.6	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	39.3	68.4	55.3			67.6	132.6	
LOS	D	E	E			E	F	
Approach Delay		59.9				107.8		
Approach LOS		E				F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	192	358	93	3	28	135	337	40	12	11	253	143
Satd. Flow (prot)	1770	1859	0	0	0	1702	1937	0	0	1719	1810	1644
Flt Permitted	0.236					0.125				0.950		
Satd. Flow (perm)	440	1859	0	0	0	224	1937	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										183
Lane Group Flow (vph)	204	550	0	0	0	192	430	0	0	36	301	183
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	15.0	35.0	0.0	0.0	14.0	14.0	34.0	0.0	12.0	12.0	24.0	24.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	41.0	33.0				39.0	32.0			5.0	17.0	17.0
Actuated g/C Ratio	0.39	0.31				0.37	0.30			0.05	0.16	0.16
v/c Ratio	0.75	0.94				1.05	0.73			0.44	1.03	0.44
Control Delay	38.5	61.2				107.4	41.1			65.4	104.2	9.4
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	38.5	61.2				107.4	41.1			65.4	104.2	9.4
LOS	D	E				F	D			E	F	A
Approach Delay		55.0					61.5				68.1	
Approach LOS		E					E				E	

Intersection Summary	
Cycle Length: 100	
Actuated Cycle Length: 105	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.11	
Intersection Signal Delay: 67.2	Intersection LOS: E
Intersection Capacity Utilization 88.5%	ICU Level of Service E
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



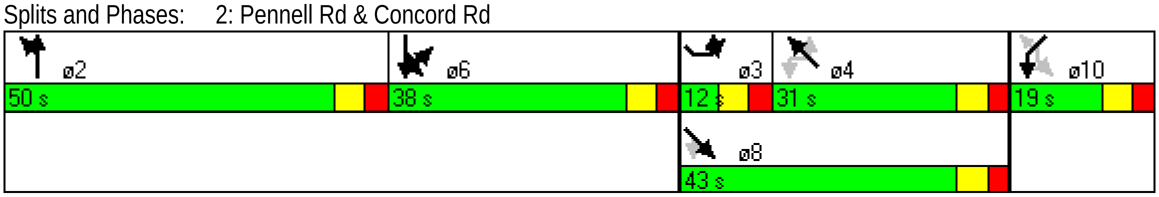
Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	56	267	181	16	4	62	102	17
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.950					0.950		
Satd. Flow (perm)	1719	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	76	310	229	0	0	84	136	0
Turn Type	Prot		Perm		Perm		Perm	
Protected Phases	7	4				10		
Permitted Phases			4		10		10	
Total Split (s)	12.0	24.0	24.0	0.0	15.0	15.0	15.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	5.0	21.8	21.8			8.0	8.0	
Actuated g/C Ratio	0.05	0.21	0.21			0.08	0.08	
v/c Ratio	0.93	0.82	0.67			0.66	1.11	
Control Delay	132.5	61.2	51.5			71.7	158.5	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	132.5	61.2	51.5			71.7	158.5	
LOS	F	E	D			E	F	
Approach Delay		66.4				125.3		
Approach LOS		E				F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	192	358	93	3	28	135	337	40	12	11	253	143
Satd. Flow (prot)	1770	1859	0	0	0	1702	1937	0	0	1719	1810	1644
Flt Permitted	0.950					0.950				0.950		
Satd. Flow (perm)	1770	1859	0	0	0	1702	1937	0	0	1719	1810	1644
Satd. Flow (RTOR)												161
Lane Group Flow (vph)	204	550	0	0	0	192	430	0	0	36	301	183
Turn Type	Split				Split	Split			Prot	Prot		Perm
Protected Phases	2	2			6	6	6		3	3	8	
Permitted Phases												8
Total Split (s)	50.0	50.0	0.0	0.0	38.0	38.0	38.0	0.0	12.0	12.0	43.0	43.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	43.0	43.0				32.0	32.0			5.0	33.5	33.5
Actuated g/C Ratio	0.29	0.29				0.22	0.22			0.03	0.23	0.23
v/c Ratio	0.40	1.02				0.52	1.03			0.62	0.74	0.37
Control Delay	45.9	95.9				58.2	108.2			112.3	65.1	11.6
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	45.9	95.9				58.2	108.2			112.3	65.1	11.6
LOS	D	F				E	F			F	E	B
Approach Delay		82.4					92.8				49.5	
Approach LOS		F					F				D	

Intersection Summary	
Cycle Length: 150	
Actuated Cycle Length: 148.6	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.06	
Intersection Signal Delay: 87.8	Intersection LOS: F
Intersection Capacity Utilization 88.5%	ICU Level of Service E
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



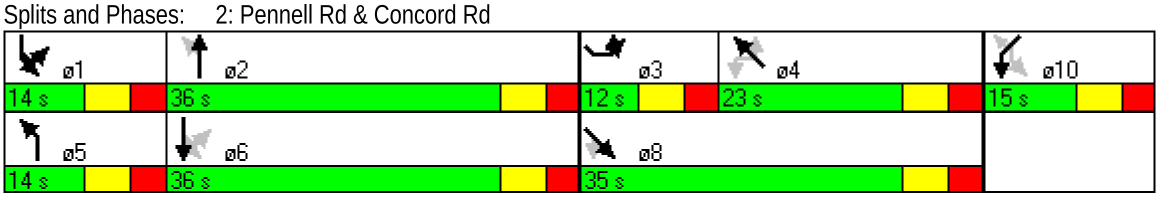
Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	56	267	181	16	4	62	102	17
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.452					0.950		
Satd. Flow (perm)	818	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	76	310	229	0	0	84	136	0
Turn Type	Perm		Perm		Perm		Perm	
Protected Phases		4				10		
Permitted Phases	4		4		10		10	
Total Split (s)	31.0	31.0	31.0	0.0	19.0	19.0	19.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	24.0	24.0	24.0			12.0	12.0	
Actuated g/C Ratio	0.16	0.16	0.16			0.08	0.08	
v/c Ratio	0.58	1.06	0.86			0.62	1.05	
Control Delay	77.1	126.9	90.0			86.7	155.1	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	77.1	126.9	90.0			86.7	155.1	
LOS	E	F	F			F	F	
Approach Delay		107.0				129.0		
Approach LOS		F				F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	192	358	93	3	28	135	337	40	12	11	253	143
Satd. Flow (prot)	1770	1859	0	0	0	1702	1937	0	0	1719	1810	1644
Flt Permitted	0.277					0.125				0.950		
Satd. Flow (perm)	516	1859	0	0	0	224	1937	0	0	1719	1810	1644
Satd. Flow (RTOR)		1					8					183
Lane Group Flow (vph)	204	550	0	0	0	192	430	0	0	36	301	183
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	14.0	36.0	0.0	0.0	14.0	14.0	36.0	0.0	12.0	12.0	35.0	35.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	39.1	32.1				39.1	32.1			5.0	23.3	23.3
Actuated g/C Ratio	0.40	0.33				0.40	0.33			0.05	0.24	0.24
v/c Ratio	0.69	0.91				0.99	0.68			0.41	0.70	0.35
Control Delay	33.3	53.6				86.7	35.4			61.6	43.8	6.4
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	33.3	53.6				86.7	35.4			61.6	43.8	6.4
LOS	C	D				F	D			E	D	A
Approach Delay		48.1					51.3				31.9	
Approach LOS		D					D				C	

Intersection Summary	
Cycle Length: 100	
Actuated Cycle Length: 98.5	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.04	
Intersection Signal Delay: 58.5	Intersection LOS: E
Intersection Capacity Utilization 88.5%	ICU Level of Service E
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



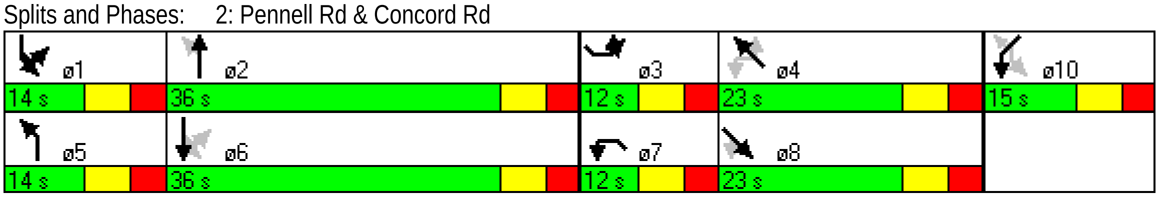
Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	56	267	181	16	4	62	102	17
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.577					0.950		
Satd. Flow (perm)	1044	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	76	310	229	0	0	84	136	0
Turn Type	Perm		Perm		Perm		Perm	
Protected Phases		4				10		
Permitted Phases	4		4		10		10	
Total Split (s)	23.0	23.0	23.0	0.0	15.0	15.0	15.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	16.4	16.4	16.4			8.0	8.0	
Actuated g/C Ratio	0.17	0.17	0.17			0.08	0.08	
v/c Ratio	0.44	1.03	0.84			0.61	1.04	
Control Delay	47.7	102.6	67.8			65.1	135.8	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	47.7	102.6	67.8			65.1	135.8	
LOS	D	F	E			E	F	
Approach Delay		82.8				108.8		
Approach LOS		F				F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	192	358	93	3	28	135	337	40	12	11	253	143
Satd. Flow (prot)	1770	1859	0	0	0	1702	1937	0	0	1719	1810	1644
Flt Permitted	0.267					0.125				0.950		
Satd. Flow (perm)	497	1859	0	0	0	224	1937	0	0	1719	1810	1644
Satd. Flow (RTOR)		1					8					183
Lane Group Flow (vph)	204	550	0	0	0	192	430	0	0	36	301	183
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	14.0	36.0	0.0	0.0	14.0	14.0	36.0	0.0	12.0	12.0	23.0	23.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	39.1	32.1				39.1	32.1			5.0	16.0	16.0
Actuated g/C Ratio	0.39	0.32				0.39	0.32			0.05	0.16	0.16
v/c Ratio	0.72	0.93				1.01	0.69			0.42	1.05	0.44
Control Delay	36.4	57.8				93.4	36.9			62.9	108.0	9.6
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	36.4	57.8				93.4	36.9			62.9	108.0	9.6
LOS	D	E				F	D			E	F	A
Approach Delay		52.0					54.3				70.2	
Approach LOS		D					D				E	

Intersection Summary	
Cycle Length: 100	
Actuated Cycle Length: 100.6	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.06	
Intersection Signal Delay: 64.4	Intersection LOS: E
Intersection Capacity Utilization 88.5%	ICU Level of Service E
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	56	267	181	16	4	62	102	17
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.223					0.950		
Satd. Flow (perm)	404	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	76	310	229	0	0	84	136	0
Turn Type	pm+pt		Perm		Perm		Perm	
Protected Phases	7	4				10		
Permitted Phases	4		4		10		10	
Total Split (s)	12.0	23.0	23.0	0.0	15.0	15.0	15.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	21.3	18.4	18.4			8.0	8.0	
Actuated g/C Ratio	0.21	0.18	0.18			0.08	0.08	
v/c Ratio	0.50	0.94	0.76			0.63	1.06	
Control Delay	42.0	79.4	58.6			67.2	143.1	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	42.0	79.4	58.6			67.2	143.1	
LOS	D	E	E			E	F	
Approach Delay		67.0				114.1		
Approach LOS		E				F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	192	358	93	3	28	135	337	40	12	11	253	143
Satd. Flow (prot)	1770	1859	0	0	0	1702	1937	0	0	1719	1810	1644
Flt Permitted	0.357					0.259				0.950		
Satd. Flow (perm)	665	1859	0	0	0	464	1937	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										183
Lane Group Flow (vph)	204	550	0	0	0	192	430	0	0	36	301	183
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	13.0	35.0	0.0	0.0	12.0	12.0	34.0	0.0	12.0	12.0	33.0	33.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	39.2	33.2				37.2	32.2			5.0	21.1	21.1
Actuated g/C Ratio	0.49	0.41				0.46	0.40			0.06	0.26	0.26
v/c Ratio	0.50	0.72				0.66	0.55			0.34	0.63	0.32
Control Delay	15.6	27.4				25.3	23.1			46.9	32.4	5.4
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	15.6	27.4				25.3	23.1			46.9	32.4	5.4
LOS	B	C				C	C			D	C	A
Approach Delay		24.2					23.8				23.9	
Approach LOS		C					C				C	

Intersection Summary	
Cycle Length: 80	
Actuated Cycle Length: 80.4	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.97	
Intersection Signal Delay: 34.0	Intersection LOS: C
Intersection Capacity Utilization 75.3%	ICU Level of Service D
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd

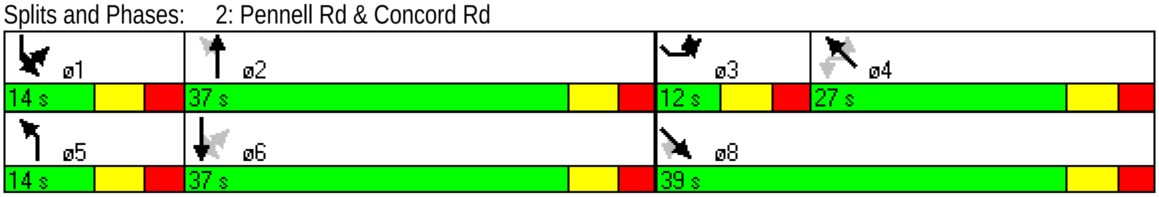
Lane Group	NWL	NWT	NWR	NWR2
Lane Configurations				
Volume (vph)	56	267	181	16
Satd. Flow (prot)	1719	1810	1644	0
Flt Permitted	0.577			
Satd. Flow (perm)	1044	1810	1644	0
Satd. Flow (RTOR)				
Lane Group Flow (vph)	76	310	229	0
Turn Type	Perm		Perm	
Protected Phases		4		
Permitted Phases	4		4	
Total Split (s)	21.0	21.0	21.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0
Act Effct Green (s)	14.3	14.3	14.3	
Actuated g/C Ratio	0.18	0.18	0.18	
v/c Ratio	0.41	0.97	0.78	
Control Delay	39.0	79.2	53.9	
Queue Delay	0.0	0.0	0.0	
Total Delay	39.0	79.2	53.9	
LOS	D	E	D	
Approach Delay		64.8		
Approach LOS		E		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	192	358	93	3	28	135	337	40	12	11	253	143
Satd. Flow (prot)	1770	1859	0	0	0	1702	1937	0	0	1719	1810	1644
Flt Permitted	0.337					0.199				0.950		
Satd. Flow (perm)	628	1859	0	0	0	357	1937	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										183
Lane Group Flow (vph)	204	550	0	0	0	192	430	0	0	36	301	183
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	14.0	37.0	0.0	0.0	14.0	14.0	37.0	0.0	12.0	12.0	39.0	39.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	39.3	32.2				39.3	32.2			5.0	26.3	26.3
Actuated g/C Ratio	0.45	0.37				0.45	0.37			0.06	0.30	0.30
v/c Ratio	0.54	0.80				0.71	0.60			0.36	0.55	0.29
Control Delay	19.2	36.0				30.3	27.5			52.1	28.8	4.7
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	19.2	36.0				30.3	27.5			52.1	28.8	4.7
LOS	B	D				C	C			D	C	A
Approach Delay		31.5					28.4				22.0	
Approach LOS		C					C				C	

Intersection Summary	
Cycle Length: 90	
Actuated Cycle Length: 86.7	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.91	
Intersection Signal Delay: 34.4	Intersection LOS: C
Intersection Capacity Utilization 77.9%	ICU Level of Service D
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



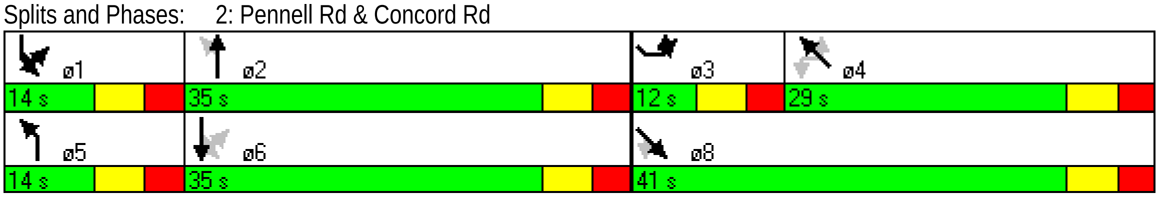
Lane Group	NWL	NWT	NWR	NWR2
Lane Configurations				
Volume (vph)	87	318	190	16
Satd. Flow (prot)	1719	1810	1644	0
Flt Permitted	0.577			
Satd. Flow (perm)	1044	1810	1644	0
Satd. Flow (RTOR)				
Lane Group Flow (vph)	118	370	238	0
Turn Type	Perm		Perm	
Protected Phases		4		
Permitted Phases	4		4	
Total Split (s)	27.0	27.0	27.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0
Act Effct Green (s)	19.5	19.5	19.5	
Actuated g/C Ratio	0.22	0.22	0.22	
v/c Ratio	0.50	0.91	0.64	
Control Delay	39.4	62.1	40.7	
Queue Delay	0.0	0.0	0.0	
Total Delay	39.4	62.1	40.7	
LOS	D	E	D	
Approach Delay		51.4		
Approach LOS		D		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	192	358	93	3	28	135	337	40	12	11	253	143
Satd. Flow (prot)	1770	1859	0	0	0	1702	1937	0	0	1719	1810	1644
Flt Permitted	0.324					0.182				0.950		
Satd. Flow (perm)	604	1859	0	0	0	326	1937	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										183
Lane Group Flow (vph)	204	550	0	0	0	192	430	0	0	36	301	183
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	14.0	35.0	0.0	0.0	14.0	14.0	35.0	0.0	12.0	12.0	41.0	41.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	39.2	32.1				39.2	32.1			5.0	28.9	28.9
Actuated g/C Ratio	0.44	0.36				0.44	0.36			0.06	0.32	0.32
v/c Ratio	0.57	0.82				0.76	0.62			0.37	0.51	0.28
Control Delay	21.3	39.0				36.8	29.2			53.9	27.5	4.5
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	21.3	39.0				36.8	29.2			53.9	27.5	4.5
LOS	C	D				D	C			D	C	A
Approach Delay		34.2					31.5				21.2	
Approach LOS		C					C				C	

Intersection Summary	
Cycle Length: 90	
Actuated Cycle Length: 89.2	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.96	
Intersection Signal Delay: 37.5	Intersection LOS: D
Intersection Capacity Utilization 80.6%	ICU Level of Service D
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



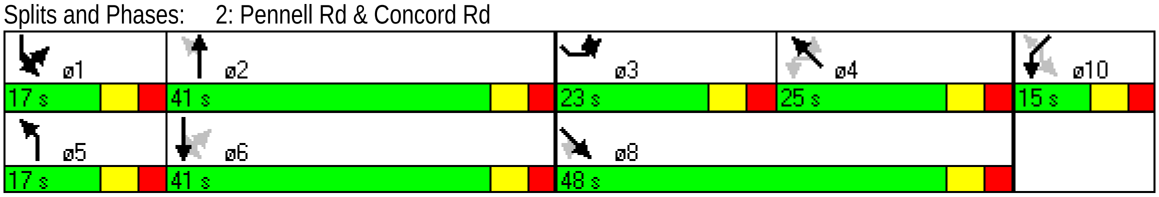
Lane Group	NWL	NWT	NWR	NWR2
Lane Configurations				
Volume (vph)	118	369	198	16
Satd. Flow (prot)	1719	1810	1644	0
Flt Permitted	0.577			
Satd. Flow (perm)	1044	1810	1644	0
Satd. Flow (RTOR)				
Lane Group Flow (vph)	159	429	247	0
Turn Type	Perm		Perm	
Protected Phases		4		
Permitted Phases	4		4	
Total Split (s)	29.0	29.0	29.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0
Act Effct Green (s)	22.1	22.1	22.1	
Actuated g/C Ratio	0.25	0.25	0.25	
v/c Ratio	0.62	0.96	0.61	
Control Delay	43.2	68.9	38.2	
Queue Delay	0.0	0.0	0.0	
Total Delay	43.2	68.9	38.2	
LOS	D	E	D	
Approach Delay		54.9		
Approach LOS		D		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	210	414	71	11	53	203	511	51	105	113	330	269
Satd. Flow (prot)	1770	1863	0	0	0	1702	1951	0	0	1719	1810	1644
Flt Permitted	0.118					0.118				0.950		
Satd. Flow (perm)	220	1863	0	0	0	211	1951	0	0	1719	1810	1644
Satd. Flow (RTOR)		2										247
Lane Group Flow (vph)	259	543	0	0	0	304	736	0	0	252	347	292
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	17.0	41.0	0.0	0.0	17.0	17.0	41.0	0.0	23.0	23.0	48.0	48.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	44.0	34.0				44.0	34.0			16.0	41.0	41.0
Actuated g/C Ratio	0.36	0.28				0.36	0.28			0.13	0.34	0.34
v/c Ratio	1.25	1.03				1.52	1.34			1.11	0.57	0.41
Control Delay	172.4	91.1				283.6	201.8			140.5	37.1	7.7
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	172.4	91.1				283.6	201.8			140.5	37.1	7.7
LOS	F	F				F	F			F	D	A
Approach Delay		117.4					225.7				56.7	
Approach LOS		F					F				E	

Intersection Summary	
Cycle Length: 121	
Actuated Cycle Length: 121	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.76	
Intersection Signal Delay: 161.2	Intersection LOS: F
Intersection Capacity Utilization 108.0%	ICU Level of Service G
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



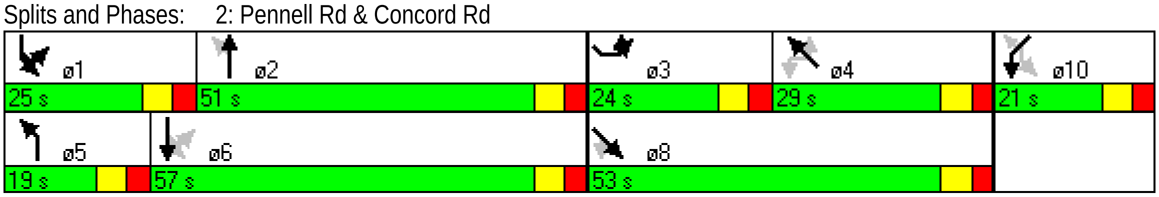
Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	14	291	213	8	9	124	130	28
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.553					0.950		
Satd. Flow (perm)	1001	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	20	338	257	0	0	160	188	0
Turn Type	Perm		Perm		Perm		Perm	
Protected Phases		4				10		
Permitted Phases	4		4		10		10	
Total Split (s)	25.0	25.0	25.0	0.0	15.0	15.0	15.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	18.0	18.0	18.0			8.0	8.0	
Actuated g/C Ratio	0.15	0.15	0.15			0.07	0.07	
v/c Ratio	0.13	1.26	1.05			1.44	1.76	
Control Delay	47.4	184.5	120.7			282.1	409.0	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	47.4	184.5	120.7			282.1	409.0	
LOS	D	F	F			F	F	
Approach Delay		153.4				350.7		
Approach LOS		F				F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	210	414	71	11	53	203	511	51	105	113	330	269
Satd. Flow (prot)	1770	1863	0	0	0	1702	1951	0	0	1719	1810	1644
Flt Permitted	0.091					0.080				0.950		
Satd. Flow (perm)	170	1863	0	0	0	143	1951	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										245
Lane Group Flow (vph)	259	543	0	0	0	304	736	0	0	252	347	292
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	19.0	51.0	0.0	0.0	25.0	25.0	57.0	0.0	24.0	24.0	53.0	53.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	56.0	44.0				68.0	50.0			17.0	46.0	46.0
Actuated g/C Ratio	0.37	0.29				0.45	0.33			0.11	0.31	0.31
v/c Ratio	1.36	0.99				1.21	1.13			1.29	0.63	0.43
Control Delay	223.8	88.9				162.6	122.7			214.2	50.5	10.0
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	223.8	88.9				162.6	122.7			214.2	50.5	10.0
LOS	F	F				F	F			F	D	A
Approach Delay		132.4					134.3				83.5	
Approach LOS		F					F				F	

Intersection Summary	
Cycle Length: 150	
Actuated Cycle Length: 150	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.36	
Intersection Signal Delay: 131.4	Intersection LOS: F
Intersection Capacity Utilization 108.0%	ICU Level of Service G
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	14	291	213	8	9	124	130	28
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.553					0.950		
Satd. Flow (perm)	1001	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	20	338	257	0	0	160	188	0
Turn Type	Perm		Perm		Perm		Perm	
Protected Phases		4				10		
Permitted Phases	4		4		10		10	
Total Split (s)	29.0	29.0	29.0	0.0	21.0	21.0	21.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	22.0	22.0	22.0			14.0	14.0	
Actuated g/C Ratio	0.15	0.15	0.15			0.09	0.09	
v/c Ratio	0.14	1.28	1.07			1.02	1.25	
Control Delay	58.5	199.2	135.5			141.9	209.5	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	58.5	199.2	135.5			141.9	209.5	
LOS	E	F	F			F	F	
Approach Delay		168.0				178.4		
Approach LOS		F				F		

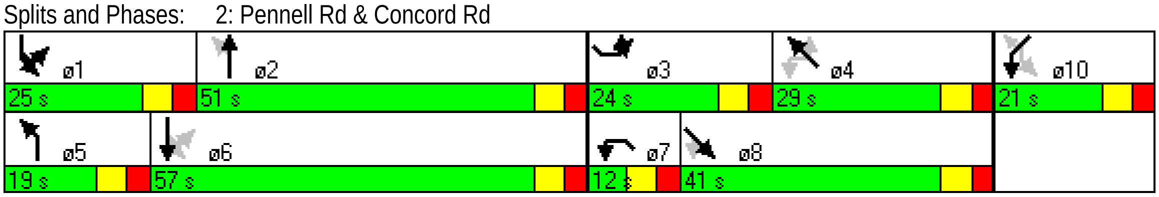
Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	210	414	71	11	53	203	511	51	105	113	330	269
Satd. Flow (prot)	1770	1863	0	0	0	1702	1951	0	0	1719	1810	1644
Flt Permitted	0.091					0.080				0.950		
Satd. Flow (perm)	170	1863	0	0	0	143	1951	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										219
Lane Group Flow (vph)	259	543	0	0	0	304	736	0	0	252	347	292
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	19.0	51.0	0.0	0.0	25.0	25.0	57.0	0.0	24.0	24.0	41.0	41.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	56.0	44.0				68.0	50.0			17.0	38.8	38.8
Actuated g/C Ratio	0.37	0.29				0.45	0.33			0.11	0.26	0.26
v/c Ratio	1.36	0.99				1.21	1.13			1.29	0.74	0.50
Control Delay	223.8	88.9				162.6	122.7			214.2	62.8	16.3
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	223.8	88.9				162.6	122.7			214.2	62.8	16.3
LOS	F	F				F	F			F	E	B
Approach Delay		132.4					134.3				90.4	
Approach LOS		F					F				F	

Intersection Summary

Cycle Length: 150
Actuated Cycle Length: 150
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.36
Intersection Signal Delay: 133.0 Intersection LOS: F
Intersection Capacity Utilization 108.0% ICU Level of Service G
Analysis Period (min) 15

Splits and Phases: 2: Pennell Rd & Concord Rd



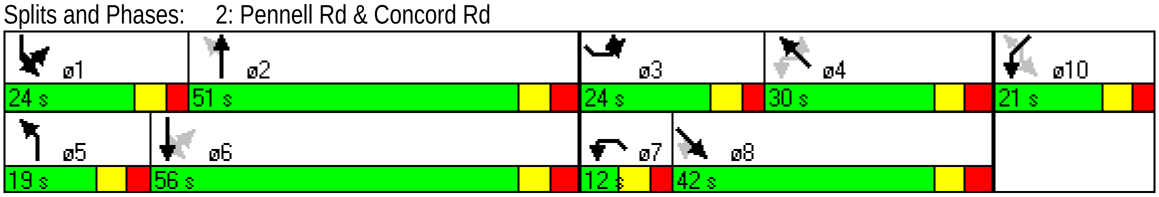
Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	14	291	213	8	9	124	130	28
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.414					0.950		
Satd. Flow (perm)	749	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	20	338	257	0	0	160	188	0
Turn Type	pm+pt		Perm		Perm		Perm	
Protected Phases	7	4				10		
Permitted Phases	4		4		10		10	
Total Split (s)	12.0	29.0	29.0	0.0	21.0	21.0	21.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	27.0	22.0	22.0			14.0	14.0	
Actuated g/C Ratio	0.18	0.15	0.15			0.09	0.09	
v/c Ratio	0.12	1.28	1.07			1.02	1.25	
Control Delay	39.5	199.2	135.5			141.9	209.5	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	39.5	199.2	135.5			141.9	209.5	
LOS	D	F	F			F	F	
Approach Delay		167.4				178.4		
Approach LOS		F				F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	210	414	71	11	53	203	511	51	105	113	330	269
Satd. Flow (prot)	1770	1863	0	0	0	1702	1951	0	0	1719	1810	1644
Flt Permitted	0.093					0.083				0.950		
Satd. Flow (perm)	173	1863	0	0	0	149	1951	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										219
Lane Group Flow (vph)	259	543	0	0	0	304	736	0	0	252	347	292
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	19.0	51.0	0.0	0.0	24.0	24.0	56.0	0.0	24.0	24.0	42.0	42.0
Total Lost Time (s)	7.0	8.0	4.0	4.0	7.0	7.0	8.0	4.0	7.0	7.0	8.0	8.0
Act Effct Green (s)	56.0	43.0				66.0	48.0			17.0	38.8	38.8
Actuated g/C Ratio	0.37	0.29				0.44	0.32			0.11	0.26	0.26
v/c Ratio	1.35	1.01				1.26	1.18			1.29	0.74	0.50
Control Delay	220.6	94.8				181.3	140.8			214.2	62.8	16.3
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	220.6	94.8				181.3	140.8			214.2	62.8	16.3
LOS	F	F				F	F			F	E	B
Approach Delay		135.4					152.7				90.4	
Approach LOS		F					F				F	

Intersection Summary	
Cycle Length: 150	
Actuated Cycle Length: 150	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.35	
Intersection Signal Delay: 138.8	Intersection LOS: F
Intersection Capacity Utilization 109.6%	ICU Level of Service H
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



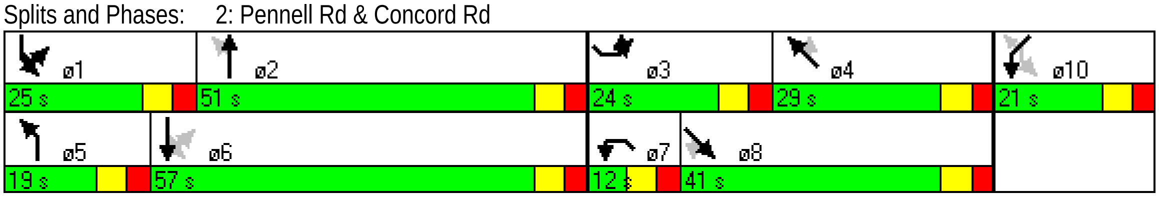
Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	14	291	213	8	9	124	130	28
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.436					0.950		
Satd. Flow (perm)	789	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	20	338	257	0	0	160	188	0
Turn Type	pm+pt		Perm		Perm		Perm	
Protected Phases	7	4				10		
Permitted Phases	4		4		10		10	
Total Split (s)	12.0	30.0	30.0	0.0	21.0	21.0	21.0	0.0
Total Lost Time (s)	7.0	8.0	8.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	28.0	22.0	22.0			14.0	14.0	
Actuated g/C Ratio	0.19	0.15	0.15			0.09	0.09	
v/c Ratio	0.11	1.28	1.07			1.02	1.25	
Control Delay	38.6	199.2	135.5			141.9	209.5	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	38.6	199.2	135.5			141.9	209.5	
LOS	D	F	F			F	F	
Approach Delay		167.3				178.4		
Approach LOS		F				F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	210	414	71	11	53	203	511	51	105	113	330	269
Satd. Flow (prot)	1770	1863	0	0	0	1702	1951	0	0	1719	1810	1644
Flt Permitted	0.091					0.080				0.950		
Satd. Flow (perm)	170	1863	0	0	0	143	1951	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										219
Lane Group Flow (vph)	259	543	0	0	0	304	736	0	0	252	347	292
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	19.0	51.0	0.0	0.0	25.0	25.0	57.0	0.0	24.0	24.0	41.0	41.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	56.0	44.0				68.0	50.0			17.0	38.8	38.8
Actuated g/C Ratio	0.37	0.29				0.45	0.33			0.11	0.26	0.26
v/c Ratio	1.36	0.99				1.21	1.13			1.29	0.74	0.50
Control Delay	223.8	88.9				162.6	122.7			214.2	62.8	16.3
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	223.8	88.9				162.6	122.7			214.2	62.8	16.3
LOS	F	F				F	F			F	E	B
Approach Delay		132.4					134.3				90.4	
Approach LOS		F					F				F	

Intersection Summary	
Cycle Length: 150	
Actuated Cycle Length: 150	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.36	
Intersection Signal Delay: 133.2	Intersection LOS: F
Intersection Capacity Utilization 108.0%	ICU Level of Service G
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



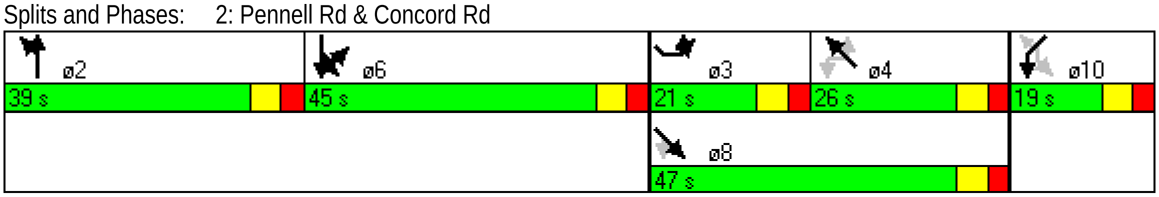
Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	14	291	213	8	9	124	130	28
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.950					0.950		
Satd. Flow (perm)	1719	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	20	338	257	0	0	160	188	0
Turn Type	Prot		Perm		Perm		Perm	
Protected Phases	7	4				10		
Permitted Phases			4		10		10	
Total Split (s)	12.0	29.0	29.0	0.0	21.0	21.0	21.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	5.0	22.0	22.0			14.0	14.0	
Actuated g/C Ratio	0.03	0.15	0.15			0.09	0.09	
v/c Ratio	0.35	1.28	1.07			1.02	1.25	
Control Delay	87.7	199.2	135.5			141.9	209.5	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	87.7	199.2	135.5			141.9	209.5	
LOS	F	F	F			F	F	
Approach Delay		168.9				178.4		
Approach LOS		F				F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	210	414	71	11	53	203	511	51	105	113	330	269
Satd. Flow (prot)	1770	1863	0	0	0	1702	1951	0	0	1719	1810	1644
Flt Permitted	0.950					0.950				0.950		
Satd. Flow (perm)	1770	1863	0	0	0	1702	1951	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										231
Lane Group Flow (vph)	259	543	0	0	0	304	736	0	0	252	347	292
Turn Type	Split				Split	Split			Prot	Prot		Perm
Protected Phases	2	2			6	6	6		3	3	8	
Permitted Phases												8
Total Split (s)	39.0	39.0	0.0	0.0	45.0	45.0	45.0	0.0	21.0	21.0	47.0	47.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	32.0	32.0				38.0	38.0			14.0	40.0	40.0
Actuated g/C Ratio	0.21	0.21				0.25	0.25			0.09	0.27	0.27
v/c Ratio	0.69	1.36				0.71	1.49			1.58	0.72	0.48
Control Delay	64.8	222.8				61.1	269.5			327.8	59.6	13.3
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	64.8	222.8				61.1	269.5			327.8	59.6	13.3
LOS	E	F				E	F			F	E	B
Approach Delay		171.8					208.6				120.3	
Approach LOS		F					F				F	

Intersection Summary	
Cycle Length: 150	
Actuated Cycle Length: 150	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.58	
Intersection Signal Delay: 187.2	Intersection LOS: F
Intersection Capacity Utilization 108.0%	ICU Level of Service G
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



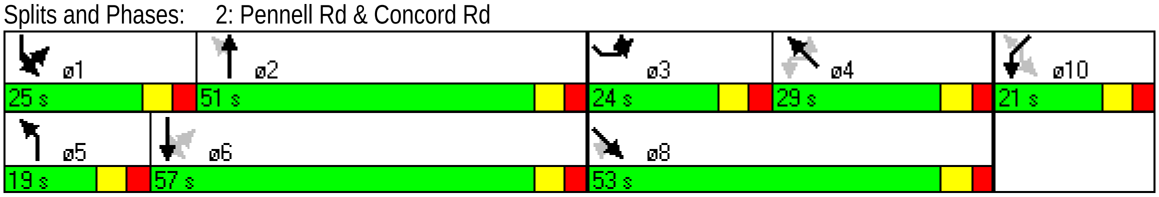
Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	14	291	213	8	9	124	130	28
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.553					0.950		
Satd. Flow (perm)	1001	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	20	338	257	0	0	160	188	0
Turn Type	Perm		Perm		Perm		Perm	
Protected Phases		4				10		
Permitted Phases	4		4		10		10	
Total Split (s)	26.0	26.0	26.0	0.0	19.0	19.0	19.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	19.0	19.0	19.0			12.0	12.0	
Actuated g/C Ratio	0.13	0.13	0.13			0.08	0.08	
v/c Ratio	0.16	1.48	1.24			1.19	1.46	
Control Delay	61.9	279.4	192.0			191.9	288.5	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	61.9	279.4	192.0			191.9	288.5	
LOS	E	F	F			F	F	
Approach Delay		235.8				244.1		
Approach LOS		F				F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	210	414	71	11	53	203	511	51	105	113	330	269
Satd. Flow (prot)	1770	1863	0	0	0	1702	1951	0	0	1719	1810	1644
Flt Permitted	0.091					0.080				0.950		
Satd. Flow (perm)	170	1863	0	0	0	143	1951	0	0	1719	1810	1644
Satd. Flow (RTOR)		1					3					245
Lane Group Flow (vph)	259	543	0	0	0	304	736	0	0	252	347	292
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	19.0	51.0	0.0	0.0	25.0	25.0	57.0	0.0	24.0	24.0	53.0	53.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	56.0	44.0				68.0	50.0			17.0	46.0	46.0
Actuated g/C Ratio	0.37	0.29				0.45	0.33			0.11	0.31	0.31
v/c Ratio	1.36	0.99				1.21	1.13			1.29	0.63	0.43
Control Delay	223.8	88.9				162.6	121.2			214.2	50.5	10.0
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	223.8	88.9				162.6	121.2			214.2	50.5	10.0
LOS	F	F				F	F			F	D	A
Approach Delay		132.4					133.3				83.5	
Approach LOS		F					F				F	

Intersection Summary	
Cycle Length: 150	
Actuated Cycle Length: 150	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.36	
Intersection Signal Delay: 131.1	Intersection LOS: F
Intersection Capacity Utilization 108.0%	ICU Level of Service G
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



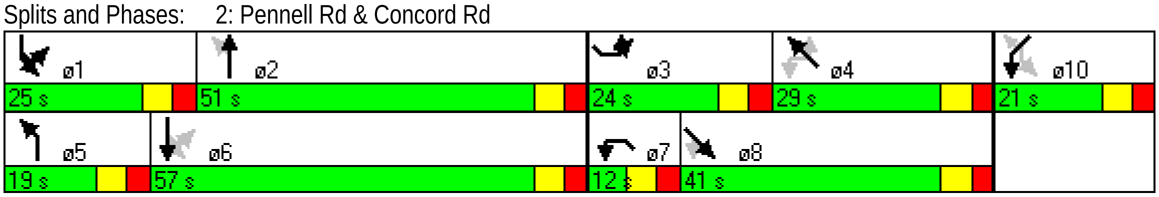
Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	14	291	213	8	9	124	130	28
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.553					0.950		
Satd. Flow (perm)	1001	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	20	338	257	0	0	160	188	0
Turn Type	Perm		Perm		Perm		Perm	
Protected Phases		4				10		
Permitted Phases	4		4		10		10	
Total Split (s)	29.0	29.0	29.0	0.0	21.0	21.0	21.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	22.0	22.0	22.0			14.0	14.0	
Actuated g/C Ratio	0.15	0.15	0.15			0.09	0.09	
v/c Ratio	0.14	1.28	1.07			1.02	1.25	
Control Delay	58.5	199.2	135.5			141.9	209.5	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	58.5	199.2	135.5			141.9	209.5	
LOS	E	F	F			F	F	
Approach Delay		168.0				178.4		
Approach LOS		F				F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	210	414	71	11	53	203	511	51	105	113	330	269
Satd. Flow (prot)	1770	1863	0	0	0	1702	1951	0	0	1719	1810	1644
Flt Permitted	0.091					0.080				0.950		
Satd. Flow (perm)	170	1863	0	0	0	143	1951	0	0	1719	1810	1644
Satd. Flow (RTOR)		1					3					219
Lane Group Flow (vph)	259	543	0	0	0	304	736	0	0	252	347	292
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	19.0	51.0	0.0	0.0	25.0	25.0	57.0	0.0	24.0	24.0	41.0	41.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	56.0	44.0				68.0	50.0			17.0	38.8	38.8
Actuated g/C Ratio	0.37	0.29				0.45	0.33			0.11	0.26	0.26
v/c Ratio	1.36	0.99				1.21	1.13			1.29	0.74	0.50
Control Delay	223.8	88.9				162.6	121.2			214.2	62.8	16.3
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	223.8	88.9				162.6	121.2			214.2	62.8	16.3
LOS	F	F				F	F			F	E	B
Approach Delay		132.4					133.3				90.4	
Approach LOS		F					F				F	

Intersection Summary	
Cycle Length: 150	
Actuated Cycle Length: 150	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.36	
Intersection Signal Delay: 132.7	Intersection LOS: F
Intersection Capacity Utilization 108.0%	ICU Level of Service G
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



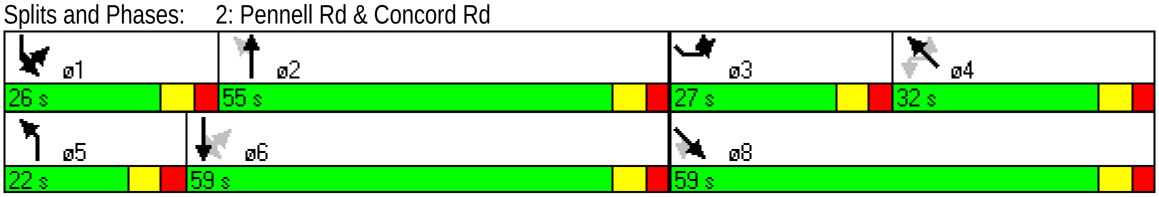
Lane Group	NWL	NWT	NWR	NWR2	SWL2	SWL	SWR	SWR2
Lane Configurations								
Volume (vph)	14	291	213	8	9	124	130	28
Satd. Flow (prot)	1719	1810	1644	0	0	1685	1612	0
Flt Permitted	0.414					0.950		
Satd. Flow (perm)	749	1810	1644	0	0	1685	1612	0
Satd. Flow (RTOR)								
Lane Group Flow (vph)	20	338	257	0	0	160	188	0
Turn Type	pm+pt		Perm		Perm		Perm	
Protected Phases	7	4				10		
Permitted Phases	4		4		10		10	
Total Split (s)	12.0	29.0	29.0	0.0	21.0	21.0	21.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0	7.0	7.0	7.0	4.0
Act Effct Green (s)	27.0	22.0	22.0			14.0	14.0	
Actuated g/C Ratio	0.18	0.15	0.15			0.09	0.09	
v/c Ratio	0.12	1.28	1.07			1.02	1.25	
Control Delay	39.5	199.2	135.5			141.9	209.5	
Queue Delay	0.0	0.0	0.0			0.0	0.0	
Total Delay	39.5	199.2	135.5			141.9	209.5	
LOS	D	F	F			F	F	
Approach Delay		167.4				178.4		
Approach LOS		F				F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	210	414	71	11	53	203	511	51	105	113	330	269
Satd. Flow (prot)	1770	1863	0	0	0	1702	1951	0	0	1719	1810	1644
Flt Permitted	0.083					0.135				0.950		
Satd. Flow (perm)	155	1863	0	0	0	242	1951	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										289
Lane Group Flow (vph)	259	543	0	0	0	304	736	0	0	252	347	292
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	22.0	55.0	0.0	0.0	26.0	26.0	59.0	0.0	27.0	27.0	59.0	59.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	63.0	48.0				71.0	52.0			20.0	52.0	52.0
Actuated g/C Ratio	0.45	0.34				0.51	0.37			0.14	0.37	0.37
v/c Ratio	1.07	0.85				0.95	1.02			1.02	0.52	0.37
Control Delay	115.4	56.4				69.5	80.7			121.7	37.6	4.7
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	115.4	56.4				69.5	80.7			121.7	37.6	4.7
LOS	F	E				E	F			F	D	A
Approach Delay		75.4					77.4				50.6	
Approach LOS		E					E				D	

Intersection Summary	
Cycle Length: 140	
Actuated Cycle Length: 140	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.07	
Intersection Signal Delay: 74.2	Intersection LOS: E
Intersection Capacity Utilization 92.3%	ICU Level of Service F
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



Lane Group	NWL	NWT	NWR	NWR2
Lane Configurations				
Volume (vph)	14	291	213	8
Satd. Flow (prot)	1719	1810	1644	0
Flt Permitted	0.553			
Satd. Flow (perm)	1001	1810	1644	0
Satd. Flow (RTOR)				
Lane Group Flow (vph)	20	338	257	0
Turn Type	Perm		Perm	
Protected Phases		4		
Permitted Phases	4		4	
Total Split (s)	32.0	32.0	32.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0
Act Effct Green (s)	25.0	25.0	25.0	
Actuated g/C Ratio	0.18	0.18	0.18	
v/c Ratio	0.11	1.05	0.87	
Control Delay	50.2	117.3	84.5	
Queue Delay	0.0	0.0	0.0	
Total Delay	50.2	117.3	84.5	
LOS	D	F	F	
Approach Delay		101.4		
Approach LOS		F		

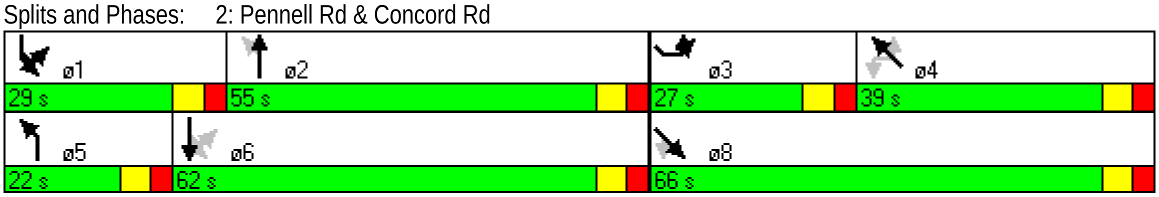
Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	210	414	71	11	53	203	511	51	105	113	330	269
Satd. Flow (prot)	1770	1863	0	0	0	1702	1951	0	0	1719	1810	1644
Flt Permitted	0.083					0.092				0.950		
Satd. Flow (perm)	155	1863	0	0	0	165	1951	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										280
Lane Group Flow (vph)	259	543	0	0	0	304	736	0	0	252	347	292
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	22.0	55.0	0.0	0.0	29.0	29.0	62.0	0.0	27.0	27.0	66.0	66.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	63.0	48.0				77.0	55.0			20.0	59.0	59.0
Actuated g/C Ratio	0.42	0.32				0.51	0.37			0.13	0.39	0.39
v/c Ratio	1.14	0.91				0.98	1.03			1.10	0.49	0.36
Control Delay	143.1	69.3				87.1	87.4			146.8	37.1	5.0
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	143.1	69.3				87.1	87.4			146.8	37.1	5.0
LOS	F	E				F	F			F	D	A
Approach Delay		93.1					87.3				57.6	
Approach LOS		F					F				E	

Intersection Summary

Cycle Length: 150
Actuated Cycle Length: 150
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.14
Intersection Signal Delay: 83.1 — Intersection LOS: F
Intersection Capacity Utilization 95.8% — ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 2: Pennell Rd & Concord Rd



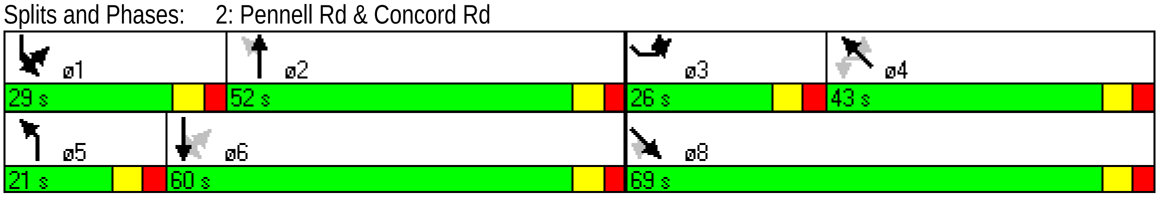
Lane Group	NWL	NWT	NWR	NWR2
Lane Configurations				
Volume (vph)	76	356	227	8
Satd. Flow (prot)	1719	1810	1644	0
Flt Permitted	0.553			
Satd. Flow (perm)	1001	1810	1644	0
Satd. Flow (RTOR)				
Lane Group Flow (vph)	109	414	272	0
Turn Type	Perm		Perm	
Protected Phases		4		
Permitted Phases	4		4	
Total Split (s)	39.0	39.0	39.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0
Act Effct Green (s)	32.0	32.0	32.0	
Actuated g/C Ratio	0.21	0.21	0.21	
v/c Ratio	0.51	1.07	0.77	
Control Delay	61.7	120.9	71.5	
Queue Delay	0.0	0.0	0.0	
Total Delay	61.7	120.9	71.5	
LOS	E	F	E	
Approach Delay		95.9		
Approach LOS		F		

Intersection Summary

Lane Group	NBL	NBT	NBR	NBR2	SBL2	SBL	SBT	SBR	SEL2	SEL	SET	SER
Lane Configurations												
Volume (vph)	210	414	71	11	53	203	511	51	105	113	330	269
Satd. Flow (prot)	1770	1863	0	0	0	1702	1951	0	0	1719	1810	1644
Flt Permitted	0.089					0.077				0.950		
Satd. Flow (perm)	166	1863	0	0	0	138	1951	0	0	1719	1810	1644
Satd. Flow (RTOR)		1										289
Lane Group Flow (vph)	259	543	0	0	0	304	736	0	0	252	347	292
Turn Type	pm+pt				pm+pt	pm+pt			Prot	Prot		Perm
Protected Phases	5	2			1	1	6		3	3	8	
Permitted Phases	2				6	6						8
Total Split (s)	21.0	52.0	0.0	0.0	29.0	29.0	60.0	0.0	26.0	26.0	69.0	69.0
Total Lost Time (s)	7.0	7.0	4.0	4.0	7.0	7.0	7.0	4.0	7.0	7.0	7.0	7.0
Act Effct Green (s)	59.0	45.0				74.0	53.0			19.0	62.0	62.0
Actuated g/C Ratio	0.39	0.30				0.49	0.35			0.13	0.41	0.41
v/c Ratio	1.20	0.97				1.02	1.07			1.16	0.46	0.34
Control Delay	165.7	82.6				102.5	99.7			164.8	34.5	4.1
Queue Delay	0.0	0.0				0.0	0.0			0.0	0.0	0.0
Total Delay	165.7	82.6				102.5	99.7			164.8	34.5	4.1
LOS	F	F				F	F			F	C	A
Approach Delay		109.4					100.5				61.4	
Approach LOS		F					F				E	

Intersection Summary	
Cycle Length: 150	
Actuated Cycle Length: 150	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.20	
Intersection Signal Delay: 93.6	Intersection LOS: F
Intersection Capacity Utilization 99.2%	ICU Level of Service F
Analysis Period (min) 15	

Splits and Phases: 2: Pennell Rd & Concord Rd



Lane Group	NWL	NWT	NWR	NWR2
Lane Configurations				
Volume (vph)	138	421	241	8
Satd. Flow (prot)	1719	1810	1644	0
Flt Permitted	0.553			
Satd. Flow (perm)	1001	1810	1644	0
Satd. Flow (RTOR)				
Lane Group Flow (vph)	197	490	288	0
Turn Type	Perm		Perm	
Protected Phases		4		
Permitted Phases	4		4	
Total Split (s)	43.0	43.0	43.0	0.0
Total Lost Time (s)	7.0	7.0	7.0	4.0
Act Effct Green (s)	36.0	36.0	36.0	
Actuated g/C Ratio	0.24	0.24	0.24	
v/c Ratio	0.82	1.13	0.73	
Control Delay	80.6	133.8	64.6	
Queue Delay	0.0	0.0	0.0	
Total Delay	80.6	133.8	64.6	
LOS	F	F	E	
Approach Delay		102.6		
Approach LOS		F		

Intersection Summary

Title of Report: ***Congestion and Crash Site Analysis Program – Aston Township, Delaware County***

Publication No.: **08052**

Date Published: December 2008

Geographic Area Covered:
The five leg intersection of Pennell Road, Concord Road, and Knowlton Road, in Delaware County.

Key Words:
Congestion, level of service, intersection, safety, crashes, crash types, statewide, strategies, signalized, traffic signal, pedestrian, actions, roadway, driveway, goal, objectives, potential, deficiency, scenario, bicycle, pedestrians, turning movements, average annual daily traffic volumes, peak hour, exclusive, approach, circulation, left turn, access, all red phase, curb ramps.

ABSTRACT: This document represents the findings and recommendations for the Delaware County Congestion and Crash Site Analysis project. This project represents an effort to improve the mobility and safety of the roadways in the DVRPC region. The goal of the program is to identify cost-effective improvement strategies that will reduce congestion and crashes and improve the mobility and safety of all road users. Working with the Delaware County Planning Department, the intersection of Pennell Road, Concord Road, and Knowlton Road was chosen for analysis. This intersection was identified as having congestion and safety issues. An in-depth crash and level of service analysis was performed to quantify and gain an understanding of the issues. With input from local stakeholders, improvement strategies were identified to address the issues. As appropriate, proposed improvement strategies were tested for level of effectiveness.

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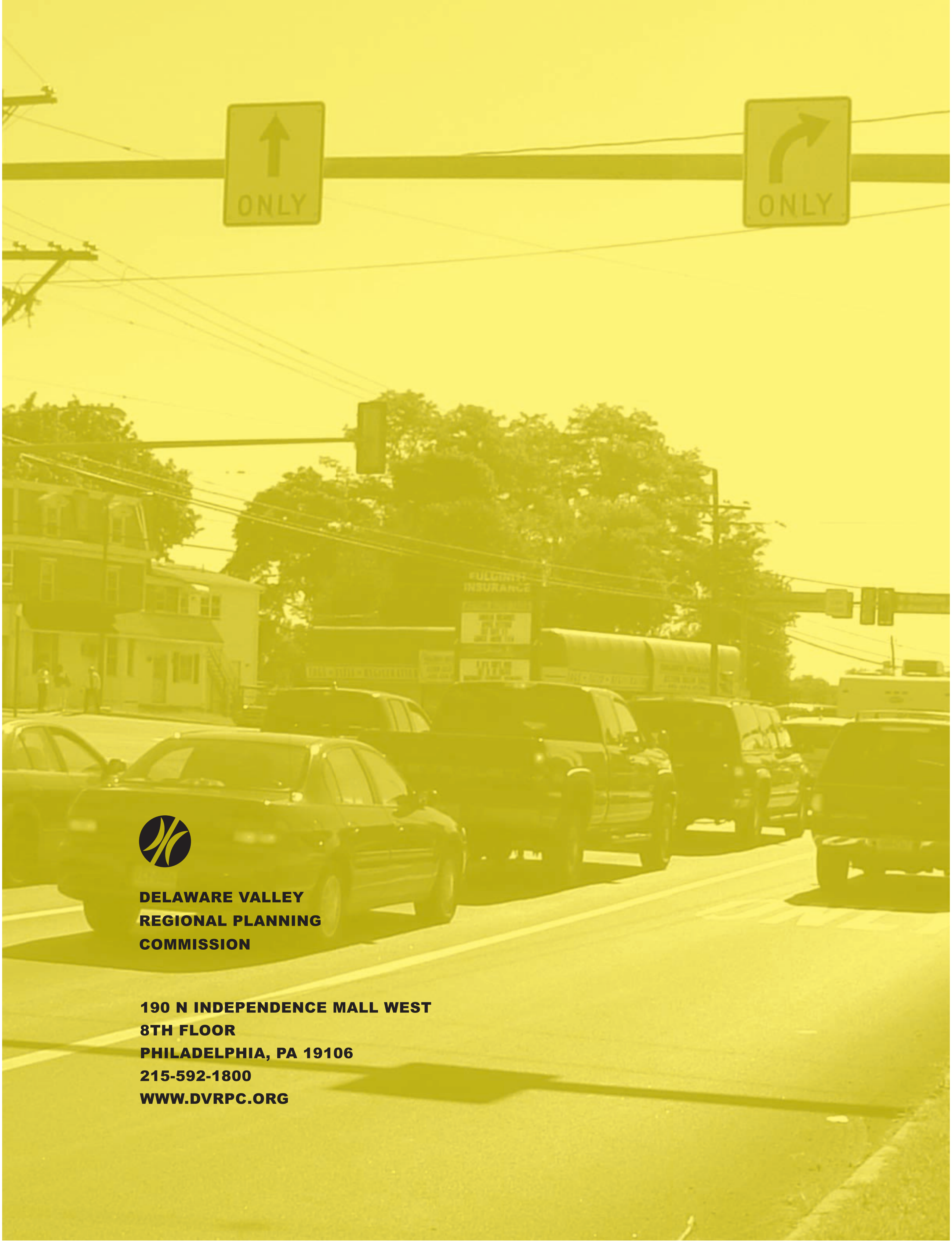

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