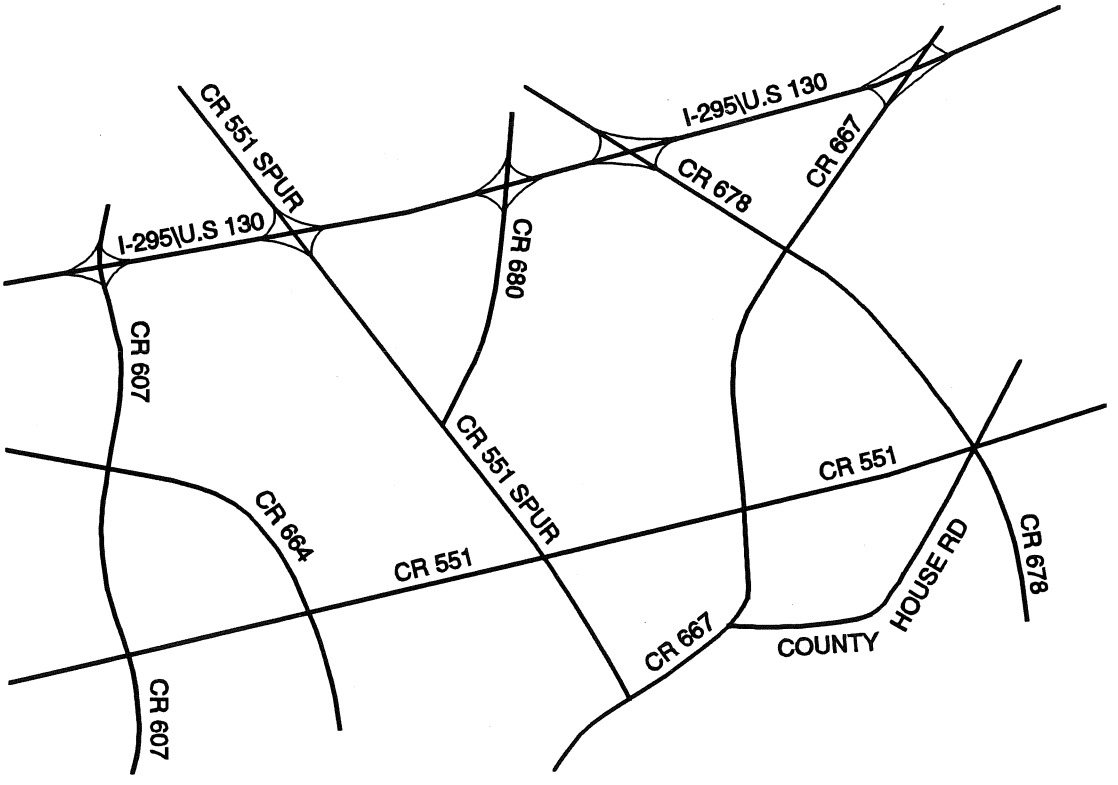
KINGS HIGHWAY CORRIDOR TRAFFIC ANALYSIS EAST GREENWICH TOWNSHIP



FEBRUARY 1993

DELAWARE VALLEY
REGIONAL PLANNING COMMISSION

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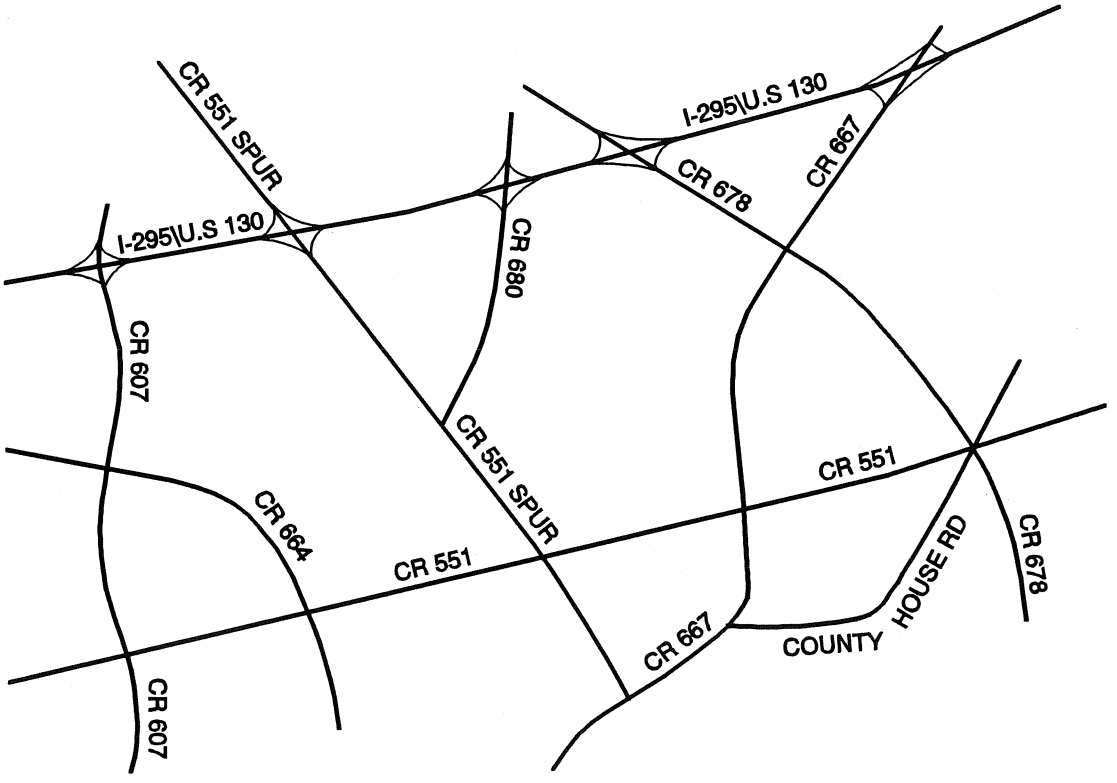

FEBRUARY 1993

DELAWARE VALLEY
REGIONAL PLANNING COMMISSION
21 SOUTH FIFTH ST.
PHILADELPHIA, PA. 19106

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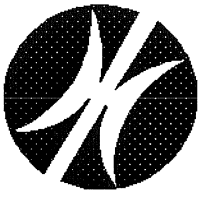
Created in 1965, the Delaware Valley Regional Planning Commission (DVRPC) is an interstate, intercounty and intercity agency which provides continuing, comprehensive and coordinated planning for the orderly growth and development of the Delaware Valley region. The region includes Bucks, Chester, Delaware, and Montgomery counties as well as the City of Philadelphia in Pennsylvania and Burlington, Camden, Gloucester, and Mercer counties in New Jersey. The Commission is an advisory agency which divides its planning and service functions among the Office of the Executive Director, the Office of Public Affairs, and three line Divisions: Transportation Planning, Regional Information Services Center, which includes the Office of Regional Planning, and the Office of Finance. DVRPC's mission for the 1990s is to emphasize technical assistance and services and to conduct high priority studies for member state and local governments, while determining and meeting the needs of the private sector.



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DELAWARE VALLEY REGIONAL PLANNING COMMISSION

Publication Abstract

TITLE	Date Published: February 1993
KINGS HIGHWAY CORRIDOR TRAFFIC ANALYSIS *East Greenwich Township*	
	Publication No. 93007

Geographic Area Covered:

The study focuses on the section of Kings Highway (CR 551) located in East Greenwich Township, Gloucester County, New Jersey.

Key Words:

Demographics, traffic simulation model, traffic zones, traffic volumes, turning movement counts, level of service analysis, traffic projections, improvement recommendations

ABSTRACT

This study addresses the section of the Kings Highway Corridor in East Greenwich Township, Gloucester County, New Jersey. The study area is largely undeveloped, yet it is anticipated that this area will experience moderate growth in the next 20 years due partly to the completion of the Blue Route (I-476) in Pennsylvania and the reconstruction of I-295 in Gloucester County. Existing demographics and traffic conditions in the study area are described. Traffic volumes and levels of service are projected for the Year 2010 based on anticipated growth trends. Recommendations are presented which address the deficiencies in the county highway system.

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I. EXECUTIVE SUMMARY

The purpose of this study is threefold: 1) to determine, based on the study area's current development scenario and its population and employment projections, what the future traffic volumes are expected to be on Kings Highway (CR 551) and the surrounding county highway network in East Greenwich Township; 2) to determine if this road network will be able to accommodate the amount of traffic which is expected to use these roads in the future; and 3) what improvements will be required if the existing highway capacity is not adequate to service the expected demand. Traffic was projected to a 20 year horizon using the Quick Response System II traffic simulation model.

Currently the study area is largely undeveloped but has the potential to become one of Gloucester County's growth areas due to the recent completion of I-476 (Blue Route) in Pennsylvania and the reconstruction and interchange improvements to I-295 in West Deptford and East Greenwich Townships.

CR 551 is a two lane road carrying one travel lane and a paved shoulder throughout most of the study area. The other roads in the study area are similarly configured and most carry considerably less traffic than CR 551. The existing demographics of the study area are presented along with the current traffic volumes and the operating conditions of the highway network. The demographics, volumes and operating conditions are projected to the Year 2010 based on anticipated growth.

All roads in the network currently operate at acceptable levels of service. Of the nine intersections analyzed, only one experienced peak hour deficiencies. The other eight operated satisfactorily in both peak periods. The projected volumes represent a modest growth in traffic and for the most part, the highway network will continue to operate with acceptable levels of service in the Year 2010. Deficiencies will occur at only one of the nine intersections. Neither the projected volumes nor the resulting operating conditions warrant widening Kings Highway to four lanes. Even with the level of anticipated growth, the resulting traffic can, in most locations, be easily absorbed by the existing highway network. Most of these facilities operate so much under capacity that, for the most part, major physical improvements are not necessary. However, minor improvements such as minor widening for the construction of shoulders or addition of left turn lanes at a few specific locations and traffic signal installation or retiming should provide congestion relief to the level for which it is needed.

II. INTRODUCTION

This report focuses on the 5.3 mile section of Kings Highway (CR 551) in East Greenwich Township. This study is the third of three to address improvements to the Kings Highway Corridor which extends from the City of Woodbury to the Salem County line. The first report addressed the section of the corridor in Woolwich Township and the Borough of Swedesboro. The second report addressed the section of the corridor in West Deptford Township. The study area for this section of the Kings Highway Corridor is East Greenwich Township. A map of the study area is presented in Figure 1. The purpose of this report is to develop an improvement plan for county-owned roads in the study area which is bounded by I-295, the Woolwich Township line, the New Jersey Turnpike and the West Deptford Township line.

The reconstruction of I-295 in Gloucester County and the completion of I-476 (Blue Route) in Delaware County, Pennsylvania is expected to accelerate development in this part of Gloucester County. The Gloucester County Planning Department, concerned about the effects of this development on the road network, requested the Delaware Valley Regional Planning Commission (DVRPC) assist them in developing an improvement plan to address these concerns.

A description of the corridor will be presented in the next section of this report. This will include the existing physical and operating conditions of the existing highway network in the study area. Existing traffic volumes on this network are also presented. A level of service analysis will be performed on key roads and intersections.

The next section documents the travel forecasting methodology with a discussion of the Quick Response System II (QRS II) Model used to develop the traffic projections for the year 2010. Input data such as the population and employment projections of the study area which are essential to the simulation process are also presented.

The following section presents the results of the travel forecast. These results document the projected daily traffic volumes for Kings Highway and the surrounding network for the Year 2010. A level of service analysis using the projected volumes is also presented in this section.

The final section of this report presents recommendations intended to address any deficiencies identified in the previous analyses. These recommendations can be used by the county in developing an improvement plan for the county-owned road network.

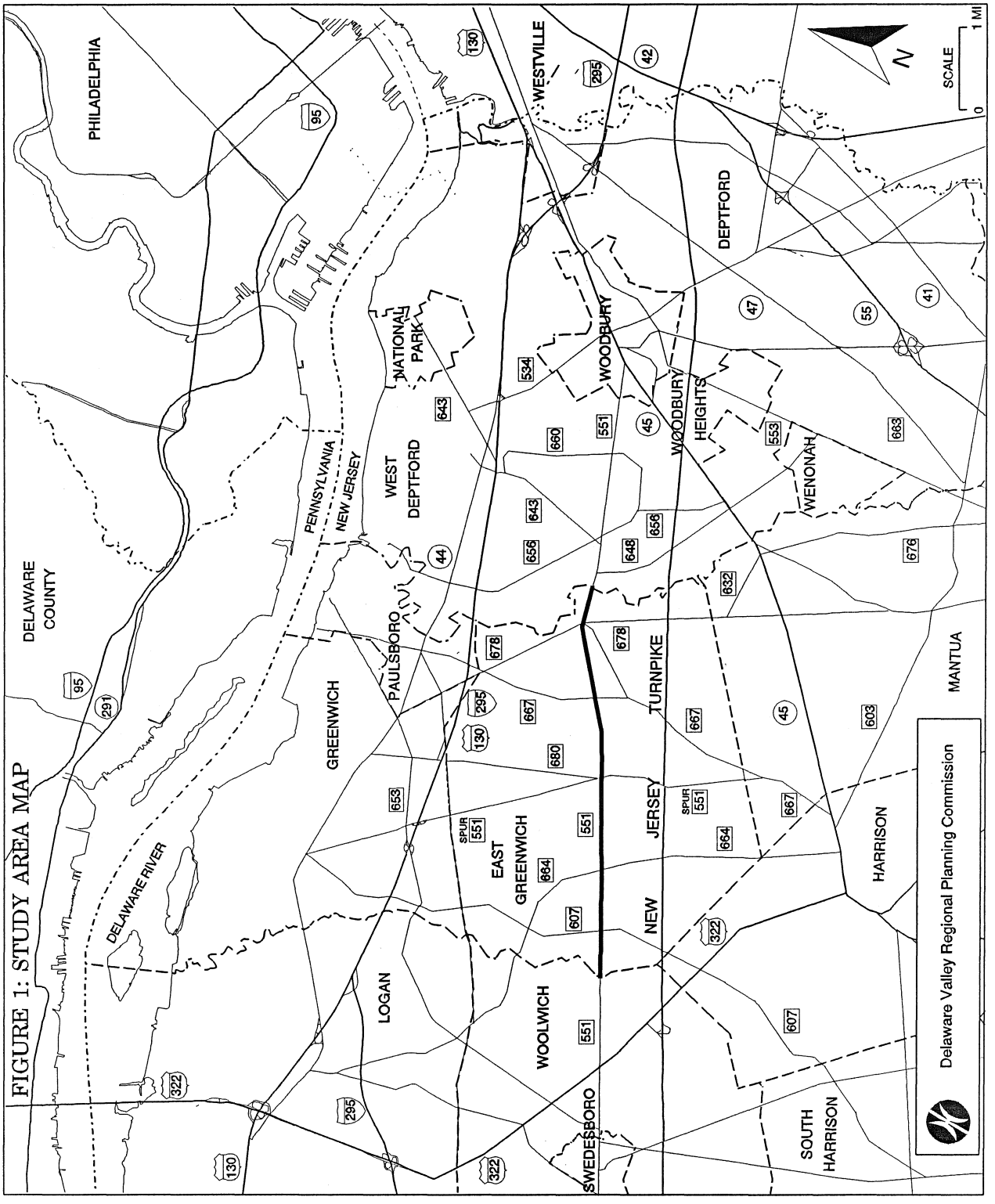

FIGURE 1: STUDY AREA MAP

III. CORRIDOR AND NETWORK DESCRIPTION

Existing Physical Conditions of the Highway Network

This section of the report examines the existing physical conditions of the network of county owned roads in East Greenwich Township. Figure 2 displays the network of county roads which are analyzed in this report. Descriptions of these roads are presented below.

Kings Highway (CR 551) runs generally parallel to and is centered between I-295 and NJ 45. For this reason, Kings Highway carries trips predominantly of a more local nature while I-295 and NJ 45 carry more regional or through trips.

Kings Highway is owned and maintained by Gloucester County. This road is classified as a minor arterial under the county's functional classification system and maintains one travel lane in each direction throughout its entire length. Within the study area, the cartway width and speed limit vary as the adjacent land uses change. Between CR 678 and CR 667, Kings Highway has a 12 foot travel lane and a five foot shoulder in each direction. The posted speed limit along the majority of this segment is 40 MPH. The land use is residential and scattered commercial. The six-legged intersection of CR 551, CR 678 and County House Road is controlled by an actuated three-phase signal. A traffic signal also controls the operations of the intersection of CR 551 and CR 667. Between CR 667 and CR 551 Spur, the lane width increases to 14 feet and the shoulder narrows to three feet. The speed limit is posted at 45 miles per hour. The land use is a mix of low density residential and agricultural uses. The intersection with CR 551 Spur is controlled by a flashing beacon. The segment of CR 551 between CR 551 Spur and CR 607 carries a 14 foot lane and a two foot shoulder in each direction and has a posted speed limit of 50 MPH. The adjacent land use is a mix of low density residential and undeveloped or agricultural land. Within this section, there are unsignalized intersections at CR 607 and at CR 664. In both locations, CR 551 is the free flow movement and the cross streets are stop controlled.

CR 678 (Berkley Road) is the only road, other than CR 551, in the study area that is classified as a minor arterial. This road runs generally perpendicular to Kings Highway and connects it to I-295 on the north and to NJ 45 on the south. CR 678 intersects Kings Highway at a six-legged signalized intersection. County House Road and North Street make up the other

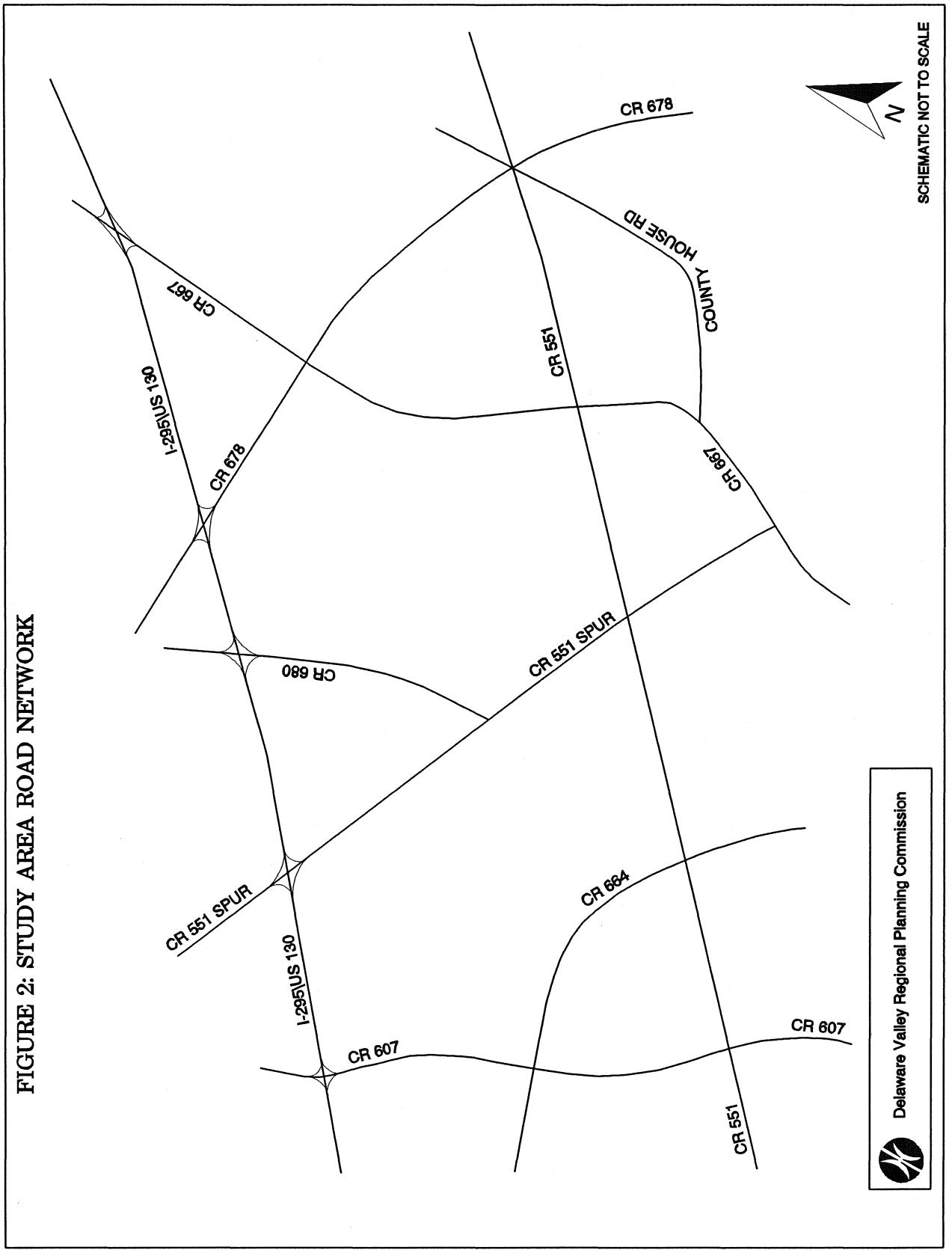

FIGURE 2: STUDY AREA ROAD NETWORK

two legs of the intersection. CR 678 carries one 12-foot travel lane by direction and has a shoulder which varies between one and three feet in width. The adjacent land use is a mix of scattered residential, agricultural and undeveloped. A traffic signal controls The intersection of CR 678 and CR 667. The posted speed limit is 50 MPH south of Kings Highway and 45 MPH north of Kings Highway.

CR 667 (Cohawkin Road), classified as a major collector, carries one 12-foot travel lane by direction and has a two-foot shoulder. This road provides access across the study area connecting I-295 and NJ 45. Traffic signals are located at Kings Highway and CR 678. The speed limit is posted at 50 MPH south of Kings Highway and 40 MPH north of Kings Highway. The adjacent land use north of Kings Highway is mostly residential with some scattered agricultural and commercial uses. South of Kings Highway the majority of the adjacent land use is agricultural.

CR 680 (Harmony Road) intersects CR 551 Spur approximately 300 feet north of Kings Highway and connects to an interchange with I-295. This minor collector consists of an eleven foot travel lane and a two foot shoulder in each direction. The posted speed limit is 45 MPH and the adjacent land use is a mix of residential and agricultural uses.

CR 551 Spur (Democrat Mickleton Road) runs basically perpendicular to Kings Highway and connects it to I-295 on the north and CR 667 on the south. This road is classified as a minor collector and consists of an eleven-foot travel lane with no shoulder in each direction, north of Kings Highway; and a twelve-foot travel lane in each direction with two-foot shoulders, south of Kings Highway. This road is abutted by mostly agricultural land with some scattered residential uses. The posted speed limit is 45 MPH. The intersection with Kings Highway is controlled by a flashing beacon with CR 551 Spur under stop control.

CR 664 (Wolfert Station Road) is classified as a local collector and runs generally perpendicular to Kings Highway. Stop signs on CR 664 control access to Kings Highway. This road connects Kings Highway to NJ 45 on the south and to CR 607 on the north. The southern segment of CR 664 consists of a thirteen-foot travel lane in each direction with no shoulders and a speed limit of 45 MPH. The northern section consists of an eleven-foot travel lane and no shoulder in both directions. The speed limit along this road is 50 MPH. The adjacent land use is almost totally agricultural with some scattered residential units.

CR 607 (Tomlin Station Road) runs perpendicular to Kings Highway and connects it to I-295 on the north and US 322 on the south. Between Kings Highway and US 322 this road consists of a ten-foot travel lane and a two-foot shoulder in each direction and has a speed limit of 45 MPH. North of Kings Highway, CR 607 narrows to a nine-foot lane in each direction with no shoulders. The speed limit varies between 40 and 45 MPH. The land use along this minor collector is mostly agricultural with scattered residential units. Stop signs on CR 607 control access to Kings Highway.

In addition to those roads listed above, several state-owned and municipal-owned roads were included in a network which was used in the process to project future traffic volumes. No analysis of the state and local roads were conducted.

This report will also examine the nine intersections created by this network. The physical conditions of those intersections are described below:

CR 551 (Kings Highway), CR 678 (Berkley Road), County House Road and North Street this is a six-legged signalized intersection. North Street is a dead end street which extends north from the intersection only several hundred feet. Several homes located on North Street generate minimal traffic through the intersection. Traffic operations at this intersection are controlled by an actuated signal. Since traffic on County House Road is light, this signal often does not cycle over to provide a phase for County House Road and North Street consequently it often operates as a two-phase actuated operation. Both approaches on Kings Highway consist of a shared through/left turn lane and a shared through/right turn lane. Both approaches on CR 678 are configured the same way. County House Road and North Street both consist of a one lane approach to serve all turning movements.

CR 551 (Kings Highway) and CR 667 (Cohawkin Road) - all four legs of this intersection contain a one lane approach to accommodate all movements. The approach lanes on Kings Highway (sixteen feet wide with a three-foot shoulder) are wider than those on CR 667 (twelve feet wide with a three-foot shoulder). Through and right turning vehicles can bypass vehicles queued up to turn left on all approaches. The intersection is controlled by a two phase actuated signal.

CR 551 (Kings Highway) and CR 551 Spur (Democrat Mickleton Road) - both

approaches of Kings Highway consist of a one lane approach, however the travel lanes are fourteen feet wide and have a paved shoulder which allows through and right turn movements to bypass vehicles queued up to turn left. The CR 551 Spur approaches also consist of one lane to serve all movements, however the lanes are narrower and have minimal shoulder width. Through and right turn movements must wait behind left turning vehicles. The intersection is controlled by a flashing beacon with the red indication flashing for CR 551 Spur.

CR 551 (Kings Highway) and CR 664 (Wolfert Station Road) - this is a four-legged unsignalized intersection. Both approaches on Kings Highway consist of a thirteen-foot travel lane and a two-foot paved shoulder. The approaches on Kings Highway are wide enough to permit through and right turning vehicles to bypass vehicles queued up to turn left onto CR 664. The one lane approaches of CR 664 are narrower and are controlled by a stop sign.

CR 551 (Kings Highway) and CR 607 (Tomlin Station Road) - this is a four-legged unsignalized intersection with stop control on CR 607. Both approaches on Kings Highway consist of a thirteen-foot travel lane and a two-foot paved shoulder. The approaches on Kings Highway are wide enough to permit through and right turning vehicles to bypass vehicles queued up to turn left onto CR 607. The one-lane approaches on CR 607 are eleven feet wide.

CR 678 (Berkley Road) and CR 667 (Cohawhin Road) - these two roads intersect at an oblique angle. The approaches on CR 678 have been widened to provide a shared through/left turn lane and a through/right turn lane. The CR 667 approaches have also been widened to provide a two lane approach plus a channelized right turn lane. Each leg has been widened to provide two departure lanes which taper back down to one travel lane. The intersection is controlled by a two phase actuated signal.

CR 551 Spur (Mickleton Jefferson Road) and CR 667 (Cohawkin Road) - this is an unsignalized three-legged intersection. CR 551 spur intersects CR 667 at an oblique angle and is controlled by a stop sign. All approaches consist of one twelve foot travel lane. Although the right turn volume from southbound CR 667 is exceptionally light throughout the day, the turning radius for this movement is extremely tight and vehicles have been observed cutting across the dirt area between the two roads to make the turn.

CR 551 Spur (Democrat Mickleton Road) and CR 680 (Harmony Road) - this is an unsignalized three-legged intersection. CR 680 intersects CR 551 Spur at an oblique angle and is controlled by a stop sign. The approaches on CR 551 Spur have a twelve foot travel lane and a two foot shoulder. CR 680 carries a ten foot travel lane.

CR 664 (Wolfert Station Road) and CR 607 (Tomlin Station Road) - this is a four-legged unsignalized intersection. The western leg of the intersection is a 22 foot wide municipal-owned road with no centerline or shoulder striping. The CR 607 approaches are ten feet wide and have a three foot shoulder. The westbound CR 664 approach is eleven feet wide and has a three foot shoulder. The intersection is stop controlled with the stop signs on Wolfert Station Road.

Existing Traffic Volumes

The DVRPC staff, with assistance from the Gloucester County Engineer's Office, has collected and analyzed the existing traffic volumes and travel patterns for the Kings Highway Corridor and surrounding road network. Two types of traffic data have been collected during this phase of the study: average annual daily traffic (AADT) and AM and PM peak hour turning movements.

The AADT counts were taken in March 1992. The raw daily traffic counts were converted into average annual daily traffic volumes to account for day of week and seasonal fluctuations in traffic levels. AADT volumes represent the average daily traffic on a road segment over the course of an entire year.

The existing AADT volumes are presented in Figure 3. The volumes on CR 551 range from approximately 4,400 vehicles per day in the vicinity of CR 607 to approximately 10,300 vehicles per day east of CR 678. The 10,300 vehicles per day on CR 551 is the highest count in the study area. The lowest volume in the study area is the 400 vehicles per day counted on CR 664 north of Kings Highway.

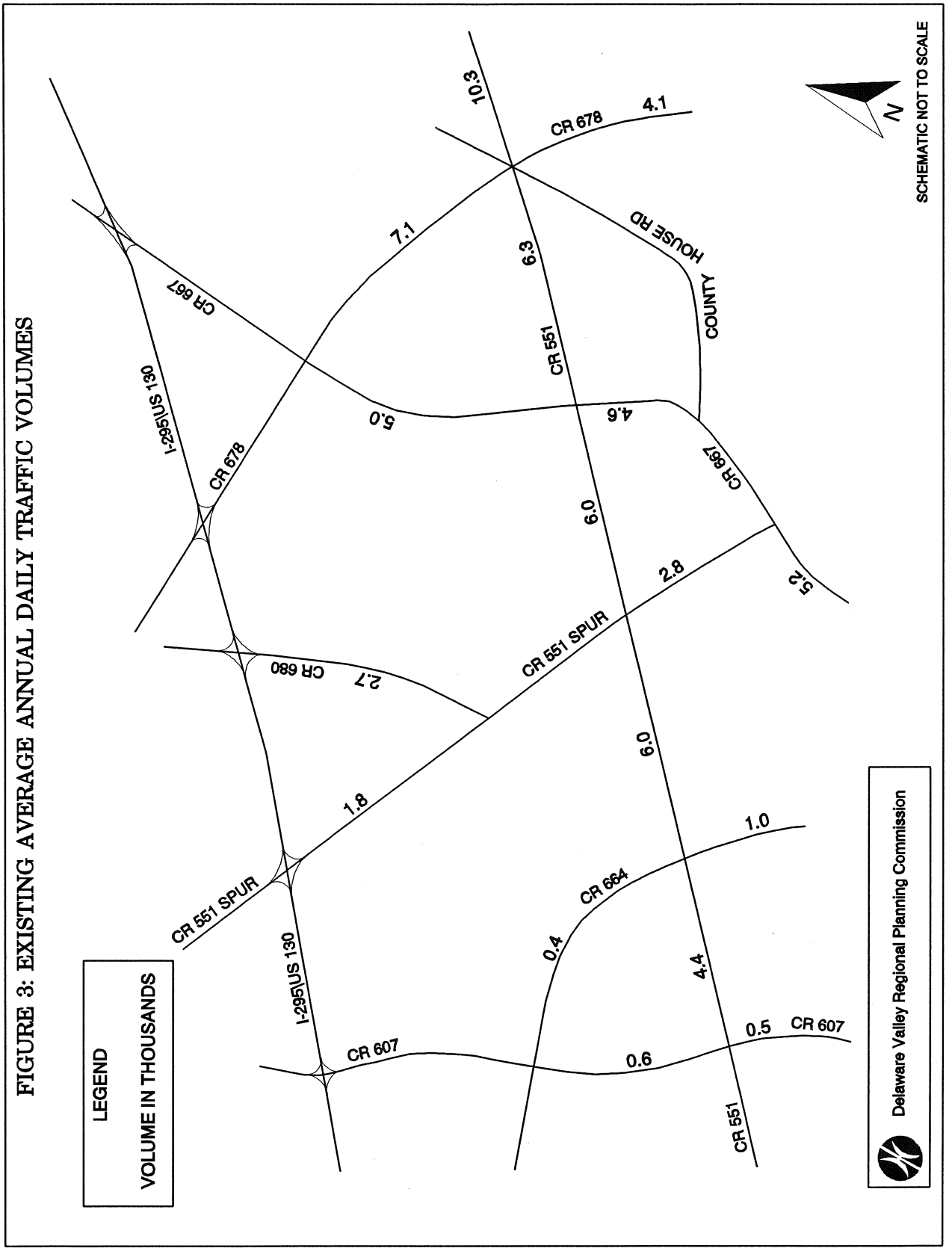
FIGURE 3: EXISTING AVERAGE ANNUAL DAILY TRAFFIC VOLUMES
LEGEND
VOLUME IN THOUSANDS
SCHEMATIC NOT TO SCALE
N
Delaware Valley Regional Planning Commission
I-295\US 130
CR 667
CR 678
CR 551
HOUSE RD
COUNTY
CR 661
CR 551 SPUR
CR 680
CR 664
CR 607
10.3
4.1
7.1
6.3
5.0
4.6
6.0
2.8
2.7
2.7
1.8
6.0
1.0
0.4
4.4
0.5
0.6

Manual turning movement counts were conducted at nine intersections in the study area during 1991 and 1992. Three signalized and six unsignalized intersections were counted. The counts were conducted in the AM peak period between 7:00 and 9:00 and in the PM peak period between 4:00 and 6:00. Peak hour traffic volumes (the four highest consecutive 15-minute periods) are presented in Figures 4 and 5. The following is a list of those intersections which were counted:

- CR 551 and CR 678
- CR 551 and CR 667
- CR 551 and CR 551 Spur
- CR 551 and CR 664
- CR 551 and CR 607
- CR 678 and CR 667
- CR 680 and CR 551 Spur
- CR 667 and CR 551 Spur
- CR 664 and CR 607

Existing Level of Service

A level of service (LOS) analysis was performed for those nine intersections as well as for selected road segments of the highway network. The results of the LOS analysis are presented in Figures 6, 7 and 8.

The concept of level of service is a qualitative measure describing operational conditions within a traffic stream and their perception by motorists in terms of speed and travel time, traffic interruptions, freedom to maneuver, comfort, and convenience. Six levels of service are defined; they are given letter designations, A to F, with level of service A representing the best operating conditions and level of service F the worst.

The existing levels of service on various road segments of the highway network and at intersections were determined by using the Highway Capacity Software, a computer model developed by the Federal Highway Administration (FHWA) based on the Highway Capacity Manual, Transportation Research Board Special Report 209. Different methodologies are specified for two lane roadways, signalized and unsignalized intersections.

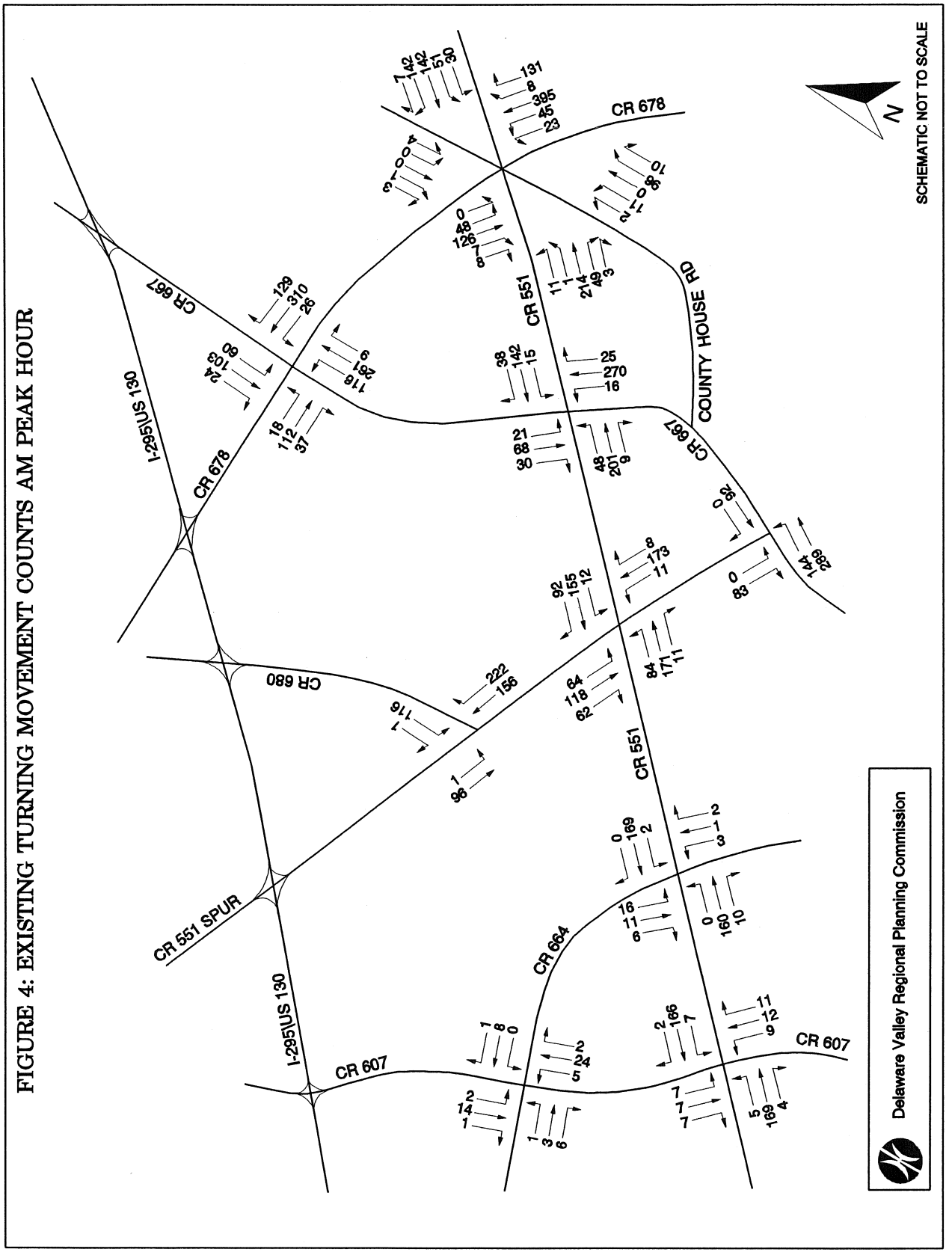
FIGURE 4: EXISTING TURNING MOVEMENT COUNTS AM PEAK HOUR
SCHEMATIC NOT TO SCALE
N
CR 678
CR 551
COUNTY HOUSE RD
CR 667
I-295\US 130
CR 680
CR 551 SPUR
CR 664
CR 607
Delaware Valley Regional Planning Commission

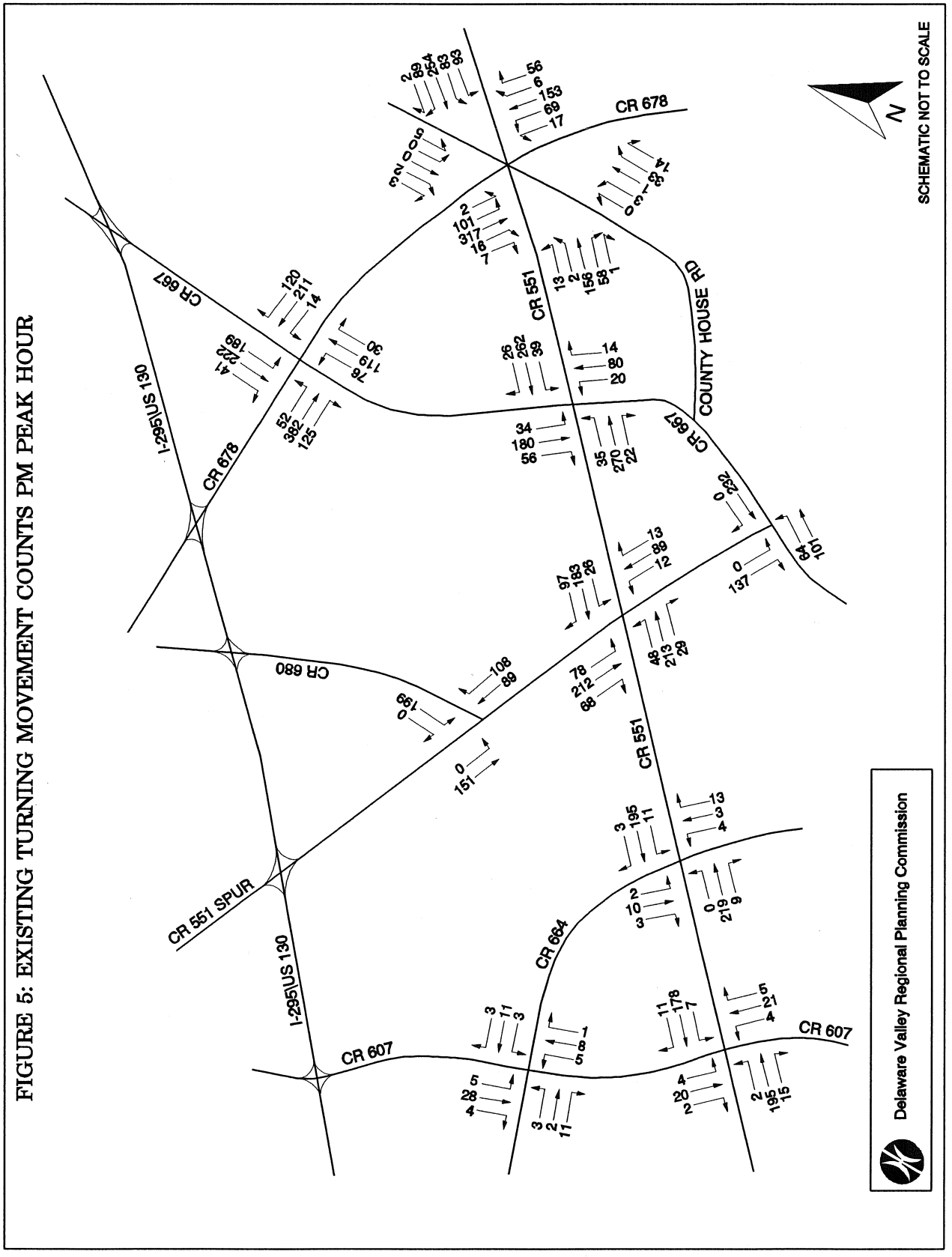

FIGURE 5: EXISTING TURNING MOVEMENT COUNTS PM PEAK HOUR

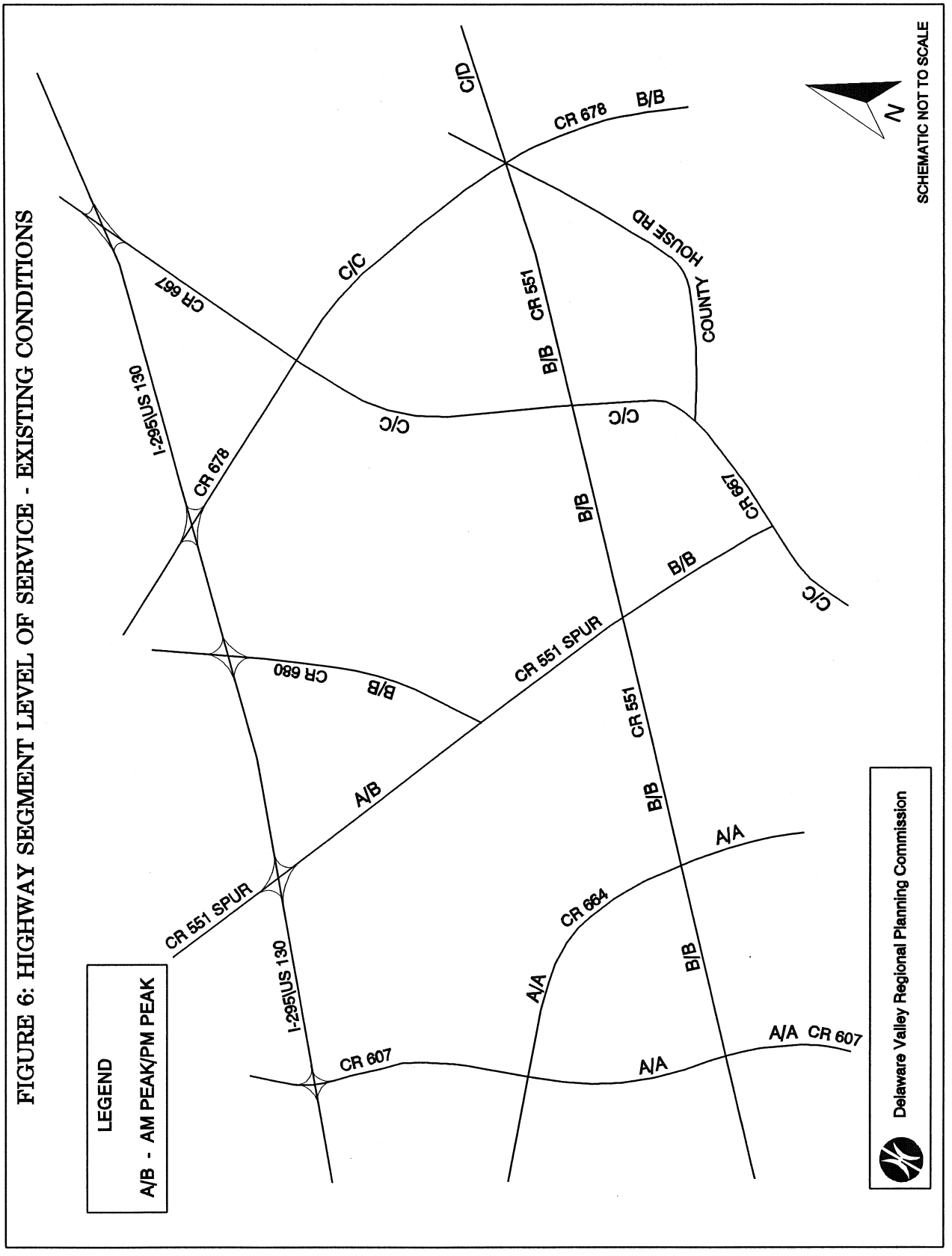
FIGURE 6: HIGHWAY SEGMENT LEVEL OF SERVICE - EXISTING CONDITIONS
LEGEND
A/B - AM PEAK/PM PEAK
SCHEMATIC NOT TO SCALE
N
Delaware Valley Regional Planning Commission
I-295\US 130
CR 667
CR 678
CR 680
CR 551 SPUR
CR 607
CR 664
CR 551
HOUSE RD
COUNTY
CR 687
C/C
C/D
B/B
A/B
A/A

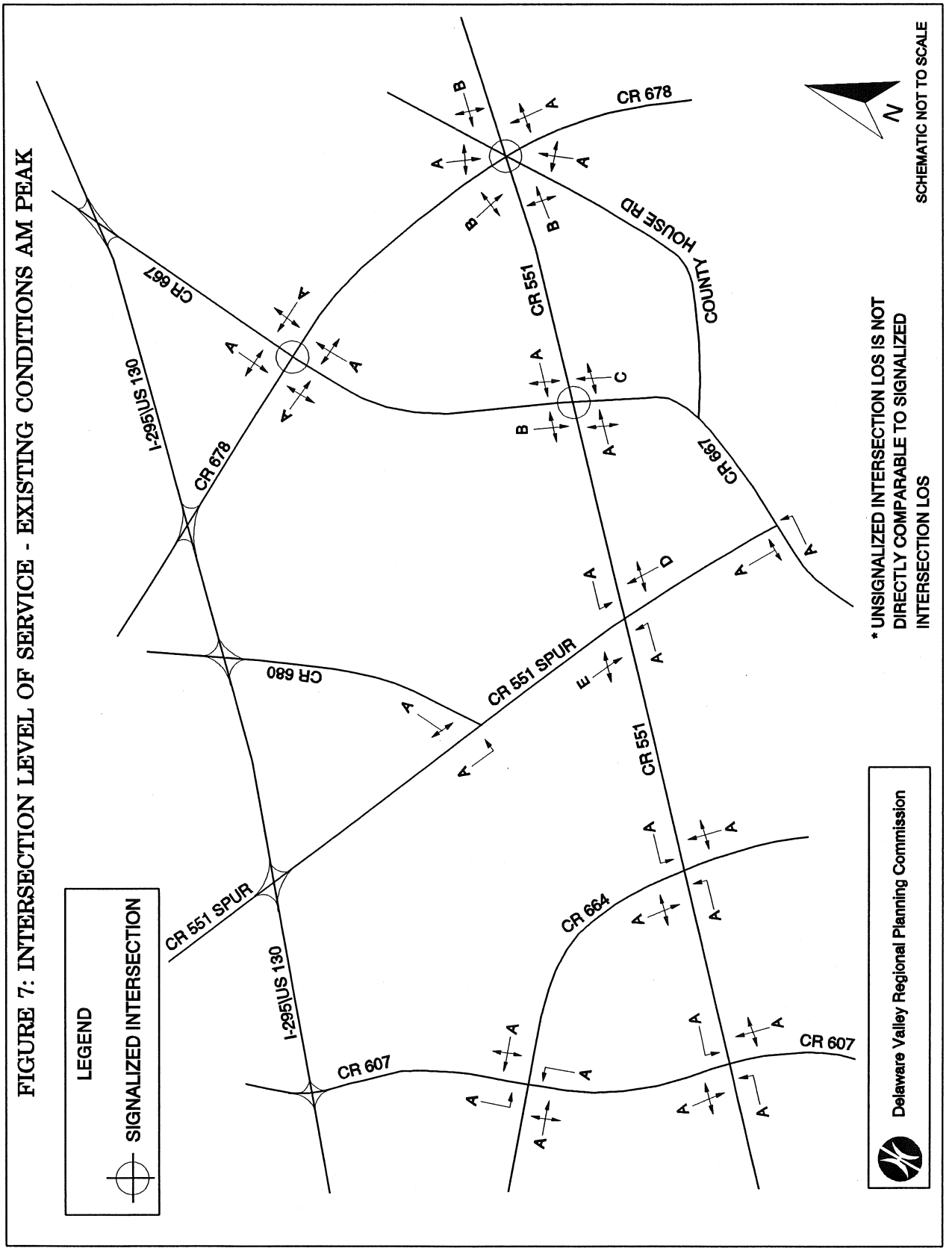
FIGURE 7: INTERSECTION LEVEL OF SERVICE - EXISTING CONDITIONS AM PEAK
LEGEND
SIGNALIZED INTERSECTION
CR 667
I-295\US 130
CR 678
CR 680
CR 551 SPUR
CR 607
CR 664
CR 551
COUNTY HOUSE RD
* UNSIGNALIZED INTERSECTION LOS IS NOT DIRECTLY COMPARABLE TO SIGNALIZED INTERSECTION LOS
SCHEMATIC NOT TO SCALE
N
Delaware Valley Regional Planning Commission

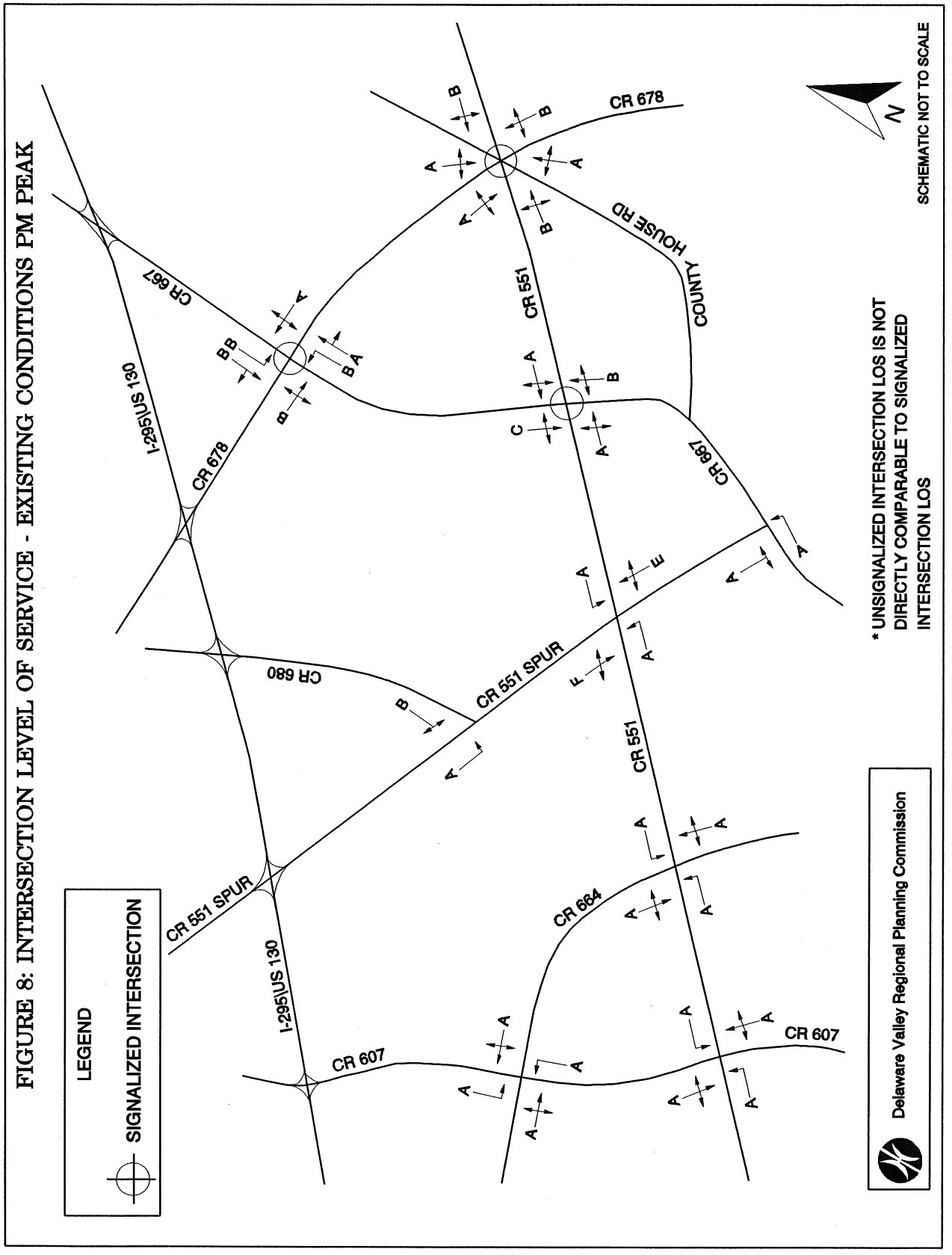
FIGURE 8: INTERSECTION LEVEL OF SERVICE - EXISTING CONDITIONS PM PEAK
LEGEND
SIGNALIZED INTERSECTION
CR 667
I-295\US 130
CR 678
CR 678
CR 551
COUNTY HOUSE RD
CR 667
CR 680
CR 551 SPUR
CR 551 SPUR
CR 551
CR 664
I-295\US 130
CR 607
CR 607
* UNSIGNALIZED INTERSECTION LOS IS NOT DIRECTLY COMPARABLE TO SIGNALIZED INTERSECTION LOS
SCHEMATIC NOT TO SCALE
N
Delaware Valley Regional Planning Commission

Two-lane highways operate under uninterrupted flow conditions when the distance between traffic signals or stop signs exceeds two miles. When the roadway segment is less than two miles in length, the intersection where flow is interrupted is the primary determinant of level of service. When uninterrupted flow conditions occur, the level of service for a two lane-highway is defined in terms of average travel speed or, more frequently, utilization of capacity, namely the ratio of the demand volume to the capacity of the roadway (v/c ratio). The capacity of a highway is a function of a number of factors including: lane and shoulder widths, percentage of "no passing zone", truck percentage, directional split in traffic flow, and roadway grade. A subjective description of each level of service is given in Table 1. It is important to note that because of the complex relationship between travel speed, percent "no passing zone", roadway grade and level of service, it is not possible to simply list a v/c ratio for each level of service. Service flows at each service level are expressed for ideal conditions. Any deviation from these conditions (for example a lane width of less than 12 feet) will reduce the service flow volume.

A level of service analysis for two-lane highways was conducted on seventeen links of the highway network in the study area. The results of this analysis indicate acceptable operating conditions on all links.

Level of service for signalized intersections is defined in terms of delay. Delay is a measure of driver discomfort, frustration, fuel consumption, and lost travel time. Delay is a complex measure dependent upon a number of variables, including the quality of signal progression, cycle length, and the volume to capacity (V/C) ratio. Level of service criteria is stated in terms of the average stopped delay per vehicle on an approach or lane basis. Table 2 gives a subjective description of each level of service and its delay range. It is important to note that delay (i.e., level of service) is not related to capacity in a simple fashion. Thus, the designation of level of service F does not automatically imply the approach is overloaded. Long cycle length and poor signal progression can result in excessive delays. Conversely, an overloaded approach with a short cycle length may result in a high level of service.

A level of service analysis was prepared for the existing conditions at the three signalized intersections in both the AM and PM peak periods. All three intersections operate at acceptable levels of service in both peak periods. The following is a summary of the findings of the level of service analysis for the existing conditions for each of the signalized intersections.

CR 551 (Kings Highway), CR 678 (Berkley Road), County House Road and North Street - this intersection operates extremely well in both peak periods. All approaches operate at LOS A or B in both the AM and PM peaks.

CR 551 (Kings Highway) and CR 667 (Cohawkin Road) - the overall intersection LOS is B in both the AM and PM peak periods. CR 667 experiences a LOS C on the northbound approach in the AM peak and LOS C on the southbound approach in the PM peak.

CR 678 (Berkley Road) and CR 667 (Cohawhin Road) - in the AM Peak, all approaches operate at LOS A. Although the intersection continues to operate at acceptable service levels during the PM peak, an increase in volume forces the shared through/left turn lanes to operate as defacto left turn lanes.

Level of service criteria for unsignalized intersections are defined in terms of reserved or unused capacity. Reserve capacity is related to general delay ranges (see Table 3). Since delay is stated in general terms, without specific numeric values, it is not possible to compare or associate unsignalized level of service with signalized level of service. The potential capacity of a lane is based upon two factors: 1) distribution of gaps in the cross traffic stream and 2) driver judgement in selecting gaps through which to execute the desired maneuvers. Reserve capacity represents the difference between the approach volume and potential capacity. The analysis focuses on lanes on the minor stopped street and left turn maneuvers from the major street.

A level of service analysis was prepared for the existing conditions at the six unsignalized intersections in both the AM and PM peak periods. The following is a summary of the findings of that analysis.

CR 551 (Kings Highway) and CR 551 Spur (Democrat Mickleton Road) - both CR 551 Spur approaches, which are controlled by stop signs, experience deficiencies in both peak periods. Left turns from CR 551 operate at LOS A.

CR 551 (Kings Highway) and CR 664 (Wolfert Station Road) - all the approaches to this intersection operate at LOS A in both the AM peak and the PM peak periods.

CR 551 (Kings Highway) and CR 607 (Tomlin Station Road) - all the approaches to this intersection operate at LOS A in both the AM and PM peak periods.

CR 551 Spur (Mickleton Jefferson Road) and CR 667 (Cohawhin Road) - the critical approaches to this intersection operate at LOS A in both the AM and PM peak periods.

CR 551 Spur (Democrat Mickleton Road) and CR 680 (Harmony Road) - the CR 680 approach operates at LOS A in the AM peak and LOS B in the PM Peak. Left turns from CR 551 Spur operate at LOS A in both peaks.

CR 664 (Wolfert Station Road) and CR 607 (Tomlin Station Road) - all the approaches to this intersection operate at LOS A in both the AM and PM peak periods.

TABLE 1: Level of Service Criteria - Two Lane Highways

Level of service A - average speeds at or above speed limit. The passing frequency required to maintain these speeds has not reached a demanding level. Passing demand is well below passing capacity; almost no platoons of three or more vehicles are observed. A maximum flow rate of 420 vehicles per hour, total in both directions, may be achieved under ideal conditions.

Level of service B - passing demands needed to maintain desired speeds become significant and approximately equals passing capacity at the lower boundary of level of service B. The number of platoons forming in the traffic stream begins to increase dramatically. Service flow rates of 750 vehicles per hour, total in both directions, can be achieved under ideal conditions.

Level of service C - noticeable increase in platoon formation, platoon size, and frequency of passing impediment. Unrestricted passing demand exceeds passing capacity. At higher volume levels, chaining of platoons and significant reductions in passing capacity begin to occur. While traffic flow is stable, it is becoming susceptible to congestion due to turning traffic and slow-moving vehicles. A service flow rate of up to 1,200 vehicles per hour, total in both directions, can be accommodated under ideal conditions.

Level of service D - unstable flow is approached. The two opposing traffic streams essentially begin to operate separately at higher volume levels, as passing becomes extremely difficult. The fraction of no passing zones along the roadway usually has little influence on passing. Turning vehicles and/or roadside distractions cause major shock waves in the traffic stream. This is the highest flow rate that can be maintained for any length of time without a high probability of a breakdown. A service flow rate of up to 1,800 vehicles per hour, total in both directions, can be accommodated under ideal conditions.

Level of service E - passing is virtually impossible and platooning becomes intense when slower vehicles or other interruptions are encountered. The highest volume attainable under level of service E defines the capacity of the highway. Under ideal conditions, capacity is 2,800 vehicles per hour total in both directions. For other conditions, capacity is lower.

Level of service F - represents heavily congested flow with traffic demand exceeding capacity. Frequently, perturbations in traffic flow as level E is approached cause a rapid transition to level of service F.

Source: Highway Capacity Manual, Transportation Research Board, Special Report 209, 1985

TABLE 2: Level of Service Criteria - Signalized Intersections

LEVEL OF SERVICE A - Very low delay, good progression; most vehicles do not stop at intersection. Delay less than 5 seconds per vehicle.

LEVEL OF SERVICE B - Generally good signal progression and/or short cycle length; more vehicles stop at intersection than Level of Service A. Delay range 5-15 seconds per vehicle.

LEVEL OF SERVICE C - Fair progression and/or longer cycle length; significant number of vehicles stop at intersection. Delay range 15-25 seconds per vehicle.

LEVEL OF SERVICE D - Congestion becomes noticeable; individual cycle failures; longer delays from unfavorable progression, long cycle length, or high volume/capacity ratios; many vehicles stop at signal. Delay range 25-40 seconds per vehicle.

LEVEL OF SERVICE E - Considered limit of acceptable delay, indicative of poor progression, long cycle length, high volume/capacity ratio; frequent individual cycle failures. Delay range 40-60 seconds per vehicle.

LEVEL OF SERVICE F - Unacceptable delay, indication of oversaturation (i.e., arrival flow exceeds capacity). Average delay exceeds 60 seconds per vehicle.

Source: Highway Capacity Manual, Transportation Research Board, Special Report 209, 1985

TABLE 3: Level of Service Criteria - Unsignalized Intersections

Level of Service	Reserve Capacity	Expected Delay to Minor Street Traffic
A	Greater than 400	Little or no delay
B	300-400	Short traffic delays
C	200-299	Average traffic delays
D	100-199	Long traffic delays
E	0-99	Very long traffic delays
F	*	*

*When demand volume exceeds the capacity of the lane, extreme delays will be encountered with queuing which may cause severe congestion affecting other traffic movements in the intersection.

Source: Highway Capacity Manual, Transportation Research Board, Special Report 209, 1985

IV. TRAVEL FORECASTING PROCEDURES

The process used to generate Year 2010 travel forecasts for the Kings Highway Corridor is an application of the Quick Response System II (QRS II) travel simulation model and the Turnflow Program. The QRS II model is a computer program commonly used for forecasting impacts of development on highway traffic and will provide projected daily traffic volumes on the identified highway network. The Turnflow Program is a spreadsheet template which utilizes the output of the QRS II model to project turning movement volumes at specified intersections.

Traffic Simulation Model

QRS was first introduced as a set of manual techniques in 1978. The original QRS, as documented in National Cooperative Highway Research Program (NCHRP) Report number 187, described several related analysis techniques: trip generation, trip distribution, mode choice, conversion of all-day person-trips to vehicle trips, traffic assignment, capacity analysis and highway spacing. The techniques principally addressed planning problems that were too small to warrant analysis with the cumbersome computer programs available at the time.

In 1981, the Federal Highway Administration (FHWA) released the first microcomputer version of QRS. QRS I served to facilitate some of the manual calculations. QRS's implementation on a microcomputer meant that somewhat larger planning problems could be handled.

The DOS version of QRS II was first released in 1987. It could be used to perform routine calculations of the manual techniques or it could be used to perform detailed analysis comparable to those done with mainframe programs such as UTPS. QRS II was interfaced to a powerful program for data entry called the General Network Editor (GNE). GNE permits the user to draw a network on the microcomputer screen, enter verbal descriptions and numerical data about each element of the network , edit the network and its data, compute intermediate results through a series of worksheets and search for network elements that meet certain criteria. GNE can also be used for displaying results from QRS II. All data for QRS II are entered through GNE.

To accurately simulate trip making in this area, the study area was expanded to encompass

nine other municipalities around East Greenwich and a designated network of roadways. The study area is described by a set of zones. Zones may vary greatly in size but they cover the whole study area without overlaps and without leaving any gaps. The traffic zone system is based on Gloucester County census tracts which have been separated into smaller zones to focus on a fine grain highway network. This results in 73 traffic zones for the expanded study area. Zones have attributes that are important to QRS II. The most important attributes of a zone are the population and employment in that zone.

The highway system is described by a network. A network consists mainly of representations of streets and intersections. Streets are shown as links and intersections are shown as nodes. Streets and intersections have attributes also. The most important attribute of a street segment (link) is the time it takes to travel from one end to the other.

Before any analysis can occur, the highway network and the set of zones must be integrated. This is accomplished by representing each zone as a special type of node called a centroid. Centroids are attached to the highway network by a special type of link called a centroid connector. QRS II uses this integrated network to find the travel times and the exact sequence of links along the shortest paths between every pair of centroids.

The process used to generate Year 2010 travel forecasts for the Kings Highway corridor is an application of the standard four step transportation modelling process.

Four Step Modeling Process

Trip Generation - QRS II accomplishes its forecasts by first determining the number of person-trips that are produced at and attracted to each zone. Estimates of internal trip productions and attractions by zone are established on the basis of trip rates applied to the zonal estimates of population and employment data. QRS II separately determines trip productions and trip attractions for each zone for three purposes: home-based work, home-based nonwork and nonhome-based.

Trip Distribution - The second step in the forecast is to determine for each purpose the number of person-trips that go from any given production zone to any given attraction zone. Two such zones are referred to as an O-D (origin-destination) pair. An O-D pair receives a relatively large allocation of trips if 1) the trip productions in the production zone are large, 2) the trip

attractions in the attraction zone are large or 3) the travel time between the zones is small.

Mode Split - If transit ridership forecasts are needed, QRS II performs a third step called modal split. During this step, the model determines for each O-D pair the number of person-trips for transit and the number of person-trips for automobiles. Since transit service is extremely limited in the study area, This process was not used in this analysis.

Traffic Assignment - This step converts highway person-trips to vehicle-trips, which are assigned to the links in the highway network following the shortest paths previously found in the trip distribution step. Traffic volumes may be estimated for any part of the day. QRS II finds the number of person-trips for each O-D pair that occurs during each hour of a requested time period, converts these hourly person-trips to hourly vehicle-trips and sums the vehicle trips over all hours in the time period.

As part of the traffic assignment step, QRS II estimates the amount of delay expected on each link and at each intersection. QRS II has delay relationships for both two-lane and multi-lane uncontrolled road segments. QRS II also has separate delay relationships for signalized intersections, two-way stop intersections and all-way stop intersections. These delays can be incorporated into the forecast to assure that traffic volumes will be consistent with intersection geometry and traffic control.

A calibration run of the QRS II model was performed to insure that the model could replicate the existing volumes counted on the road network. The model was run with data representing the existing conditions and the output was compared to the existing traffic volumes. The calibration run was conducted, making minor adjustments to input data, so that the output volumes closely matched the existing counts. When the calibration was completed, demographic data for the Year 2010 was entered and the model was rerun to project future volumes.

To convert the projected daily traffic volumes into turning movements at intersections, a program called Turnflow was used. The Turnflow Program was written as a spreadsheet template for use with Lotus 1-2-3$_{(TM)}$ Release 2 and is based on the algorithm and technique described by Hauer, Pagitsas and Shin (Estimation of Turning Flows from Automatic Counts, Transportation Research Record 795, 1981). The algorithm and technique provides a balanced set of intersection turning flows from a set of pre-specified inbound and outbound intersection flows and an estimate of the probable turning proportions at each approach. The inbound and

outbound intersection flows are derived by applying the K factor and D factor of the existing AADT to the corresponding future daily traffic projection. The estimate of probable turning movement proportions are taken from the turning movement proportions of the corresponding existing intersection turning movement count.

Socio-Economic Projections

Travel forecasting models require that the estimates of population and employment data be made for small areas or zones. For the QRS II model this requires estimates for each of the following variables:

- population
- retail employment
- non-retail employment

This requirement is derived from the need to assign trip making associated with households and businesses to the streets and transit facilities serving them.

As part of ongoing regional planning activities completed by DVRPC, staff has prepared Year 2010 zonal forecasts of the socio-demographic inputs to the travel simulation process. These 2010 projections form the basis for the Kings Highway corridor travel projections included in this report.

In these forecasts, the population of the DVRPC region is expected to grow 9.6 percent in the 20 years between 1990 and 2010. The population of Gloucester County is expected to increase by 22 percent. Within the study area, the population is expected to grow by 11.6 percent. Table 4 displays the forecasted population growth for each of the municipalities in the study area.

Employment across the region is expected to grow consistent with the regional population growth rate. The regional increase is projected to be 10 percent. An increase in employment of 27.8 percent is expected for Gloucester County. The study area employment is projected to experience a 21.9 percent growth. Table 5 displays the forecasted employment growth for each of the municipalities in the study area.

TABLE 4: POPULATION GROWTH IN THE KINGS HIGHWAY STUDY AREA

Municipality	1990 US Census	2010 DVRPC Forecast	Change Number	Change Percent
Deptford	24,137	27,184	3,034	12.6%
East Greenwich	5,258	6,137	879	16.7%
Greenwich	5,102	5,172	70	1.4%
Mantua	10,074	12,350	2,276	22.6%
National Park	3,413	3,502	89	2.6%
Paulsboro	6,577	6,482	-95	-1.4%
Wenonah	2,331	2,639	308	13.2%
West Deptford	19,380	22,683	3,303	17.0%
Woodbury	10,904	11,315	411	3.8%
Woodbury Heights	3,392	3,642	250	7.4%
Study Area Total	90,568	101,106	10,538	11.6%

TABLE 5: EMPLOYMENT GROWTH IN THE KINGS HIGHWAY STUDY AREA

Municipality	1990 DVRPC Estimate	2010 DVRPC Forecast	Change Number	Change Percent
Deptford	11,820	14620	2800	23.7%
East Greenwich	1,430	1,680	250	17.5%
Greenwich	3,440	3,830	390	11.3%
Mantua	4,910	6,600	1,690	35.6%
National Park	310	420	110	35.5%
Paulsboro	4,700	5,750	1,050	22.3%
Wenonah	470	600	130	27.7%
West Deptford	6,520	8,350	1,830	28.1%
Woodbury	9,480	10,540	1,060	11.2%
Woodbury Heights	2,130	2,740	610	28.6%
Study Area Total	45,210	55,130	9,920	21.9%

Several municipalities within the study area were subdivided into smaller areas called zones in order to more accurately create a well defined highway network. Since the population and employment data is presented at the municipal level, it was necessary to assign the appropriate amount of population and employment into the proper zones. East Greenwich Township was subdivided into 15 smaller zones. The appropriate levels of population and employment was assigned to each.

To project future traffic volumes on the road network, the municipal level population and employment forecasts for the Year 2010 needed to be assigned to the subdivided zones. While increases in population and employment had been developed at the municipal level, local expertise was required in locating areas of expected growth within the municipality. Municipal officials in East Greenwich Township were provided with the municipal level forecasts and asked to assign the appropriate growth to the proper zones. Their assistance in this task was essential in producing the future trip generation and O-D patterns used to develop the future traffic projections.

V. FUTURE TRAFFIC

Future Traffic Volumes

This section will present the Year 2010 traffic projections for the highway network developed through the QRS II modelling process and projected intersection turning movements which resulted from applications of the Turnflow Program. Both of these computer models have been explained in the previous section.

The Year 2010 daily traffic projections for the highway segments are presented in Table 6 along with the absolute and percent change from the existing AADT's for this network. The Year 2010 traffic forecasts are also displayed in Figure 9. The traffic volumes on CR 551 are projected to increase approximately 1,300 to 1,600 vehicles per day in the study area. This represents increases that range from approximately 15 to 32 percent. Traffic volumes on the other roads in the network are projected to experience only minor increases which range from 100 to 1,400 vehicles per day. The location of the highest projected volume in the study area corresponds to the location of the highest existing count. The forecasted volume of 11,900 vehicles per day on CR 551 just east of CR 678 is a 15.5% increase over the existing count of 10,300. The lowest projected volume in the study area occurs on CR 607 between CR 551 and US 322. The existing AADT of 500 is projected to increase only 100 to 600 vehicles per day which represents a 20 % increase. There are three segments on the network which are projected to increase by only about 6 to 7 percent, however the absolute increases in traffic volumes are consistent with other similar segments of the network. Two of these segments serve essentially the same travel patterns: CR 680 from I-295 to CR 551 Spur and CR 551 Spur from I-295 to CR 680 connect Kings Highway in Mickleton to I-295. The third segment is CR 551 Spur from CR 551 to CR 667.

Figures 10 and 11 display the projected AM and PM peak hour intersection turning movements. These turning movements were derived by converting the daily volumes into peak hour volumes using the K factor from the corresponding existing AADT. The intersection inflows and outflows were determined by applying the D factor from the corresponding existing count to these future peak hour volumes. The inflows and outflows were input into the Turnflow Program and were balanced to develop the future AM and PM peak hour intersection turning movements.

TABLE 6: Year 2010 Traffic Projections

County Route No.	Segment Limits	1991 AADT	2010 Volume	Absolute Change	Percent Change
CR 551	CR 648 to CR 678	10,300	11,900	1,600	15.5%
CR 551	CR 678 to CR 667	6,300	7,600	1,300	20.6%
CR 551	CR 667 to CR 551 Spur	6,000	7,400	1,400	23.3%
CR 551	CR 551 SPUR to CR 664	6,000	7,600	1,600	26.7%
CR 551	CR 664 to CR 607	4,400	5,800	1,400	31.8%
CR 678	CR 551 to NJ 45	4,100	4,900	800	19.5%
CR 678	CR 551 to CR 667	7,100	8,500	1,400	19.7%
CR 667	CR 551 to CR 678	5,000	5,900	900	18.0%
CR 667	CR 551 to CR 551 Spur	4,600	5,400	800	17.4%
CR 667	CR 551 SPUR to NJ 45	5,200	5,900	700	13.5%
CR 680	CR 551 SPUR to I-295	2,700	2,900	200	7.4%
CR 551 Spur	I-295 to CR 680	1,800	1,900	100	5.6%
CR 551 Spur	CR 551 to CR 667	2,800	3,000	200	7.1%
CR 664	CR 551 to CR 607	400	700	300	75.0%
CR 664	CR 551 to NJ 45	1,000	1,400	400	40.0%
CR 607	CR 551 to CR 664	600	700	100	16.7%
CR 607	CR 551 to US 322	500	600	100	20.0%

Future Level of Service

A level of service (LOS) analysis was performed for the nine intersections and the seventeen highway segments on the network using the Year 2010 projected volumes and the existing intersection and roadway configurations. The results of this analysis are presented in Figures 12, 13 and 14.

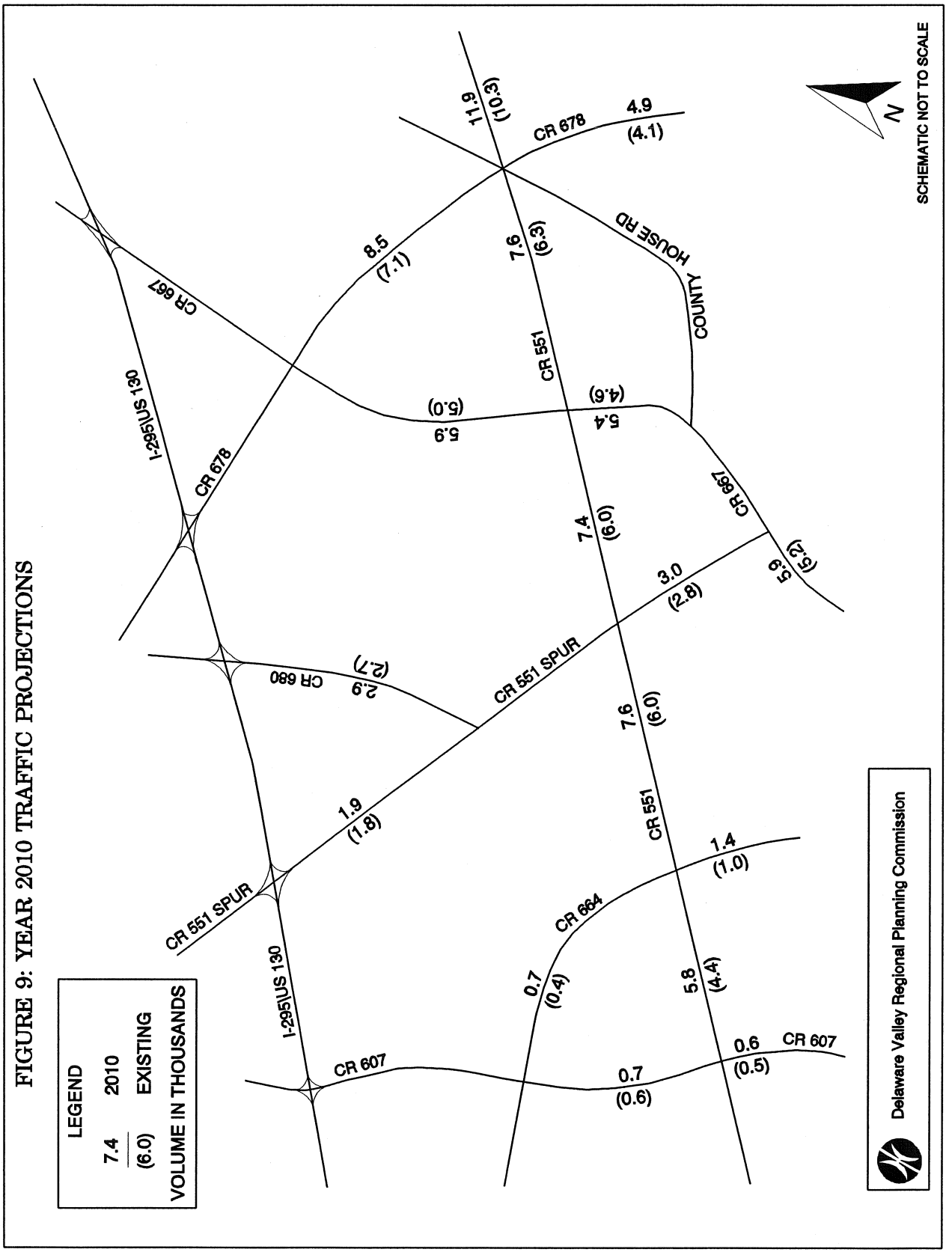
FIGURE 9: YEAR 2010 TRAFFIC PROJECTIONS
LEGEND
7.4 2010
(6.0) EXISTING
VOLUME IN THOUSANDS
SCHEMATIC NOT TO SCALE
N
Delaware Valley Regional Planning Commission
CR 607
I-295\US 130
CR 551 SPUR
CR 680
CR 678
CR 667
I-295\US 130
CR 551
CR 664
CR 607
CR 678
HOUSE RD
COUNTY
CR 667
CR 551
CR 551 SPUR
0.7 (0.6)
0.6 (0.5)
0.7 (0.4)
5.8 (4.4)
1.4 (1.0)
1.9 (1.8)
2.9 (2.7)
7.6 (6.0)
3.0 (2.8)
5.9 (5.2)
7.4 (6.0)
5.9 (5.0)
5.4 (4.6)
8.5 (7.1)
7.6 (6.3)
11.9 (10.3)
4.9 (4.1)

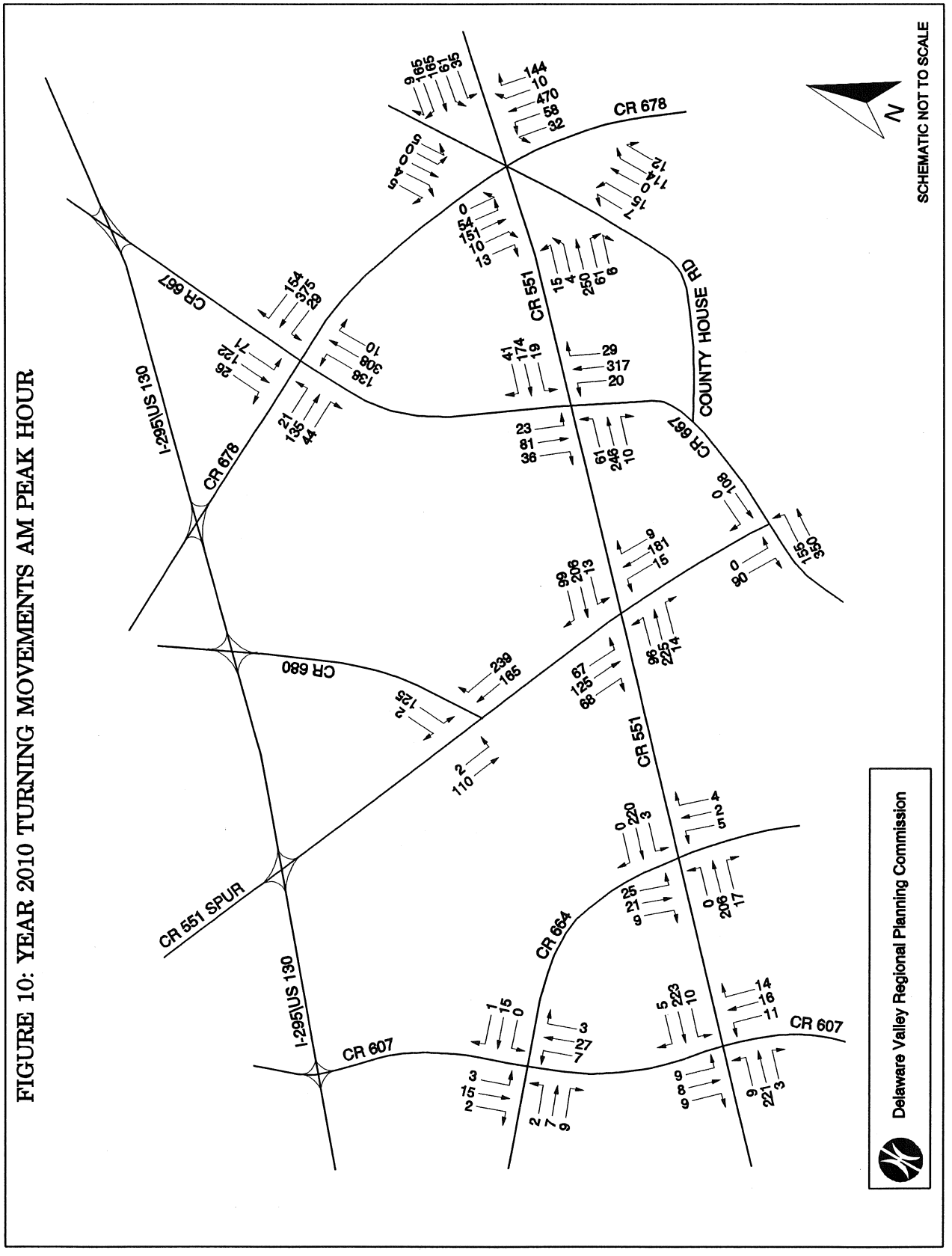
FIGURE 10: YEAR 2010 TURNING MOVEMENTS AM PEAK HOUR
SCHEMATIC NOT TO SCALE
N
CR 678
CR 667
I-295\US 130
CR 551
COUNTY HOUSE RD
CR 680
CR 551 SPUR
CR 664
CR 607
Delaware Valley Regional Planning Commission

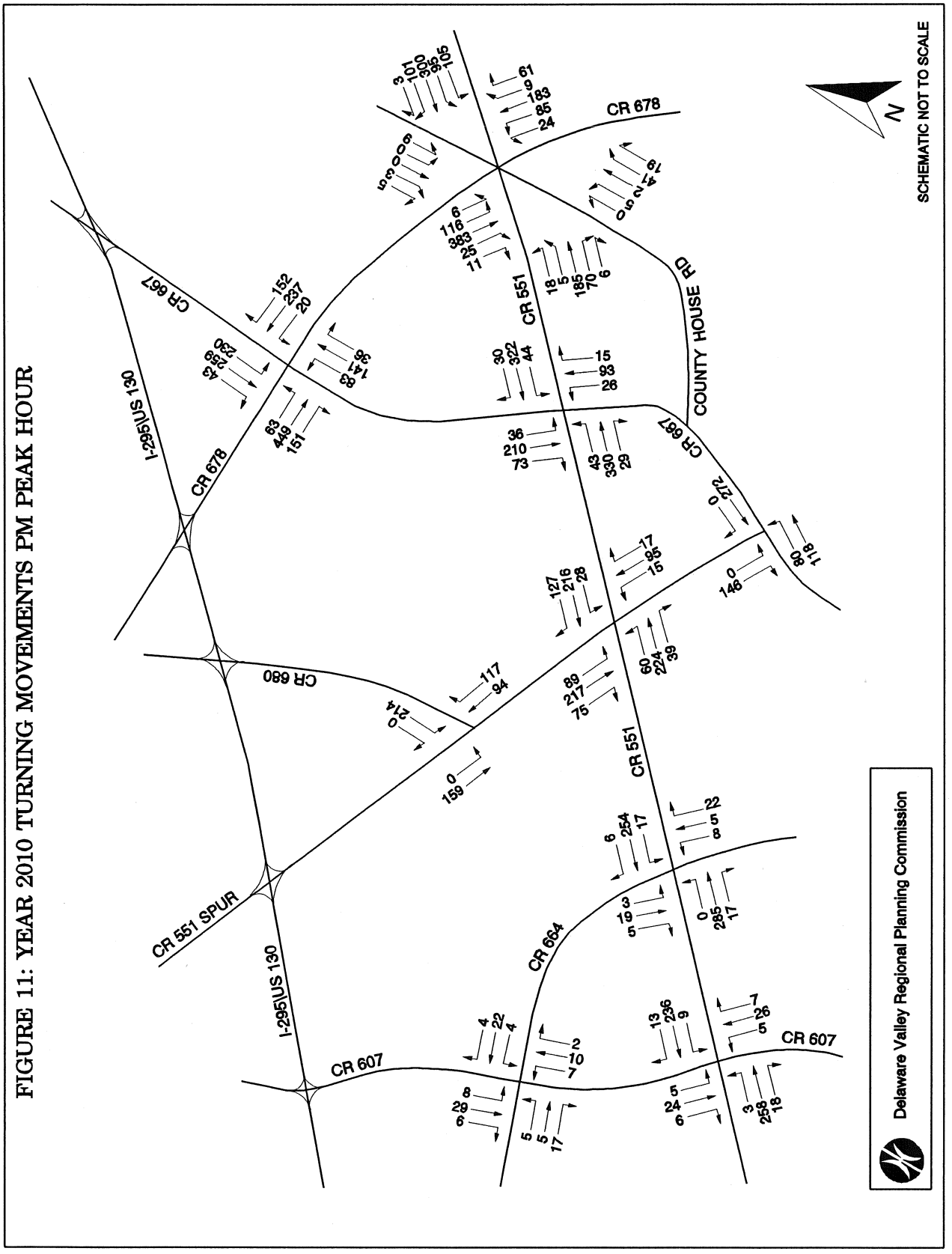
FIGURE 11: YEAR 2010 TURNING MOVEMENTS PM PEAK HOUR
SCHEMATIC NOT TO SCALE
N
CR 678
CR 667
I-295\US 130
CR 551
COUNTY HOUSE RD
CR 680
CR 551 SPUR
CR 664
CR 607
Delaware Valley Regional Planning Commission

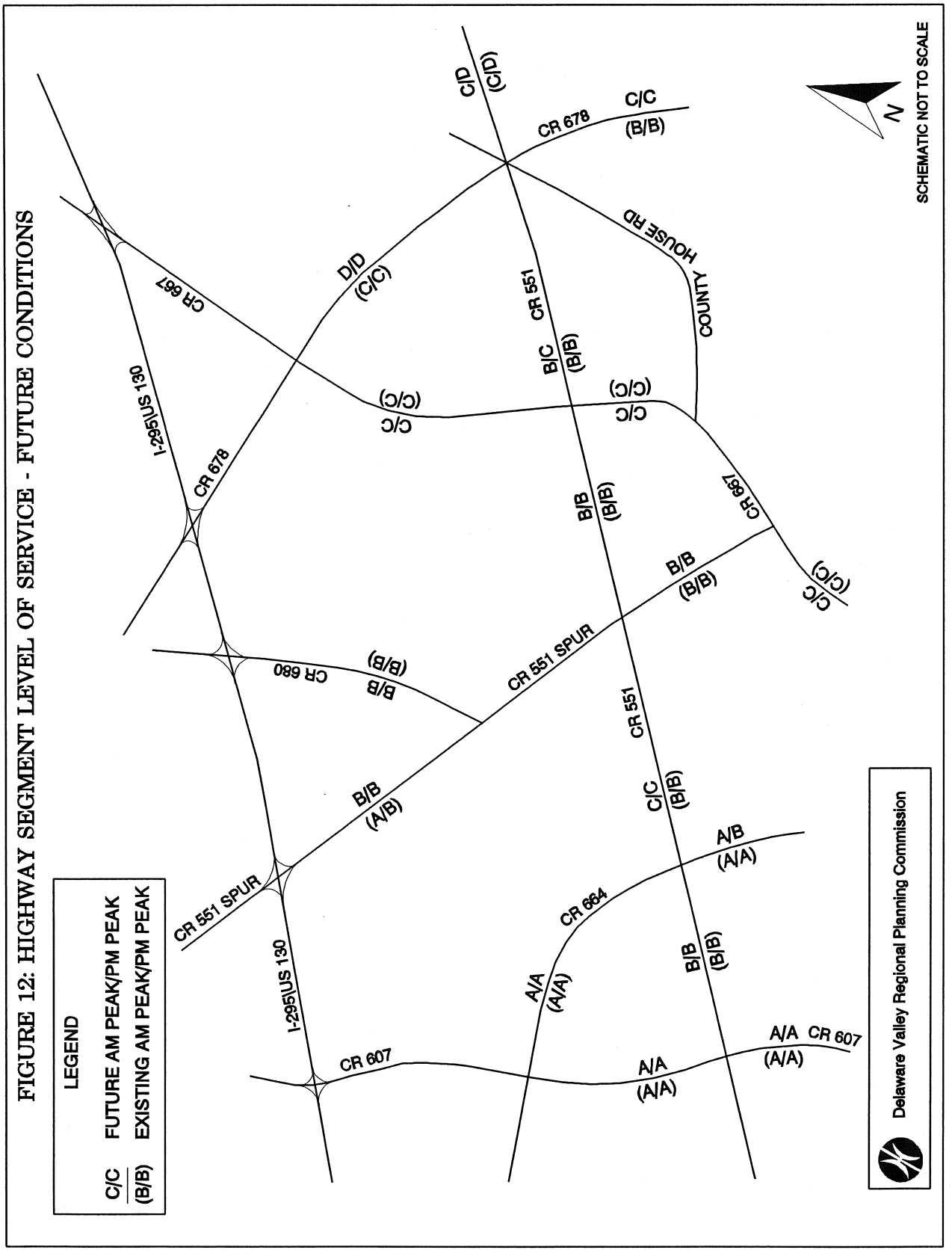
FIGURE 12: HIGHWAY SEGMENT LEVEL OF SERVICE - FUTURE CONDITIONS
LEGEND
C/C FUTURE AM PEAK/PM PEAK
(B/B) EXISTING AM PEAK/PM PEAK
SCHEMATIC NOT TO SCALE
N
Delaware Valley Regional Planning Commission
CR 667
I-295\US 130
CR 678
D/D (C/C)
C/D (C/D)
CR 678
C/C (B/B)
HOUSE RD
COUNTY
CR 551
B/C (B/B)
C/C (C/C)
C/C (C/C)
CR 667
B/B (B/B)
B/B (B/B)
C/C (C/C)
CR 680
B/B (B/B)
CR 551 SPUR
B/B (A/B)
CR 551
C/C (B/B)
CR 551 SPUR
I-295\US 130
CR 664
A/B (A/A)
A/A (A/A)
B/B (B/B)
CR 607
A/A (A/A)
A/A CR 607 (A/A)

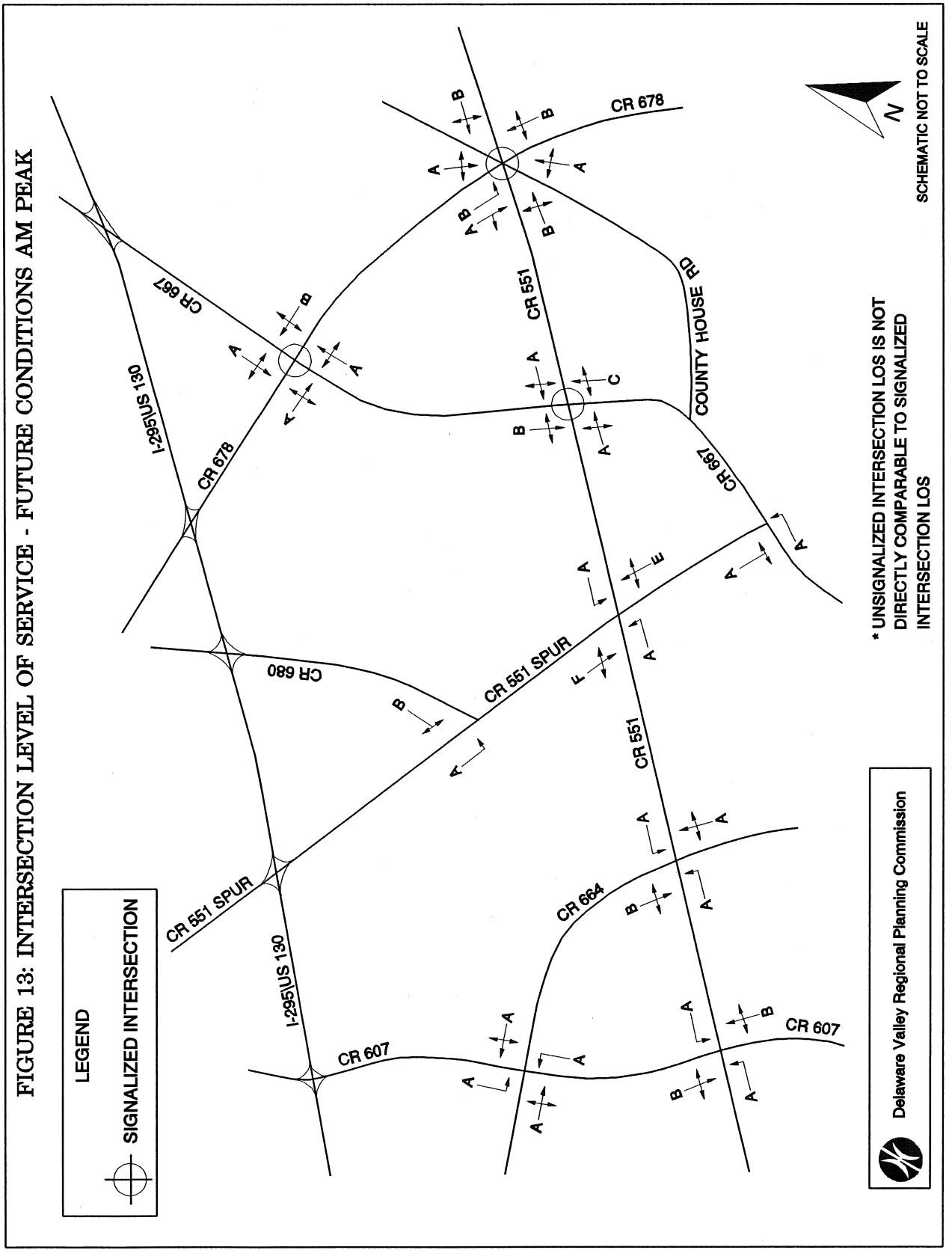
FIGURE 13: INTERSECTION LEVEL OF SERVICE - FUTURE CONDITIONS AM PEAK
LEGEND
SIGNALIZED INTERSECTION
CR 667
I-295\US 130
CR 678
CR 680
CR 551 SPUR
CR 607
CR 664
CR 551
COUNTY HOUSE RD
CR 678
* UNSIGNALIZED INTERSECTION LOS IS NOT DIRECTLY COMPARABLE TO SIGNALIZED INTERSECTION LOS
SCHEMATIC NOT TO SCALE
N
Delaware Valley Regional Planning Commission

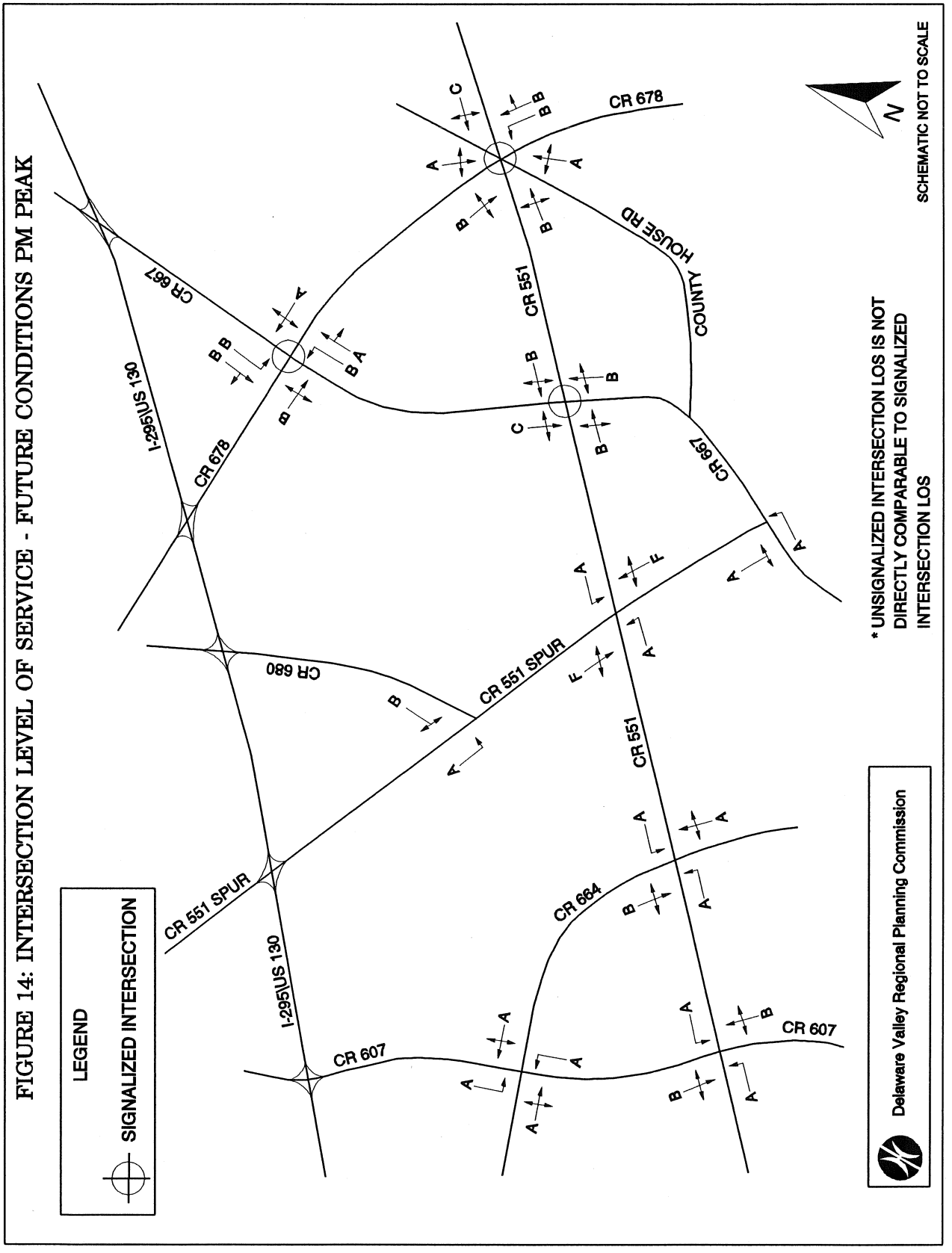
FIGURE 14: INTERSECTION LEVEL OF SERVICE - FUTURE CONDITIONS PM PEAK
LEGEND
SIGNALIZED INTERSECTION
CR 667
I-295\US 130
CR 678
CR 680
CR 551 SPUR
CR 607
CR 664
CR 551
COUNTY HOUSE RD
CR 678
CR 667
CR 551 SPUR
I-295\US 130
CR 607
* UNSIGNALIZED INTERSECTION LOS IS NOT DIRECTLY COMPARABLE TO SIGNALIZED INTERSECTION LOS
SCHEMATIC NOT TO SCALE
N
Delaware Valley Regional Planning Commission

The level of service analysis for two-lane highways indicates acceptable operating conditions on all links. Only minor deterioration of existing conditions is expected to occur. There are no links that are expected to experience LOS F, however, as in the existing conditions, the segment of Kings Highway just east of CR 678 is expected to experience LOS D in the PM peak period. The section of CR 678 between CR 551 and CR 667 is expected to go from LOS C in the existing AM and PM peak periods to LOS D in both peak periods in the future.

The level of service analyses prepared for the three signalized intersections indicated that the intersection operations are expected to be acceptable. The following is a summary of the findings of the level of service analysis for the future conditions for each of the signalized intersections.

CR 551 (Kings Highway), CR 678 (Berkley Road), County House Road and North Street - all approaches are expected to operate at exceptional levels of service in both the AM and PM peaks.

CR 551 (Kings Highway) and CR 667 (Cohawkin Road) - all approaches are expected to operate at acceptable levels of service in both the AM and PM peaks.

CR 678 (Berkley Road) and CR 667 (Cohawkin Road) - all approaches of this intersection are expected to operate at exceptional levels of service in both the AM peak and the PM peak.

The findings of the level of service analysis prepared for the six unsignalized intersections using projected traffic volumes and existing configurations is presented below.

CR 551 (Kings Highway) and CR 551 Spur (Democrat Mickleton Road) - In the AM peak the southbound CR 551 approach operates at LOS F and the northbound approach operates at LOS E. Both of these approaches operate at LOS F in the PM peak.

CR 551 (Kings Highway) and CR 664 (Wolfert Station Road) - all the approaches to this intersection operate at exceptional levels of service in both peak periods.

CR 551 (Kings Highway) and CR 607 (Tomlin Station Road) - all the approaches to this intersection operate at exceptional levels of service in both peak periods.

CR 551 Spur (Mickleton Jefferson Road) and CR 667 (Cohawhin Road) - the critical approaches to this intersection operate at LOS A in both the AM and PM peak periods.

CR 551 Spur (Democrat Mickleton Road) and CR 680 (Harmony Road) - the CR 680 approach operates at LOS B in both peak periods. The left turns from CR 551 Spur operate at LOS A in both peaks.

CR 664 (Wolfert Station Road) and CR 607 (Tomlin Station Road) - all the approaches to this intersection operate at LOS A in both the AM and PM peak periods.

VI. RECOMMENDATIONS

This section discusses recommendations for physical improvements to the highway network to be required as a result of the projected traffic volumes. The future level of service analysis indicates that, for the most part, the highway network will continue to operate with acceptable service levels in the Year 2010. However, there are some locations where conditions are expected to deteriorate and physical improvements to the network will be necessary. The following recommendations will address improvements to those locations.

CR 551 is expected to be able to accommodate the Year 2010 projected traffic volumes. In the AM peak, CR 551 is expected to operate at LOS B or C throughout the study area. In the PM peak, similar operations are expected except for the segment east of CR 678 which is expected to experience LOS D.

The projected increases in traffic volumes on CR 551 of approximately 1,300 to 1,600 vehicles per day over a 20 year time period represent, at most, moderate growth. Neither the projected volumes nor the resulting operating conditions warrant widening this road to four lanes. However, traffic flow could be aided by upgrading and standardizing the highway to a 50 foot cartway as specified on the official county map. This cartway should consist of one travel lane and a paved shoulder in each direction plus provisions for a left turn lane where needed at major intersections. The projected traffic increases on the remaining roads in the network are expected to range from 100 to 1,400 vehicles per day and should be easily absorbed by the existing facility.

The traffic operations at the intersection of CR 551 and CR 551 Spur are controlled by a flashing beacon with stop signs on the CR 551 Spur approaches. With this control, the CR 551 Spur approaches currently operate at LOS E and F during the peak periods and service levels are expected to deteriorate in the future as volumes increase. A traffic signal warrant analysis should be conducted at this intersection. A level of service analysis was conducted for both the AM and PM peak periods using the projected turning movements and assuming the installation of a traffic signal with a two-phase, 60 second cycle operation. This analysis indicated all approaches would operate at LOS B in both the AM and PM peaks. This report recommends the installation of a traffic signal at this intersection providing it meets the applicable warrants.

Over the next 20 years, the Kings Highway Corridor is expected to experience, at best, moderate growth rates both in terms of development and traffic volumes predicated partially on the completion of I-476 (Blue Route) in Pennsylvania and the reconstruction of I-295 in West Deptford and East Greenwich Townships. Even with the level of anticipated growth, the resulting traffic can in most locations, be easily absorbed by the existing highway network. Most of these facilities operate so much under capacity that, for the most part, major physical improvements are not necessary. However, minor improvements such as minor widening for the construction of shoulders, addition of left turn lanes and traffic signal installation or retiming should provide congestion relief to the level for which it is needed.