Recurrent and non-recurrent causality: Are congested areas being caused by recurring bottlenecks or by recurring incidents (i.e., a weave area that has a high rate of crashes), or by random incidents?

The success of a traffic congestion tracking and monitoring effort depends on how the available data and selected measures respond to the spatial-temporal, statistical, and point-of-view criteria for congestion measures, and how that data adheres to the overall characteristics of good performance measures. All of the measures in this report use observed data, except for one that uses forecasting results from the Department's travel demand model, TRAVEL/2 (which is validated using observed data).

5. Current Congestion (Observed Data)

Simply stated, congestion is too many people and/or vehicles in the same general place at the same general time. When the physical space for movement is constrained, or alternatively used as at intersections, the movement slows, sometimes stops, and queues often develop so that the people and vehicles can safely move in a proper turn.

There are more than 3,200 miles of state, county, and municipal roads in the County with over 750 signalized intersections. Directly measuring such congestion at all places at all times would be a Herculean task as would be the analysis and summary of the vast amount of data. As such this report uses different performance measures that sample the use of the roadway network from different data sources at different places and times to be able to estimate and report on the extent, intensity, duration, variability, and causality of congestion. Six measures included in this report and their respective data sources follow below:

- Critical Lane Volumes (CLVs) at signalized intersections from the Park and Planning Database
- Intensity of Arterial Use from the County's Advanced Transportation Management System (ATMS) traffic volume data, archived in Park and Planning's Data Acquisition Software and Hardware (DASH) system
- Average Freeway Speeds and Travel Times from MWCOG-Skycomp
- Route-Specific Arterial Travel Times and Speeds from GPS probes of MWCOG and by Motion Maps LLC for the report
- Monitored Freeway Speeds and Travel Times from the State's Coordinated Highways Reponse Action Team (CHART) data archive by the University of Maryland Center for Advanced Transportation Technology (UMD-CATT).
- Short-Range Forecasted (year 2010) V/C ratio and average speeds from the Park and Planning TRAVEL/2 Model

Critical Lane Volumes (CLVs) at Signalized Intersections

The Critical Lane Volume method of calculating the level of congestion at a signalized or unsignalized intersection is generally accepted by most public agencies in Maryland, including the State Highway Administration (SHA), the Montgomery County Department of Public Works and Transportation (DPWT), the Cities of Rockville, Gaithersburg, and Takoma Park, as well as the Transportation Planning staff at M-NCPPC. The CLV methodology will fit most intersection configurations and can be varied easily for special situations and unusual conditions. Whereas some assumptions, such as lane use factors, may vary from jurisdiction to jurisdiction, the general CLV methodology is consistent.[5] The Board recently reaffirmed the use of CLV in traffic impact studies during their review of the Local Area Transportation Review (LATR) guidelines.

To support LATR, the Department has been collecting CLV data (primarily at signalized intersections) submitted for traffic impact studies since the 1980s. Most of those counts sit in paper files; however, beginning in 2003, the LATR guidelines required submission of intersection turning movement traffic counts and CLV information in digital form for loading into the Department's intersection analysis database. The database has been further supplemented by using counts collected by SHA, and staff has performed considerable work converting paper counts from before 2003 into digital form and loading them into the database. The population of the database, while not yet complete for all locations, has enabled a richer analysis of CLVs over a large area of the county. Table 5.1 shows the 10 most congested intersections of those reported.

Table 5.1: The 10 Most Congested Intersections

Rank	Intersection Name	Policy Area	LATR Standard*	CLV**
1	Rockville Pike at W Cedar Ln	Bethesda/Chevy Chase	1600	2391
2	Rockville Pike at Jones Bridge/Center	Bethesda/Chevy Chase	1600	2299
3	Key West Ave at Darnestown Rd	North Potomac	1475	2225
4	Key West Ave at W Gude Dr	Rockville	1500	2080
5	Montrose Rd at E Jefferson St	North Bethesda	1550	2077
6	Hungerford Dr at Middle Ln/Park Rd	Rockville	1500	2040
7	Hungerford Ln (MD 355) at Gude Dr	Rockville	1500	2028
8	Connecticut Ave at Veirs Mill Rd	Kensington/Wheaton	1600	1975
9	Connecticut Ave at Jones Bridge Rd	Bethesda/Chevy Chase	1600	1974
10	Shady Grove Rd at Midcounty Hwy	Derwood	1475	1961

*In effect starting July 1, 2004

**The maximum of the morning or evening peak hour CLV

[5] Further information on CLV methodology can be found in the recently approved LATR guidelines or on the SHA website at http://www.sha.state.md.us/businesswithsha/permits/OHD/Impact_guide.asp

Consult Appendix I for the full ranked sample of 320 signalized intersections within the county.[6] The congestion rankings are determined by the raw CLV; however, the tables also include a figure obtained by dividing the CLV by the current LATR standard for that intersection's policy area, where a value of more than 1.00 means the CLV exceeds the LATR standard. Table 5.2 shows the LATR standards that went into effect on July 1, 2004.

As seen in Figures 5.1 and 5.2, almost one-fifth of the intersections sampled had CLVs that exceeded their LATR congestion standards during either their morning or evening peak hour (or both). Approximately another one-quarter of the intersections sampled had CLVs that were at least 80% of their LATR standard. These CLVs are for the existing traffic condition. Under the LATR guidelines, applicants must mitigate traffic when the CLV for the total traffic condition[7] exceeds the area's congestion standard. This does not mean improvements at these congested intersections cannot be funded and built using other means.

Table 5.2: LATR Congestion Standards

Congestion (CLV) Standard	Policy Area
1400	Rural Areas (Poolesville, Damascus, Goshen, Patuxent, Darnestown / Travilah)
1450	Clarksburg Damascus Gaithersburg Germantown Town Center Germantown West Germantown East Montgomery Village / Airpark
1475	Cloverly Derwood North Potomac Olney Potomac R&D Village
1500	Aspen Hill Fairland / White Oak Rockville
1550	North Bethesda
1600	Bethesda / Chevy Chase Kensington / Wheaton Silver Spring / Takoma Park
1800	Bethesda CBD Friendship Heights CBD Glenmont Grosvenor Shady Grove Silver Spring CBD Twinbrook Wheaton CBD White Flint

[6] Representing approximately 40% of the signalized intersections in the county. Data are from the year 2000 and forward.

[7] In the LATR Guidelines, total traffic is defined as the existing traffic, plus trips from approved but unbuilt developments, plus the trips from the proposed development during the peak hour of the weekday morning and evening peak periods.

Figure 5.1
AM Peak Hour CLVs -- Ratio to LATR Standard (number of intersections sampled = 320)

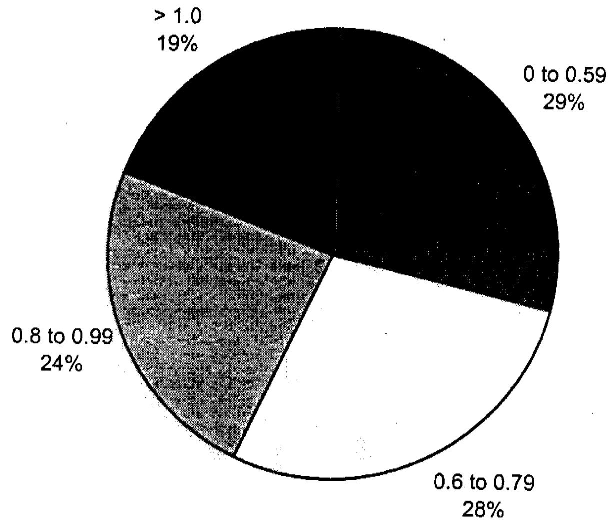
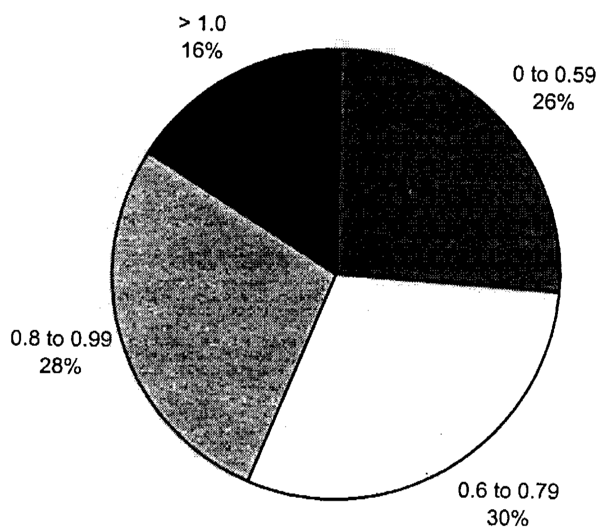


Figure 5.2
PM Peak Hour CLVs -- Ratio to LATR Standard (number of intersections sampled=320)



Figures 5.3 through 5.8 show maps of the signalized intersection locations for the county. Where a recent CLV is contained in the database, the intersection is displayed by dividing its CLV by its LATR congestion standard.

- Within the CBD or Metro Station Policy Areas (MSPAs), Wheaton CBD, Silver Spring CBD, Bethesda CBD, and Friendship Heights CBD have most of their intersections with CLVs well below the standard of 1800.

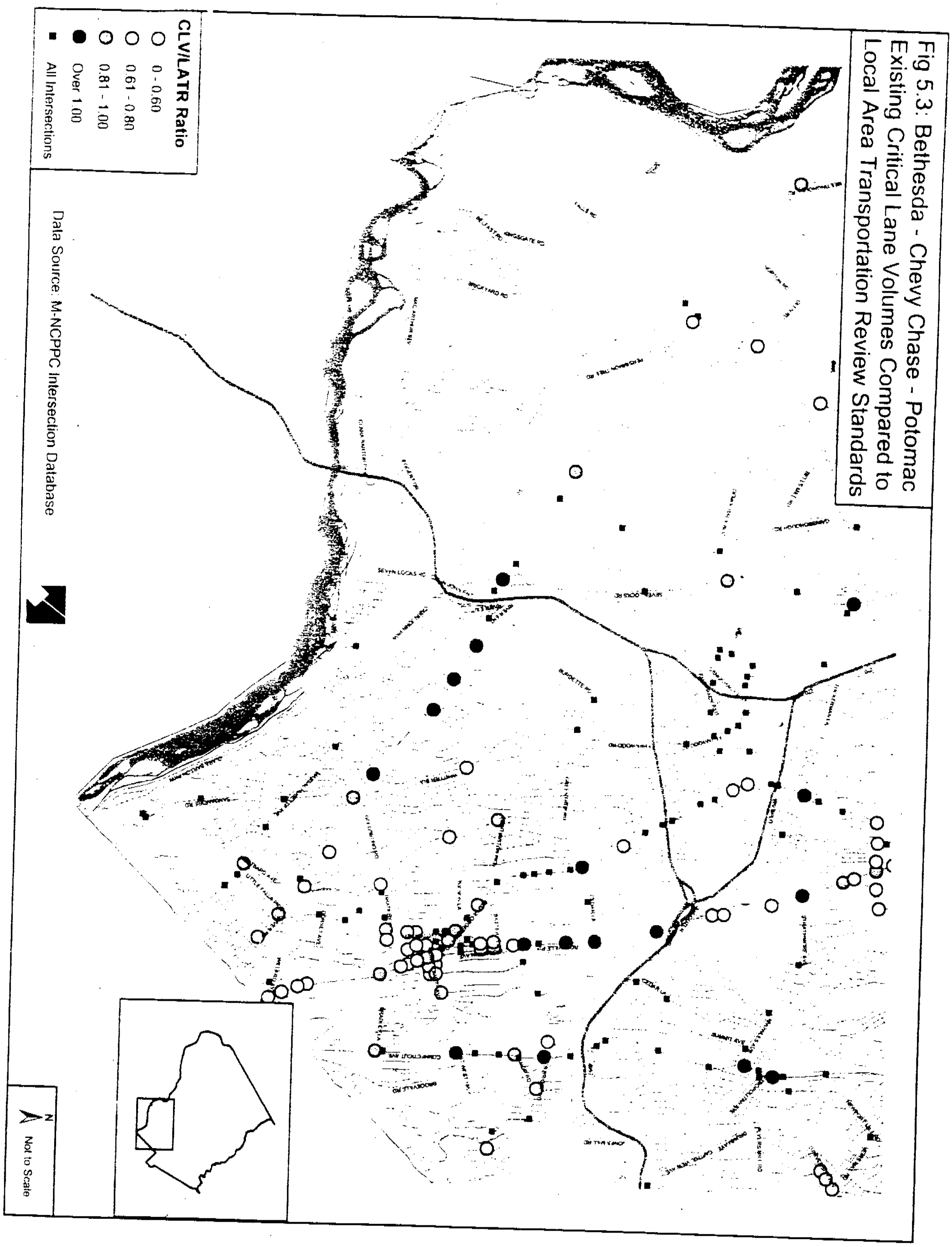


Fig 5.3: Bethesda - Chevy Chase - Potomac Existing Critical Lane Volumes Compared to Local Area Transportation Review Standards

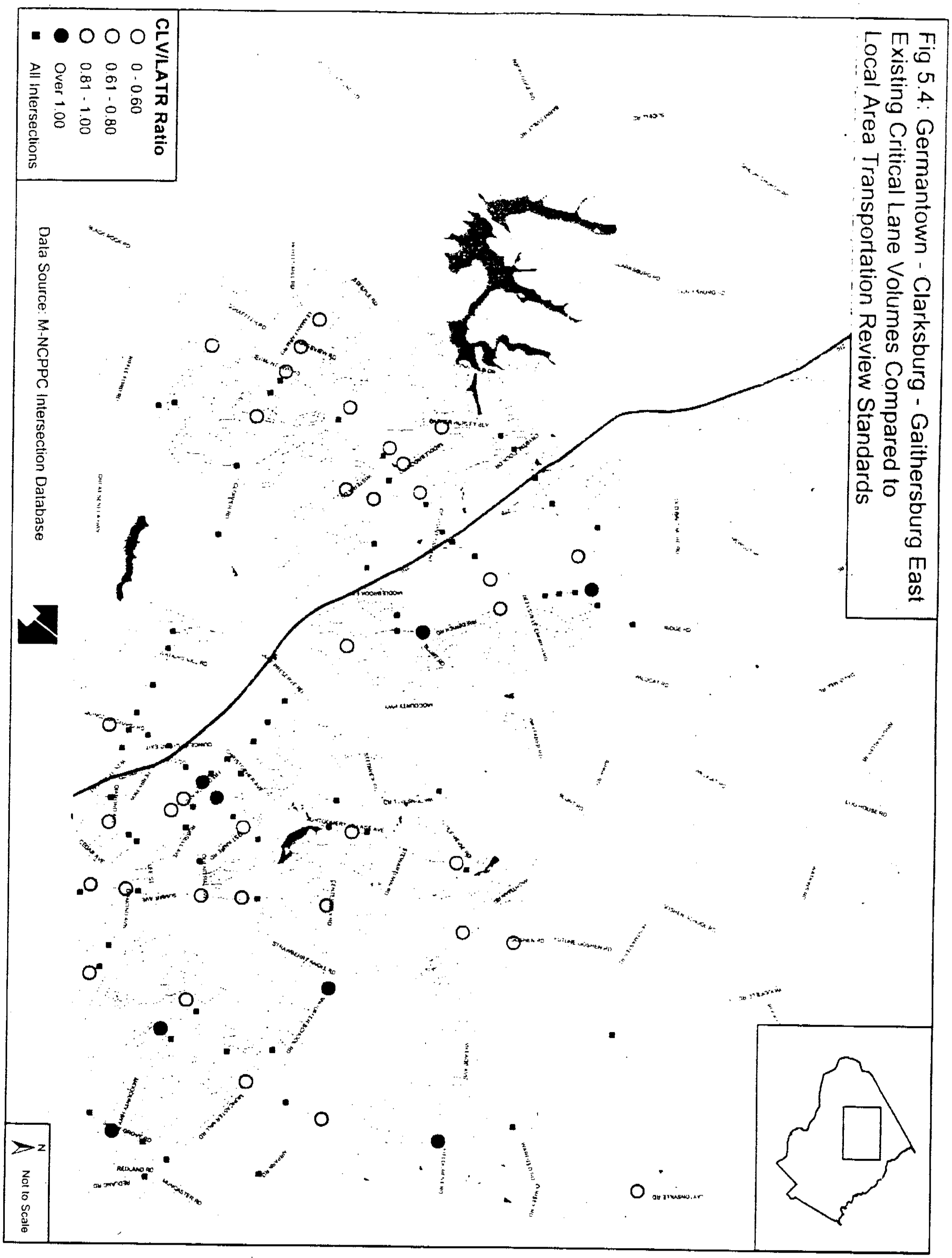


Fig 5.4: Germantown - Clarksburg - Gaithersburg East Existing Critical Lane Volumes Compared to Local Area Transportation Review Standards

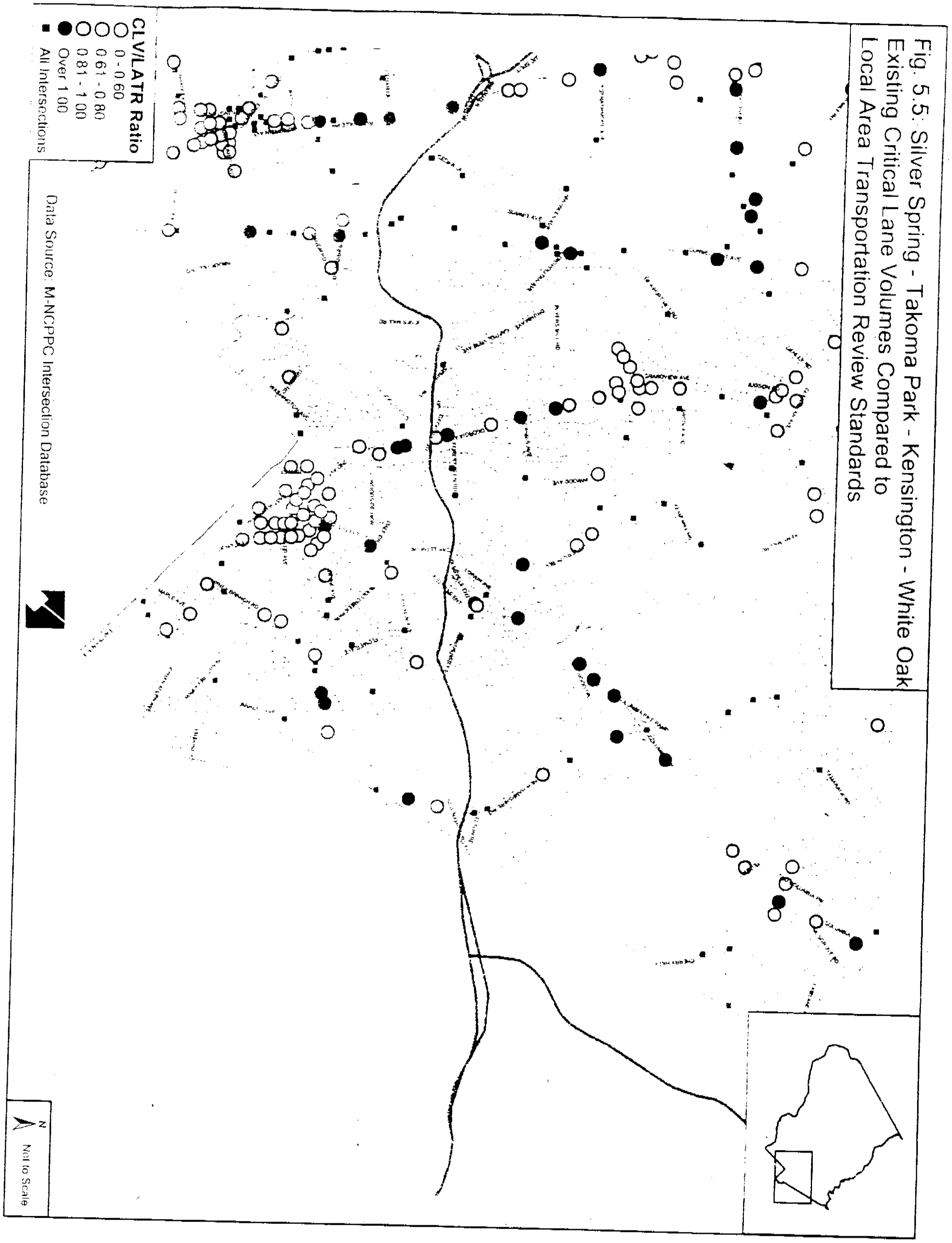


Fig. 5.5: Silver Spring - Takoma Park - Kensington - White Oak
Existing Critical Lane Volumes Compared to
Local Area Transportation Review Standards

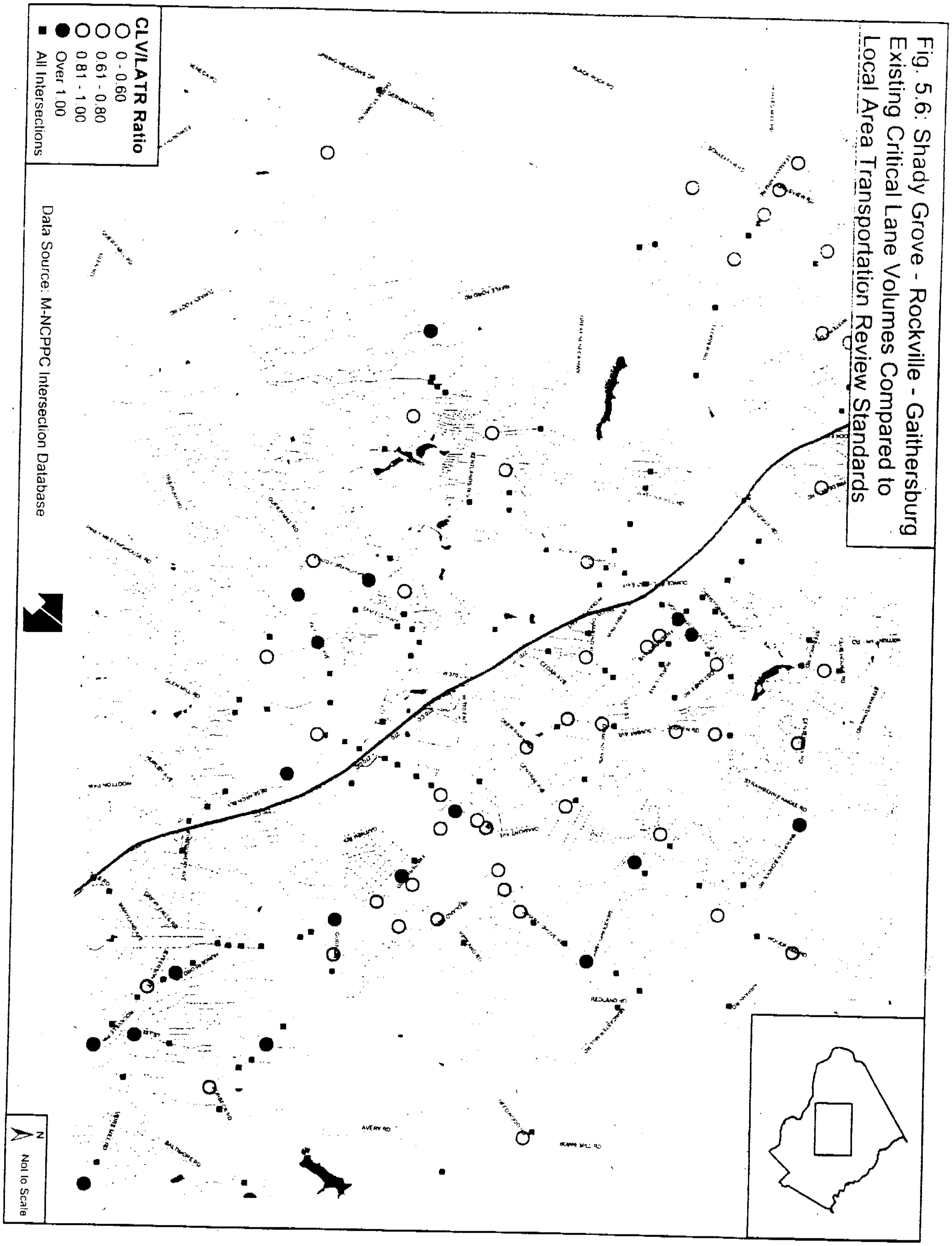


Fig. 5.6: Shady Grove - Rockville - Gaithersburg Existing Critical Lane Volumes Compared to Local Area Transportation Review Standards

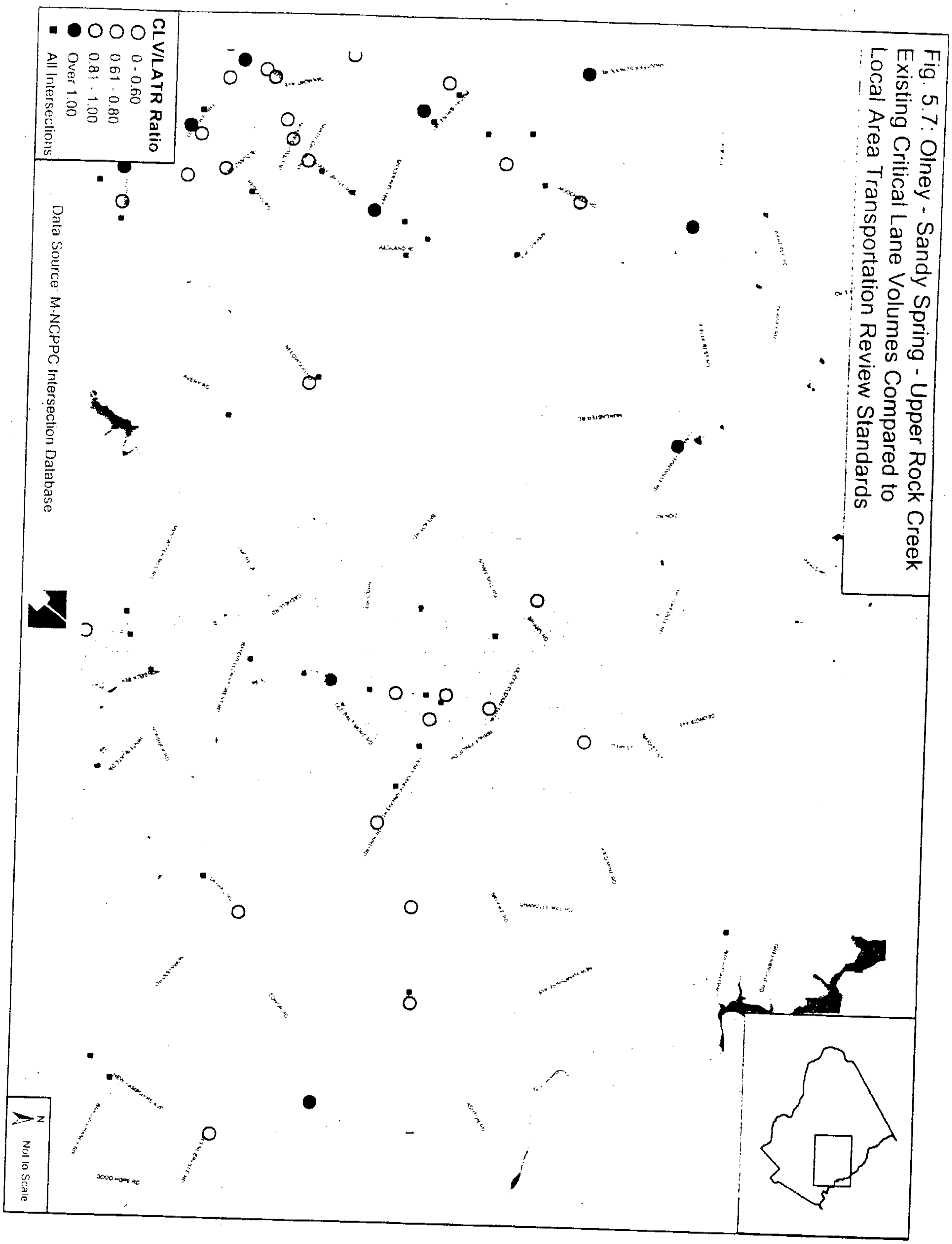


Fig. 5.7: Olney - Sandy Spring - Upper Rock Creek Existing Critical Lane Volumes Compared to Local Area Transportation Review Standards

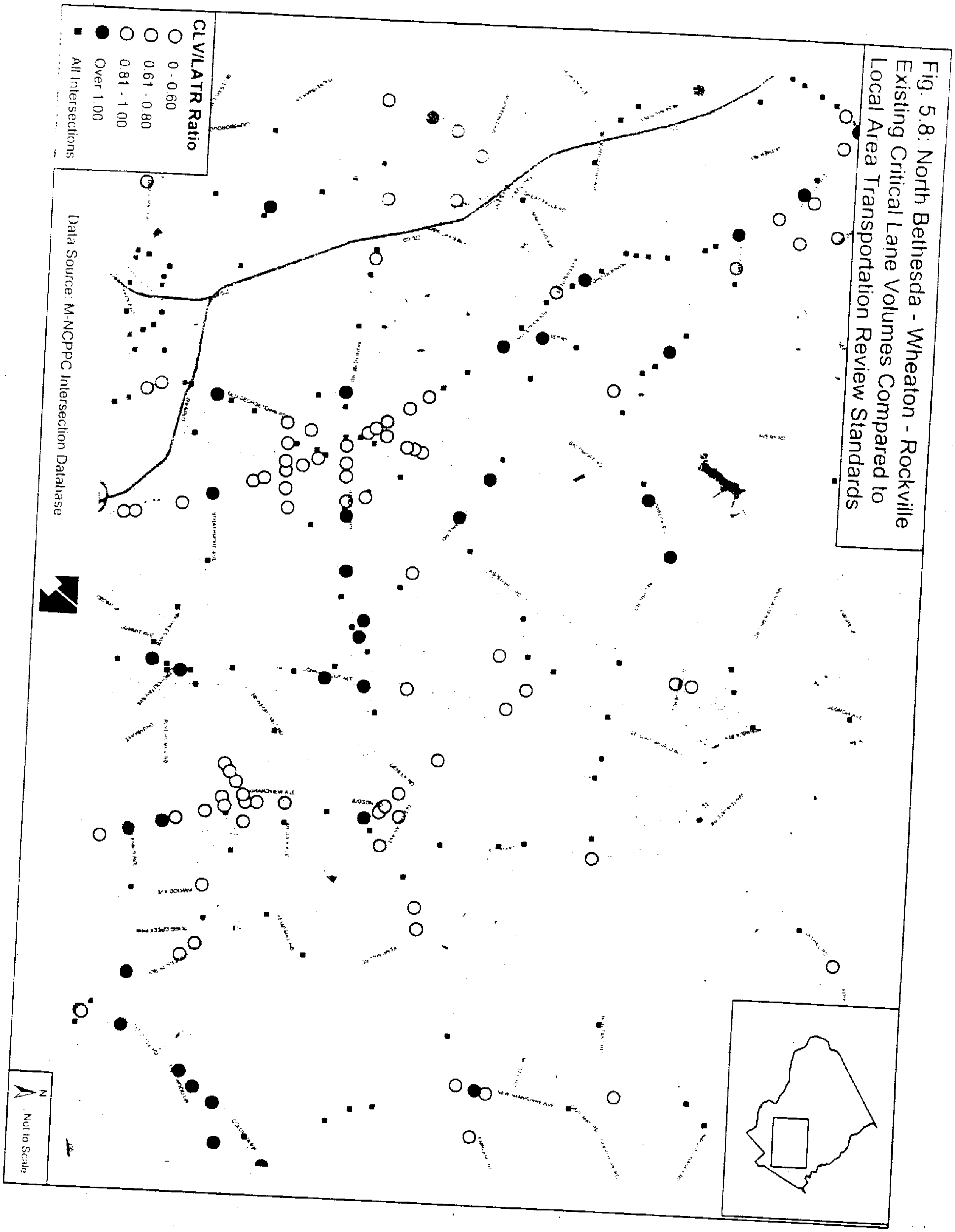


Fig. 5.8: North Bethesda - Wheaton - Rockville Existing Critical Lane Volumes Compared to Local Area Transportation Review Standards

- The remaining Metro Station Policy Areas, Shady Grove, Twinbrook, White Flint, Grosvenor, and Glenmont, have higher levels of congestion. These areas do not have the street grid density to adequately disperse and handle the corresponding level of automobile trips when compared with the first group of MSPAs above. They also lack a critical mass of transit-supportive and accessible land uses that encourage travelers to take Metrorail, which in turn takes auto trips off the network within the MSPA.

- The areas immediately outside the MSPAs, many of which are major gateways to CBDs or major job centers, have CLVs close to or exceeding the LATR standard for their respective areas. Bethesda / Chevy Chase and North Bethesda are good examples of this phenomenon, which is also observed in the Silver Spring / Takoma Park, Aspen Hill and Kensington / Wheaton policy areas along the gateways to Rockville (and to a lesser extent, White Flint). These results may also be attributed to a lack of street grid density in the outlying areas, as well as the impact of transit within the MSPAs. All the traffic has to move through a few intersections to access the street grid in the morning, and the traffic dispersed throughout the street grid converges back on those gateway intersections in the evening. Some of that traffic consists of through trips with destinations not located in the policy area, such as traffic heading for the District of Columbia using Rockville Pike (MD 355) or Georgia Ave (MD 97)

- Countywide, the CLVs during the evening peak hour are still worse than CLVs in the morning peak hour. Among the intersections sampled, the average (mean) CLV for the morning peak hour was 1174, and for the evening peak hour it was 1195. However, for the 25 intersections in the sample where *both* the morning and evening peak hour CLVs exceeded the LATR standard, 17 of those 25 intersections had higher CLVs during the morning peak hour.

- Continuous series of congested intersections can be found on most major north-south and east-west arterial routes, including Georgia Ave (MD 97), Connecticut Ave (MD 185), MD 355, Randolph Rd, Veirs Mill Rd (MD 586), US 29, River Rd (MD 190), MD 28, and Ridge Rd (MD 27).

- Many of these congested intersections have well-documented historical congestion and that congestion is being addressed through major capital improvements currently under construction or in project planning studies, such as along Columbia Pike (US 29), the intersections of Georgia Ave (MD 97) at Randolph Rd, Georgia Ave (MD 97) at Norbeck Rd (MD 28), and Rockville Pike (MD 355) at Montrose Rd / Randolph Rd.

- There are still many other "hot spot" intersections throughout the county where congestion needs to be addressed. Some of these intersections have improvements specified in master plans, but no facility planning has taken place to date; others may require spot improvements that are below the level of those usually considered in a master plan, which looks primarily at grade-separated interchanges, but can be addressed in a capital budget item.

Intensity of Arterial Use (DASH Data)

Historically, analysis of travel conditions in the county has focused on the weekday morning and evening peak periods and/or peak hours. However, as congestion has grown, more calls have come to examine both off-peak (midday) weekday and weekend travel conditions, with some suggesting that in certain locations in the county, the midday or weekend conditions are actually worse than those observed during the "traditional" peak periods.[8] While most manual data collection programs still only operate during weekdays and peak periods, the advent of automated data collection systems, such as the County's ATMS and the State's CHART system allow for theoretical 24/7/365 travel monitoring.

Park and Planning's Data Acquisition Software and Hardware (DASH) system began archiving traffic volume data collected by the county ATMS in December 2000. While data coverage is often spotty due to individual detector failure or system problems, enough valid data has been collected to analyze the differences between peak and off-peak utilization of the county's arterial (non-freeway) network in certain geographic areas. For this report, as for the analysis performed for the recent review of the LATR guidelines, the analysis focused on areas of good data coverage in locations along or near major commercial corridors or centers, since those areas are most likely to generate high volumes of off-peak traffic. Locations along the following corridors were analyzed: Frederick Rd / Rockville Pike / Wisconsin Ave (MD 355), Democracy Blvd, Olney-Sandy Spring Rd (MD 108), Connecticut Ave (MD 185), Old Georgetown Rd (MD 187) and Georgia Ave (MD 97). The complete set of graphics for the observed data may be found in Appendix J.

The data contained in the DASH archive shows continuously observed volumes at the departing legs of signalized intersections at 15-minute intervals.[9] Depending the available data at each intersection location, observed volumes are from Sunday March 10, 2002 12:00am to Saturday, March 16, 2002 11:59pm, or from Sunday, September 8, 2002 12:00am to Saturday, September 14, 11:59pm. The 15-minute segments for both departing main line legs of the intersection were added together to create bi-directional successive hourly volumes for the intersection. While the available data are neither spatially nor temporally consistent enough to make any conclusions regarding congestion over a large area, they are able to provide some initial answers to common questions about the nature of congestion in certain parts of the county that will have future policy implications and will have more observations as data collection improves.

How Do Off-Peak Weekday and Weekend Volumes Compare With Traditional Peak Periods?

The typical distribution of travel on the arterial network in the county is a curve showing traditional weekday diurnal (morning and evening) peak periods and single, flatter peak of lower

[8] The Planning Board heard testimony on this matter during the public hearing on the updated LATR guidelines in April 2004.

[9] The inductive loop and other detectors deployed by DPWT actually collect data every minute and produce summary volumes at 5 minute volumes for each detector. Those figures are collected and aggregated by the DASH system to produce the 15-minute departure leg volumes. Departure leg volumes from intersections cannot be used as turning movement counts, which require counts of approaching vehicles. Therefore, the DASH data cannot be used for CLV calculation.

intensity on the weekends. An example of this pattern is shown for the intersection of Connecticut Ave (MD 185) and Jones Bridge Rd in Figure 5.9.

This pattern is representative of nearly all the other sampled locations. With very few exceptions, the data sampled for these corridors show that observed midday and weekend volumes rarely approach or exceed the observed weekday peak hour volumes. The notable exception to this pattern occurred along the Rockville Pike (MD 355) commercial corridor in North Bethesda, as seen below in Figure 5.10. At the intersection of Rockville Pike and the Best Buy Plaza, the midday volumes exceeded the morning peak hour volumes but did not exceed the evening peak hour volumes. This is reflective of the fact that many retail stores along Rockville Pike either are not open or experience low customer activity during the morning peak period.

Figure 5.9: Connecticut Ave (MD 185) at Jones Bridge Rd
Two-Way Successive Hourly Volumes 3/10/02 to 3/17/02

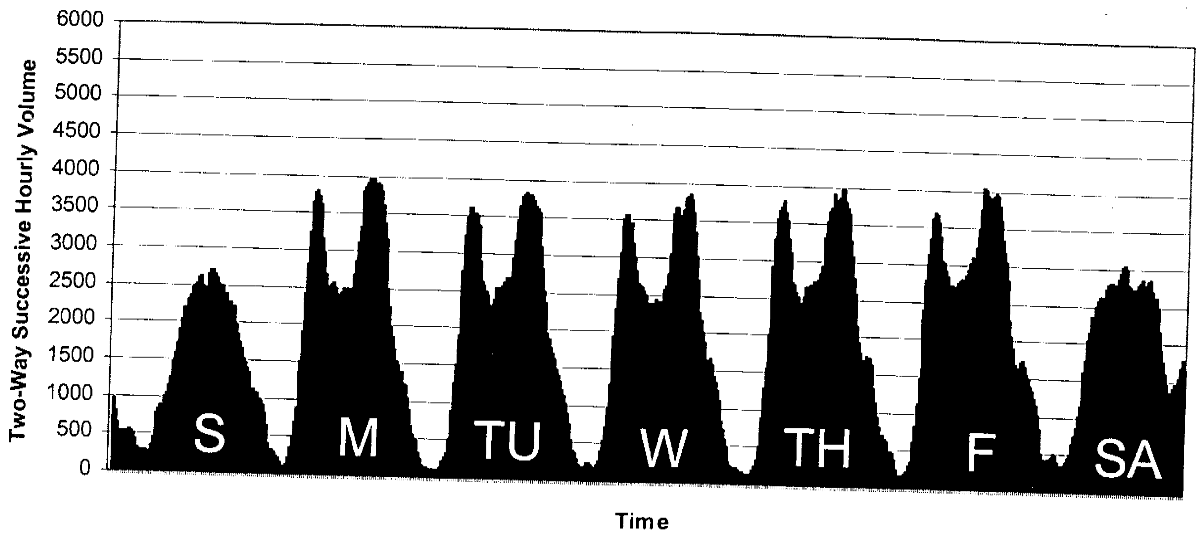
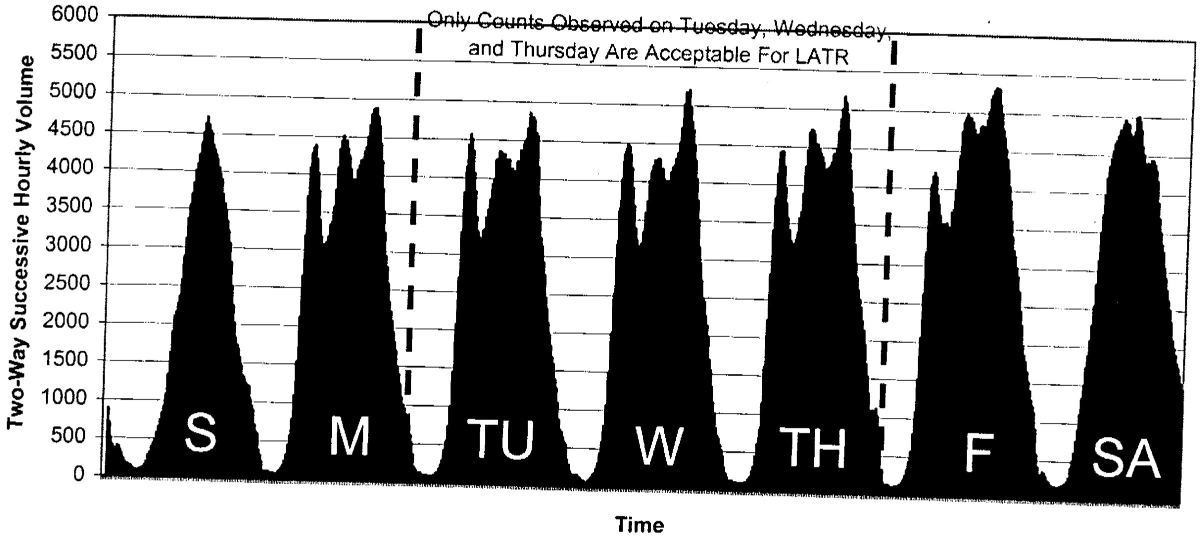
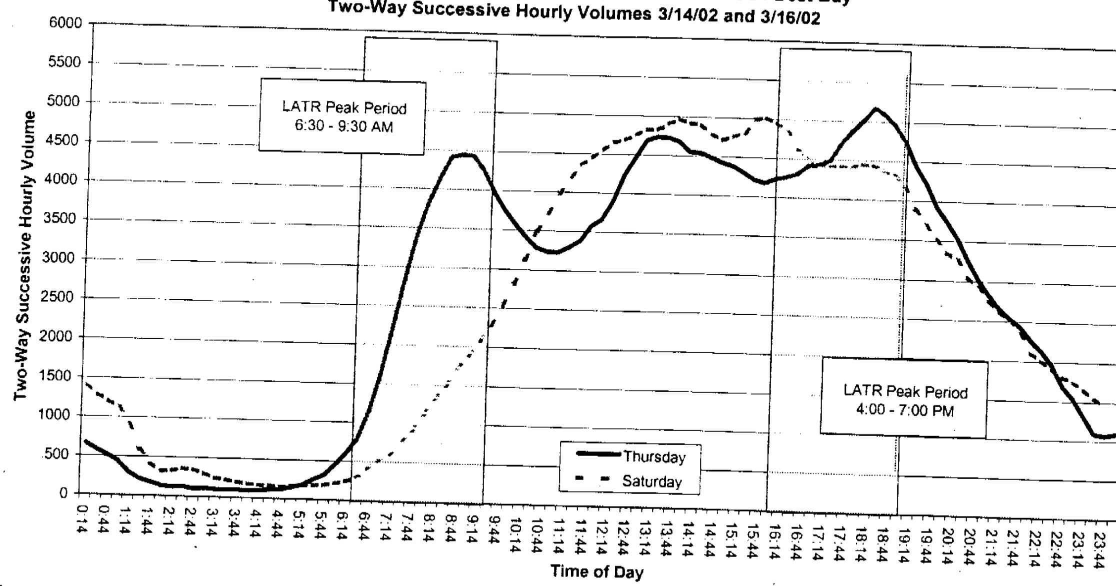


Figure 5.10: Rockville Pike (MD 355) at Woodmont CC / Best Buy Plaza
Two-Way Successive Hourly Volumes 3/10/02 to 3/17/02



The locations sampled along Rockville Pike between the Rockville line and the Capital Beltway (I-495) show a clearly defined mid-day weekday peak whose intensity approaches and sometimes exceeds that of the morning peak. This mid-day peak represents nearby workers venturing out onto Rockville Pike for lunch or errands, where most of them choose to make those trips in their cars. In some cases, the mid-day peak volumes never truly recede and are

Figure 5.11: Rockville Pike (MD 355) at Woodmont CC / Best Buy
Two-Way Successive Hourly Volumes 3/14/02 and 3/16/02



merely a precursor to the traditional evening peak period. This situation is illustrated by "drilling down" into the data from Figure 5.10 and showing one or two days at a time, as seen in Figure 5.11.

Rather than displaying the traditional diurnal peaking that is typical around the rest of the county arterial network, the duration of peak traffic volumes on Thursday at this location is almost continuous from 12:30 pm until 7:30 pm, with volumes exceeding the morning peak period volume for nearly that entire time. In some locations not on Rockville Pike this pattern occurs, but on Fridays only.

Figure 5.11 also shows the different character of travel along Rockville Pike on Saturdays – there is a single peak that starts later in the morning and is more sustained over the afternoon and into the evening. The period of sustained peaking on the Saturday has higher volumes compared with the same time on the Thursday of the same week, a "typical" day, but not higher than those experienced during the weekday peak period. In one location in the sample, Rockville Pike (MD 355) at Old Georgetown Rd (MD 187), weekend two-way hourly volumes exceeded weekday two-way hourly volumes. This is reflective of the heavy retail activity along Rockville Pike on a typical Saturday, but does not necessarily suggest a higher level of congestion (i.e. a higher critical lane volume). Lower signal cycle lengths and efforts by County traffic operations staff to "balance" signal progression in both directions along Rockville Pike are factors that contribute to intersection congestion. The weekly data from this intersection are shown in Figure 5.12, and a comparison of Wednesday and Saturday volumes shown in Figure 5.13.

Figure 5.12: Rockville Pike (MD 355) at Old Georgetown Rd (MD 187)
Two-Way Successive Hourly Volumes 3/10/02 to 3/17/02

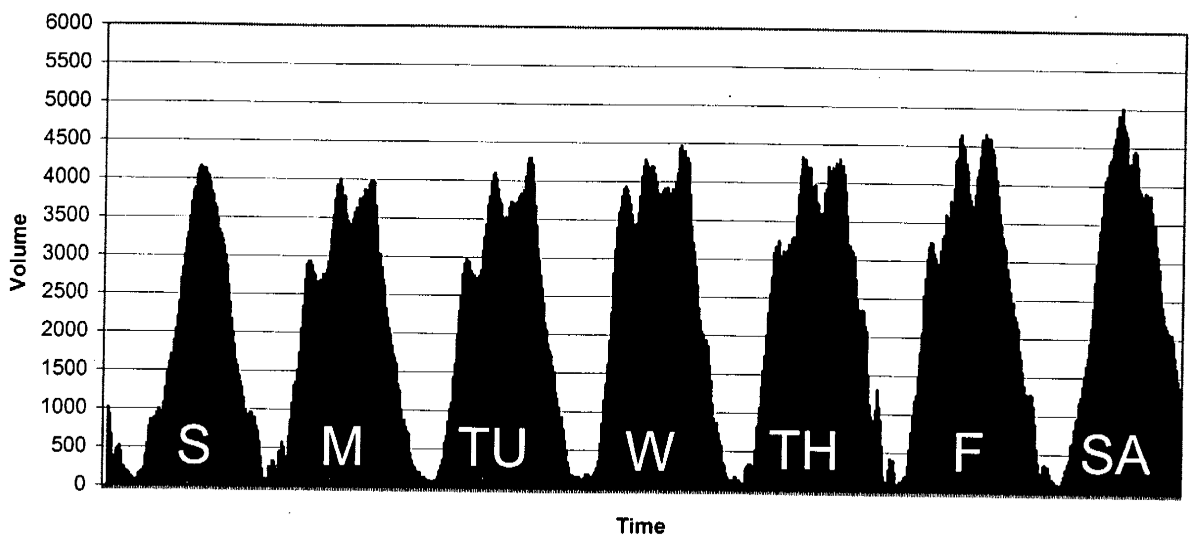
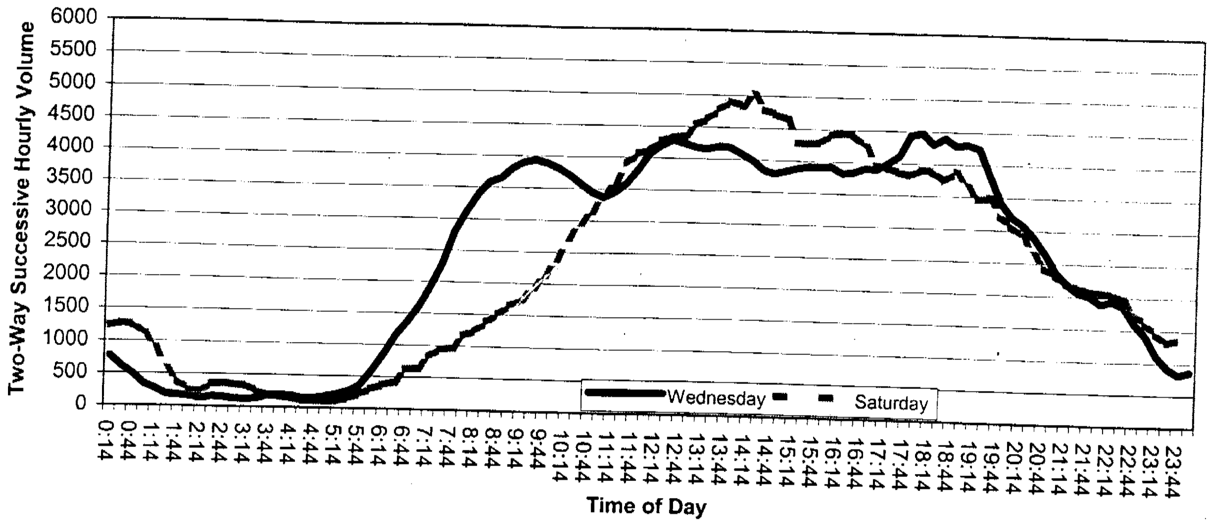


Figure 5.13: Rockville Pike (MD 355) at Old Georgetown Rd (MD 187)
Two-Way Successive Hourly Volumes Wednesday 3/13/02 and Saturday 3/16/02

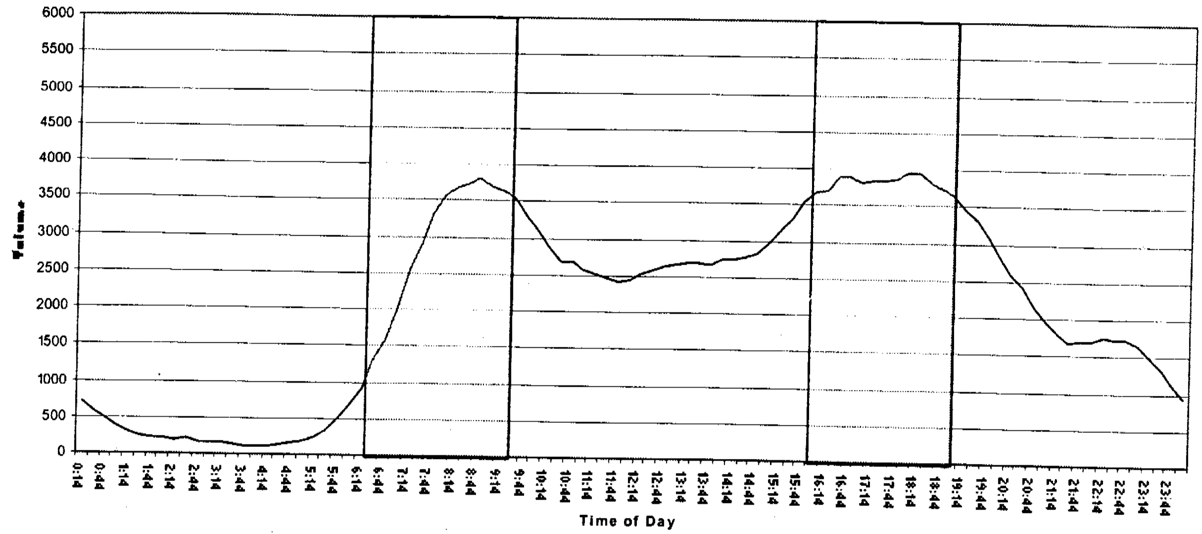


It is important to remember that the congestion patterns along Rockville Pike are unique in the County at present time. The results shown in Figures 5.12 and 5.13 were not found at any of the other sampled locations in the county, even though commercial destinations were present, and the infrequency of this type of congestion in the county is why the current LATR guidelines limiting required data collection only during the three-hour morning and evening peak periods on Tuesdays, Wednesdays, and Thursdays (except in special circumstances) were retained. However, if congestion is to be tracked to see if off-peak and weekend volumes increase in the future, then investment in improving the functionality of the DASH system and changing data collection policies to include collection of off-peak and weekend volumes represent the best means to ensure the availability of reliable data for this purpose. The ensuing data could also be used to provide more analysis on the questions below on the nature of congestion in the county.

Are we experiencing peak spreading?

The phenomenon of peak spreading occurs when congestion during the traditional peak periods is so severe that the peak begins to flatten out, resulting in congested conditions during times outside the peak period, or a longer duration of congestion over the course of the day. Figures 5.14 and 5.15 show two-way volumes at intersections in Bethesda / Chevy Chase and Olney, respectively.

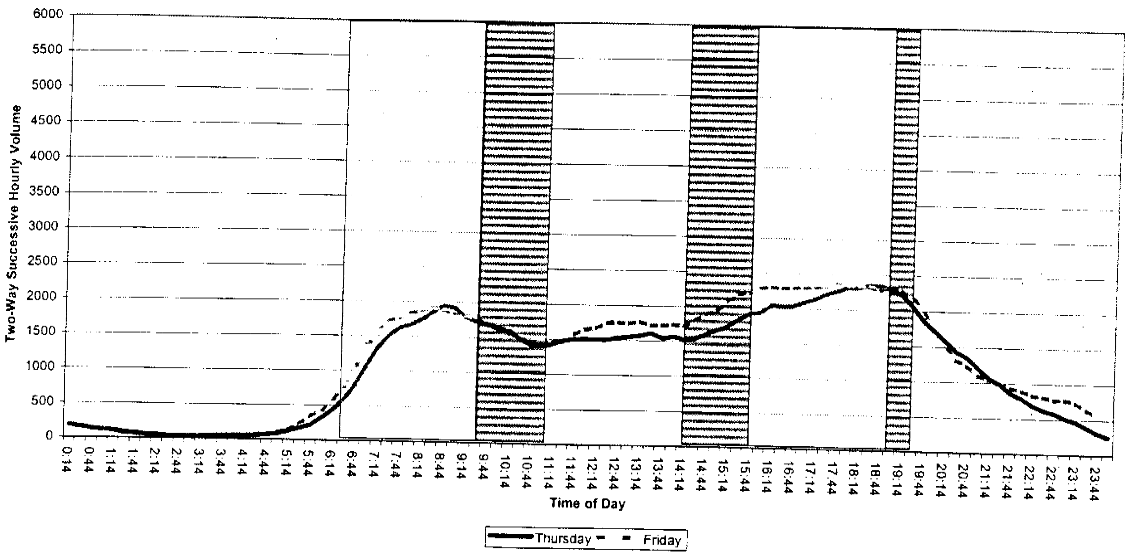
Figure 5.14: MD 185 at Jones Bridge Rd
Two-Way Successive Hourly Volumes 3/14/02 (TH)



The shaded bars represent the peak periods as defined in LATR. Very little if any peak spreading is occurring at this location during this time, even though a recent count at this intersection recorded a high CLV during the evening peak hour (see Appendix I).

The light shaded bars in Figure 5.15 represent the peak period as defined in LATR. The darker shaded bars represent areas falling outside of the traditional peak periods where volumes are still near those of the peak period. The best example above occurs during the evening peak period on Friday, which, again, is not a typical day for weekday traffic conditions and is not analyzed during LATR, except for special circumstances. However, peak spreading is clearly occurring during this time at the intersection at the heart of downtown Olney. The volumes are 30% of those observed along the lower sections of Rockville Pike, but the peak is spreading nonetheless.

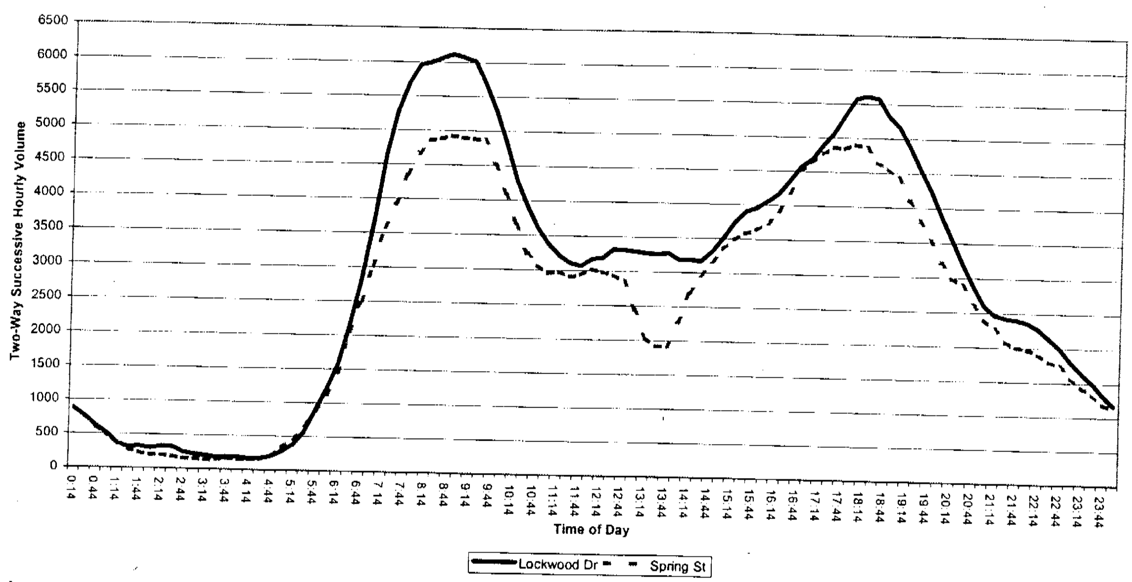
Figure 5.15: MD 108 at MD 97
Two-Way Successive Hourly Volumes 3/14/02 and 3/15/02



How does the peak hour differ throughout the county?

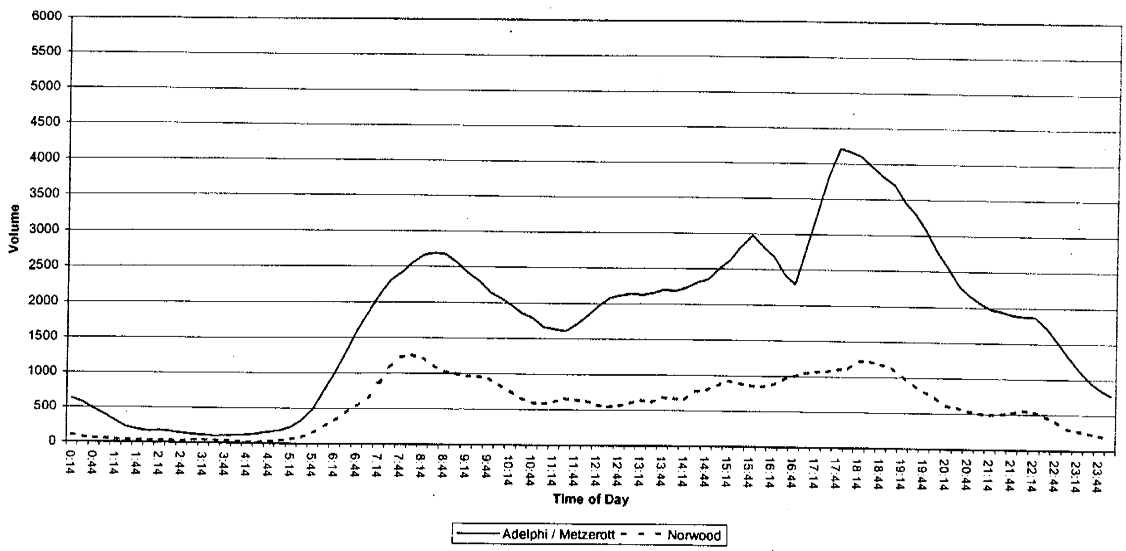
Many of the county's arterials are long enough and cross multiple commute corridors (in addition to the road itself being a commuting corridor) that peak volumes occur at different times along different sections of the road. Like peak spreading, this phenomenon can also occur as a result of congestion and queuing, and will be discussed in the section on travel times and speeds. In general, the peak in the county moves from north to south and east to west in the morning, and then the reverse direction in the evening; however, if there is a particularly capacity-constrained

Figure 5.16: US 29 -- Two-Way Successive Hourly Volumes Thursday 3/14/02



point in the network (e.g., a bottleneck), the peaks may behave somewhat differently over time. The situation observed in the CLV data, where gateways to CBDs or MSPAs were congested even though the denser areas were less congested also can add variation to the movement of the peak hour. Figure 5.16 compares the different characteristics of the peak periods along US 29 in Fairland / White Oak and the Silver Spring CBD. Figure 5.17 compares the different characteristics of the peak periods along New Hampshire Ave (MD 650) in Cloverly and Silver Spring / Takoma Park.

Figure 5.17
New Hampshire Ave (MD 650) -- Two-Way Successive Hourly Volumes 3/13/02 (W)



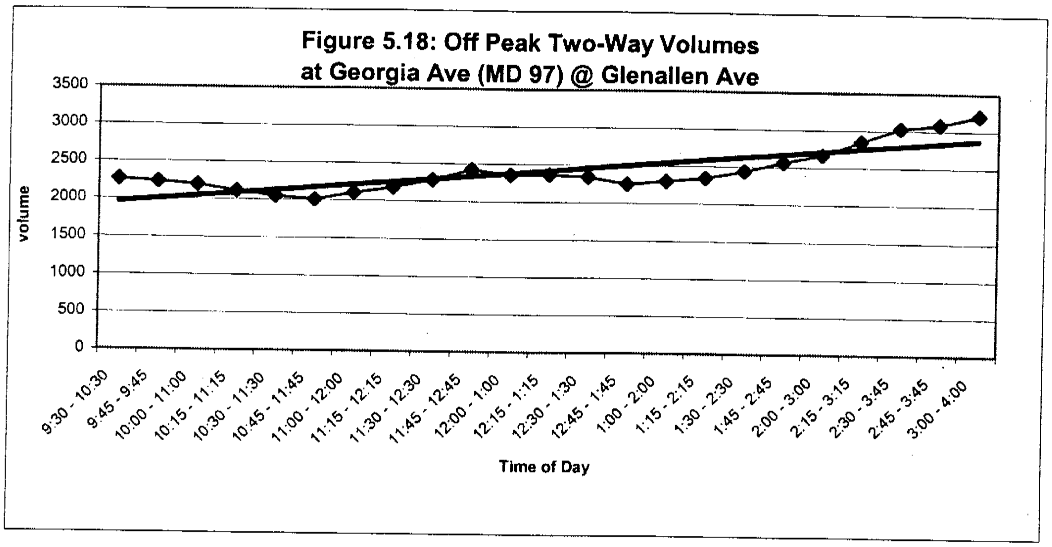
On US 29 during the morning peak period, there is an overall high intensity of use, but the intensity decreases at Spring St compared with the upstream location at Lockwood Dr. This is probably caused by vehicles traveling south on US 29 that take the Outer Loop of I-495 to continue their journey, rather than continuing south along US 29 to Silver Spring and other destinations. During the evening peak period, the overall intensity at Lockwood is less when compared with the morning, and the differential between the volumes at Spring St and Lockwood is also less, but the peak of the peak period at Lockwood occurs 15 minutes later than the peak of the peak period at Spring St.

On New Hampshire Ave (MD 650) the overall intensity of use is much less than US 29, and the differential between the roadway at Norwood Rd and Adelphi Rd inside the Beltway is higher when compared with US 29 at Lockwood Dr and Spring St. Vehicles traveling south on New Hampshire Ave at Norwood in the morning are likely to take one of the crossing east-west roadways, such as Bel Pre Rd / Bonifant Rd, or Randolph Rd, to reach destinations in the I-270 corridor. In addition, since New Hampshire does not directly connect with any major job centers inside the Beltway, vehicles that have not diverted onto Bel Pre or Randolph already most likely get on the Beltway, leading to the lower intensity of use shown crossing Adelphi Rd.

How Do Off-Peak CLVs Compare With Peak Hour CLVs?

An analysis of off-peak CLVs was conducted for 40 intersections throughout the County. The analysis used 12 and 13-hour turning movement counts collected by and obtained from SHA, since counts collected by the Department for LATR are only six hours in duration. Through observation of successive hourly volumes between the hours of 9:30am and 4:00pm, Tuesday-Thursday, in conjunction with a series of calculations, the peak hour of the off-peak period was identified for each intersection. The off-peak, peak hour volumes for each intersection were then used to calculate the off-peak CLVs. The complete list of intersections and CLVs may be found in Appendix K.

A majority of the intersections analyzed exhibited a similar trend with regards to distribution of volumes over the off-peak period, as shown in Figure 5.18. The distribution of volumes at most intersections appears to decrease slightly just as the morning rush concludes. The volumes remain constant throughout the course of the morning and early afternoon. Volumes then increase continuously during the early afternoon period leading up to the evening peak period, with the peak of the off-peak typically occurring just before the start of the evening peak period. A large portion of the increase in volumes just before the evening peak period can be directly attributed to the dismissal of schools.



4 out of the 40 intersections analyzed had an off-peak CLV that exceeded the designated standard for their policy area:

- Connecticut Ave (MD 185) at Knowles Ave (MD 547)
- Georgia Ave (MD 97) at Olney-Sandy Spring/Laytonsville Rd (MD 108)
- Hungerford Ln (MD 355) at Gude Dr
- Montgomery Village Ave (MD 124) at Russell Dr

Of the 40 intersections analyzed, River Rd (MD 190) at Goldsboro Rd was the only intersection that had an off-peak CLV that was higher than both the existing morning and evening-peak CLVs for this location. This situation appears to be due to the close proximity of Walt Whitman High School.

Analysis of off-peak and weekend traffic, weekly distribution of traffic, peak spreading, spatio-temporal movement of the peaks, and off-peak CLVs all help paint a richer picture of congestion in the county. The examples shown here are based on a limited set of available data and for the most part are insufficient to draw any significant conclusions about the nature of traffic congestion over the entire county. However, the data are sufficient to begin to illustrate the nature of traffic congestion in a few geographic areas in the county over a short period of time, and with more detailed data covering longer time periods and collected over a larger geographic area, the questions about congestion lead to more detailed analysis that leads to more detailed answers. Some of the question about the nature of congestion in the county that are given an initial answer using the above datasets can also be explored using data that are actually collected by a driver experiencing congestion on the transportation network, and is in some ways more understandable by the thousands of other individuals experiencing that same congestion as part of their daily travel.

Average Freeway Speeds based upon Traffic Density

Since the early 1990s MWCOG has contracted with Skycomp, Inc. for a series of studies that track the changes in freeway congestion by using aerial surveillance. Studies have been conducted in 1993, 1996, 1999, and 2002. Skycomp analyzes sequential photographs of the density of directional freeway traffic between interchanges and from that makes an estimate of the average speed for that time period. By using one or more aircraft they can sample most of the regional freeway system on about an hourly rotation resulting in hour-by-hour estimates of speed by direction between interchanges for the morning and evening weekday peak periods. MWCOG and Skycomp made available data summaries of the regional results for use in this report.

Motion Maps reformatted and analyzed that data to create a series of displays that show congestion on freeways and parkways in and near Montgomery County on an hour-by-hour basis for the morning and evening peak periods. These displays were prepared using a Geographic Information System (GIS) that shows the speed ranges of freeway segments for opposing directions as well as for the local lanes and High Occupancy Lanes on I-270. Figures 5.19 and 5.20 show the peak hours for the morning and evening peak periods, respectively. During the morning peak hour (8:00 to 9:00 am), congestion and slow speeds exist along I-270 from Germantown to the split near Rock Spring Park, westbound on I-495 (Capital Beltway) from College Park east of I-95 to Silver Spring, southbound on I-95 (in Prince George's County) to the Beltway and then on the Beltway itself again from River Rd (MD 190) into Northern Virginia. During the evening peak hour (5:00 to 6:00 pm), the congestion is less intensive and of shorter extent northbound on I-270 from Shady Grove to Clarksburg; however, congestion on I-495 is more intensive, extending all the way around from College Park back to Northern Virginia. There is also significant congestion on northbound I-95 towards Laurel.

The series of displays for the other peak period hourly time periods show less extensive and intensive congestion but still a significant amount of congestion. Those displays are contained in Appendix L.

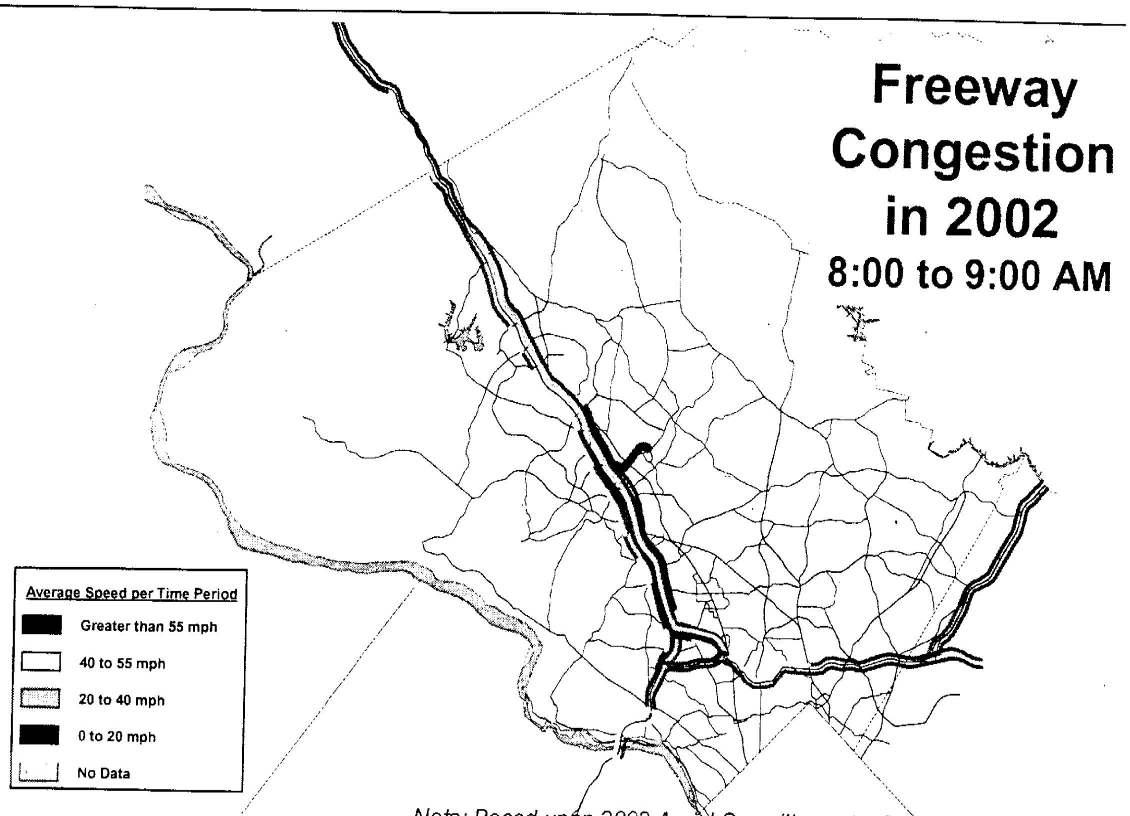


Figure 5.19: Example of Peak Morning Congestion from Average Freeway Speed Data

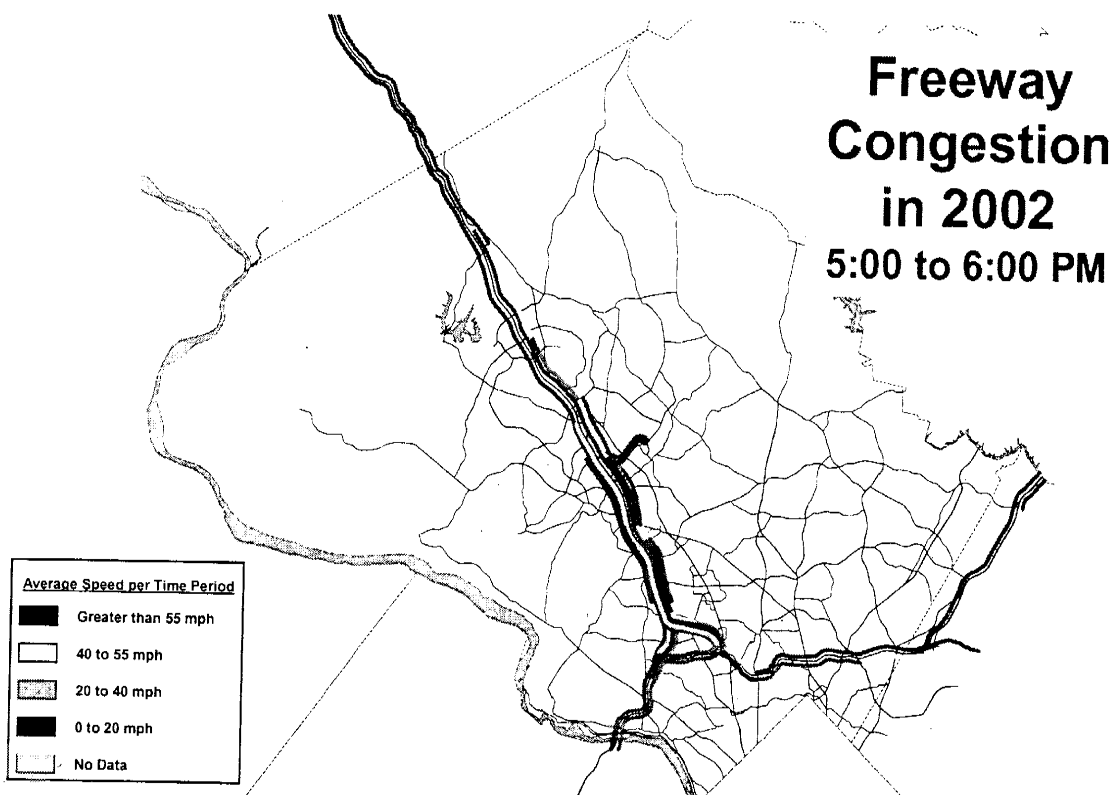


Figure 5.20: Example of Peak Morning Congestion from Average Freeway Speed Data

The overall body of surveying and sampling changes in traffic congestion patterns on the regional freeway system is an excellent example of a consistent, periodic, and long-term tracking of an important measurement of system performance. That full collection of information can be used to compare differences in congestion over time and associate that with changes in network infrastructure and/or operations. In addition, there are sets of photographs and other display summaries that can be use to assess the particular details of the congestion at particular locations. However, the estimates of average speed are for relatively long sections averaging a mile or more and there is no information for the in-between-times during the hourly summary period. In addition, this performance measure is not as straight forwardly applied to measuring congestion on arterials. The next performance measure can address those two needs for more specificity and detail and can be easily applied to major highways, arterials, and local roads.

Route-Specific Freeway and Arterial Speeds and Travel Times

The previously described performance measures of traffic congestion have each been based upon sampling particular transportation facilities or component parts of them, such as an intersection. Those are measures that have been developed mainly from the perspective of the system providers. For example, it has been relatively easy but still difficult for transportation agencies to count turning traffic at intersections and to use that to calculate CLVs. In these days of increasing concern for the customer perspective on services, other measures such as route specific speeds and travel times may be more in tune with the perspective of transportation system users. Users understand if there average morning peak period travel time from Clarksburg to Bethesda is 40 minutes, or if the average speed on a section of northbound Connecticut Avenue (MD 185) inside the Beltway at 5:15 PM is 18 miles/hour.

Transportation and planning agencies may now take advantage of technological innovations to collect, analyze, and summarize these types of data and information. Previously, collecting route-specific speed and travel time data required one person to drive a probe vehicle and another to measure the elapsed time and distance and record the data by hand. Data analysis, summary, and display was even more labor intensive. This report uses data collected with Global Positioning System (GPS) devices that automatically record the second-by-second route of the probe vehicle.

When the probe vehicle is driven at the general speed of the surrounding traffic then the recorded data is representative of the congestion at those places and times. The GPS technology provides reasonably accurate enough second-by-second location (latitude and longitude) to track probe vehicles. The GPS devices also use a Greenwich Mean Time (GMT) based time stamp for each data record that is given in Greenwich Mean Time that allows full synchronization with multiple probes. The resulting electronic file can be analyzed to get information such as the incremental spot speed along a route and cumulative travel time for the whole route or any of its sections.

One challenge with using this new technology is that the amount of data potentially available for analysis can become overwhelming unless proper and effective data management tools and techniques are available. One of these tools is a GIS-based database management system that can track the multiple data files that represent travel along a particular route at a particular time, such as that used by Motion Maps for this report. The system learns the locations and time periods that were sampled, and can then analyze, summarize, and display the resulting information in appropriate groupings or combinations of the individual travel time and speed samples.

Three main sources of samples of GPS travel time and speed runs were available for use in this report, in total consisting of over 1,500 separate route-specific files. These include files from MWCOG, files specifically collected for the ADAC Report, and a collection of files previously collected by Motion Maps as part of their research and development. The particular characteristics of these data sources are outlined below, as well as other future potential sources:

- **MWCOG GPS Data Files**: Since 2000 MWCOG has used GPS tracking devices to periodically sample a selected but limited set of arterials throughout the region, including sections of Norbeck Rd (MD 28), Clopper Rd (MD 117), University Blvd (MD 193), MD 198, MD 355, Veirs Mill Rd (MD 586), and Randolph Rd. That sampling has been relatively intensive with a probe traveling in each direction at once every twenty minutes between the hours of about 1:00 and 8:00 PM. The sampling has generally occurred over two to four separate days. The overall sampling plan has each of these routes being surveyed once every three years and as such a few of them have had their second sampling. Upon request and with some funding support from MDOT, MWCOG has made these data files available for use by the ADAC Report.

- **ADAC Report Data Files**: Supplemental data collection along the MWCOG-sampled routes was performed for a larger number of state and county routes as well to get morning conditions for some of the routes sampled by MWCOG. The sampling was less frequent and for a shorter duration – about once every 30 minutes between the hours of 6 to 9 AM and 4 to 7 PM.

- **Ad Hoc Sampling by Motion Maps**: Over the past three years Motion Maps has been using a GPS device to record travel during business and personal trips, which constitutes an ad hoc sample of different routes of interest to the ADAC Report. In addition, one-shot samples were made of particular routes as part of this project to get a broader geographic coverage and to cover gaps from the other two samples.

- **Other Potential Data Sources**: MWCOG has also performed GPS travel time runs in Montgomery County for other activities, in particular an access study to the regional airports and for the monitoring of HOV use in the I-270 corridor. Work is beginning to be carried out for MCDPWT and MDOT/SHA as part of traffic signal retiming activities that is using GPS tracking devices to study before and after conditions. These and other similar data sources may be available for future summaries.

Figure 5.21 is an example that shows the particular extent and intensity of congestion on I-270 for a set of morning and evening samples for the section of I-270 between Old Hundred Rd (MD 109) in Hyattstown and either the Democracy Blvd or Rockledge Dr interchanges, which is approximately a 20.1-mile distance. In this example the speed shown is the average speed every 1/10th of a mile. While the congested southbound travel time starting at about 7:19 AM was about 45 minutes and finished at about 8:04, the actual second of the start and end times are available if they are needed for improved understanding. The northbound, un-congested travel time was about 18 minutes. The average congested southbound speed was about 27.1 mph. The corresponding afternoon travel time runs showed that it took about 48 minutes to go northbound starting at about 4:38 PM. A thunderstorm made the last part of that run go even slower and slowed the return southbound trip by about 5 minutes to a travel time of about 23 minutes.

Figure 5.22 is an example display that shows the general extent and intensity of evening congestion on main highways and freeways in the county. When compared to a similar display for the morning (shown in Appendix L) the evening conditions are more congested in that the geographic extent of the slower speeds is greater and the operational intensity in many places is slower or more congested. Figure 5.22 also has many more routes that had observations as more sampling was done during the evening. However, not all of these routes shown were for times during the evening peak period. That is because due to the one-shot sampling some of those routes were only surveyed in the mid-day or early afternoon time period. They are shown here in order to give an indication of possible coverage. There are some lines shown either as a brown or teal that indicates those are ones that only had sampling done in the morning and not at all during the evening.

Figures 5.23 and 5.24 are examples in which the geographic scale and coverage is a zoom-in on the same basic data files from Figure 5.22. Figure 5.23 shows the sub-area in the vicinity of Shady Grove, Rockville and Gaithersburg while Figure 5.24 shows the sub-area in the vicinity of Silver Spring, Takoma Park, Kensington, and White Oak. In both of these figures the level of detail has also been sharpened so as to show average speeds every $1/20^{th}$ of a mile. That distance is 264 feet or about ten to eleven car lengths. These displays focus on where the congestion occurs as and clearly show the extent of queues. One example can be seen in Figure 5.23 along westbound Clopper Rd (MD 117), where the road narrows after passing Longdraft Rd. Sometimes, the "congestion" associated with an intersection may not actually be located at the intersection per se but rather in queues upstream of the intersection. This can be seen in Figure 5.24 for the northbound approach along Georgia Ave (MD 97) at the intersection with Randolph Rd. In these two figures there is also a set of "circles" which indicates those locations for which there are CLV calculations available.

There are two other basic types of summary displays that can readily be prepared on a selective basis for a particular route. They are (a) overall route travel time variation by time of day, and (b) a travel time versus distance profile. Samples of data for northbound Connecticut Avenue (MD 185) between Western Avenue and Georgia Avenue (MD 97) in Aspen Hill are used here as an example. The distance of this corridor is approximately 8.3 miles. Figure 5.25 shows the route travel time variation and Figure 5.26 shows the travel time versus distance profile for this section of MD 185.

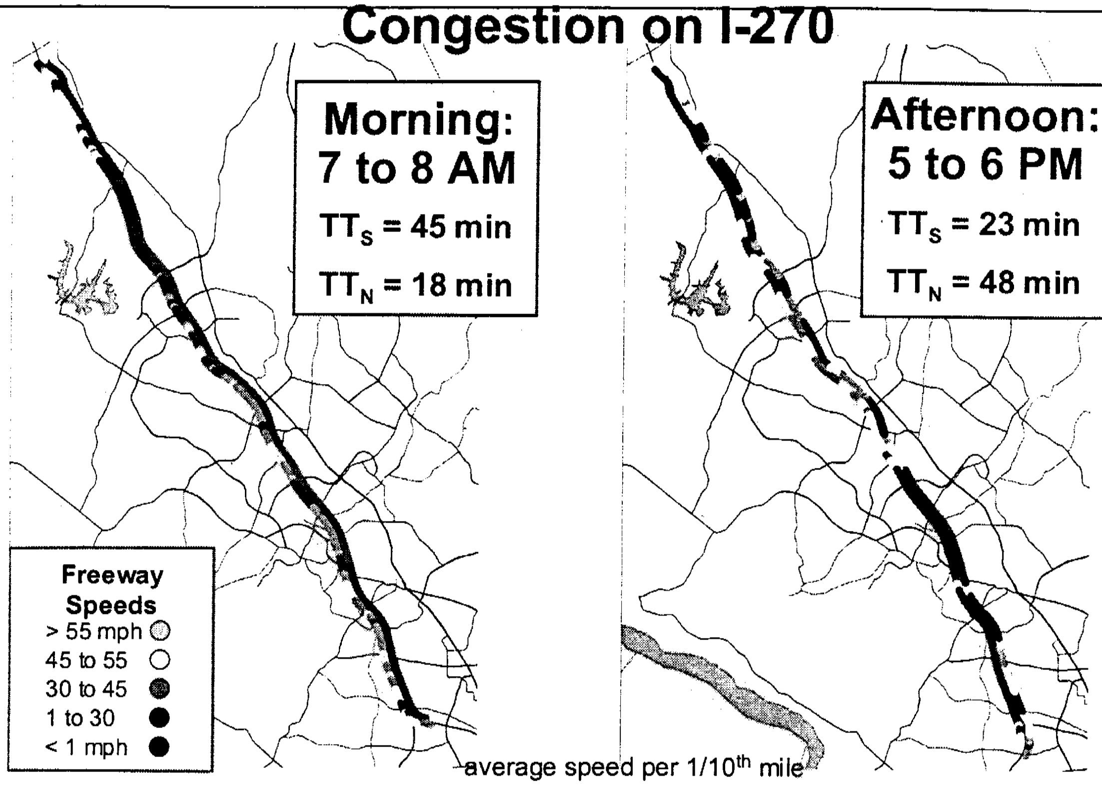


Figure 5.21: Example of the Extent and Intensity of Congestion for I-270

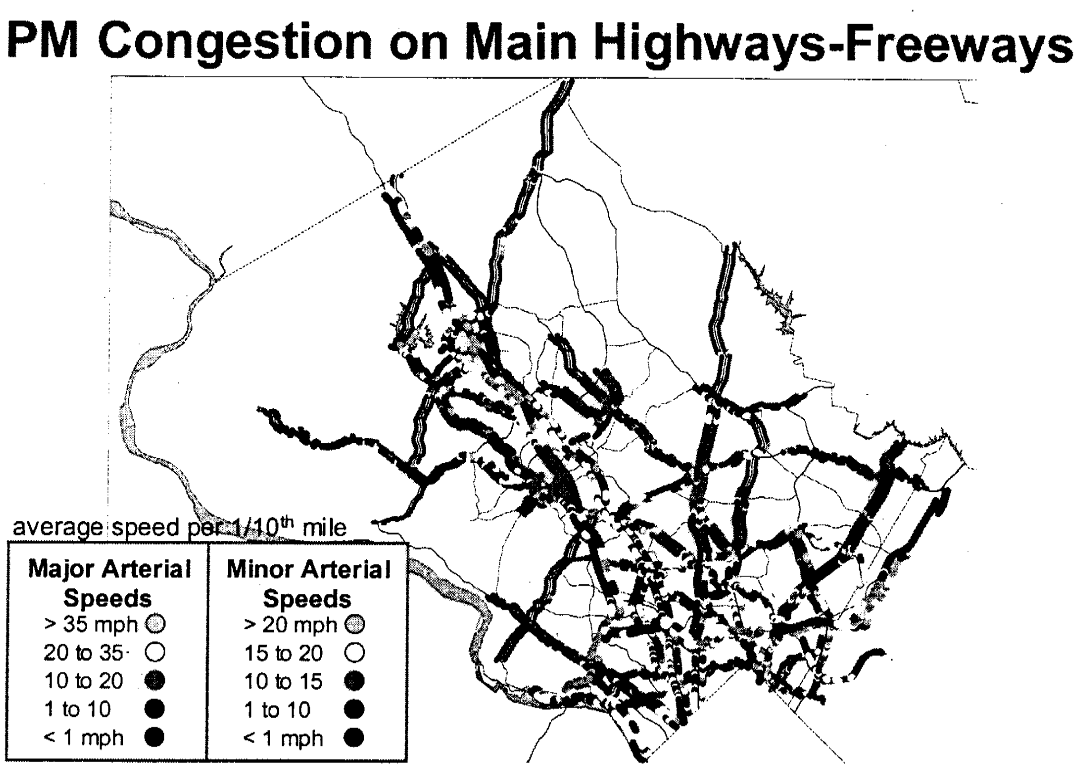


Figure 5.22: Example of the Extent and Intensity of evening Congestion Countywide

In total, 11 northbound and 11 southbound travel time runs were performed. The fastest northbound run of about 12.8 minutes was for a run that started at about 7:14 AM while the slowest was about 30.7 minutes for a run that started about 5:10 PM. Thus the slowest observed travel time was about 2.4 times slower than the fastest observed travel time. This is a very high peak "Travel Time Ratio" when compared to many other corridors, which may have values of 1.5 to 2.0. However, such a comprehensive tabulation and evaluation has not been performed. The Travel Time Ratio for the southbound observed trips was about 1.7. Other examples of this variation in route travel time by time of day are contained in Appendix L.

Figure 5.26 presents a subset of that same basic data presented in Figure 5.25 in a different manner to focus on where along the corridor the congestion or slowness was observed. In Figure 5.26 the total travel time (expressed in hours) is the Y-axis and the distance in miles from Western Avenue is the X-axis. The fastest and slowest travel time runs of the previous figure are shown as well that for the first northbound evening run that started about 3:48 and took about 24.7 minutes. The shapes or "profiles" of these lines indicate the relative congestion experienced by the traveler along the route. The fast time, the green line has a more gentle and uniform slope with few jumps up. The travel distance of 8.3 miles divided by the travel time of .21 hours results in an average speed of about 39.5 mph for the fastest run. The relative uniformity of the slope of the line also indicates a rather uniform speed. This is especially noticeable in contrast to the two other lines for the slowest and the first run of the afternoon. Those lines have several steep slopes that indicate that the traveler experienced significant time with little forward movement – congestion. There are also many short jumps, which are associated with stopping for traffic signals but necessarily being delayed for too long at any one signal. Long queues of traffic can also be discerned in this figure, particularly on the approach to East-West Hwy (MD 410) and to Knowles Ave (MD 547).

There are numerous summary displays serving different audiences that can be prepared using these data. The availability of this new source of GPS based travel time and speed data will present many opportunities to develop even more informed analyses regarding the spatial extent, operational intensity, temporal duration, concurrent variability over time and space, and the basic causes of the particular observed congestion – whether recurrent or non-recurrent. Non-recurrent congestion, which is associated with incidents and events, is becoming more of an everyday occurrence. A significant proportion of the congestion that travelers experience is associated with such incident and event conditions. For example, a major incident on one of the freeways may be reported on the radio newscasts and as a result many travelers change either their route and/or their time of departure resulting in abnormally high congestion of other nearby routes. Some other travelers may not hear the news not know why their usually normal traffic is so congested that day.

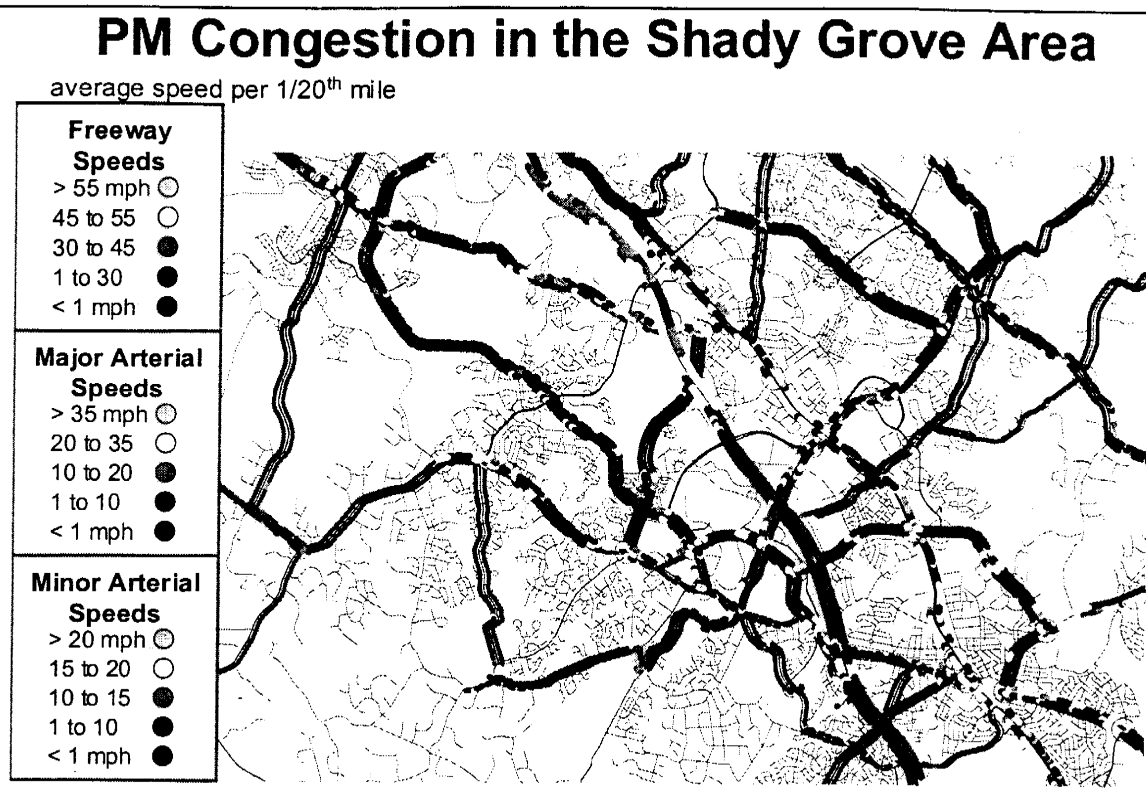


Figure 5.23: Example of Localized Evening Congestion for the Shady Grove Area

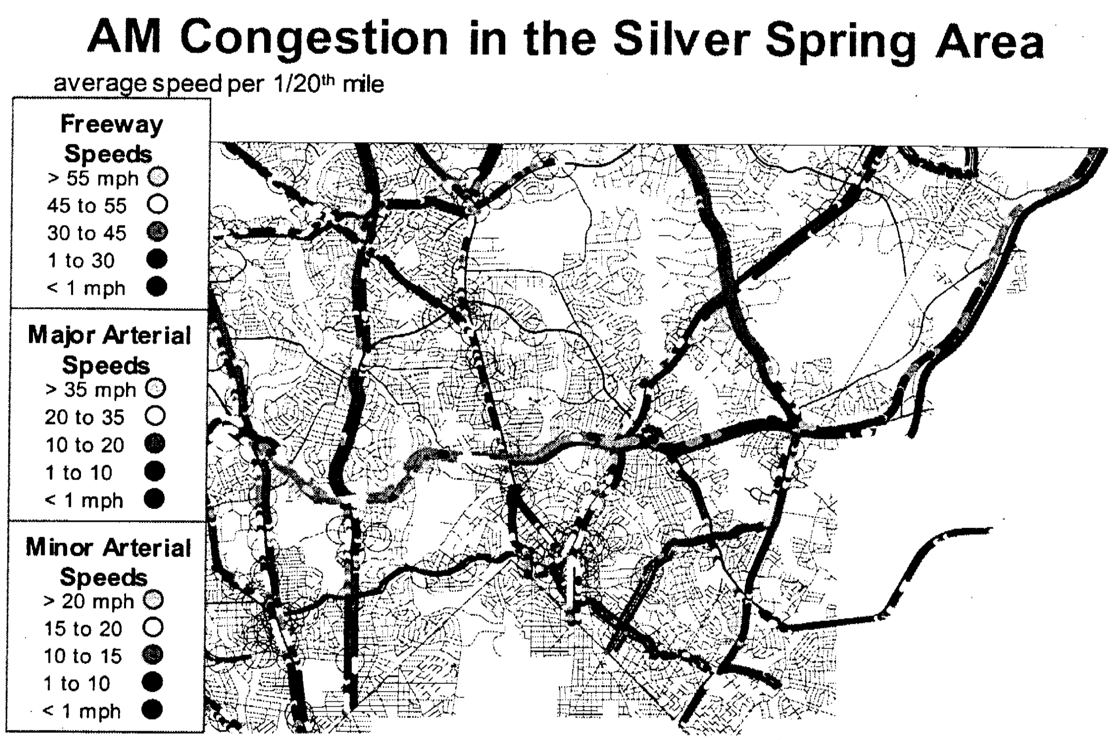


Figure 5.24: Example of Localized Morning Congestion for the Silver Spring Area

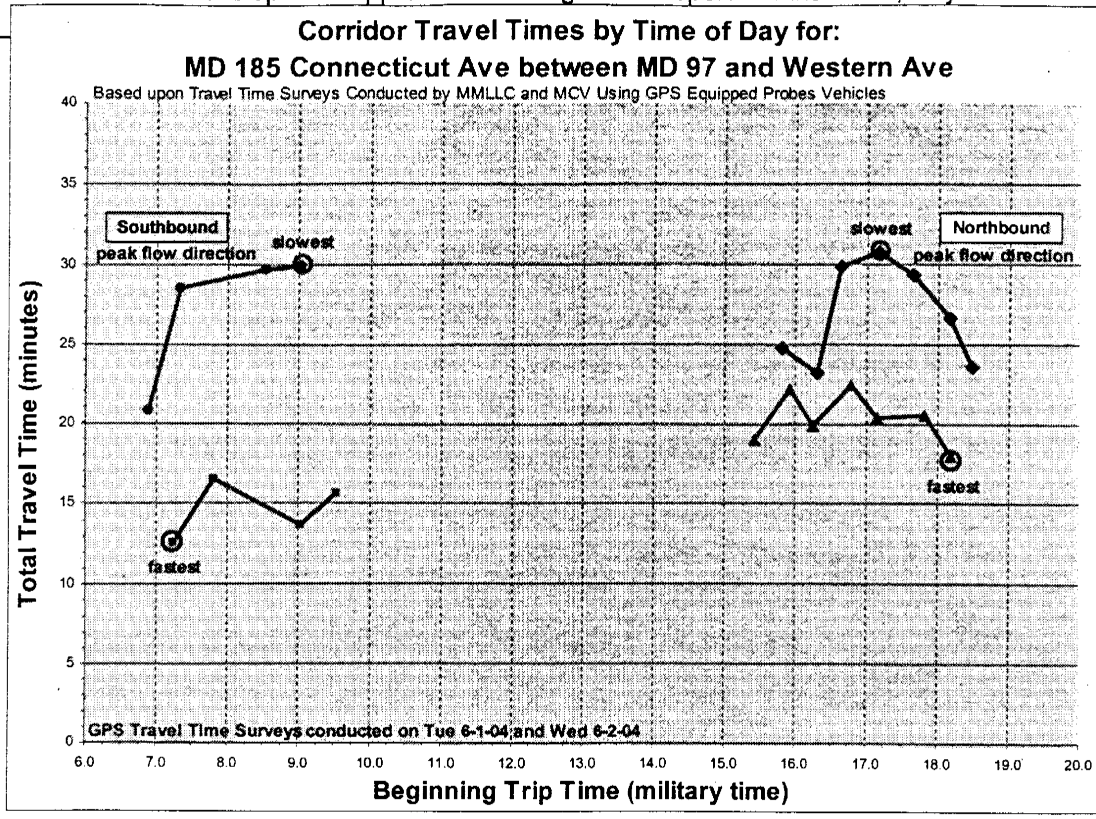


Figure 5.25: Example of Route Travel Time Variation by Time of Day

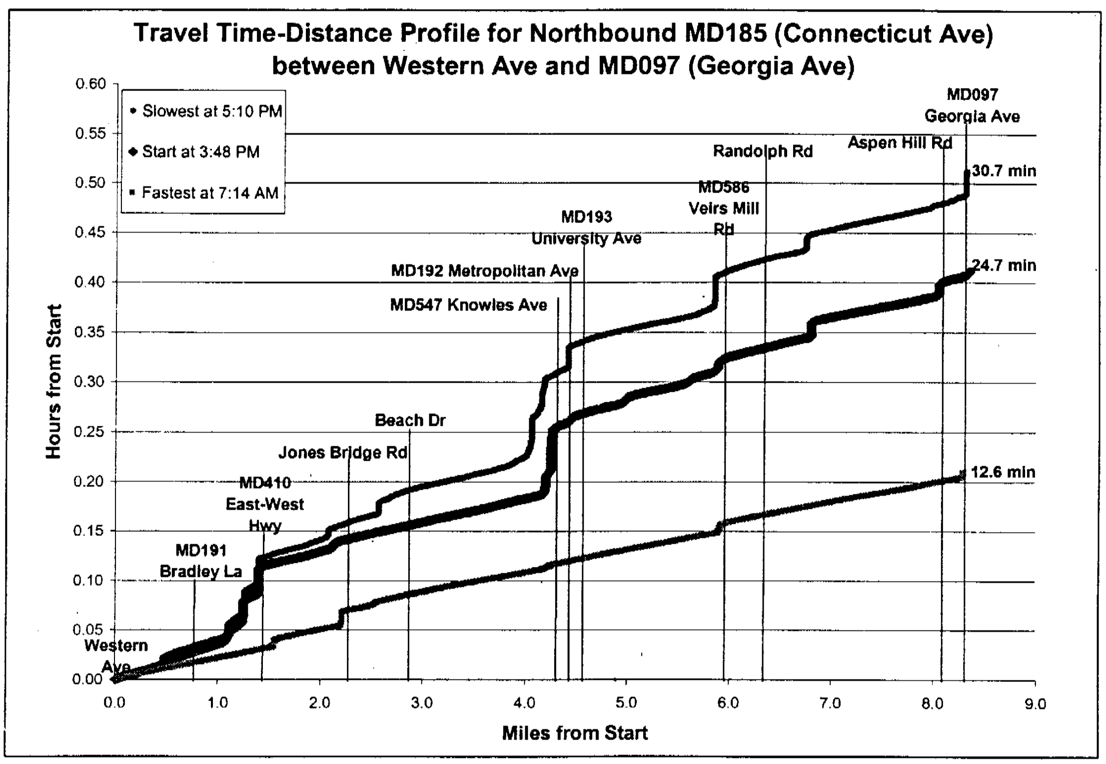


Figure 5.26: Example of Travel Time versus Distance Profile for MD 185

Monitored Freeway Speeds from CHART Traffic Flow Detectors

For nearly ten years MDOT has operated the CHART statewide traffic management center. CHART has several key missions that include incident management, traffic management, traveler information, and traffic and roadway monitoring. As part of these interdependent missions CHART continuously monitors (24/7/365) traffic flows throughout Maryland, including freeway locations in Greater Washington. While the temporal coverage is very complete, the spatial coverage is presently much more limited.

There are several ways in which the monitoring occurs: (a) the use of strategically placed closed circuit television (CCTV) cameras, (b) traffic flow detectors, and (c) through personal observations by the CHART service patrols, maintenance personnel, and the State Police and other emergency service personnel. Over the years various technologies have been used for the traffic flow detectors and maintaining their effective operation and of the necessary communications systems has been a significant challenge. Higher priority has been given to effective functioning the CCTV cameras and to the variable message signs that span many freeways. There are traffic flow detectors located near several of the main freeway gateways to the county, along I-270 in Frederick County, along the Capital Beltway (I-495) at I-95 in Prince George's County, and along I-95 itself. However, there are also limitations – the functioning CHART detectors on I-270 currently only extend as far down as I-370, and there are significant gaps along the Capital Beltway in those sections that are frequently congested. A list of current CHART detector locations may be found in Appendix M.

There are plans to deploy more detectors to give better geographic coverage but funding continues to be tight. Proposals from private sector companies to install privately provided detectors for them to use in traveler information systems have been under consideration in the Baltimore and Washington regions. That may result in a more extensive deployment of such detectors in the near-term future.

The CHART traffic flow detectors currently collect data on: (1) traffic volume, (2) average speed, and (3) "lane occupancy", a measure of the density of use of the roadway during the monitoring time period. The monitoring time period for CHART is one minute. Originally, that minute-by-minute monitoring data on speed and volume was discarded after its immediate use by the CHART program. However, in recent years an Archived Data Management System (ADMS) has been incorporated into the mission of CHART, which has resulted in this data being saved for analysis by CHART staff and for secondary uses by others – such as in the ADAC Report. UMD-CATT maintains the data archive for the CHART detector data. UMD-CATT and CHART staff provided samples of the archived detector data for evaluation in this ADAC Report. The time period for the archive currently aggregates the data to five-minute intervals although plans are underway this summer to switch to a one-minute aggregation level.
The most unique and interesting aspect of this potential new data source is the concurrency of the data – the same type of data is being collected at many places at the same time for the same time-period. Except for the DASH data, all of the other data sources being used in the ADAC Report depend upon a sampling of traffic conditions at different places at different times. While the CHART detector data may be limited in spatial coverage, they can be analyzed to show

concurrent variability of traffic flows and congestion in time and space. These data could be periodically sampled to track congestion rather than conducting field studies.

Figures 5.27 and 5.28 show morning southbound and evening northbound congestion on I-270 using a sample of the CHART archived detector data. Experience with studying similar detector data from other traffic management centers has shown that when (a) the speeds per time period per detector can be sorted and arrayed by (b) increasing time, and (c) direction of flow from detector-to-detector, that displays like these two result. These figures show the concurrent temporal duration and spatial extent of the congestion on parts of I-270 where the direction of traffic flow is from left to right. Figure 5.27 shows for example, that for the right-most column for the detector at I-370 that the time period of about 7:50 to 8:15 AM was the most congested while congestion was heavy for the 15 minutes before and ten minutes after that. The upstream congestion at the next working detector at Darnestown-Germantown Rd (MD 118) in Germantown shows less intense but longer duration congestion that occurs earlier – mainly from about 6:30 to 8:00 AM. Information of the effect on I-270 congestion from the traffic flows entering from Quince Orchard Rd (MD 124) and Clopper Rd (MD 117) is missing.

Figure 5.28 shows similar information for the following afternoon where the direction of traffic flow is from right to left. However, due to the more continuous and evenly-spaced series of detectors up into Frederick County (the four right most columns), a pattern of a shock-wave of congestion moving against the direction of flow emerges, as illustrated by the shaded arrow. It shows that the intense half-hour of congestion north of the county line in Frederick County between about 4:00 to 4:30 PM appears to result in a backward cascading of congestion in time and space back into Montgomery County during the subsequent half hour to forty-five minutes such that the effects are felt by travelers between Shady Grove and Germantown (the two left most columns) between about 5:00 and 5:20 PM.

I-270 Southbound for AM Peak Period

Thursday 3-11-04

North → UMD Catt Lab Daily Speed Report of CHART Data – reformatted for Mont. Co. Congestion Report → South

I-270 South on 03/11/04 (Thursday)

5 min Time Periods Starting	I-270 @ MD 85	I-270 bet Park Mills Rd and Scenic Overlook	I-270 @ MD 80	I-270 @ Doctor Perry Rd	I-270 @ MD 109	I-270 SB @ MSP Truck Weigh Station	I-270 SB @ Comus Rd	I-270 SB @ MD 121	I-270 SB @ MD 118	I-270 SB @ I-370	Day of Week and Date
5:30	47	65	51	52	49	82		76	65	56	Thu 3-11-04
5:35	49	75	51	52	47	82		69	65	60	Thu 3-11-04
5:40	43	77	46	55	47			75	65	56	Thu 3-11-04
5:45	56	69	48	60	55	82		66	60	57	Thu 3-11-04
5:50	56	55	52	49	55	82			64	55	Thu 3-11-04
5:55	53	55	48	61	51			76	63	57	Thu 3-11-04
6:00	54	60	48	54	51	82		74	64	54	Thu 3-11-04
6:05	56	62	46	58	49	86		72	67	56	Thu 3-11-04
6:10	50	60	46	46	45	86		75	47	56	Thu 3-11-04
6:15	62	58	49		48	71		70		59	Thu 3-11-04
6:20	59	56	43	63	47	71		68	41	58	Thu 3-11-04
6:25	53	67	49	67	50			73	[illegible]	58	Thu 3-11-04
6:30	57	57	42	59	48	71		74	[illegible]	57	Thu 3-11-04
6:35	61	61	44	52	51	71		74	[illegible]	54	Thu 3-11-04
6:40	47	59	44	48	52			72	[illegible]	51	Thu 3-11-04
6:45	56	58	53	73	50	65		66	[illegible]	50	Thu 3-11-04
6:50	54	59	56	53	51	65		68	[illegible]	49	Thu 3-11-04
6:55	53	59	51	61	49	74		69	[illegible]	42	Thu 3-11-04
7:00	48	74	44	51	48	61		72	[illegible]	46	Thu 3-11-04
7:05	40	67	51	67	49	61		71	[illegible]	42	Thu 3-11-04
7:10	51	72	47	60	50	61		73	[illegible]	45	Thu 3-11-04
7:15	55	78	51	61	54	61		66	[illegible]	40	Thu 3-11-04
7:20	60	81	50	57	56	61		69	[illegible]	42	Thu 3-11-04
7:25	44	62	52	54	56	55		77	[illegible]	[illegible]	Thu 3-11-04
7:30	43	55	52	55	54	63		71	[illegible]	43	Thu 3-11-04
7:35	46	67	55	51	52	66		72	[illegible]	[illegible]	Thu 3-11-04
7:40	57	66	56	50	52	66		71	[illegible]	[illegible]	Thu 3-11-04
7:45	63	63	51	55	54	57		72	[illegible]	[illegible]	Thu 3-11-04
7:50	51	68	57	44	48	57		71	[illegible]		Thu 3-11-04
7:55	47	78	49	71	50	57		61	[illegible]		Thu 3-11-04
8:00	48	75	63	54	51	54			[illegible]		Thu 3-11-04
8:05	46	70	55	63	49	54		72	40		Thu 3-11-04
8:10	49	65	55	47	57	54		67			Thu 3-11-04
8:15	49	70	61	47	56	54		73	45	[illegible]	Thu 3-11-04
8:20	43	73	56	47	50	56		73	[illegible]	[illegible]	Thu 3-11-04
8:25	48	73	56		48	56		70	42	42	Thu 3-11-04
8:30	48	80	48	54	51	60		69	61	41	Thu 3-11-04
8:35	47	76	63	50	51	63		70	62	42	Thu 3-11-04
8:40	66	74	55	50	56			72	63	43	Thu 3-11-04
8:45	45	72	59	40	49	59		72	56	41	Thu 3-11-04
8:50	65	72	66	56	50	65		70	48	42	Thu 3-11-04
8:55	54	72	66	63	50	53		68	65	45	Thu 3-11-04
9:00	54	69	63	47	50	55		65	48	44	Thu 3-11-04
9:05	54	68	64	56	51	69		70	63	44	Thu 3-11-04
9:10	42	71	65	53	53	65		65	60	[illegible]	Thu 3-11-04
9:15	63	66	63	58	55	63		62	67	46	Thu 3-11-04
9:20	50	67	66	58	56			73	63	51	Thu 3-11-04
9:25	50	65	63	57	56			65	70	51	Thu 3-11-04

6:00 AM

7:00 AM

8:00 AM

9:00 AM

Average Speed per Time Period

- Greater than 55 mph
- 40 to 55 mph
- 20 to 40 mph
- 0 to 20 mph
- No Data

Figure 5.27: Morning Congestion Duration based upon CHART Traffic Flow Detectors

I-270 Northbound for PM Peak Period

Friday 3-12-04

South → UMD Catt Lab Daily Speed Report of CHART Data – reformatted for Mont. Co. Congestion Report → North

I-270 North on 03/12/04 (Friday)

5 min Time Periods Starting	I-270 NB @ I-370	I-270 NB @ MD 118	I-270 NB @ MD 121	I-270 NB @ Comus Rd	I-270 NB @ MSP Truck Weigh Station	I-270 @ MD 109	I-270 @ Doctor Perry Rd	I-270 @ MD 80	I-270 bet Park Mills Rd and Scenic Overlook	I-270 @ MD 85	Day of Week and Date
15:00		67	45	53	68	58		69	48	61	Fri 3-12-04
15:05	57	64	[illegible]	59	67	58			62	61	Fri 3-12-04
15:10		64	[illegible]	56	68	57		52	62	61	Fri 3-12-04
15:15		66	[illegible]	61	66	59	54	40	65	61	Fri 3-12-04
15:20		66	42	58	68	66	54	65	65	61	Fri 3-12-04
15:25	55	60	41	58	66	62	52		60	61	Fri 3-12-04
15:30	58	67		63	66	63	51	53	51	61	Fri 3-12-04
15:35	57	66		56	67	63	53	63	52	61	Fri 3-12-04
15:40		64		61	66	61		51	51	61	Fri 3-12-04
15:45		48	[illegible]	58	66	57	54	61	44	61	Fri 3-12-04
15:50	58	64		63	67		41	62	[illegible]	61	Fri 3-12-04
15:55	53	68	[illegible]	65	67	60			46	61	Fri 3-12-04
16:00	55	41		58	66	64			49	61	Fri 3-12-04
16:05	56	66		62	69	62	47		54	61	Fri 3-12-04
16:10	57	65		59	68	62		68	64	61	Fri 3-12-04
16:15		67	[illegible]	58	69	52		64	67	61	Fri 3-12-04
16:20	57	66		62	64	51			67	61	Fri 3-12-04
16:25	58	56	[illegible]	47	49	[illegible]			66	61	Fri 3-12-04
16:30	57	66		[illegible]	52	54		66	67	61	Fri 3-12-04
16:35		69	[illegible]	41	49	51	[illegible]	65	68	61	Fri 3-12-04
16:40		70	[illegible]	[illegible]	45	58	[illegible]		70	61	Fri 3-12-04
16:45	59	67		[illegible]	58	60	[illegible]	66	71	61	Fri 3-12-04
16:50	58	56	[illegible]	42	66	61			71	61	Fri 3-12-04
16:55	60	58	[illegible]	55	69	53	[illegible]		69	61	Fri 3-12-04
17:00	57	48	[illegible]	56	65	57	[illegible]		69	61	Fri 3-12-04
17:05	57	[illegible]	[illegible]	46	54	62			66	61	Fri 3-12-04
17:10	[illegible]	51		[illegible]	67	55	[illegible]	63	64	69	Fri 3-12-04
17:15	[illegible]	70	[illegible]	40	70	61			73	69	Fri 3-12-04
17:20	60	69		53	69	53	41	63	71	69	Fri 3-12-04
17:25	64	71		56	64	60		68	61	69	Fri 3-12-04
17:30		50	[illegible]	[illegible]	58	60	52	69	55	69	Fri 3-12-04
17:35	64	69		48	65	61	44	70	60	69	Fri 3-12-04
17:40	60	66		59	70	60	45		70	69	Fri 3-12-04
17:45		69	46	61	69	59	45	68	72	68	Fri 3-12-04
17:50	60	70		57	71	60	[illegible]	66	75	69	Fri 3-12-04
17:55	60	68	[illegible]	61	70	57		68	67	69	Fri 3-12-04
18:00	64	69	47	56	67	58	56		75	69	Fri 3-12-04
18:05	58	69		61	63	57	53	67	69	69	Fri 3-12-04
18:10		69	44	57	67	63	60	67	68	69	Fri 3-12-04
18:15	56	68		56	67	56	65	71	61	69	Fri 3-12-04
18:20	56	67		62	66	61	64	70	53	69	Fri 3-12-04
18:25	56	67		62	73	60	67	71	54	69	Fri 3-12-04
18:30		66	74	62	67	59		73	63	69	Fri 3-12-04
18:35		67	72	62	70	62	68	70	69	69	Fri 3-12-04
18:40	56	69		64	70	59	67	68	78	69	Fri 3-12-04
18:45	61	67		70	74	59	70		71	69	Fri 3-12-04
18:50		69	75	69	71	62	70	72	78	69	Fri 3-12-04
18:55	66	65		67	74	61	68	71	66	69	Fri 3-12-04

3:00 PM

4:00 PM

5:00 PM

6:00 PM

7:00 PM

Average Speed per Time Period

- Greater than 55 mph
- 40 to 55 mph
- 20 to 40 mph
- 0 to 20 mph
- No Data

Figure 5.28: Evening Congestion Duration based upon CHART Traffic Flow Detectors