I-95 Corridor Coalition

Mid-Atlantic Truck Operations Study

Final Report

October 2009

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Prepared for:

I-95 Corridor Coalition

Maryland Department of Transportation
New Jersey Department of Transportation
Pennsylvania Department of Transportation
Delaware Department of Transportation
Virginia Department of Transportation
New York State Department of Transportation

Sponsored by:

I-95 Corridor Coalition

Prepared by:

Cambridge Systematics, Inc.

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This report was produced by the I-95 Corridor Coalition. The I-95 Corridor Coalition is a partnership of state departments of transportation, regional and local transportation agencies, toll authorities, and related organizations, including law enforcement, port, transit and rail organizations, from Maine to Florida, with affiliate members in Canada. Additional information on the Coalition, including other project reports, can be found on the Coalition's web site at http://www.i95coalition.org.

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Executive Summary

The objective of the Mid-Atlantic Truck Operations (MATOps) study is to identify and analyze major highway bottlenecks causing delay to trucks traveling on the Mid-Atlantic region's highway system and develop a consensus-based approach for reducing those delays and their economic costs.

The goal of the study is to help state departments of transportation (DOT), metropolitan planning organizations (MPO), and motor carriers develop capital, operating, and regulatory solutions that reduce delays at highway truck bottlenecks, set priorities for project funding, and implement improvements.

The study was sponsored by the I-95 Corridor Coalition, an alliance of transportation agencies, toll authorities, and related organizations, including public safety, from the State of Maine to the State of Florida, with affiliate members in Canada. The Coalition provides a forum for key decision and policy-makers to address transportation management and operations issues of common interest.

The MATOps study was conducted with oversight from a technical steering committee representing state transportation officials from the six Mid-Atlantic states – Maryland, New York, New Jersey, Pennsylvania, Virginia, and Delaware. The study benefited from review and advice from these officials as well as from the American Trucking Associations (ATA) and MPOs within the Mid-Atlantic region.

The MATOps study was motivated by the I-95 Corridor Coalition's Mid-Atlantic Rail Operations Study (MAROps), which examined rail choke points in the Mid-Atlantic region. The Coalition sought to expand the analysis to the region's highways to better assess the overall impact of bottlenecks on freight movement and the regional economy.

The MATOps project leverages research on national highway and truck bottlenecks conducted by the Federal Highway Administration. This research identified several hundred significant highway bottlenecks across the United States and made preliminary estimates of the hours of delay accrued by trucks traveling through these bottlenecks. Many of the major bottlenecks were in the Mid-Atlantic region.

The work undertaken in the MATOps study: 1) identifies the truck bottlenecks in the region, estimates the truck-hours of delay at each, and then develops detailed delay estimates for the five worst truck bottlenecks in each state; 2) describes the Mid-Atlantic economy, its growth industries, and commodities they ship and receive; 3) estimates the value and tonnage of the commodities caught in the truck bottlenecks as a proxy for the economic impact of the bottlenecks; 4) maps the commodity flows against truck freight bottlenecks and identifies "bottleneck strings" along the region's trade corridors; 5) reports current bottleneck reduction strategies; and 6) recommends actions that the Coalition and its member agencies can pursue as the next steps in reducing truck bottleneck delays.

The study identifies 152 truck freight bottlenecks in the Mid-Atlantic region. Of these, 4 are among the top 30 bottlenecks in the nation. The study estimates that the 152 bottlenecks in the Mid-Atlantic region cause 19.6 million hours of truck delay annually. This translates into $706 million in lost time, 35 million gallons of fuel burned, and 0.39 million tons of carbon dioxide emissions, the major component of greenhouse gases.

The 5 worst truck bottlenecks in each state were studied in greater detail. (The State of Delaware identified 4 bottlenecks.) These 29 bottlenecks were found to account for 47 percent of all truck-hours of delay accrued at bottlenecks across the Mid-Atlantic region. The annual impacts of these 29 bottlenecks alone were estimated at $334 million in lost time, 16 million gallons of fuel burned, and 0.18 million tons of carbon dioxide emissions. These costs are a substantial drain on the productivity of the region's economy, the energy security of the nation, and the health of the population.

Without concerted action, these costs will increase. The population of the region is projected to grow by 21 percent, and the size of the economy will more than double between 2005 and 2035. Without improvements to the freight transportation system that preserve capacity and reduce delays, the costs of feeding, housing, and clothing the population and the costs of supporting the region's growth industries will go up.

Almost all of the major bottlenecks – measured in truck-hours of delay – are in urban areas at interchanges on or adjacent to the I-95 corridor. Reducing the cost of truck freight delays and congestion along the I-95 corridor will have the greatest benefit to the freight system and the region's economy. The I-95 corridor bottlenecks should be the focus of future Coalition and member state efforts.

Most of the major bottlenecks along the Mid-Atlantic trade corridors are strung closely together. Many medium- and long-distance truck moves using these corridors encounter one or more strings of bottlenecks depending on their route and the time of day. An improvement to a single bottleneck within these strings will reduce delays at that bottleneck, but will often shift the congestion to the next downstream bottleneck. To achieve significant reductions in truck delay and improve freight flows along the Mid-Atlantic trade corridors, strings of bottlenecks must be considered and managed as a whole.

The strings of bottlenecks span two and sometimes three states as well as multiple jurisdictions within metropolitan areas. This means that planning, funding, and implementing improvements to reduce delay and congestion must be done on a cooperative basis. This will require continuing efforts to build and sustain coalitions among Federal, state, and local agencies, and with the private sector. Finally, while the literature review identified a broad spectrum of capital, operating, and regulatory solutions that could be applied to freight bottlenecks, the state of practice in dealing with major freight bottlenecks is not well developed. Major freight bottlenecks are often regarded as too big to tackle – because of their technical, institutional, and funding complexities – and, therefore, put off for the future.

However, the Mid-Atlantic region cannot afford to ignore the mounting demand for freight transportation and the consequences of inaction. The region needs policies and programs to address the capacity and performance needs of its freight transportation system. The consequence of transportation failure – failing to keep up with growth and trade, failing to fix major truck bottlenecks, failing to fix major rail chokepoints, and failing to provide adequate access to the nation's ports and international trade gateways – will be higher costs and slower economic growth, which will compound the problems created by the recent recession.

Based on the findings and conclusions of the study, the I-95 Corridor Coalition and its member agencies may wish to consider the following actions:

- Select a high-priority bottleneck string.
- Conduct a detailed examination of the bottlenecks within the string, including examination of the physical, operational, and institutional factors that may cause them. A further analysis of commodity flows may provide insight about the bottlenecks that have the most economic impact to the region. Commodities can be disaggregated by industry, and value-hours of delay and ton-hours calculated for each commodity/industry group, to provide a more precise assessment of economic impact.
- Work with the Mid-Atlantic states to identify a portfolio of cost-effective strategies to reduce truck- and commodity-hours of delay across the string of bottlenecks.
- Provide the information to the Mid-Atlantic states to assist the appropriate member states in undertaking projects to address these bottlenecks, including projects that may be applicable for planning and implementation funding under the Federal Projects of National and Regional Significance (PNRS) program (or new programs that emerge from the surface transportation authorization).
- In parallel with the development of the bottleneck string program, examine how other improvements to the Mid-Atlantic rail and marine transportation systems might help relieve truck pressure at the bottlenecks and elsewhere on the highway network.

The Coalition also may wish to:

- Examine truck bottlenecks in the Northeast and Southeast regions to complete a picture of bottlenecks and bottleneck strings in the I-95 Corridor region.
- Continue work with the FHWA, member states, motor carrier associations, and motor carriers on traffic count and fleet speed data programs. These activities could generate better performance data, which could be used to more quickly and accurately identify bottlenecks, track delay trends, estimate economic impacts, and set priorities for improvements.

1.0 Objective

The objective of the Mid-Atlantic Truck Operations (MATOps) study is to identify and analyze major highway bottlenecks causing delay to trucks traveling on the Mid-Atlantic region's highway system, and develop a consensus-based approach for reducing those delays and their economic costs. The study findings will help state DOTs, MPOs, and motor carriers develop capital, operating, and regulatory solutions that reduce delays at highway truck bottlenecks, set priorities for project funding, and implement improvements.

2.0 Background

2.1 Origins of the Study

The MATOps study parallels and complements the I-95 Corridor Coalition's 2002 Mid-Atlantic Rail Operations (MAROps) study, which examined rail chokepoints and options to increase rail freight and intercity passenger capacity in the Mid-Atlantic region. That study was prompted by concerns about growing congestion on the highway systems, and parallel concerns that the regional rail system might not have sufficient capacity to readily absorb future freight traffic if truck freight were to divert from the congested highway system to the rail system. The MAROps study identified specific chokepoints in the regional rail system and concluded that an investment of $6.2 billion over a 20-year period would be necessary to maintain the freight capacity of the rail system and keep freight from shifting from rail to truck.[1] With the MATOps study, the Coalition seeks to expand the bottleneck analysis to the region's highways to better assess the overall impact of bottlenecks on freight movement and the economy of the region.

The MATOps study leverages research on national highway and truck bottlenecks conducted by the Federal Highway Administration.[2] This research identified several hundred significant highway bottlenecks across the United States and made preliminary estimates of the hours of delay accrued by trucks traveling through these bottlenecks. The findings prompted the I-95 Corridor Coalition and the six Mid-Atlantic states (New York, New Jersey, Maryland, Delaware, Pennsylvania, and Virginia) – in cooperation with national motor carriers and the MPOs representing the major cities in the region – to make a more detailed inventory and analysis of highway truck bottlenecks in the Mid-Atlantic region and their impact on the region's economy.

By commissioning the study, the I-95 Corridor Coalition seeks to provide a regional perspective on highway bottlenecks affecting truck traffic and develop information that member agencies can use to set priorities for reducing delays at bottlenecks. The Coalition does not intend that the study provide detailed engineering and funding solutions; that remains the responsibility of the individual state DOTs, working with shippers, carriers, and local jurisdictions.

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[1] I-95 Corridor Coalition, *Mid-Atlantic Rail Operations Study: Summary Report*, prepared by Cambridge Systematics, Inc., April 2002. A recently completed update to the MAROps study estimated the amounts of freight that might be diverted to rail from the highway system with improvements to the rail system.

[2] INRIX, *National Traffic Scorecard: Online Summary*, 2007; http://scorecard.inrix.com/2007/Summary.aspx (accessed August 26, 2009).

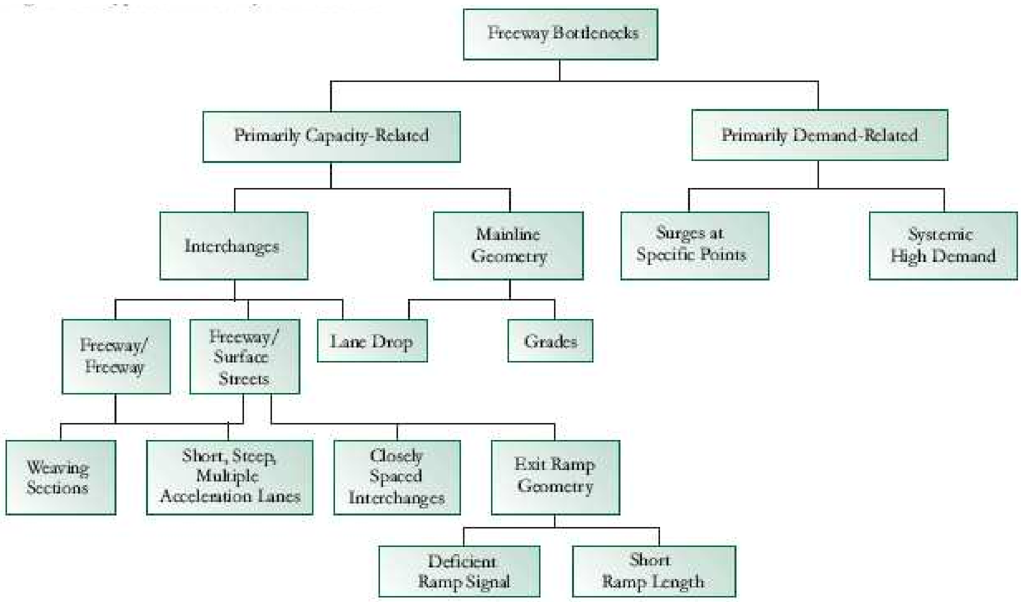
Together, the MATOps and MAROps studies identify the major highway and rail bottlenecks in the Mid-Atlantic region, show how they affect freight transportation and the economy, and provide information that can be used as a foundation for the planning and programming of cost-effective freight transportation improvements.

2.2 HIGHWAY BOTTLENECKS

Bottlenecks are specific physical locations on highways that routinely experience recurring congestion and traffic backups because traffic volumes exceed highway capacity at those locations. Bottlenecks that cause significant delays to trucks are referred to as truck freight bottlenecks. Figure 2.1 shows the typical causes of capacity- and demand-related highway bottlenecks. They include:

- Highway-to-highway interchanges, where ramps channel traffic flows from one highway to another. These are often the most severe form of physical bottleneck because of the high volumes of automobiles and trucks involved.
- Lane drops, where one or more traffic lanes are lost. These occur most often at bridge crossings and in work zones; however, work zones are a temporary constraint and the congestion usually dissipates when the work zone is removed.
- Weaving areas, where traffic merges across one or more lanes to reach entry or exit ramps.
- Highway on-ramps, which are merging areas where traffic from local streets joins a highway.
- Abrupt changes in highway alignment, which may occur at sharp curves and on hills and cause drivers to slow down either because of safety concerns or because their vehicles cannot maintain speed on upgrades. Another example of this type of bottleneck is a work zone where lanes are redirected or "shifted" during construction.
- Intended interruptions to traffic flow, designed to manage system flow; examples are traffic signals, freeway ramp meters, and tollbooths.

Figure 2.1 Types of Highway Bottlenecks



Source: Federal Highway Administration, Traffic Bottlenecks: A Primer, Focus on Low-Cost Operational Improvements, prepared by Cambridge Systematics, Inc., July 2007. http://ops.fhwa.dot.gov/publications/bnprimer/bottleneck_jul07.pdf (accessed August 26, 2009).

2.3 National Bottleneck Studies

Recent national studies indicate that there are a significant number of major bottlenecks within the Mid-Atlantic region. INRIX, a national traffic information service, mapped congested roadways based on the observed travel speeds of automobiles and trucks.[3] Figure 2.2, from INRIX's National Traffic Scorecard report, shows the nation's 100 "most delayed" highway segments colored in red, and all analyzed segments colored in green. There is a pronounced concentration of red highway segments – indicating slow travel speeds and high levels of congestion – in the Mid-Atlantic region.

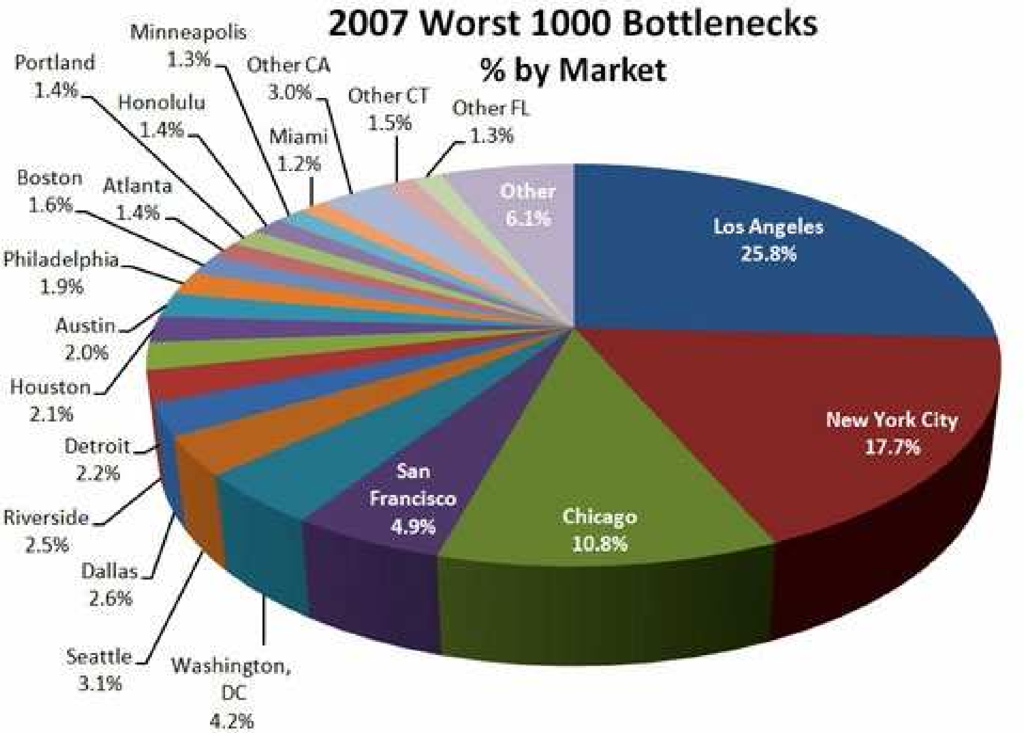
[3] INRIX, *National Traffic Scorecard: Online Summary*, 2007; http://scorecard.inrix.com/2007/Summary.aspx (accessed August 26, 2009).

Figure 2.2 INRIX Map of 100 Most Delayed Highway Segments
2007

Source: INRIX, *National Traffic Scorecard: On-Line Summary*, 2007; http://scorecard.inrix.com/2007/Summary.aspx (accessed August 26, 2009).

INRIX's data indicate that the New York City region (the combined base statistical area or CBSA) has the second-highest number of bottlenecks in the nation, behind only Los Angeles. Other Mid-Atlantic areas with significant numbers of bottlenecks include Washington, D.C. and Philadelphia, Pennsylvania. Figure 2.3 shows the distribution of the 1,000 worst bottlenecks identified by INRIX. The chart shows the percentage of bottlenecks by metropolitan area.

Figure 2.3 Distribution of 1,000 Worst Bottlenecks by Area
2007

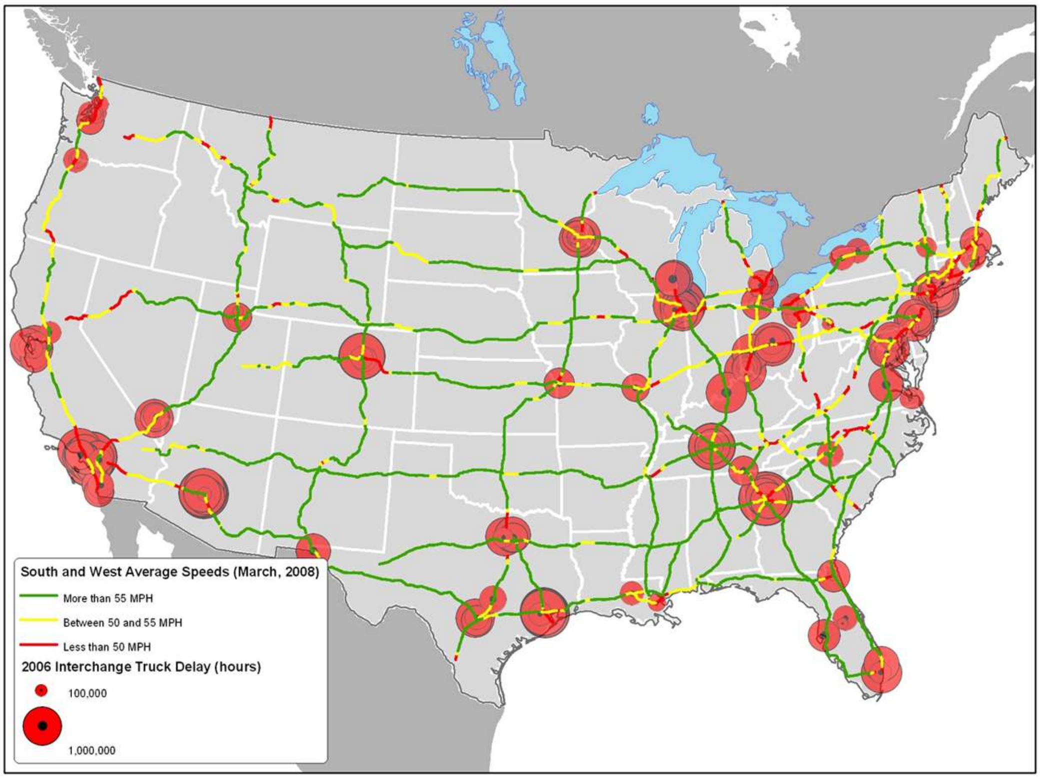


Source: INRIX, *National Traffic Scorecard: On-Line Summary*, 2007; http://scorecard.inrix.com/2007/Summary.aspx (accessed August 26, 2009).

The FHWA bottleneck study, which was cited earlier in this section and focused on truck bottlenecks, also shows a significant concentration of bottlenecks and heavily congested highway segments in the Mid-Atlantic region. The bottlenecks and congested highway sections stretch from Boston to Richmond.[4] Figure 2.4 maps the location of the truck bottlenecks and levels of congestion on the highways. The bottlenecks are represented by dots with the circles around each dot sized proportionally to represent the relative hours of truck delay at each bottleneck. The highways are color-coded to represent annual average link speeds: a green line represents highway segments that operate, on average, at or above free-flow speeds (e.g., more than 55 mph); the yellow line, links that operate at, or below, free flow speed (e.g., between 50 mph and 55 mph); and the red lines, links that operate well below free flow speed (e.g., less than 50 mph).

[4] Federal Highway Administration, *Estimated Cost of Freight Involved in Highway Bottlenecks*, prepared Cambridge Systematics, Inc., November 12, 2008.

Figure 2.4 Interchange Bottlenecks (Identified Using the HPMS Scan Method) and Average Highway Speeds by Link (for Traffic Flows in the South and West Directions)
2006



Source: Federal Highway Administration, *Estimated Cost of Freight Involved in Highway Bottlenecks*, prepared by Cambridge Systematics, Inc., November 12, 2008.

A separate analysis of truck speeds by the American Transportation Research Institute (ATRI), the research arm of the American Trucking Associations, reported similar findings.[5] The ATRI study used speedometer readings and GPS location data captured by on-board computers to map actual truck speeds by highway segment. Both FHWA and ATRI reported that four Mid-Atlantic truck bottlenecks are among the worst in the nation.

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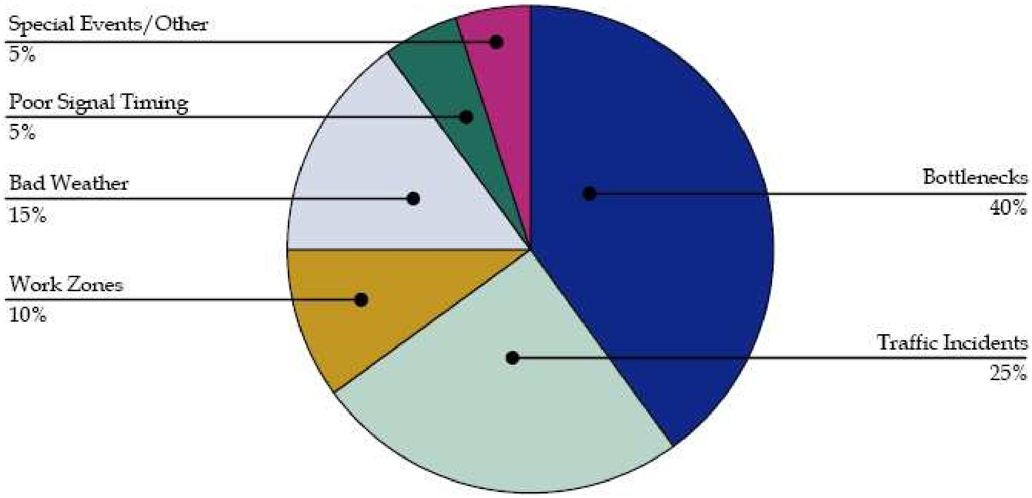
[5] American Transportation Research Institute, *Freight Performance Measures Analysis of 30 Freight Bottlenecks*, March 2009.

2.4 COST OF BOTTLENECK CONGESTION

Highway bottlenecks are a major source of delay, accounting for an estimated 40 percent of national highway congestion, as illustrated in Figure 2.5.

Figure 2.5 The Sources of Congestion: National Summary



Source: Federal Highway Administration, *Traffic Congestion and Reliability: Linking Solutions to Problems*, prepared by Cambridge Systematics, Inc. and Texas Transportation Institute, July 19, 2004.

No figures are available for the Mid-Atlantic region as a whole, but the Texas Transportation Institute (TTI) has estimated the costs of congestion for the urban areas within the Mid-Atlantic region. Since the Mid-Atlantic region is heavily urbanized, the TTI statistics likely account for much of the travel in the region and most of the congested travel. The TTI data show that the 19 million highway users traveling in the region's urban areas in 2005 experienced more than 750 million hours of delay at a cost of $14 billion in lost time.[6] On average, each highway user lost the equivalent of one full-time workweek (41 hours) to congestion.

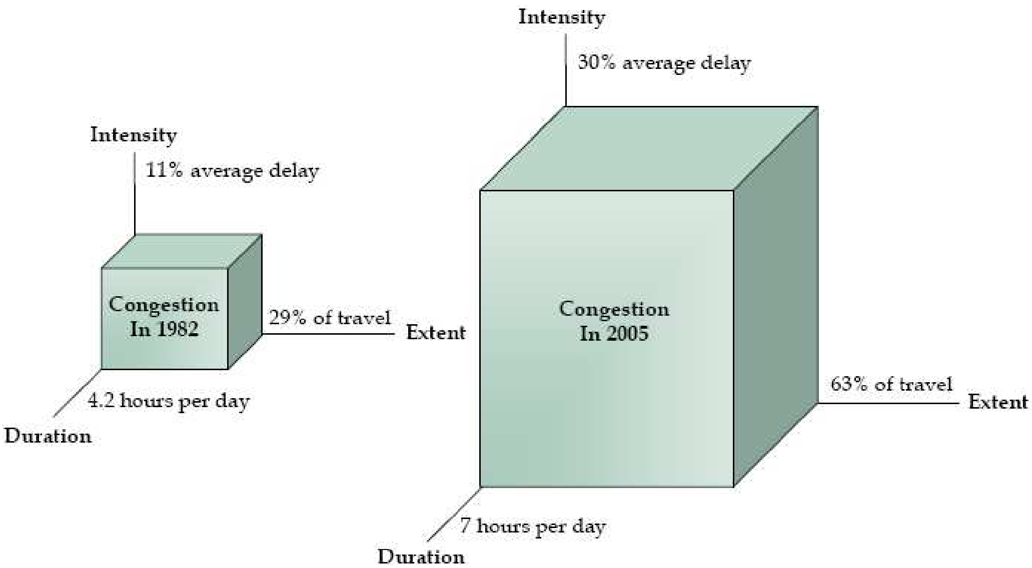
Highway congestion also increases energy use and greenhouse gas emissions. Compared to free flow conditions, vehicles caught up in congestion in the urban areas of the Mid-Atlantic region burned an extra 491 million gallons of fuel at a

[6] Texas Transportation Institute, *The 2007 Urban Mobility Report*, September 2007; http://tti.tamu.edu/documents/mobility_report_2007_wappx.pdf (accessed October 2, 2008).

cost of $1.7 billion in 2005.[7] The additional fuel consumption generated about 1.2 million metric tons of carbon dioxide emissions.[8]

Analysis of national and metropolitan traffic data shows that congestion and delay grew steadily between 1982 and 2005. Figure 2.6 illustrates the relative increase in congestion as measured by intensity (length of time delayed), duration (hours of the day delay is present), and extent (more roadways).

Figure 2.6 Growth in Congestion
1982-2005



Source: Federal Highway Administration, *Traffic Congestion and Reliability Trends and Advanced Strategies for Congestion Mitigation*, prepared by Cambridge Systematics, Inc. and Texas Transportation Institute, September 1, 2005.

The rate of growth in highway travel, congestion, and delay has slowed during the recent recession, but is expected to increase again as the economy, employment, and trade levels recover. FHWA projections, based on Highway Performance Monitoring System (HPMS) trends, suggest that vehicle-miles traveled in the Mid-Atlantic region will more than double by 2035. If these projections prove true, and investments in highway and transit infrastructure con-

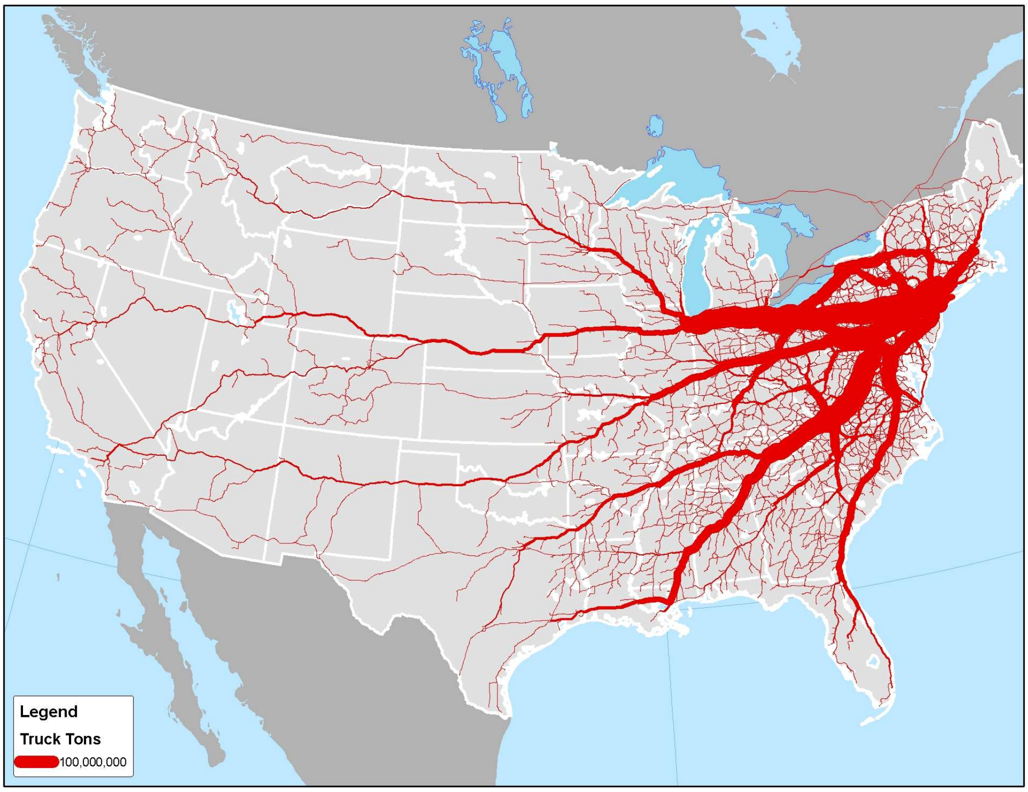
[7] Fuel cost estimated at $3.50 per gallon.

[8] When burned, a gallon of petroleum-based fuel generates about 20 pounds of carbon dioxide, (19.4 pounds per gallon of gasoline; 22.2 pounds per gallon of diesel fuel) which are released into the atmosphere.

tinue at the current pace, the Mid-Atlantic region's roadways will become more congested and delays to freight trucks will increase substantially.

This is an immediate concern to the I-95 Corridor Coalition, its member agencies, and motor carriers who operate in the region because the delay impacts their daily operations. It also is a concern to all regional stakeholders, whether they experience delay first hand or not, because delay imposes indirect costs on the Mid-Atlantic economy. Freight truck traffic moving through the Mid-Atlantic region serves businesses and communities across much of the Eastern United States. Figure 2.7 maps the flow of goods into, out of, and through the Mid-Atlantic region. The width of the flow line indicates the tons of freight moving by truck along the highway: the wider the line, the greater the volume of freight. The map shows heavy flows of freight to and from Boston, Chicago, Ohio, Indiana, Tennessee, and the Carolinas, with significant freight flows to and from Florida, Louisiana, the Upper Midwest, and the West Coast.

Figure 2.7 Tons of Commodity Flowing Into, Out Of, or Through the Mid-Atlantic Region
2005



Source: Cambridge Systematics, Inc., based on commodity flow data prepared by IHS-Global Insight, Inc.

FHWA's Freight Analysis Framework (FAF) estimates that trucks carry 84 percent of the Mid-Atlantic region's goods measured by value. Delays at bottlenecks add to the cost of driver labor, vehicle operation and maintenance, fuel, and inventory-carrying charges. These costs are eventually passed along from manufacturers to distributors, to retailers, and finally to businesses and consumers. This drives up the cost of doing business and the cost of living, making the region and its cities less competitive in national and global markets.

Weisbrod and Fitzroy describe how congestion impacts highway truck operations and how that affects a regional economy.[9] The impacts are either growth constraints or cost impacts:

- **Effects on Freight and Service Delivery –** Reduced market size. Increased congestion and restrictions on truck driver service causes market radii to shrink or, conversely, increases the vehicle operating cost and labor cost because truck drivers cover less distance in the same time.
- **Effects on Business Scheduling –** Smaller operating windows and inefficient backhaul operations. As congestion grows, industries experience smaller available delivery windows. Many industries have moved the last afternoon delivery to 3:00 p.m. to avoid afternoon peak congestion. As peaks grow, congestion-free delivery windows will continue to get smaller. As operating windows close, backhaul operations become less efficient. Smaller operating windows and the loss in backhaul efficiency increases labor costs and causes firms to purchase more trucks to meet demand.
- **Effects on Business Operations –** Reduced just-in-time efficiencies in delivery operations. The efficiencies that were developed are being consumed by roadway congestion. Congestion increases variability of travel times and forces companies to hold more inventory in-house to account for less reliable delivery, forces shippers to hold inventory in the pipeline (on the highway) longer, and wastes labor and vehicle operating costs.
- **Effects on Intermodal Connections –** Missed connections. Intermodal terminal freight connections are highly vulnerable to variability of arrival time. Intermodal connections are typically scheduled – if the truck delivery misses the scheduled departure of the train, plane, or barge, then the delivery could potentially be delayed for one or more days. This kind of delay causes significant impacts to just-in-time delivery.
- **Effects on Business Locations –** Moving to find more cost-effective locations. Causes businesses and intermodal terminals to locate in areas with appropriate labor market, competitive access to multiple commodity markets, and more reliable access. Historically, these sites exist outside of the city.

[9] Weisbrod and Fitzroy, *Defining the Range of Urban Congestion Impacts on Freight and their Consequences for Business Activity*, presentation at TRB Annual Conference, 2008.

In reaction to the increased labor, operating, and inventory costs, local-serving businesses either reduce profit, increase productivity in other ways to balance the lost revenue, or pass the added cost to the consumer, which raises the cost of living. Trade-oriented businesses simply move their business to avoid congestion; this might mean moving jobs out of the region.

It is critically important that the Mid-Atlantic region remain productive and economically competitive. It is home to 19 percent of the U.S. population and accounts for 21 percent of the U.S. gross domestic product (GDP).[10] If the region's economy were considered on its own, it would rank as the world's fourth largest economy.[11]

The I-95 Corridor Coalition has a mandate to help alleviate congestion across its member states. Given the number of major bottlenecks in the region, the impact of delay at bottlenecks on truck freight flows, and the importance of trucking to the regional economy, it is critical that the Coalition investigate regionally important bottlenecks and develop an approach for mitigating their impact.

[10] Census 2000 Population and 2007 Gross Domestic Product by State, Bureau of Economic Analysis, U.S. Department of Commerce.

[11] World Rank of 2007 Gross Domestic Product, 2007, CIA World Factbook; and 2007 Gross Domestic Product by State, Bureau of Economic Analysis, U.S. Department of Commerce.

3.0 Technical Approach

The process of identifying and analyzing key bottlenecks causing delays to trucks traveling on the Mid-Atlantic region's highway system is summarized below and described in more detail in the next sections. The key steps were:

- **Establish a Steering Committee –** Identify stakeholders and technical leads from each state;
- **Identify Bottlenecks and Estimate Bottleneck Delay –** Locate bottlenecks, prepare an initial estimate of delay, identify the five worst bottlenecks by state, then refine delay estimates for those bottlenecks;
- **Describe the Mid-Atlantic Economy –** Obtain an economic profile and forecast for the region, define the key Mid-Atlantic industries, and identify the key Mid-Atlantic commodities;
- **Estimate Delay Impacts –** Estimate value-hours of delay and ton-hours of delay by commodity and bottleneck string; then, rank order bottlenecks and bottleneck strings by their relative freight and economic impacts;
- **Map the Commodity Flows against Truck Freight Bottlenecks –** Assign key commodities to the highway network, identify commodity corridors, and identify bottlenecks and the "bottleneck strings" affecting truck freight flows along corridors; and
- **Identify Bottleneck Mitigation Strategies –** Report bottleneck mitigation strategies.

3.1 Establish Steering Committee

A steering committee was formed with one technical liaison from each member state – New York, New Jersey, Maryland, Delaware, Virginia, and Pennsylvania. The committee provided technical advice to the study team and helped identify and verify major highway truck bottlenecks. National and state truck association officials, motor carriers, and MPO planning staff also were consulted to identify bottlenecks and help assess the impact of the bottlenecks on carriers, businesses, and industries.

3.2 Identify Bottlenecks and Estimate Bottleneck Delay

Locate Bottlenecks

A list of 152 truck freight bottlenecks in the Mid-Atlantic region were identified through the following sources:

- Prior bottleneck studies by the FHWA, the American Highway Users Alliance, and INRIX.[12]
- A computerized scan and analysis of all HPMS roadway segments in the Mid-Atlantic region. The scan identified highway sections with high volumes (number of vehicles) and relatively low capacity (number of lanes). The scan provided a cost-effective means of canvassing the region for bottlenecks, but its accuracy was limited by the quality of data available on truck and total traffic volumes, and the geographic resolution of the data (e.g., a bottleneck may overlap two highway sections).
- Interviews of state DOT personnel. The team used the HPMS scan as a starting point and asked state DOT planning and engineering staff to review and the verify the bottleneck lists. The interviews were effective at identifying special conditions such as bottlenecks on roads that prohibited truck traffic, and bottlenecks in locations for which there was no current HPMS data.
- ATRI truck speed studies. The American Transportation Research Institute (ATRI) captures and analyzes fleet truck speed data for FHWA's Freight Performance Measures (FPM) project. Truck GPS data, generated from in-vehicle monitoring, communication and tracking systems, provides the observations of fleet truck speeds. Highway segments with annual average truck speeds below free-flow speeds (55 mph) indicate locations where trucks experience delay. Any road segment with an average annual truck fleet flow speed of 45 mph or less was identified as a potential truck freight bottleneck. The ATRI data was used to cross-check the bottlenecks identified by the HPMS scan and state DOT officials. The data also were effective at pinpointing bottlenecks created by toll barriers and inspection stations.

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[12] Federal Highway Administration, *Estimated Cost of Freight Involved in Highway Bottlenecks*, prepared by Cambridge Systematics, Inc., November 12, 2008.

American Highway Users Alliance, *Unclogging America's Arteries: Effective Relief for Highway Bottlenecks, 1999-2004*, prepared by Cambridge Systematics, Inc., February 2004.

INRIX, *National Traffic Scorecard: Online Summary*, 2007; http://scorecard.inrix.com/2007/Summary.aspx (accessed August 26, 2009).

Estimate Initial Annual Truck Delay at Bottlenecks

An initial estimate of delay at each of the 152 bottlenecks was made using a methodology developed for the 1999 American Highway Users Alliance study of highway bottlenecks and refined for use in a second AHUA study in 2004 and the FHWA studies in 2005 and 2008. The calculations of delay are based on predictive equations constructed using a simplified queuing-based model called QSIM, which was developed by Richard Margiotta, Harry Cohen, and Patrick DeCorla-Souza.[13]

The inputs to the model are average annual daily traffic volumes (AADT) for trucks and autos, and the total number of travel lanes on the highway segment. The model uses the AADT and number of travel lanes on the worst leg of the interchange – that is, the approach with the highest volume-to-capacity ratio – under the assumption that that leg likely represents most of the delay at the interchange. The method was developed to take advantage of the HPMS data, which is the only data set that covers all major highways in the United States and is available publicly. The quality of the data varies somewhat by state, but can be supplemented by detailed traffic counts, which are often available at locations where state DOTs or MPOs have done recent planning and engineering studies.

Identify the Five Worst Bottlenecks in Each MATOps State

The results of the initial delay analysis were used to identify the five worst bottlenecks – as measured by annual peak-period hours of truck delay – in each Mid-Atlantic state. The Coalition and steering committee asked each state to verify its top five bottlenecks for further study to ensure each participated equally in the study and to provide a foundation for future work. The screening resulted in a list of 29 bottlenecks (Delaware, with relatively few miles of Interstate highway, identified only four significant bottlenecks). State DOT officials, ATA representatives, and MPO staff were asked to review the list a second time for accuracy and appropriateness.

Refine Delay Estimates for Top Bottlenecks in Each State

The delay estimates for the 29 bottlenecks identified by the states were refined using two methods: an advanced delay estimate methodology, and direct calculation of delay using detailed truck speed data for the bottlenecks provided by ATRI.

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[13] Richard Margiotta, Harry Cohen, and Patrick DeCorla-Souza, *Speed and Delay Prediction Models for Planning Applications*, Proceedings of the Transportation Research Board Conference on Planning for Small- and Medium-Size Communities, Spokane, Washington, 1998.

The advanced delay estimate methodology was developed for the Ohio DOT in 2005[14] and used in FHWA bottlenecks studies in 2006[15] and 2008.[16] The method involves:

- Defining interchange geometrics (supply). Satellite-based photos available from Google Earth were used to identify the interchange-specific geometrics of each interchange (e.g., number of lanes upstream and downstream of each merge or weave section). These data provide the basis for the estimation of interchange capacity.
- Developing turning movement volumes for each ramp (demand). Actual ramp traffic counts provide the best measures of total bottleneck demand; these data were used where available. Where the ramp-specific data were not available (the majority of cases), estimates of turning movement volumes were developed from HPMS approach volume data using the balancing procedure first defined in NCHRP Report 255 and now in widespread use by travel demand modelers.[17]
- Model delay estimates. The methodology uses actual interchange geometrics and turning movement volumes as inputs and applies a queuing procedure to each ramp to estimate delay. The model estimates truck-hours of delay at each merge point within an interchange. The analysis method is similar to operational-level traffic analysis methods described in the Highway Capacity Manual.

The model results were cross-checked by direct calculation of delay using detailed truck speed data for the bottlenecks provided by ATRI. Average annual truck speeds on the interchange legs and ramps were developed from truck fleet data and then multiplied by the total traffic and total truck volumes from HPMS to estimate truck-hours of travel time under congested and uncongested conditions. The method was effective at estimating delay in complex interchanges with many weave and merge sections. With more detailed observations of truck speeds over time, estimates could be developed to show the distribution of truck-hours of delay over a day and across weeks and seasons.

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[14]Ohio Department of Transportation, *Ohio Freight Mobility*, prepared by Cambridge Systematics, Inc., December 30, 2005.

[15]Federal Highway Administration, *Application of Detailed Interchange Analysis to Top Freight Bottlenecks: Methods, Results, and Road Map for Future Research*, prepared by Cambridge Systematics, Inc., September 1, 2006.

[16]Federal Highway Administration, *Estimated Cost of Freight Involved in Highway Bottlenecks*, prepared by Cambridge Systematics, Inc., November 12, 2008.

[17]N.J. Pedersen and Don Amdahl, *Highway Traffic Data for Urbanized Area Project Planning and Design*, NCHRP Report 255, prepared for the National Cooperative Highway Research Program, Transportation Research Board, December 1982.

3.3 Describe the Mid-Atlantic Economy

A profile of the Mid-Atlantic regional economy, prepared by IHS-Global Insight, Inc., was analyzed to identify key growth industries and industries that are dependent on truck freight transportation. Industries were analyzed at the two-digit North American Industrial Classification System (NAICS) level. Current and projected employment levels, value of total output, and volume of commodities were examined to identify those industry sectors expected to generate the greatest growth and freight demand in the Mid-Atlantic region. The commodities associated with the key growth industries – as inputs and outputs – were determined using Bureau of Economic Analysis (BEA) input/output tables.

3.4 Estimate Delay Impacts

Three measures of delay were calculated for each bottleneck and bottleneck string: truck-hours of delay; commodity-ton-hours of delay; and commodity-value-hours of delay. Ton-hours and value-hours are similar in concept to the measure of passenger-hours of delay used in passenger transportation, where the delay accrued by two passengers in a single vehicle delayed for an hour is counted as two passenger-hours of delay. Ton-hours and value-hours of truck delay are imperfect measures of the impact of bottleneck delay on truck trips, but provide a means of capturing the impact of delay on heavy commodities such as construction materials and the impact of delay on high-value commodities such as pharmaceuticals, flowers, and courier packages. Finally, the bottlenecks were rank ordered by the measures (e.g., truck-hours of delay, ton-hours of delay, and commodity-value-hours of delay.)

3.5 Map Commodity Flows Against Truck Freight Bottlenecks

The commodity flows associated with the key industries were mapped against the Mid-Atlantic and national highway networks. IHS-Global Insight assigned the commodity flows to the highway networks based on the county-level origins and destinations of the commodities. The flow patterns were evaluated to identify critical commodity corridors in the Mid-Atlantic region; that is, corridors that carried a noticeably larger volume of a commodity than other corridors. The commodity flows and critical commodity corridors then were compared to the location of the worst five bottlenecks identified by each state.

Within each corridor, "bottleneck strings" were identified. A bottleneck string is defined as the set of bottlenecks that a truck carrying a specific commodity would likely encounter during its trip. The string may include both major and minor bottlenecks and may extend over two or more highway routes that make up a commodity corridor. An attempt was made to limit strings to logical clusters of adjacent bottlenecks. Select link network analysis was used to test a number of bottleneck strings and determine which subset of bottlenecks within a string affected the most truck trips in corridor. This was not applied to all possible bottleneck strings because of time and budget constraints, but could be used in future studies to define bottleneck strings more precisely.

3.6 Identify Bottleneck Mitigation Strategies

Conduct a scan of professional practices to identify strategies that have been used successfully, either on their own or together with other strategies, to improve operations and reduce delay at highway bottlenecks.

4.0 Findings

4.1 BOTTLENECKS

The study identified 152 truck bottlenecks within the Mid-Atlantic region, based on 2006 HPMS data. The bottlenecks include Interstate highway interchanges, arterial roadway intersections, toll barriers, border crossings stations, and lane drops. Nearly all the bottlenecks – 143 of the 152 or 99.5 percent – are located in or immediately adjacent to the New York, Philadelphia, Wilmington, Baltimore, and Washington, D.C. urbanized areas.[18] Figure 4.1 shows the location of all identified bottlenecks. A list of the individual bottlenecks is provided in Appendix A.

[18] An urbanized area (UA), as defined by the 2000 Census, consists of contiguous, densely settled census block groups (BGs) and census blocks that meet minimum population density requirements, along with adjacent densely settled census blocks that together encompass a population of at least 50,000 people. Bottlenecks were counted as within the Census urbanized area if they were within a two-mile buffer surrounding the urbanized area. This captures industrial and commercial areas that serve the urbanized areas but are not yet included in the formal definition of the urbanized area.

Figure 4.1 Location of Mid-Atlantic Region Truck Bottlenecks
2006

Source: Cambridge Systematics, Inc.

Table 4.1 summarizes the impacts of these bottlenecks using the delay values generated by the initial scan and analysis methodology.[19] It is estimated that the bottlenecks cause 19.6 million hours of truck delay annually. This translates into $706 million in lost time, nearly 35 million gallons of fuel burned, and 0.39 million tons of carbon dioxide emissions.

Table 4.1 Impacts of Mid-Atlantic Region Bottlenecks
2006

Geography	Measures	Bottlenecks
Within Mid-Atlantic Region	Bottlenecks	152
	Annual Peak-Period Truck Delay (Million Hours)	19.6
	Motor Carrier Cost (Million Dollars)	706
	Fuel (Million Gallons)	35
	Emissions (Million Tons of CO_2 Equivalent)	0.39
Within Urbanized Areas of the Mid-Atlantic Region	Bottlenecks	143 *(94%)*
	Annual Peak-Period Truck Delay (Million Hours)	19.5 *(99.5%)*
	Trucker Cost (Million Dollars)	703
	Fuel (Million Gallons)	35
	Emissions (Million Tons of CO_2 Equivalent)	0.39

4.2 WORST FIVE BOTTLENECKS IN EACH STATE

Based on the initial estimates of truck-hours of delay, the five worst bottlenecks in each state were identified (The State of Delaware identified four bottlenecks). They are listed by state in Table 4.2.

[19]See Section 3.0, Technical Approach for details.

Table 4.2 Worst Five Bottlenecks in Each State Based on Initial Estimates of Delay
2006

Interchange	State	Peak-Period Truck-Hours of Delay
I-95 at DE-896	DE	412,000
I-95 at DE-1	DE	169,000
I-295 at U.S. 13 and U.S. 40	DE	79,000
I-95 at DE-141	DE	31,000
I-70 at I-695	MD	649,000
I-695 at I-83 and MD-25	MD	648,000
I-83 at I-695	MD	582,000
I-95 at I-495	MD	551,000
I-695 at I-95 (S.)	MD	504,000
I-95 at NJ-4[a]	NJ	692,000
I-95 at NJ-32 and NJ-612	NJ	128,000
NJ-495 at NJ-3	NJ	126,000
I-78 at I-95	NJ	108,000
I-295 at I-76 and NJ-42	NJ	104,000
I-95 at NY-9A[a]	NY	629,000
I-495 at Exit 33	NY	355,000
I-678 at NY-25A	NY	350,000
I-678 at Grand Central Parkway	NY	285,000
I-678 at Cross Island Parkway	NY	266,000
I-95 at I-476	PA	505,000
I-95 at PA-90	PA	379,000
I-76 at I-476	PA	352,000
I-95 at Academy Road	PA	320,000
I-95 at U.S. 322	PA	308,000
I-95 at VA-234	VA	184,000
I-264 east of I-64	VA	167,000
I-95 at VA-7100	VA	141,000
I-495 at American Legion Bridge	VA	131,000
I-495 at I-66	VA	100,000

Note: The State of Delaware identified four bottlenecks; [a]Bottlenecks at I-95 at NJ-4 and I-95 at NY-9A are the west and east approaches, respectively to the George Washington Bridge.

Table 4.3 summarizes the impacts of these 29 bottlenecks using the initial delay values, and compares their impacts to the impacts of all 152 bottlenecks identified in the region. The worst 5 bottlenecks in each state account for 19 percent of all truck bottlenecks in the region. It is estimated that the bottlenecks cause 9.3 million hours of truck delay annually or 47 percent of the total truck-hours of delay. These delay hours translate into $334 million in lost time, nearly 16 million gallons of additional fuel burned, and 0.18 million tons of carbon dioxide emissions.

Table 4.3 Impact of Five Worst Truck Bottlenecks in Each State Based on Initial Estimates of Delay
2006

Geography	Measures	All Identified Bottlenecks	Worst Five Bottlenecks by State
Mid-Atlantic Region	Bottlenecks	152	29 *(19%)*
	Annual Peak-Period Truck Delay (Million Hours)	19.6	9.2 *(47%)*
	Motor Carrier Cost (Million Dollars)	706	334
	Fuel (Million Gallons)	35	16
	Emissions (Million Tons of CO_2 Equivalent)	0.39	0.18

Note: The State of Delaware identified four bottlenecks.

Figure 4.2 maps the locations of the worst bottlenecks in each state as identified by the states. All of these bottlenecks are located in or immediately adjacent to urbanized areas. Most are located at the interchanges of major urban highways.

Figure 4.2 Location of the Five Worst Truck Bottlenecks in Each State

Source: Cambridge Systematics, Inc.

Note: The State of Delaware identified four bottlenecks.

In prior research for national bottleneck studies, use of HPMS data was found to be a cost-effective and appropriate means of making a comprehensive scan for bottlenecks. However, the research also found cases where HPMS data were underreported or missing. To correct for this, an advanced delay estimate methodology was applied to the 29 bottlenecks.[20] The results of this re-estimation are reported in Table 4.4 under the column heading "Annual Peak-Period Truck Delay MODELED (Hours)." The results were reviewed with state DOT officials, trucking association representatives, motor carriers, and MPO planners. The review determined that HMPS data for some bottlenecks were incomplete, and the delay estimation methodology was not estimating the full delay impacts for very complicated highway interchanges (e.g., interchanges with five or more approaches).

To correct these problems, data on observed truck speeds were used to cross-check and update the model results. ATRI collected the observed truck speed data as part of an ongoing study for the FHWA. The truck speeds were reported as annual average truck speeds by highway section. The most currently available HPMS data were used to estimate total vehicle and truck volumes moving through the bottleneck. The results are reported in Table 4.4 under the column heading "Annual Peak-Period Truck Delay OBSERVED (Hours)."

Comparison of the model and observed delay estimates showed that the model delay estimates were generally lower than the observed delay estimates, with some specific exceptions. The observed delay estimates were significantly higher for bottlenecks involving toll barriers, bridges, tunnels, tight curves, highways with parallel roadways (e.g., HOV lanes paralleling the general travel lanes) and very complex interchanges. Where there were differences in the delay estimates, the observed delay estimate was used. Table 4.5 shows all 29 bottlenecks ranked by the observed truck-hours of delay. The bottlenecks with the most delay in the MATOps region are the approaches to the George Washington Bridge – the New Jersey approach (I-95 at NJ-3) and the New York approach (I-95 at NY-9A).

[20] See Section 3.0, Technical Approach for details.

Table 4.4 Five Worst Truck Bottlenecks in Each State Ranked by Observed Delay

2006

Interchange	ST	Annual Peak-Period Truck Delay OBSERVED (Hours)	Rank	Annual Peak-Period Truck Delay MODELED (Hours)	Rank
I-95 at NY-9A[a]	NY	1,121,000	1	219,000	8
I-95 at NJ-4[a]	NJ	759,000	2	626,000	1
NJ-495 at NJ-3	NJ	392,000	3	13,000	27
I-678 at Grand Central Parkway	NY	195,000	4	285,000[b]	3
I-70 at I-695	MD	190,000	5	393,000	2
I-678 at Cross Island Parkway	NY	176,000	6	42,000	22
I-95 at VA-7100	VA	175,000	7	263,000	5
I-78 at I-95	NJ	174,000	8	12,000	28
I-95 at PA-90	PA	168,000	9	170,000	13
I-695 at I-95 (S.)	MD	141,000	10	258,000	6
I-95 at I-495	MD	138,000	11	187,000	10
I-495 at I-66	VA	136,000	12	117,000	17
I-495 at American Legion Bridge	VA	133,000	13	137,000	16
I-76 at I-476	PA	124,000	14	100,000	18
I-95 at I-476	PA	123,000	15	40,000	24
I-495 at Exit 33	NY	113,000	16	185,000	12
I-95 at VA-234	VA	106,000	17	246,000	7
I-83 at I-695	MD	106,000	18	217,000	9
I-678 at NY-25A	NY	105,000	19	267,000	4
I-695 at I-83 and MD-25	MD	101,000	20	161,000	14
I-95 at U.S. 322	PA	93,000	21	156,000	15
I-295 at I-76 and NJ-42	NJ	93,000	22	83,000	19
I-95 at DE-141	DE	70,000	23	42,000	23
I-95 at DE-896	DE	54,000	24	20,000	26
I-95 at DE-1	DE	52,000	25	186,000	11
I-295 at U.S. 13 and U.S. 40	DE	51,000	26	79,000	20
I-95 at Academy Road	PA	46,000	27	51,000	21
I-264 east of I-64	VA	34,000	28	30,000	25
I-95 at NJ-32 and NJ-612	NJ	8,000	29	6,000	29

Note: The State of Delaware identified four bottlenecks; [a] Bottlenecks at I-95 at NJ-4 and I-95 at NY-9A are the west and east approaches, respectively to the George Washington Bridge; [b] Estimate is based on single-segment delay. The I-678 at Grand Central Parkway interchange has five legs, which makes it too complicated for the model analysis.

Finally, Table 4.5 summarizes the impacts of the five worst truck bottlenecks in each state based on the observed truck-hours of delay. Truck drivers experience at least 100,000 hours of peak-period delay annually at 20 of the State's worst five bottlenecks, the equivalent of 11.4 years of delay.

Table 4.5 Impacts of Five Worst Truck Bottlenecks in Each State Based on Observed Delay
2006

Geography	Measures	Worst Five Bottlenecks in Each State
Mid-Atlantic Region	Bottlenecks	29
	Annual Peak-Period Truck Delay (Million Hours)	5.2
	Motor Carrier Cost (Million Dollars)	187
	Fuel (Million Gallons)	9
	Emissions (Million Tons of CO_2 Equivalent)	0.109

Note: The State of Delaware identified four bottlenecks.

4.3 MID-ATLANTIC ECONOMY

Key Industries

Figure 4.3 profiles the economy of the Mid-Atlantic region. The major sectors of the economy – at the two-digit North American Industry Classification System (NAICS) level – are listed along the horizontal axis of the chart. The vertical axis of the chart shows the value of each industry's output (production) in 2005 and the projected value in 2035. The values are shown in billions of current 2005 dollars. Output (production) value describes the contribution of an industry to the Gross Domestic Product (GDP) and is a measure its relative importance to the regional economy.

The key industries in the Mid-Atlantic region – defined here as those that are projected to generate the greatest growth and will rely heavily on efficient freight movement to achieve that growth – are highlighted in yellow. The key industries include:

- **Utilities –** The Utilities industry is driven by population growth. As population grows, there will be more homes to heat, more water to distribute, and more computers to power. Coal-fired power plants require significant inbound freight shipments of coal for power generation.
- **Construction –** The Construction industry is driven by population growth. Construction industries, like building construction, bridge construction, or

building equipment contractors, rely on shipments of masonry, pipes, beams, and wood products to build the region's homes, retail outlets, offices, and infrastructure.

- **Manufacturing –** There are three main types of manufacturing that are key to the continued growth of the Mid-Atlantic region: Food Product Manufacturing, Petroleum and Coal Product Manufacturing, and Chemical Product Manufacturing. The Animal Food Manufacturing and the Grain and Oilseed Manufacturing sectors will drive growth in the Food Product Manufacturing industry. As a whole, the Food Product Manufacturing industry will experience revenue growth of 2.1 percent per year while productivity improvements will mean that employment will grow at 0.1 percent per year. The finished food products are shipped to grocery store and market warehouse and distribution centers throughout the country.

  The Petroleum and Coal Manufacturing industry will experience 2.4 percent revenue growth per year but will lose employment at the rate of 1 percent per year due to significant improvements in productivity per employee. Petroleum makes a significant contribution to distribution freight traffic volumes.

  The Agricultural Chemical Manufacturing (fertilizers) and Pharmaceutical and Medicine Manufacturing sectors will drive growth in the Chemical Manufacturing industry. Revenues will grow 3.45 percent per year, faster than either Food or Petroleum Manufacturing industries, but will experience employment loss of 1.4 percent per year due to significant employee productivity improvements.

- **Wholesale Trade –** Durable Goods Wholesale growth will be driven by the Lumber and Construction Material; Hardware, Plumbing, and Heating Equipment, and Motor Vehicle Parts sectors. As a whole, revenue will grow at 3.8 percent per year but similar to the story of other key growth industries, the employment will grow at 0.5 percent per year due to productivity improvements. Increase in durable wholesale trade will increase inbound freight volumes of durable goods like autos, motor vehicles, motor vehicle parts, computers, photographic equipment, hobby goods, etc.

  Nondurable Goods Wholesale growth will be driven by the Farm Products and Drug and Druggists Sundries industries. Revenue will grow at 3.7 percent with employment will grow at 0.46 percent per year. Increase in nondurable wholesale trade will increase inbound freight volumes of nondurable goods like food, beverage, and tobacco products, apparel, or chemical products.

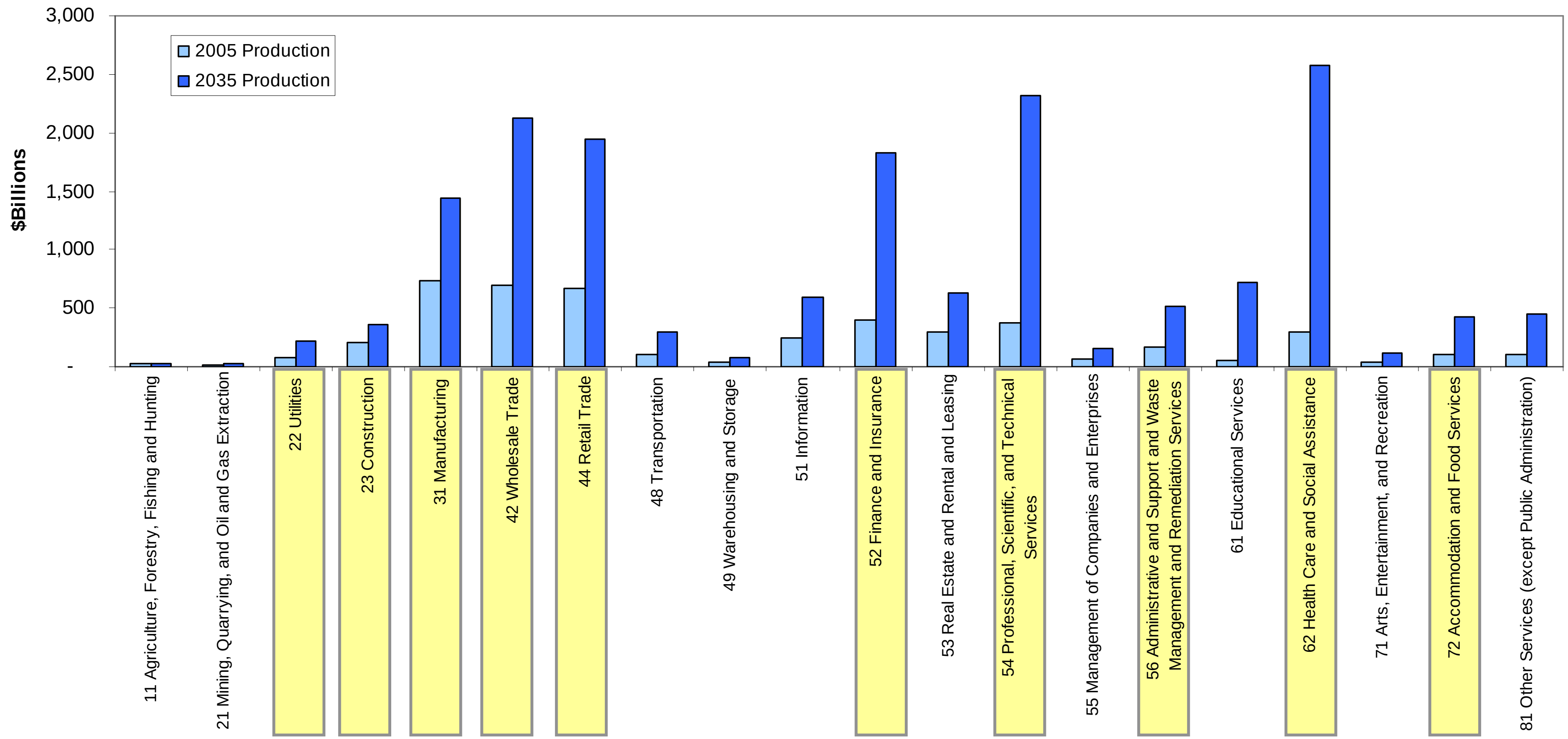
- **Retail Trade –** Retail Trade growth will be driven by population growth. As the population grows, there will be more demand for consumer goods, groceries, etc. Growth in the retail trade industry will increase inbound freight volumes of all kinds of consumer goods.

- **Finance and Insurance –** Growth in the Finance and Insurance industry will be driven by Insurance Carriers and Related Activities and the Funds, Trusts, and Other Financial Vehicles sectors. The only industry that will beat national growth rates, revenue is forecasted to grow at 5.3 percent per year. The industry will not demand or produce much freight, requiring only inbound shipment of supplies and equipment.

- **Professional, Scientific, and Technical Services –** Growth in the Professional, Scientific, and Technical Services industry will be driven by the Computer Systems and Design Services sector. Revenue is projected to grow at 6.2 percent per year with employment growing at 2.2 percent per year. Increases in revenue and employment in this industry will require additional inbound shipment of supplies and equipment, but far less inbound shipments than manufacturing industry.
- **Administrative Support and Waste Management and Remediation –** Growth in the Administrative and Waste Management industry revenue will be driven by sectors like employment services, investigation and security, pest control, landscaping, waste collection, and waste treatment. Revenues will grow at a rate of 3.7 percent per year. The waste centers, specifically, produce a lot of truck traffic.
- **Health Care and Social Assistance –** An aging and growing population will create growth in demand for Health Care and Social Assistance industry. Dentists, doctors, hospitals, home health care, mental health, day care, and homeless shelters will need inbound shipments of supplies. These shipments will be relatively small in size compared to the demands or a more freight driven industry like manufacturing.
- **Accommodation and Food Service –** Growth in the Accommodation and Food Service industry will be driven by growth the Accommodations sector. Revenue will grow a 4.7 percent per year with lower employment growth due to increase in per employee productivity. The hotels, RV parks, places offering room and board, restaurants, and bars, will require inbound shipments of supplies and consumer goods in relatively small quantities.

Figure 4.3 Value of Output by Mid-Atlantic Industry Sectors, 2005

Billions of 2005 Dollars



Key Commodities

Table 4.6 lists the freight commodities shipped and received by the key industries in Mid-Atlantic region, listed by industry name and two-digit Standard Transportation Commodity Code (STCC). These commodities account for 63 percent of the region's total commodity flow by value.

Table 4.6 Key Mid-Atlantic Commodities

Two-Digit STCC	Top 10 Commodity Inputs to, or Outputs of, Key Mid-Atlantic Industries
28	Chemicals or Allied Products
20	Food or Kindred Products
36	Electrical Equipment
29	Petroleum or Coal Products
37	Transportation Equipment
33	Primary Metal Products
34	Fabricated Metal Products
35	Machinery
13	Crude Petroleum or Natural Gas
30	Rubber or Miscellaneous Plastics

The commodities were identified by analyzing the major inputs and outputs of each industry. The Bureau of Economic Analysis (BEA) publishes national input-output tables that describe the commodities supplied to each industry and produced by each industry. As an example, Figure 4.4 shows the major input and output commodities for the Wood Products Manufacturing industry, a key Manufacturing sector industry. The Wood Products Manufacturing industry receives deliveries of wood products (e.g., logs, wood chips, and plywood) and fabricated metal products (e.g., metal forms and shapes, and metal containers). The output of the industry is furniture, other wood products, plastic, and rubber products.

Figure 4.4 Example of Key Industry Inputs and Outputs, Wood Products Manufacturing Industry

4.4 Value and Tonnage of Commodities Moving Through Bottleneck Locations

Table 4.7 shows the bottlenecks ordered by total value of the commodities moving through them. The corresponding Table 4.8 shows the bottlenecks ordered by total tonnage of the commodities moving through. These rankings do not reflect the impact of delays, only the volume of truck traffic and type of commodities. The highest-ranked bottleneck by value is I-78 at I-95. The highest-ranked bottleneck by tonnage is I-495 at I-66 in Virginia.

Commodity flows are described by both value and weight (tons) to reflect the fact that there are commodities such as electronic equipment, which are light and valuable, and there are commodities, such as gravel and cereal grains, which are inexpensive and heavy. Valuable goods tend to be very sensitive to the speed and reliability of the delivery. Shippers are more likely to require just-in-time delivery and are less sensitive to the price of delivery. Shippers of heavy goods tend to be less sensitive to speed and reliability but more sensitive to cost. Large tonnage flows imply heavier commodities, while higher value flows imply fewer, but more valuable shipments.

Table 4.7 Worst Five Truck Bottlenecks in Each State Ranked by Total Commodity Value

Interchange	ST	Key Commodity Value (Million Dollars)	Rank	Key Commodity Tons (1,000)	Rank
I-78 at I-95	NJ	860,000	1	180,000	6
I-495 at I-66	VA	820,000	2	190,000	1
I-495 at American Legion Bridge	VA	810,000	3	190,000	2
I-95 at NJ-4	NJ	770,000	4	150,000	10
I-95 at DE-1	DE	770,000	5	190,000	5
I-95 at VA-234	VA	770,000	6	190,000	3
I-95 at DE-896	DE	750,000	7	180,000	8
I-95 at DE-141	DE	750,000	8	180,000	7
I-95 at VA-7100	VA	750,000	9	190,000	4
I-695 at I-95 (S.)	MD	650,000	10	160,000	9
I-295 at U.S. 13 and U.S. 40	DE	590,000	11	140,000	11
I-495 at Exit 33	NY	580,000	12	100,000	15
I-95 at I-495	MD	580,000	13	140,000	12
I-95 at NY-9A	NY	440,000	14	90,000	17
I-95 at NJ-32 and NJ-612	NJ	430,000	15	100,000	13
I-70 at I-695	MD	340,000	16	100,000	14
I-695 at I-83 and MD-25	MD	320,000	17	90,000	16
I-76 at I-476	PA	270,000	18	80,000	18
I-95 at U.S. 322	PA	260,000	19	70,000	19
I-83 at I-695	MD	240,000	20	70,000	21
I-95 at I-476	PA	240,000	21	70,000	20
NJ-495 at NJ-3	NJ	170,000	22	40,000	23
I-295 at I-76 and NJ-42	NJ	130,000	23	50,000	22
I-95 at PA-90	PA	110,000	24	30,000	24
I-264 east of I-64	VA	90,000	25	30,000	25
I-678 at Cross Island Parkway	NY	70,000	26	20,000	26
I-678 at NY-25A	NY	70,000	27	20,000	27
I-95 at Academy Road	PA	60,000	28	10,000	28
I-678 at Grand Central Parkway[a]	NY	-	29	-	29

Note: The State of Delaware identified four bottlenecks; [a] I-678 at Grand Central Parkway carries some freight traffic, but because origin-destination flows are at a county-to-county level, not all freight moves at all interchanges are mapped accurately.

Table 4.8 Worst Five Truck Bottlenecks in Each State Ranked by Total Commodity Tonnage

Interchange	ST	Key Commodity Value (Million Dollars)	Rank	Key Commodity Tons (1,000)	Rank
I-495 at I-66	VA	820,000	2	190,000	1
I-495 at American Legion Bridge	VA	810,000	3	190,000	2
I-95 at VA-234	VA	770,000	6	190,000	3
I-95 at VA-7100	VA	750,000	9	190,000	4
I-95 at DE-1	DE	770,000	5	190,000	5
I-78 at I-95	NJ	860,000	1	180,000	6
I-95 at DE-141	DE	750,000	8	180,000	7
I-95 at DE-896	DE	750,000	7	180,000	8
I-695 at I-95 (S.)	MD	650,000	10	160,000	9
I-95 at NJ-4	NJ	770,000	4	150,000	10
I-295 at U.S. 13 and U.S. 40	DE	590,000	11	140,000	11
I-95 at I-495	MD	580,000	13	140,000	12
I-95 at NJ-32 and NJ-612	NJ	430,000	15	100,000	13
I-70 at I-695	MD	340,000	16	100,000	14
I-495 at Exit 33	NY	580,000	12	100,000	15
I-695 at I-83 and MD-25	MD	320,000	17	90,000	16
I-95 at NY-9A	NY	440,000	14	90,000	17
I-76 at I-476	PA	270,000	18	80,000	18
I-95 at U.S. 322	PA	260,000	19	70,000	19
I-95 at I-476	PA	240,000	21	70,000	20
I-83 at I-695	MD	240,000	20	70,000	21
I-295 at I-76 and NJ-42	NJ	130,000	23	50,000	22
NJ-495 at NJ-3	NJ	170,000	22	40,000	23
I-95 at PA-90	PA	110,000	24	30,000	24
I-264 east of I-64	VA	90,000	25	30,000	25
I-678 at Cross Island Parkway	NY	70,000	26	20,000	26
I-678 at NY-25A	NY	70,000	27	20,000	27
I-95 at Academy Road	PA	60,000	28	10,000	28
I-678 at Grand Central Parkway[a]	NY	-	29	-	29

Note: The State of Delaware identified four bottlenecks.

[a] I-678 at Grand Central Parkway carries some freight traffic, but because origin-destination flows are at a county-to-county level, not all freight moves at all interchanges are mapped accurately.

4.5 Commodity Value-Hours of Delay and Ton-Hours of Delay by Bottleneck

To more accurately depict the impact of the truck-hours of delay at bottlenecks with different mixes of commodity, composite measures – commodity value-hours of delay and commodity ton-hours of delay – were calculated for each bottleneck. Table 4.9 lists the five worst truck bottlenecks in each state by commodity value-hours of delay. The companion Table 4.10 lists the five worst truck bottlenecks in each state by commodity ton-hours of delay. These measures provide a uniform way of comparing the relative impact of each bottleneck on the Mid-Atlantic region economy. Each table also shows the observed truck-hours of delay.

Table 4.9 Worst Five Truck Bottlenecks in Each State Ranked by Commodity Value-Hours of Delay

Interchange	ST	Key Commodity Value-Hours of Delay (Trillion Dollar-Hours)	Rank	Key Commodity Ton-Hours of Delay (Trillion Ton-Hours)	Rank	Observed Peak-Period Delay (Hours)	Rank
I-95 at NJ-4	NJ	587,000	1	115,000	1	759,000	2
I-95 at NY-9A	NY	492,000	2	96,000	2	1,121,000	1
I-78 at I-95	NJ	150,000	3	32,000	4	174,000	8
I-95 at VA-7100	VA	131,000	4	33,000	3	175,000	7
I-495 at I-66	VA	111,000	5	26,000	5	136,000	12
I-495 at American Legion Bridge	VA	108,000	6	26,000	6	133,000	13
I-695 at I-95 (S.)	MD	92,000	7	22,000	7	141,000	10
I-95 at VA-234	VA	81,000	8	20,000	8	106,000	17
I-95 at I-495	MD	80,000	9	19,000	10	138,000	11
NJ-495 at NJ-3	NJ	68,000	10	17,000	11	392,000	3
I-495 at Exit 33	NY	65,000	11	11,000	13	113,000	16
I-70 at I-695	MD	64,000	12	19,000	9	190,000	5
I-95 at DE-141	DE	53,000	13	13,000	12	70,000	23
I-95 at DE-896	DE	41,000	14	10,000	15	54,000	24
I-95 at DE-1	DE	40,000	15	10,000	14	52,000	25
I-76 at I-476	PA	34,000	16	10,000	16	124,000	14
I-695 at I-83 and MD-25	MD	33,000	17	9,000	17	101,000	20
I-95 at I-476	PA	30,000	18	7,000	19	51,000	26
I-295 at U.S. 13 and U.S. 40	DE	30,000	19	8,000	18	123,000	15
I-83 at I-695	MD	26,000	20	7,000	20	106,000	18
I-95 at U.S. 322	PA	24,000	21	7,000	21	93,000	21
I-95 at PA-90	PA	19,000	22	4,000	23	168,000	9
I-678 at Cross Island Parkway	NY	12,000	23	3,000	24	176,000	6
I-295 at I-76 and NJ-42	NJ	12,000	24	4,000	22	93,000	22
I-678 at NY-25A	NY	7,000	25	2,000	25	105,000	19
I-95 at Academy Road	PA	3,000	26	1,000	27	8,000	29
I-264 east of I-64	VA	3,000	27	1,000	26	34,000	28
I-95 at NJ-32 and NJ-612	NJ	3,000	28	1,000	28	46,000	27
I-678 at Grand Central Parkway	NY	-	29	-	29	195,000	4

Note: The State of Delaware identified four bottlenecks.

Table 4.10 Worst Five Truck Bottlenecks in Each State Ranked by Commodity Ton-Hours of Delay

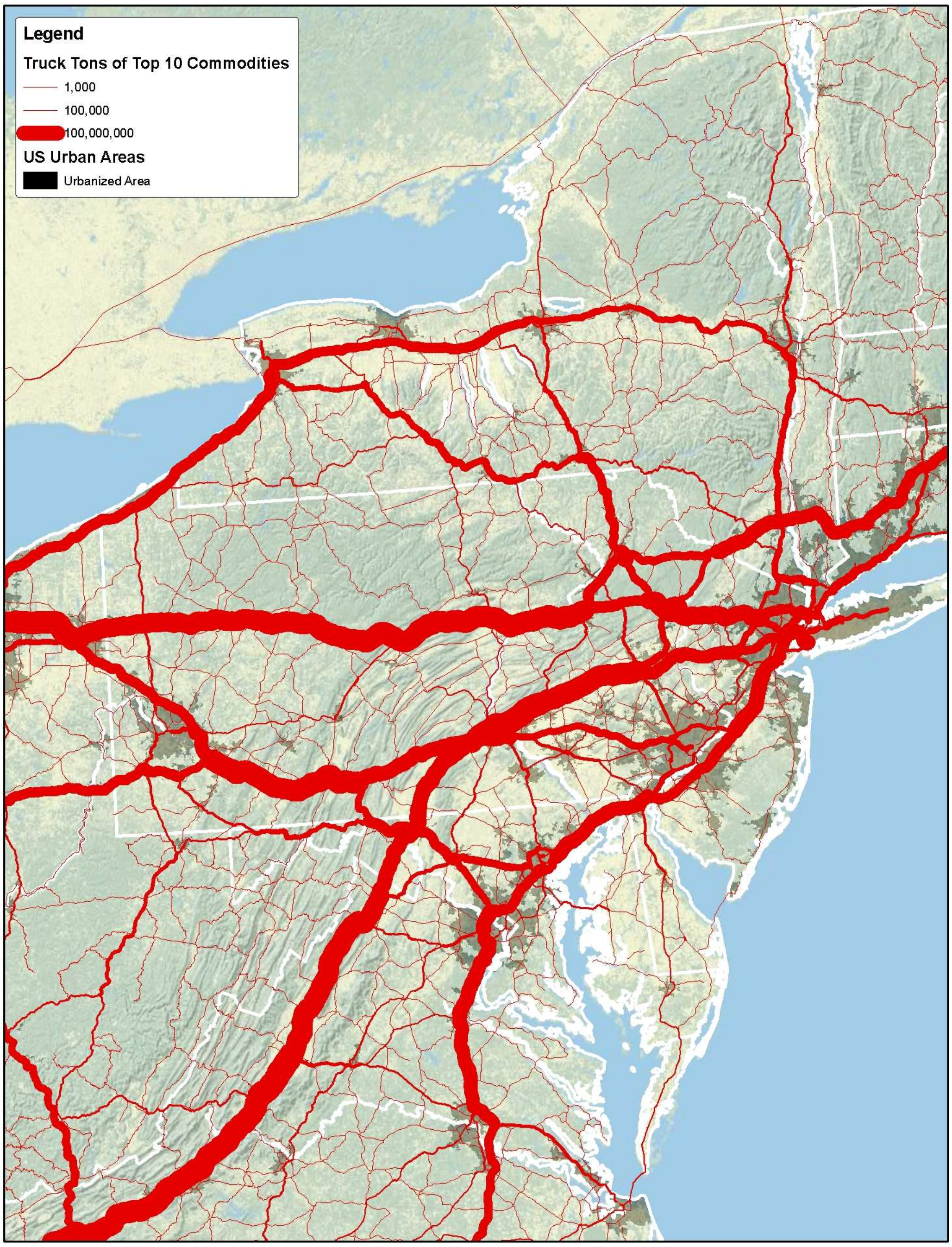
Interchange	ST	Key Commodity Value-Hours of Delay (Trillion Dollar-Hours)	Rank	Key Commodity Ton-Hours of Delay (Trillion Ton-Hours)	Rank	Observed Peak-Period Delay (Hours)	Rank
I-95 at NJ-4	NJ	587,000	1	115,000	1	759,000	2
I-95 at NY-9A	NY	492,000	2	96,000	2	1,121,000	1
I-95 at VA-7100	VA	131,000	4	33,000	3	175,000	7
I-78 at I-95	NJ	150,000	3	32,000	4	174,000	8
I-495 at I-66	VA	111,000	5	26,000	5	136,000	12
I-495 at American Legion Bridge	VA	108,000	6	26,000	6	133,000	13
I-695 at I-95 (S.)	MD	92,000	7	22,000	7	141,000	10
I-95 at VA-234	VA	81,000	8	20,000	8	106,000	17
I-70 at I-695	MD	64,000	12	19,000	9	190,000	5
I-95 at I-495	MD	80,000	9	19,000	10	138,000	11
NJ-495 at NJ-3	NJ	68,000	10	17,000	11	392,000	3
I-95 at DE-141	DE	53,000	13	13,000	12	70,000	23
I-495 at Exit 33	NY	65,000	11	11,000	13	113,000	16
I-95 at DE-1	DE	40,000	15	10,000	14	52,000	25
I-95 at DE-896	DE	41,000	14	10,000	15	54,000	24
I-76 at I-476	PA	34,000	16	10,000	16	124,000	14
I-695 at I-83 and MD-25	MD	33,000	17	9,000	17	101,000	20
I-295 at U.S. 13 and U.S. 40	DE	30,000	19	8,000	18	123,000	15
I-95 at I-476	PA	30,000	18	7,000	19	51,000	26
I-83 at I-695	MD	26,000	20	7,000	20	106,000	18
I-95 at U.S. 322	PA	24,000	21	7,000	21	93,000	21
I-295 at I-76 and NJ-42	NJ	12,000	24	4,000	22	93,000	22
I-95 at PA-90	PA	19,000	22	4,000	23	168,000	9
I-678 at Cross Island Parkway	NY	12,000	23	3,000	24	176,000	6
I-678 at NY-25A	NY	7,000	25	2,000	25	105,000	19
I-264 east of I-64	VA	3,000	27	1,000	26	34,000	28
I-95 at Academy Road	PA	3,000	26	1,000	27	8,000	29
I-95 at NJ-32 and NJ-612	NJ	3,000	28	1,000	28	46,000	27
I-678 at Grand Central Parkway	NY	-	29	-	29	195,000	4

Note: The State of Delaware identified four bottlenecks.

4.6 COMMODITY FLOWS AND CORRIDORS

The commodity flows associated with the key industries were mapped against the Mid-Atlantic and national highway networks. The flow patterns were evaluated to identify critical commodity corridors in the Mid-Atlantic region; that is, corridors that carried a noticeably larger volume of a commodity than other corridors. Figure 4.5 shows the critical commodity corridors in the Mid-Atlantic region. These corridors carry key commodities between the major Mid-Atlantic markets (New York-New Jersey, Philadelphia-Wilmington, and Baltimore-Washington, D.C.) and their major trading partners (the Midwest, the Gulf Coast, and the Southeast).

Figure 4.5 Critical Commodity Corridors in the Mid-Atlantic Region



Source: Cambridge Systematics, Inc., based on commodity flow data prepared by IHS-Global Insight, Inc.

The commodity flows and critical commodity corridors then were compared to the locations of the five worst bottlenecks identified in each state, as shown in Figure 4.6. Within each corridor, "bottleneck strings" were identified. A bottleneck string is defined as the set of bottlenecks that a truck carrying a specific commodity would likely encounter during its trip. The string may include both major and minor bottlenecks and may extend over two or more highway routes that make up a commodity corridor. An attempt was made to limit strings to logical clusters of adjacent bottlenecks.

Some trucks travel through individual bottlenecks, meeting no upstream or downstream bottlenecks, while other trucks travel through one bottleneck after another. Many bottlenecks in the Mid-Atlantic region are strung closely together; therefore, many medium- and long-distance truck moves using these corridors will encounter one or more stringed together bottlenecks, depending on their route and the time of day. An improvement to one bottleneck in a close string will reduce delays at that bottleneck, but will often aggravate delay at the next downstream bottleneck. Strings of bottlenecks must be considered and managed as a whole to significantly reduce delays and improve freight flows along trade corridors.

The designation of bottleneck strings is somewhat arbitrary and can be improved with more detail breakouts of truck flow by commodity and industry, but a first approximation suggests that there are at least six major bottleneck strings within the Mid-Atlantic region:

1. I-95 New York/New Jersey bottleneck string, as mapped in Figure 4.6 and listed, from north to south, in Table 4.11;
2. I-95 Wilmington bottleneck string, as mapped in Figure 4.6 and listed, from north to south, in Table 4.11;
3. I-95 Baltimore/Washington bottleneck string, as mapped in Figure 4.6 and listed, from north to south, in Table 4.11;
4. Metropolitan New York bottleneck string, as mapped in Figure 4.7 and listed, from north to south, in Table 4.12;
5. I-695 Baltimore bottleneck string, where trucks carrying goods between the Midwest or the Gulf Coast and the Mid-Atlantic travel on I-70 and merge onto the I-95 by way of I-695 around Baltimore, as mapped in Figure 4.8 and listed, from north to south, in Table 4.13; and
6. I-95 Philadelphia bottleneck string, affecting trucks carrying goods between the Philadelphia market and the Midwest, Southeast, and the Gulf Coast markets, as mapped in Figure 4.9 and listed, from north to south, in Table 4.14.

Figure 4.6 I-95 Trunk Line Bottleneck Strings

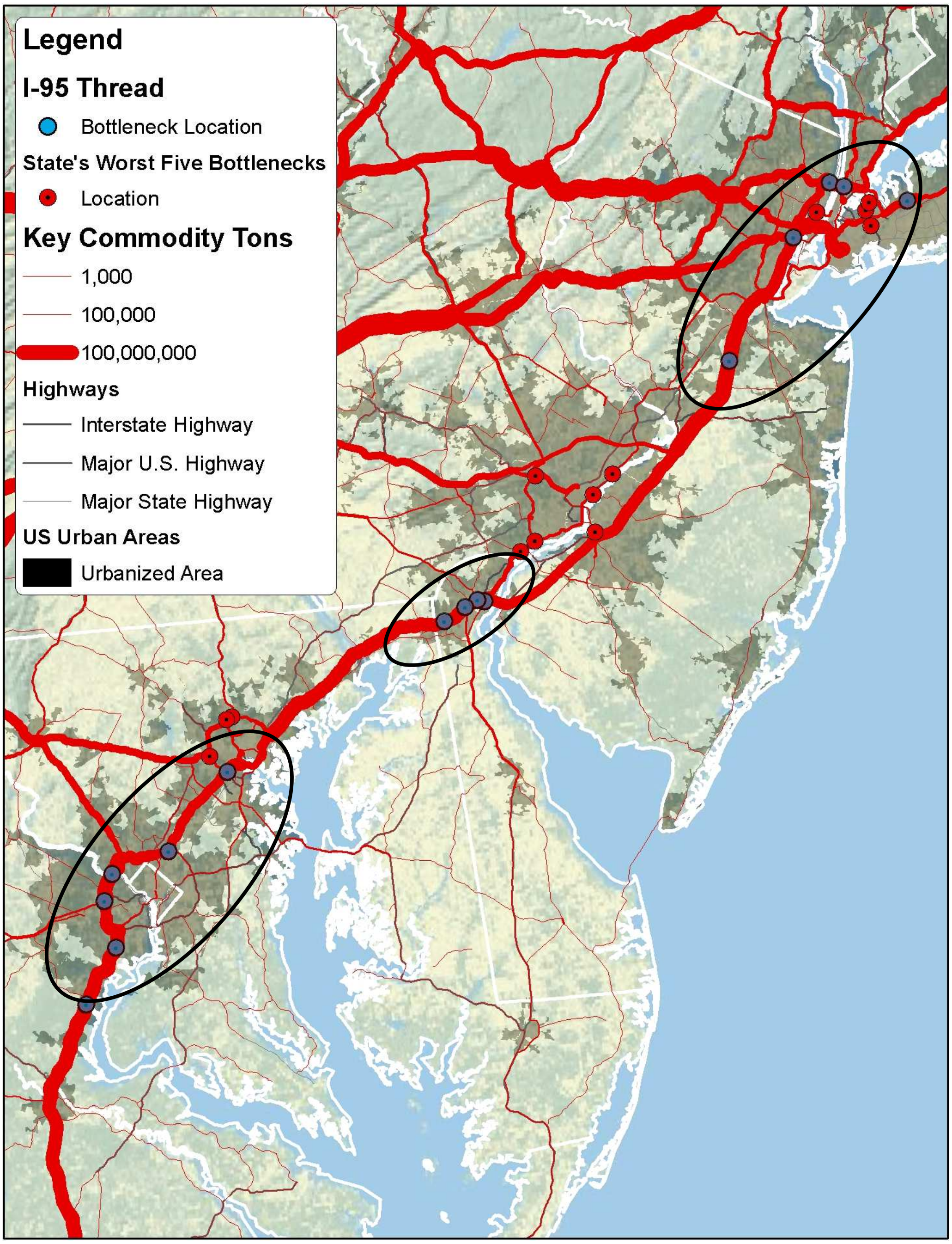
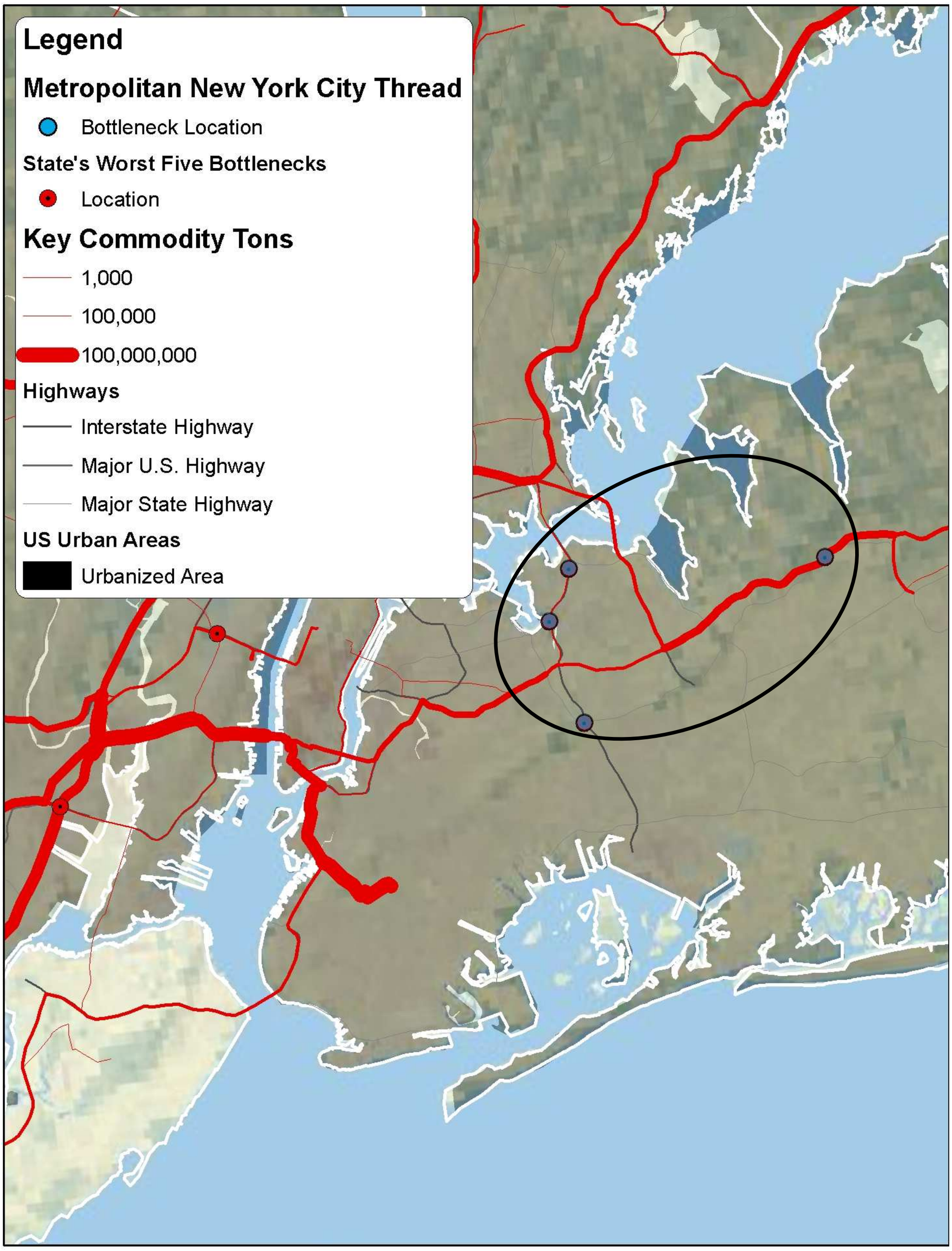


Table 4.11 I-95 Trunk Line Bottlenecks

Interchange	State	Key Commodity Value-Hours of Delay (Trillion Dollar-Hours)	Rank	Key Commodity Ton-Hours of Delay (Trillion Ton-Hours)	Rank	Observed Delay (Hours)	Rank
I-95 New York/New Jersey Bottleneck String							
I-495 at Exit 33	NY	65,000	11	11,000	13	113,000	16
I-95 at NY-9A	NY	492,000	2	96,000	2	1,121,000	1
I-95 at NJ-4	NJ	587,000	1	115,000	1	759,000	2
I-78 at I-95	NJ	150,000	3	32,000	4	174,000	8
I-95 at NJ-32 and NJ-612	NJ	3,000	28	1,000	28	46,000	27
Totals		**1,297,000**		**255,000**		**2,213,000**	
I-95 Wilmington Bottleneck String							
I-95 at DE-141	DE	53,000	13	13,000	12	70,000	23
I-95 at DE-1	DE	40,000	15	10,000	14	52,000	25
I-95 at DE-896	DE	41,000	14	10,000	15	54,000	24
Totals		**134,000**		**33,000**		**176,000**	
I-95 Baltimore/Washington Bottleneck String							
I-695 at I-95 (S.)	MD	92,000	7	22,000	7	141,000	10
I-95 at I-495	MD	80,000	9	19,000	10	138,000	11
I-495 at American Legion Bridge	VA	108,000	6	26,000	6	133,000	13
I-495 at I-66	VA	111,000	5	26,000	5	136,000	12
I-95 at VA-7100	VA	131,000	4	33,000	3	175,000	7
I-95 at VA-234	VA	81,000	8	20,000	8	106,000	17
Totals		**603,000**		**146,000**		**829,000**	

Figure 4.7 Metropolitan New York Bottleneck String



Note: IHS Global Insight, Inc. truck commodity data do not accurately represent intra-urban truck flows. Specifically, the map does not, and consequently, the commodity-delay analysis results do not, accurately represent significant freight flows on I-678 in the Metropolitan New York Area between the John F. Kennedy International Airport and Manhattan or Long Island.

Table 4.12 Metropolitan New York Bottlenecks

Interchange	State	Key Commodity Value-Hours of Delay (Trillion Dollar-Hours)	Rank	Key Commodity Ton-Hours of Delay (Trillion Ton-Hours)	Rank	Observed Delay (Hours)	Rank
Metropolitan New York Bottlenecks							
I-495 at Exit 33	NY	65,000	11	11,000	13	113,000	16
I-678 at Cross Island Parkway	NY	12,000	23	3,000	24	176,000	6
I-678 at NY-25A	NY	7,000	25	2,000	25	105,000	19
I-678 at Grand Central Parkway	NY	-	29	-	29	195,000	4
Totals		**84,000**		**16,000**		**589,000**	

Figure 4.8 I-695 Baltimore Bottleneck String

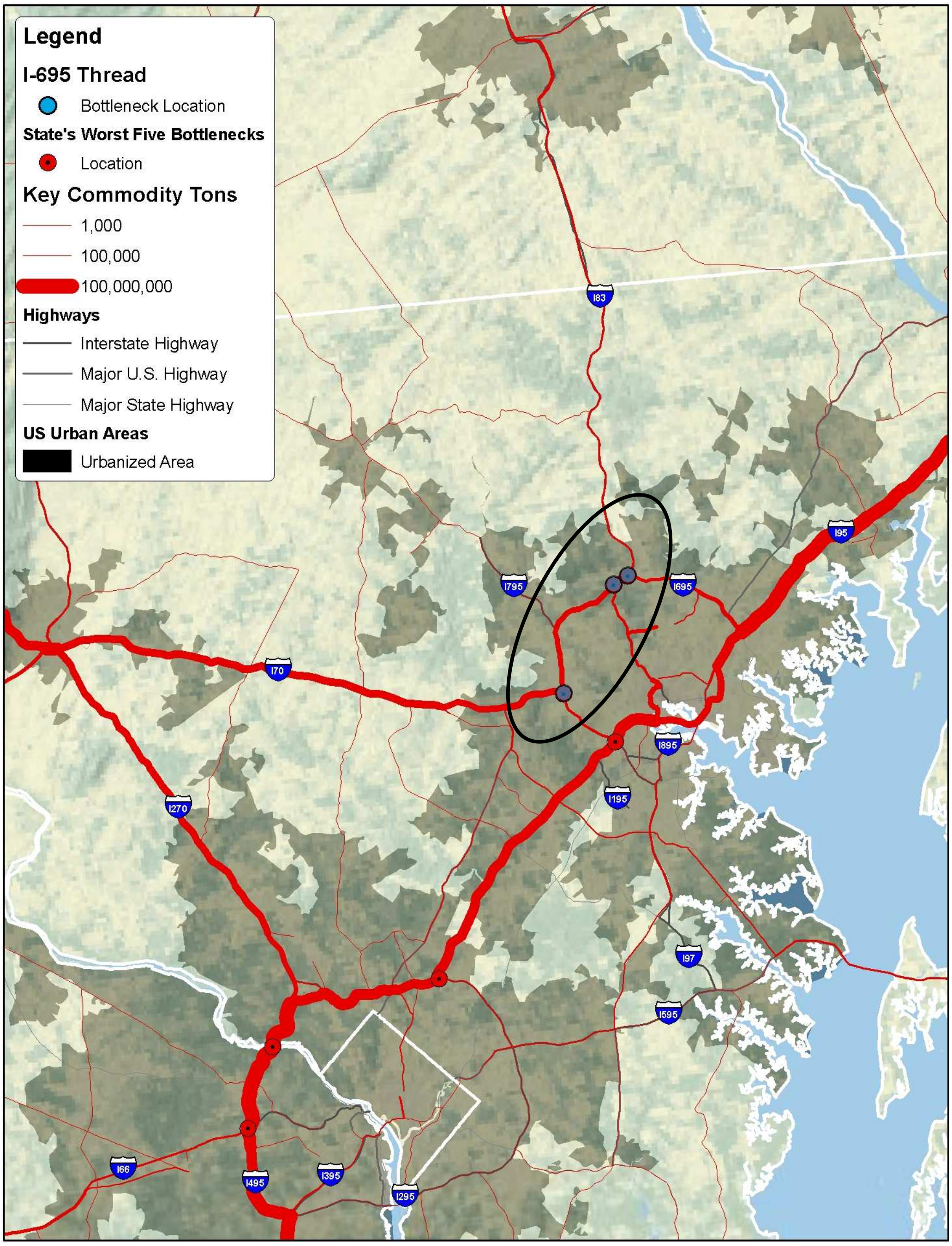


Table 4.13I-695 Baltimore Bottlenecks

Interchange	State	Key Commodity Value-Hours of Delay (Trillion Dollar-Hours)	Rank	Key Commodity Ton-Hours of Delay (Trillion Ton-Hours)	Rank	Observed Delay (Hours)	Rank
I-695 Baltimore Bottleneck String							
I-83 at I-695	MD	26,000	20	7,000	20	106,000	18
I-695 at I-83 and MD-25	MD	33,000	17	9,000	17	101,000	20
I-70 at I-695	MD	64,000	12	19,000	9	190,000	5
Totals		**123,000**		**35,000**		**397,000**	

Figure 4.9 I-95 Philadelphia Bottleneck String

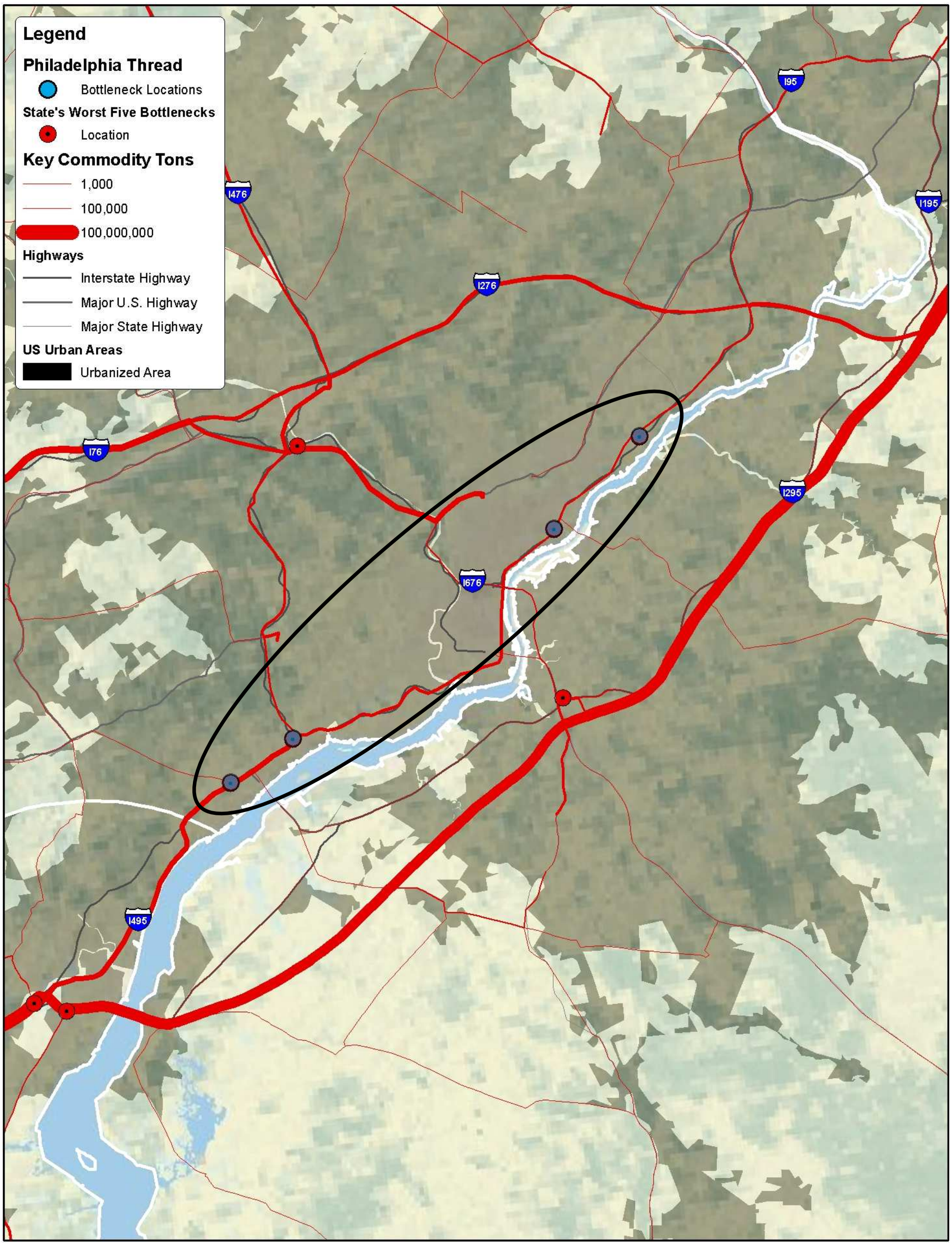


Table 4.14 I-95 Philadelphia Bottlenecks

Interchange	State	Key Commodity Value-Hours of delay (Trillion Dollar-Hours)	Rank	Key Commodity Ton-Hours of delay (Trillion Ton-Hours)	Rank	Observed Delay (Hours)	Rank
I-95 Philadelphia Bottlenecks String							
I-95 at Academy Road	PA	3,000	26	1,000	27	8,000	29
I-95 at PA-90	PA	19,000	22	4,000	23	168,000	9
I-95 at I-476	PA	30,000	18	7,000	19	51,000	26
I-95 at U.S. 322	PA	24,000	21	7,000	21	93,000	21
Totals		**76,000**		**19,000**		**320,000**	

4.7 Strategies for Addressing Truck Freight Bottlenecks

A brief scan of current professional practice was conducted to identify strategies that have been used successfully, either on their own or together with other strategies, to improve traffic operations and reduce delays at bottlenecks. The current toolkit of strategies includes the following actions:

- Correct specific capacity deficiencies such as:
  - Eliminate low-capacity weaving sections;
  - Eliminate low-capacity short acceleration or deceleration ramps;
  - Eliminate low-capacity left exits;
  - Add more through lanes; and
  - Reconstruct the entire interchange to higher design.
- Shift or reduce facility demand:
  - Construct high-occupancy vehicle (HOV) or high-occupancy toll (HOT) lanes through the interchange;
  - Improve transit service, including light/heavy rail in corridor to remove trips from the roadway; and
  - Change freight receivers' dock hours to nonpeak travel times so that trucks are not forced to travel through severely congested bottlenecks during peak periods.

- Improve facility operations:
  - Implement aggressive incident management to remove nonrecurring delay quickly;
  - Install ramp metering, including freeway-to-freeway, to maintain appropriate capacity at facility;
  - Implement traveler information program to reroute trips to other, less-congested facilities during peak traffic periods;
  - Implement the active traffic management techniques;
  - Change policies to allow "hard shoulder running" to increase through capacity of the roadway;
  - Implement lane control, especially at merge points;
  - Implement variable speed limits; and
  - Install queue warning system.
- Deploy portfolio approaches, using multiple strategies in combination to address capacity, demand, and/or operations problems. For example, to reduce congestion and delays at the I-25 and I-225 interchange in Denver, Colorado, engineers and planners employed a combination of strategies, including:
  - Redesign of the interchange;
  - Addition of through lanes on I-225;
  - Construction of light rail in the highway median;
  - Construction of park-and-ride lots; and
  - Spot improvements at other ramps in corridor to reduce turbulent flow in the corridor.

5.0 Conclusions and Recommendations

A comprehensive search for bottlenecks identified 152 truck freight bottlenecks in the Mid-Atlantic region. Of these, 4 are among the top 30 bottlenecks in the nation. It is estimated that the 152 bottlenecks in the Mid-Atlantic region cause 19.6 million hours of truck delay annually. This translates into $706 million in lost time, 35 million gallons of fuel burned, and 0.39 million tons of carbon dioxide emissions, the major component of greenhouse gases.

The 5 worst truck bottlenecks in each state were studied in greater detail. (The State of Delaware identified 4 bottlenecks.) The 29 bottlenecks were found to account for 47 percent of all truck-hours of delay accrued at bottlenecks across the Mid-Atlantic region. The annual impacts of these 29 bottlenecks were estimated at $334 million in lost time, 16 million gallons of fuel burned, and 0.18 million tons of carbon dioxide emissions. These costs are a substantial drain on the productivity of the region's economy, the energy security of the nation, and the health of the population.

Without concerted action, these costs will increase. The population of the region is projected to grow by 21 percent and the size of the economy will more than double between 2005 and 2035. The key industries that are expected to generate new jobs, higher business and household income, and greater tax revenues for the region – health care; professional, scientific, and technical services; finance; wholesale and retail trade, and manufacturing – all depend directly or indirectly on fast, cost-effective, and reliable freight transportation. Without improvements to the freight transportation system that preserve capacity and reduce delays, the costs of feeding, housing, and clothing the population and the costs of supporting the region's growth industries will go up. The impacts of freight congestion will be felt as reduced market size, smaller operating windows and more inefficient backhaul operations, reduced just-in-time efficacy for manufacturing and retailing, missed intermodal connections, and in the worst case, the out-migration of industries to lower-cost and more competitive cities and regions.

Almost all of the major bottlenecks – measured in truck-hours of delay – are in urban areas at major highway-to-highway interchanges on or adjacent to the I-95 corridor. Reducing the cost of truck freight delays and congestion along the I-95 corridor will have the greatest benefit to the freight system and the region's economy. The I-95 corridor bottlenecks should be the focus of future Coalition and member state efforts.

Most of the major bottlenecks along the Mid-Atlantic trade corridors are strung closely together. Many medium- and long-distance truck moves using these corridors encounter one or more strings of bottlenecks depending on their route and the time of day. The six worst bottleneck strings in the Mid-Atlantic region are summarized in Table 5.1. The cost of these bottleneck strings is measured in commodity value-hours of delay as a proxy for the economic impact of the delays to shippers, carriers, and consumers.

Table 5.1 Relative Impacts of Mid-Atlantic Truck Bottleneck Strings

Bottleneck String	Key Commodity Value-Hours of Delay (Trillion Dollar-Hours)	Key Commodity Ton-Hours of Delay (Trillion Ton-Hours)	Observed Delay (Hours)
I-95 New York/New Jersey Bottleneck String	1,297,000	255,000	2,213,000
I-95 Baltimore/Washington Bottleneck String	603,000	146,000	829,000
I-95 Wilmington Bottleneck String	134,000	33,000	176,000
I-695 Baltimore Bottleneck String	123,000	35,000	397,000
Metropolitan New York Bottleneck String	84,000	16,000	589,000
I-95 Philadelphia Bottlenecks String	76,000	19,000	320,000

An improvement to a single bottleneck within these strings will reduce delays at that bottleneck, but will often shift the congestion to the next downstream bottleneck. To achieve significant reductions in truck delay and improve freight flows along the Mid-Atlantic trade corridors, strings of bottlenecks must be considered and managed as a whole.

The strings of bottlenecks span two and sometimes three states as well as multiple jurisdictions within metropolitan areas. This means that planning, funding, and implementing improvements to reduce delay and congestion must be done on a cooperative basis. This will require continuing efforts to build and sustain coalitions among Federal, state, and local agencies, and with the private sector.

Finally, while there is a broad spectrum of capital, operating, and regulatory solutions that could be applied to freight bottlenecks, the state of practice in dealing with major freight bottlenecks is not well developed. Major freight bottlenecks are often regarded as too big to tackle – because of their technical, institutional, and funding complexities – and, therefore, put off for the future.

However, the Mid-Atlantic region cannot afford to ignore the mounting demand for freight transportation and the consequences of inaction. The region needs policies and programs to address the capacity and performance needs of its freight transportation system. The consequence of transportation failure – failing to keep up with growth and trade, failing to fix major truck bottlenecks, failing to fix major rail chokepoints, and failing to provide adequate access to the nation's ports and international trade gateways – will be higher costs and slower economic growth, which will compound the problems created by the recent recession.

Based on the findings and conclusions of the study, the I-95 Corridor Coalition and its member agencies may wish to consider the following actions:

- Select a high-priority bottleneck string.
- Conduct a detailed examination of the bottlenecks within the string, including examination of physical, operational, and institutional factors that cause them. A further analysis of commodities may provide insights about the bottlenecks that have the most economic impact to the region. Commodities can be disaggregated by industry, and value-hours of delay and ton-hours calculated for each commodity/industry group to provide a more precise assessment of economic impact.
- Work with the Mid-Atlantic states to identify a portfolio of cost-effective strategies to reduce truck and commodity hours of delay across the string of bottlenecks.
- Provide the information to the Mid-Atlantic states to assist the appropriate member states in undertaking projects to address these bottlenecks, including projects that may be applicable for planning and implementation funding under the Federal Projects of National and Regional Significance (PNRS) program (or new programs that emerge from the surface transportation authorization).
- In parallel with the development of the bottleneck string program, examine how other improvements to the Mid-Atlantic rail and marine transportation systems might help relieve truck pressure at the bottlenecks and elsewhere on the highway network.

The Coalition also may wish to:

- Examine truck bottlenecks in the Northeast and Southeast regions to complete a picture of bottlenecks and bottleneck strings in the I-95 Corridor region.
- Continue work with the FHWA, member states, motor carrier associations, and motor carriers on traffic count and fleet speed data programs. These activities could generate better performance data, which could be used to more quickly and accurately identify bottlenecks, track delay trends, estimate economic impacts, and set priorities for improvements.

Appendix A

Mid-Atlantic Region Truck Bottlenecks

A. Mid-Atlantic Region Truck Bottlenecks

Bottleneck Name	Initial Estimate of 2006 Annual Peak Period Truck Delay	County	State	Worst 30 Truck Bottlenecks in Mid-Atlantic	Worst Five Truck Bottlenecks by Mid-Atlantic State
I-95 at DE-896	412,000	New Castle	DE	1	1
I-95 at DE-1	169,000	New Castle	DE		1
I-295 at U.S. 13 and U.S. 40	79,000	New Castle	DE		1
I-95 at DE-141	31,000	New Castle	DE		1
I-70 at I-695	649,000	Baltimore	MD	1	1
I-695 at I-83 and MD-25	648,000	Baltimore,	MD	1	1
I-83 at I-695	582,000	Baltimore	MD	1	1
I-95 at I-495	551,000	Prince Georges	MD	1	1
I-695 at I-95 (S.)	504,000	Baltimore	MD	1	1
I-695 at I-95 (N.)	414,000	Baltimore	MD	1	
I-95 at I-895	369,000	Baltimore city	MD	1	
I-95 at I-295	287,000	Prince Georges	MD	1	
I-95 at MD-295	269,000	Prince Georges	MD	1	
I-95 at I-395	238,000	Baltimore	MD	1	
I-795 at I-695	193,000	Baltimore	MD	1	
I-270 at I-495	193,000	Montgomery	MD		
I-97 at I-595	190,000	Anne Arundel	MD		
I-370 at I-270	88,000	Montgomery	MD		
I-695 at MD-295	77,000	Anne Arundel	MD		
I-95 at MD-210	55,000	Prince Georges	MD		
U.S. 29 at MD-100	55,000	Howard	MD		
I-95 at MD-22	21,000	Harford	MD		

Bottleneck Name	Initial Estimate of 2006 Annual Peak Period Truck Delay	County	State	Worst 30 Truck Bottlenecks in Mid-Atlantic	Worst Five Truck Bottlenecks by Mid-Atlantic State
MD-295 at Russell Street	0	Baltimore City	MD		
I-95 at NJ-4	692,000	Bergen	NJ	1	1
I-80 at Garden State Parkway	140,000	Bergen	NJ		State: Not truck bottleneck
I-95 at NJ-32 and NJ-612	128,000	Middlesex	NJ		1
NJ-495 at NJ-3	126,000	Hudson	NJ		1
I-95 at I-195	113,000	Mercer	NJ		State: Not truck bottleneck
I-78 at I-95	108,000	Essex	NJ		1
I-295 at I-76 and NJ-42	104,000	Camden	NJ		1
I-76 at I-295 and NJ-42	102,000	Camden	NJ		
I-78 at NJ-139 and Holland Tunnel Approaches	96,000	Hudson	NJ		
I-95 at U.S. 1, U.S. 9, TrU.S. 1, and TrU.S. 9	52,000	Essex	NJ		
NJ-495 at Lincoln Tunnel	36,000	Hudson	NJ		
I-95 at Delaware River Crossing	12,000	Mercer	NJ		
I-80 at I-287	10,000	Morris	NJ		
I-78 at Delaware River Crossing	0	Warren	NJ		
I-95 at NY-9A	629,000	New York	NY	1	1
Southern State Parkway at Exit 25A	467,000	Nassau	NY	State: Trucks restricted	State: Trucks restricted
FDR Drive south of Triborough Bridge	402,000	New York	NY	State: Trucks restricted	State: Trucks restricted
I-495 at Exit 33	355,000	Nassau	NY	1	1
I-678 at NY-25A	350,000	Queens	NY	1	1
I-278 at Verrazano-Narrows Bridge	294,000	Richmond	NY	Delay caused by toll booth	Delay caused by toll booth
I-678 at Grand Central Parkway	285,000	Queens	NY	1	1
I-678 at Cross Island Parkway	266,000	Queens	NY	1	1
I-287 at NY-100 and 119	209,000	Westchester	NY	1	
I-95 at I-278 and I-678 and I-295 and I-695	196,000	Bronx	NY	1	

Bottleneck Name	Initial Estimate of 2006 Annual Peak Period Truck Delay	County	State	Worst 30 Truck Bottlenecks in Mid-Atlantic	Worst Five Truck Bottlenecks by Mid-Atlantic State
I-287 at I-87	175,000	Westchester	NY		
I-495 at NY-110	172,000	Suffolk	NY		
I-678 at Grand Central Parkway	171,000	Queens	NY		
I-278 at I-495	157,000	Kings	NY		
I-495 at NY-454	135,000	Suffolk	NY		
I-490 at NY-590	129,000	Monroe	NY		
I-290 at NY-5	102,000	Erie	NY		
I-495 at I-278	90,000	Queens	NY		
I-95 at Bronx River Parkway	76,000	Bronx	NY		
I-495 at Little Neck Parkway	69,000	Nassau	NY		
I-495 at Van Wyck Expressway	62,000	Queens	NY		
NY-27 at Heckscher State Parkway	57,000	Suffolk	NY		
I-278 at Battery Tunnel and Queens Expressway	55,000	Kings	NY		
I-95 at White Plains Road and Westchester Avenue	47,000	Bronx	NY		
NY-25 at 59th Street Bridge	46,000	Queens	NY		
I-90 at I-787	36,000	Albany	NY		
I-87 at I-95	35,000	Bronx	NY		
I-495 at I-295	29,000	Queens	NY		
I-84 at I-684	26,000	Putnam	NY		
I-684 at I-287	25,000	Westchester	NY		
NY-440 at SIE and Korean War Veteran Parkway	25,000	Richmond	NY		
NY-27 at Patchogue Yaphank Road- County Route 101	20,000	Suffolk	NY		
NY-590 at NY-104	15,000	Monroe	NY		
I-190 at West River Parkway	11,000	Erie	NY		
I-684 at I-84	10,000	Putnam	NY		
I-590 at I-490	10,000	Monroe	NY		
Mid-Hudson Bridge, NY-9 to 9W	5,000	Dutchess	NY		
NY-27 at Conduit Avenue	4,000	Queens	NY		

Bottleneck Name	Initial Estimate of 2006 Annual Peak Period Truck Delay	County	State	Worst 30 Truck Bottlenecks in Mid-Atlantic	Worst Five Truck Bottlenecks by Mid-Atlantic State
NY-347 at NY-111	3,000	Suffolk	NY		
I-87 at I-90	3,000	Albany	NY		
Rt.22, I-84/I-684 to CR 65	2,000	Putnam	NY		
I-81 at NY-26	0	Broome	NY		
U.S. 9 at NY-113	0	Dutchess	NY		
I-81 at I-690	0	Onondaga	NY		
I-81 at NY-80	0	Onondaga	NY		
I-87 at U.S. 9	0	Warren	NY		
I-90 at I-290	0	Erie	NY		
I-490 at Rochester Inner Loop Highway	0	Monroe	NY		
I-390 at NY-33A	0	Monroe	NY		
I-87 Border Crossing	0	Clinton	NY		
I-81 Border Crossing	0	Jefferson	NY		
I-95 at I-476	505,000	Delaware	PA	1	1
I-95 at PA-90	379,000	Philadelphia	PA	1	1
I-76 at I-476	352,000	Montgomery	PA	1	1
I-95 at Academy Road	320,000	Philadelphia	PA	1	1
I-95 at U.S. 322	308,000	Delaware	PA	1	1
I-279 at I-376, PA-51, PA-19, and PA-121	299,000	Allegheny	PA	1	
I-76 at I-676	285,000	Philadelphia	PA	1	
I-95 at I-676 and Ben Franklin Bridge	254,000	Philadelphia	PA	1	
I-76 to U.S. 30	239,000	Philadelphia	PA	1	
I-95 at PA-291	220,000	Delaware	PA	1	
I-476 at I-95	149,000	Delaware	PA		
I-83 at U.S. 322 and I-283	113,000	Dauphin	PA		
I-78 at PA-100	98,000	Lehigh	PA		
I-95 at PA-452	96,000	Delaware	PA		
U.S. 22 at 3rd Street	88,000	Lehigh	PA		
I-76 at U.S. 1	81,000	Montgomery	PA		
I-76 at South 34th Street	77,000	Philadelphia	PA		

Bottleneck Name	Initial Estimate of 2006 Annual Peak Period Truck Delay	County	State	Worst 30 Truck Bottlenecks in Mid-Atlantic	Worst Five Truck Bottlenecks by Mid-Atlantic State
I-95 at PA-63	77,000	Philadelphia	PA		
I-81 at I-476	70,000	Luzerne	PA		
I-80 at U.S. 209	65,000	Monroe	PA		
I-81 at PA-307	64,000	Lackawanna	PA		
I-83 at PA-581	63,000	Cumberland	PA		
I-81 at U.S. 11 and PA-502	61,000	Lackawanna	PA		
I-376 at Beechwood Boulevard	57,000	Allegheny	PA		
I-79 at I-279 and U.S. 22 and U.S. 30	53,000	Allegheny	PA		
I-476 at PA-3	53,000	Delaware	PA		
I-81 at I-83	49,000	Dauphin	PA		
I-279 at PA-28 and I-579	42,000	Allegheny	PA		
U.S. 22 at PA-378	31,000	Northampton	PA		
I-79 at I-279	25,000	Allegheny	PA		
U.S. 202 at U.S. 30	13,000	Chester	PA		
I-76 at I-79	11,000	Allegheny	PA		
U.S. 422 at PA-23	9,000	Montgomery	PA		
I-83 at U.S. 30	6,000	York	PA		
U.S. 422 at PA-363	5,000	Montgomery	PA		
I-84 at I-380	5,000	Lackawanna	PA		
I-376 at I-76 and U.S. 22	4,000	Allegheny	PA		
U.S. 15 at U.S. 11 and PA-581	2,000	Cumberland	PA		
I-76 at I-70	1,000	Westmoreland	PA		
I-376 to I-279 (Squirrel Tunnel)	0	Allegheny	PA		
I-76 in the Appalachians	0	Fulton	PA		
I-495 at 1-95 and I-395	413,000	Fairfax	VA	State: Completed reconstruction project	State: Completed reconstruction project
I-95 at VA-234	184,000	Prince William	VA		1
I-264 east of I-64	167,000	Norfolk	VA		1

Bottleneck Name	Initial Estimate of 2006 Annual Peak Period Truck Delay	County	State	Worst 30 Truck Bottlenecks in Mid-Atlantic	Worst Five Truck Bottlenecks by Mid-Atlantic State
I-95/I-495 at Woodrow Wilson Bridge	158,000	Alexandria	VA		State: Interchange under construction
I-95 at VA-7100	141,000	Fairfax	VA		1
I-495 at American Legion Bridge	131,000	Fairfax	VA		1
I-495 at I-66	100,000	Fairfax	VA		1
I-64 at I-95	98,000	Richmond	VA		
I-495 at VA-267	91,000	Fairfax	VA		
I-64 at I-264	48,000	Norfolk	VA		
I-64 at VA-143	47,000	Newport News	VA		
I-64 in Norfolk	37,000	Norfolk	VA		
I-264 at U.S. 58	36,000	Norfolk	VA		
I-66 at U.S. 29 (E. Falls Church)	32,000	Arlington	VA		
I-64 at I-564	28,000	Norfolk	VA		
I-64 at U.S. 60	20,000	Hampton	VA		
I-264 Downtown Tunnel	19,000	Norfolk	VA		
I-81 at U.S. 250	17,000	Augusta	VA		
I-64 at I-264 and I-664	8,000	Chesapeake	VA		
I-64 at High Rise Bridge	7,000	Chesapeake	VA		
I-395 at GW Parkway	5,000	Arlington	VA		
I-81 at U.S. 11	1,000	Rockbridge	VA		