CAMBRIDGE SYSTEMATICS

An Initial Assessment of Freight Bottlenecks on Highways

white

paper

prepared for

Federal Highway Administration
Office of Transportation Policy Studies

prepared by

Cambridge Systematics, Inc.

in association with

Battelle Memorial Institute
Columbus, Ohio

October 2005

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Executive Summary

The nation is entering the early stages of a freight transportation capacity crisis. The last several decades have witnessed steady growth in the demand for freight transportation in the United States, driven by economic expansion and global trade. But freight transportation capacity, especially highway capacity, is expanding too slowly to keep up with demand. The effects of growing demand and limited capacity are felt as congestion, upward pressure on freight transportation prices, and less reliable trip times as freight carriers struggle to meet delivery windows.

Freight congestion problems are most apparent at bottlenecks on highways: specific physical locations on highways that routinely experience recurring congestion and traffic backups because traffic volumes exceed highway capacity. Bottlenecks are estimated to account for about 40 percent of vehicle hours of delay. The balance—about 60 percent of delay—is estimated to be caused by nonrecurring congestion, the result of transitory events such as construction work zones, crashes, breakdowns, extreme weather conditions, and suboptimal traffic controls. This paper focuses on bottlenecks that cause recurring congestion.

Bottlenecks on highways that serve high volumes of trucks are "freight bottlenecks." They are found on highways serving major international gateways like the Ports of Los Angeles and Long Beach, at major domestic freight hubs like Chicago, and in major urban areas where transcontinental freight lanes intersect congested urban freight routes.

This white paper is an initial effort to identify and quantify, on a national basis, highway bottlenecks that delay trucks and increase costs to businesses and consumers. The paper is the first to look specifically at the impacts and costs of highway bottlenecks on truck freight shipments.

A truck bottleneck is defined by a combination of three features: the type of constraint, the type of roadway, and the type of freight route. A truck bottleneck may be caused by congestion at an interchange on a freeway serving as an intercity truck corridor, or a truck bottleneck may be caused by poorly timed traffic signals at intersections on an arterial road that serves as an urban truck corridor.

These highway truck bottlenecks can be identified and differentiated from general traffic bottlenecks. A relatively comprehensive inventory of highway truck bottlenecks can be made using available FHWA Highway Performance Monitoring System (HPMS) data and Freight Analysis Framework (FAF) data. The impact of these bottlenecks can be measured by total truck hours of delay, hours of delay to large trucks making longer-distance trips, and the tonnage and value of commodities in the trucks.

We located and estimated truck hours of delay for 14 types of highway truck bottlenecks. These bottlenecks accrue significant truck hours of delay, totaling upwards of 243 million hours annually. At a delay cost of $32.15 per hour, the conservative value used by the FHWA's Highway Economic Requirements System model for estimating national highway costs and benefits, the direct user cost of these bottlenecks is about $7.8 billion per year.

Table ES.1 lists the types of bottlenecks and the annual truck hours of delay associated with each type. The bottleneck types are sorted in descending order of truck hours of delay by constraint type (e.g., interchange, geometry, intersection, and capacity) and then within each group by the truck hours of delay for each bottleneck type.

Table ES.1 Truck Hours of Delay by Type of Highway Freight Bottleneck

Bottleneck Type			National Annual Truck Hours of Delay, 2004 (Estimated)
Constraint	**Roadway**	**Freight Route**	
Interchange	Freeway	Urban Freight Corridor	123,895,000
			Subtotal **123,895,000***
Steep Grade	Arterial	Intercity Freight Corridor	40,647,000
Steep Grade	Freeway	Intercity Freight Corridor	23,260,000
Steep Grade	Arterial	Urban Freight Corridor	1,509,000
Steep Grade	Arterial	Truck Access Route	303,000
			Subtotal **65,718,000‡**
Signalized Intersection	Arterial	Urban Freight Corridor	24,977,000
Signalized Intersection	Arterial	Intercity Freight Corridor	11,148,000
Signalized Intersection	Arterial	Truck Access Route	6,521,000
Signalized Intersection	Arterial	Intermodal Connector	468,000
			Subtotal **43,113,000‡**
Lane Drop	Freeway	Intercity Freight Corridor	5,221,000
Lane Drop	Arterial	Intercity Freight Corridor	3,694,000
Lane Drop	Arterial	Urban Freight Corridor	1,665,000
Lane Drop	Arterial	Truck Access Route	41,000
Lane Drop	Arterial	Intermodal Connector	3,000
			Subtotal **10,622,000‡**
			Total 243,032,000

* The delay estimation methodology calculated delay resulting from queuing on the critically congested roadway of the interchange (as identified by the scan) and the immediately adjacent highway sections. Estimates of truck hours of delay are based on two-way traffic volumes. However, the methodology did not calculate delay on the other roadway at the interchange. This means that truck hours of delay were calculated on only one of the two intersecting highways or two of the four legs on an interchange, probably underreporting total delay at the interchange. The bottleneck delay estimation methodology also did not account for the effects of weaving and merging at interchanges, which aggravates delay, but could not be calculated from the available HPMS data. Estimates have been rounded to the nearest thousand.

‡ The HPMS sampling framework supports expansion of volume-based data from these sample sections to a national estimate, but does not support direct estimation of the number of bottlenecks. Estimates of truck hours of delay are based on two-way traffic volumes. Estimates have been rounded to the nearest thousand.

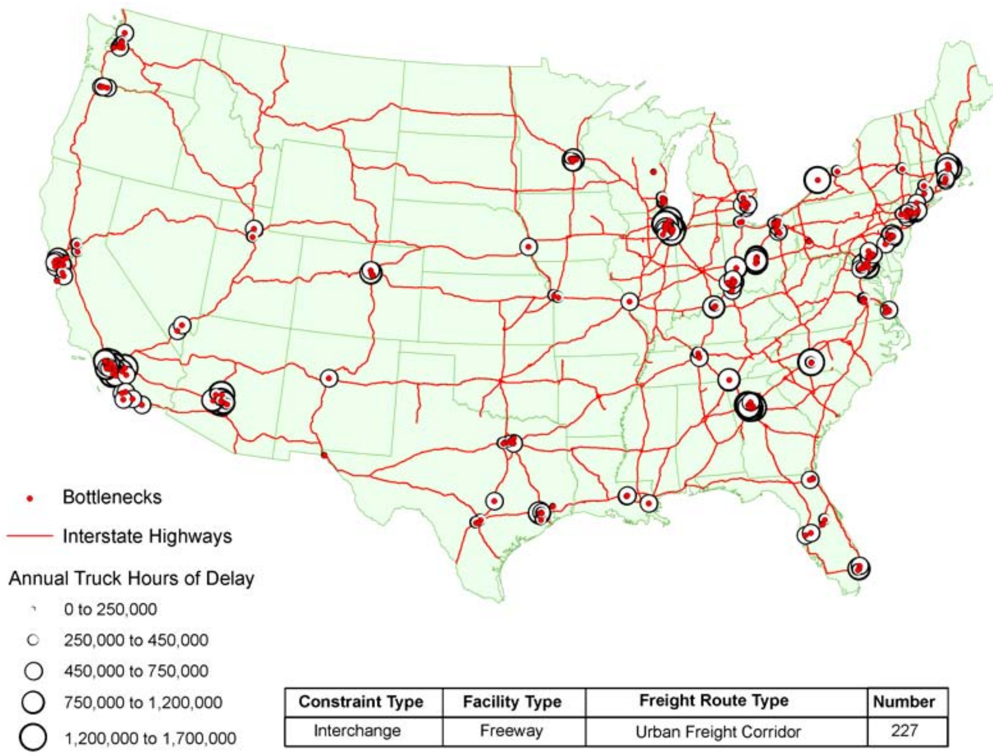
Source: Cambridge Systematics.

Of the four major types of bottlenecks analyzed, highway interchange bottlenecks ("interchanges on freeways serving as urban freight corridors") account for the most truck hours of delay, estimated at about 124 million hours annually in 2004. The direct user cost associated with interchange bottlenecks is about $4 billion per year.

The truck hours of delay at individual highway interchange bottlenecks are significant. The top 10 highway interchange bottlenecks cause an average of 1.5 million truck hours of delay each. Of the 227 highway interchange bottlenecks, 173 cause more than 250,000 truck hours of delay annually. By comparison only a few dozen of all the other truck bottlenecks cause more than 250,000 truck hours of delay annually (e.g., of the identified highway truck bottlenecks, only 12 steep-grade bottlenecks, one lane-drop bottleneck, and two signalized intersection bottlenecks accrue more than 250,000 truck hours of delay).

Figure ES.1 shows the location of highway interchange bottlenecks for trucks. The bottleneck locations are indicated by a solid dot. Most are located at urban Interstate interchanges. The size of the open circles accompanying each dot indicates the relative annual truck hours of delay associated with the bottleneck. These highway interchange bottlenecks delay metropolitan and local truck traffic, but they also delay national and international truck flows because they sit astride many of the key intersections of the nation's long-haul and transcontinental freight corridors.

Figure ES.1 Major Highway Interchange Bottlenecks for Trucks



Source: Cambridge Systematics, Inc.

Highway freight bottlenecks, especially interchange bottlenecks, are of Federal interest because they are a significant national problem for trucking and the efficient operation of the national freight transportation system. Highway interchange bottlenecks affecting trucking are widely distributed across the United States along Interstate freight corridors. The primary truck delay on these nationally significant routes is in the major urban areas, including major international trade gateways and hubs such as Los Angeles, New York, and Chicago, and major distribution centers such as Atlanta, Dallas-Fort Worth, Denver, Columbus (Ohio), and Portland (Oregon). These urban interchange bottlenecks create sticky nodes that slow long-distance truck moves along Interstate and other National Highway System regional, transcontinental, and NAFTA freight transportation corridors.

Our findings and conclusions suggest that FHWA may wish to consider the following recommendations.

- The FHWA should work closely with the states, metropolitan planning organizations, and industry to monitor truck delay at urban Interstate interchange bottlenecks on freight routes of national significance.

- The FHWA also should work closely with states and metropolitan planning organizations to focus Federal highway improvement and operations programs on highway interchange bottlenecks.

- To support these policy and program actions, the FHWA should continue the development of data and analytical methods to better estimate truck hours of delay at highway bottlenecks. FHWA should consider developing a spatially enabled interchange database that would support safety- and congestion-related analyses including the following truck-specific initiatives: re-estimate truck hours of delay at highway interchanges using the next-generation methodology to better account for delays caused by traffic merges and weaves at interchanges and capture delays on all legs of an interchange; and develop procedures to estimate the exposure of trucks to congestion by time of day.

Freight bottlenecks are a problem today because they delay large numbers of truck freight shipments. They will become increasingly problematic in the future as the U.S. economy grows and generates more demand for truck freight shipments. If the U.S. economy grows at a conservative annual rate of 2.5 to 3 percent over the next 20 years, domestic freight tonnage will almost double and the volume of freight moving through the largest international gateways may triple or quadruple. Without new strategies to increase capacity, congestion at freight bottlenecks on highways may impose an unacceptably high cost on the nation's economy and productivity.

1.0 Introduction

1.1 The Problem of Congestion

The last several decades have witnessed steady growth in the demand for freight transportation in the United States, driven by economic expansion and global trade. But today, the nation is entering the early stages of a capacity crisis. Freight transportation capacity is expanding too slowly to keep up with demand, and the freight productivity improvements gained though investment in the Interstate highway system and economic deregulation of the freight transportation industry in the 1980s are showing diminishing returns.

The effects of growing demand and limited capacity are felt as congestion, upward pressure on freight transportation prices, and less reliable trip times as freight carriers struggle to meet delivery windows. Higher transportation prices and lower reliability can mean increased supply costs for manufacturers, higher import prices, and a need for businesses to hold more expensive inventory to prevent stock outs. The effect on individual shipments and transactions is usually modest, but over time the costs can add up to a higher cost of doing business for firms, a higher cost of living for consumers, and a less productive and competitive economy.

Freight congestion problems are most apparent at bottlenecks on highways: specific physical locations on highways that routinely experience recurring congestion and traffic backups because traffic volumes exceed highway capacity. Bottlenecks on highways that serve high volumes of trucks are "freight bottlenecks." They are found on highways serving major international gateways like the Ports of Los Angeles and Long Beach, at major domestic freight hubs like Chicago, and in major urban areas where transcontinental freight lanes intersect congested urban freight routes.

Freight bottlenecks are a problem today because they delay large numbers of truck freight shipments. They will become increasingly problematic in the future as the U.S. economy grows and generates more demand for truck freight shipments. If the U.S. economy grows at a conservative annual rate of 2.5 to 3 percent over the next 20 years, domestic freight tonnage will almost double and the volume of freight moving through the largest international gateways may triple or quadruple. Without new strategies to increase capacity, congestion at freight bottlenecks on highways may impose an unacceptably high cost on the nation's economy and productivity.

1.2 The Federal Role

The Intermodal Surface Transportation Efficiency Act (ISTEA) and the Transportation Equity Act for the 21st Century (TEA-21) called upon the Federal government to develop a "National Intermodal Transportation System that is economically efficient and environmentally sound, provides the foundation for the Nation to compete in the global economy, and will move people and goods in an energy efficient manner…."[1] The recently enacted Safe, Accountable, Flexible, Efficient Transportation Equity Act: Legacy for Users (SAFETEA-LU) reaffirms the need for Federal government leadership in freight transportation. Therefore, the U.S. Department of Transportation (DOT) will have an increasing responsibility to develop and shape freight transportation policy options and programs. To do so, the Federal Highway Administration (FHWA), which oversees a National Highway System that carries 71 percent of all freight tonnage, must build a new generation of freight planning and policy analysis tools. The FHWA must be able to understand freight patterns, anticipate changes, and estimate the benefits and costs of capital investment, policy, and regulatory strategies to improve freight transportation.

The FHWA Office of Policy has begun to build these capabilities under is its "Strategic Analysis of Multimodal Transportation Policy Options" initiative. This initiative will develop a multimodal freight transportation network model and benefit/cost analysis tools that can evaluate capital, policy, and regulatory strategies for freight transportation.

1.3 The Objective of This Paper

This white paper is an initial effort to identify and quantify, on an national basis, highway bottlenecks that delay trucks and increase costs to businesses and consumers. The paper is the first to look specifically at the impacts and costs of highway bottlenecks on truck freight shipments. The paper builds on three streams of research:

- Bottlenecks – The paper improves and applies a bottleneck identification methodology developed for a project commissioned by American Highway Users Alliance that identified general highway bottlenecks—"Unclogging America's Arteries: Effective Relief for Highway Bottlenecks: 1999-2004."[2] That project built on prior work by Cambridge Systematics and others for the FHWA's mobility monitoring initiative and the FHWA's Highway Performance Monitoring System. The improved method provided a means of rapidly and systematically identifying and quantifying the congestion and delay associated with freight bottlenecks.

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[1] See Section 2, Declaration of Policy, "Intermodal Surface Transportation Efficiency Act of 1991," H.R. 2950 (Enrolled Bill), Public Law 102-240, 105 Stat. 1914.

[2] "Unclogging America's Arteries: Effective Relief for Highway Bottlenecks—1999-2004." Prepared by Cambridge Systematics, Inc. for the American Highway Users Alliance, Washington, D.C., 2004. See http://www.highways.org/pdfs/bottleneck2004.pdf.

- Freight Flows – The bottleneck identification methodology was applied to commodity and truck flow estimates developed by Battelle, Cambridge Systematics, and others under the FHWA's Freight Analysis Framework project.[3] The project integrated data from a variety of public and private sources to estimate commodity flows and related freight transportation activity among counties, states, regions, and major international gateways for the years 1998, 2010, and 2020. It provided the first, comprehensive picture of truck freight flows over the National Highway System, and provided a foundation for identifying truck freight bottlenecks and quantifying delay to trucks at the bottlenecks.

- Congestion – The paper also drew on research and findings reported by the Texas Transportation Institute's series of studies and reports on urban mobility, and on research on congestion undertaken by Cambridge Systematics and the Texas Transportation Institute for the FHWA's Office of Operations.[4,5] The paper begins to fill in information about impacts and costs of congestion on trucks and freight transportation separate from the impacts and costs of congestion on automobiles and passenger transportation, which have been the general focus of prior research.

The paper sets up a typology for highway freight bottlenecks, identifies an initial list of significant bottlenecks, and recommends ways to improve the analysis of bottlenecks and use the information in developing policies, programs, and projects to improve freight flows. The methods, findings, conclusions, and recommendations of the white paper are organized and presented as follows:

- Section 2.0, **National Freight System Capacity and Performance**, describes recent trends in national freight system capacity and performance and the implications of increasing freight demand and diminishing freight transportation capacity for shippers and carriers.

- Section 3.0, **Highway Truck Bottleneck Typology**, sets out a typology of highway bottlenecks for describing and classifying bottlenecks. The typology is based on the type of bottleneck constraint, the type of roadway, and the type of freight route. The typology is necessary to avoid double counting when calculating truck hours of delay and to establish—for future policy and program analysis work—a framework for attaching strategies and costs for congestion mitigation to each type of bottleneck.

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[3] See http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm.

[4] See David Schrank and Tim Lomax, *2003 Annual Urban Mobility Report*, Texas Transportation Institute, available at http://mobility.tamu.edu/ums.

[5] See "Traffic Congestion and Reliability: Linking Solutions to Problems," prepared by Cambridge Systematics, Inc. for the Federal Highway Administration, Office of Operations, Washington, D.C., July 2004. See http://www.ops.fhwa.dot.gov/congestion_report/index.htm.

- Section 4.0, **Methodology**, describes the data and analytical methods used to identify highway bottlenecks and estimate the truck hours of delay accruing to trucks caught in the bottlenecks.

- Section 5.0, **Highway Truck Bottlenecks**, summarizes the key findings about the number of bottlenecks identified and the truck hours of delay associated with each type of bottleneck.

- Section 6.0 presents the **Conclusions and Recommendations** of the paper.

The paper has four appendices.

- Appendix A lists bottlenecks caused by urban interchanges (freeway-to-freeway, and freeway-to-arterial roadway);

- Appendix B lists bottlenecks caused by steep grades on intercity and urban roads;

- Appendix C lists bottlenecks caused by congestion at signalized intersections on arterial roadways; and

- Appendix D lists bottlenecks caused by congestion at highway lane-drops (e.g., where highways narrow from three to two or two to one lane) on freeways and arterial roadways.

2.0 National Freight System Capacity and Performance

While the United States has seen remarkable improvements in freight transportation since the 1980s, congestion threatens to increase travel times, drive up logistics costs, and undermine the reliability of freight shipments. The problem of congestion is especially acute for trucking.

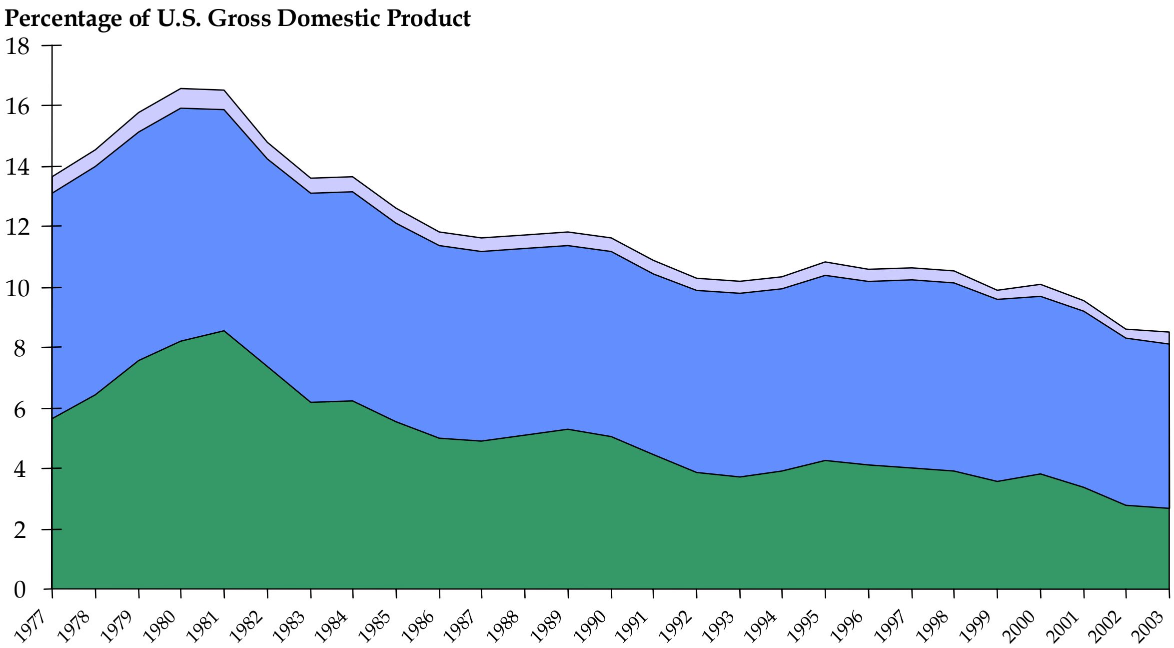
One measure of the performance of the nation's freight transportation system is total logistics cost. Total logistics cost is the cost of managing, moving, and storing goods. The major components of total logistics cost are administration (e.g., management, insurance), transportation (e.g., by truck, rail, air, and water), and inventory carrying costs. Figure 2.1 shows total logistics cost as a percentage of the U.S. gross domestic product (GDP). Logistics costs rose through the 1960s and 1970s to a high of about 16 percent in 1980, then declined through the 1980s and 1990s. Total logistics costs today are estimated to be about eight percent of GDP.

A major factor in the decline in total logistics cost has been lower truck, rail, air, and water freight transportation costs.[1] Freight transportation costs are lower because:

- Economic deregulation and the subsequent restructuring of the freight transportation industry in the 1980s triggered strong competition and lower shipping prices;
- Public sector investment in the Interstate highway system in the 1980s and early 1990s reduced travel time and improved trip reliability for motor carriers; and
- Adoption of new technologies such as intermodal freight containers, computers and related information technologies, bar coding, radio-frequency-identification tags, and satellite communications by shippers and carriers significantly improved the productivity and reliability of freight operations.

[1] Other contributing factors have been the growth of services, which generate less demand for freight service, and lower interest rates which reduce inventory carrying costs.

Figure 2.1 Total Logistics Cost as Percentage of U.S. Gross Domestic Product
Cost Trend



Source: Rosalyn A. Wilson, *State of Logistics Report*, Council of Logistics Management, 2003

Shippers have taken advantage of the lower transportation costs to buy more frequent, more reliable, and more long-distance freight transportation. They have done so for a number of reasons, including:

- To outsource production to Asia and reduce the cost of labor and parts;
- To implement just-in-time manufacturing and reduce the cost of holding inventory; and
- To support larger, more cost-effective, regional warehouses and reduce distribution costs.

These changes have hastened a broad shift in business logistics practices from manufacture-to-supply or inventory-based logistics ("push logistics") to manufacture-to-order or replenishment-based logistics ("pull logistics"). "Push logistics" relies on careful maintenance of large inventories—between parts suppliers and manufacturers, between manufacturers and wholesalers, and between wholesalers and retailers—to buffer the bullwhip effect of unanticipated surges in supply and demand and guard against stock-outs along the supply chain. "Pull logistics" relies less on expensive inventory and more on accurate information and timely transportation to match supply and demand and prevent stock-outs. Better coordinated "pull logistics" is the underpinning of just-in-time manufacturing and just-in-time retailing.

"Pull logistics" has produced a tightly integrated and very efficient freight transportation network, generating enormous savings for U.S. businesses, expanding the choice of goods and services available to consumers, and allowing U.S. manufacturers to compete effectively in global markets. However, these benefits have come at a cost. The freight transportation network today is tightly strung and very sensitive to disruption. Congestion threatens to disrupt this freight network, increasing travel times, undermining reliability, and driving up transportation costs.

2.1 The Impact of Congestion

Highways

The extent of congestion today can been seen in the map in Figure 2.2, which shows congested roadways in 1998.[2] Congestion is calculated by comparing roadway capacity to average annual daily traffic (AADT) volumes as reported in the FHWA Highway Performance Monitoring System (HPMS). When traffic volume approaches 90 to 95 percent of capacity, highways become intensely congested. Highway segments shown in red in the figure are exceeding capacity, while highway segments in yellow are approaching capacity.[3] The congestion is reported only for roadways in the National Highway System and reflect average conditions. Actual congestion levels vary substantially by hour, day, and week.

Congestion means longer travel times, increased costs, and less reliable pick-up and delivery times for truck operators. To compensate, motor carriers typically add vehicles and drivers and extend their hours of operation. Over time, most of these costs are passed along to shippers and consumers. The Federal Highway Administration (FHWA) estimates that increases in travel time cost shippers and carriers an additional $25 to $200 per hour depending on the product carried. The cost of unexpected truck delays can add another 50 percent to 250 percent.[4]

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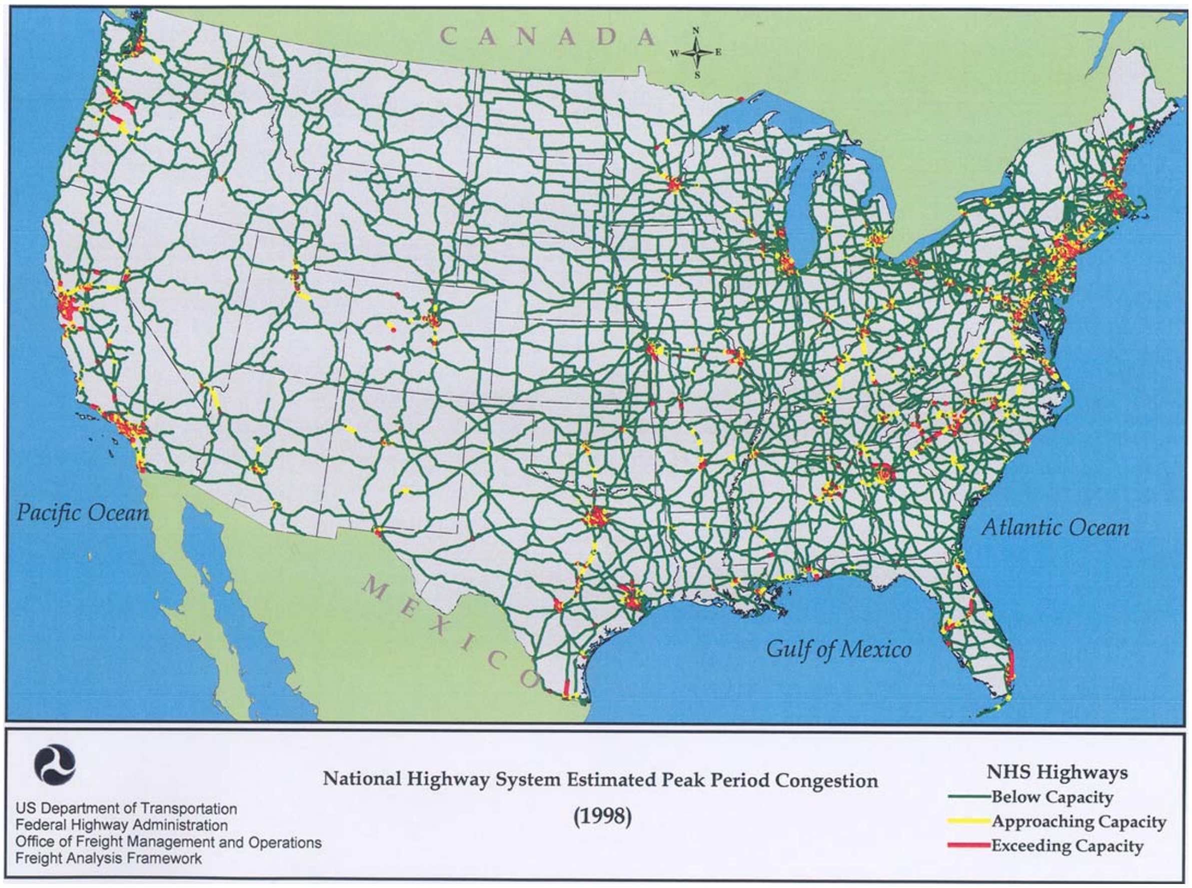
[2] FHWA Freight Analysis Framework. See http://www.ops.fhwa.dot.gov/freight/freight_news/faf/us_1998.pdf.

[3] For a detailed description of the methodology and data sources used to develop the FAF highway network and estimate capacity, see "Freight Analysis Framework Highway Capacity Analysis: Methodology Report" (April 2002), prepared by Battelle for the FHWA Office of Freight Management and Operations and available at http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm.

[4] Federal Highway Administration, *The Freight Story: A National Perspective on Enhancing Freight Transportation*. See www.ops.fhwa.dot.gov/freight/freight_analysis/freight_story/today.htm#1.

Figure 2.2 Congested Highways
1998

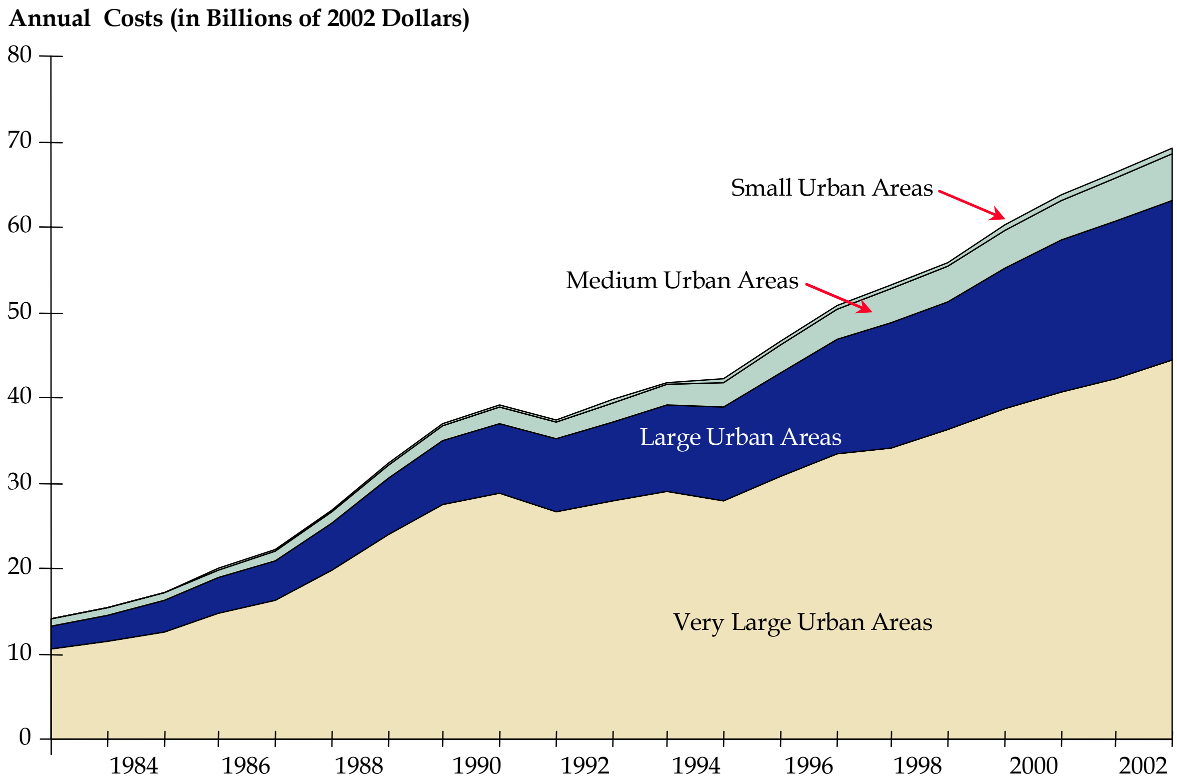


Source: Federal Highway Administration Freight Analysis Framework.

No statistics describe the cost of congestion to the nation's freight transportation system as a whole. However, data from the Texas Transportation Institute's "Annual Mobility Reports" show large and steady increases over the last 20 years in the cost of congestion to automobile and truck drivers in the nation's metropolitan areas. Figure 2.3 shows the estimated annual congestion costs in 85 small, medium, and large urban areas from 1982 to 2002, with the annual cost approaching $63 billion in 2002.[5]

[5] David Schrank and Tim Lomax, *2003 Annual Urban Mobility Report*, Texas Transportation Institute, available at http://mobility.tamu.edu/ums.

Figure 2.3 Annual Congestion Costs
85 Metropolitan Areas

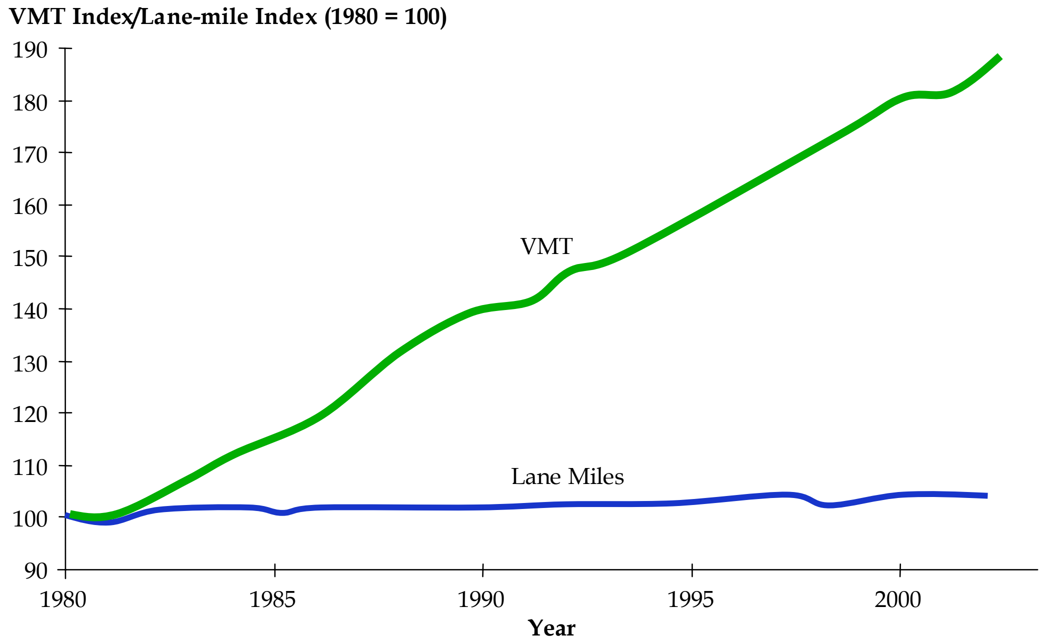


Source: Texas Transportation Institute (TTI).

The increase in congestion and congestion costs reflects the fact that over the last 20 years vehicle miles of travel (VMT) on U.S. roads have nearly doubled while lane miles have increased only about four percent. Figure 2.4 compares the growth in VMT to the growth in lane miles.[6] The index year is 1980.

[6] U.S. Department of Transportation, Federal Highway Administration, *The Freight Story: A National Perspective on Enhancing Freight Transportation*, page 12, available at http://ops.fhwa.dot.gov/freight/freight_analysis/freight_story/freight.pdf.

Figure 2.4 Vehicle Miles of Travel and Roadway Lane Miles
Growth Index, 1980 to 2002

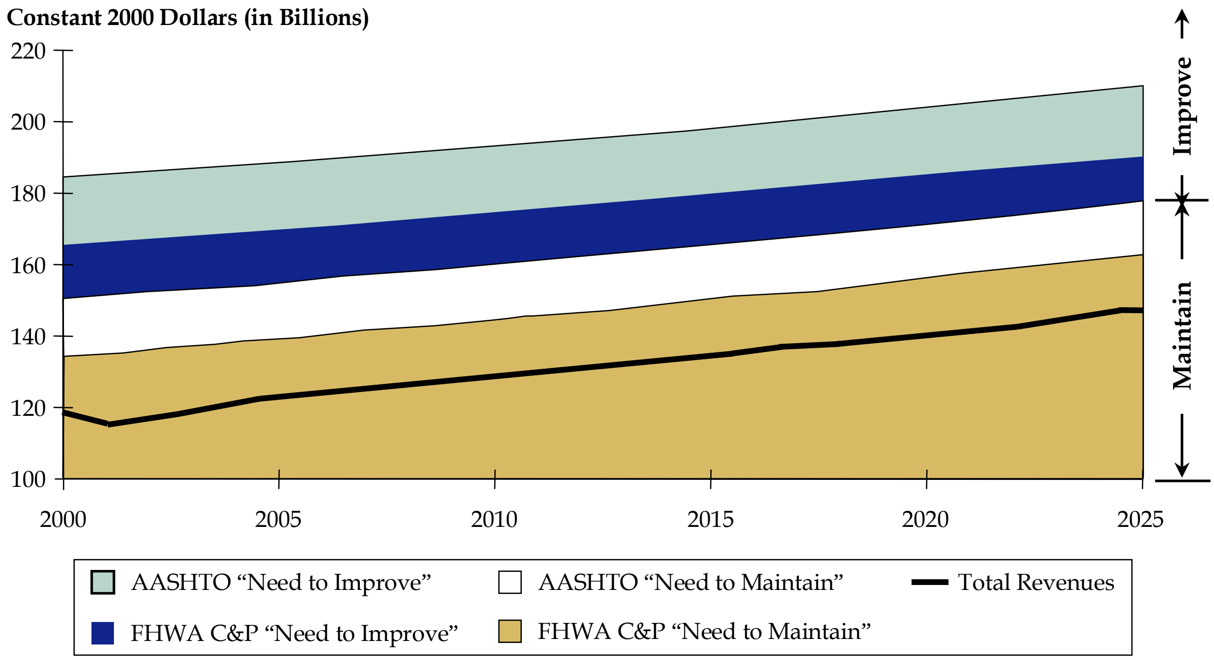


Source: Federal Highway Administration data.

It is unlikely that highway capacity will expand rapidly in the coming decades. The FHWA, in its *Condition and Performance Report* to Congress, and the American Association of State Highway and Transportation Officials (AASHTO), in its *Bottom Line Report*, estimate the levels of future capital expenditures needed to *maintain* and *improve* the performance of the nation's highway system. Figure 2.5 compares the four estimates of annual highway needs—including operations and maintenance costs—to the forecast of annual highway revenues for the period 2000 to 2025.[7] Current annual revenues will suffice only to maintain the highway system, not provide significant new capacity.

[7] Cambridge Systematics, Inc. analysis of Federal Highway Administration *Condition and Performance Report* data and AASHTO *Bottom Line Report* data.

Figure 2.5 Annual Highway Needs Compared to Annual Highway Revenues, *2000-2025, Base Case Forecasts*

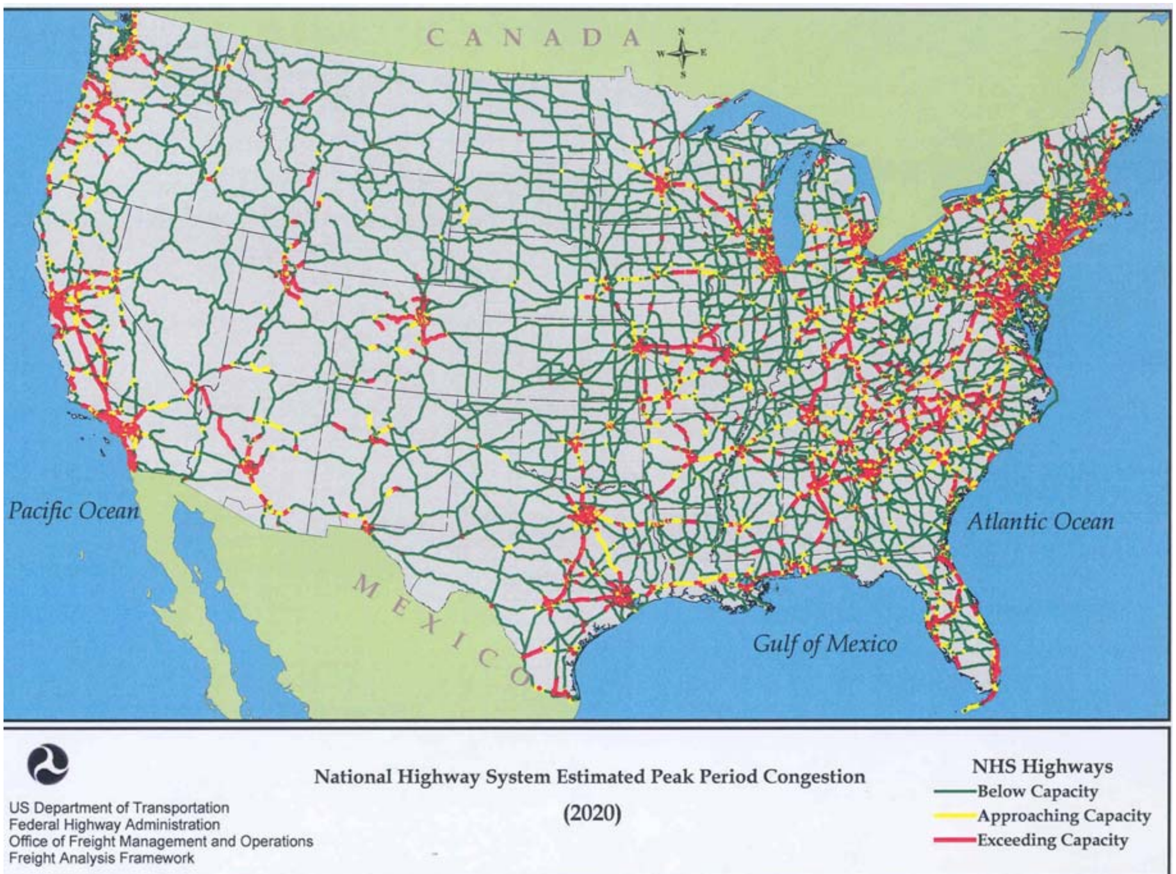


Source: Cambridge Systematics based on FHWA and AASHTO data.

Without significant improvements in capacity or throughput, congestion on the nation's highways will increase, driven by population growth, economic development, and the resulting demand for freight transportation. Between 1998 and 2020, total VMT is projected to increase at a rate averaging about 2.5 percent annually with truck VMT rising faster that automobile VMT.[8] Figure 2.6 shows potentially congested highways in 2020. Again, the map shows average conditions, but suggests clearly that today's metropolitan congestion may extend well into intercity highway freight corridors by 2020.

[8] U.S. Department of Transportation, Federal Highway Administration, *The Freight Story*, page 12.

Figure 2.6 Potentially Congested Highways
2020

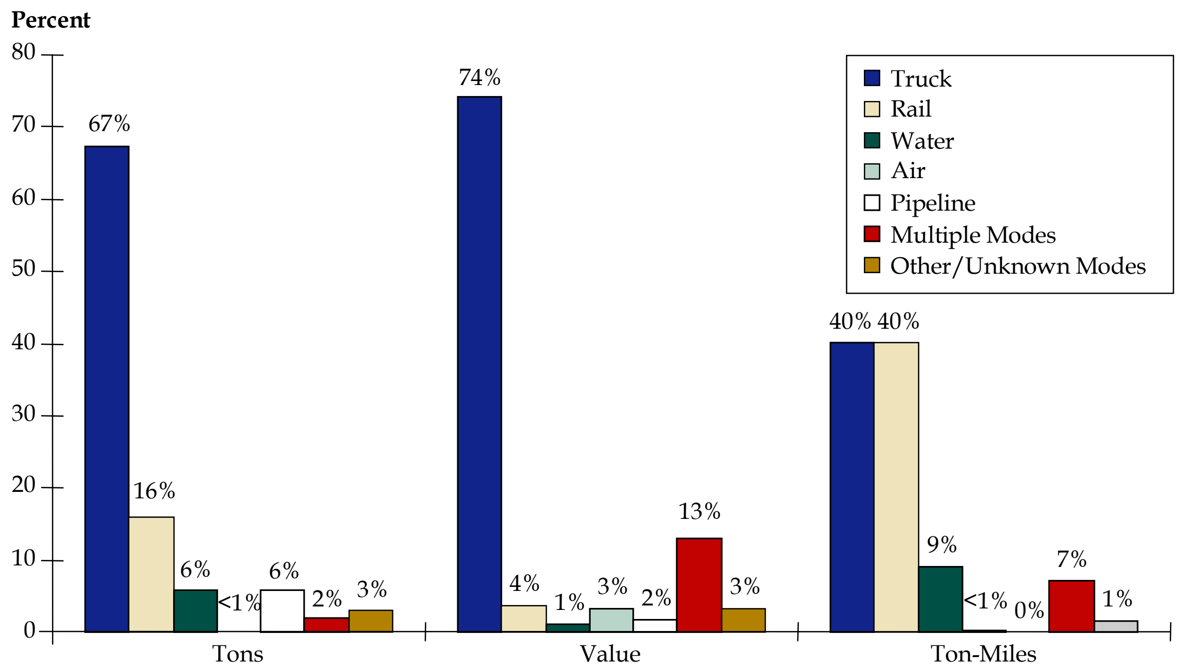


Source: Federal Highway Administration Freight Analysis Framework.

Trucking is heavily exposed to congestion because it is the dominant freight transportation mode. According to the 2002 Commodity Flow Survey, trucks carried 67 percent of domestic shipments by tons, 74 percent by value, and 40 percent by ton-miles. Figure 2.7 shows the breakdown of freight shipments by mode in tons, value, and ton-miles.[9]

[9] Bureau of Transportation Statistics and U.S. Census Bureau, "2002 Economic Census, Transportation, 2002 Commodity Flow Survey," Table 1b. Shipment Characteristics by Mode of Transportation for the United States: Percent of Total for 2002, 1997, and 1993.

Figure 2.7 Freight Tons, Value, and Ton-Miles by Mode
2002



Source: Bureau of Transportation Statistics and U.S. Census Bureau, "*2002 Ecnomic Census, Transportation, 2002 Commodity Flow Survey,*" Table 1b.

Trucking is the dominant mode today because it provides fast, reliable, and competitively priced freight transportation service that can be tailored to the needs of shippers and receivers. The demand for trucking, and the number of trucking companies, has grown in step with the economy. The number of interstate motor carriers increased from 18,000 in 1975 to over 500,000 in 2000.[10]

The cost and productivity of trucking depend in part on the condition and performance of the National Highway System. Figure 2.8 shows the density of truck freight shipments along major highway corridors; the wider the line representing the roadway, the more truck freight tonnage carried on that route.[11]

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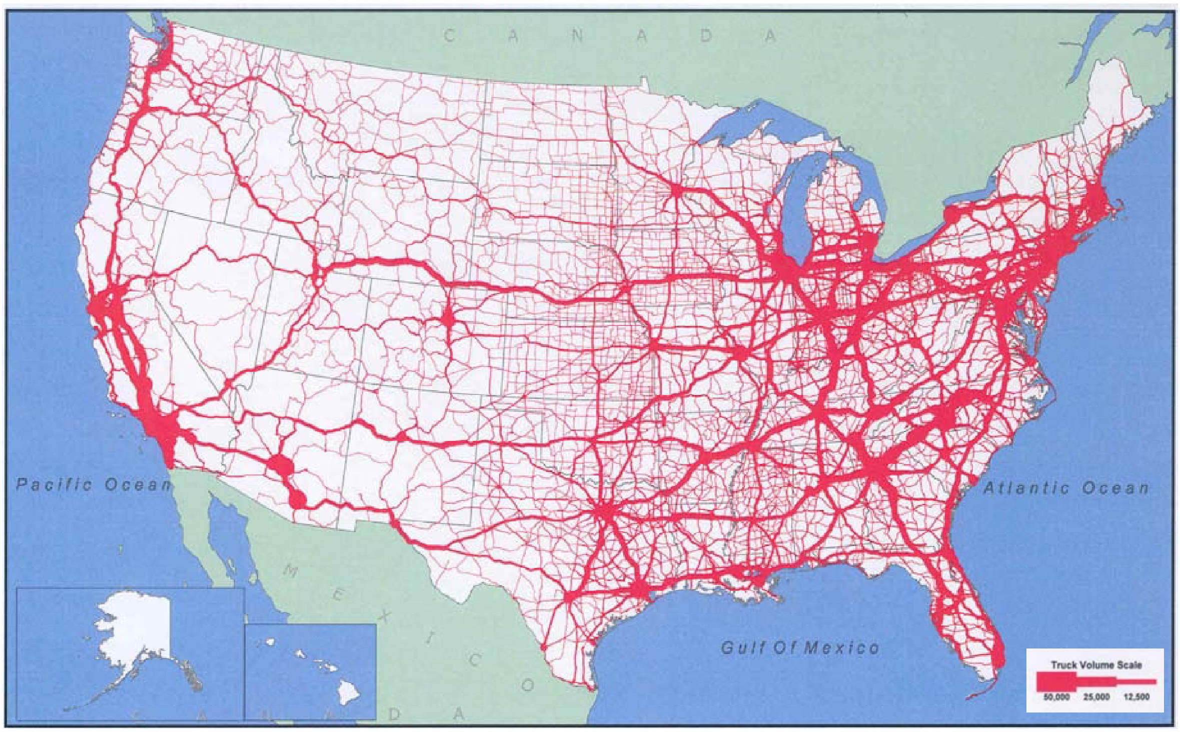
[10]U.S. Department of Transportation, Bureau of Transportation Statistics data, 2001.

[11]FHWA Freight Analysis Framework National Freight Transportation Statistics and Maps. See http://www.ops.fhwa.dot.gov/freight/freight_news/faf/us_1998.pdf.

Figure 2.8 Average Annual Daily Truck Traffic
1998



Source: Federal Highway Administration Freight Analysis Framework.

Trucking will be more exposed to congestion in the future. The FHWA projects that between 1998 and 2020 domestic freight volumes will grow by more than 65 percent, increasing from 13.5 billion tons to 22.5 billion tons.[12] Trucks are expected to move over 75 percent more tons in 2020, capturing a somewhat larger share of total freight tonnage than currently. To carry this freight, truck VMT is expected to grow at a rate of more than three percent annually over the same period.

Without major capacity investments, the FHWA estimates that by 2020, 29 percent of urban National Highway System routes will be congested or exceed capacity for much of the day and 42 percent of National Highway System routes will be congested during peak periods. By comparison, only 10 percent of the urban National Highway System routes were congested in 1998.

Urban Interstate highways, the portion of the National Highway System that carries the most freight trucks, are and will continue to be the most traveled segments. The FHWA estimates that the percentage of urban Interstate sections carrying more than 10,000 trucks

[12]http://www.ops.fhwa.dot.gov/freight/freight_news/faf/talkingfreight_faf.htm.

per day will increase from 27 percent in 1998 to 69 percent in 2020.[13] Approximately 53 percent of urban Interstate mileage will be congested in 2020 as compared to about 20 percent today.

These statistics suggest that, as congestion increases in the coming decades, the speed and reliability of truck freight transportation will deteriorate and costs to shippers and receivers may rise.

Other Modes

Other freight transportation modes will carry more freight as the economy grows, but they will complement, not replace, truck freight transportation.

The volume of cargo by air is growing rapidly, but air cargo is limited to lighter, high-value shipments and is only economical over longer distances.

The water transportation system, including coastal and inland-waterway barge service, is critically important for the transportation of heavy, bulky grains, clays, gravels, etc., but water transportation services are restricted to coastal areas and major waterways. The Maritime Administration is working with several states and carriers to explore expanded short-sea shipping services for truck trailers and intermodal containers (e.g., for moves between major international gateways and regional ports), but the provisions of the Jones Act, which restricts most U.S. coastal shipping business to U.S. flag carriers, make rapid expansion of short-sea shipping services unlikely.

The railroads are expanding intermodal freight service, carrying more trailers and domestic and international containers for motor carriers on long-haul moves. Motor carriers such as United Parcel Service are among the railroads' largest customers today. Rail intermodal traffic has been growing steadily and is now the largest source of revenue (although not the most profitable source) for several railroads. However, the railroads' capacity to expand intermodal service quickly while maintaining carload and unit train (bulk) service is limited.

Federal government rescinded economic regulation of the freight railroads in 1980. The railroads responded by reorganizing and downsizing to match the shrinking demand for freight-rail services in the 1980s. However, economic growth over the last decade has absorbed much of the underutilized capacity of the railroads' deregulated and downsized system, and congestion is now increasing at major network choke points. The major freight-rail gateways and corridors thought to be most at risk because of congestion are:

[13] "FAF Capacity Analysis: Scenario Analysis Results Report," prepared by Battelle for the Federal Highway Administration, 2002.

- The **Chicago rail hub**, which is critically important for freight-rail traffic moving from Pacific ports to Midwest and East Coast markets, and Midwest exports moving to U.S. and global markets;
- The **Mid-Atlantic rail network**, which connects the South and Southeast to the Washington D.C.-New York-Boston megalopolis;
- The **Alameda Corridor East**, the second leg of the rail corridor connecting the Ports of Los Angeles and Long Beach to the transnational rail network; and
- The **Pacific Northwest West Coast ("I-5") rail corridor**, which connects British Columbia, Washington State, and Oregon to the large Southern California markets.

New freight-rail capacity is needed to keep pace with the expected growth in the economy and relieve congestion at these major network choke points, but creating this capacity will be a challenge for the railroads. The railroad industry today is stable, productive and competitive, with enough business and profit to operate, but it does not have the resources to replenish its infrastructure quickly or grow rapidly. Productivity and volume have gone up since deregulation of the railroads in 1980, and prices have gone down. But competitive pricing has forced rail revenues down.[14]

AASHTO, in its *Freight-Rail Bottom Line Report*, estimated that the railroads must invest $175 to $195 billion over the next 20 years to address the worst bottlenecks and keep pace with the growth of the economy.[15] AASHTO estimated that the freight railroads are capable of funding about $142 billion of that program, leaving a budget shortfall of up to $53 billion (or $2.65 billion annually). The recent surge in rail demand has made it possible for the railroads to raise their rates and increase earnings and profits, but industry observers do not expect revenues to increase sufficiently to close the longer-term funding gap and ensure that the railroads can keep up with the demand generated by economic growth.

If the freight railroads cannot maintain their current share of national freight, then some rail freight will be shed to trucks on an already congested highway system. This will impose greater costs on state and local highway agencies, which must maintain roads; on highway users, who will experience increasingly congested roads; and on shippers, who will pay higher rates for truck service than they did for rail service.

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[14] American Association of Railroads, "Overview of U.S. Freight Railroads," available at http://www.aar.org/PubCommon/Documents/AboutTheIndustry/Overview.pdf.

[15] Cambridge Systematics, Inc., *Freight-Rail Bottom Line Report*, American Association of State Highway and Transportation Officials, Washington, D.C. January 2003, available at http://freight.transportation.org/doc/ FreightRailReport.pdf.

2.2 Highway Bottlenecks

In an environment of diminishing returns from investments in the Interstate highway system and deregulation of the freight transportation industry, growing highway congestion threatening to undermine trucking productivity, and limitations on the railroad industry's capacity to expand quickly, it is important to look closely at strategies to attack congestion by reclaiming capacity from the existing highway freight system.

As illustrated in Figure 2.9, about 40 percent of the congestion is estimated to be caused by bottlenecks—recurring congestion at locations where the volume of traffic routinely exceeds the capacity of the roadway, resulting in stop-and-go traffic flow and long backups.[16] The balance, about 60 percent of delay, is estimated to be caused by non-recurring congestion, the result of transitory events such as construction work zones, crashes, breakdowns, extreme weather conditions, and suboptimal traffic controls.[17]

This paper focuses on bottlenecks that create recurring congestion. State DOTs and metropolitan planning organizations have identified many of these bottlenecks. The American Highway Users Alliance released a report in 2004 that identified and compared the worst bottlenecks nationally.[18] However, these studies have not looked specifically at how highway bottlenecks affect truck traffic.

The objective of this white paper is to take an initial and comprehensive look at highway truck bottlenecks to answer questions about how many there are, where they are, how many truck hours of delay they cause, and whether they affect long- or short-distance truck trips. This information will help the FHWA consider and shape policies and programs to minimize the delays caused by highway truck bottlenecks.

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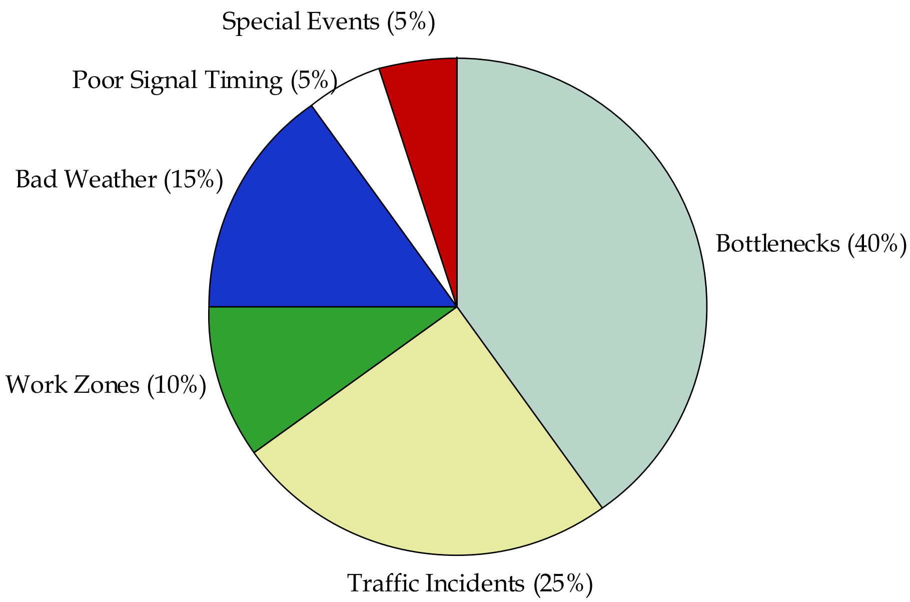
[16] "Traffic Congestion and Reliability: Linking Solutions to Problems," prepared by Cambridge Systematics, Inc. for the Federal Highway Administration, Office of Operations, Washington, D.C., July 2004. See http://www.ops.fhwa.dot.gov/congestion_report/index.htm.

[17] For a detailed analysis of capacity losses and delay caused by transitory events such as construction work zones, crashes, breakdowns, extreme weather conditions, and suboptimal traffic controls, see "Temporary Losses of Highway Capacity and Impacts on Performance." Report prepared for the Federal Highway Administration Office of Operations by S.M. Chin, O. Franzese, D.L. Greene, and H.L. Hwang of the Oak Ridge National Laboratory and R.C. Gibson of The University of Tennessee. Oak Ridge National Laboratory, Knoxville, Tennessee. May 2002.

[18] Unclogging America's Arteries: Effective Relief for Highway Bottlenecks—1999-2004, prepared by Cambridge Systematics, Inc. for the American Highway Users Alliance, Washington, D.C., 2004. See http://www.highways.org/pdfs/bottleneck2004.pdf.

Figure 2.9 Sources of Congestion



Source: "Traffic Congestion and Reliability: Linking Solutions to Problems," prepared by Cambridge Systematics, Inc. for the Federal Highway Administration, Office of Operations, Washington, D.C., July 2004.

3.0 Highway Truck Bottleneck Typology

A typology of truck bottlenecks was developed to categorize bottlenecks clearly and consistently. A typology is necessary to avoid double counting when calculating truck hours of delay and to establish—for future for policy and program analysis work—a framework for attaching strategies and costs for congestion mitigation to each type of bottleneck.

To develop the typology we reviewed relevant literature and information about highway bottlenecks from several sources:

- The findings and recommendations of National Cooperative Highway Research Program (NCHRP) Report 399, *Multimodal Corridor and Capacity Analysis Manual*;
- Research on truck issues and travel patterns conducted for the FHWA Office of Freight Management and Operations under the Freight Analysis Framework program;
- Studies on congestion done for the FHWA Office of Operations' Mobility Monitoring program;
- Prior research for the American Trucking Associations and the FHWA on truck incidents and highway incident management;
- Analysis of large-truck crash patterns provided by the Federal Motor Carrier Safety Administration;
- Information provided by state department of transportation and metropolitan planning organization staff researching urban and rural highway bottlenecks; and
- Professional opinions of motor carrier managers.

For the purposes of this paper, we recommend that highways bottlenecks for trucks be defined by a combination of three features: the type of constraint, the type of roadway, and the type of freight route. The elements for describing bottlenecks are summarized in Table 3.1.

Table 3.1 Truck Bottleneck Typology

Constraint Type	Roadway Type	Freight Route Type
Lane-Drop	Freeway	Intercity Truck Corridor
Interchange	Arterial	Urban Truck Corridor
Intersection/Signal	Collectors/Local Roads	Intermodal Connector
Roadway Geometry		Truck Access Route
Rail Grade Crossing		
Regulatory Barrier		

More detailed definitions of each element are provided below, but as an example, a truck bottleneck may be caused by a lane drop that creates insufficient lane capacity on a freeway used as an intercity truck corridor, or a bottleneck may be caused by lane drop on an arterial that serves as a urban truck corridor. Similarly, a truck bottleneck may be caused by congestion at an interchange on a freeway serving as an intercity truck corridor, or a truck bottleneck may be caused by poorly timed traffic signals at intersections on an arterial road that serves as an urban truck corridor.

Several combinations are not used; for example, neither signalized intersections nor rail grade crossings exist on freeways; and most truck access routes are by definition on arterial roadways or collectors/local roadways, not freeways. Other combinations such as an interchange involving a collector/local road are rare.

Finally, while the paper identified and examines a few bottlenecks on collector/local roads serving as intermodal connectors and truck access routes, because of data limitations, the majority of attention in the paper is focused on bottlenecks that occur on freeways and arterials.

The six capacity constraints are:

1. **Lane-Drop Constraint.** An example of this type of bottleneck would be a lane drop, where a highway narrows from three to two lanes or two lanes to one lane, reducing throughput and creating traffic queues. These bottlenecks typically affect one direction of traffic flow.

2. **Interchange Constraint.** An example of this type of bottleneck would be an urban interchange connecting two Interstate highways (or an interchange connecting an Interstate highway and a major arterial) where the geometry of the interchange, traffic weaving and merging movements, and high volumes of traffic reduce throughput and create traffic queues on the ramps and the mainlines. Severely congested interchanges may cause queues on one or both highways. Where interchanges are closely spaced,

queues from one interchange may create additional bottlenecks at upstream interchanges, producing a series of closely linked bottlenecks.

3. **Intersection/Signal Constraint.** An example of this type of bottleneck would be an urban or suburban arterial road with closely spaced intersections operating at or near capacity, often with poorly timed signals. As with queues at closely spaced interchanges, queues at one congested intersection often impact traffic flow at other intersections upstream of the affected location. These bottlenecks may affect flows in both directions on all intersecting roadways.

4. **Roadway Geometry Constraint.** An example of this type of bottleneck would be a steep hill, where heavily loaded trucks must slow to climb and descend. The total volume of traffic, the number of heavy trucks, the number of lanes, and the presence or absence of an additional climbing lane determine the throughput of these bottlenecks. Other roadway geometry barriers include curves with insufficient turning radii for trucks (usually on two-lane roadways), bridges with gross vehicle weight limits that force trucks to make long detours, and tunnels with reduced overhead or side clearance.

5. **Rail Grade Crossing Constraint.** An example of this type of bottleneck would be a highway-rail at-grade crossing where an urban roadway carrying high volumes of truck traffic crosses a rail line carrying high volumes of passenger or freight trains. Frequent gate closings may cause long traffic queues in both directions on the roadway.

6. **Regulatory Barrier Constraint.** Examples of this type of bottleneck include toll barriers, international border custom inspection stations, and increasingly, security inspection checkpoints. Also included in this category are permanent safety, hazardous materials (hazmat), and weight restrictions that prohibit truck movements across a bridge, through a tunnel, or along a road, forcing trucks to make long detours.

The three roadway types are:

1. **Freeways.** This group includes Interstates, expressways, toll roads, major state highways, and other limited-access (typically divided) highways with multiple lanes and access control.

2. **Arterials.** This group includes major state and city roads. They are typically multi-lane, but not divided roadways. In urban areas, they carry much of the traffic circulating within the urban area.

3. **Collectors/Local Roads.** Collectors are typically two-lane roads that collect and distribute traffic to and from the freeway and arterial systems, proving connections to and among residential neighborhoods and commercial and industrial areas.

The four types of freight routes are:

1. **Intercity Truck Corridors.** Intercity truck corridors are transcontinental and inter-regional routes, using rural Interstate highways and rural state highways. Almost all

these corridors are designated as truck corridors on the National Truck Network and state truck networks.

2. **Urban Truck Corridors.** Urban truck corridors are Interstate highways and major state and city arterials that serve both local distribution and through moves. Most but not all of these corridors are designated as truck corridors on the National Truck Network, and state and city truck networks.

3. **Intermodal Connectors.** Intermodal connectors are the "last mile" of National Highway System roadway connecting major port, airport, rail, or truck terminals to intercity routes.

4. **Truck Access Routes.** Truck access routes include designated truck routes to industrial or commercial zones, warehousing and distribution centers, central business districts, and suburban centers. The category includes local, urban, and rural routes not designated as urban truck corridors or intermodal connectors.

The typology is not exhaustive. The categories have been designed so that they can be broadened when additional detail is needed for future studies. For example, roadway capacity constraints could be expanded to include temporary operational constraints such as roadway construction work zones and emergency closures for crashes and other incidents. These are not addressed in this white paper because comprehensive, nationwide data on these capacity constraints is not readily available. Similarly, the category "freeways" could be subdivided into its component roadways—Interstates, expressways, toll roads, major state highways, other limited-access highways—and engineering cost estimates assigned to each.

In urban areas, the categories also could be described by their role in an urban system. For example, freeway/urban truck corridors could be further defined as circumferential urban Interstate highways or as radial arterial roadways used as urban truck corridors, etc. Greater definition would require detailed examination of each bottleneck in the context of a metropolitan map.

More definition also could be provided for the type of freight route. This was not done for the initial typology because data were not readily available to clearly differentiate freight route functions. A capacity bottleneck on a rural Interstate highway can be readily classified as impacting an intercity truck corridor. However, a capacity bottleneck on an urban Interstate highway such as a circumferential beltway may affect transcontinental truck trips, intraregional truck trips, metropolitan distribution trips, and local pickup and delivery operations. Most urban truck corridors serve two or more of these functions. Information on the length of the truck trips passing through the bottleneck may indicate whether the majority of trips are longer or shorter, but in most cases does not clearly differentiate the type of freight route.

4.0 Methodology

This section describes the data and analytical methods used to locate highway truck bottlenecks and calculate truck hours of delay. The analysis involved three steps:

1. Locating highway bottlenecks;

2. Determining truck volumes at the bottlenecks; and

3. Estimating truck hours of delay at the bottlenecks.

4.1 Locating Highway Bottlenecks

The first step was to locate highway truck bottlenecks. The bottlenecks were located by scanning the FHWA Highway Performance Monitoring System (HPMS) database for highway sections that were highly congested as indicated by a high volume of traffic in proportion to the available roadway capacity (the volume-to-capacity ratio).

The information in the HPMS database is submitted by State DOTs and compiled by the FHWA annually. The HPMS database describes physical and traffic conditions for all major roads in the United States. For reporting purposes, the roadways are divided into sections. The average HPMS roadway section in urban areas is 0.7 miles long. In rural areas HPMS roadway sections are longer; they average 2 miles long and can range up to 20 miles or more in length in very isolated areas.

The HPMS has two databases: the Universe database, which reports physical and traffic conditions on all sections on all major roads, providing about 30 data elements describing each highway section; and the Sample database, which covers a limited number of roadway sections, but provides over 100 data elements for each section. These sections are a statistically selected sample, designed so that information reported on traffic volumes and conditions in the sample sections can be extrapolated to represent other similar, but unsampled, sections.

The HPMS 2002 Universe database was used to scan for interchange bottlenecks on urban Interstate highway sections. From prior work with the HPMS, we knew that almost all urban Interstate interchanges or their adjoining sections were represented in the Universe database. The HPMS Universe database reports traffic volumes for each section but not highway capacity. Capacity was calculated from information on the type of roadway, number of lanes, and default values for lane width, shoulder width, and percent trucks.

After the initial scan, these capacity estimates were replaced with more refined estimates of capacity provided by Battelle. These were calculated by identifying the nearest HPMS Sample section, then extrapolating detailed information from the Sample section to the Universe section to more accurately estimate capacity. The refined capacity estimates provided by Battelle were used in all subsequent delay calculations.

The HPMS 2002 Sample database was used to scan for lane-drop, signalized-intersection, and steep-grade bottlenecks on rural Interstate highway sections, rural arterial roads, and urban arterials. The HPMS Sample database was used because it provides more detailed information with which to calculate highway section capacity. The designs of rural Interstate highway sections, rural arterial roads, and urban arterials vary considerably. Using default capacity values and the limited information in the HPMS Universe database, as was done for the more uniform urban Interstate highway sections, does not produce consistently reliable capacity estimates for rural Interstate highway sections, rural arterial roads, and urban arterials. The more detailed HPMS Sample database produces better capacity estimates; however, the HPMS Sample database covers a limited number of highway sections. Therefore, we were able to identify bottlenecks only on those roadway sections that were covered by the HPMS Sample database.[1]

The specifics of each scan are as follows:

- Interchange capacity bottlenecks and other roadway capacity bottlenecks on urban freeways. An initial set of urban freeway bottlenecks was identified as part of an earlier study of bottlenecks commissioned by the American Highway Users Alliance (AHUA).[2] For that study, Cambridge Systematics developed a brief questionnaire that was distributed to all state departments of transportation by the American Association of State Highway and Transportation Officials (AASHTO). The state DOTs were asked to provide information about the worst traffic bottlenecks within their jurisdictions. Twenty-four states responded, identifying about 100 bottlenecks, most of which where urban Interstate interchanges. To supplement the state DOT nominations, an automated scan was run on the HPMS Universe database as part of the AHUA study. That scan identified an additional 150 potential bottlenecks, again primarily interchanges on urban freeways. The HPMS Universe database was rescanned for this white paper using the 2002 HPMS data.

  After the initial scan, Battelle used geographic information system (GIS) technology to map the locations of the sections. With this information, two refinements were made. First, section locations were compared to interchange locations. Where an HPMS Universe section identified in the scan was found to be upstream or downstream of the

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[1] Additional roadway capacity, intersection/signal capacity, and steep grade bottlenecks on rural Interstate highway sections, rural arterial roads, and urban arterials could be identified by scanning individual state roadway databases which provide greater coverage and more detailed data than are reported to the HPMS.

[2] Cambridge Systematics, Inc., *Unclogging America's Arteries: Effective Relief for Highway Bottlenecks, 1999-2004*, American Highway Users Alliance, Washington, D.C., February 2004.

actual interchange location, Battelle identified the HPMS Universe section closest to the interchange. Second, Battelle identified the HPMS Sample sections closest to the HPMS Universe sections. Battelle used the more detailed HPMS Sample section information to refine the estimates of capacity for the HPMS Universe section. These refined capacity estimates were used in all subsequent delay calculations for the interchange bottlenecks.

- Lane-drop bottlenecks. Roadway capacity bottlenecks on rural Interstate highway sections, rural arterial roads, and urban arterials without signals were identified using the HPMS Sample database. Sections with a volume-to-capacity ratio greater than 0.925 (highly congested) were selected for further analysis.

- Signalized intersection bottlenecks. The HPMS Sample database also was used to scan arterials and locate highly congested signalized intersections. Again, sections with a volume-to-capacity ratio greater than 0.925 (highly congested) were selected for further analysis.

- Steep-grade bottlenecks. Steep grades on interstates and arterials were identified by scanning the HPMS Sample database for roadway sections with grades greater than 4.5 percent and more than a mile long.

Section 5.0 summarizes the findings of the scans. The urban Interstate interchange bottlenecks are summarized in Section 5.0 and listed in Appendix A. The steep-grade, signalized-intersection, and lane-drop bottlenecks are listed in Appendices B, C, and D, respectively. No scans were conducted for rail grade-crossing bottlenecks or regulatory barrier bottlenecks such as those at international border crossings.[3]

4.2 Determining Truck Volumes at the Bottlenecks

The second step in calculating truck hours of delay was to determine the number of trucks passing through the bottlenecks. The earlier AHUA study did not differentiate automobiles from trucks in calculating the vehicle hours of delay caused by the bottlenecks.

Two sources of truck volume data were used: the FHWA Freight Analysis Framework (FAF) database was used to identify truck volumes for the interchange bottlenecks; and the HPMS Sample database was used to calculate trucks volumes for the roadway capacity,

[3] State DOTs' roadway data inventory databases contain information on highway-rail at-grade crossings, but the information on train and truck traffic volumes by time of day, which is needed to calculate truck hours of delay at these crossings, must be collected for each crossing. This could not be done within the scope and budget of this white paper. The General Services Administration, working with U.S. Customs and Border Protection, collects data on automobile and truck volumes and delays at most major U.S./Canada and U.S./Mexico border crossings; however, because of the increased concern about terrorism, GSA has been reluctant to release this data.

intersection/signal capacity, and steep grade bottlenecks. The next sections describe the databases, their strengths and weaknesses for the purposes of this paper, and how the truck volumes were estimated.

The FAF Database

The FAF is a database of county-to-county freight flows over the national highway, railroad, water, and air freight networks. The FAF is based on public and private surveys and estimates of the tonnage of freight moving into and out of each county. The freight movements are described by commodity type and mode. The commodity tonnage estimates in the FAF are tied to national, regional, and industry economic input-output models so that future year freight flows can be estimated from anticipated industry growth rates.[4] For commodities shipped by truck, commodity tonnage is divided by the average truck payload for each commodity to estimate the number of truck trips generated or attracted annually by each county.

The current and forecast county-to-county truck trips are then assigned to a FAF highway network. The FAF highway network is a subset of the National Highway Planning Network (NHPN); it includes the Interstate highway system, most major state highways, and many, but not all, urban and rural arterials. The major product of the FAF is an estimate of freight flows—in tons, trucks, and value—over each highway section in the FAF highway network.

Using the FAF database, Battelle identified the volume of "all trucks," "FAF trucks," and "non-FAF trucks" at each of the urban Interstate interchange bottlenecks. While not a precise distinction, the "FAF trucks" represent national and regional, longer-distance truck moves while the "non-FAF trucks" represent metropolitan and local, shorter-distance truck moves. The "FAF trucks" are estimated from the county-to-county commodity flows. The "non-FAF trucks" are estimated by subtracting the "FAF trucks" on each highway from the total of "all trucks" as counted and reported by the state DOT for the HPMS Universe or Sample database section. For the purposes of this white paper, "FAF trucks" are described as "large trucks making longer-distance trips."

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[4] Information about the Freight Analysis Framework (FAF) is available at http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm. The report, "Derivation of FAF Database and Forecast (April 2002)," prepared by Battelle, Reebie Associates, Wilbur Smith Associates, and Global Insight for the FHWA Office of Freight Management and Operations and available on the FHWA web site, describes the methodology and data sources for the development of the FAF commodity and freight movement database. The companion report, "Freight Analysis Framework Highway Capacity Analysis: Methodology Report" (April 2002), prepared by Battelle for the FHWA Office of Freight Management and Operations and also available on the FHWA web site, describes the methodology and data sources for the development of the FAF highway network and assignment of truck trips to the network.

The FAF produces reasonably accurate estimates of the number of longer-distance, large-truck trips along major highway corridors, but it cannot estimate accurately the volume of trucks moving on specific roadways, especially on lower-volume roads. The FAF was designed as a national-level freight analysis tool, not a project-level analysis tool. To ensure that data collection and computation were manageable at the national level, the FAF was constructed using county-to-county commodity flow data, which does not include many local, intracounty truck trips, and assumed that all freight shipments originate or terminate at a single central point (centroid) in a county. Using a single centroid in each county as the origin and destination point for truck trips means that trips are routed from the centroid to the nearest major roadway instead of being routed along actual local roads and arterials.

As a result, fewer truck trips are assigned to local roads and arterials and more to major highways. This problem is magnified by the well-known shortcomings of transportation model traffic-assignment procedures. These procedures tend to route longer-distance trips over the most direct major highway when actual truck trips may take parallel and more circuitous routes to pick-up or drop-off shipments, avoid tolls, etc. To address this problem, Battelle checked the FAF assignments against HPMS data and reviewed the results with State DOT staff. Where significant discrepancies were found, the estimated FAF truck volumes were adjusted to correspond to actual on-the-road truck counts.

To compensate for the lack of precision in estimating the number of "FAF trucks" on specific roadways, the number of "FAF trucks" at urban Interstate interchanges were estimated by multiplying the volume of "all trucks" on a bottleneck section by the average percentage of "FAF trucks" in the surrounding urbanized area. The percentage of "FAF trucks" in the urbanized area was calculated by summing "FAF truck" vehicle miles of travel in the urbanized area and dividing by the sum of "all truck" vehicle miles of travel in the urbanized area, as reported in the FAF database.

A similar procedure was used to estimate the percentage of "FAF trucks" making trips longer than 500 miles. The percentage of "FAF trucks" making trips longer than 500 miles was calculated by summing "FAF truck" vehicle miles of travel in the urbanized area for "FAF trucks" making trips longer than 500 miles and dividing by the sum of all "FAF truck" vehicle miles of travel in the urbanized area. The procedure helps identify bottlenecks that delay long-distance freight moves, but does not differentiate between long-distance truck trips that are caught in a bottleneck as they pass though the urbanized area and long-distance truck trips that are caught in a bottleneck because the trip originates or terminates within the urbanized area.[5]

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[5] Select link analysis procedures can be used to estimate the full distribution of the trip lengths of trucks caught in a specific bottleneck. Select link analysis determines all the travel paths that could use the bottleneck (i.e., the selected link), then extracts and cumulates the data for each of the trips actually using the select link. The procedure is time and computation intensive and was not done for this initial scan of bottlenecks.

The final step in the analysis process was to estimate the tonnage and value of the commodities moving through the bottlenecks. Battelle identified the commodity tonnage and value for all "FAF trucks" for each of the interchange bottlenecks. These data were used to calculate average commodity tonnage and average commodity value per "FAF truck" and applied to the estimated number of "FAF trucks" and "FAF trucks" making trips longer than 500 miles.

The FAF truck volumes and commodity tonnage and value estimates were based on 1998 data. The FAF estimates were adjusted to 2004 by interpolating the 1998 and 2010 FAF truck volumes.

The HPMS Sample Database

Since most of the lane-drop, signalized-intersection, and steep-grade bottlenecks are on lower-volume highways and arterials, the HPMS Sample database was use to calculate truck volumes for these bottlenecks. The HPMS Sample database provides data on total traffic volume and estimates the percentage of trucks. The HPMS estimates of the percentage of trucks are more consistent than the FAF database estimates for lower-volume highways and arterials; however, the accuracy and reliability of the HPMS estimates vary by state and type of roadway. Some states conduct extensive truck counts and classifications; some conduct infrequent counts and estimate trucks between counts; and yet others apply a statewide "average percentage trucks" to estimate truck volumes for HPMS sections.

The HPMS truck volumes were calculated using 2002 data. The HPMS volumes were adjusted to 2004 using traffic growth factors for each highway section provided by the state DOTs as a part of the HPMS reporting program.

■ 4.3 Estimating Truck Hours of Delay at the Bottlenecks

The third step in the analysis process was to calculate truck hours of delay at each bottleneck. The calculations were based on predictive equations constructed using a simplified queuing-based model, QSIM, developed by Richard Margiotta, Harry Cohen, and Patrick DeCorla-Souza.[6] QSIM incorporates several features, including:

[6] 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. For copies of the paper, contact the author, Richard Margiotta, through the Cambridge Systematics web site "Contact Us" page at www.camsys.com/conta02.htm.

- Use of queuing analysis to determine delay in oversaturated conditions (queues are carried over into successive time periods and delay in queues is tracked);
- Use of temporal distributions as a basis for developing hourly traffic estimates;
- Estimation of peak spreading;
- Accounting for daily variation in traffic by allowing hourly traffic estimates to vary stochastically;
- For freeways, the inclusion of a capacity drop after flow has broken down (i.e., after the onset of queuing);
- For arterials, considering the effects of signal density and progression;
- Separate functions to estimate speeds in queuing and free-flow conditions based on relationships developed with microscopic traffic simulation models;
- Use of the concept of highway capacity to determine when traffic operates under free-flow and queuing conditions as well as a basis for estimating free-flow speeds and the extent of queuing on the test link; and
- Estimating delay rather than speed as the predictive variable. (Speed is then developed as a function of delay and free-flow speed.)

The model was used to develop a dataset from which a series of predictive equations were developed. The equations use only a few, readily available independent variables for each bottlenecks: annual average daily traffic (AADT), roadway capacity, signal density, and signal progression. The output variable for these equations is "hours of delay per 1,000 vehicle-miles" at each bottleneck. Total truck delay was found by multiplying this value by truck vehicle miles of travel for the bottleneck location. Only the "daily" delay for weekday/weekend combined was considered in this analysis.

The method has been incorporated into the FHWA's Surface Transportation Efficiency Analysis Model (STEAM) and Highway Economic Requirements System (HERS) models. The method is similar in concept to the one used by the Texas Transportation Institute in developing data on national congestion trends, but the development of the method was more detailed for this analysis, particularly with regard to queuing.

Limitations

Delay at Interchange Bottlenecks

At interchanges, the scan identified only the critically congested roadway and the corresponding two-way truck traffic volumes on that roadway. The delay estimation methodology calculates delay resulting from queuing on the critically congested roadway and adjacent highway sections; however, it does not calculate delay on the other roadway at the interchange. This means that truck hours of delay are calculated on only one of the two intersecting highways or two of the four legs on a interchange, probably underreporting total delay at the interchange. The bottleneck delay estimation methodology also does not account for the effects of weaving and merging at interchanges, which aggravate delay, but cannot be calculated from the available HPMS and FAF data.

The Ohio Department of Transportation has commissioned research to develop a more comprehensive delay estimation method based on detailed case studies of congested urban Interstate interchanges in Ohio.[7] When the results of this research are available, it should be possible to improve the truck-hours-of-delay estimates reported in this white paper.

Incident Delay

The analysis does not account adequately for variability in delay, especially for variability caused by nonrecurring congestion (i.e., congestion caused by incidents and crashes). Much of the delay accruing to trucks, especially in urban areas, is caused by nonrecurring incidents. This type of delay is a major factor in determining the reliability of travel times. Information on the patterns and variability of recurring and nonrecurring urban congestion are being developed under the FHWA's Mobility Monitoring project, but are only available for selected freeways in 29 urban areas and could not be used for this scan.

Truck Exposure to Delay

The calculation of truck hours of delay does not account for actual truck exposure to congestion. The HPMS and FAF databases report annual average daily traffic (AADT) volumes, not hourly traffic volumes. The calculations assume that truck trips are distributed across a 24-hour day much as passenger car trips are; e.g., the highest volume of trips are made in the morning and evening peak periods. However, most motor carriers work aggressively to schedule and route their truck moves outside of peak periods and around known bottlenecks. Truck volumes typically peak during the midday, especially on urban Interstate highways, and are relatively high in the early morning and at night compared to automobile volumes. This suggests that only a portion of the trucks reported in HPMS and FAF may be exposed to the full impact of peak-period congestion; however, the HPMS and FAF do not have information on the distribution of truck trips by time of day. The truck hours of delay reported in this white paper provide a good index to the relative impact of the bottlenecks, but not reliable absolute numbers.

Expansion of Delay Estimates Based on HPMS Sample Data

The statistical-sample framework that underlies the HPMS database is based on volume, mileage, road classification, and state. Volume-related data such as truck hours of delay for the HPMS Sample section bottlenecks can be expanded statistically to estimate total truck hours of delay for all HPMS roadways for all states, but data such as the number of

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[7] "Freight, Mobility, Access, and Safety" research project being conducted by Cambridge Systematics for the Ohio Department of Transportation, Office of Research and Development. State job number: 134167; anticipated completion date, summer 2005.

bottlenecks cannot be expanded. This means that while the analysis can identify the number of bottlenecks within the HPMS Sample sections, calculate the truck hours of delay at these bottlenecks, and extrapolate the delay hours to estimate the total, national truck hours of delay for a category of bottlenecks, it cannot identify the total number of bottlenecks or the location of bottlenecks other than those in Sample sections. This also means that the analysis may not have identified the worst lane-drop, signalized intersection, and steep-grade bottlenecks.

5.0 Highway Truck Bottlenecks

5.1 Overview

We located and estimated truck hours of delay for 14 types of highway truck bottlenecks. Table 5.1 lists the types of bottlenecks and the annual truck hours of delay associated with each type. The bottleneck types are sorted in descending order of truck hours of delay by constraint type (e.g., interchange, geometry, intersection, and capacity) and then within each group by the truck hours of delay for each bottleneck type.

Table 5.1 Truck Hours of Delay by Type of Highway Freight Bottleneck

Bottleneck Type			National Annual Truck Hours of Delay, 2004 (Estimated)
Constraint	**Roadway**	**Freight Route**	
Interchange	Freeway	Urban Freight Corridor	123,895,000
			Subtotal **123,895,000***
Steep Grade	Arterial	Intercity Freight Corridor	40,647,000
Steep Grade	Freeway	Intercity Freight Corridor	23,260,000
Steep Grade	Arterial	Urban Freight Corridor	1,509,000
Steep Grade	Arterial	Truck Access Route	303,000
			Subtotal **65,718,000‡**
Signalized Intersection	Arterial	Urban Freight Corridor	24,977,000
Signalized Intersection	Arterial	Intercity Freight Corridor	11,148,000
Signalized Intersection	Arterial	Truck Access Route	6,521,000
Signalized Intersection	Arterial	Intermodal Connector	468,000
			Subtotal **43,113,000‡**
Lane Drop	Freeway	Intercity Freight Corridor	5,221,000
Lane Drop	Arterial	Intercity Freight Corridor	3,694,000
Lane Drop	Arterial	Urban Freight Corridor	1,665,000
Lane Drop	Arterial	Truck Access Route	41,000
Lane Drop	Arterial	Intermodal Connector	3,000
			Subtotal **10,622,000‡**
			Total 243,032,000

* The delay estimation methodology calculated delay resulting from queuing on the critically congested roadway of the interchange (as identified by the scan) and the immediately adjacent highway sections. Estimates of truck hours of delay are based on two-way traffic volumes. However, the methodology did not calculate delay on the other roadway at the interchange. This means that truck hours of delay were calculated on only one of the two intersecting highways or two of the four legs on a interchange, probably underreporting total delay at the interchange. The bottleneck delay estimation methodology also did not account for the effects of weaving and merging at interchanges, which aggravates delay, but could not be calculated from the available HPMS data. Estimates have been rounded to the nearest thousand.

‡ The HPMS sampling framework supports expansion of volume-based data from these sample sections to a national estimate, but does not support direct estimation of the number of bottlenecks. Estimates of truck hours of delay are based on two-way traffic volumes. Estimates have been rounded to the nearest thousand.

Source: Cambridge Systematics.

The bottlenecks accrue 243 million hours of delay annually. At a delay cost of $32.15 per hour, the conservative value used by the FHWA's Highway Economic Requirements System model for estimating national highway costs and benefits, the direct user cost of the bottlenecks is about $7.8 billion per year.[1]

The individual bottlenecks in each category are unique and assigned to only one bottleneck type or category. Bottlenecks are not double counted across categories.

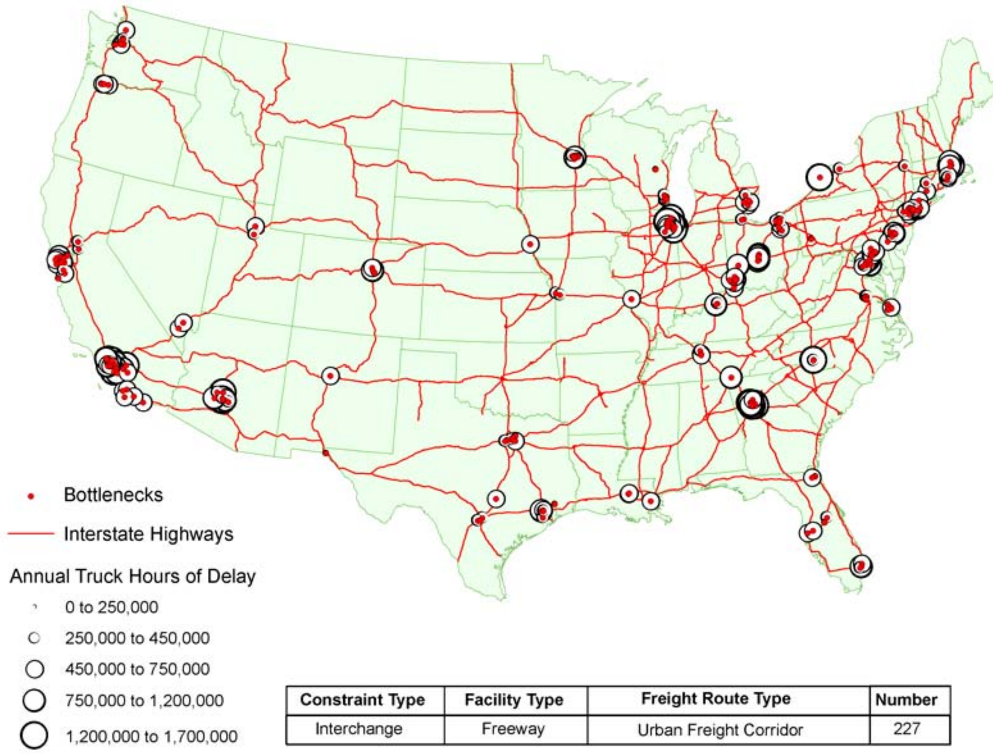
5.2 Interchange Bottlenecks for Trucks

We located 227 interchange bottlenecks on freeways serving as urban freeway corridors. Most of these bottlenecks were at urban Interstate interchanges. The interchange bottlenecks include freeway-to-freeway interchanges and freeway-to-arterial interchanges. The bottlenecks were located by scanning the HPMS Universe database and represent a reasonably complete national inventory of this type of bottleneck. The total delay associated nationally with these bottlenecks in 2004 was estimated at about 124 million truck hours or 51 percent of the estimated total. At a delay cost of $32.15 per hour, the direct user cost of the bottlenecks is about $4 billion per year. The truck hours of delay were estimated using truck volumes and highway capacity calculations drawn from the FHWA's Freight Analysis Framework (FAF) database by Battelle.

Figure 5.1 shows the location of ***all highway interchange bottlenecks for trucks***. The bottleneck locations are indicated by a solid dot. Most are located on urban Interstate interchanges. The size of the open circles accompanying each dot indicates the relative annual truck hours of delay associated with the bottleneck.

[1] The FHWA Highway Economic Requirements System model uses a current value of truck time of $32.15 per hour. Other researchers have suggested higher rates, typically between $60 and $70 per hour.

Figure 5.1 Interchange Capacity Bottlenecks on Freeways Used as Urban Truck Corridors

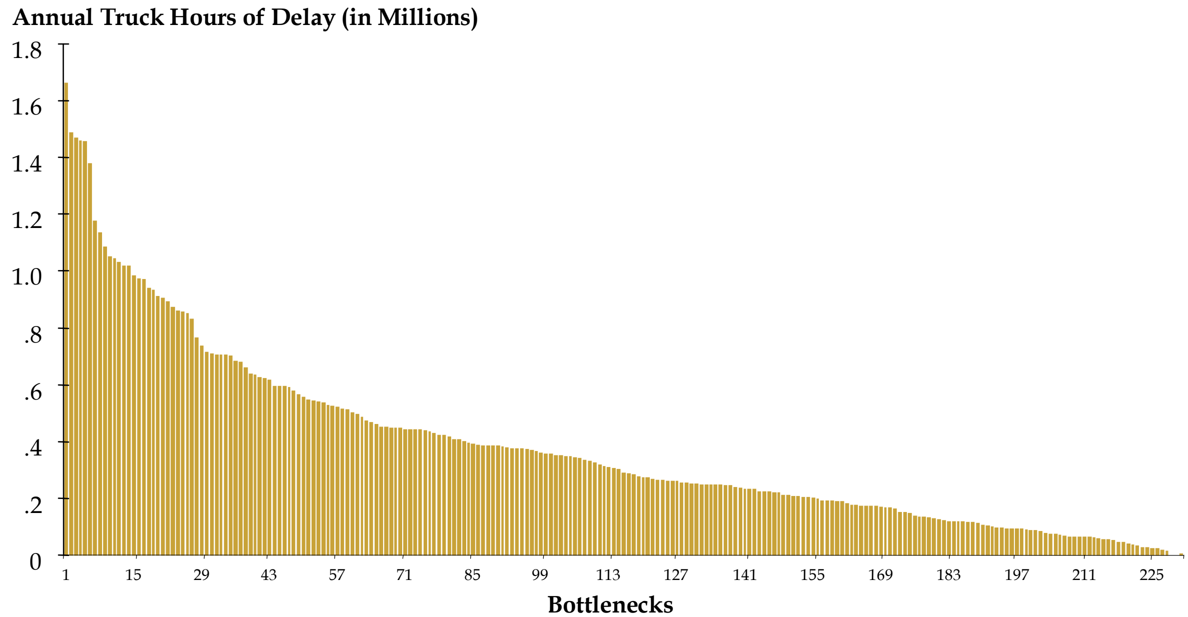


Constraint Type	Facility Type	Freight Route Type	Number
Interchange	Freeway	Urban Freight Corridor	227

Source: Cambridge Systematics, Inc.

Figure 5.2 is a histogram showing the distribution of truck hours of delay for ***all highway interchange bottlenecks for trucks***. The individual bottlenecks, each represented on the horizontal axis by an identification number, are sorted in descending order of annual truck hours of delay, which are measured on the vertical axis. Of the 227 highway interchange bottlenecks, 173 cause more than 250,000 truck hours of delay annually (equivalent to a direct user cost of about $8 million per year). By comparison only a few dozen of all the other truck bottlenecks cause more than 250,000 truck hours of delay annually.

Figure 5.2 Distribution of Annual Truck Hours of Delay at Highway Interchange Bottlenecks, 2004



Source: Cambridge Systematics, based on FHWA Freight Analysis Framework data.

The delay estimation methodology calculated truck delay resulting from queuing on the critically congested roadway of the interchange (as identified by the scan) and the immediately adjacent highway sections. It did not calculate delay on the other roadway at the interchange. This means that truck hours of delay were calculated on only one of the two intersecting highways or two of the four legs on a interchange, potentially underreporting total delay at the interchange. The bottleneck delay estimation methodology also did not account for the effects of weaving and merging at interchanges, which aggravates delay, but could not be calculated from the available HPMS data.

The next two tables list the top highway interchange bottlenecks for trucks. Table 5.2 lists the top 25 interchange bottlenecks ranked by annual hours of delay for ***all trucks***. Table 5.3 lists the top 25 interchange bottlenecks ranked by annual hours of delay for ***large trucks making trip greater than 500 miles***.

There is overlap between the tables, but the ranking by all trucks tends to flag interchanges in the nation's major freight hubs and trade gateways that serve high volumes of metropolitan and intercity truck traffic. The ranking by large trucks making trips greater than 500 miles tends to flag interchange bottlenecks that sit astride many of the key intersections of the nation's long-haul and transcontinental freight corridors.

In the tables, AADT is the abbreviation for Annual Average Daily Traffic, the number of vehicles, including automobiles and trucks of all sizes, traveling the critically congested roadway each day. AADTT is the abbreviation for Annual Average Daily Truck Traffic, the number of trucks of all sizes traveling the critically congested roadway each day.

For comparison, Table 5.4 lists the top 25 most congested highway interchanges as identified in the American Highway Users Alliance study. These bottlenecks are ranked in descending order of annual hours of delay for all vehicles, including trucks.

Appendix A provides the full set of tables—as listed in Table 5.5—along with detailed definitions of each of the column headings and information about the sources of the data reported in the tables.

Table 5.2 Top 25 Highway Interchange Bottlenecks for Trucks

*Ranked By Annual Hours of Delay for All Trucks**

				2004											
Bottleneck				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-90 @ I-290	Buffalo-Niagara Falls	90	4	136,500	8.3	33,100	24%	1,661,900	7,300	22%	367,000	2,632,500	$2,968,000	58%	212,900
I-285 @ I-85 Interchange ("Spaghetti Junction")	Atlanta	285	8	265,300	10.0	27,100	10%	1,641,200	7,800	29%	472,600	2,943,700	$3,262,000	52%	245,800
I-17 (Black Canyon Fwy): I-10 Interchange (the "Stack") to Cactus	Phoenix	17	6	217,300	9.2	28,900	13%	1,608,500	9,000	31%	501,600	3,326,700	$3,792,000	48%	240,800
I-90/94 @ I-290 Interchange ("Circle Interchange")	Chicago-Northwestern IN	90	8	305,800	9.7	26,300	9%	1,544,900	9,200	35%	540,400	3,718,000	$4,218,000	53%	286,400
San Bernardino Fwy	Los Angeles	10	8	268,700	7.2	34,900	13%	1,522,800	11,200	32%	488,700	4,094,500	$4,780,000	31%	151,500
I-94 (Dan Ryan Expwy) @ I-90 Skyway Split (Southside)	Chicago-Northwestern IN	94	8	271,700	7.9	31,600	12%	1,512,900	11,100	35%	531,500	4,485,900	$5,089,000	53%	281,700
I-285 @ I-75 Interchange	Atlanta	285	6	226,300	9.6	25,700	11%	1,497,300	7,400	29%	431,500	2,792,800	$3,095,000	52%	224,400
SR 134 @ SR 2 Interchange	Los Angeles	134	8	247,900	8.3	29,600	12%	1,489,400	9,500	32%	477,500	3,473,000	$4,054,000	31%	148,000
I-77 @ Tryon Rd	Charlotte	77	6	170,500	8.3	29,600	17%	1,487,100	7,300	25%	367,000	2,700,200	$2,983,000	45%	165,200
Long Beach Fwy	Los Angeles	710	8	246,100	8.3	27,500	11%	1,380,300	8,800	32%	442,400	3,217,100	$3,756,000	31%	137,100
I-20 @ I-285 Interchange	Atlanta	20	6	187,200	8.3	27,000	14%	1,359,400	7,800	29%	392,100	2,943,700	$3,262,000	52%	203,900
I-80/I-94 split (Southside)	Chicago-Northwestern IN	80	4	139,600	8.6	25,600	18%	1,343,600	9,000	35%	472,400	3,637,200	$4,127,000	53%	250,400
SR 60 @ I-605 Interchange	Los Angeles	60	8	233,000	8.3	26,100	11%	1,314,200	8,400	32%	422,300	3,070,900	$3,585,000	31%	130,900
Pulaski Rd @ I-55	Chicago-Northwestern IN	55	6	197,200	7.5	28,700	15%	1,300,400	10,000	35%	453,700	4,041,300	$4,585,000	53%	240,500

Table 5.2 Top 25 Highway Interchange Bottlenecks for Trucks (continued)

*Ranked By Annual Hours of Delay for All Trucks**

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-75 @ I-85 Interchange	Atlanta	75	10	339,600	9.1	23,400	7%	1,288,800	6,800	29%	374,900	2,566,300	$2,844,000	52%	194,900
I-93 @ I-95 Interchange	Boston	93	6	188,400	8.3	25,500	14%	1,280,100	2,800	11%	140,800	1,020,000	$1,220,000	36%	50,700
I-290 @ I-355	Chicago-Northwestern IN	290	6	223,100	8.3	24,800	11%	1,246,200	8,700	35%	437,300	3,515,900	$3,989,000	53%	231,800
I-405 (San Diego Fwy) @ I-605 Interchange	Los Angeles	405	10	331,700	9.8	20,900	6%	1,245,500	6,700	32%	398,600	2,449,400	$2,859,000	31%	123,600
I-80 @ Central St.	San Francisco-Oakland	80	8	270,200	8.3	23,800	9%	1,196,700	7,800	33%	392,100	2,851,500	$3,329,000	29%	113,700
San Gabriel River Fwy	Los Angeles	91	10	295,700	8.1	24,100	8%	1,194,300	7,700	32%	381,100	2,815,000	$3,286,000	31%	118,100
I-20 @ Fulton St.	Atlanta	20	6	207,300	8.1	23,700	11%	1,172,700	6,800	29%	336,500	2,566,300	$2,844,000	52%	175,000

* Annual Hours of Delay for All Trucks is the number of hours of delay accruing annually to all trucks delayed by congestion at the bottleneck. (e.g., Daily Minutes of Delay per Vehicle multiplied by 2004 AADTT for All Trucks). Because the underlying Highway Performance Monitoring System data do not detail traffic counts by time of day, the actual number of trucks exposed to peak-period congestion is unknown, and therefore the reported truck hours of delay shown here provide good index to the relative impacts of the bottlenecks, but are not reliable absolute numbers.

Table 5.3 Top 25 Highway Interchange Bottlenecks for Trucks

*Ranked By Annual Hours of Delay for Large Trucks Making Trips Longer Than 500 Miles**

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-24 @ I-440N Interchange	Chattanooga (TN-GA)	24	4	118,200	8.3	18,500	16%	927,500	9,200	50%	462,500	3,330,000	$3,750,000	85%	393,100
U.S. 95 @ I 15 Interchange ("Spaghetti Bowl")	Las Vegas	95	6	199,900	9.8	11,300	6%	670,400	5,600	50%	333,100	1,992,500	$2,286,000	90%	299,800
I-90/94 @ I-290 Interchange ("Circle Interchange")	Chicago-Northwestern IN	90	8	305,800	9.7	26,300	9%	1,544,900	9,200	35%	540,400	3,718,000	$4,218,000	53%	286,400
I-94 (Dan Ryan Expwy) @ I-90 Skyway Split (Southside)	Chicago-Northwestern IN	94	8	271,700	7.9	31,600	12%	1,512,900	11,100	35%	531,500	4,485,900	$5,089,000	53%	281,700
I-75 @ I-74 Interchange	Cincinnati (OH-KY)	75	6	193,100	9.7	19,200	10%	1,128,900	6,900	36%	405,300	2,735,200	$3,044,000	63%	255,300
I-10 @ I-110 Interchange	Baton Rouge	10	6	150,400	7.2	15,200	10%	665,000	8,600	57%	375,200	3,163,900	$3,591,000	68%	255,100
I-80/I-94 split (Southside)	Chicago-Northwestern IN	80	4	139,600	8.6	25,600	18%	1,343,600	9,000	35%	472,400	3,637,200	$4,127,000	53%	250,400
I-285 @ I-85 Interchange ("Spaghetti Junction")	Atlanta	285	8	265,300	10.0	27,100	10%	1,641,200	7,800	29%	472,600	2,943,700	$3,262,000	52%	245,800
I-17 (Black Canyon Fwy): I-10 Interchange (the "Stack") to Cactus	Phoenix	17	6	217,300	9.2	28,900	13%	1,608,500	9,000	31%	501,600	3,326,700	$3,792,000	48%	240,800
Pulaski Rd @ I-55	Chicago-Northwestern IN	55	6	197,200	7.5	28,700	15%	1,300,400	10,000	35%	453,700	4,041,300	$4,585,000	53%	240,500
I-290 @ I-355	Chicago-Northwestern IN	290	6	223,100	8.3	24,800	11%	1,246,200	8,700	35%	437,300	3,515,900	$3,989,000	53%	231,800

Table 5.3 Top 25 Highway Interchange Bottlenecks for Trucks (continued)

*Ranked By Annual Hours of Delay for Large Trucks Making Trips Longer Than 500 Miles**

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-40 @ I-24 Interchange	Nashville	40	4	147,600	8.3	14,600	10%	735,200	5,800	40%	291,600	2,099,300	$2,364,000	77%	224,500
I-285 @ I-75 Interchange	Atlanta	285	6	226,300	9.6	25,700	11%	1,497,300	7,400	29%	431,500	2,792,800	$3,095,000	52%	224,400
I-35 @ Martin Luther King Jr	Austin	35	6	229,500	8.3	12,600	5%	635,000	11,200	89%	563,000	4,123,900	$4,768,000	39%	219,600
I-15 between Tropicana and Flamingo	Las Vegas	15	6	165,900	6.4	12,400	7%	486,700	6,200	50%	242,800	2,206,000	$2,530,000	90%	218,500
I-12 @ Amite River, Baton Rouge	Baton Rouge	12	4	105,000	6.4	14,400	14%	561,900	8,100	57%	317,200	2,980,000	$3,383,000	68%	215,700
I-75 @ U.S. 35 Interchange	Dayton	75	4	127,400	8.3	18,400	14%	923,100	7,900	43%	397,100	3,131,600	$3,485,000	54%	214,400
I-90 @ I-290	Buffalo-Niagara Falls	90	4	136,500	8.3	33,100	24%	1,661,900	7,300	22%	367,000	2,632,500	$2,968,000	58%	212,900
I-20 @ I-285 Interchange	Atlanta	20	6	187,200	8.3	27,000	14%	1,359,400	7,800	29%	392,100	2,943,700	$3,262,000	52%	203,900
I-75 @ I-85 Interchange	Atlanta	75	10	339,600	9.1	23,400	7%	1,288,800	6,800	29%	374,900	2,566,300	$2,844,000	52%	194,900
I-264 @ I-64 Interchange	Louisville (KY-IN)	264	6	181,100	8.3	16,400	9%	825,500	5,400	33%	271,400	1,990,200	$2,218,000	69%	187,300
I-55 (Stevenson Expwy) @ I-294 Interchange	Chicago-Northwestern IN	55	6	172,600	9.6	17,200	10%	1,001,600	6,000	35%	349,900	2,424,800	$2,751,000	53%	185,400
I-80 @ I-480 Interchange	Omaha (NE-IA)	80	5	173,600	7.9	13,800	8%	658,500	4,500	32%	215,500	1,638,000	$1,856,000	86%	185,300
I-76 @ SR 77 Interchange+J179	Akron	76	4	122,600	8.3	14,000	11%	705,200	7,000	50%	351,900	2,774,800	$3,088,000	52%	183,000
I-15 @ I-215 Interchange (the "Fishbowl")	Las Vegas	15	6	165,600	6.6	10,100	6%	403,200	5,000	50%	200,300	1,779,100	$2,041,000	90%	180,300

* Annual Hours of Delay for All Trucks is the number of hours of delay accruing annually to all trucks delayed by congestion at the bottleneck. (e.g., Daily Minutes of Delay per Vehicle multiplied by 2004 AADTT for All Trucks). Because the underlying Highway Performance Monitoring System data do not detail traffic counts by time of day, the actual number of trucks exposed to peak-period congestion is unknown, and therefore the reported truck hours of delay shown here provide good index to the relative impacts of the bottlenecks, but are not reliable absolute numbers.

Table 5.4 The Worst Physical Bottlenecks in the United States, *2002*
American Highway Users Alliance Study

Rank	City	Freeway	Location	Annual Hours of Delay (Hours in Thousands)
1	Los Angeles	U.S. 101	U.S. 101 (Ventura Freeway) at I-405 Interchange	27,144
2	Houston	I-610	I-610 at I-10 Interchange (West)	25,181
3	Chicago	I-90	I-90/94 at I-290 Interchange ("Circle Interchange")	25,068
4	Phoenix	I-10	I-10 at SR 51/SR 202 Interchange ("Mini-Stack")	22,805
5	Los Angeles	I-405	I-405 (San Diego Freeway) at I-10 Interchange	22,792
6	Atlanta	I-75	I-75 south of the I-85 Interchange	21,045
7	Washington (DC-Maryland-Virginia)	I-495	I-495 at I-270 Interchange	19,429
8	Los Angeles	I-10	I-10 (Santa Monica Freeway) at I-5 Interchange	18,606
9	Los Angeles	I-405	I-405 (San Diego Freeway) at I-605 Interchange	18,606
10	Atlanta	I-285	I-285 at I-85 Interchange ("Spaghetti Junction")	17,072
11	Chicago	I-94	I-94 (Dan Ryan Expressway) at I-90 Skyway Split (Southside)	16,713
12	Phoenix	I-17	I-17 (Black Canyon Freeway) at I-10 Interchange (the "Stack") to Cactus Road	16,310
13	Los Angeles	I-5	I-5 (Santa Ana Freeway) at SR 22/SR 57 Interchange ("Orange Crush")	16,304
14	Providence	I-95	I-95 at I-195 Interchange	15,340
15	Washington (DC-Maryland-Virginia)	I-495	I-495 at I-95 Interchange	15,035
16	Tampa	I-275	I-275 at I-4 Interchange ("Malfunction Junction")	14,371
17	Atlanta	I-285	I-285 at I-75 Interchange	14,333
18	Seattle	I-5	I-5 at I-90 Interchange	14,306
19	Chicago	I-290	I-290 (Eisenhower Expressway) Between Exits 17b and 23a	14,009
20	Houston	I-45	I-45 (Gulf Freeway) at U.S. 59 Interchange	13,944

Table 5.4 The Worst Physical Bottlenecks in the United States, 2002 (continued)
American Highway Users Alliance Study

Rank	City	Freeway	Location	Annual Hours of Delay (Hours in Thousands)
21	San Jose	U.S. 101	U.S. 101 at I-880 Interchange	12,249
22	Las Vegas	U.S. 95	U.S. 95 west of the I-15 Interchange ("Spaghetti Bowl")	11,152
23	San Diego	I-805	I-805 at I-15 Interchange	10,992
24	Cincinnati	I-75	I-75, from Ohio River Bridge to I-71 Interchange	10,088

Source: *Unclogging America's Arteries: Effective Relief for Highway Bottlenecks*, American Highway Users Alliance, February 2004. Delay is the extra time it would take to travel through the bottlenecks compared to completely uncongested conditions. The report did not consider many severe bottlenecks from the New York City area. As most travelers know, congestion in and around the boroughs of New York can be significant. However, a very large amount of delay in the New York area is related to bridge and tunnel crossings into Manhattan, most of which are toll facilities. Also, while the New York metropolitan area is laced with Interstates, parkways, and expressways, they seldom reach the proportions seen in other major areas, except where multiple highways converge on bridge of tunnel crossings. (A typical lane configuration for a New York area freeway is six lanes, three in each direction. But there are many of these.) Toll facilities were excluded from the study because toll facilities are fundamentally different from other physical bottlenecks (such as freeway-to-freeway interchanges) that are prevalent around the country. Delay comparisons between toll facilities and other types of bottlenecks might not be consistent since different modeling techniques would be used. If objective field measurements of delay could be made at all locations around the country, several river crossings into Manhattan would no doubt be included in a list of the nation's worst bottlenecks.

Table 5.5 List of Appendix A Tables of Highway Interchange Bottlenecks for Trucks

Appendix A Table Number	Bottlenecks	Ranked in Descending Order of Annual Truck Hours of Delay for …
Table A.1	Top 25	All Trucks
Table A.2	Top 25	Large Trucks Making Longer Distance Trips ("FAF Trucks")
Table A.3	Top 25	Large Trucks Making Longer Distance Trips ("FAF Trucks") Greater Than 500 Miles
Table A.4	All top-ranked bottlenecks as identified in Tables 6.1, 6.2, and 6.3, eliminating duplicate listings	Large Trucks Making Longer Distance Trips ("FAF Trucks") Greater Than 500 Miles
Table A.5	All	All Trucks

5.3 Steep-Grade Bottlenecks for Trucks

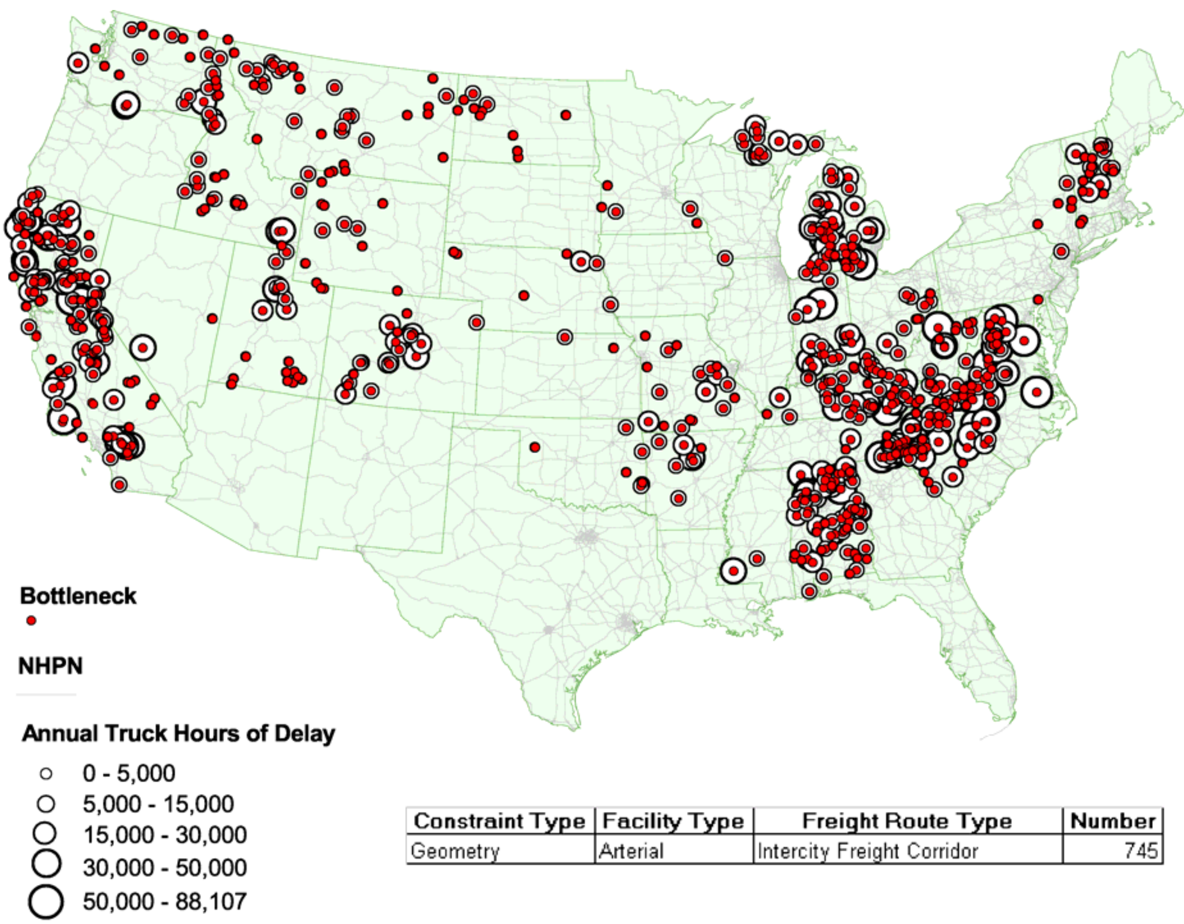
We located 859 bottlenecks created by steep grades on freeways and arterials. These bottlenecks were located by scanning the HPMS Sample database for roadway sections with grades greater than 4.5 percent and more than a mile long. These bottlenecks represent a partial inventory of this type of bottleneck. Using HPMS expansion factors, we estimate that the total delay associated nationally with this type of bottleneck in 2004 was about 66 million truck hours or 27 percent of the total truck hours of delay. At a delay cost of $32.15 per hour, the direct user cost of the bottlenecks is about $2.1 billion per year.

The estimates were made by applying the sample expansion factors provided in the HPMS Sample database to truck hours of delay for each the identified bottlenecks. The statistical framework for the HPMS makes it possible to estimate the total truck hours of delay associated nationally with freight bottlenecks on these roadway but not to estimate the actual number of bottlenecks or pinpoint all their locations.[2] The truck volumes and highway capacity calculations were based on the HPMS Sample statistics.

[2] Our best professional guess is that the total number of steep-grade, signalized-intersection, and lane-drop bottlenecks reported in this paper represent 30 to 50 percent of the actual total of these types of truck bottlenecks. However, this guesstimate is based solely on our experience working with State and Federal roadway inventory data bases such as the Federal Highway Performance Monitoring System. We would not be surprised to find that the actual total was higher.

Steep-grade bottlenecks on arterial roadways serving as intercity freight corridors accounted for 40 million of the 66 million truck hours of delay attributed to steep-grade bottlenecks. Figure 5.3 shows the location of the ***steep-grade bottlenecks on arterial roadways serving as intercity freight corridors***. The bottleneck locations are indicated by a solid dot. Most are located on urban Interstate interchanges. The size of the open circles accompanying each dot indicates the relative annual truck hours of delay associated with the bottleneck. Again, because of the constraints of the HPMS Sample database, the map does not identify all bottlenecks of this type.

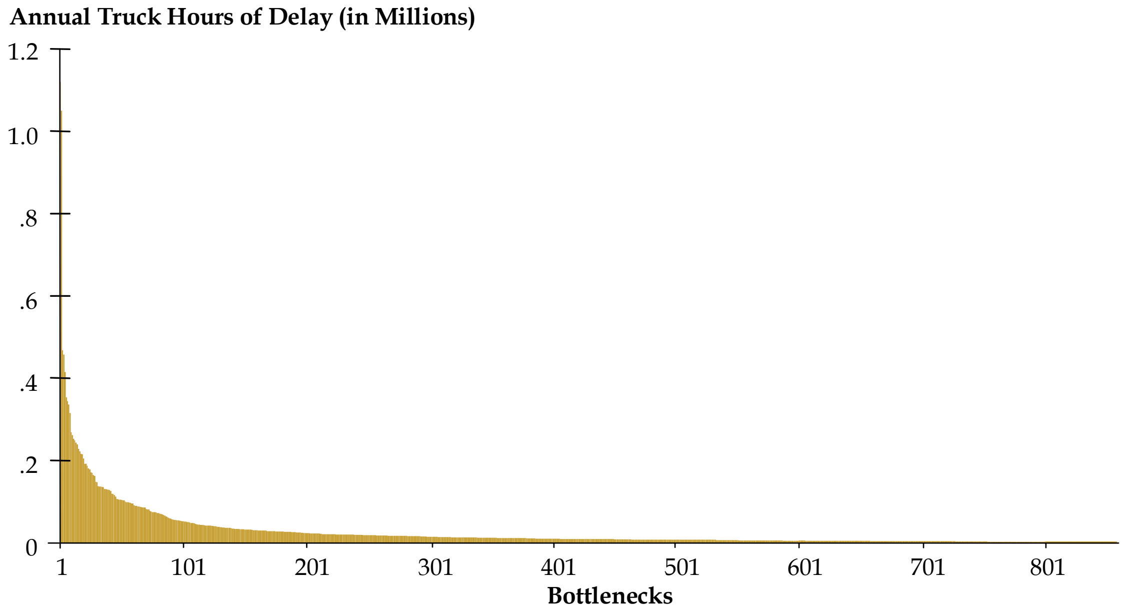
Figure 5.3 Steep Grade Bottlenecks on Arterials Used As Intercity Truck Corridors
HPMS Sample Sections Only



Constraint Type	Facility Type	Freight Route Type	Number
Geometry	Arterial	Intercity Freight Corridor	745

Figure 5.4 shows the distribution of truck hours of delay by bottleneck for ***all steep-grade bottlenecks***. The vertical-axis scale has been adjusted downward to the highest delay value in the chart. The figure shows only those bottlenecks identified from the HPMS Sample database and therefore undercounts the actual number of these bottlenecks. The delay hours shown are the unexpanded estimates for the individual bottlenecks.

Figure 5.4 Distribution of Annual Truck Hours of Delay at Steep Grade Bottlenecks
2004, HPMS Sample Sections Only



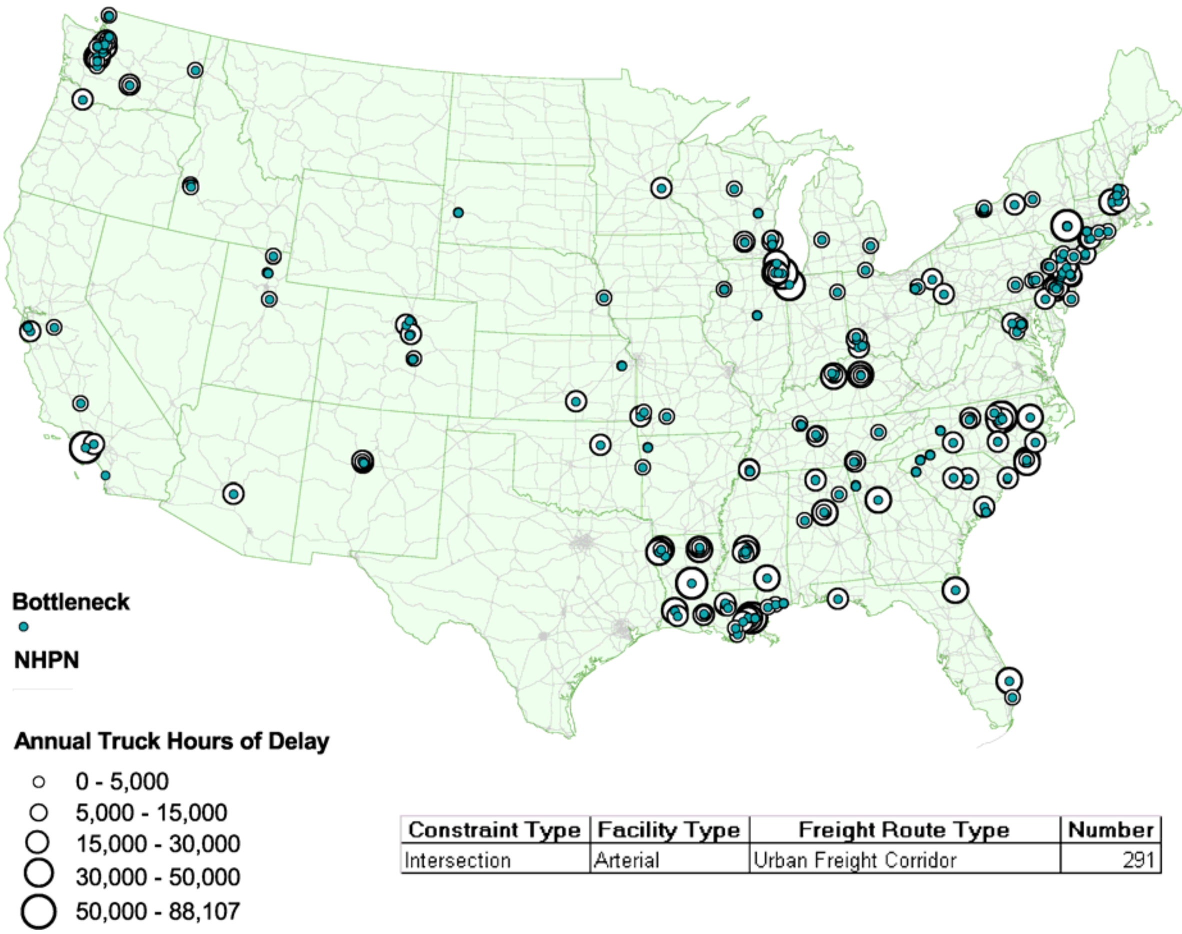
Source: Cambridge Systematics, based on FHWA HPMS 2002 data.

5.4 Signalized Intersection Bottlenecks for Trucks

We located 517 bottlenecks caused by signalized intersections on arterials. These bottlenecks were located by scanning the HPMS Sample database for signalized roadway sections with a volume-to-capacity ratio greater than 0.925. These bottlenecks also represent a partial inventory of this type of bottleneck. Expanding the sample, we estimate that the total delay associated nationally with this type of bottleneck in 2004 was about 43 million truck hours of delay. At a delay cost of $32.15 per hour, the direct user cost of the bottlenecks is about $1.4 billion per year. The truck volumes and highway capacity calculations were based on the HPMS Sample statistics.

Signalized-intersection bottlenecks on arterials serving as urban freight corridors accounted for 25 million truck hours of delay or 58 percent of the total for Signalized-intersection bottlenecks. Figure 5.5 shows the location of ***signalized-intersection bottlenecks on arterials serving as urban freight corridors***. The bottleneck locations are indicated by a solid dot. Most are located on urban Interstate interchanges. The size of the open circles accompanying each dot indicates the relative annual truck hours of delay associated with the bottleneck.

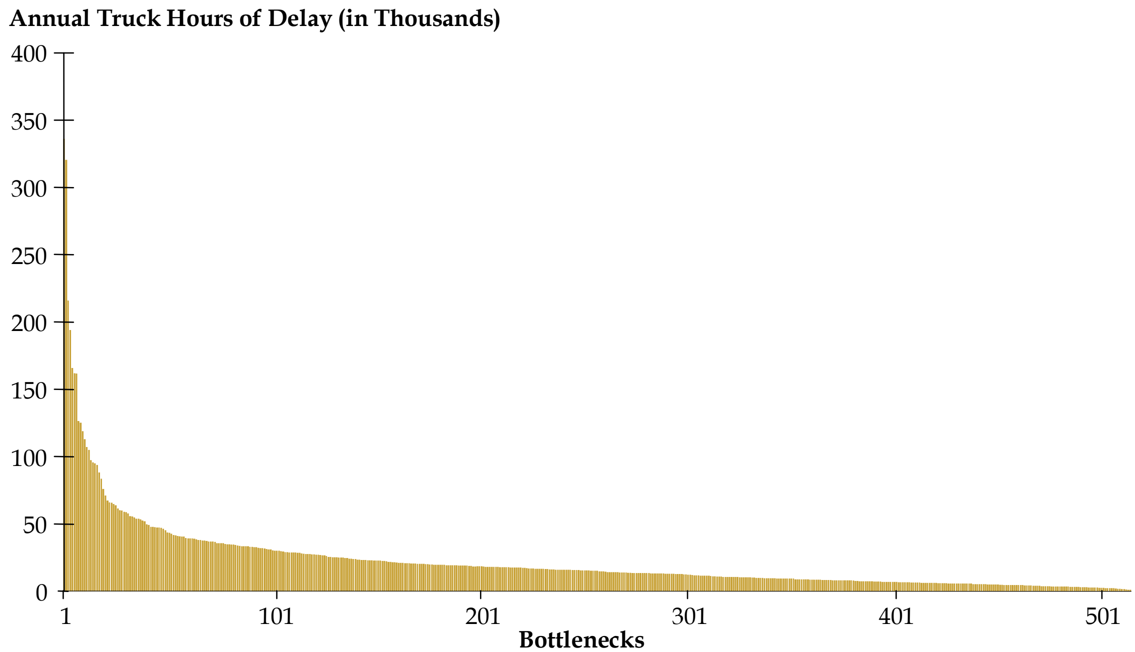
Figure 5.5 Signalized Intersection Bottlenecks on Arterials Used As Urban Truck Corridors
HPMS Sample Sections Only



Constraint Type	Facility Type	Freight Route Type	Number
Intersection	Arterial	Urban Freight Corridor	291

Figure 5.6 shows the distribution of truck hours of delay by bottleneck for ***all signalized-intersection bottlenecks for trucks***. Again, the vertical-axis scale has been adjusted downward to the highest delay value in the chart. The figure shows only those bottlenecks identified from the HPMS Sample database and therefore undercounts the actual number of these bottlenecks. The delay hours shown are the unexpanded estimates for the individual bottlenecks.

Figure 5.6 Distribution of Truck Hours of Delay at Signalized Intersection Bottlenecks
2004, HPMS Sample Sections Only



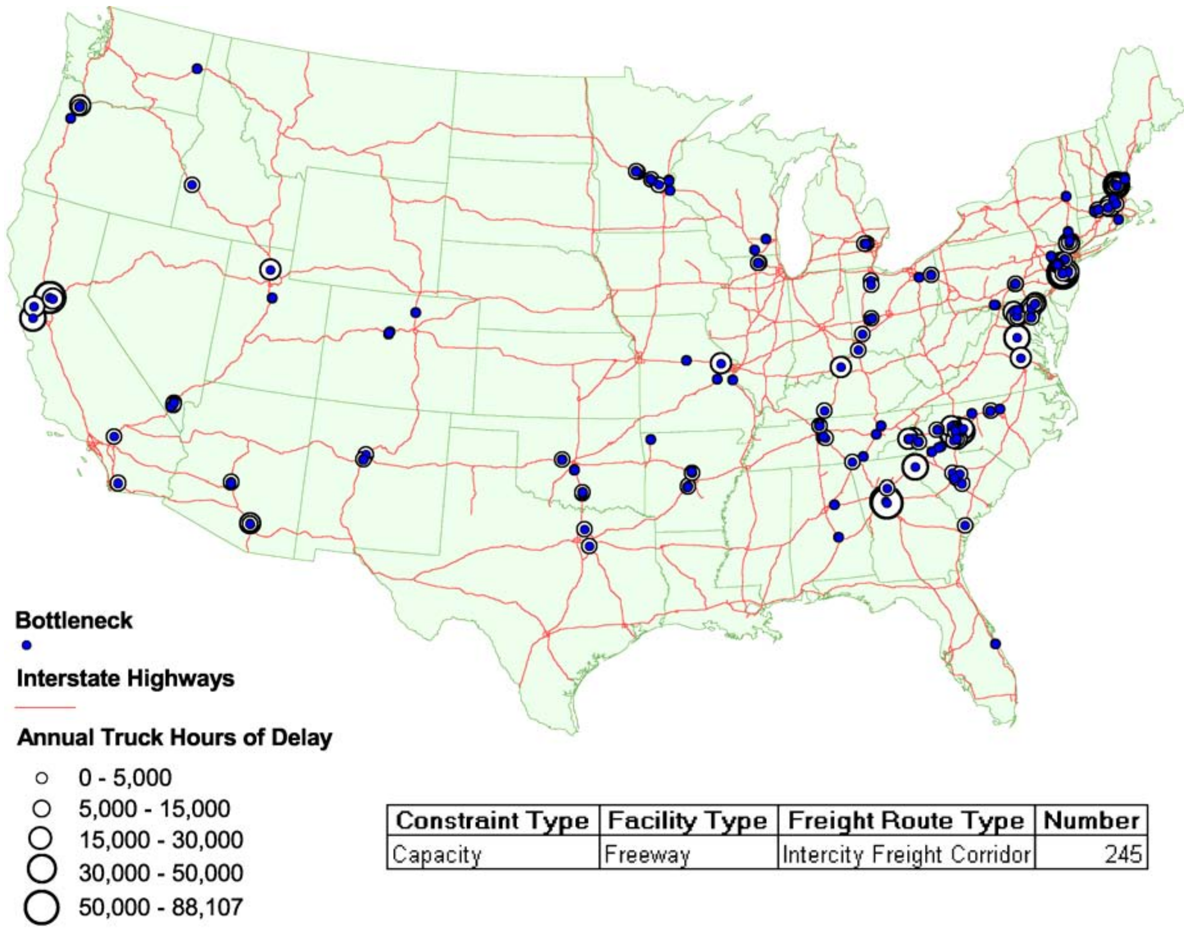
Source: Cambridge Systematics, based on FHWA HPMS 2002 data.

■ 5.5 Lane-Drop Bottlenecks for Trucks

Finally, we located 507 bottlenecks created by lane drops and restricted capacity on arterials and freeways, typically locations where a roadway necks down from three lanes to two or two lanes to one and the volume-to-capacity ratio is greater than 0.925. These bottlenecks were located by scanning the HPMS Sample database. Expanding the sample, we estimated that the total delay from this type of bottleneck nationally in 2004 was about 11 million truck hours of delay or 5 percent of the total. At a delay cost of $32.15 per hour, the direct user cost of the bottlenecks is about $354 million per year. The truck volumes and highway capacity calculations were based on the HPMS Sample statistics.

Lane-drop bottlenecks on freeways serving intercity freight corridors accounted for 5.6 million annual truck hours of delay or about 53 percent, Figure 5.8 shows the location of ***lane-drop bottlenecks on freeways serving intercity freight corridors***. The bottleneck locations are indicated by a solid dot. Most are located on urban Interstate interchanges. The size of the open circles accompanying each dot indicates the relative annual truck hours of delay associated with the bottleneck.

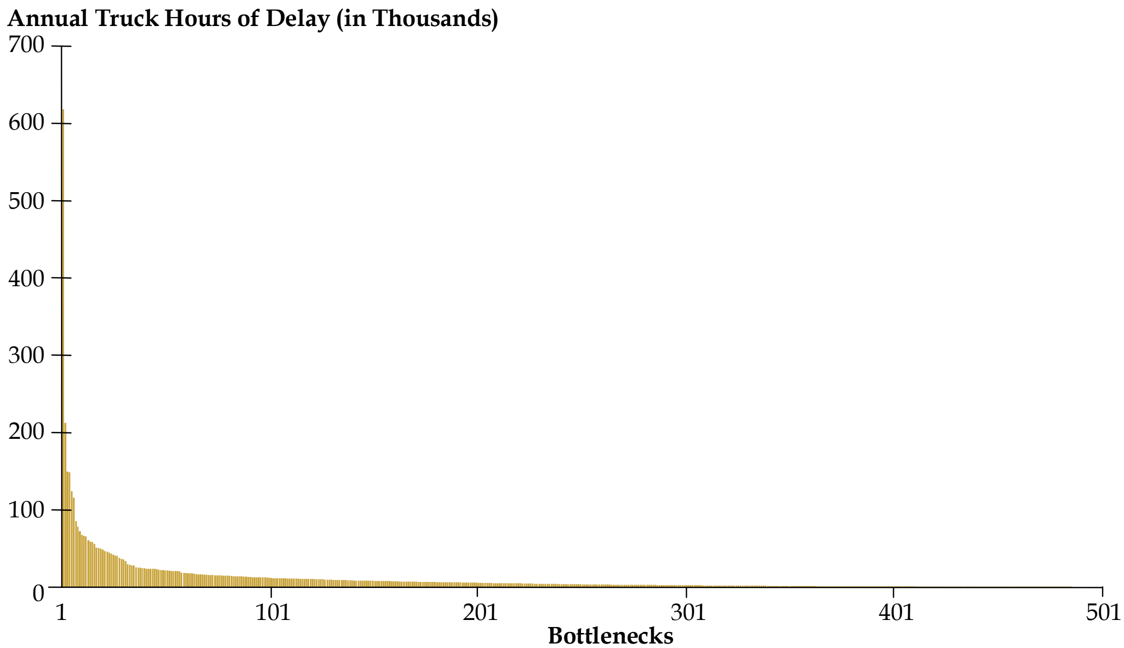
Figure 5.7 Capacity Bottlenecks on Freeways Used As Intercity Truck Corridors
HPMS Sample Sections Only



Constraint Type	Facility Type	Freight Route Type	Number
Capacity	Freeway	Intercity Freight Corridor	245

Figure 5.9 shows the distribution of truck hours of delay by bottleneck for ***all lane-drop bottlenecks for trucks***. The vertical-axis scale has been adjusted downward to the highest delay value in the chart. The figure shows only those bottlenecks identified from the HPMS Sample database and therefore undercounts the actual number of these bottlenecks. The delay hours shown are the unexpanded estimates for the individual bottlenecks.

Figure 5.8 Distribution of Annual Truck Hours of Delay at Lane-Drop Bottlenecks
2004, HPMS Sample Sections Only



Source: Cambridge Systematics based on FHWA 2002 HPMS data.

6.0 Conclusions and Recommendations

Our conclusions from the analysis of highway truck bottlenecks are as follows.

Highway truck bottlenecks can be identified and differentiated from general traffic bottlenecks. A relatively comprehensive inventory of highway truck bottlenecks can be made using available FHWA Highway Performance Monitoring System (HPMS) data and Freight Analysis Framework (FAF) data.

The impact of the highway truck bottlenecks can be measured by total truck hours of delay, hours of delay to large trucks making longer-distance trips, and the tonnage and value of the commodities in the trucks. These measures provide a good relative ranking of individual bottlenecks, but because of data and analysis limitations, they do not provide absolute measures of the truck hours of delay at each bottleneck. For example, at highway interchanges, the current analysis methods account for truck hours on the critically congested highway, but not on the intersecting highway or arterial roadway. Moreover, the analysis methods do not yet adequately account for the congestion effects of traffic weaving and merging at on- and off-ramps. These limitations cause the total truck hours of delay to be underestimated.

Highway truck bottlenecks accrue significant truck hours of delay, totaling upwards of 243 million hours annually. At a delay cost of $32.15 per hour, the conservative value used by the FHWA's Highway Economic Requirements System model for estimating national highway costs and benefits, the direct user cost of the bottlenecks is about $7.8 billion per year.

Of the four major types of bottlenecks studied (interchange, steep-grade, signalized-intersection, and lane-drop bottlenecks) interchange bottlenecks account for the most truck hours of delay, estimated at about 124 million hours annually in 2004. The direct user cost associated with interchange bottlenecks is about $4 billion per year.

The truck hours of delay caused by individual highway interchange bottlenecks are significant. The top 10 highway interchange bottlenecks cause an average of 1.5 million truck hours of delay each. Of the 227 highway interchange bottlenecks, 173 cause more than 250,000 truck hours of delay annually. By comparison only a few dozen of all the other truck bottlenecks cause more than 250,000 truck hours of delay annually. The number of bottlenecks by type accruing over 250,000 annual truck hours of delay are as follows:

- Highway interchange bottlenecks (based on HPMS Universe database) – 173
- Steep-grade bottlenecks (based on HPMS Sample database only) – 12

- Lane-drop bottlenecks (based on HPMS Sample database only) – 1
- Signalized-intersection bottlenecks (based on HPMS Sample database only) – 2

Highway interchange bottlenecks are of Federal interest because they are a significant national problem for trucking and the efficient operation of the national freight transportation system. Highway interchange bottlenecks affecting trucking are widely distributed across the United States along Interstate freight corridors of national significance. The primary truck delay on these nationally significant routes is in the major urban areas, including major international trade gateways and hubs such as Los Angeles, New York, and Chicago, and major distribution centers such as Atlanta, Dallas-Fort Worth, Denver, Columbus (Ohio), and Portland (Oregon). These urban interchange bottlenecks create sticky nodes that slow long-distance truck moves along Interstate and other National Highway System regional, transcontinental, and NAFTA freight transportation corridors.

Our findings and conclusions suggest that FHWA may wish to consider the following recommendations.

The FHWA should work closely with the states, metropolitan planning organizations, and industry to monitor truck delay at urban Interstate interchange bottlenecks on freight routes of national significance. As part of its strategic and performance planning efforts, FHWA has begun an effort to identify nationally significant freight routes and measure performance over time on these corridors. More accurate information on delays at highway interchanges will help the FHWA and carriers understand the contribution of interchange delays to overall travel time and reliability in these corridors.

The FHWA also should work closely with states and metropolitan planning organizations to focus Federal highway improvement and operations programs on highway interchange bottlenecks. The Federal highway improvement and operations programs would include existing programs such as the core Federal-aid highway programs for Interstate Maintenance and NHS and discretionary programs such as the Corridors program and ITS Deployment program. The FHWA also should focus new freight programs such as the Projects of Regional and National Significance program and the Truck Lanes program on highway interchange bottlenecks.

To support these policy and program actions, the FHWA should continue the development of data and analytical methods to better estimate truck hours of delay at highway bottlenecks. Specific initiatives would include the following:

- Re-estimate truck hours of delay at highway interchanges using the next-generation methodology being developed for the Ohio Department of Transportation. This methodology will better account for delays caused by traffic merges and weaves at interchanges and capture delays on all legs of an interchange.

- Develop procedures to estimate the exposure of trucks to congestion by time of day. The current generation of delay estimation methods assumes that the distribution of long-distance truck trips is similar to the distribution of short-distance automobile and service truck trips; that is, they are concentrated during the morning and evening peak commute periods. Research studies and anecdotal evidence suggest that many long-distance truck trips are scheduled to avoid peak-period urban congestion. This would tend to reduce truck exposure to congestion and reduce truck hours of delay. More information is needed on the time-of-day distribution of truck trips and the actual exposure of trucks to congestion.

- Consider developing a spatially enabled interchange database that would support safety- and congestion-related analyses including the following truck-specific initiatives: re-estimate truck hours of delay at highway interchanges using the next-generation methodology to better account for delays caused by traffic merges and weaves at interchanges and capture delays on all legs of an interchange; and develop procedures to estimate the exposure of trucks to congestion by time of day.

- Estimate the cumulative, corridor-level impact of closely spaced bottlenecks on longer distance truck trips. The current analysis treated each bottleneck as an independent event.

- Conduct case studies to trace and explain the supply chain and economic impacts of highway truck bottlenecks. The case studies should examine how motor carriers adjust to bottleneck delay, examine how delay costs are passed on to shippers and consumers, and estimate the economic costs of delay by industry sector.

- Inventory and track current and planned improvements that would reduce future delays to trucks at the 200 most significant highway interchange bottlenecks. The tracked improvements would include construction of new by-passes, redesign of existing interchange, implementation of ITS (intelligent transportation systems) services, improved operations such as better incident management, introduction of managed toll lanes open to trucks, etc.

Highway interchange bottlenecks are a significant problem today and will become a bigger problem in the future. We recommend that the FHWA continue its initiatives to focus on freight bottlenecks and develop policies and programs that will reduce the costs of delay.

Appendix A

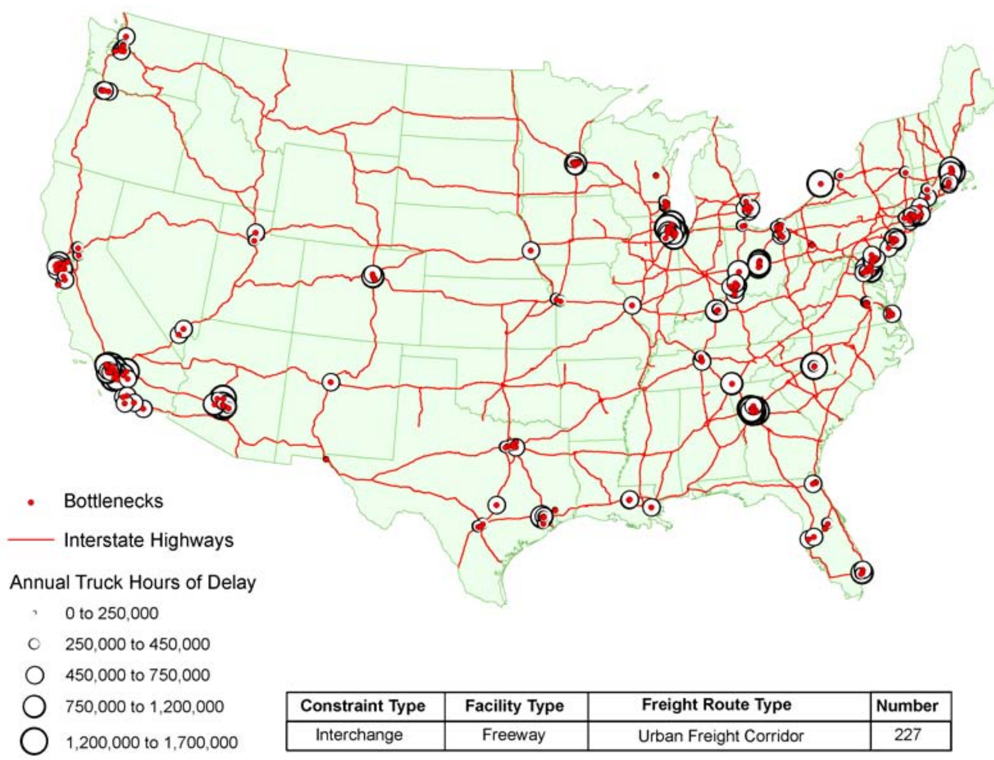
Highway Interchange Bottlenecks

Highway Interchange Bottlenecks

■ A.1 Location of Highway Interchange Bottlenecks for Trucks

Figure A.1 shows the location of highway interchange bottlenecks for trucks. The bottleneck locations are indicated by a solid dot. Most are located on urban Interstate interchanges. The size of the open circles accompanying each dot indicate the relative annual truck hours of delay associated with the bottleneck.

Figure A.1 Interchange Capacity Bottlenecks on Freeways Used as Urban Truck Corridors



Constraint Type	Facility Type	Freight Route Type	Number
Interchange	Freeway	Urban Freight Corridor	227

Source: Cambridge Systematics, Inc.

A.2 Listing of Highway Interchange Bottlenecks for Trucks

This section presents six tables. Tables A.1, A.2, and A.3 list the top 25 highway interchange bottlenecks, ranking them in descending order of annual truck hours of delay for "all trucks" (Table A.1); for "large trucks making longer-distance trips" (i.e., "FAF Trucks") (Table A.2); and for "large trucks making longer-distance trips ("FAF trucks") greater than 500 miles" (Table A.3).

Table A.4 combines the top 25 highway interchange bottlenecks from each of the preceding tables and ranks them in descending order of annual truck hours of delay for "large trucks making longer distance trips (i.e., "FAF trucks") greater than 500 miles."

Table A.5 lists all the highway interchange bottlenecks for trucks identified in the scan, ranking them in descending order of annual truck hours of delay for "all trucks."

Finally, for comparison, Table A.6 lists the top 25 most congested highway interchanges as identified in the American Highway Users Alliance study. These bottlenecks are ranked in descending order of annual hours of delay for all vehicles, including trucks.

The bottleneck ranking in Tables A.1 to A.5 are summarized below.

Table Number	Bottlenecks	Ranked in Descending Order of Annual Truck Hours of Delay for …
Table A.1	Top 25	All Trucks
Table A.2	Top 25	Large Trucks Making Longer Distance Trips ("FAF Trucks")
Table A.3	Top 25	Large Trucks Making Longer Distance Trips ("FAF Trucks") Greater Than 500 Miles
Table A.4	All top-ranked bottlenecks as identified in Tables 6.1, 6.2, and 6.3, eliminating duplicate listings	Large Trucks Making Longer Distance Trips ("FAF Trucks") Greater Than 500 Miles
Table A.5	All	All Trucks

The data in the tables and their sources, by column heading, are as follows.

Bottleneck

- **Location**. The names of the interchange routes and local nickname of the interchange as identified by the state departments of transportation, Cambridge Systematics, and Battelle.

- **Urban Area**. The name of the urban area in which the interchange is located as identified in the FHWA 2002 HPMS database.

- **Critically Congested Route Number**. The route number of the critically congested highway section in the interchange as identified by Cambridge Systematics and Battelle from HPMS database and state department of transportation maps. The scan identified only the critically congested roadway and the corresponding two-way truck traffic volumes on that roadway. The delay estimation methodology calculates delay resulting from queuing on the critically congested roadway and adjacent highway sections; however, it does not calculate delay on the other roadway at the interchange. This means that hours of delay are calculated on only one of the two intersecting highways or two of the four legs on a interchange, potentially underreporting total delay at the interchange.

- **Number of Lanes**. The number of traffic lanes as reported in the 2002 HPMS database.

All Vehicles

- **AADT**. The number of vehicles, including automobiles and trucks of all sizes, traveling the critically congested roadway each day. *Annual Average Daily Traffic* as reported in the 2002 HPMS database and extrapolated to 2004.

- **Daily Minutes of Delay per Vehicle**. The number of minutes each vehicle is delayed each day by congestion at the bottleneck. *Daily Minutes of Delay per Vehicle for All Vehicles* as estimated by Cambridge Systematics.

All Trucks

- **AADTT**. The number of trucks of all sizes traveling the critically congested roadway each day. *Annual Average Daily Truck Traffic* (i.e., number of trucks per day on the critically congested roadway) as provided by Battelle from the FHWA Freight Analysis Framework database, based on HPMS data and state department of transportation vehicle counts. Extrapolated to 2004.

- **Percent of All Vehicles**. The number of trucks as a percentage of all vehicles. *All Trucks* as a percentage of *All Vehicles* (AADTT divided by AADT).

- **Annual Hours of Delay for All Trucks**. The number of hours of delay accruing annually to all trucks delayed by congestion at the bottleneck. *Daily Minutes of Delay per Vehicle* multiplied by 2004 *AADTT for All Trucks*.

Large Trucks Making Longer Distance Trips (i.e., "FAF Trucks")

- **AADTT (Large Trucks…)**. The estimated number of large freight trucks—assumed to be primarily five-axle tractor-semitrailers—traveling the critically congested roadway each day. *Annual Average Daily Truck Traffic of Large Trucks Making Longer Distance*

Trips (i.e., "FAF Trucks") calculated by multiplying *AADTT for All Trucks* by the estimated percentage of *Large Trucks Making Longer Distance Trips (i.e., "FAF Trucks").*

- **Percent of All Trucks**. The number of large freight trucks as a percentage of all trucks. *Large Trucks Making Longer Distance Trips (i.e., "FAF Trucks")* as a percent of *All Trucks* as estimated by Cambridge Systematics based on FHWA Freight Analysis Framework data developed by Battelle. Percentages are for the urbanized area and may over- or underestimate the actual number of *Large Trucks Making Longer Distance Trips (i.e., "FAF Trucks")* for a specific roadway.

- **Annual Hours of Delay… Large Trucks…**. The number of hours of delay accruing annually to large freight trucks delayed by congestion at the bottleneck. *Daily Minutes of Delay per Vehicle* multiplied by *AADTT for Large Trucks Making Longer Distance Trips (i.e., "FAF Trucks").*

- **Annual Commodity Tons… Large Trucks…**. The approximate tonnage of the cargo carried by large freight trucks delayed by congestion at the bottleneck. *AADTT (Large Trucks…)* multiplied by approximate commodity tons per truck provided by Battelle from the FHWA Freight Analysis Framework database.

- **Annual Commodity Value… Large Trucks…**. The approximate value of the cargo carried by large freight trucks delayed by congestion at the bottleneck. *AADTT (Large Trucks…)* multiplied by approximate commodity value per truck provided by Battelle from the FHWA Freight Analysis Framework database.

- **Percent Trips… Greater Than 500 Miles.** The number of large freight trucks traveling more than 500 miles as a percentage of all large freight trucks; a proxy for long-haul "transcontinental" truck trips. *Large Trucks Making Longer Distance Trips (i.e., "FAF Trucks") Greater Than 500 Miles* as a percent of *AADTT (Large Trucks…)* as estimated by Cambridge Systematics based on FHWA Freight Analysis Framework data developed by Battelle. Percentages are for the urbanized area and may over- or underestimate the actual number of *Large Trucks Making Longer Distance Trips (i.e., "FAF Trucks") Greater Than 500 Miles* for a specific roadway.

- **Annual Hours of Delay… Greater Than 500 Miles**. The number of hours of delay accruing annually to large freight trucks traveling more than 500 miles delayed by congestion at the bottleneck. *Daily Minutes of Delay per Vehicle* multiplied by *AADTT (Large Trucks…)* multiplied by *Percent Trips Greater Than 500 Miles*.

Table A.1 Top 25 Highway Interchange Bottlenecks for Trucks
Ranked By Annual Hours of Delay for All Trucks

				2004											
Bottleneck				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-90 @ I-290	Buffalo-Niagara Falls	90	4	136,500	8.3	33,100	24%	1,661,900	7,300	22%	367,000	2,632,500	$2,968,000	58%	212,900
I-285 @ I-85 Interchange ("Spaghetti Junction")	Atlanta	285	8	265,300	10.0	27,100	10%	1,641,200	7,800	29%	472,600	2,943,700	$3,262,000	52%	245,800
I-17 (Black Canyon Fwy): I-10 Interchange (the "Stack") to Cactus	Phoenix	17	6	217,300	9.2	28,900	13%	1,608,500	9,000	31%	501,600	3,326,700	$3,792,000	48%	240,800
I-90/94 @ I-290 Interchange ("Circle Interchange")	Chicago-Northwestern IN	90	8	305,800	9.7	26,300	9%	1,544,900	9,200	35%	540,400	3,718,000	$4,218,000	53%	286,400
San Bernardino Fwy	Los Angeles	10	8	268,700	7.2	34,900	13%	1,522,800	11,200	32%	488,700	4,094,500	$4,780,000	31%	151,500
I-94 (Dan Ryan Expwy) @ I-90 Skyway Split (Southside)	Chicago-Northwestern IN	94	8	271,700	7.9	31,600	12%	1,512,900	11,100	35%	531,500	4,485,900	$5,089,000	53%	281,700
I-285 @ I-75 Interchange	Atlanta	285	6	226,300	9.6	25,700	11%	1,497,300	7,400	29%	431,500	2,792,800	$3,095,000	52%	224,400
SR 134 @ SR 2 Interchange	Los Angeles	134	8	247,900	8.3	29,600	12%	1,489,400	9,500	32%	477,500	3,473,000	$4,054,000	31%	148,000
I-77 @ Tryon Rd	Charlotte	77	6	170,500	8.3	29,600	17%	1,487,100	7,300	25%	367,000	2,700,200	$2,983,000	45%	165,200
Long Beach Fwy	Los Angeles	710	8	246,100	8.3	27,500	11%	1,380,300	8,800	32%	442,400	3,217,100	$3,756,000	31%	137,100
I-20 @ I-285 Interchange	Atlanta	20	6	187,200	8.3	27,000	14%	1,359,400	7,800	29%	392,100	2,943,700	$3,262,000	52%	203,900
I-80/I-94 split (Southside)	Chicago-Northwestern IN	80	4	139,600	8.6	25,600	18%	1,343,600	9,000	35%	472,400	3,637,200	$4,127,000	53%	250,400
SR 60 @ I-605 Interchange	Los Angeles	60	8	233,000	8.3	26,100	11%	1,314,200	8,400	32%	422,300	3,070,900	$3,585,000	31%	130,900
Pulaski Rd @ I-55	Chicago-Northwestern IN	55	6	197,200	7.5	28,700	15%	1,300,400	10,000	35%	453,700	4,041,300	$4,585,000	53%	240,500

Table A.1 Top 25 Highway Interchange Bottlenecks for Trucks (continued)

Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-75 @ I-85 Interchange	Atlanta	75	10	339,600	9.1	23,400	7%	1,288,800	6,800	29%	374,900	2,566,300	$2,844,000	52%	194,900
I-93 @ I-95 Interchange	Boston	93	6	188,400	8.3	25,500	14%	1,280,100	2,800	11%	140,800	1,020,000	$1,220,000	36%	50,700
I-290 @ I-355	Chicago-Northwestern IN	290	6	223,100	8.3	24,800	11%	1,246,200	8,700	35%	437,300	3,515,900	$3,989,000	53%	231,800
I-405 (San Diego Fwy) @ I-605 Interchange	Los Angeles	405	10	331,700	9.8	20,900	6%	1,245,500	6,700	32%	398,600	2,449,400	$2,859,000	31%	123,600
I-80 @ Central St.	San Francisco-Oakland	80	8	270,200	8.3	23,800	9%	1,196,700	7,800	33%	392,100	2,851,500	$3,329,000	29%	113,700
San Gabriel River Fwy	Los Angeles	91	10	295,700	8.1	24,100	8%	1,194,300	7,700	32%	381,100	2,815,000	$3,286,000	31%	118,100
I-20 @ Fulton St.	Atlanta	20	6	207,300	8.1	23,700	11%	1,172,700	6,800	29%	336,500	2,566,300	$2,844,000	52%	175,000

Table A.2 Top 25 Highway Interchange Bottlenecks for Trucks

Ranked By Annual Hours of Delay for Large Trucks Making Longer-Distance Trips

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-35 @ Martin Luther King Jr	Austin	35	6	229,500	8.3	12,600	5%	635,000	11,200	89%	563,000	4,123,900	$4,768,000	39%	219,600
I-90/94 @ I-290 Interchange ("Circle Interchange")	Chicago-Northwestern IN	90	8	305,800	9.7	26,300	9%	1,544,900	9,200	35%	540,400	3,718,000	$4,218,000	53%	286,400
I-94 (Dan Ryan Expwy) @ I-90 Skyway Split (Southside)	Chicago-Northwestern IN	94	8	271,700	7.9	31,600	12%	1,512,900	11,100	35%	531,500	4,485,900	$5,089,000	53%	281,700
I-17 (Black Canyon Fwy): I-10 Interchange (the "Stack") to Cactus	Phoenix	17	6	217,300	9.2	28,900	13%	1,608,500	9,000	31%	501,600	3,326,700	$3,792,000	48%	240,800
San Bernardino Fwy	Los Angeles	10	8	268,700	7.2	34,900	13%	1,522,800	11,200	32%	488,700	4,094,500	$4,780,000	31%	151,500
SR 134 @ SR 2 Interchange	Los Angeles	134	8	247,900	8.3	29,600	12%	1,489,400	9,500	32%	477,500	3,473,000	$4,054,000	31%	148,000
I-285 @ I-85 Interchange ("Spaghetti Junction")	Atlanta	285	8	265,300	10.0	27,100	10%	1,641,200	7,800	29%	472,600	2,943,700	$3,262,000	52%	245,800
I-80/I-94 split (Southside)	Chicago-Northwestern IN	80	4	139,600	8.6	25,600	18%	1,343,600	9,000	35%	472,400	3,637,200	$4,127,000	53%	250,400
I-24 @ I-440N Interchange	Chattanooga (TN-GA)	24	4	118,200	8.3	18,500	16%	927,500	9,200	50%	462,500	3,330,000	$3,750,000	85%	393,100
Pulaski Rd @ I-55	Chicago-Northwestern IN	55	6	197,200	7.5	28,700	15%	1,300,400	10,000	35%	453,700	4,041,300	$4,585,000	53%	240,500
Long Beach Fwy	Los Angeles	710	8	246,100	8.3	27,500	11%	1,380,300	8,800	32%	442,400	3,217,100	$3,756,000	31%	137,100
I-290 @ I-355	Chicago-Northwestern IN	290	6	223,100	8.3	24,800	11%	1,246,200	8,700	35%	437,300	3,515,900	$3,989,000	53%	231,800

Table A.2 Top 25 Highway Interchange Bottlenecks for Trucks (continued)

Ranked By Annual Hours of Delay for Large Trucks Making Longer-Distance Trips

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-285 @ I-75 Interchange	Atlanta	285	6	226,300	9.6	25,700	11%	1,497,300	7,400	29%	431,500	2,792,800	$3,095,000	52%	224,400
SR 60 @ I-605 Interchange	Los Angeles	60	8	233,000	8.3	26,100	11%	1,314,200	8,400	32%	422,300	3,070,900	$3,585,000	31%	130,900
I-75 @ I-74 Interchange	Cincinnati (OH-KY)	75	6	193,100	9.7	19,200	10%	1,128,900	6,900	36%	405,300	2,735,200	$3,044,000	63%	255,300
I-405 (San Diego Fwy) @ I-605 Interchange	Los Angeles	405	10	331,700	9.8	20,900	6%	1,245,500	6,700	32%	398,600	2,449,400	$2,859,000	31%	123,600
I-75 @ U.S. 35 Interchange	Dayton	75	4	127,400	8.3	18,400	14%	923,100	7,900	43%	397,100	3,131,600	$3,485,000	54%	214,400
I-20 @ I-285 Interchange	Atlanta	20	6	187,200	8.3	27,000	14%	1,359,400	7,800	29%	392,100	2,943,700	$3,262,000	52%	203,900
I-80 @ Central St.	San Francisco-Oakland	80	8	270,200	8.3	23,800	9%	1,196,700	7,800	33%	392,100	2,851,500	$3,329,000	29%	113,700
San Gabriel River Fwy	Los Angeles	91	10	295,700	8.1	24,100	8%	1,194,300	7,700	32%	381,100	2,815,000	$3,286,000	31%	118,100
I-10 @ I-110 Interchange	Baton Rouge	10	6	150,400	7.2	15,200	10%	665,000	8,600	57%	375,200	3,163,900	$3,591,000	68%	255,100
I-75 @ I-85 Interchange	Atlanta	75	10	339,600	9.1	23,400	7%	1,288,800	6,800	29%	374,900	2,566,300	$2,844,000	52%	194,900
I-90 @ I-290	Buffalo-Niagara Falls	90	4	136,500	8.3	33,100	24%	1,661,900	7,300	22%	367,000	2,632,500	$2,968,000	58%	212,900
I-77 @ Tryon Rd	Charlotte	77	6	170,500	8.3	29,600	17%	1,487,100	7,300	25%	367,000	2,700,200	$2,983,000	45%	165,200
I-880 @ I-238	San Francisco-Oakland	880	8	282,700	8.3	22,000	8%	1,106,700	7,200	33%	361,900	2,632,200	$3,073,000	29%	105,000

Table A.3 Top 25 Highway Interchange Bottlenecks for Trucks

Ranked By Annual Hours of Delay for Large Trucks Making Longer Trips Greater Than 500 Miles

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-24 @ I-440N Interchange	Chattanooga (TN-GA)	24	4	118,200	8.3	18,500	16%	927,500	9,200	50%	462,500	3,330,000	$3,750,000	85%	393,100
U.S. 95 @ I 15 Interchange ("Spaghetti Bowl")	Las Vegas	95	6	199,900	9.8	11,300	6%	670,400	5,600	50%	333,100	1,992,500	$2,286,000	90%	299,800
I-90/94 @ I-290 Interchange ("Circle Interchange")	Chicago-Northwestern IN	90	8	305,800	9.7	26,300	9%	1,544,900	9,200	35%	540,400	3,718,000	$4,218,000	53%	286,400
I-94 (Dan Ryan Expwy) @ I-90 Skyway Split (Southside)	Chicago-Northwestern IN	94	8	271,700	7.9	31,600	12%	1,512,900	11,100	35%	531,500	4,485,900	$5,089,000	53%	281,700
I-75 @ I-74 Interchange	Cincinnati (OH-KY)	75	6	193,100	9.7	19,200	10%	1,128,900	6,900	36%	405,300	2,735,200	$3,044,000	63%	255,300
I-10 @ I-110 Interchange	Baton Rouge	10	6	150,400	7.2	15,200	10%	665,000	8,600	57%	375,200	3,163,900	$3,591,000	68%	255,100
I-80/I-94 split (Southside)	Chicago-Northwestern IN	80	4	139,600	8.6	25,600	18%	1,343,600	9,000	35%	472,400	3,637,200	$4,127,000	53%	250,400
I-285 @ I-85 Interchange ("Spaghetti Junction")	Atlanta	285	8	265,300	10.0	27,100	10%	1,641,200	7,800	29%	472,600	2,943,700	$3,262,000	52%	245,800
I-17 (Black Canyon Fwy): I-10 Interchange (the "Stack") to Cactus	Phoenix	17	6	217,300	9.2	28,900	13%	1,608,500	9,000	31%	501,600	3,326,700	$3,792,000	48%	240,800
Pulaski Rd @ I-55	Chicago-Northwestern IN	55	6	197,200	7.5	28,700	15%	1,300,400	10,000	35%	453,700	4,041,300	$4,585,000	53%	240,500
I-290 @ I-355	Chicago-Northwestern IN	290	6	223,100	8.3	24,800	11%	1,246,200	8,700	35%	437,300	3,515,900	$3,989,000	53%	231,800

Table A.3 Top 25 Highway Interchange Bottlenecks for Trucks

Ranked By Annual Hours of Delay for Large Trucks Making Longer Trips Greater Than 500 Miles

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-40 @ I-24 Interchange	Nashville	40	4	147,600	8.3	14,600	10%	735,200	5,800	40%	291,600	2,099,300	$2,364,000	77%	224,500
I-285 @ I-75 Interchange	Atlanta	285	6	226,300	9.6	25,700	11%	1,497,300	7,400	29%	431,500	2,792,800	$3,095,000	52%	224,400
I-35 @ Martin Luther King Jr	Austin	35	6	229,500	8.3	12,600	5%	635,000	11,200	89%	563,000	4,123,900	$4,768,000	39%	219,600
I-15 between Tropicana and Flamingo	Las Vegas	15	6	165,900	6.4	12,400	7%	486,700	6,200	50%	242,800	2,206,000	$2,530,000	90%	218,500
I-12 @ Amite River, Baton Rouge	Baton Rouge	12	4	105,000	6.4	14,400	14%	561,900	8,100	57%	317,200	2,980,000	$3,383,000	68%	215,700
I-75 @ U.S. 35 Interchange	Dayton	75	4	127,400	8.3	18,400	14%	923,100	7,900	43%	397,100	3,131,600	$3,485,000	54%	214,400
I-90 @ I-290	Buffalo-Niagara Falls	90	4	136,500	8.3	33,100	24%	1,661,900	7,300	22%	367,000	2,632,500	$2,968,000	58%	212,900
I-20 @ I-285 Interchange	Atlanta	20	6	187,200	8.3	27,000	14%	1,359,400	7,800	29%	392,100	2,943,700	$3,262,000	52%	203,900
I-75 @ I-85 Interchange	Atlanta	75	10	339,600	9.1	23,400	7%	1,288,800	6,800	29%	374,900	2,566,300	$2,844,000	52%	194,900
I-264 @ I-64 Interchange	Louisville (KY-IN)	264	6	181,100	8.3	16,400	9%	825,500	5,400	33%	271,400	1,990,200	$2,218,000	69%	187,300
I-55 (Stevenson Expwy) @ I-294 Interchange	Chicago-Northwestern IN	55	6	172,600	9.6	17,200	10%	1,001,600	6,000	35%	349,900	2,424,800	$2,751,000	53%	185,400
I-80 @ I-480 Interchange	Omaha (NE-IA)	80	5	173,600	7.9	13,800	8%	658,500	4,500	32%	215,500	1,638,000	$1,856,000	86%	185,300
I-76 @ SR 77 Interchange+J179	Akron	76	4	122,600	8.3	14,000	11%	705,200	7,000	50%	351,900	2,774,800	$3,088,000	52%	183,000
I-15 @ I-215 Interchange (the "Fishbowl")	Las Vegas	15	6	165,600	6.6	10,100	6%	403,200	5,000	50%	200,300	1,779,100	$2,041,000	90%	180,300

Table A.4 Highway Interchange Bottlenecks for Trucks

All High-Ranked Bottlenecks Ranked By Annual Hours of Delay for Large Trucks Making Longer Trips Greater Than 500 Miles

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-24 @ I-440N Interchange	Chattanooga (TN-GA)	24	4	118,200	8.3	18,500	16%	927,500	9,200	50%	462,500	3,330,000	$3,750,000	85%	393,100
U.S. 95 @ I-15 Interchange ("Spaghetti Bowl")	Las Vegas	95	6	199,900	9.8	11,300	6%	670,400	5,600	50%	333,100	1,992,500	$2,286,000	90%	299,800
I-90/94 @ I-290 Interchange ("Circle Interchange")	Chicago-Northwestern IN	90	8	305,800	9.7	26,300	9%	1,544,900	9,200	35%	540,400	3,718,000	$4,218,000	53%	286,400
I-94 (Dan Ryan Expwy) @ I-90 Skyway Split (Southside)	Chicago-Northwestern IN	94	8	271,700	7.9	31,600	12%	1,512,900	11,100	35%	531,500	4,485,900	$5,089,000	53%	281,700
I-75 @ I-74 Interchange	Cincinnati (OH-KY)	75	6	193,100	9.7	19,200	10%	1,128,900	6,900	36%	405,300	2,735,200	$3,044,000	63%	255,300
I-10 @ I-110 Interchange	Baton Rouge	10	6	150,400	7.2	15,200	10%	665,000	8,600	57%	375,200	3,163,900	$3,591,000	68%	255,100
I-80/I-94 split (Southside)	Chicago-Northwestern IN	80	4	139,600	8.6	25,600	18%	1,343,600	9,000	35%	472,400	3,637,200	$4,127,000	53%	250,400
I-285 @ I-85 Interchange ("Spaghetti Junction")	Atlanta	285	8	265,300	10.0	27,100	10%	1,641,200	7,800	29%	472,600	2,943,700	$3,262,000	52%	245,800
I-17 (Black Canyon Fwy): I-10 Interchange (the "Stack") to Cactus	Phoenix	17	6	217,300	9.2	28,900	13%	1,608,500	9,000	31%	501,600	3,326,700	$3,792,000	48%	240,800
Pulaski Rd @ I-55	Chicago-Northwestern IN	55	6	197,200	7.5	28,700	15%	1,300,400	10,000	35%	453,700	4,041,300	$4,585,000	53%	240,500
I-290 @ I-355	Chicago-Northwestern IN	290	6	223,100	8.3	24,800	11%	1,246,200	8,700	35%	437,300	3,515,900	$3,989,000	53%	231,800

Table A.4 Highway Interchange Bottlenecks for Trucks (continued)

All High-Ranked Bottlenecks Ranked By Annual Hours of Delay for Large Trucks Making Longer Trips Greater Than 500 Miles

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-40 @ I-24 Interchange	Nashville	40	4	147,600	8.3	14,600	10%	735,200	5,800	40%	291,600	2,099,300	$2,364,000	77%	224,500
I-285 @ I-75 Interchange	Atlanta	285	6	226,300	9.6	25,700	11%	1,497,300	7,400	29%	431,500	2,792,800	$3,095,000	52%	224,400
I-35 @ Martin Luther King Jr	Austin	35	6	229,500	8.3	12,600	5%	635,000	11,200	89%	563,000	4,123,900	$4,768,000	39%	219,600
I-15 between Tropicana and Flamingo	Las Vegas	15	6	165,900	6.4	12,400	7%	486,700	6,200	50%	242,800	2,206,000	$2,530,000	90%	218,500
I-12 @ Amite River, Baton Rouge	Baton Rouge	12	4	105,000	6.4	14,400	14%	561,900	8,100	57%	317,200	2,980,000	$3,383,000	68%	215,700
I-75 @ U.S. 35 Interchange	Dayton	75	4	127,400	8.3	18,400	14%	923,100	7,900	43%	397,100	3,131,600	$3,485,000	54%	214,400
I-90 @ I-290	Buffalo-Niagara Falls	90	4	136,500	8.3	33,100	24%	1,661,900	7,300	22%	367,000	2,632,500	$2,968,000	58%	212,900
I-20 @ I-285 Interchange	Atlanta	20	6	187,200	8.3	27,000	14%	1,359,400	7,800	29%	392,100	2,943,700	$3,262,000	52%	203,900
I-75 @ I-85 Interchange	Atlanta	75	10	339,600	9.1	23,400	7%	1,288,800	6,800	29%	374,900	2,566,300	$2,844,000	52%	194,900
I-264 @ I-64 Interchange	Louisville (KY-IN)	264	6	181,100	8.3	16,400	9%	825,500	5,400	33%	271,400	1,990,200	$2,218,000	69%	187,300
I-55 (Stevenson Expwy) @ I-294 Interchange	Chicago-Northwestern IN	55	6	172,600	9.6	17,200	10%	1,001,600	6,000	35%	349,900	2,424,800	$2,751,000	53%	185,400
I-80 @ I-480 Interchange	Omaha (NE-IA)	80	5	173,600	7.9	13,800	8%	658,500	4,500	32%	215,500	1,638,000	$1,856,000	86%	185,300
I-76 @ SR 77 Interchange+J179	Akron	76	4	122,600	8.3	14,000	11%	705,200	7,000	50%	351,900	2,774,800	$3,088,000	52%	183,000
I-15 @ I-215 Interchange (the "Fishbowl")	Las Vegas	15	6	165,600	6.6	10,100	6%	403,200	5,000	50%	200,300	1,779,100	$2,041,000	90%	180,300

Table A.4 Highway Interchange Bottlenecks for Trucks (continued)

All High-Ranked Bottleneck Ranked By Annual Hours of Delay for Large Trucks Making Longer Trips Greater Than 500 Miles

				2004											
Bottleneck				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-20 @ Fulton St.	Atlanta	20	6	207,300	8.1	23,700	11%	1,172,700	6,800	29%	336,500	2,566,300	$2,844,000	52%	175,000
I-77 @ Tryon Rd	Charlotte	77	6	170,500	8.3	29,600	17%	1,487,100	7,300	25%	367,000	2,700,200	$2,983,000	45%	165,200
San Bernardino Fwy	Los Angeles	10	8	268,700	7.2	34,900	13%	1,522,800	11,200	32%	488,700	4,094,500	$4,780,000	31%	151,500
SR-134 @ SR 2 Interchange	Los Angeles	134	8	247,900	8.3	29,600	12%	1,489,400	9,500	32%	477,500	3,473,000	$4,054,000	31%	148,000
Long Beach Fwy	Los Angeles	710	8	246,100	8.3	27,500	11%	1,380,300	8,800	32%	442,400	3,217,100	$3,756,000	31%	137,100
SR 60 @ I-605 Interchange	Los Angeles	60	8	233,000	8.3	26,100	11%	1,314,200	8,400	32%	422,300	3,070,900	$3,585,000	31%	130,900
I-405 (San Diego Fwy) @ I-605 Interchange	Los Angeles	405	10	331,700	9.8	20,900	6%	1,245,500	6,700	32%	398,600	2,449,400	$2,859,000	31%	123,600
San Gabriel River Fwy	Los Angeles	91	10	295,700	8.1	24,100	8%	1,194,300	7,700	32%	381,100	2,815,000	$3,286,000	31%	118,100
I-80 @ Central St.	San Francisco-Oakland	80	8	270,200	8.3	23,800	9%	1,196,700	7,800	33%	392,100	2,851,500	$3,329,000	29%	113,700
I-880 @ I-238	San Francisco-Oakland	880	8	282,700	8.3	22,000	8%	1,106,700	7,200	33%	361,900	2,632,200	$3,073,000	29%	105,000
I-93 @ I-95 Interchange	Boston	93	6	188,400	8.3	25,500	14%	1,280,100	2,800	11%	140,800	1,020,000	$1,220,000	36%	50,700

Table A.5 All Highway Interchange Bottlenecks for Trucks
Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-90 @ I-290	Buffalo-Niagara Falls	90	4	136,500	8.3	33,100	24%	1,661,900	7,300	22%	367,000	2,632,500	$2,968,000	58%	212,900
I-285 @ I-85 Interchange ("Spaghetti Junction")	Atlanta	285	8	265,300	10.0	27,100	10%	1,641,200	7,800	29%	472,600	2,943,700	$3,262,000	52%	245,800
I-17 (Black Canyon Fwy): I-10 Interchange (the "Stack") to Cactus	Phoenix	17	6	217,300	9.2	28,900	13%	1,608,500	9,000	31%	501,600	3,326,700	$3,792,000	48%	240,800
I-90/94 @ I-290 Interchange ("Circle Interchange")	Chicago-Northwestern IN	90	8	305,800	9.7	26,300	9%	1,544,900	9,200	35%	540,400	3,718,000	$4,218,000	53%	286,400
San Bernardino Fwy	Los Angeles	10	8	268,700	7.2	34,900	13%	1,522,800	11,200	32%	488,700	4,094,500	$4,780,000	31%	151,500
I-94 (Dan Ryan Expwy) @ I-90 Skyway Split (Southside)	Chicago-Northwestern IN	94	8	271,700	7.9	31,600	12%	1,512,900	11,100	35%	531,500	4,485,900	$5,089,000	53%	281,700
I-285 @ I-75 Interchange	Atlanta	285	6	226,300	9.6	25,700	11%	1,497,300	7,400	29%	431,500	2,792,800	$3,095,000	52%	224,400
SR 134 @ SR 2 Interchange	Los Angeles	134	8	247,900	8.3	29,600	12%	1,489,400	9,500	32%	477,500	3,473,000	$4,054,000	31%	148,000
I-77 @ Tryon Rd	Charlotte	77	6	170,500	8.3	29,600	17%	1,487,100	7,300	25%	367,000	2,700,200	$2,983,000	45%	165,200
Long Beach Fwy	Los Angeles	710	8	246,100	8.3	27,500	11%	1,380,300	8,800	32%	442,400	3,217,100	$3,756,000	31%	137,100
I-20 @ I-285 Interchange	Atlanta	20	6	187,200	8.3	27,000	14%	1,359,400	7,800	29%	392,100	2,943,700	$3,262,000	52%	203,900
I-80/I-94 split (Southside)	Chicago-Northwestern IN	80	4	139,600	8.6	25,600	18%	1,343,600	9,000	35%	472,400	3,637,200	$4,127,000	53%	250,400
SR 60 @ I-605 Interchange	Los Angeles	60	8	233,000	8.3	26,100	11%	1,314,200	8,400	32%	422,300	3,070,900	$3,585,000	31%	130,900
Pulaski Rd @ I-55	Chicago-Northwestern IN	55	6	197,200	7.5	28,700	15%	1,300,400	10,000	35%	453,700	4,041,300	$4,585,000	53%	240,500

Table A.5 All Highway Interchange Bottlenecks for Trucks (continued)
Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-75 @ I-85 Interchange	Atlanta	75	10	339,600	9.1	23,400	7%	1,288,800	6,800	29%	374,900	2,566,300	$2,844,000	52%	194,900
I-93 @ I-95 Interchange	Boston	93	6	188,400	8.3	25,500	14%	1,280,100	2,800	11%	140,800	1,020,000	$1,220,000	36%	50,700
I-290 @ I-355	Chicago-Northwestern IN	290	6	223,100	8.3	24,800	11%	1,246,200	8,700	35%	437,300	3,515,900	$3,989,000	53%	231,800
I-405 (San Diego Fwy) @ I-605 Interchange	Los Angeles	405	10	331,700	9.8	20,900	6%	1,245,500	6,700	32%	398,600	2,449,400	$2,859,000	31%	123,600
I-80 @ Central St.	San Francisco-Oakland	80	8	270,200	8.3	23,800	9%	1,196,700	7,800	33%	392,100	2,851,500	$3,329,000	29%	113,700
San Gabriel River Fwy	Los Angeles	91	10	295,700	8.1	24,100	8%	1,194,300	7,700	32%	381,100	2,815,000	$3,286,000	31%	118,100
I-20 @ Fulton St.	Atlanta	20	6	207,300	8.1	23,700	11%	1,172,700	6,800	29%	336,500	2,566,300	$2,844,000	52%	175,000
I-75 @ I-74 Interchange	Cincinnati (OH-KY)	75	6	193,100	9.7	19,200	10%	1,128,900	6,900	36%	405,300	2,735,200	$3,044,000	63%	255,300
I-880 @ I-238	San Francisco-Oakland	880	8	282,700	8.3	22,000	8%	1,106,700	7,200	33%	361,900	2,632,200	$3,073,000	29%	105,000
SR 315 @ I-70 Interchange	Columbus	315	2	64,000	8.3	21,800	34%	1,097,600	5,500	25%	276,500	2,180,200	$2,426,000	14%	38,700
Columbia Rd @ I-93	Boston	93	6	189,300	6.4	27,600	15%	1,081,800	3,000	11%	117,500	1,092,900	$1,307,000	36%	42,300
I-270 @ I-70 Interchange (West)	Columbus	270	4	122,600	9.5	18,600	15%	1,077,800	4,700	25%	271,900	1,863,100	$2,073,000	14%	38,100
SR 91 @ I-215 Interchange	Riverside-San Bernardino	91	10	276,500	6.7	26,100	9%	1,067,600	8,000	31%	327,700	2,924,600	$3,414,000	34%	111,400
I-710 @ Whittier Blvd	Los Angeles	60	8	257,500	5.5	31,500	12%	1,059,700	10,100	32%	340,200	3,692,300	$4,310,000	31%	105,500
Loop-202: Dobson to I-10	Phoenix	202	8	228,000	7.5	23,300	10%	1,055,700	7,200	31%	326,700	2,661,300	$3,033,000	48%	156,800
Worcester Rd @ I-95	Boston	95	6	173,600	8.1	21,000	12%	1,041,800	2,300	11%	113,800	837,900	$1,002,000	36%	41,000
I-10 @ SR 51/SR 202 Interchange ("Mini-Stack")	Phoenix	10	8	293,000	7.9	21,700	7%	1,038,000	6,700	31%	320,800	2,476,500	$2,823,000	48%	154,000
Orange Fwy	Los Angeles	91	7	244,200	8.0	21,100	9%	1,029,700	6,800	32%	331,100	2,485,900	$2,902,000	31%	102,600
I-495 @ I-95 Interchange (MD)	Washington (DC-MD-VA)	95	5	193,100	9.7	17,300	9%	1,020,100	2,400	14%	141,900	880,600	$978,000	53%	75,200

Table A.5 All Highway Interchange Bottlenecks for Trucks (continued)

Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-95 @ I-595 Interchange	Miami-Hialeah	95	9	308,500	8.3	20,100	7%	1,011,400	3,900	20%	196,000	1,467,900	$1,657,000	50%	98,000
I-55 (Stevenson Expwy) @ I-294 Interchange	Chicago-Northwestern IN	55	6	172,600	9.6	17,200	10%	1,001,600	6,000	35%	349,900	2,424,800	$2,751,000	53%	185,400
I-10 @ I-17 Interchange West (the "Stack")	Phoenix	10	8	238,800	8.4	19,300	8%	982,600	6,000	31%	306,200	2,217,800	$2,528,000	48%	147,000
I-76 @ Girard Ave	Philadelphia (PA-NJ)	76	6	200,400	7.3	22,100	11%	982,200	5,600	26%	249,200	2,133,600	$2,397,000	26%	64,800
I-71 @ I-70 Interchange	Columbus	71	3	112,500	8.3	19,300	17%	968,800	4,900	25%	246,300	1,942,400	$2,162,000	14%	34,500
SR 91 @ I-215 Interchange	Riverside-San Bernardino	91	10	275,500	6.7	23,600	9%	966,900	7,300	31%	299,000	2,668,700	$3,115,000	34%	101,700
Darby Paoli Rd @ U.S. 202	Philadelphia (PA-NJ)	202	4	114,200	8.3	18,900	17%	950,600	4,800	26%	241,300	1,828,800	$2,055,000	26%	62,700
U.S. 57 @ U.S. 91	Los Angeles	57	10	291,000	7.9	19,800	7%	946,900	6,300	32%	301,700	2,303,100	$2,689,000	31%	93,500
I-24 @ I-440N Interchange	Chattanooga (TN-GA)	24	4	118,200	8.3	18,500	16%	927,500	9,200	50%	462,500	3,330,000	$3,750,000	85%	393,100
I-75 @ U.S. 35 Interchange	Dayton	75	4	127,400	8.3	18,400	14%	923,100	7,900	43%	397,100	3,131,600	$3,485,000	54%	214,400
I-110 @ Saulson Ave	Los Angeles	110	10	333,500	8.3	18,100	5%	910,000	5,800	32%	291,600	2,120,400	$2,475,000	31%	90,400
I-5 (San Diego Fwy) @ I-405 Interchange ("El Toro")	Los Angeles	5	11	371,500	7.0	20,800	6%	887,600	6,700	32%	286,400	2,449,400	$2,859,000	31%	88,800
I-495 @ I-270 Interchange	Washington (DC-MD-VA)	495	7	253,700	8.6	16,800	7%	884,100	2,400	14%	126,000	880,600	$978,000	53%	66,800
I-70 @ I-25 Interchange ("Mousetrap")	Denver	70	4	157,300	8.3	17,100	11%	859,200	2,900	17%	145,800	1,099,000	$1,243,000	67%	97,700
U.S. 101 (Ventura Fwy) @ I-405 Interchange	Los Angeles	101	10	331,300	9.8	14,400	4%	855,600	4,600	32%	273,700	1,681,700	$1,963,000	31%	84,800
I-70 @ U.S. 23 Interchange	Columbus	70	5	163,900	8.3	16,700	10%	839,100	4,200	25%	211,100	1,664,900	$1,853,000	14%	29,600

Table A.5 All Highway Interchange Bottlenecks for Trucks (continued)

Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-264 @ I-64 Interchange	Louisville (KY-IN)	264	6	181,100	8.3	16,400	9%	825,500	5,400	33%	271,400	1,990,200	$2,218,000	69%	187,300
I-35W @ SR 62 Interchange	Minneapolis-St. Paul	35	6	183,300	10.0	13,500	7%	815,600	4,400	33%	266,600	1,634,500	$1,866,000	58%	154,600
I-610 @ I-10 Interchange (West)	Houston	610	8	307,700	9.3	14,200	5%	808,500	5,600	40%	318,400	2,062,000	$2,384,000	44%	140,100
I-405 (San Diego Fwy) @ I-10 Interchange	Los Angeles	405	10	308,500	10.0	12,900	4%	784,300	4,100	32%	248,400	1,498,900	$1,750,000	31%	77,000
I-40 @ I-24 Interchange	Nashville	40	4	147,600	8.3	14,600	10%	735,200	5,800	40%	291,600	2,099,300	$2,364,000	77%	224,500
I-57 @ 12th St.	Chicago-Northwestern IN	57	6	174,200	3.8	31,600	18%	733,800	11,100	35%	257,600	4,485,900	$5,089,000	53%	136,500
I-5 (Santa Ana Fwy) @ SR 22/SR 57 Interchange ("Orange Crush")	Los Angeles	5	10	321,300	6.0	19,900	6%	726,400	6,400	32%	233,100	2,339,700	$2,731,000	31%	72,300
I-70 @ U.S. 67 Interchange	St. Louis (MO-IL)	70	6	177,100	8.3	14,400	8%	721,500	3,100	21%	155,800	1,148,000	$1,303,000	75%	116,900
I-76 @ SR 77 Interchange+J179	Akron	76	4	122,600	8.3	14,000	11%	705,200	7,000	50%	351,900	2,774,800	$3,088,000	52%	183,000
I-105 @ U.S. 107 Interchange	Los Angeles	105	8	240,200	8.1	14,200	6%	702,100	4,500	32%	222,700	1,645,100	$1,920,000	31%	69,000
Southern State Parkway @ Exit 25A	New York-Northeastern NJ	908	6	204,500	5.4	21,400	10%	699,800	6,200	29%	203,200	2,235,800	$2,521,000	27%	54,900
U.S. 101 @ I-280 Interchange	San Francisco-Oakland	101	8	261,600	8.3	13,400	5%	673,400	4,400	33%	221,200	1,608,500	$1,878,000	29%	64,100
U.S. 95 @ I-15 Interchange ("Spaghetti Bowl")	Las Vegas	95	6	199,900	9.8	11,300	6%	670,400	5,600	50%	333,100	1,992,500	$2,286,000	90%	299,800
U.S. 101 @ I-880 Interchange	San Jose	101	8	254,500	9.3	11,900	5%	669,000	2,700	23%	152,000	987,100	$1,152,000	16%	24,300

Table A.5 All Highway Interchange Bottlenecks for Trucks (continued)

Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004												
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"							
									All Trips						Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-10 @ I-110 Interchange	Baton Rouge	10	6	150,400	7.2	15,200	10%	665,000	8,600	57%	375,200	3,163,900	$3,591,000	68%	255,100
U.S. 101 @ SR 92 Interchange	San Francisco-Oakland	101	8	263,600	8.3	13,200	5%	663,800	4,300	33%	216,200	1,572,000	$1,835,000	29%	62,700
I-75 @ I-275 Interchange	Cincinnati (OH-KY)	75	6	174,800	4.7	23,400	13%	662,900	8,400	36%	237,800	3,095,900	$3,451,000	63%	149,800
Between I-25 and Paseo Del Norte	Albuquerque	40	4	157,100	8.3	13,200	8%	662,600	2,500	19%	125,700	974,500	$1,100,000	91%	114,400
I-80 @ I-480 Interchange	Omaha (NE-IA)	80	5	173,600	7.9	13,800	8%	658,500	4,500	32%	215,500	1,638,000	$1,856,000	86%	185,300
I-278 @ Exit 36	New York-Northeastern NJ	278	6	210,000	7.7	13,900	7%	654,600	4,000	29%	188,200	1,442,500	$1,626,000	27%	50,800
Pomona Fwy: SR 91 Interchange	Riverside-San Bernardino	215	6	175,300	7.7	13,900	8%	653,800	4,300	31%	202,400	1,572,000	$1,835,000	34%	68,800
I-5: Interstate Bridge and bridge influence area	Portland-Vancouver (OR-WA)	5	4	109,900	8.7	12,100	11%	644,200	4,100	34%	218,100	1,484,600	$1,716,000	33%	72,000
U.S. 1 @ I-95 Interchange	Philadelphia (PA-NJ)	95	8	207,800	5.7	18,600	9%	643,900	4,700	26%	162,600	1,742,100	$1,938,000	26%	42,300
I-94 @ I-75 Interchange	Detroit	94	6	167,200	6.9	15,400	9%	643,700	4,400	29%	184,200	1,597,400	$1,795,000	32%	58,900
SR 167 SB @ 15th St. in Auburn	Seattle	167	5	121,800	9.4	11,100	9%	638,900	2,700	24%	154,900	990,000	$1,119,000	15%	23,200
I-5 @ SR 56 Interchange	San Diego	5	8	234,200	7.7	13,500	6%	635,100	3,600	27%	169,400	1,316,100	$1,536,000	16%	27,100
I-35 @ Martin Luther King Jr	Austin	35	6	229,500	8.3	12,600	5%	635,000	11,200	89%	563,000	4,123,900	$4,768,000	39%	219,600
I-695: Between I-70 and I-95	Baltimore	695	6	180,800	8.4	12,100	7%	616,800	2,700	22%	137,800	990,600	$1,101,000	49%	67,500
U.S. 87 @ U.S. 36	Denver	25	7	247,700	8.0	12,600	5%	614,100	2,100	17%	102,300	795,800	$900,000	67%	68,500

Table A.5 All Highway Interchange Bottlenecks for Trucks (continued)

Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-90 @ I-94 Interchange ("Edens Interchange")	Chicago-Northwestern IN	90	6	189,700	8.3	11,900	6%	596,300	4,200	35%	211,100	1,697,300	$1,926,000	53%	111,900
I-10 @ U.S. 17A Interchange	Jacksonville	10	4	141,500	8.3	11,800	8%	595,200	1,800	15%	90,500	677,500	$765,000	29%	26,200
I-278 (Staten Island Expwy) before Verrazano Br	New York-Northeastern NJ	278	6	204,400	7.3	13,300	7%	593,400	3,900	29%	173,600	1,406,400	$1,586,000	27%	46,900
I-66 @ I-495 (Capitol Beltway) Interchange	Washington (DC-MD-VA)	66	6	188,500	8.3	11,700	6%	588,500	1,600	14%	80,400	580,700	$645,000	53%	42,600
I-15 @ SR 78 Interchange (Escondido)	San Diego	15	8	211,900	6.0	15,500	7%	566,200	4,100	27%	149,300	1,498,900	$1,750,000	16%	23,900
I-64 @ I-264 Interchange	Norfolk (036)-Virginia Beach-Newport	64	5	150,000	8.4	11,000	7%	563,700	2,400	22%	122,500	871,100	$967,000	22%	27,000
Centreville Rd @ I-66	Washington (DC-MD-VA)	66	6	196,000	8.3	11,200	6%	563,500	1,600	14%	80,400	580,700	$645,000	53%	42,600
I-12 @ Amite River, Baton Rouge	Baton Rouge	12	4	105,000	6.4	14,400	14%	561,900	8,100	57%	317,200	2,980,000	$3,383,000	68%	215,700
I-95 @ Chestnut St.	Philadelphia (PA-NJ)	95	6	177,000	4.7	19,600	11%	553,900	5,000	26%	141,500	1,905,000	$2,141,000	26%	36,800
I-91 @ U.S. 1 Interchange	New Haven (064)-Meriden (212)	91	3	97,400	7.0	12,900	13%	550,100	4,200	33%	179,600	1,550,900	$1,741,000	35%	62,900
I-275 @ I-4 Interchange ("Malfunction Junction")	Tampa (059)-St. Petersburg (057)-Clearwater	275	6	210,100	7.7	11,500	5%	540,500	2,500	22%	117,600	941,000	$1,062,000	38%	44,700
I-15 @ I-215 Interchange	Salt Lake City	15	6	187,400	8.3	10,600	6%	535,100	4,800	45%	241,300	1,744,700	$1,985,000	59%	142,400
I-96 @ Jct I-275	Detroit	96	8	202,000	9.9	8,700	4%	527,200	2,500	29%	150,900	907,600	$1,020,000	32%	48,300

Table A.5 All Highway Interchange Bottlenecks for Trucks (continued)
Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004												
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"							
									All Trips						Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-678 @ SR 27 Interchange (JFK)	New York-Northeastern NJ	678	4	140,900	8.3	10,500	7%	526,300	3,100	29%	155,800	1,117,900	$1,260,000	27%	42,100
I-95 Between I-895 and SR 43	Baltimore	95	8	194,200	4.4	19,800	10%	525,100	4,400	22%	116,900	1,614,400	$1,794,000	49%	57,300
I-355 @ I-55	Chicago-Northwestern IN	355	3	91,100	4.5	19,100	21%	523,100	6,700	35%	183,800	2,707,700	$3,072,000	53%	97,400
SR 400 @ I-285 Interchange	Atlanta	400	6	223,600	3.3	25,700	11%	514,800	7,400	29%	148,300	2,792,800	$3,095,000	52%	77,100
U.S. 75 @ Lemmon Ave.	Dallas-Fort Worth	75	6	194,400	8.3	10,200	5%	511,600	2,700	26%	135,700	994,200	$1,149,000	54%	73,300
Garden State Parkway @ I-78	New York-Northeastern NJ	GSPW	6	201,500	7.9	10,600	5%	509,800	3,100	29%	148,400	1,132,300	$1,266,000	27%	40,100
I-494 @ I-35W Interchange	Minneapolis-St. Paul	494	6	160,800	6.0	14,000	9%	508,800	4,600	33%	167,500	1,708,800	$1,951,000	58%	97,200
I-95 @ Golden Glades Interchange	Miami-Hialeah	95	6	187,100	3.6	23,600	13%	508,800	4,600	20%	99,400	1,731,400	$1,954,000	50%	49,700
I-10 @ I–610 Interchange	New Orleans	10	5	159,500	6.1	13,600	9%	508,700	2,800	21%	104,500	1,030,100	$1,169,000	39%	40,800
I-95 @ U.S. 7 Interchange	Bridgeport-Milford	95	6	151,900	5.2	15,900	10%	506,000	5,100	32%	162,500	1,883,200	$2,114,000	30%	48,800
I-275 Between I-74 and SR 126	Cincinnati (OH-KY)	275	4	117,700	8.0	10,400	9%	504,700	3,700	36%	180,200	1,466,700	$1,632,000	63%	113,500
I-84 @ U.S. 30 Interchange	Portland-Vancouver (OR-WA)	84	6	184,300	8.3	10,000	5%	503,500	3,400	34%	170,900	1,231,200	$1,423,000	33%	56,400
I-83 @ I-695 Interchange	Baltimore	SL1	5	159,300	5.7	14,300	9%	496,400	3,100	22%	107,200	1,137,400	$1,264,000	49%	52,500
I-205 @ Powell Blvd	Portland-Vancouver (OR-WA)	205	6	175,700	7.7	10,500	6%	496,200	3,500	34%	164,700	1,267,400	$1,465,000	33%	54,400

Table A.5 All Highway Interchange Bottlenecks for Trucks (continued)

Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-495 (Long Island Expwy) @ Exit 33	New York-Northeastern NJ	495	6	211,500	7.7	10,400	5%	491,600	3,000	29%	141,200	1,081,800	$1,220,000	27%	38,100
Mission Valley Fwy	San Diego	8	9	258,600	8.3	9,700	4%	489,800	2,600	27%	130,700	950,500	$1,110,000	16%	20,900
I-15 between Tropicana and Flamingo	Las Vegas	15	6	165,900	6.4	12,400	7%	486,700	6,200	50%	242,800	2,206,000	$2,530,000	90%	218,500
I-695 @ I-70 Interchange	Baltimore	695	7	228,700	6.3	12,400	5%	473,100	2,700	22%	103,300	990,600	$1,101,000	49%	50,600
7 Mile Rd @ I-75	Detroit	75	6	179,400	4.9	15,500	9%	467,200	4,400	29%	132,300	1,597,400	$1,795,000	32%	42,300
I-440S @ U.S. 431	Nashville	440	4	115,800	7.7	9,900	9%	465,500	3,900	40%	183,500	1,411,600	$1,590,000	77%	141,300
I-805 @ I-15 Interchange	San Diego	805	8	248,200	8.6	8,900	4%	464,500	2,400	27%	126,000	877,400	$1,024,000	16%	20,200
I-95 @ I--87 Interchange	New York-Northeastern NJ	95	6	181,600	8.3	9,200	5%	461,800	2,700	29%	135,700	973,700	$1,098,000	27%	36,600
I-280 @ U.S. 1 Interchange	San Francisco-Oakland	280	8	230,800	3.6	21,300	9%	460,500	7,000	33%	151,200	2,559,000	$2,987,000	29%	43,800
I-5 NB @ SR 526 in Everett	Seattle	5	6	153,500	6.0	12,600	8%	457,200	3,000	24%	109,300	1,100,000	$1,243,000	15%	16,400
I-95 @ I-195 Interchange	Providence-Pawtucket (RI-MA)	95	8	267,200	6.7	11,100	4%	455,300	600	5%	24,600	224,300	$255,000	28%	6,900
I-45 @ I-610 Interchange	Houston	45	8	277,700	7.5	10,000	4%	452,300	4,000	40%	181,500	1,472,800	$1,703,000	44%	79,900
I-10 @ I-17 Interchange West (the "Stack")	Phoenix	10	8	239,000	4.7	15,800	7%	448,000	4,900	31%	138,700	1,811,200	$2,064,000	48%	66,600
I-10 (Santa Monica Fwy) @ I-5 Interchange	Los Angeles	10	10	323,000	5.8	12,500	4%	445,500	4,000	32%	142,000	1,462,300	$1,707,000	31%	44,000

Table A.5 All Highway Interchange Bottlenecks for Trucks (continued)

Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-95 @ SR 9A (Westside Hwy)	New York-Northeastern NJ	95	9	310,300	7.2	10,200	3%	445,200	3,000	29%	130,900	1,081,800	$1,220,000	27%	35,300
U.S. 60 (Superstition Fwy): Loop-101 to I-10	Phoenix	60	6	174,100	2.9	24,600	14%	439,000	7,700	31%	137,200	2,846,200	$3,244,000	48%	65,900
I-77 @ SR 8 Interchange	Akron	77	4	130,900	8.3	8,700	7%	438,000	4,400	50%	221,200	1,744,200	$1,941,000	52%	115,000
I-95 @ I-476 Interchange	Philadelphia (PA-NJ)	95	5	153,400	5.1	14,100	9%	437,200	3,600	26%	111,500	1,371,600	$1,541,000	26%	29,000
I-70 @ I-435 Interchange	Kansas City (MO-KS)	70	4	116,700	8.3	8,600	7%	433,300	4,600	54%	231,200	1,703,500	$1,933,000	64%	148,000
I-84 @ SR 2 Interchange ("Mixmaster East")	Hartford-Middletown	84	5	123,800	6.7	10,600	9%	433,000	2,500	24%	102,400	923,200	$1,036,000	66%	67,600
Harding Pl @ I-24	Nashville	24	4	138,300	7.6	9,300	7%	431,200	3,700	40%	171,000	1,339,200	$1,508,000	77%	131,700
Florida Turnpike @ I-595	Miami-Hialeah	595	6	187,400	8.3	8,500	5%	426,100	1,700	20%	85,500	639,900	$722,000	50%	42,800
I-278 (BQE) @ I-495 Interchange	New York-Northeastern NJ	278	6	209,800	7.6	9,100	4%	422,500	2,600	29%	120,200	937,600	$1,057,000	27%	32,500
I-696 @ Jct I-75	Detroit	696	8	222,800	6.6	10,500	5%	418,900	3,000	29%	120,200	1,089,100	$1,224,000	32%	38,500
I-10 @ I-410 Loop North Interchange	San Antonio	10	5	166,400	6.7	10,200	6%	418,300	1,800	18%	73,700	662,800	$766,000	41%	30,200
I-55 from Naperville to Weber	Chicago-Northwestern IN	55	4	108,600	7.0	9,500	9%	405,900	3,300	35%	141,100	1,333,600	$1,513,000	53%	74,800
I-15 @I-215 Interchange (the "Fishbowl")	Las Vegas	15	6	165,600	6.6	10,100	6%	403,200	5,000	50%	200,300	1,779,100	$2,041,000	90%	180,300
I-580 MP 17-19	San Francisco-Oakland	580	8	197,300	4.4	15,000	8%	398,300	4,900	33%	130,200	1,791,300	$2,091,000	29%	37,800

Table A.5 All Highway Interchange Bottlenecks for Trucks (continued)

Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-495 (Long Island Expwy) @ Grand Ave.	New York-Northeastern NJ	495	7	232,600	6.3	10,200	4%	390,600	3,000	29%	114,700	1,081,800	$1,220,000	27%	31,000
I-5 @ I-90 Interchange	Seattle	5	10	313,800	5.2	12,200	4%	387,300	2,900	24%	92,400	1,063,300	$1,201,000	15%	13,900
I-45 (Gulf Fwy) @ U.S. 59 Interchange	Houston	45	8	260,800	6.0	10,600	4%	386,900	4,200	40%	153,000	1,546,500	$1,788,000	44%	67,300
I-75 @ I-280 Interchange	Toledo (OH-MI)	75	3	90,700	4.0	16,000	18%	384,200	6,000	38%	144,200	2,378,400	$2,647,000	40%	57,700
I-80 @ I-294 Interchange	Chicago-Northwestern IN	80	6	137,600	3.8	16,400	12%	380,700	5,700	35%	132,300	2,303,500	$2,614,000	53%	70,100
I-64 @ I-65/I-71 Interchange ("Spaghetti Junction")	Louisville (KY-IN)	64	4	123,500	8.3	7,500	6%	375,900	2,500	33%	125,700	921,400	$1,027,000	69%	86,700
I-475 - 9.63-14.66	Toledo (OH-MI)	475	4	102,900	5.5	11,000	11%	371,800	4,100	38%	138,100	1,625,300	$1,809,000	40%	55,200
I-287 @ SR 24	New York-Northeastern NJ	287	3	102,800	7.2	8,500	8%	370,100	2,500	29%	109,100	913,100	$1,021,000	27%	29,500
I-95 - Woodrow Wilson Bridge	Washington (DC-MD-VA)	95	7	205,400	4.8	12,500	6%	364,100	1,800	14%	52,500	653,300	$725,000	53%	27,800
I-238 @ I-550	San Francisco-Oakland	238	4	121,000	5.1	11,700	10%	363,600	3,800	33%	117,700	1,389,200	$1,622,000	29%	34,100
I-75 @ Jct M-8	Detroit	75	8	193,500	3.8	15,500	8%	360,500	4,400	29%	102,100	1,597,400	$1,795,000	32%	32,700
I-590 @ I-490/SR 590 Interchange "Can of Worms")	Rochester	590	4	114,300	8.3	7,000	6%	352,800	1,700	24%	85,500	613,000	$691,000	20%	17,100
U.S. 45 @ I-94/I-894 Interchange (the "Zoo")	Milwaukee	45	4	149,000	4.5	12,700	9%	347,300	4,900	39%	134,400	1,792,200	$2,007,000	33%	44,400
I-85 @ SR 7	Gastonia	85	4	115,700	7.7	7,400	6%	346,500	3,700	51%	174,100	1,368,600	$1,512,000	43%	74,900

Table A.5 All Highway Interchange Bottlenecks for Trucks (continued)

Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-35 @ Loop 410 Interchange	San Antonio	35	6	170,200	3.8	14,600	9%	338,600	2,600	18%	60,300	957,300	$1,107,000	41%	24,700
SR 99 @ Stockton Blvd	Sacramento	99	6	179,600	2.8	19,500	11%	333,900	8,600	44%	147,100	3,144,000	$3,670,000	63%	92,700
I-494 @ I-394 Interchange	Minneapolis-St. Paul	494	4	100,500	6.6	8,200	8%	329,500	2,700	33%	108,200	1,003,000	$1,145,000	58%	62,800
Loop-101 Agua Fria: 67th Ave to I-17	Phoenix	101	4	113,400	4.1	13,200	12%	329,000	4,100	31%	102,000	1,515,500	$1,727,000	48%	49,000
Loop-101 Agua Fria: 67th Ave to I-17	Phoenix	101	4	113,400	4.1	13,200	12%	329,000	4,100	31%	102,000	1,515,500	$1,727,000	48%	49,000
U.S. 59 @ SR 6 Interchange	Houston	59	4	154,000	4.7	11,600	8%	328,600	4,600	40%	130,200	1,693,800	$1,958,000	44%	57,300
I-405 in Downtown Bellevue	Seattle	405	8	209,200	8.9	6,000	3%	324,700	1,400	24%	75,400	513,300	$580,000	15%	11,300
SR 288 @ U.S. 59	Houston	288	5	163,800	6.3	8,100	5%	309,200	3,200	40%	122,400	1,178,300	$1,362,000	44%	53,900
FDR Drive south of Triborough Bridge	New York-Northeastern NJ	907	6	170,000	3.7	13,700	8%	307,400	4,000	29%	89,600	1,442,500	$1,626,000	27%	24,200
U.S. 202 @ U.S. 422	Philadelphia (PA-NJ)	202	4	123,400	5.2	9,500	8%	301,300	2,400	26%	76,500	914,400	$1,027,000	26%	19,900
I-75 @ I-696 Interchange	Detroit	75	6	184,500	3.2	15,600	8%	300,600	4,500	29%	86,800	1,633,700	$1,836,000	32%	27,800
I-80 @ Garden State Pkwy	New York-Northeastern NJ	80	4	125,700	5.5	8,700	7%	293,600	2,500	29%	84,200	913,100	$1,021,000	27%	22,700
I-95 @ Route 4 Interchange	Providence-Pawtucket RI-MA)	95	8	181,100	2.9	16,400	9%	292,300	900	5%	16,000	336,500	$383,000	28%	4,500
Northern State Parkway @ Exit 36A	New York-Northeastern NJ	908	4	116,500	4.4	10,900	9%	288,900	3,200	29%	85,000	1,154,000	$1,301,000	27%	23,000
I-271 @ I-480 Interchange	Cleveland	271	5	144,600	7.5	6,300	4%	286,900	3,100	49%	140,600	1,228,900	$1,368,000	49%	68,900

Table A.5 All Highway Interchange Bottlenecks for Trucks (continued)
Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-15 @ I-80 Interchange	Salt Lake City	15	6	203,400	7.7	6,000	3%	283,100	2,700	45%	127,100	981,400	$1,116,000	59%	75,000
I-480 Between SR 10 and SR 17	Cleveland	480	4	105,700	5.5	8,300	8%	279,800	4,100	49%	138,100	1,625,300	$1,809,000	49%	67,700
I-76 @ Walnut La	Philadelphia (PA-NJ)	76	4	129,800	2.7	17,000	13%	278,500	4,300	26%	70,500	1,638,300	$1,841,000	26%	18,300
I-64 @ I-264 Interchange	Washington (DC-MD-VA)	64	5	145,200	4.1	11,000	8%	274,700	1,500	14%	37,300	544,400	$604,000	53%	19,800
I-90 @ I-87 Interchange	Albany-Schenectady-Troy	90	4	118,200	7.9	5,600	5%	269,300	3,000	53%	143,700	1,081,800	$1,220,000	23%	33,100
SR 183 @ SR 360	Dallas-Fort Worth	360	4	151,000	8.3	5,300	4%	268,900	1,400	26%	70,400	515,500	$596,000	54%	38,000
I-35W @ SH-121 Interchange	Dallas-Fort Worth	35	4	106,300	5.8	7,500	7%	267,100	2,000	26%	71,000	736,400	$851,000	54%	38,300
M-39 @ M-5 Interchange	Detroit	39	6	184,500	8.3	5,300	3%	264,800	1,500	29%	75,400	544,600	$612,000	32%	24,100
I-4 @ SR 408 Interchange (East/West Toll)	Orlando	4	6	190,600	9.0	4,900	3%	264,500	1,700	34%	92,700	639,900	$722,000	20%	18,500
I-880 @ SR 237 Interchange	San Jose	880	6	192,000	3.7	11,700	6%	262,700	2,600	23%	58,200	950,500	$1,110,000	16%	9,300
I-64 @ I-95 Interchange	Richmond	64	3	101,500	7.0	5,900	6%	254,000	2,900	48%	124,000	1,052,600	$1,168,000	40%	49,600
SR 562 @ I-75 Interchange	Cincinnati (OH-KY)	562	2	71,900	8.3	4,900	7%	244,900	1,800	36%	90,500	713,500	$794,000	63%	57,000
I-10 @ I-110/U.S. 54 Interchange	El Paso (TX-NM)	10	7	209,600	4.4	9,100	4%	241,800	2,100	23%	55,800	773,200	$894,000	97%	54,100
SR 4 @ Willow Pass Rd	Antioch-Pittsburgh	4	4	129,400	6.3	6,300	5%	241,200	2,200	35%	84,100	804,300	$939,000	39%	32,800

Table A.5 All Highway Interchange Bottlenecks for Trucks (continued)

Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004												
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"							
									All Trips						Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-95 @ SR 3	New York-Northeastern NJ	95	10	305,400	2.3	17,100	6%	235,800	5,000	29%	68,900	1,826,200	$2,042,000	27%	18,600
I-35 @ Loop 410 Interchange	San Antonio	35	6	167,800	3.0	12,700	8%	235,300	2,200	18%	40,800	810,100	$937,000	41%	16,700
M-39 @ Jct M-5	Detroit	39	6	184,300	8.4	4,500	2%	230,900	1,300	29%	66,300	472,000	$530,000	32%	21,200
I-94 @ I-35E Interchange ("Spaghetti Bowl")	Minneapolis-St. Paul	94	6	166,300	3.3	11,500	7%	230,300	3,700	33%	74,200	1,374,500	$1,569,000	58%	43,000
I-71 @ I-75 Interchange	Cincinnati (OH-KY)	71	4	139,000	3.6	10,600	8%	229,900	3,800	36%	82,100	1,506,300	$1,676,000	63%	51,700
Sunset Highway @ Murray Blvd	Portland-Vancouver (OR-WA)	26	4	125,400	3.4	11,000	9%	229,600	3,700	34%	77,000	1,339,800	$1,549,000	33%	25,400
Roosevelt Rd @ I-355	Chicago-Northwestern IN	355	4	130,500	8.3	4,600	4%	229,100	1,600	35%	80,400	646,600	$734,000	53%	42,600
SR 80 @ U.S. 101 Interchange	San Francisco-Oakland	80	8	227,400	2.7	13,900	6%	228,800	4,600	33%	75,500	1,681,700	$1,963,000	29%	21,900
SR 1 @ SR 17 Interchange	Santa Cruz	1	4	114,700	7.2	5,100	4%	221,000	1,100	23%	48,000	402,100	$469,000	16%	7,700
I-94 @ I-35W Interchange	Minneapolis-St. Paul	94	6	165,400	3.2	11,300	7%	217,700	3,700	33%	71,400	1,374,500	$1,569,000	58%	41,400
I-35E @ I-30 Interchange ("Mixmaster")	Dallas-Fort Worth	35	6	190,000	5.4	6,600	3%	217,100	1,700	26%	55,700	626,000	$724,000	54%	30,100
Balt/Wash Pkwy: I-495/I-95 to Powder Mill Rd	Washington (DC-MD-VA)	295	4	110,400	8.3	4,200	4%	211,000	600	14%	30,200	220,100	$245,000	53%	16,000

Table A.5 All Highway Interchange Bottlenecks for Trucks (continued)
Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004 All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips" All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-664 @ U.S. 13 Interchange	Norfolk Virginia Beach-Newport News	664	4	130,800	6.0	5,400	4%	196,900	1,200	22%	43,700	435,600	$483,000	22%	9,600
I-225 @ U.S. 87 Interchange	Denver	225	4	117,000	3.3	9,700	8%	193,700	1,600	17%	32,100	606,300	$686,000	67%	21,500
I-376 @ Centreville Rd	Pittsburgh	376	4	116,100	3.3	9,500	8%	189,800	3,300	35%	66,100	1,257,300	$1,413,000	39%	25,800
I-55 @ I-294 Interchange	Chicago-Northwestern IN	55	6	173,400	8.3	3,600	2%	180,100	1,300	35%	65,300	525,400	$596,000	53%	34,600
Balt/Wash Pkwy @ I-495/I-95 Interchange	Washington (DC-MD-VA)	295	4	111,700	7.2	4,100	4%	178,900	600	14%	26,200	220,100	$245,000	53%	13,900
U.S. 50 @ I-75 Interchange	Cincinnati (OH-KY)	50	3	93,800	3.7	7,900	8%	177,300	2,800	36%	62,700	1,109,900	$1,235,000	63%	39,500
U.S. 169 @ I-394 Interchange	Minneapolis-St. Paul	169	4	106,200	5.5	5,300	5%	177,100	1,700	33%	57,300	631,500	$721,000	58%	33,200
SR 121 @ I-820	Dallas-Fort Worth	820	5	160,300	5.5	5,200	3%	174,500	1,400	26%	47,200	515,500	$596,000	54%	25,500
I-680 @ U.S. 13	San Francisco-Oakland	680	6	177,300	2.5	10,600	6%	159,500	3,500	33%	52,700	1,279,500	$1,494,000	29%	15,300
I-264 @ Downtown Tunnel	Norfolk (036)-Virginia Beach-Newport	264	4	118,800	7.9	3,200	3%	152,100	700	22%	33,500	254,100	$282,000	22%	7,400
I-35E @ TH 36 Interchange	Minneapolis-St. Paul	35	6	144,000	3.6	6,800	5%	146,500	2,200	33%	47,500	817,200	$933,000	58%	27,600
I-95 @ U.S. 90 Interchange	Jacksonville	10	5	173,300	7.2	3,300	2%	144,600	500	15%	21,800	188,200	$212,000	29%	6,300

Table A.5 All Highway Interchange Bottlenecks for Trucks (continued)
Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
SR 176 between Snow Rd and Broadview Rd	Cleveland	176	2	65,400	6.3	3,500	5%	133,700	1,700	49%	65,000	673,900	$750,000	49%	31,900
MOPAC Expy-Capital of Texas	Austin	SL1	4	129,900	8.3	2,300	2%	115,800	2,000	89%	100,500	736,400	$851,000	39%	39,200
SR 16 @ Sprague Ave	Seattle	16	4	121,600	4.5	3,500	3%	95,500	800	24%	21,900	293,300	$331,000	15%	3,300
I-94 W of Marquette Interchange	Milwaukee	94	6	161,900	5.5	2,700	2%	92,200	1,100	39%	37,100	402,300	$451,000	33%	12,200
I-80 @I-294 Interchange	Chicago-Northwestern IN	80	6	136,900	1.2	12,100	9%	91,700	4,200	35%	31,700	1,697,300	$1,926,000	53%	16,800
SR 400 @ I-285 Interchange	Atlanta	400	4	112,400	2.6	5,800	5%	91,700	1,700	29%	26,700	641,600	$711,000	52%	13,900
U.S. 192 @ I-4	Orlando	192	4	114,200	1.4	10,300	9%	86,800	3,500	34%	29,500	1,317,400	$1,487,000	20%	5,900
I-277 @ I-77 Interchange	Akron	277	2	60,200	4.5	3,000	5%	82,300	1,500	50%	41,100	594,600	$662,000	52%	21,400
I-475 @ Monroe St.	Toledo (OH-MI)	475	3	116,600	1.2	10,200	9%	76,900	3,800	38%	28,700	1,506,300	$1,676,000	40%	11,500
SR 520 Floating Bridge	Seattle	520	4	104,500	6.9	1,800	2%	76,200	400	24%	16,700	146,700	$166,000	15%	2,500
I-195 @ SR 76 Interchange	Richmond	195	3	92,400	3.0	3,900	4%	72,400	1,900	48%	35,200	689,600	$765,000	40%	14,100
I-75, from Ohio River Bridge to I-71 Interchange	Cincinnati (OH-KY)	75	4	141,600	0.8	14,900	11%	70,900	5,300	36%	25,300	2,100,900	$2,338,000	63%	15,900
U.S. 1 @ Chippenham Pkwy	Richmond	150	2	56,000	3.3	3,500	6%	69,700	1,700	48%	34,100	617,000	$685,000	40%	13,600
I-394 @ TH 100 Interchange	Minneapolis-St. Paul	394	6	152,900	2.0	5,300	3%	64,000	1,700	33%	20,400	631,500	$721,000	58%	11,800
Loop 410 @U.S. 281 Interchange	San Antonio	410	6	174,700	3.7	2,800	2%	62,400	500	18%	11,200	184,100	$213,000	41%	4,600

Table A.5 All Highway Interchange Bottlenecks for Trucks (continued)
Ranked By Annual Hours of Delay for All Trucks

Bottleneck				2004											
				All Vehicles		All Trucks			"Large Trucks Making Longer Distance Trips"						
									All Trips					Trips Greater Than 500 Miles	
Location	Urban Area	Critically Congested Route No.	No. of Lanes	AADT	Daily Minutes of Delay per Vehicle	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	AADTT	Percent of All Trucks	Annual Hours of Delay	Annual Commodity Tons	Annual Commodity Value	Percent of Large Truck Trips	Annual Hours of Delay
I-290 (Eisenhower Expwy) Between Exits 17b and 23a	Chicago-Northwestern IN	290	6	202,500	6.4	1,500	0.7%	59,400	500	35%	19,600	202,100	$229,000	53%	10,400
SR 100 @ I-394 Interchange	Minneapolis-St. Paul	100	4	104,500	1.2	6,800	7%	48,900	2,200	33%	15,700	817,200	$933,000	58%	9,100
I-43 N. of Marquette Interchange	Milwaukee	43	6	146,100	1.5	4,800	3%	42,400	1,900	39%	16,900	694,900	$778,000	33%	5,600
I-96 @ I-275 Interchange	Detroit	96	8	201,600	8.3	700	0.3%	35,100	200	29%	10,100	72,600	$82,000	32%	3,200
I-66 @ U.S. 29 Interchange (E. Falls Church)	Washington (DC-MD-VA)	66	4	118,400	7.5	800	0.7%	34,500	100	14%	4,500	36,300	$40,000	53%	2,400
U.S. 10 @ U.S. 441 Interchange	Appleton-Neenah	10	2	62,100	4.8	900	1.4%	26,000	200	23%	5,800	73,200	$82,000	66%	3,800
I-64 (Hampton Roads Tunnel)	Norfolk (036)-Virginia Beach-Newport	64	4	98,500	0.5	7,500	8%	22,200	1,600	22%	4,700	580,700	$645,000	22%	1,000
U.S. 75 to SR 190 F	Dallas-Fort Worth	75	8	249,100	4.8	700	0%	21,100	200	26%	5,800	73,600	$85,000	54%	3,100
SR 16 @ SR 3	Bremerton	16	2	65,900	1.0	3,500	5%	21,000	800	24%	4,800	293,300	$331,000	15%	700
SR 146 @ La Porte Fwy	Houston	146	2	68,400	6.7	500	0.7%	19,400	200	40%	8,200	73,600	$85,000	44%	3,600
Woodland Ave @ I-77	Cleveland	77	2	75,100	0.2	13,500	18%	17,500	6,600	49%	8,600	2,616,300	$2,911,000	49%	4,200
I-635 @ N. Dallas Tollway	Dallas-Fort Worth	635	8	272,400	6.6	100	0.04%	4,300	30	26%	1,200	11,000	$13,000	54%	600

Table A.6 The Worst Physical Bottlenecks in the United States, *2002*
American Highway Users Alliance Study

Rank	City	Freeway	Location	Annual Hours of Delay (Hours in Thousands)
1	Los Angeles	U.S. 101	U.S. 101 (Ventura Freeway) at I-405 Interchange	27,144
2	Houston	I-610	I-610 at I-10 Interchange (West)	25,181
3	Chicago	I-90	I-90/94 at I-290 Interchange ("Circle Interchange")	25,068
4	Phoenix	I-10	I-10 at SR 51/SR 202 Interchange ("Mini-Stack")	22,805
5	Los Angeles	I-405	I-405 (San Diego Freeway) at I-10 Interchange	22,792
6	Atlanta	I-75	I-75 south of the I-85 Interchange	21,045
7	Washington (DC-Maryland-Virginia)	I-495	I-495 at I-270 Interchange	19,429
8	Los Angeles	I-10	I-10 (Santa Monica Freeway) at I-5 Interchange	18,606
9	Los Angeles	I-405	I-405 (San Diego Freeway) at I-605 Interchange	18,606
10	Atlanta	I-285	I-285 at I-85 Interchange ("Spaghetti Junction")	17,072
11	Chicago	I-94	I-94 (Dan Ryan Expressway) at I-90 Skyway Split (Southside)	16,713
12	Phoenix	I-17	I-17 (Black Canyon Freeway) at I-10 Interchange (the "Stack") to Cactus Road	16,310
13	Los Angeles	I-5	I-5 (Santa Ana Freeway) at SR 22/SR 57 Interchange ("Orange Crush")	16,304
14	Providence	I-95	I-95 at I-195 Interchange	15,340
15	Washington (DC-Maryland-Virginia)	I-495	I-495 at I-95 Interchange	15,035
16	Tampa	I-275	I-275 at I-4 Interchange ("Malfunction Junction")	14,371
17	Atlanta	I-285	I-285 at I-75 Interchange	14,333
18	Seattle	I-5	I-5 at I-90 Interchange	14,306
19	Chicago	I-290	I-290 (Eisenhower Expressway) Between Exits 17b and 23a	14,009
20	Houston	I-45	I-45 (Gulf Freeway) at U.S. 59 Interchange	13,944

Table A.6 The Worst Physical Bottlenecks in the United States, 2002 (continued)
American Highway Users Alliance Study

Rank	City	Freeway	Location	Annual Hours of Delay (Hours in Thousands)
21	San Jose	U.S. 101	U.S. 101 at I-880 Interchange	12,249
22	Las Vegas	U.S. 95	U.S. 95 west of the I-15 Interchange (“Spaghetti Bowl”)	11,152
23	San Diego	I-805	I-805 at I-15 Interchange	10,992
24	Cincinnati	I-75	I-75, from Ohio River Bridge to I-71 Interchange	10,088

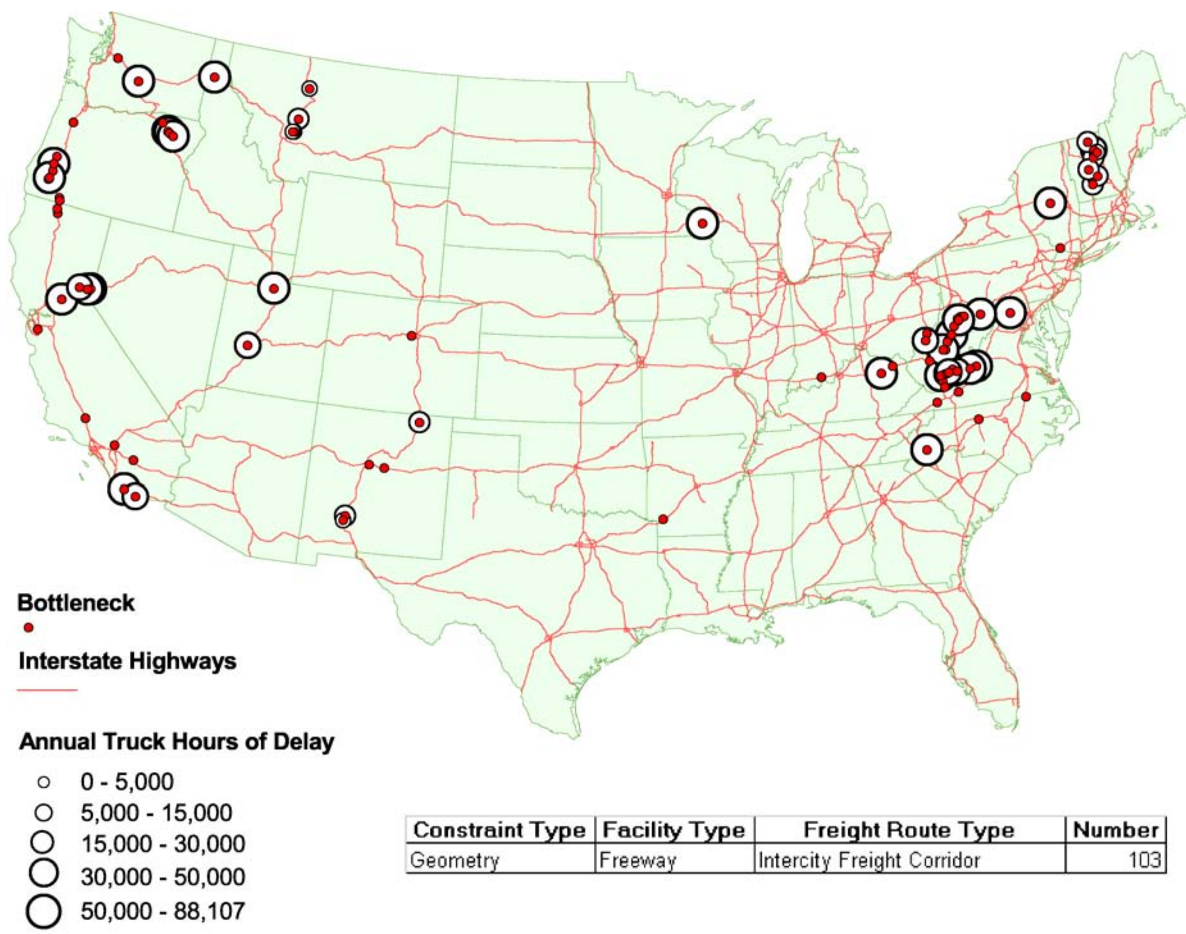
Source: *Unclogging America’s Arteries: Effective Relief for Highway Bottlenecks*, American Highway Users Alliance, February 2004. Delay is the extra time it would take to travel through the bottlenecks compared to completely uncongested conditions. The report did not consider many severe bottlenecks from the New York City area. As most travelers know, congestion in and around the boroughs of New York can be significant. However, a very large amount of delay in the New York area is related to bridge and tunnel crossings into Manhattan, most of which are toll facilities. Also, while the New York metropolitan area is laced with Interstates, parkways, and expressways, they seldom reach the proportions seen in other major areas, except where multiple highways converge on bridge of tunnel crossings. (A typical lane configuration for a New York area freeway is six lanes, three in each direction. But there are many of these.) Toll facilities were excluded from the study because toll facilities are fundamentally different from other physical bottlenecks (such as freeway-to-freeway interchanges) that are prevalent around the country. Delay comparisons between toll facilities and other types of bottlenecks might not be consistent since different modeling techniques would be used. If objective field measurements of delay could be made at all locations around the country, several river crossings into Manhattan would no doubt be included in a list of the nation’s worst bottlenecks.

Appendix B

Steep-Grade Bottlenecks

Steep-Grade Bottlenecks

Figure B.1 Steep-Grade Bottlenecks on Freeways Used As Intercity Truck Corridors
HPMS Sample Sections Only

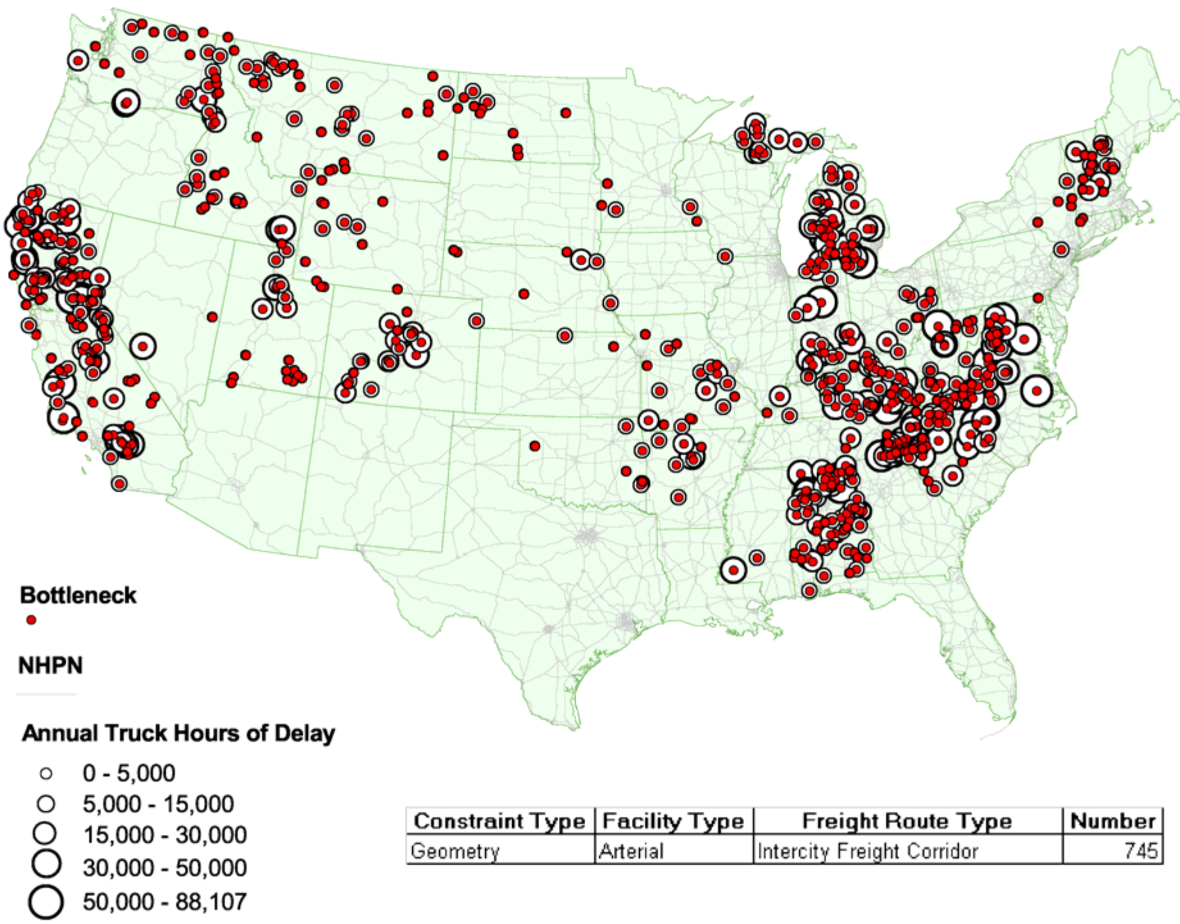


Constraint Type	Facility Type	Freight Route Type	Number
Geometry	Freeway	Intercity Freight Corridor	103

Table B.1 Top 25 Steep-Grade Bottlenecks on Freeways Used As Intercity Truck Corridors
HPMS Sample Sections Only

Route Number	Bottleneck Location	No. of Lanes	2004 All Vehicles AADT	2004 All Trucks AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	Annual Hours of Delay All Trucks (Expanded)
5	Kern, California	8	66,763	22,032	33%	1,119,438	1,272,800
15	San Bernardino, California	8	122,751	22,095	18%	1,049,160	1,403,777
10	Riverside, California	4	22,279	8,689	39%	466,219	699,328
IS81	Montgomery, Virginia	4	44,039	14,092	32%	456,645	2,141,666
77	Mercer, West Virginia	4	31,051	6,521	21%	414,253	433,723
IS81	Smyth, Virginia	4	32,174	8,365	26%	352,215	1,357,789
5	Jackson, Oregon	4	16,345	6,701	41%	342,763	342,763
5	Josephine, Oregon	4	20,767	7,061	34%	314,310	314,310
5	Siskiyou, California	4	15,234	4,875	32%	267,495	299,326
40	St. Francis, Arkansas	4	31,716	14,589	46%	260,546	876,997
8	San Diego, California	4	21,009	4,202	20%	252,015	378,022
84	Umatilla, Oregon	4	10,144	4,058	40%	247,521	247,521
84	Malheur, Oregon	4	8,543	4,015	47%	242,338	242,338
5	Josephine, Oregon	4	20,231	7,890	39%	238,749	238,749
77	Raleigh, West Virginia	4	42,029	8,826	21%	227,184	234,681
40	Guilford, North Carolina	8	82,904	15,752	19%	221,883	777,257
5	Douglas, Oregon	4	19,857	6,751	34%	214,815	214,815
5	Marion, Oregon	4	64,150	13,472	21%	214,408	214,408
64	Crawford, Indiana	4	17,430	5,229	30%	203,965	271,681
30	Hempstead, Arkansas	4	23,030	10,594	46%	191,543	964,992
5	Jackson, Oregon	4	15,300	6,273	41%	186,236	186,236
64	Carter, Kentucky	4	15,098	4,529	30%	179,446	179,446
95	Northampton, North Carolina	4	36,071	6,853	19%	168,934	258,130
77	Kanawha, West Virginia	4	32,315	6,786	21%	163,371	172,683
40	Torrance, New Mexico	4	15,448	6,179	40%	161,660	495,488

Figure B.2 Steep-Grade Bottlenecks on Arterials Used As Intercity Truck Corridors
HPMS Sample Sections Only



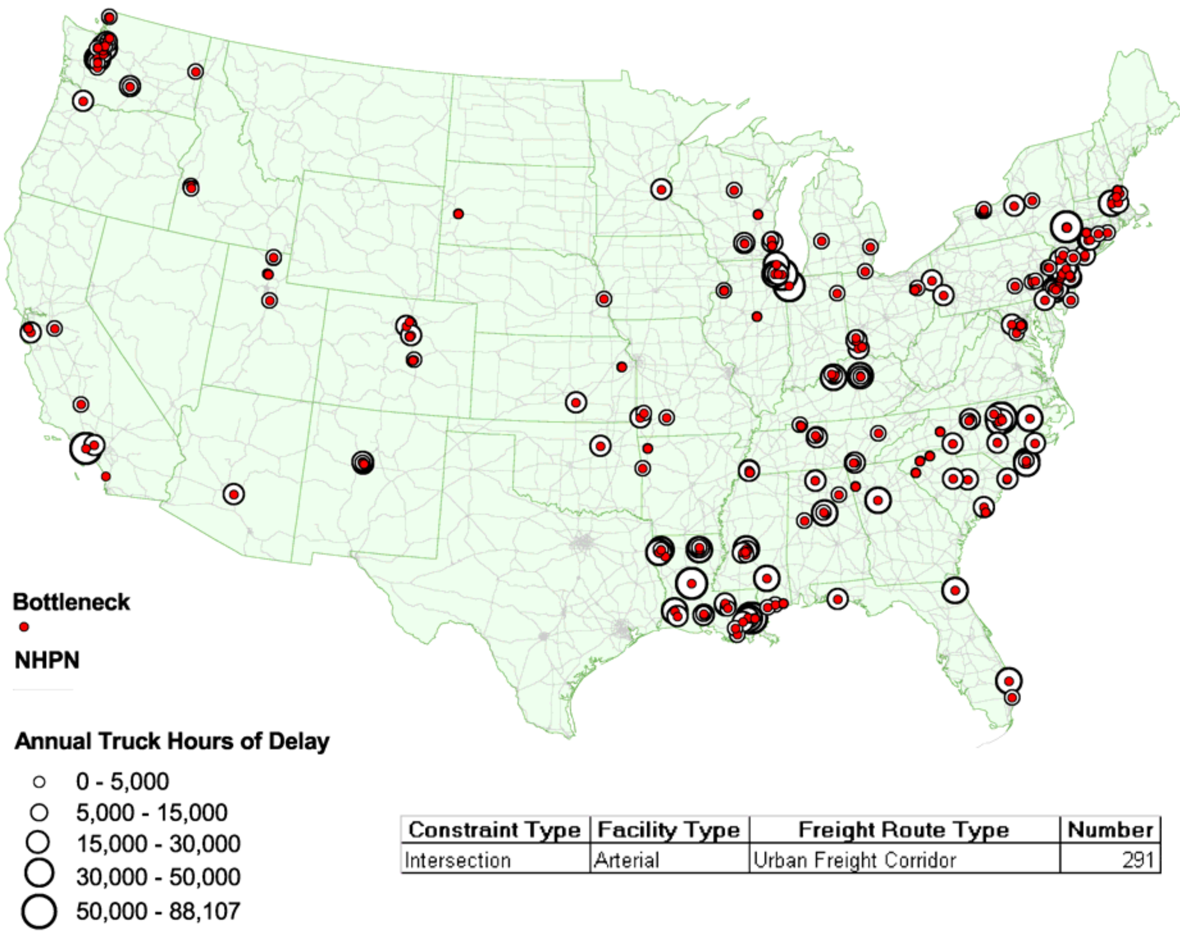
Constraint Type	Facility Type	Freight Route Type	Number
Geometry	Arterial	Intercity Freight Corridor	745

Table B.2 Top 25 Steep-Grade Bottlenecks on Arterials Used As Intercity Truck Corridors

HPMS Sample Sections Only

Route Number	Bottleneck Location	No. of Lanes	2004 All Vehicles AADT	2004 All Trucks AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	Annual Hours of Delay All Trucks (Expanded)
58	Kern, California	4	20,813	6,868	33%	334,820	758,033
131	Kent, Mississippi	4	42,604	5,112	12%	191,106	445,851
18	San Bernardino, California	2	10,757	1,936	18%	169,939	855,813
58	Kern, California	4	21,961	7,247	33%	146,081	330,726
101	Santa Barbara, California	4	30,027	3,904	13%	134,025	303,433
17	Santa Clara, California	4	63,616	2,545	4%	128,589	143,891
17	Santa Cruz, California	4	63,654	3,183	5%	114,915	128,589
U.S. 220	Franklin, Virginia	4	15,365	2,458	16%	104,076	726,033
299	Shasta, California	2	4,084	1,266	31%	85,000	194,650
223	Lenawee, Mississippi	2	10,227	1,841	18%	84,656	364,866
23	Madison, North Carolina	2	8,419	1,179	14%	81,267	149,693
15	Perry, Kentucky	2	11,029	1,654	15%	79,887	158,976
31	Miami, Indiana	4	21,874	3,937	18%	74,565	195,285
74	Cleveland, North Carolina	4	26,261	3,677	14%	68,099	226,632
31	Berrien, Mississippi	2	20,001	1,600	8%	61,697	404,609
80	Floyd, Kentucky	4	14,454	1,734	12%	58,703	116,819
U.S. 220	Henry, Virginia	4	17,823	3,030	17%	57,441	422,710
19	Haywood, North Carolina	2	10,100	1,010	10%	55,453	546,157
U.S. 30	Bannock, Idaho	4	5,102	1,429	28%	53,570	104,782
50	El Dorado, California	4	26,577	1,860	7%	53,480	121,080
154	Santa Barbara, California	2	14,140	1,131	8%	52,873	266,266
23	Macon, North Carolina	4	23,231	3,252	14%	52,222	173,794
25E	Bell, Kentucky	4	20,446	2,045	10%	50,443	88,276
89	Siskiyou, California	2	2,254	766	34%	49,531	113,425
U.S. 58	Halifax, Virginia	4	9,069	1,723	19%	49,200	162,853

Figure B.3 Steep-Grade Bottlenecks on Arterials Used As Urban Truck Corridors
HPMS Sample Sections Only



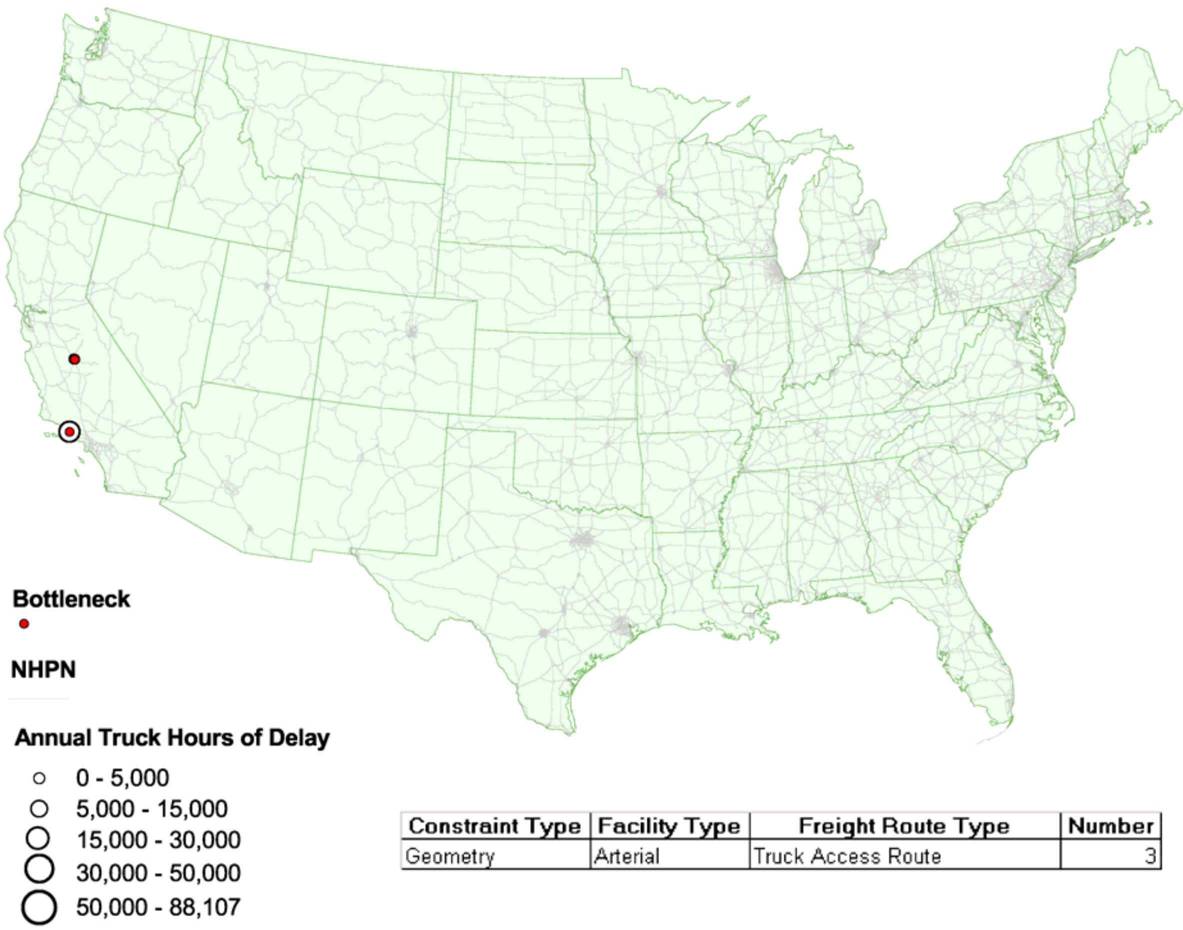
Constraint Type	Facility Type	Freight Route Type	Number
Intersection	Arterial	Urban Freight Corridor	291

Table B.3 Steep-Grade Bottlenecks on Arterials Used As Urban Truck Corridors

HPMS Sample Sections Only

			2004				
			All Vehicles	All Trucks			
Route Number	Bottleneck Location	No. of Lanes	AADT	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	Annual Hours of Delay All Trucks (Expanded)
280	Shelby, Alabama	4	51,411	5,141	10%	177,156	415,961
1	Aiken, South Carolina	4	20,889	2,298	11%	72,395	95,199
14	Los Angeles, California	4	20,115	1,006	5%	27,184	476,319
74	Riverside, California	4	20,269	1,419	7%	23,025	28,666
100	St. Louis, Missouri	4	25,265	1,516	6%	16,609	233,485
CR 948	12086	6	19,371	969	5%	16,567	34,178
21	Jefferson, Missouri	4	17,830	1,070	6%	14,992	153,311
78	Jackson, Missouri	4	24,869	1,492	6%	13,227	44,945
60	Boyd, Kentucky	4	25,559	1,022	4%	8,608	9,443
SR 43	Jefferson, Ohio	4	20,322	813	4%	7,317	7,485
431	Madison, Alabama	4	20,687	414	2%	5,064	10,006

Figure B.4 Steep-Grade Bottlenecks on Arterials Used As Truck Access Routes
HPMS Sample Sections Only



Constraint Type	Facility Type	Freight Route Type	Number
Geometry	Arterial	Truck Access Route	3

Table B.4 Steep-Grade Bottlenecks on Arterials Used As Truck Access Routes

HPMS Sample Sections Only

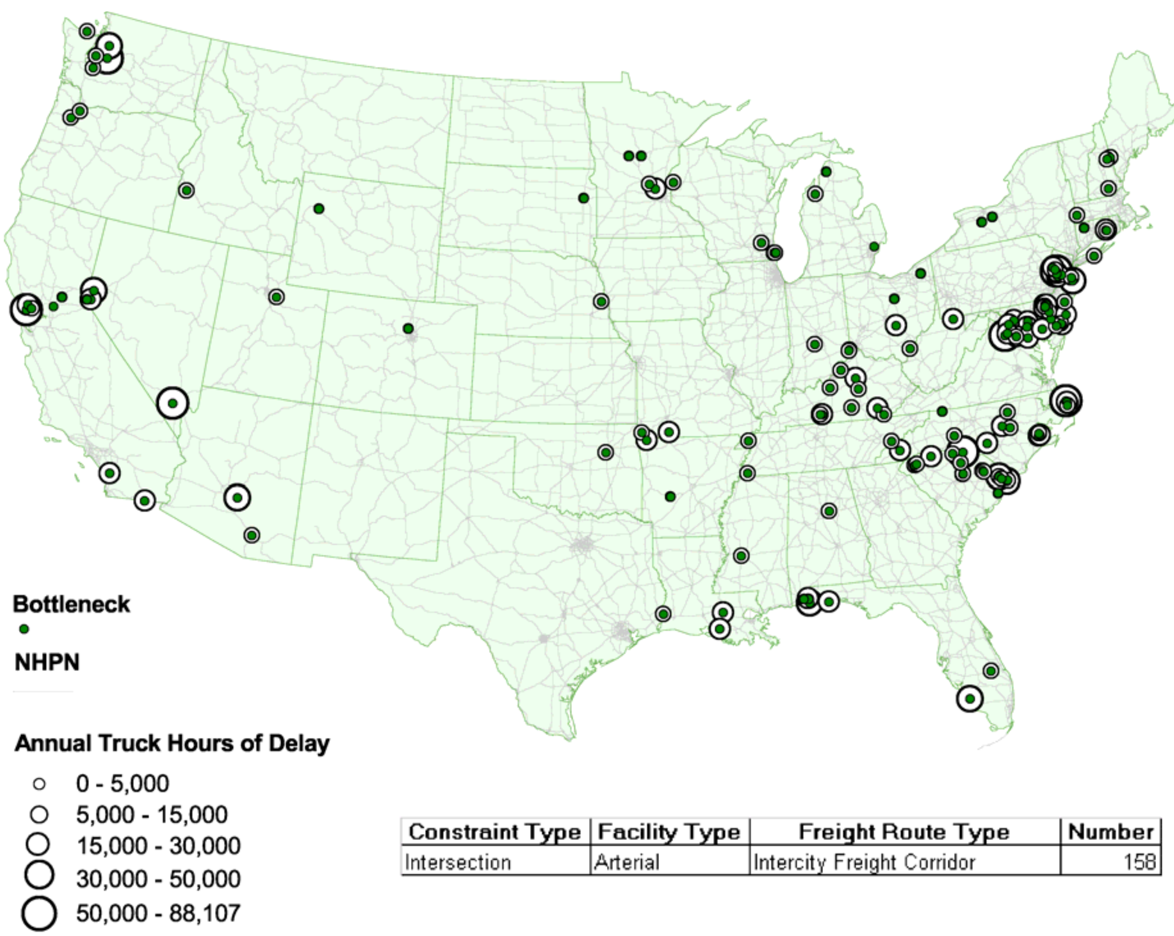
			2004				
			All Vehicles	All Trucks			
Route Number	Bottleneck Location	No. of Lanes	AADT	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	Annual Hours of Delay All Trucks (Expanded)
–	Fresno, California	4	35,858	3,227	9%	42,064	276,610
–	Ventura, California	4	36,728	1,102	3%	13,043	13,043
–	Fresno, California	4	15,118	454	3%	5,517	13,257

Appendix C

Signalized Intersection Bottlenecks

Signalized Intersection Bottlenecks

Figure C.1 Signalized Intersection Bottlenecks on Arterials Used As Intercity Truck Corridors
HPMS Sample Sections Only



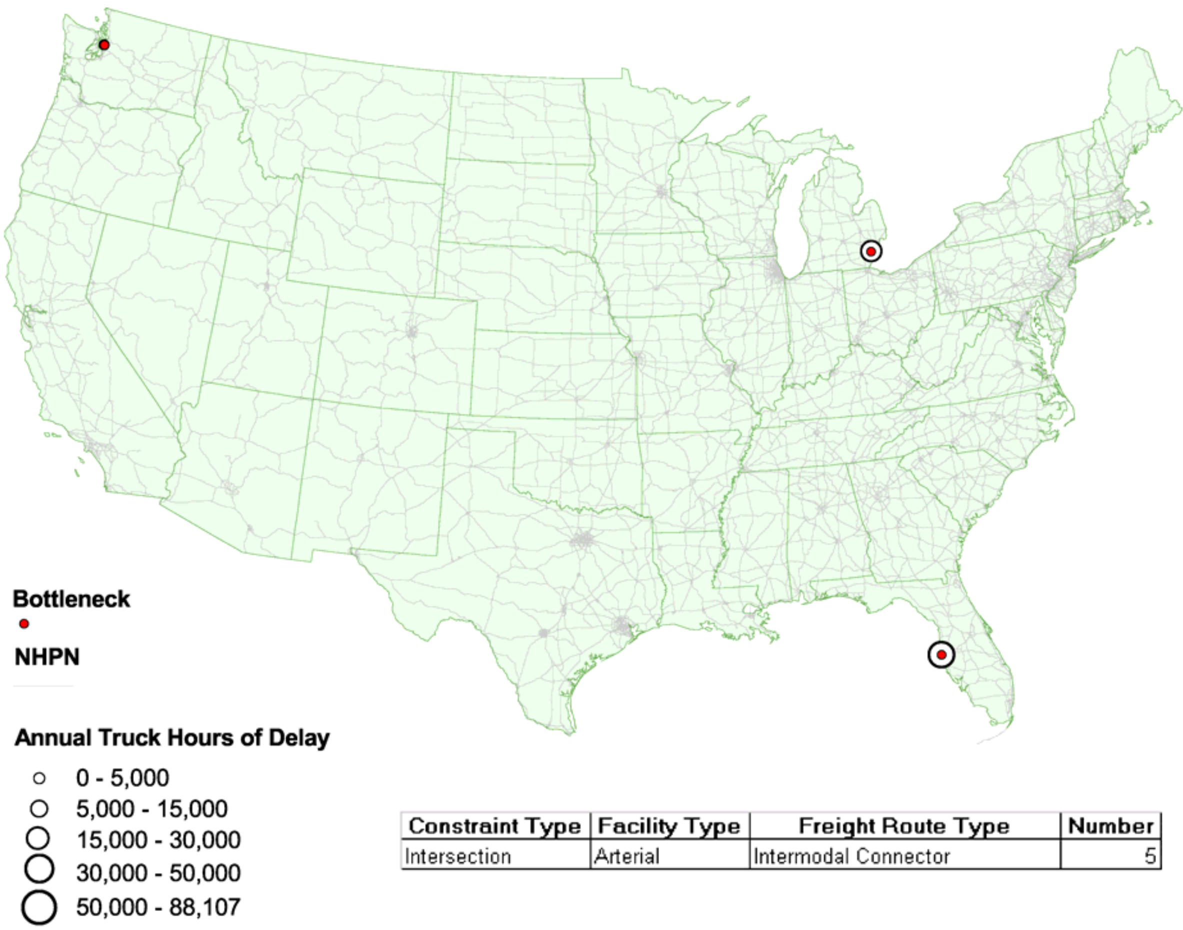
Constraint Type	Facility Type	Freight Route Type	Number
Intersection	Arterial	Intercity Freight Corridor	158

Table C.1 Top 25 Signalized Intersection Bottlenecks on Arterials Used As Intercity Truck Corridors

HPMS Sample Sections Only

			2004				
			All Vehicles	All Trucks			
Route Number	Bottleneck Location	No. of Lanes	AADT	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	Annual Hours of Delay All Trucks (Expanded)
158	Dare, North Carolina	4	41,299	4,130	10%	118,559	426,458
501	Horry, South Carolina	4	49,465	5,936	12%	97,115	176,555
U.S. 202	Hunterdon, New Jersey	4	38,825	2,330	6%	87,978	499,893
17	Horry, South Carolina	6	65,620	7,874	12%	66,950	74,046
Del1	Sussex, Delaware	5	58,915	7,070	12%	65,427	110,965
169	King, Washington	2	27,134	2,713	10%	55,367	72,253
9	Snohomish, Washington	2	21,338	2,561	12%	52,243	68,177
50	Dearborn, Indiana	4	37,396	6,731	18%	49,035	148,820
37	Sonoma, California	4	45,817	4,124	9%	47,584	95,835
74	Union, North Carolina	4	56,465	4,517	8%	46,806	60,146
430	Washoe, Nevada	4	40,401	6,868	17%	45,085	85,301
U.S. 41	Lee, Florida	4	48,271	2,896	6%	43,316	329,635
NJ 31	Hunterdon, New Jersey	2	21,693	1,519	7%	40,711	256,562
70	Pima, Arizona	4	30,166	6,033	20%	39,307	93,945
301	Prince Georges, Maryland	4	69,883	6,988	10%	39,049	81,379
1	Moore, North Carolina	4	35,226	4,932	14%	37,243	171,617
U.S. 29	Fauquier, Virginia	4	45,853	3,210	7%	37,141	233,802
59	Baldwin, Alabama	4	25,865	2,069	8%	36,605	94,697
NJ 31	Hunterdon, New Jersey	4	25,808	2,065	8%	36,407	229,435
231	Warren, Kentucky	4	39,035	1,952	5%	35,195	62,894
50	Dearborn, Indiana	4	32,254	5,806	18%	35,144	106,662
U.S. 9	Sussex, Delaware	5	44,363	5,324	12%	34,670	62,475
U.S. 29	Prince William, Virginia	4	53,955	3,777	7%	34,181	35,891
158	Dare, North Carolina	4	41,299	4,130	10%	34,143	122,812
65	Taney, Missouri	2	15,857	2,537	16%	33,290	208,359

Figure C.2 Signalized Intersection Bottlenecks on Arterials Used As Intermodal Connectors
HPMS Sample Sections Only



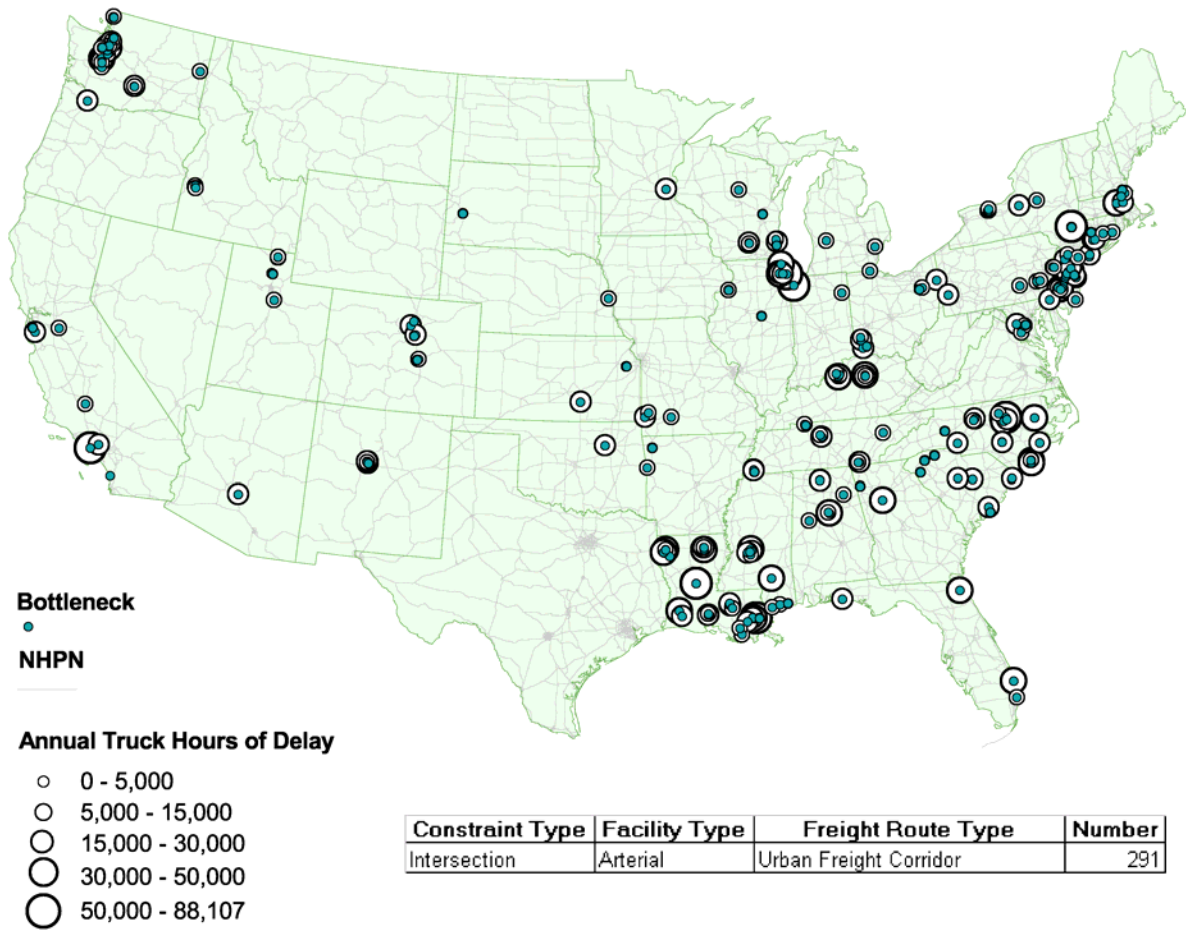
Constraint Type	Facility Type	Freight Route Type	Number
Intersection	Arterial	Intermodal Connector	5

Table C.2 Top 25 Signalized Intersection Bottlenecks on Arterials Used As Intermodal Connectors
HPMS Sample Sections Only

			2004				
			All Vehicles	All Trucks			
Route Number	Bottleneck Location	No. of Lanes	AADT	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	Annual Hours of Delay All Trucks (Expanded)
165	Ouachita, Louisiana	4	66,448	11,296	17%	335,812	335,812
110	Suffolk, New York	4	74,289	5,200	7%	193,803	383,537
1	Caddo, Louisiana	4	29,553	9,161	31%	165,532	271,637
90	Orleans, Louisiana	6	43,720	4,809	11%	161,489	694,566
165	Ouachita, Louisiana	4	37,625	9,406	25%	126,208	182,623
90	Orleans, Louisiana	6	45,929	4,593	10%	125,005	293,011
29	Greenville, South Carolina	6	35,177	3,869	11%	112,798	465,970
17	Horry, South Carolina	6	45,993	5,059	11%	104,662	150,400
90	Lafayette, Louisiana	4	47,763	10,985	23%	95,410	109,721
S12	San Diego, California	6	53,495	4,280	8%	94,645	383,406
U.S. 59	Webb, Texas	4	28,369	6,241	22%	83,354	150,704
47	St. Bernard, Louisiana	4	30,820	5,856	19%	75,717	182,024
264	Pitt, North Carolina	4	33,539	2,683	8%	70,925	96,529
50	11002	6	72,048	15,851	22%	65,705	84,431
71	Rapides, Louisiana	4	34,826	3,831	11%	64,550	84,754
25	Rankin, Mississippi	4	57,474	8,621	15%	63,682	63,682
U.S. 1	Mercer, New Jersey	6	75,347	8,288	11%	60,983	65,374
41	Lake, Illinois	4	71,043	8,525	12%	59,737	2,011,173
200	Wake, North Carolina	4	37,026	2,962	8%	58,371	189,530
	Hinds, Mississippi	4	39,584	5,938	15%	57,649	112,127
U.S. 30	Camden, New Jersey	4	33,054	3,636	11%	55,555	535,382
90	Orleans, Louisiana	4	31,061	3,106	10%	54,618	131,303
SH 289	Collin, Texas	6	53,359	3,202	6%	53,141	172,442
90	Dutchess, New York	6	52,111	2,606	5%	51,653	60,950
NJ 73	Burlington, New Jersey	4	64,355	7,079	11%	49,604	458,590

Figure C.3 Signalized Intersection Bottlenecks on Arterials Used As Urban Truck Corridors

HPMS Sample Sections Only



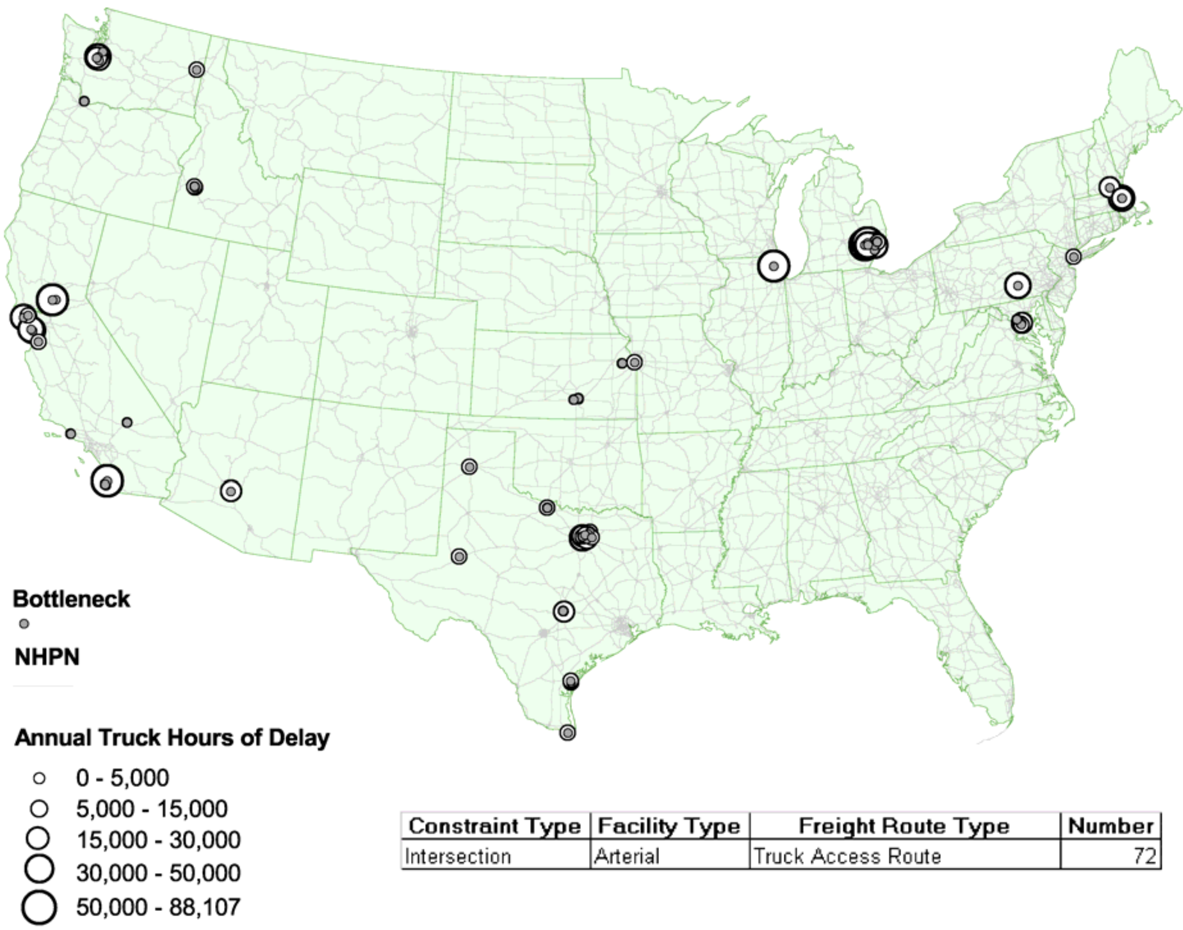
Constraint Type	Facility Type	Freight Route Type	Number
Intersection	Arterial	Urban Freight Corridor	291

Table C.3 Signalized Intersection Bottlenecks on Arterials Used As Urban Truck Corridors

HPMS Sample Sections Only

			2004				
			All Vehicles	All Trucks			
Route Number	Bottleneck Location	No. of Lanes	AADT	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	Annual Hours of Delay All Trucks (Expanded)
	Collier, Florida	6	54,106	2,164	4%	41,106	98,162
SR 686	Pinellas, Florida	6	90,397	6,328	7%	38,914	43,661
SR 686	Pinellas, Florida	4	90,397	6,328	7%	30,598	34,330
–	Wayne, Mississippi	4	43,595	2,616	6%	17,826	254,471
–	King, Washington	4	55,416	3,325	6%	9,927	37,227

Figure C.4 Signalized Intersection Bottlenecks on Arterials Used As Truck Access Routes
HPMS Sample Sections Only



Constraint Type	Facility Type	Freight Route Type	Number
Intersection	Arterial	Truck Access Route	72

Table C.4 Top 25 Signalized Intersection Bottlenecks on Arterials Used As Truck Access Routes

HPMS Sample Sections Only

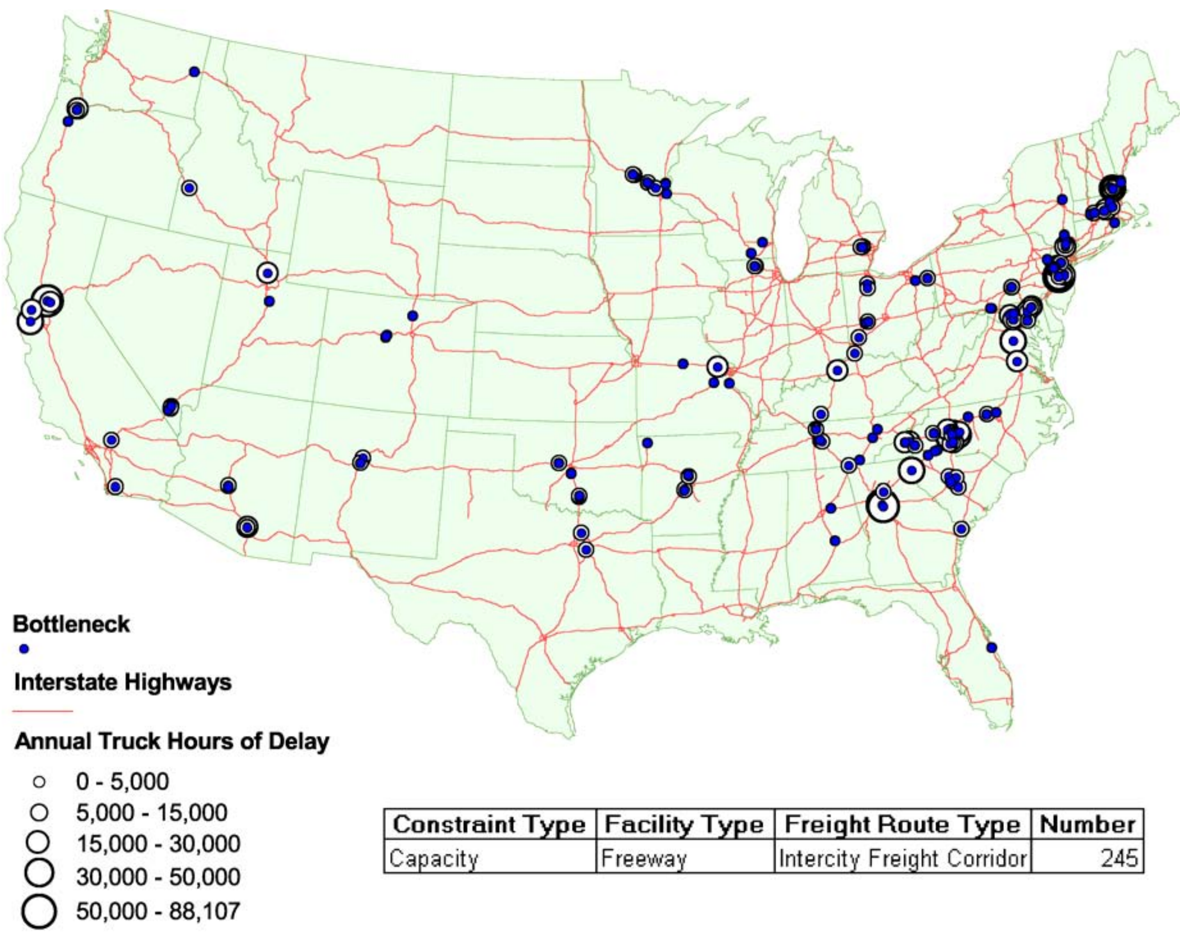
			2004				
			All Vehicles	All Trucks			
Route Number	Bottleneck Location	No. of Lanes	AADT	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	Annual Hours of Delay All Trucks (Expanded)
–	Sacramento, California	6	86,185	18,099	21%	320,265	320,265
–	San Diego, California	6	100,194	8,016	8%	215,711	215,711
–	San Diego, California	4	55,814	8,372	15%	161,312	180,669
–	Oakland, Mississippi	6	56,513	17,519	31%	106,834	392,937
–	King, Washington	4	45,571	3,646	8%	93,466	294,979
–	Oakland, Mississippi	4	38,825	1,941	5%	59,550	850,070
–	San Bernardino, California	4	37,942	5,691	15%	58,749	92,177
–	Santa Clara, California	6	80,790	7,271	9%	53,662	53,662
–	Oakland, Mississippi	4	58,601	2,930	5%	53,592	197,111
–	Santa Clara, California	6	84,103	2,523	3%	46,754	46,754
–	Oakland, Mississippi	4	74,876	3,744	5%	40,058	121,455
–	Dallas, Texas	6	54,617	1,639	3%	37,581	121,952
–	Sacramento, California	4	53,508	4,816	9%	35,150	56,345
–	Santa Clara, California	6	55,526	3,887	7%	34,893	148,332
–	Oakland, Mississippi	4	74,876	8,236	11%	34,572	104,821
–	Spokane, Washington	4	25,549	2,555	10%	30,681	100,603
–	San Diego, California	4	34,064	1,703	5%	30,138	306,077
–	Pierce, Washington	4	45,074	3,155	7%	28,163	88,884
–	11002	7	77,772	3,111	4%	26,818	34,461
–	Dallas, Texas	6	64,524	1,936	3%	24,597	228,211
–	Cook, Illinois	8	93,702	3,748	4%	19,831	172,172
–	Hillsborough, New Hampshire	4	29,705	2,079	7%	19,261	36,981
–	Dallas, Texas	6	40,492	1,215	3%	18,998	88,854
–	Dallas, Texas	6	49,322	1,480	3%	17,280	56,075
–	Maricopa, Arizona	4	28,139	3,658	13%	16,650	155,811

Appendix D

Capacity Bottlenecks

Capacity Bottlenecks

Figure D.1 Capacity Bottlenecks on Freeways Used As Intercity Truck Corridors
HPMS Sample Sections Only

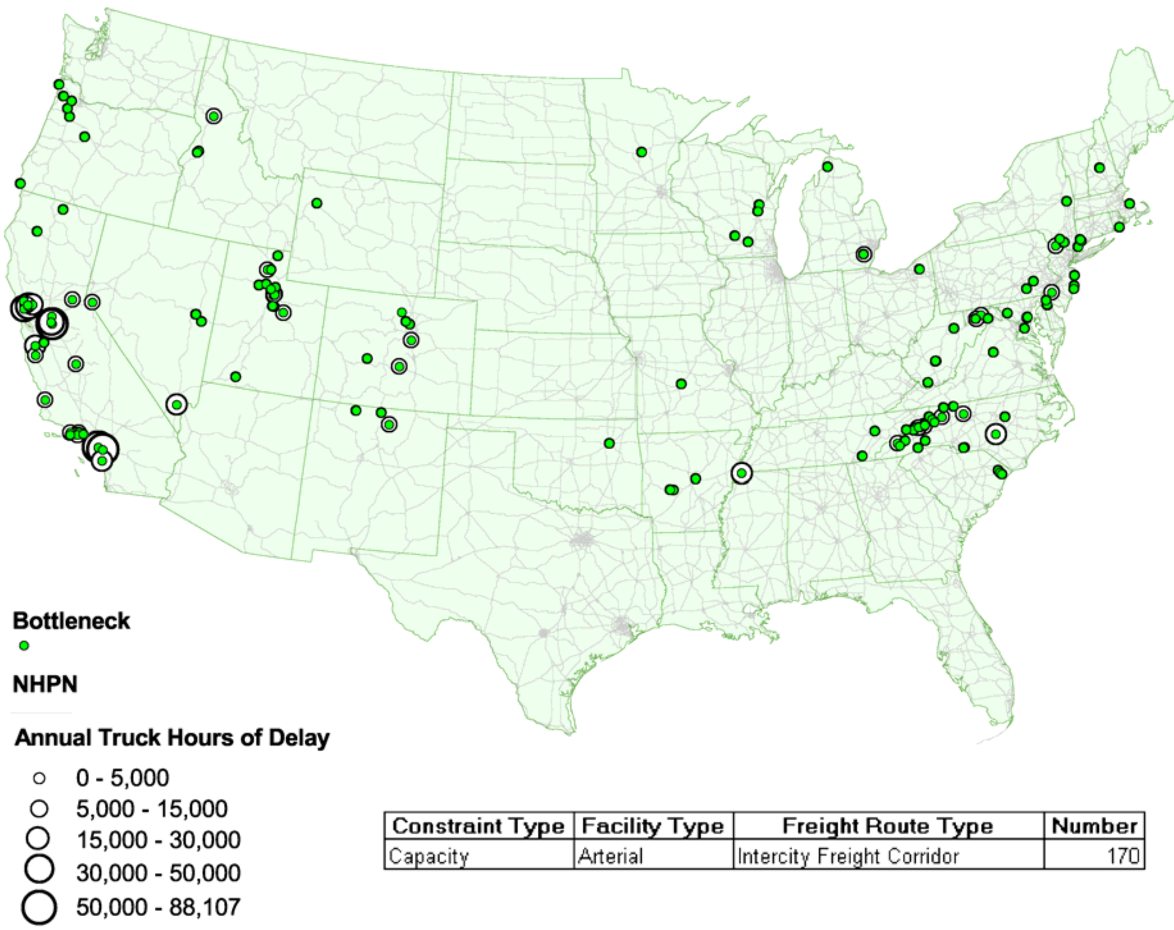


Constraint Type	Facility Type	Freight Route Type	Number
Capacity	Freeway	Intercity Freight Corridor	245

Table D.1 Top 25 Capacity Bottlenecks on Freeways Used As Intercity Truck Corridors
HPMS Sample Sections Only

			2004				
			All Vehicles	All Trucks			
Route Number	Bottleneck Location	No. of Lanes	AADT	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	Annual Hours of Delay All Trucks (Expanded)
85	Mecklenburg, North Carolina	4	94,761	18,005	19%	212,021	260,786
75	Henry, Georgia	6	133,850	34,801	26%	148,845	266,134
75	Henry, Georgia	6	137,399	35,724	26%	148,056	180,036
80	Yolo, California	6	133,207	11,989	9%	85,317	194,437
93	Rockingham, New Hampshire	4	98,403	11,808	12%	67,024	67,024
580	Alameda, California	8	158,093	30,038	19%	64,881	115,684
95	Mercer, New Jersey	6	110,159	19,829	18%	60,228	63,300
77	Iredell, North Carolina	4	76,834	14,598	19%	57,778	165,880
IS95	Stafford, Virginia	6	124,787	14,974	12%	55,103	137,206
10	Pima, Arizona	4	82,344	31,291	38%	50,247	50,247
95	Harford, Maryland	8	138,995	29,189	21%	49,414	49,414
15	Weber, Utah	4	92,058	23,015	25%	48,088	48,088
93	Rockingham, New Hampshire	4	84,369	10,124	12%	46,136	46,136
95	Mercer, New Jersey	6	109,359	19,685	18%	43,941	46,182
95	Harford, Maryland	6	106,982	22,466	21%	42,756	94,704
85	Rowan, North Carolina	4	64,715	11,649	18%	39,756	68,778
78	Hunterdon, New Jersey	6	108,031	19,446	18%	35,923	37,755
85	Anderson, South Carolina	4	42,763	11,974	28%	29,161	78,211
95	Baltimore, Maryland	8	149,757	22,464	15%	28,182	73,527
78	Hunterdon, New Jersey	6	98,785	17,781	18%	25,143	25,143
93	Rockingham, New Hampshire	4	94,043	11,285	12%	24,545	24,545
95	Middlesex, New Jersey	6	115,783	20,841	18%	24,303	25,542
85	Rowan, North Carolina	4	61,532	11,691	19%	24,190	41,849
87I	Orange, New York	6	94,696	17,045	18%	23,466	23,466
85	Rowan, North Carolina	4	66,678	16,003	24%	23,430	121,064

Figure D.2 Capacity Bottlenecks on Arterials Used As Intercity Truck Corridors
HPMS Sample Sections Only

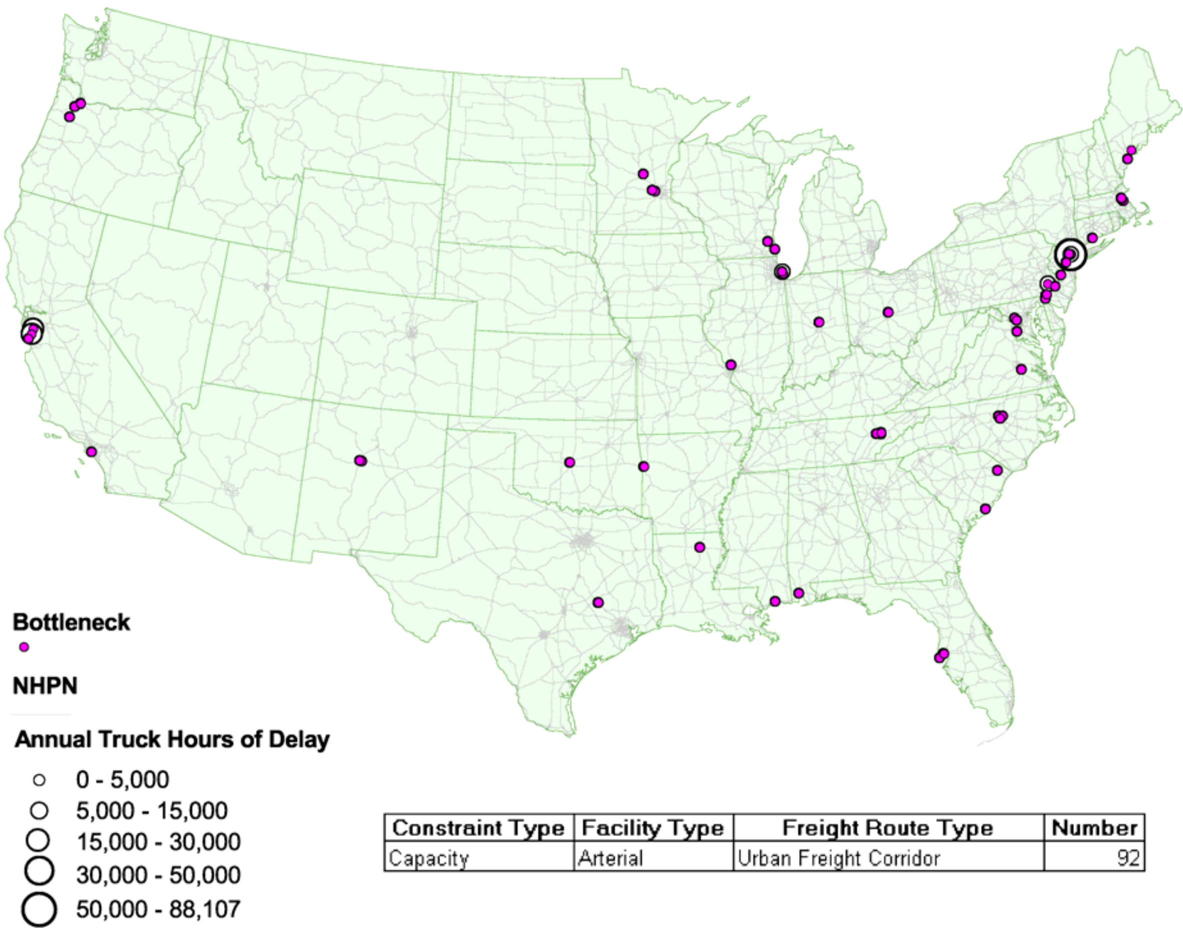


Constraint Type	Facility Type	Freight Route Type	Number
Capacity	Arterial	Intercity Freight Corridor	170

Table D.2 Top 25 Capacity Bottlenecks on Arterials Used As Intercity Truck Corridors
HPMS Sample Sections Only

			2004				
			All Vehicles	All Trucks			
Route Number	Bottleneck Location	No. of Lanes	AADT	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	Annual Hours of Delay All Trucks (Expanded)
99	San Joaquin, California	4	109,083	21,817	20%	617,667	975,913
99	San Joaquin, California	4	113,123	28,281	25%	123,662	226,301
101	Sonoma, California	4	108,493	7,595	7%	77,816	199,132
37	Solano, California	2	32,822	5,580	17%	71,618	124,258
57	Los Angeles, California	10	216,303	25,956	12%	65,984	65,984
61	DeSoto, Mississippi	2	34,977	6,646	19%	58,088	142,780
71	Riverside, California	2	46,680	5,135	11%	41,448	83,476
U.S. 59	Montgomery, Texas	4	92,945	10,224	11%	40,193	40,193
99	San Joaquin, California	4	82,824	15,737	19%	37,224	68,120
101	Marin, California	4	95,481	4,774	5%	33,241	85,065
95	Clark, Nevada	6	207,515	6,225	3%	27,668	27,668
12	Napa, California	2	33,518	2,681	8%	16,952	57,399
24	Harnett, North Carolina	2	19,665	2,753	14%	16,608	46,071
74	Orange, California	2	16,665	1,667	10%	15,374	77,424
101	San Benito, California	4	61,854	9,278	15%	15,064	16,857
28	Hampshire, West Virginia	2	6,067	849	14%	14,524	96,335
37	Sonoma, California	2	32,557	2,930	9%	13,453	23,341
99	Fresno, California	6	87,602	21,024	24%	12,448	31,854
101	Monterey, California	4	77,451	12,392	16%	11,364	20,795
19E	Yancey, North Carolina	2	13,792	1,931	14%	10,789	29,648
395	Douglas, Nevada	2	8,202	1,312	16%	10,750	23,199
421	Wilkes, North Carolina	2	28,309	3,963	14%	10,612	35,318
NJTPK	Gloucester, New Jersey	4	54,341	8,151	15%	10,306	10,306
23	Washtenaw, Mississippi	4	66,980	6,698	10%	10,277	10,277
101	San Luis Obispo, California	4	68,686	6,182	9%	10,098	11,300

Figure D.3 Capacity Bottlenecks on Arterials Used As Urban Truck Corridors
HPMS Sample Sections Only



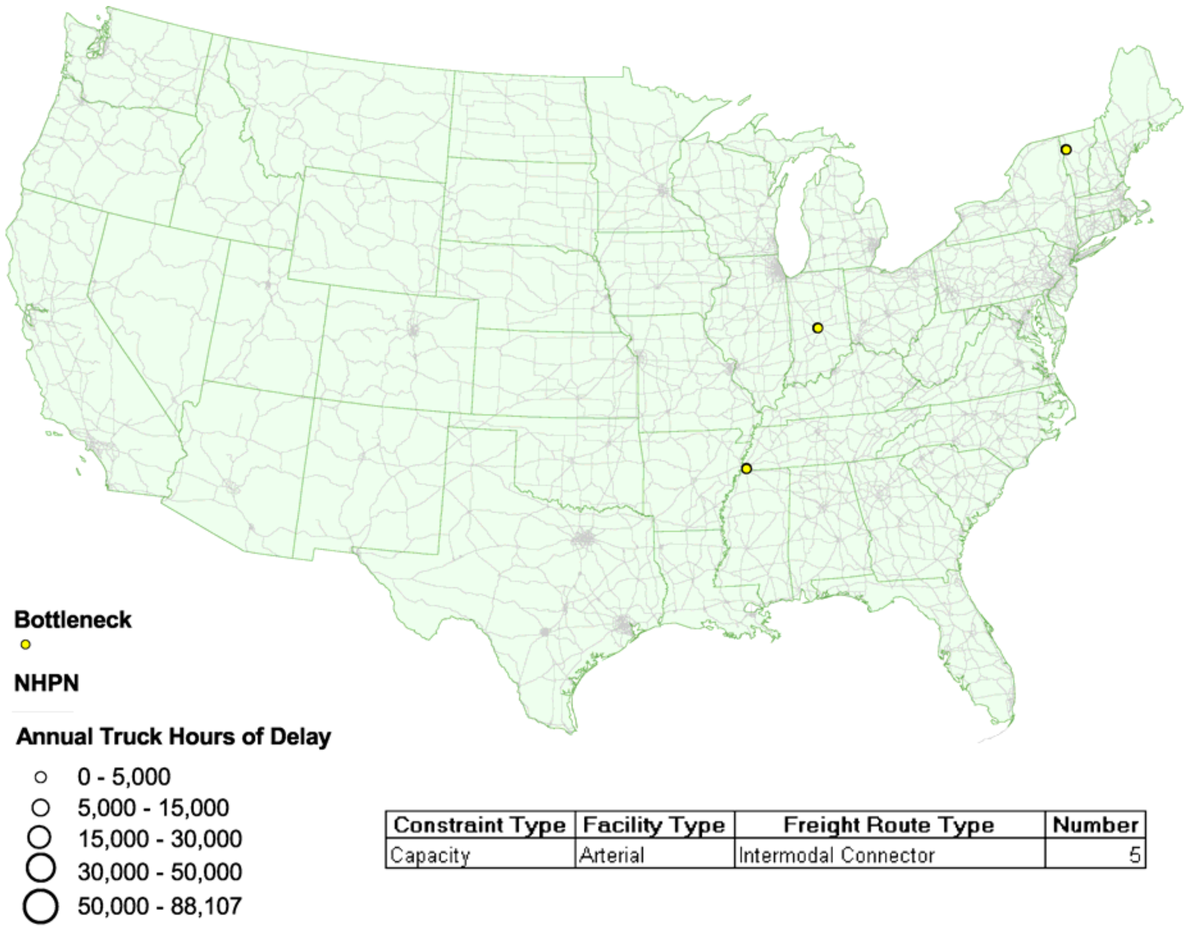
Constraint Type	Facility Type	Freight Route Type	Number
Capacity	Arterial	Urban Freight Corridor	92

Table D.3 Top 25 Capacity Bottlenecks on Arterials Used As Urban Truck Corridors

HPMS Sample Sections Only

			2004				
			All Vehicles	All Trucks			
Route Number	Bottleneck Location	No. of Lanes	AADT	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	Annual Hours of Delay All Trucks (Expanded)
NJ 17	Bergen, New Jersey	6	129,291	15,515	12%	115,448	639,235
SH 183	Tarrant, Texas	6	154,770	10,834	7%	50,368	126,928
SL 8	Harris, Texas	6	163,410	3,268	2%	45,480	146,173
SH 183	Tarrant, Texas	6	144,450	10,112	7%	35,104	88,462
SH 183	Tarrant, Texas	6	147,461	10,322	7%	27,426	69,113
237	Santa Clara, California	6	126,247	8,837	7%	24,614	24,614
SH 183	Tarrant, Texas	6	147,462	10,322	7%	20,305	51,167
85	Santa Clara, California	6	144,783	2,896	2%	17,341	17,341
U.S. 202	Montgomery, Pennsylvania	4	123,415	8,639	7%	7,743	28,532
SH 183	Tarrant, Texas	6	159,885	9,593	6%	6,968	17,559
SH 183	Tarrant, Texas	6	159,886	9,593	6%	6,913	17,420
NJ 4	Bergen, New Jersey	6	100,247	12,030	12%	6,848	109,700
U.S. 30	Camden, New Jersey	4	82,920	8,292	10%	5,956	29,422
NJ 4	Bergen, New Jersey	6	114,035	13,684	12%	4,964	27,486
NJ 4	Bergen, New Jersey	5	100,247	12,030	12%	3,836	61,449
SR 60	Hillsborough, Florida	8	180,798	12,656	7%	3,833	8,106
31	Hamilton, Indiana	4	73,229	13,181	18%	3,791	3,791
U.S. 1	12086	6	92,612	6,483	7%	3,722	15,952
SH 114	Tarrant, Texas	6	121,989	7,319	6%	3,386	8,534
22	Los Angeles, California	4	97,972	2,939	3%	3,177	3,177
U.S. 22	Union, New Jersey	5	95,560	11,467	12%	2,903	46,497
DEL141	New Castle, Delaware	4	78,532	6,283	8%	2,328	2,328
1	Wake, North Carolina	4	46,843	3,747	8%	2,284	4,609
165	Ouachita, Louisiana	4	67,187	16,797	25%	2,140	2,140
SR 60	Hillsborough, Florida	8	146,482	8,789	6%	2,108	4,458

Figure D.4 Capacity Bottlenecks on Arterials Used As Intermodal Connectors (Code 1-2-3)
HPMS Sample Sections Only

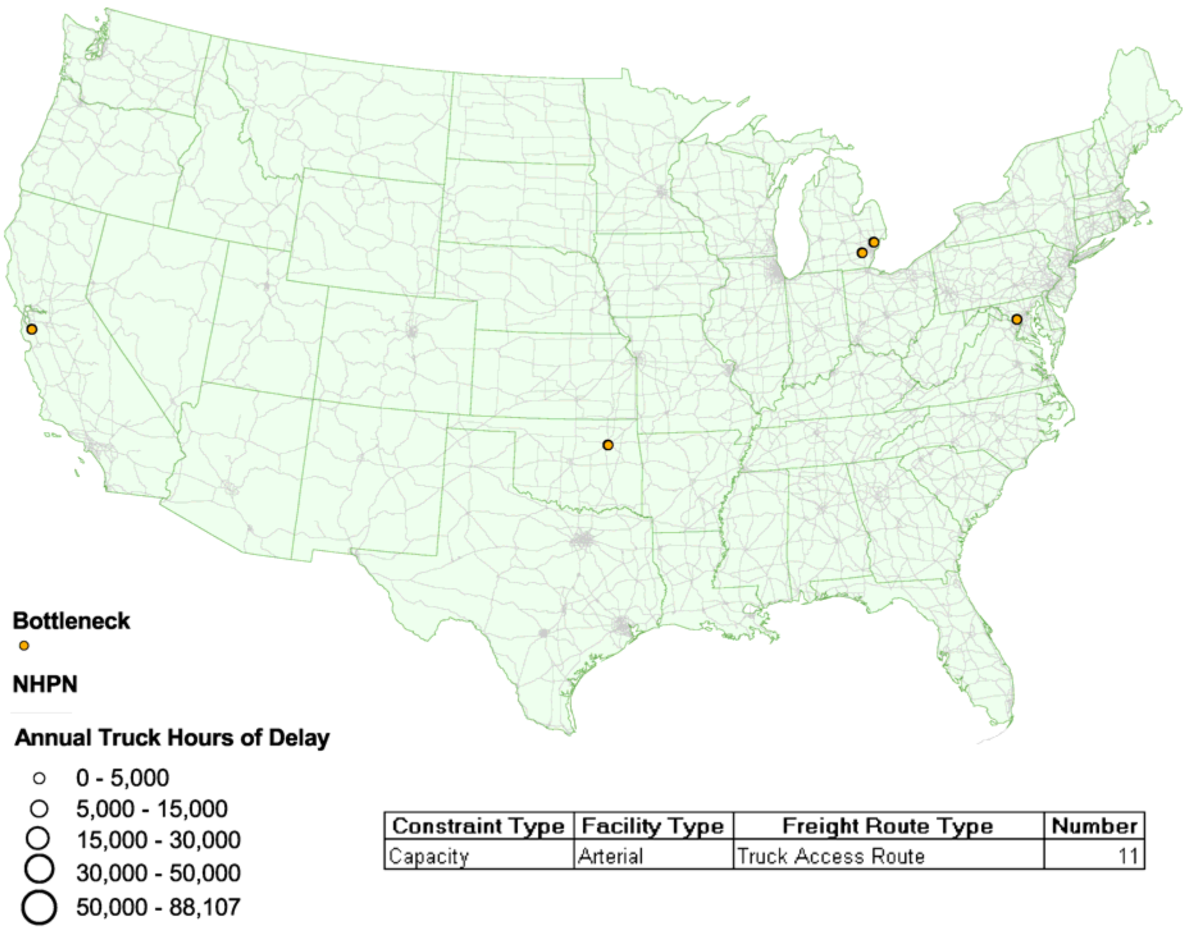


Constraint Type	Facility Type	Freight Route Type	Number
Capacity	Arterial	Intermodal Connector	5

Table D.4 Capacity Bottlenecks on Arterials Used As Intermodal Connectors
HPMS Sample Sections Only

			2004				
			All Vehicles	All Trucks			
Route Number	Bottleneck Location	No. of Lanes	AADT	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	Annual Hours of Delay All Trucks (Expanded)
36	Marion, Indiana	4	68,833	5,507	8%	402	1,440
	Shelby, Tennessee	4	69,316	2,773	4%	331	639
2	Chittenden, Vermont	4	61,963	3,718	6%	281	281
2	Chittenden, Vermont	4	49,694	2,982	6%	144	144
–	Shelby, Tennessee	4	67,108	2,684	4%	60	117

Figure D.5 Capacity Bottlenecks on Arterials Used As Truck Access Routes
HPMS Sample Sections Only



Constraint Type	Facility Type	Freight Route Type	Number
Capacity	Arterial	Truck Access Route	11

Table D.5 Top Capacity Bottlenecks on Arterials Used As Truck Access Routes
HPMS Sample Sections Only

			2004				
			All Vehicles	All Trucks			
Route Number	Bottleneck Location	No. of Lanes	AADT	AADTT	Percent of All Vehicles	Annual Hours of Delay All Trucks	Annual Hours of Delay All Trucks (Expanded)
–	Montgomery, Maryland	4	75,398	4,524	6%	5,937	29,139
–	Santa Clara, California	4	72,025	5,762	8%	1,517	1,517
–	Oakland, Mississippi	4	85,248	1,705	2%	1,074	3,257
–	Oakland, Mississippi	4	71,196	3,560	5%	1,046	3,849
–	Oklahoma City, Oklahoma	4	61,212	1,836	3%	493	993
–	Washtenaw, Mississippi	4	55,019	4,402	8%	457	457
–	Tulsa, Oklahoma	4	62,560	626	1%	384	384
–	Tulsa, Oklahoma	4	62,560	626	1%	304	304
–	Champaign, Illinois	4	49,077	2,945	6%	202	202
–	Washtenaw, Mississippi	4	43,324	3,466	8%	150	224
–	Pulaski, Arkansas	4	44,558	1,337	3%	95	254