Identifying, Anticipating, and Mitigating Freight Bottlenecks on Alabama Interstates

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Prepared by

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University Transportation Center for Alabama

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16. Abstract

This project established a framework for the creation and maintenance of a statewide strategy for identifying, anticipating, and mitigating freight bottlenecks on interstate highways in the state of Alabama. It used methodology developed by Cambridge Systematics to identify and quantify bottlenecks.

This research identified nine freight bottlenecks on Alabama interstates using 2006 traffic data supplied by ALDOT. These include six "capacity" bottlenecks, which are caused by an insufficient capacity in relation to demand (where the ratio of Average Annual Daily Traffic to the capacity of the roadway in passenger cars per hour per lane is greater than 8). The other three bottlenecks are "interchange" bottlenecks, which are similar to capacity bottlenecks except they occur at interchanges involving two or more interstates.

The six sections of roadway identified as capacity bottlenecks follow:

- Interstate 65 from Exit 252 to Exit 259B
- Interstate 65 from Exit 238 to Exit 246
- Interstate 20/59 from Exit 123 to Exit 130
- Interstate 65 from Exit 247 to Exit 250
- Interstate 10 from 26A to Exit 27
- Interstate 10 from Exit 15B to Exit 17A

The three interchanges identified as interchange bottlenecks follow:

- Interstate 459 at Interstate 65
- Interstate 20/59 at Interstate 65
- Interstate 20/59 diverge (into Interstate 20 and Interstate 59)

A third type of bottleneck—a "roadway geometry" bottleneck—involves congested roadways that have at least a mile of grade in excess of 4.5%. However, none of these bottlenecks were found on Alabama interstates because there is no stretch of interstate of that length with that steep a grade.

Identification of bottleneck locations was made using a GIS database created for this project. This database

merged existing databases, including the National Highway Planning Network, the Highway Performance Monitoring System, and the Freight Analysis Framework.

We estimated the cost of delays for each bottleneck for 2006, 2025, and 2040. This information is useful to planners when selecting sections of interstate highway for upgrade. Similarly, projections of delay cost were calculated for interchanges and sections of interstate classified as bottlenecks from the 2006 data. For example, delays in the George C. Wallace Tunnel in Mobile, which is the capacity bottleneck on Interstate 10 from Exit 26A to Exit 27, cost freight movements roughly \$150,000 in 2006, but those costs are expected to rise to \$1,836,000 by 2025. That is more than a ten-fold increase.

The report also lists methods through which the basic framework established in this report can be improved to provide greater accuracy in bottleneck identification and delay-cost calculations.

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Executive Summary

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The report also lists methods through which the basic framework established in this report can be improved to provide greater accuracy in bottleneck identification and delay-cost calculations.

Section 1 Introduction

This project intends to set the framework for the creation and maintenance of a statewide strategy for identifying, anticipating, and mitigating interstate highway freight bottlenecks for the state of Alabama. This component of the project provides the means for analyzing and modeling freight bottlenecks, supplies specific recommendations for bottleneck mitigation, and devises a methodology for conducting additional studies regarding freight bottlenecks in Alabama. This report focuses on freight bottlenecks on the interstate highway system, but the procedures used here can be modified for other roadway types.

1.1 Objective

The overall purpose of this project is to inform administrators of locations where there must be changes in capacity or demand on Alabama interstates to prevent bottlenecking now or in the future. This report focuses on bottlenecks that inhibit the flow of freight only for the interstate facilities within Alabama.

This project also intends to create a methodology for analysis of bottlenecks and delay on the entire national highway system in the state of Alabama, including both US routes and state routes.

Creating a comprehensive system monitoring delay for the state can aid in policy decisions regarding future investment in capacity improvement, alternative travel mode, and active roadway management projects.

1.2 Defining "Freight Bottleneck"

This report includes a methodology for analyzing roadway sections, calculating the annual hours of freight delay, and determining whether a roadway section is a freight bottleneck. The methodology includes numeric criteria for delay, which qualify a roadway section as a freight bottleneck.

There are several definitions that have been previously used to define what qualifies a particular section of roadway as a bottleneck (FHWA 2007):

- A critical point of traffic congestion evidenced by queues upstream and free-flowing traffic downstream.
- A location on a highway where there is loss of physical capacity, surges in demand, or both.

- A point where traffic demand exceeds normal capacity.
- A location where demand for use of a highway section periodically exceeds the section's physical ability to handle it and is independent of traffic-disrupting events that can occur on the roadway.

A major concern is that bottlenecks will adversely affect the flow of freight vehicles traveling the roadways. When this occurs to large freight movements, a standard bottleneck becomes a "freight bottleneck." In their bottleneck report, the National Center for Freight Infrastructure Research and Education defined a freight bottleneck as "the segment of highway that constricts the efficient movement of trucks and leads to significant delay for freight transportation on the highway network" (Guo, *et al.* 2010). This definition is suitable for this report as well.

Bottlenecks having a significant effect on freight movements should be inventoried and analyzed to discover remediation measures that may have a significant positive impact on freight movements.

This report describes three types of freight bottlenecks that can constrain freight flow on the interstate highway system (Cambridge Systematics 2005):

- capacity bottlenecks
- roadway-geometry bottlenecks
- interchange bottlenecks

Classifying freight bottlenecks on the interstate system based on these three categories aids in the inventorying and monitoring of congestion conditions.

1.3 History of the Methodology

Ideally, we would look at each section of roadway to see whether it experiences bottlenecking. However, there is a need to inventory bottleneck locations and intensities on a larger scale quickly and accurately.

Cambridge Systematics—an engineering firm specializing in the policy, strategic planning, and management of transportation systems—has worked to classify and inventory freight bottlenecks on highways. This report follows the Cambridge Systematics methodology because it is relatively easy to use and the data it requires are available.

Through a series of reports, Cambridge Systematics created, added to, and modified its bottleneck-identification methodology. Table 1-1 lists the titles and dates of these reports.

Table 1-1. Freight-bottleneck reports released by Cambridge Systematics

Report Title	Release Date
An Initial Assessment of Freight Bottlenecks on Highways	October 2005
Ohio Freight Mobility, Access, and Safety Strategies	March 2006
Estimated Cost of Freight Involved in Highway Bottlenecks	November 2008

The initial report, from October 2005, created the classification system used for freight bottlenecks on the highway system. This report included methodologies to estimate delay for the three types of interstate freight bottlenecks. The methodology used the delay-prediction models created by Margiotta, Cohen, and DeCorla-Souza (Cambridge Systematics 2005).

The Ohio freight report, released in March 2006, separated the methodologies for interchange bottlenecks from the capacity and roadway-geometry bottlenecks. It also introduced queuing models and methods for identifying bottleneck locations within an interchange (Cambridge Systematics 2006).

The report released in 2008 expanded on the methodology for interchange bottlenecks and adapted a series of equations from the existing methodology for the estimation of delay in interchanges due to recurring bottlenecks (Cambridge Systematics 2008).

As Cambridge Systematics or another agency improves the methodology, this report may warrant updates.

1.4 Data Sources

The data used in this report came from three sources:

- The National Highway Planning Network (NHPN)
- The Freight Analysis Framework (FAF)
- The Highway Performance Monitoring System (HPMS)

The Federal Highway Administration (FHWA) manages the National Highway Planning Network, which is a linear referencing system (LRS) that encompasses the United States. Contained in the NHPN is useful information regarding daily traffic flow and the number of through-lanes of traffic on interstate roadway sections. The most recent release of the NHPN is v2005.08, which came out in 2010. This is the release used for this report.

Also released by FHWA is the Freight Analysis Framework. The FAF integrates data from the NHPN and other sources to give a big-picture view of freight movements among states and major metropolitan areas. The most recent release of the FAF is the Freight Analysis Framework 3.1 (FAF3), which was released in 2010. This is the version of the FAF used for this report.

The Alabama Department of Transportation (ALDOT) provided traffic data for this report. The data include the annual traffic counts taken by ALDOT for inclusion in the Highway Performance Monitoring System. The data include every traffic count available for Alabama interstates from 1965 to 2006.

The pertinent data included in this package includes average annual daily traffic, grade information, and the percentage of day traffic that is trucks. The traffic counts are categorized by interstate exit, and grade data are categorized by every tenth of a mile of interstate roadway.

From these three data sources (NHPN, FAF, HPMS), a singular database has been created to perform the calculations in this report. The database has been created using a geographic information system (GIS). The process for the creation of this database is explained later in this report.

Section 2 Background and Literature Review

Previous works can be found in the references section (Section 9) of this report. The sources include previous bottleneck inventories performed at the national and regional levels. Other sources include national reports on congestion and previous studies on congestion problems in the United States.

2.1 Trends in Freight Congestion

Freight congestion trends can be examined at a national level or a state level. Several reports addressing current congestion conditions and trends have been published by various agencies and have addressed current congestion issues in Alabama.

2.1.1 National Trends and Growth of Congestion

The population of the United States is growing at a rate that it is beginning to overwhelm the existing infrastructure. Between 1980 and 2006, traffic on the interstates increased by 150%, while interstate capacity increased by only 15% (AASHTO 2010). The strain produced by a population growing faster than the infrastructure is expected to continue, as the US population is expected to grow from 308 million in 2010 to 420 million in 2040. That rapid population expansion will lead to an increase in the demand for goods and, in turn, more freight shipments across the United States.

In 2010, the American Association of State Highway and Transportation Officials (AASHTO) made the case for upgrading the transportation infrastructure (AASHTO 2010). They made the following predictions:

- In 2020, the US trucking industry will ship three billion more tons of freight than in 2010 and have 1.8 million more trucks on the road than in 2010.
- In 2030, there will be 50% more trucks traveling the roads than in 2010.
- By 2050, overall freight demand will double from 15 billion tons in the year 2010 to 30 billion tons. Because of this demand, the number of trucks on the road is also expected to double.

A change in the way the public uses interstates also affects congestion. Interstates were initially conceived as limited-access highways for intercity trips. However, closely placed interchanges have allowed them to be used for short trips, such as shopping and recreation. The increased use of interstates for these reasons has contributed to the growth of congestion problems.

2.1.2 Alabama Trends in Freight Congestion

AASHTO has identified the Interstate 10 Mobile Bay Bridge located in Mobile and Baldwin counties as being in urgent need of capacity upgrades to address freight movements (AASHTO 2010). In 2009, the American Transportation Research Institute studied both the I-459 at I-59/I-20 interchange in Birmingham and I-10 east of the tunnel in Mobile. Using its methodology for determining bottlenecks, neither of those areas studied qualified as a bottleneck at that time (ATRI 2009). However, the fact that these two locations were studied in the first place indicates concern about their future status.

2.1.3 Cost of Congestion

In a letter written in 2006, then-Secretary of Transportation Norman Mineta described traffic congestion as "one of the single largest threats to our economic prosperity and way of life" (USDOT 2006). The US Department of Transportation (USDOT) estimated that congestion cost America an estimated \$200 billion in 2006 (USDOT 2006). A USDOT estimate put the congestion-related costs of carrying freight between \$25 and \$200 an hour (FHWA 2006); these losses include lower fuel efficiency, a diminished capability to predict and meet delivery times, and the subsequent disruptions to production and sales. Unexpected delays in freight delivery can increase the cost of transporting goods by 50 to 250% (FHWA 2006). In short, trucking congestion can hurt regional, state, and local economies.

2.2 Causes of Congestion

The Freight Performance Measures (FPM) initiative is an ongoing FHWA effort to measure speed and travel-time reliability on significant freight corridors and crossing and delay time at major US land-border crossings. The FPM studies a range of factors that can affect freight movements on the interstates. Knowing these factors can make it easier to identify the areas of study for this bottleneck analysis.

In addition to the delay when the demand on a roadway facility exceeds the capacity of that roadway, there are other factors that can cause a bottleneck. The terrain of an area affects the speed of commercial trucks much more dramatically than it affects passenger cars that travel that same section of interstate. Mountainous regions in particular can dramatically slow heavy trucks on long inclines and on downhill runs with tight curves. However, this is not as much a problem in Alabama as it is in a place such as I-8 east of San Diego, CA, which is used heavily by trucks.

Weather can also affect traffic flow, and it is estimated to cause 15% of all highway delay. Rain accounts for roughly 70% of weather delay, which is a large concern in Alabama. Traffic crashes are another problem affecting the free flow of traffic. Improvements to traffic-accident response can help avoid unwanted delay in the traffic system. Similarly, work zones can cause bottleneck and traffic delays.

2.3 Classifying Bottlenecks

There are several constraint types that can cause freight bottlenecks on the interstate. The classification criteria recommended by Cambridge Systematics, Inc. recommends that bottlenecks for trucks be defined by the combination of three features: constraint type, roadway type, and freight route type (Cambridge Systematics 2005). Table 2-1 shows the types of each of these features.

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

Table 2-1. Truck-bottleneck features

By using a combination of the three feature categories, bottlenecks can be classified (e.g. a bottleneck may be caused by an interchange on a freeway that is used as an urban truck corridor). The focus of this study only includes freeways, which limits the possible types of freight routes to "Intercity Truck Corridor" and "Urban Truck Corridor." An intercity truck corridor includes transcontinental and inter-regional routes using rural interstate highways and rural state highways. An urban truck corridor includes interstate highways that serve both local and through movements.

Because this study is limited to freeways, the only constraint types that will occur are *lane drop*, *interchange*, and *roadway geometry*. These constraints, which cause delay on interstates and create freight bottlenecks, are given more complete descriptions below:

- <u>Lane drop</u> (also referred to as "capacity bottlenecks"): an example of this constraint is where an interstate narrows from four lanes to three or from three lanes to two. This constraint may occur upstream and downstream of an interstate exit. Lane drops can reduce throughput and create traffic queues.
- <u>Interchange</u>: an example of this bottleneck is an interchange that connects two interstates. The geometry of the interchange, traffic weaving and merging movements, and high volumes of traffic can reduce throughput and create traffic queues on the ramps and mainlines.
- <u>Roadway geometry</u>: an example of this type of constraint is a steep hill where trucks must slowly climb. The volume of traffic, number of heavy trucks, and number of lanes determine the throughput of these bottlenecks.

The types of freight bottlenecks included in the Cambridge Systematics report are not exhaustive and can be broadened when needed. The freight-route type that is given can also be further classified (Cambridge Systematics 2005).

2.4 Calculating Delay

The methodologies for calculating freight delay at the different types of bottlenecks vary. Interchange bottlenecks use a queuing equation that is dependent on lane/ramp configurations for determining total delay. Lane-drop interchanges and road-geometry interchanges use a separate equation. However, both equations use the ratio of average annual daily traffic (AADT) to the capacity of the roadway.

2.4.1 Interchange Delay

To perform the freight-delay calculations for a potential interchange bottleneck, the following variables were needed: mainline volumes, ramp volumes, and lane/ramp configurations. Using those data, a three-step process was performed to analyze potential bottlenecks in Alabama (Cambridge Systematics 2006):

- 1) Make a preliminary list of bottlenecks for study.
- 2) Collect data for each potential bottleneck.
- 3) Estimate delay using the queuing model.

The equations used for estimating delay at interchange bottlenecks (Figure 3-2) are found in Section 3.2 of this report.

2.4.2 Capacity Delay

Calculating freight-associated capacity delay involves using the equation developed by Margiotta, *et al.* (1998). Total delay caused by capacity constraints is a function of the total length of the road that is experiencing congestion. Detailed explanations on how to use this equation to determine delay at capacity bottlenecks can be found in Section 3.3 of this report.

2.4.3 Roadway-Geometry Delay

The calculations for determining freight delay at a roadway-geometry bottleneck are similar to the delay calculations for a lane-drop (capacity) bottleneck. The chief difference is that the AADT on the roadway must be adjusted upward using the passenger-car equivalent methodology found in the Highway Capacity Manual. Table 2-2 shows the adjustment factors for trucks using the passenger-car equivalents adapted from the HCM to include only the applicable factors.

Up Grade (%)	Length (mi)		I	Percent	age of	E _T Trucks	and Bu	uses (%	5)	
		2	4	5	6	8	10	15	20	25
> 4 - 5	>1.00	5.0	4.0	4.0	4.0	3.5	2.5	3.0	3.0	3.0
> 5 - 6	>1.00	6.0	5.0	5.0	4.5	3.5	3.5	3.5	3.5	3.5
> 6	>1.00	7.0	6.0	5.5	5.5	5.0	4.5	4.0	4.0	4.0

 Table 2-2.
 Passenger-car equivalents for roadway-geometry bottlenecks

After adjusting the traffic flow upward to account for the number of trucks within the traffic flow, the delay equations used in the lane-drop calculations can be used to rank the severity of each of the bottlenecks.

2.5 Efforts to Reduce Congestion on Interstates

To counteract the increased demands on the interstate system by the expected increase in truck traffic, AASHTO has suggested the following increases in capacity by the year 2050 (AASHTO 2010):

- Add 32,000 lane-miles to the current Interstate system.
- Upgrade 14,000 lane-miles of the current National Highway System to Interstate standards.
- Add 8,000 lane-miles of truck-only toll facilities.
- Add 400 lane-miles to provide access to key port and intermodal facilities.

In addition to the capacity upgrades, AASHTO has suggested increased funding for intermodal connectors, which are usually local roads in older areas used by truckers to travel between major highways and the nation's ports, rail terminals, and air-cargo hubs.

2.5.1 National Strategy to Reduce Congestion on America's Transportation Network

In May 2006, the US Department of Transportation released the *National Strategy to Reduce Congestion on America's Transportation Network*. This report states that poor policy choices and a failure to identify effective solutions cause increasing congestion.

The strategy includes a plan that includes six areas of emphasis that have shown potential to reduce congestion in the short term and to build the foundation for successful, longer-term congestion-reduction efforts (USDOT 2006):

- Relieve urban congestion by creating and expanding bus services, establishing telecommuting and flex-scheduling programs, and expediting completion of the most significant highway-capacity projects.
- Encourage more private-sector investment in construction, ownership, and operation of transportation infrastructure.
- Promote operational and technological improvements that increase information dissemination and incident-response capabilities.
- Establish a "Corridors of the Future" competition in which the USDOT accelerates development of multi-state, multi-use transportation corridors.
- Target major freight bottlenecks and expand freight-policy outreach by involving shippers from different economic sectors, as well as freight carriers and logistics firms.
- Accelerate any major aviation capacity projects and provide a future funding framework.

By creating this national strategy, the USDOT has created a template for the goals of future major traffic projects.

2.6 Remediation Measures for Freight Bottlenecks

In June 2008, the Denver Regional Council of Governments released its *Congestion Mitigation Toolkit* (DRCOG 2008). That report discussed methods for improving congested conditions on travel routes in detail. There are three categories of remediation measures covered in the toolkit: active roadway management, travel demand management/alternative travel modes, and physical roadway capacity. Table 2-3 shows the types of remediation measures covered in the *Congestion Mitigation Toolkit* to alleviate freight bottlenecks on interstate facilities.

Active Roadway Management	Travel Demand Management and Alternative Travel Mode	Physical Roadway Capacity
Ramp meters	New fixed guideway transit travelways	Acceleration/deceleration lanes
Incident Management Plans (IMP)	Transit service expansion	Hill-climbing lanes
Courtesy patrol	Transit vehicle travel information	HOV bypass lanes at ramp meters
Traveler information devices	Electronic fare collection	New HOV/HOT lanes
Traffic management center	Telework and flexible work schedules	New travel lanes (widening)
Electronic toll collection	Ridesharing travel services	New roadways
Cordon area congestion fees	Alternative travel mode events and	
Roadway signage improvements	assistance	
Communications networks and roadway		
surveillance coverage		

2.6.1 Active Roadway Management

Active roadway mitigation measures typically include implementation of intelligent transportation systems (ITS) infrastructure and operation controls and traffic-control strategies that do not require physical modification of the roadway (DRCOG 2008). Table 2-3 lists remediation measures that may be applicable to this project, but the source material contains a longer list of measures that apply to freeways and other types of roadways.

Ramp metering is a traffic-control device that controls the traffic stream as it enters a freeway. The cost of ramp metering is considered low to moderate because the equipment and rampmodification costs are relatively low. Ramp metering improves speed and travel times on freeways, increases traffic volumes and vehicle throughput, and decreases the crash rate on the freeway.

An incident management plan (IMP) is an operational plan that defines what is to be done by agencies and personnel in the event of an incident. The cost of an IMP is low and can be completed in four to six months. IMPs reduce travel delay due to incidents and increase roadway safety during and after an incident.

A courtesy patrol is a service created to assist travelers with vehicle breakdowns, stalls, and crashes. The cost for a service like this is considered low. Denver has a courtesy patrol that covers approximately 100 square miles at an annual cost of \$2 million. A courtesy patrol reduces vehicle delay for traffic affected by an incident and helps decrease secondary crashes.

2.6.2 Travel Demand Management and Alternative Travel Mode

To alleviate bottlenecks, travel-demand management and alternative travel-mode measures encourage travel alternatives that reduce the demand for single-occupancy vehicle trips (DRCOG 2008). Table 2-3 lists remediation measures that may be applicable to this project, but the source material contains a longer list of measures that apply to freeways and other types of roadways.

New fixed guideway transit travelways (such as light rail/commuter rail) increase the capacity of a travel corridor. The cost of these types of projects vary but are considered to be moderate to high, with a potential to be high due to acquisition of rights-of-way, materials, and infrastructure. These travelways provide more consistent and, sometimes, faster travel times than driving.

Telework and flexible work schedules include adopting policies that allow workers to work from home and permit employees to adjust their work schedules to decrease the number of days that they drive to work. This decreases the number of drivers during peak periods and commuting time and expenses for employees.

2.6.3 Physical Roadway Capacity

This category of mitigation measures includes roadway-construction projects, such as adding travel lanes or improving roads. Compared to the other categories of mitigation measures, roadway-capacity projects generally require lengthy implementation and can be very costly (DRCOG 2008). Table 2-3 includes descriptions of several examples of physical roadway-capacity projects that may be applicable to this project, but please refer to the source material for a full listing and description.

Acceleration/deceleration lanes provide drivers an area to increase or decrease speeds to better merge into or diverge from the mainline traffic stream. This type of remediation measure might be needed in areas with a large number of merging or weaving vehicles or freeway approaches to off-ramps that require a significant speed reduction.

New (or converted) high-occupancy-vehicle (HOV) lanes could be used in highly congested areas that have an extensive bus service. Construction of a new lane is more costly than converting preexisting traffic lanes.

New travel lanes are needed on roads with insufficient capacity or safety deficiencies. A capacity-expansion project can take five to twenty years to complete, including planning, engineering, environmental analysis, and construction. These projects are considered costly.

2.7 Literature Review Summary

Freight congestion in the United States is becoming more important as freight shipments are on the rise. As the population increases, there is a greater need for freight and the interstate highway system is likely to see rapid growth in passenger cars and freight trucks.

Congestion on America's roadways is a hindrance to economic prosperity and is estimated by the USDOT to cost America \$200 billion a year. These economic costs make apparent the importance of decreasing delays on the interstate system.

The overarching cause of congestion is that existing roadways are unable to meet demand. However, there are also unexpected causes, including traffic accidents and weather events.

Other entities have done much work to create a classification system for freight bottlenecks. Freight bottlenecks have been placed into three categories for the interstate system: lane-drop (capacity), interchange, and roadway geometry. Cambridge Systematics has refined their procedure since they release the initial freight-bottleneck report in 2005.

Governments and government associations have not ignored freight bottlenecks. AASHTO has suggested interstate improvements to better handle the expected increases in demand, and USDOT adopted a national strategy for reducing congestion on America's roadways in 2006 under then-Transportation Secretary Norman Mineta.

Work has also been done on strategies that can be used to decrease delay on roadways beyond additional increases to physical roadway capacity. This toolkit, released by the Denver Regional Council of Governments in 2008, provides useful strategies for planning for the long-term health of America's transportation network.

Section 3 Methodology

To assist in identification of bottlenecks and calculation of delays for freight congestion on Alabama interstates, a GIS database with the data required for freight-bottleneck analysis has been created. The database only includes the interstate highway system for Alabama; however, the same procedures used to create this database could be used to include non-interstate routes.

This report considers three types of interstate freight bottlenecks:

- Interchange bottlenecks
- Capacity bottlenecks
- Roadway-geometry bottlenecks

To identify each type of bottleneck, we used the GIS database to search for roadway whose ratio of average annual daily traffic to capacity meets our criteria.

Once bottlenecks were identified, we calculated the delay for each. We then ordered the bottlenecks in descending order of truck delay.

There is a three-step procedure used in this report that allows for the ranking of the freight bottlenecks on Alabama interstates:

- 1. Identification
- 2. Data gathering
- 3. Delay calculations

For each bottleneck type, these three steps were expanded on based on the requirements of the methodology.

3.1 Creating the GIS Database

For convenience and flexibility, a GIS database with all the required data was created. To perform the required calculations for freight bottlenecks, the following factors are needed:

- Average annual daily traffic
- Average annual daily truck traffic
- Number of through lanes or capacity
- Grade information

The required data were synthesized from NHPN, HPMS, and FAF. For the database, the data were separated into exit-to-exit roadway segments. We then used grade values from the HPMS, which includes roadway grade for every tenth of a mile.

3.1.1 The National Highway Planning Network

The National Highway Planning Network (NHPN) is a linear referencing system managed by FHWA and available in shapefile format through their website. The NHPN is a 1:100,000 scale network database containing line features representing over 450,000 miles of current and planned interstates, principal arterials, and minor arterials in the United States. The NHPN can be viewed in a GIS program. It has been used in bottleneck analyses performed by separate entities (Cambridge Systematics 2005; Guo, *et al.* 2010).

The Freight Analysis Framework (FAF) is a subset of NHPN. The most important value exclusive to this database is the number of traffic through lanes for a particular section of roadway.

3.1.2 Errors in the National Highway Planning Network

The most recent NHPN version available is 2005.08, which was released in August 2005. Because the NHPN has not been updated since August 2005, any expansion projects completed since that time are not reflected in the database.

However, the errors in the NHPN are not solely the consequence of a relatively old database. Errors also come from the spatial representations of roadway sections in the GIS format. Each section of roadway in the database includes the beginning mile post and ending milepost for the roadway section. These numbers do not always line up perfectly and lead to missing data.

In addition to the missing data, there are obvious errors in the existing data. Beginning and end mileposts are often mislabeled. Every spur route and bypass interstate highway in the state (I-165, I-565, I-359, I-459, I-759) has the beginning mile post as starting at the number of the milepost of the exit from the primary interstate route. For example, the beginning mile post in the database for the I-359 servicing Tuscaloosa shows the beginning mile post marker to be 71.70 and the end mile post as 73.40. The beginning mile post should be 0.00 because it begins a new interstate roadway. These errors were corrected in the new database created for this report. The correct beginning and ending mile posts were retrieved from the HPMS database.

Because of the numerous obvious errors in the NHPN database, this project used the NHPN data to create a new GIS database. A similar bottleneck inventory reported that the matches between the database and actual freeway segments were 97.33% accurate (Guo, *et al.* 2010); however, the Alabama data were only 93.97% accurate, meaning it had many errors. Thus, we took considerable time correcting those values in the new database.

The NHPN has multiple uses. In addition to traffic analysis, the NHPN is used for mapping, planning, water-quality analysis, earthquake-risk analysis, and other applications. Improvements to the framework could have significant positive effects for multiple applications.

There have been discussions about improving and updating the NHPN, but they have not lead to meaningful improvements.

3.1.3 Modification of the National Highway Planning Network

The NHPN database needs to be corrected for the state of Alabama. A complete correction was not performed for this report, and it may prove exceedingly time-consuming. We only corrected the values necessary for freight-congestion analysis.

A number of headings found in the NHPN database file are not pertinent to this bottleneck analysis, so they were not corrected. Examples include the Strategic Highway Planning Network Classification (STRAHNET) and the LRS key for each section of road. In a full correction, these would need to be checked for accuracy.

Table 3-1 shows the ten NHPN headings used in this project's GIS database; it includes a short description of the data found under the heading. The following FHWA webpage includes a full list of headings included in the NHPN database:

http://www.fhwa.dot.gov/planning/nhpn/docs/metadata.txt.

Database Heading	Description
VERSION	This database heading indicates what release this shape was included in. For
VENSION	maintenance purposes, every shape is now version 2011.06.
SOURCE	This heading indicates what the source of the arc is. Examples include 'T' for Tiger File or
SOUNCE	'S' for State. In this database, every arc has a source value of 'A' for UTCA.
LGUBB	Three-digit HPMS urbanized area code for the adjusted urbanized area in which the arc
ECOND	lies. A value of 0 indicates the arc lies outside the HPMS urbanized areas.
SIGN1	Contains the designated primary sign route for the arc.
SIGN2	Contains the designated secondary sign route for the arc.
MILES	Contains the accurate measurement in miles for an arc. This number is calculated from the
	HPMS source but implanted into the NHPN.
PECMP	Beginning mile point for the NHPN arc segment. This number is taken from the HPMS
DEGIVIF	source.
ENDMP	End mile point for the NHPN arc segment. This number is taken from the HPMS source.
AADT	The Annual Average Daily Traffic comes from the 2002 HPMS. This number has been
	updated to year 2006 in the newly created GIS database.
	The number of through lanes indicates the number of striped lanes in both directions. Does
ThruLanes	not include weaving lanes, turning lanes, or acceleration/deceleration lanes. We updated
	this heading by viewing satellite photographs of Alabama interstates.

Table 3-1. Database headings from NHPN

LGURB was kept for detailed analysis of the overall state of delay in Alabama. *MILES*, *AADT*, and *ThruLanes* were kept for delay calculations. The other database headings were kept for monitoring purposes (e.g. *SIGN1* tells the user which interstate a bottleneck is found on).

3.1.4 Alabama DOT/Highway Performance Monitoring System Database

Data provided by the Alabama Department of Transportation were used to correct the NHPN database and to extend the database used in this report.

The ALDOT data, which is taken from the HPMS database, splits traffic data based on exit. Each exit-to-exit section of roadway found in the database translates to one arc in the GIS database. The management of these data is sometimes confusing, however, because roadway sections can be split several times between exits in the ALDOT database. As a result, there are 315 sections of roadway in this ALDOT database but only 259 sections in the final GIS database product of this report.

The types of ALDOT data used to update information in the NHPN database headings include the following:

- Beginning mile point and ending mile point were obtained from ALDOT and used for the roadway sections in the database.
- The NHPN *MILES* heading was modified to reflect the difference in the beginning and ending mile points found in the ALDOT data.
- *AADT* for year 2006 was included in the new GIS database and used to update the 2002 numbers found in the NHPN.

The ALDOT database also supplied information for one new heading in the GIS database. The new database heading and its description are found in Table 3-2.

	Table 3-2. Database headings from ALDOT
Database Heading	Description
TADT	Truck Average Daily Traffic. percentage of trucks that drive a roadway section on any particular day.
	There are any traine, percentage of there that unive a readway section of any particular day.

3.1.5 Freight-Analysis Framework

The Freight-Analysis Framework is released by the Federal Highway Administration and integrates data from a variety of sources to give an idea of freight movements among states and major metropolitan areas. Included in the framework are traffic flows assigned to the highway network for the years 2007 and 2040. The most recent FAF is version 3.1, which was released in 2010. This most recent version was used in this report.

In the most recent release, there is only a traffic-flow projection to year 2040. However, the overall rates of growth were extracted from this information and projections can be made for any year in the new GIS database.

The road network used by FAF3 is a subsection of the NHPN database. However, the lines in the FAF database were too aggregated for use for the GIS database created for this report. For example, one arc in FAF3 may be the length of four arcs in the new database. This would limit the functionality and accuracy of the new GIS database. So instead of using the FAF3 database for these data, we obtained our numbers using the NHPN and ALDOT databases.

Table 3-3 shows the attributes we recreated from FAF3 for our database and the equations used to calculate the new values factors in Tables 3-1 and 3-2.

Database Heading	Description	Equation
AADTT	The Average Annual Daily Truck Traffic for a section of roadway is the number of freight trucks that travel that roadway on the typical day.	AADT * TADT
Capacity	The total capacity for a roadway section given in passenger cars per hour per lane (pcphpl) of travel. In this report, each lane of travel has a capacity of 2,200 pcphpl.	Thrulanes * 2,200

Table 3-3. Database nearings nom FA	Table 3-3.	Database	headings	from	FAF
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Projections of traffic flows for different years are a key component of the FAF3. The projections give the user the expected future conditions of the roadways. The GIS database created for this report duplicates these projections.

3.1.6 New Database Headings

The next step in database creation was to create headings needed for the delay calculations of freight bottlenecks.

All the calculations needed for capacity bottlenecks can be performed inside the GIS program. For interchange bottlenecks, the required calculations are more complicated and parts need to be performed outside the GIS program. However, all the data needed to perform the interchange bottleneck calculations can be retrieved from the GIS database.

Table 3-4 shows the data fields added to the GIS database. They include data required to show or calculate delay.

Table 5-4. New database nearlings for delay calculations				
Database Heading	Description			
LANE_MILES	Found by taking the number of roadway miles and multiplying times the number of through lanes (MILES * ThruLanes). Underestimates actual number of lane miles because it does not include weaving, acceleration/deceleration, or ramp lanes.			
PC_AADT	Average Annual Daily Traffic in passenger-car equivalents. This uses the passenger-car equivalent methodology found in the HCM to adjust the traffic stream.			
AADT_C	AADT/C. Ratio used in the delay equation of 'PC_AADT' / 'Capacity' from the newly created database.			
Delay	Delay calculation using the equation developed by Margiotta, Cohen, and DeCorla-Souza. Value is in hours for every 1000 VMT.			
ATHD	Annual Truck Hours of Delay. From the delay equation, the total hours of delay that occurs yearly per mile of roadway for trucks on the roadway section.			
EXP_DELAY	The expected delay for a car traveling the entire length of a roadway section given in hours.			

Table 3-4. New d	atabase hea	adings for d	delay calcu	lations
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Table 3-4 shows the headings for delay calculations in the base year, 2006. However, in addition to these headings for the current year, future year projections were also needed.

3.1.7 Projections in the Database

Section 3.1.6 describes values required to perform current year delay calculations in the new GIS database. However, projections were needed to predict the future bottleneck delays if capacity upgrades are not performed.

Two projections were performed for this report. The projection uses growth values that are used by the FHWA in the FAF. Discussion of the projection methods can be found in Section 4.4 of this report.

The projections for the years 2025 and 2040 were made inside the GIS program. Table 3-5 shows the data fields that were added to the new GIS database to perform the traffic-flow projections needed.

Database Heading	Description
DPCT_FAFXX	Daily passenger car traffic. FAF projection to year 20XX. Grows at an exponential rate of 2.4% per year.
DTT_FAFXX	Daily truck traffic. FAF projection to year 20XX. Grows at an exponential rate of 1.9% per year.
PCE FAFXX	Passenger-car equivalents for the FAF projection to year 20XX. Adjusted traffic stream using passenger-car
	equivalents from HCM.
PCEC_FAFXX	AADT/C for the FAF projection to year 20XX.
	Delay for FAF projection to year 20XX. Used the equation developed by Margiotta, Cohen, and DeCorla-
DEL_FAFAA	Souza. Value is in hours for every 1000 VMT.
ATHD_FAFXX	Annual truck hours of delay in hours/year/mile for FAF projection to year 20XX.
	The expected delay for a car traveling the entire length of a roadway section given in hours for roadways with
	a FAF projection to year 20XX.

 Table 3-5. New database headings for projected-delay calculations

Table 3-4 shows that for each year for which projections are made, there are twelve data columns added to the database. For this report, projections are performed out to 2025 and 2040. Therefore, twenty-four columns were added to the GIS database.

3.1.8 Future Improvements to the Database

There are multiple reasons why the GIS database could require future updates. As the years go by, there will be different reasons for an update. There are different projects that are being discussed or that are underway that would require the addition of completely new roads to the database. Sample projects include the following:

- Interstate 22. In progress, expected completion in 2014.
- Interstate 85 Extension (Montgomery to Mississippi state line). Under discussion.
- Interstate 422 (Birmingham "Northern Beltline"). Preliminary stages.

In addition to the interstates being built, other fields may require change. The spatial representations of the roadways are not perfect. Our project did not require perfect accuracy. For greater accuracy, lines would need to be traced using satellite imagery or another accurate source.

Roadway capacities may also require updating. For this report, roadway capacity was set to 2,200 pcphpl. This is a good number for the current project, but it is only an estimate. In some areas, such as the George C. Harrison Tunnel in Mobile, capacity may be lower. In other areas, such as rural interstates, capacity may be higher.

3.2 Interchange Bottlenecks

Interchange bottlenecks typically occur at urban freeway-to-freeway interchanges and urban freeway-to-arterial interchanges. However, in the case of a freeway-to-arterial interchange, the arterial is typically the congested roadway. Because the freeway is not the congested roadway, freeway-to-arterial interchanges were not inventoried in this report.

Table 3-6 shows the methodology used in this report to identify bottlenecks at interstate-tointerstate interchanges and perform delay calculations.

Table 3-6. Interchange-bottleneck procedure				
Step	Sub-step			
Identification	Create list of candidates (all freeway-to-freeway interchanges) Identify bottleneck locations (interchanges with at least one converging roadway with an AADT/C > 8)			
Data Gathering	Retrieve mainline-traffic volumes (from GIS database) Determine lane and ramp configurations, identify merge locations (from aerial photography) Determine ramp volumes (available for some states; if not available, must use ramp-balancing procedure from NCHRP 255)			
Delay Calculations	Calculate annual hours of delay for freight for every merge on the interchange Determine controlling merge for each exiting direction of the interchange Sum the controlling merges for each direction to determine total annual hours of delay for freight for the interchange			

3.2.1 Identification of Interchange Bottlenecks

The initial candidate list for interchange bottlenecks should include every interstate-to-interstate interchange within the study area. The list then should be narrowed to only include interchanges with at least one converging roadway having an AADT/C ratio over 8. This is done because an AADT/C ratio of 8 is where queuing begins, according to the delay equations used in this report.

3.2.2 Data Gathering for Interchange Bottlenecks

The first step of data gathering is to retrieve the mainline-traffic volumes from the GIS database. In the database, traffic counts are kept in the annual average daily traffic format. For the calculations, directional AADT is needed. We obtain directional AADT by first calculating one half of the AADT then subtracting ramp volumes (calculations for ramp volumes will be described later). We also retrieved the number of approaching lanes and the truck percentages for the traffic stream from the GIS database. The equation for determining directional AADT is shown below.

Dir. AADT =
$$\frac{1}{2}$$
 x AADT – RV

Where:

- Dir. AADT = directional average annual daily traffic
- AADT = average annual daily traffic
- RV = ramp volumes that exit the freeway

The next step for gathering data can be determined by analyzing aerial photographs for each location. The values needed are the lane counts for each merge that takes place in the interchange. If two lanes from a ramp merge with three lanes of traffic on the interstate to create a four-lane traffic stream, the lane count for that particular merge is four.

The last step required for data gathering is determining ramp volumes for interchanges. Unfortunately, the state of Alabama does not record ramp volumes for vehicles performing freeway-to-freeway turning movements. Because of this lack of data, a methodology for estimating ramp volumes is used. The standard procedure for estimating ramp volumes is the ramp-balancing procedure laid out in NCHRP 255 (Pedersen, *et al.* 1982).

<u>3.2.2.1 Ramp-Balancing Procedure</u> NCHRP 255, which was released in 1982, describes the method that investigators have used to calculate ramp volumes. It contains separate methodologies to calculate ramp volumes at three-way and four-way interchanges.

For three-way interchanges, only the approaching volumes from each of the three converging roadways are needed. From these values, all of the turning movements can be calculated. The equations for calculating ramp flows on three-way interchanges follow:

$$\begin{split} X &= (A - B + C) \ / \ 2 \\ Y &= (C - A + B) \ / \ 2 \end{split}$$

Where:

- A is the non-directional AADT of one of the non-terminal converging roadways
- *B* is the non-directional AADT of the other of the non-terminal converging roadways
- *C* is the non-directional AADT of the roadway that terminates at the interchange
- X is the AADT value for the turning movements involving roadways A and C
- Y is the AADT value for the turning movements involving roadways B and C

As a check, the sum of the two turning movements (X and Y) must equal the link volume C. The calculations for three-way interchange ramp volume are much simpler than the calculations for four-way interchange ramp volumes.

Calculating four-way interchange bottlenecks is not as precise a procedure as the procedure for calculating ramp volumes at three-way interchanges. The methodology requires five steps for calculating ramp volumes:

- 1. Estimate total turning percentage
- 2. Calculate the relative weight of each intersection approach
- 3. Perform initial allocation of turns
- 4. Adjust turning volumes based on total turning percentage
- 5. Balance the approach volume and adjusted turn volumes

An estimating turning percentage for all vehicles approaching the interchange is required to perform the ramp-balancing procedures. Unfortunately, estimates for these percentages are not available for Alabama. Due to the lack of these data, it is assumed that the true turning percentage at each interchange is between 20% and 30%. For each interchange, a value for 20% and a value for 30% were calculated to determine a range of possibilities. For a more accurate analysis, either actual turning volumes or an actual turning percentage estimate would be required.

The details of the procedure for calculating ramp volumes can be found in chapter 8 of the NCHRP 255. The procedure uses relative weights for vehicles turning and then performs corrections based on either a difference or a ratio method.
3.2.3 Freight Delay Calculations for Interchange Bottlenecks

Delay at interchange bottlenecks is highly dependent on the actual configuration of the interchange. The most recent methodology for calculated delay at interstate interchanges is found in the Cambridge Systematics report released in November 2008 (Cambridge Systematics, Inc. 2008). The equation shown below calculates delay in hours/day and is used for each direction for every merge of multiple streams of traffic.

Total Delay at Merge = $(H_u \times VMT) + (H_r \times AADT)$

Where:

- $H_u = factor for travel time without queuing$
- VMT = vehicle miles traveled; found by multiplying the directional AADT times onehalf because it is assumed that is the distance traveled by a vehicle using the interchange
- $H_r = factor for travel time with queuing$
- AADT = *directional* average annual daily traffic

Capacity at ramp junctions is assumed to be controlled by the number of lanes immediately downstream. The two queuing factors, H_r (travel time without queuing) and H_u (travel time with queuing), depend on the ratio of AADT to capacity of the roadway. The capacity of the roadway is assumed to equal 2,200 passenger cars per hour per lane (pcphpl) on the section of roadway immediately downstream of the merge. This value may be too high for some locations but is used to help avoid overestimation of delay (Cambridge Systematics 2006).

The equations for determining queuing factors can be found in Figure 3-1. The equations used depend on whether the peak direction of flow is in before or after noon and also on whether the ratio of AADT to capacity, X, exceeds 8. This figure was adapted from a Cambridge Systematics report (Cambridge Systematics 2008). The equations in Figure 3-1 are for use when the free flow speed is 60 miles per hour. This is the assumed free-flow speed for this report. If the free-flow speed was different than 60 miles per hour, we would expect the queuing factors to be different.

If the on ramp is constructed so two ramps handling separate turning movements merge before combining with the mainline, the higher delay of the two is chosen instead of being summed because when two bottlenecks are closely spaced, one will control operations. Only one value for each exiting direction is used. Total freight delay for an interchange is summed for every direction of the interchange.

3.2.4 Limitations of Interchange Bottleneck Delay Calculations

Cambridge Systematics says that, to date, field data has not been used to validate the procedure of using the queuing factors to calculate delay that was used in this report (Cambridge Systematics 2008). The equations used were originally intended for other uses and are believed by Cambridge Systematics to be applicable to analyzing freight interchange bottlenecks. The delay calculations that are performed on the potential interchange bottlenecks are potentially flawed because of their simplicity. The delay calculations fail to account for the effects of weaving and merging at an intersection. There is also no consideration of the volumes of the split between the separate merging traffic flows; the only number used is the total of the two flows.

S_f = free flow speed = 60 mph	
X = AADT/C	
a.m. Peak Direction, 24-hour Delay	
Travel Time Without Queuing (hours per vehicle mile)	
$H_u = 1 / Speed = (1/S_f) \times [1 + (5.44) \times (10^{-12}) \times (X^{10})]$	for X ≤ 8
$H_u = 1 / Speed = (1/S_f) x (1.23 - 0.0712 X + 0.00678 X^2 - 0.000183 X^3)$	for $X \ge 8$
Delay Due to Recurring Queues (hours per vehicle using the bottleneck)	
Hr = RECURRING DELAY = 0	for X ≤ 8
Hr = RECURRING DELAY = 0.00677 x (X-8) + 0.00413 x (X-8) ² + 0.00129 x (X-8) ³	for $X \ge 8$
p.m. Peak Direction, 24-hour Delay	
Travel Time Without Queuing (hours per vehicle mile)	
$H_u = 1 / Speed = (1/S_f) \times [1 + (7.37) \times (10^{-12}) \times (X^{10})]$	for X ≤ 8
H_u = 1 / Speed = (1/S _f) x (1.13 – 0.0439 X + 0.00468 X ² – 0.000132 X ³)	for $X \ge 8$
Delay Due to Recurring Queues (hours per vehicle using the bottleneck)	
Hr = RECURRING DELAY = 0	for X ≤ 8
Hr = RECURRING DELAY = $0.00411 \times (X-8) + 0.00126 \times (X-8)^2 + 0.000403 \times (X-8)^3$	for $X \ge 8$

Figure 3-1. Queuing factors for interchange delay calculations

The methodology for calculations needs to be expanded to include different bottleneck scenarios. That could include restricted diverge areas, limited acceleration lanes, or other types of limited geometry (Cambridge Systematics 2008).

3.3 Capacity Bottlenecks

Capacity bottlenecks occur when the capacity of a roadway is insufficient for the number of vehicles traversing it. The methodology used in this report to identify interstate capacity bottlenecks and perform proper delay equations is shown in Table 3-7.

	Table 3-7. Capacity-bottleneck procedure
Step	Sub-step
	Determine locations where AADT/C ratio exceeds 8
Identification	Combine adjacent roadway sections meeting this criteria to establish end points of the bottleneck
Data Gathering	Determine AADT and capacity (from GIS database)
Delay Calculations	Use delay calculation to determine the annual hours of delay for freight that occurs for every roadway section contained in the bottleneck

When comparing the procedure for capacity bottlenecks and interchange bottlenecks, it can be seen that the procedure for capacity bottlenecks is simpler.

3.3.1 Identification of Capacity Bottlenecks

Bottleneck-selection methods typically have a set volume-to-capacity ratio greater than 0.925 for an area deserving study (Cambridge Systematics, Inc. 2008). A peak volume-to-capacity ratio of

0.99 is equivalent to an AADT/C of 9.0, and a peak volume-to-capacity ratio of 0.88 is equivalent to an AADT/C of 8.0 (Margiotta, *et al.* 1998).

The GIS database created for this report uses the AADT/C ratio. For this study, because of the unavailability of reliable data regarding peak volume-to-capacity levels, an AADT/C ratio of 8.0 is used. This value is a conservative estimate, given that the ratio lines up to a peak volume-to-capacity ratio of 0.88, which is lower than the previously cited value of 0.925.

Scanning the GIS database created for this report reveals that, in several locations, there are multiple consecutive roadway segments that exceed the AADT/C ratio criterion. In these cases, the entire section, from end-to-end, is considered one capacity bottleneck.

For long, continuous sections of roadway considered a bottleneck, it is possible that segments on either side will grow enough in volume to also be considered a bottleneck. This is evident in some of the projections performed in this report. However, in this report, the initial bottleneck endpoints will be used for the projections and the potential expansion of the bottlenecks will be noted.

3.3.2 Data Gathering for Capacity Bottlenecks

All of the data required to perform the capacity-bottleneck calculations can be retrieved from the GIS database created for this report. Those values include AADT, TADT, and capacity.

3.3.3 Freight-Delay Calculations for Capacity Bottlenecks

After potential lane-drop bottleneck locations were identified and the required data were gathered, delay calculations were performed to rank the selections. The identified areas were typically urban two- or three-lane sections with high AADTs and high truck traffic.

To calculate truck delay, we used the equation developed by Margiotta, *et al.* (1998). The model uses the ratio of Average Annual Daily Traffic to roadway capacity (AADT/C). The equation that calculates capacity delay on a freeway follows:

 $\begin{array}{c} \text{Delay=}0.0461854203^{*}(\text{X})^{3}\text{-}0.0154380323^{*}(\text{X})^{4}\text{+}0.0018559670^{*}(\text{X})^{5}\text{-}\\ 0.0000887095^{*}(\text{X})^{6}\text{+}0.0000014614^{*}(\text{X})^{7} \end{array}$

Where:

• X = AADT/C

The delay equation gives the hours of delay experienced by a vehicle for every 1,000 VMT. The annual hours of freight delay were calculated by multiplying this estimate by the number of trucks that travel the roadway section annually.

Because the equation for calculating delay is assumed accurate for roads experiencing an AADT/C between 1 and 18, the highest value possible for the equation is limited. A roadway

experiencing an AADT/C equal to 18 has an estimated delay of 33.197 hours for every 1000 VMT.

The capacity value used for the roadways being studied is 2,200 passenger cars per hour per lane. This value is used so delay is not underestimated in urban areas, yielding a more conservative estimate. This value was derived using methods found in the HCM, and it has been used in other bottleneck reports (Cambridge Systematics 2005, 2006, 2008).

This delay equation enables us to rank freeway sections by annual freight delay to show where roadway efficiency is most needed. Typically, delay was calculated and ranked by hours of delay per mile of roadway.

3.4 Roadway-Geometry Bottlenecks

No section of interstate in the state of Alabama meets the grade criteria required to justify classification as a roadway-geometry bottleneck. Thus, this third type of truck bottleneck was not included in the results section of this report. Despite this result, a short description of the procedure that would be used to identify interstate roadway-geometry bottlenecks and perform proper delay calculations is shown in Table 3-8.

I	able 3-8. Roadway-geometry bottleneck procedure
Step	Sub-step
Identification	Determine locations where roadway grade exceeds 4.5% for longer than 1.0 consecutive miles
Data Gathering	Determine the AADT in passenger-car equivalents using the truck factors for steep grades Determine the capacity of the roadway section (from GIS database)
Delay Calculations	Use delay calculation to determine the annual hours of delay for freight that occurs for every roadway section contained in the bottleneck

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When comparing the procedure for capacity bottlenecks and roadway-geometry bottlenecks, it can be seen that the procedures for the two types are similar. Each of the two procedures uses the same delay equation. The primary difference between the two types of bottlenecks is that roadway-geometry bottlenecks have no requirement for traffic levels; they only require that the grade exceeds 4.5% for one mile.

3.4.1 Identification of Roadway-Geometry Bottlenecks

For a section of roadway to be classified as a roadway-geometry bottleneck, it must have a grade exceeding 4.5% for at least one mile (Cambridge Systematics 2005). Grade information was provided by ALDOT for Alabama interstates for every tenth of a mile. To find potential roadway-geometry bottlenecks, this database was scanned to find any roadway sections that met the geometry requirement.

As opposed to the other types of bottlenecks, there is no AADT/C requirement for a freight bottleneck to be a roadway-geometry bottleneck. This is because the constraining factor for flow is not the lack of capacity but because of long sections of high-grade road.

3.4.2 Data Gathering for Roadway-Geometry Bottlenecks

The data required to identify roadway-geometry bottlenecks can be retrieved from the GIS database created for this report. The grades of the roadway segments, however, were not included in the GIS database because it had already been determined that there were no sections of Alabama interstate that met the grade requirements of a roadway-geometry bottleneck.

3.4.3 Freight Delay Calculations for Roadway-Geometry Bottlenecks

Though they were not used in this report, the calculations used for determining freight delay at a roadway-geometry bottleneck are similar to the delay calculations used for a capacity bottleneck. The key difference is that the AADT is converted using passenger-car equivalents for trucks (capacity bottlenecks and interchange bottlenecks use a flat rate of 1.5 passenger cars per truck) found in the Highway Capacity Manual. This method is covered in Section 2.4.3.

After adjusting the traffic flow upward to account for the number of trucks within the traffic flow, the same equation used for lane-drop bottleneck calculations is used to rank the bottlenecks by delay severity. The equation is shown below.

$$Delay=0.0461854203^{*}(X)^{3}-0.0154380323^{*}(X)^{4}+0.0018559670^{*}(X)^{5}-0.0000887095^{*}(X)^{6}+0.0000014614^{*}(X)^{7}$$

Where:

• X = AADT/C

3.5 Forecasting Future Delay

The researchers for this project used the FAF growth model to predict future AADT on the locations selected for analysis. This is the projection method that has been used in other bottleneck inventory reports. The FAF forecasts for growth assumed 2.4% annual growth for truck traffic and 1.9% annual growth for other vehicle types.

Traffic cannot grow forever at these rates. However, without the aid of a travel-demand forecasting model, it is not possible to model the dampening of traffic growth. The FAF model does not account for traffic growth dampening. For this report, traffic growth is assumed to stop when the ratio of AADT/C exceeds 18. That is because the delay model is only assumed to be accurate for AADT/C up to that level and anything beyond that is rarely seen in practice (Margiotta, *et al.* 1998).

By using the growth-adjusted traffic volumes, future freight delay was estimated with the same methodology used for calculating current-year delay. Traffic volumes for the roadway sections being studied were estimated using the FAF growth percentages for the years 2025 and 2040.

3.6 Determining Economic Costs of Delay

After total truck hours of delay were calculated for current and future years, the economic costs of delay were calculated for each section. The delay costs per vehicle-hour were taken from the FHWA Highway Economic Requirements System (HERS) model. The values reflect average vehicle occupancy, inventory costs, and vehicle costs. The value for passenger-car delay is \$18.32 per hour and freight-truck delay is \$31.34 per hour (Cambridge Systematics 2006).

The benefits in the HERS model include travel-time savings for passenger cars and freight trucks based on dollar savings per hour of delay avoided. There are secondary benefits that may be enjoyed given an improved roadway; however, these benefits are not included in the analysis. Examples of secondary benefits could be costs saved from a potential reduction in automobile crashes and costs saved from decreased exhaust emissions from trucks and passenger cars. Because the estimates for benefit from roadway improvements do not include the secondary benefits, the estimates for benefit can be considered to be relatively conservative.

The total economic costs of delay for each bottleneck can be determined by multiplying the annual hours of delay for the separate vehicle types by their respective values of delay. This should be considered to be a cost to the economy and not as a direct cost to the state.

3.7 Present and Future Projects

The state of Alabama already has a five-year plan for statewide roadway improvements. This plan can be matched to bottlenecks identified in this report to estimate their benefits. For the remainder of the bottlenecks, multiple improvement scenarios can be analyzed.

The projects outlined in the five-year plan are shown in Appendix B. Appendix B also includes projects on the construction bulletin maintained by ALDOT and projects included on "Progress" websites maintained by ALDOT (progress65.com, progress20.com, progress59.com).

After determining possible scenarios for improvement, potential projects in the state can be ranked based on which have the highest benefit. Given accurate construction costs, the cost effectiveness of any improvements could be rated based on the project's dollar value for freight costs saved per dollar spent yearly.

Section 4 Alabama Interchange Bottlenecks

The methodology for identifying interchange bottlenecks, calculating freight delay, and ranking the results is found in Section 3.2 of this report. Using that methodology, the researchers identified three interchanges that warranted further study. They were studied individually as described in the remaining portion of this section.

For each of the three interchange bottlenecks identified in this section, an identical progression of headings is given. Standardizing the analysis of each interchange bottleneck into eight sections allows for easy comparison. The headings for each bottleneck follow:

- 1. Mainline-Traffic Volumes
- 2. Ramp Volumes
- 3. Merge Profiles
- 4. Delay Calculations
- 5. Future Projections of Delay
- 6. Current Status of Improvements
- 7. Benefits of Planned Improvements
- 8. Possible Future Improvements

Satellite imagery and maps for all the bottlenecks presented in this section may be found in Appendix A.

4.1 Interchange-Identification Results

There were three freeway-to-freeway interchanges in the state of Alabama that warranted further study according to our criteria. Table 4-1 shows the locations of the interchanges that met the initial criteria.

labi	e 4-1. Interch	ange-bottleneck locatio	ns
Interchange Bottleneck #	Urban Area	Intersecting Freeway 1	Intersecting Freeway 2
1	Birmingham	Interstate 20	Interstate 59
2	Birmingham	Interstate 20/59	Interstate 65
3	Birmingham	Interstate 459	Interstate 65

Table 4-1.	Interchange-bottleneck locations
	interonange bottleneok looatione

Notice that all three interchanges occur in the Birmingham metropolitan area. There are a total of twelve freeway-to-freeway interchanges statewide, six of which are in metro Birmingham. Half the interchanges in metro Birmingham (three of six) warranted further study.

The locations of the three interchange bottlenecks identified in Table 4-1 are shown in Figure 4-1. The map focuses on the area surrounding Birmingham.



Figure 4-1. Interchange bottleneck locations (GIS)

4.2 Interchange Bottleneck #1: Interstate 20/59 Diverge

The interchange where Interstate 20/59 diverges into separate interstates has one critically congested leg coming into the interchange (I-20/59 from the west). This is a three-legged interchange.

4.2.1 Interchange Bottleneck #1: Mainline-Traffic Volumes

Three converging interstates comprise this interchange. Table 4-2 shows the mainline-traffic volumes for each.

a	Die 4-2. Inte	i change bottlene		
	Roadway	Lanes of Travel	Directional AADT	TADT
ſ	I-59	3	40,700	0.08
	I-20	2	31,560	0.17
	I-20/59	4	69,750	0.11

Table 4-2.	Interchange	bottleneck #1	mainline-traffic volumes
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The westbound I-20 roadway terminates, and the traffic must exit on a ramp to either I-20/59 or I-59. Also, I-20 heading eastbound from the interchange begins with a merge of traffic from I-20/59 and I-59.

4.2.2 Interchange Bottleneck #1: Ramp Volumes

ALDOT does not collect exact ramp volumes for this interchange. However, this interchange is a three-legged interchange, so each ramp volume may be calculated as a precise number rather than a range of numbers. Table 4-3 shows the results for the ramp-balancing procedures for the first interchange bottleneck.

able 4-3. Intercha	ange bottleneci	k #1 ramp volume
From Interstate	To Interstate	Volume (AADT)
I-20/59	I-20	20.205
I-20	I-20/59	30,305
I-20	I-59	1 055
I-59	I-20	1,200

Table 4-3. Interchange bottleneck #1 ramp volumes

4.2.3 Interchange Bottleneck #1: Merge Profiles

Because this is a three-way interchange, there is one merge for each direction. The directional AADT is, therefore, equal to the mainline directional AADT that converges on the interchange. Table 4-4 gives the merge profiles for interchange bottleneck #1.

				Merge 1		Merg	e 2
Bottleneck Name	County/State	Exiting Leg	Percentage Trucks	Number of Lanes	Dir AADT	Number of Lanes	Dir AADT
		I-59	0.08	3	40,700	-	-
#1	Jefferson, AL	I-20	0.17	2	31,560	-	-
		I-20/59	0.11	4	69,750	-	-

Table 4-4. Interchange bottleneck #1 merge profiles

4.2.4 Interchange Bottleneck #1: Delay Calculations

Because this interchange is a three-legged interchange, there is only one merge for each direction, and that merge is the controlling merge. Table 4-5 shows the daily delay caused by each merge in this interchange for all vehicle types. The equations used to calculate delay can be found in Section 3.2.3.

		interonung		go doldy	
			Merge 1		Merge 2
Bottleneck Name	Exiting Leg	AADT/C	Daily Delay Hours	AADT/C	Daily Delay Hours
	I-59	6.413	339.5	-	-
#1	I-20	7.782	264.6	-	-
	I-20/59	8.362	705.4	-	-

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The daily delay hours from Table 4-5 can be extrapolated to include delay for the entire year. Also, multiplying the total yearly delay by truck percentage gives the value used to rank bottlenecks in this report: total yearly hours of freight delay. For every exiting direction at this interchange, the controlling merge is "merge 1" because there is only one merge per direction. Table 4-6 shows the calculations to determine the total yearly hours of freight delay at this bottleneck.

Bottleneck Name	Exiting Leg	Controlling Merge	Yearly Hours of Delay	Yearly Hours of Freight Delay	Total Yearly Hours of Freight Delay
	I-59	Merge 1	123,903	9,912	
#1	I-20	Merge 1	96,572	16,417	54,653
	I-20/59	Merge 1	257,486	28,323	

4.2.5 Interchange Bottleneck #1: Future Projections of Delay

Table 4-7 and Table 4-8 show merge delay for interchange bottleneck #1 using the FAF projections for 2025 and 2040 respectively. Projecting increases of delay can be an uncertain proposition. The calculations for future delay assume there are no planned capacity improvements to the interchange.

Table 4-7. I	nterchange bottleneck #1 merge delay	y (FAF 2025)	
			_

		Mer	ge 1	Merge 2	
Bottleneck Name	Exiting Leg	AADT/C	Daily Delay Hours	AADT/C	Daily Delay Hours
	I-59	9.274	974.3	-	-
#1	I-20	11.383	2,413.5	-	-
	I-20/59	12.139	7,655.2	-	-

Table 4-8. Interchange bottleneck #1 merge delay (FAF 2040)

······································							
		Merge 1		Merge 2			
Bottleneck Name	Exiting Leg	AADT/C	Daily Delay Hours	AADT/C	Daily Delay Hours		
	I-59	12.416	6,750.3	-	-		
#1	I-20	15.386	16,688.3	-	-		
	I-20/59	16.307	48,716.4	-	-		

Table 4-9 and Table 4-10 shows the total yearly hours of freight delay expected at interchange #1 for the FAF projections to 2025 and 2040 respectively.

Table 4-9.	Interchange	bottleneck #1	total freight	delay	(FAF 2025)	

Bottleneck Name	Exiting Leg	Controlling Merge	Yearly Hours of Delay	Yearly Hours of Freight Delay	Total Yearly Hours of Freight Delay
	I-59	Merge 1	355,615	30,980	
#1	I-20	Merge 1	880,979	161,684	526,401
	I-20/59	Merge 1	2,794,128	333,737	

Table 4-10.	Interchange	bottleneck #1	total freight	delay (FAF 2040)
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Bottleneck Name	Exiting Leg	Controlling Merge	Yearly Hours of Delay	Yearly Hours of Freight Delay	Total Yearly Hours of Freight Delay	
	I-59	Merge 1	2,463,871	229,474		
#1	I-20	Merge 1	6,091,387	1,186,518	3,681,022	
	I-20/59	Merge 1	17,781,497	2,265,030		

These two tables show how drastic the increase of freight delay would be if no capacity improvements were made to the roadway. The expected freight delay would be 9.6 times as much in 2025 and 67.4 times as much in 2040 as in 2006. These increases are alarming and show that capacity improvements will likely be needed in the next thirty years.

4.2.6 Interchange Bottleneck #1: Current Status of Improvements

Appendix B contains tables that describe all of the improvement projects planned for Alabama interstates in the immediate future. The projects described include projects on the ALDOT

construction bulletin and the projects included in the Five-Year Plan. However, no project on either list is set to directly influence delay at this interchange.

4.2.7 Interchange Bottleneck #1: Benefits of Planned Improvements

As discussed in Section 4.2.6, there are no projects planned for Alabama interstates in the immediate future that will have a tangible effect on delay at this interchange. Therefore, no calculations for planned improvements can be performed. However, in the next section, possible improvements are discussed.

4.2.8 Interchange Bottleneck #1: Possible Future Improvements

The calculations for future delay performed for this interchange show that the largest expected source of delay is the I-20/59 leg of the interchange west of the diverge. This leg causes 51.8% of the freight delay experienced at this interchange.

The merge that happens on the I-20/59 leg of the interchange already hovers around the limit where losing a lane becomes restraining because the merging traffic had 1,850 ft to merge, which exceeds the 1,500 ft distance that was put forth in the methodology. However, the traffic in this situation is still considered to be constrained to four lanes because this section of roadway forces traffic to weave.

Using the methodology for delay calculations in this report, the improvement project expected to be most beneficial for this interchange would be to increase capacity of the roadway for the westbound-exiting direction. The method for improving the capacity of this roadway is to increase the number of lanes from four to five for the I-20/59 exiting leg.

Tables 4-11 and 4-12 show the expected improvement in delay conditions if lane additions were made. The calculations were performed for 2006 even though 2006 passed and capacity-improvement projects would take several years from conceptualization to implementation.

Tubi								
Year	THD, THD, fear without with Improvement Improvement		Absolute Change in Freight Delay	Percentage Change in Freight Delay				
2006	28,323	23,368	-4,956	-17.5%				
2025	333,737	93,520	-240,217	-72.0%				
2040	2,265,030	711,316	-1,553,714	-68.6%				

 Table 4-11. Interchange #1, possible future improvement #1 (congested leg)

Year	THD, without Improvement	THD, with Improvement	Absolute Change in Freight Delay	Percentage Change in Freight Delay	Value of Improvement (Freight \$ Saved Yearly)
2006	54,653	49,697	-4,956	-9.1%	\$155,321
2025	526,383	286,166	-240,217	-45.6%	\$7,528,401
2040	3,680,915	2,127,201	-1,553,714	-42.2%	\$48,693,396

4.3 Interchange Bottleneck #2: Interstate 20/59 – Interstate 65

On the north side of Birmingham, Interstate 20/59 and Interstate 65 intersect to form an interchange that is sometimes called "Malfunction Junction." There are two critically congested

legs on the interchange: the I-20/59 approaches from the east and west. This is a four-legged interchange.

4.3.1 Interchange Bottleneck #2: Mainline-Traffic Volumes

Two intersecting interstates comprise this interchange. Table 4-13 shows the mainline-traffic volumes for each. The direction given under the roadway heading is the direction of travel for vehicles entering the interchange.

IK	ble 4-13. Interchange bottleneck #2 mainline-trainc volum						
	Roadway	TADT					
	I-20/59 W	4	79,910	0.10			
	I-65 N	4	67,195	0.08			
	I-20/59 E	4	69,600	0.09			
	I-65 S	4	54,210	0.12			

Table 4-13. Interchange bottleneck #2 mainline-traffic volu	mes
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4.3.2 Interchange Bottleneck #2: Ramp Volumes

ALDOT does not publish exact ramp volumes for interchange #2. This is a four-legged interchange, and the ramp volumes have been calculated using the ramp-balancing procedures found in NCHRP 255.

Table 4-14 shows the ramp volumes calculated using the ramp-balancing procedures assuming 20-30% of the vehicles entering the interchange take a ramp.

From Interstate	To Interstate	Volume (AADT)					
I-20/59 E	I-65 N	11.004 10.700					
I-65 S	I-20/59 W	11,304 - 10,782					
I-20/59 W	I-65 N	10.407 10.045					
I-65 S	I-20/59 E	13,427 - 18,845					
I-20/59 E	I-65 S	17.057 00.675					
I-65 N	I-20/59 W	17,257 - 22,675					
I-20/59 W	I-65 S	14 700 00 110					
I-65 N	I-20/59 E	14,700 - 20,118					

Table 4-14. Interchange bottleneck #2 ramp volumes

4.3.3 Interchange Bottleneck #2: Merge Profiles

In this four-way interchange, there are two merges for every exiting direction that can be the controlling source of delay. This interchange is symmetrical, in that it has identical merges for each direction. What this means is that every exiting direction features two separate merges; for example, all of the traffic movement going from I-20/59 E to I-65 S merges, then all of the traffic movement from I-20/59 W to I-65 S merges with the traffic stream (which already has the I-20/59 E traffic merged). Table 4-15 gives the merge profiles for interchange bottleneck #2.

					je 1	Mer	ge 2
Bottleneck Name	County/State	Exiting Leg	Percentage Trucks	Number of Lanes	Dir AADT	Number of Lanes	Dir AADT
	#2 Jefferson, AL	I-20/59 E	0.10	4	59,792 - 65,210	4	79,910
#0		I-65 S	0.08	4	44,520 -49,938	4	67,195
#∠		I-20/59 W	0.09	4	52,818 - 58,236	4	69,600
1		I-65 N	0.12	4	35,365 - 40,783	4	54,210

Table 4-15.	Interchange	bottleneck #2	merge profiles
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Every merge in this interchange involves a merge into four lanes of traffic. There is not a single merge of two ramps before a merge with the mainline. Thus, because of the geometry of this interchange, the second merge for every single direction is the controlling merge.

4.3.4 Interchange Bottleneck #2: Delay Calculations

This is a four-legged interchange. Therefore, there are two merges for each direction. In this interchange, the merges involve the ramp from a single direction merging with the mainline of traffic (as opposed to two ramps merging before merging with the mainline). The equations used to perform the calculations for delay are found in Section 3.2.3.

Every exiting direction at this interchange is controlled by the second merge, which has a volume equal to the directional AADT. Because of this situation, the delay calculations are considered more accurate than they would be if estimates for ramp volumes were necessary. Table 4-16 shows the delay caused by each of the merges in this interchange for all vehicle types.

		Merge 1		Merge 2		
Bottleneck Name	Exiting Leg	AADT/C	Daily Delay Hours	AADT/C	Daily Delay Hours	
	I-20/59 E	7.134 – 7.781	499.5 - 545.6	9.535	1,538.5	
#0	I-65 S	5.261 - 5.902	371.0 - 416.3	7.942	564.1	
#∠	I-20/59 W	6.272 – 6.916	440.5 - 486.2	8.265	669.64	
	I-65 N	4.260 - 4.912	294.7 - 339.9	6.530	452.22	

Table 4-16. Interchange bottleneck #2 merge delay

The daily delay hours found in Table 4-16 can be extrapolated to include delay for the entire year. Also, multiplying the total yearly delay by the truck percentage will give the value used to rank bottlenecks in this report: total yearly hours of freight delay. Table 4-17 shows the estimated total yearly hours of freight delay at this bottleneck.

Table 4-17. Interchange bottleneck #2 total height delay							
Bottleneck Name	Exiting Leg	Controlling Merge	Yearly Hours of Delay	Yearly Hours of Freight Delay	Total Yearly Hours of Freight Delay		
	I-20/59 E I-65 S	Merge 2 Merge 2	561,548 205,887	56,155 16,470	114,431		
#2	I-20/59 W	Merge 2	244,418	21,998			
	I-65 N	Merge 2	165,060	19,807			

Table 4-17. Interchange bottleneck #2 total freight delay

4.3.5 Interchange Bottleneck #2: Future Projections of Delay

Table 4-18 and Table 4-19 show merge delay for interchange bottleneck #2 using the 2025 and 2040 FAF projections. Projecting increases of delay is an uncertain proposition. The estimates of future delay assume no capacity improvements are made to the interchange.

The maximum possible value for AADT/C is only 18. Therefore, if the estimated AADT/C exceeds 18, 18 is assumed. We boldfaced and italicized the values where we made that change.

Notice that in Table 4-19 the AADT/C for merge number 2 exceeds 18. This number is not sustainable and is outside of the range that would normally be encountered on interstates.

· · · · · · · · · · · · · · · · · · ·						
		Merge 1		Merge 2		
Bottleneck Name	Exiting Leg	AADT/C	Daily Delay Hours	AADT/C	Daily Delay Hours	
	I-20/59 E	10.343 - 11.281	2,618.0 - 4,702.8	13.824	17,903.1	
#0	I-65 S	7.608 - 8.534	537.2 - 796.4	11.483	5,355.7	
#2	I-20/59 W	9.082 - 10.013	1,136.4 - 2,119.2	11.967	7,030.8	
	I-65 N	6.192 - 7.141	426.6 - 492.9	9.492	1,473.5	

Table 4-18.	. Interchange bottleneck #2 merge delay (FAF	2025)
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Table 4-19.	Interchange bottleneck #2 merge delay (FAF	2040)
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		Merge 1		Merge 2	
Bottleneck Name	Exiting Leg	AADT/C	Daily Delay Hours	AADT/C	Daily Delay Hours
	I-20/59 E	13.879 – 15.137	18,299.6 - 31,349.7	*18*	89,353.1
#0	I-65 S	10.186 - 11.426	2,380.3 - 5,164.5	15.374	34,830.3
#∠	I-20/59 W	12.173 - 13.421	7,850.2 - 14,858.9	16.040	44,667.0
	I-65 N	8.327 - 9.602	680.5 - 1,580.8	12.764	10,561.5

Table 4-20 and Table 4-21 show the FAF projections for the total yearly hours of freight delay at interchange #2 in 2025 and 2040 respectively. The largest expected delay occurs where the I-20/59 leg exits the interchange traveling east.

Table 4-20. Interchange bottleneck #2 total freight delay (FAF 2025)

Bottleneck Name	Exiting Leg	Controlling Merge	Yearly Hours of Delay	Yearly Hours of Freight Delay	Total Yearly Hours of Freight Delay
	I-20/59 E	Merge 2	6,534,647	710,231	
#0	I-65 S	Merge 2	1,955,224	170,335	1 201 844
#2	I-20/59 W	Merge 2	2,566,251	251,269	1,201,844
	I-65 N	Merge 2	537,812	70,009	

Table 4-21. Interchange bottleneck #2 total freight delay (FAF 2040)

Bottleneck Name	Exiting Leg	Controlling Merge	Yearly Hours of Delay	Yearly Hours of Freight Delay	Total Yearly Hours of Freight Delay
#2	I-20/59 E I-65 S	Merge 2 Merge 2	32,613,894 12,713,065	3,783,428 1,184,051	
	I-20/59 W I-65 N	Merge 2 Merge 2	16,303,469 3,854,945	1,705,212 534,737	7,207,428

4.3.6 Interchange Bottleneck #2: Current Status of Improvements

Appendix B shows the planned roadway improvements affecting this interchange and the improvement projects planned for Alabama interstates in the near future. Having this information available allows for assessments of the benefits of these planned projects.

There are no capacity projects that will affect the bottlenecking at this interchange.

4.3.7 Interchange Bottleneck #2: Benefits of Planned Improvements

As discussed in Section 4.3.6, there are no projects planned for the immediate future on Alabama interstates that will tangibly affect delay at this interchange. However, in the next section, possible improvements are discussed.

4.3.8 Interchange Bottleneck #2: Possible Future Improvements

The largest expected source of delay for this interchange is the I-20/59 leg that exits the interchange going east. This leg is estimated to cause 49.1% of the freight delay at this interchange.

The section of roadway exiting east from the interchange ("Merge 2") is classified as a weaving section. The length of this weaving section is roughly 950 feet long. The weaving section constrains traffic flow at the interchange.

Using this report's methodology for delay calculations, the improvement project expected to be most beneficial for this interchange would increase the capacity of the roadway for the east exiting direction on I-20/59. This can be done by increasing the number of lanes for the merge from four to five by adding a lane or extending the merging lane.

Tables 4-22 and 4-23 show the improvement in delay conditions expected to occur if the suggested roadway-improvement project were to be performed. The estimates are made for 2006 even though 2006 has passed and the implementation of any capacity-improvement projects would take several years to move from conception to implementation.

Table 4-22. Interchange #2, possible future improvement #1 (congested leg)

Year	THD, without Improvement	THD, with Improvement	Absolute Change in Freight Delay	Percentage Change in Freight Delay
2006	56,155	24,425	-31,730	-56.5%
2025	710,231	203,908	-506,323	-71.3%
2040	3,783,428	1,469,523	-2,313,905	-61.2%

Table 4-23. Interchange #2, possible future improvement #1 (entire interchange)

Year	THD, without Improvement	THD, with Improvement	Absolute Change in Freight Delay	Percentage Change in Freight Delay	Value of Improvement (Freight \$ Saved Yearly)
2006	114,431	82,701	-31,730	-27.7%	\$994,418
2025	1,201,844	695,521	-506,323	-42.1%	\$15,868,163
2040	7,207,428	4,893,523	-2,313,905	-32.1%	\$72,517,782

These tables show that improving the capacity on the interchange leg exiting on I-20/59 to the east could greatly improve the efficiency of the interchange. Increasing capacity would immediately eliminate more than half of the freight delay on the congested leg and 27.7% on the entire interchange. By 2025 that extra capacity would reduce freight delay by 42%.

4.4 Interchange Bottleneck #3: Interstate 459 – Interstate 65

In southern Birmingham, I-459 and I-65 intersect to form an interchange. There is one critically congested leg on the interchange: I-65 south of the interchange. This interchange is four-legged.

4.4.1 Interchange Bottleneck #3: Mainline-Traffic Volumes

Two intersecting interstates comprise this interchange. Table 4-24 shows the mainline-traffic volumes on the roads that form this interchange. The direction under the roadway heading is the direction of travel for the roadway entering the interchange.

a	able 4-24. Interchange bottleneck #5 mainine-trainc volume								
	Roadway Lanes of Travel		Directional AADT	TADT					
	I-459 W	4	51,875	0.10					
	I-65 N	3	56,110	0.13					
	I-459 E	4	54,425	0.11					
	I-65 S	4	58,965	0.11					

Table 4-24. Interchange bottleneck #3 mainline-traffic volumes

4.4.2 Interchange Bottleneck #3: Ramp Volumes

ALDOT does not publish exact ramp volumes for interchange #3. This is a four-legged interchange, and the ramp volumes have been calculated using the ramp-balancing procedures found in NCHRP 255.

Table 4-25 shows the ramp volumes calculated using the ramp-balancing procedures assuming 20-30% of total vehicles entering the interchange take a ramp.

able 4-25. Interchange bottleneck #5 ramp volum						
From Interstate		To Interstate	Volume (AADT)			
I-459 E		I-65 N	10 200 16 729			
	I-65 S	I-459 W	12,300 - 10,720			
	I-459 W	I-65 N	11 601 16 607			
	I-65 S	I-459 E	11,021 - 10,007			
	I-459 E	I-65 S	10.052 15.902			
	I-65 N	I-459 W	10,952 - 15,605			
	I-459 W	I-65 S	11 509 16 590			
	I-65 N	I-459 E	11,590 - 10,560			

Table 4-25. Interchange bottleneck #3 ramp volumes

4.4.3 Interchange Bottleneck #3: Merge Profiles

In a four-way interchange, there are two separate merges for every exiting direction that can be the source of delay. This interchange is symmetrical, in that it has identical merges for each direction. Two ramp volumes merge (e.g. eastbound-to-southbound turns and westbound-to-southbound turns), then that traffic merges with the mainline traffic stream. Table 4-26 gives the merge profiles for interchange bottleneck #3.

				Merge 1		Merge 2	
Bottleneck Name	County/State	Exiting Leg	Percentage Trucks	Number of Lanes	Dir AADT	Number of Lanes	Dir AADT
#3 Jefferso		I-459 E	0.10	2	23,219 - 33,187	4	51,875
	lofforcon Al	I-65 S	0.13	1	22,550 - 32,383	3	56,110
	Jellerson, AL	I-459 W	0.11	2	23,252 - 32,531	4	54,425
		I-65 N	0.11	2	23,921 - 33,335	4	58,965

Table 4-26	Interchange	hottleneck #3	merce	nrofiles
1 abie 4-20.	merchange	DULLIELIECK #3	merge	promes

4.4.4 Interchange Bottleneck #3: Delay Calculations

This is a four-legged interchange, and there are two separate merges that occur for each exiting direction from the interchange. In this case, as opposed to interchange #2, the two directional ramps merge before eventually merging with the mainline traffic. This means that the controlling merge may not be the mainline merge.

Table 4-27 below shows the daily delay hours caused by this interchange bottleneck using 2006 data. The "Merge 1" for every direction involves the merging of separate ramps, and the "Merge 2" for every direction involves the combination of those two ramps merging with the mainline.

		Me	erge 1	Merge 2		
Bottleneck Name Exiting Leg		AADT/C	Daily Delay Hours	AADT/C	Daily Delay Hours	
	I-459 E	5.541 - 7.920	193.5 – 278.5	6.190	432.6	
#0	I-65 S	10.916 – 15.676	932.1 – 9,621.5	9.054	824.2	
#3	I-459 W	5.575 - 7.800	193.8 – 272.8	6.525	454.0	
	I-65 N	5.736 - 7.993	199.4 - 280.0	7.069	492.5	

Table 4-27. Interchange bottleneck #3 merge delay

Table 4-27 shows that the major concern for this particular interchange is the I-65 southbound merge of the two directional ramps of traffic before the merge into the mainline. It is the only direction in which the two ramps merge into one lane before merging with the mainline. For every other direction, the ramps merge into two lanes.

The daily delay hours found in Table 4-27 can be extrapolated to produce delay for the entire year. Also, multiplying the total yearly delay by the truck percentage will give the value used to rank bottlenecks in this report: total yearly hours of freight delay. Table 4-28 shows the results of calculations to determine the total yearly hours of freight delay at this bottleneck.

Table 4-20. Interchange bottleheck #5 total height delay							
Bottleneck Name	Exiting Leg	Controlling Merge	Yearly Hours of Delay	Yearly Hours of Freight Delay	Total Yearly Hours of Freight Delay		
#3	I-459 E	Merge 2	157,882	15,788			
	I-459 W	Merge 2	165,713	44,229 - 456,539 18,228	98,109 - 510,329		
	I-65 N	Merge 2	179,764	19,774			

Table 4-28. Interchange bottleneck #3 total freight delay

Table 4-28 shows that the total yearly hours of freight delay at this bottleneck depend on the number of vehicles using the ramps that handle movements going southbound. Depending on the number of vehicles merging in that direction, the sum of total freight delay on that exiting direction can range from roughly 100,000–500,000. This bottleneck is a good example of why it is important to have accurate counts for interstate-to-interstate movements.

4.4.5 Interchange Bottleneck #3: Future Projections of Delay

Table 4-29 and Table 4-30 show merge delay for interchange bottleneck #3 using the FAF projections for 2025 and 2040 respectively. Projecting increases of delay can be an uncertain proposition. The estimates of future delay assume that there are no capacity improvements to the interchange.

The maximum possible value for AADT/C is only 18. Therefore, if the estimated AADT/C exceeds 18, 18 is assumed. We boldfaced and italicized the values where we made that change.

		Μ	lerge 1	Merge 2			
Bottleneck Name	Exiting Leg	AADT/C	Daily Delay Hours	AADT/C	Daily Delay Hours		
	I-459 E	8.033 – 11.482	287.1 – 2,649.6	8.974	1,052.3		
#0	I-65 S	15.888 – * 18 *	10,371.6 – 27,157.4	13.178	9,737.3		
#3	I-459 W	8.094 - 11.323	296.5 - 2,400.0	9.472	1,461.7		
	I-65 N	8.326 - 11.603	343.3 - 2,829.3	10.262	2,470.8		

Table 4-29. Interchange bottleneck #3 merge delay (FAF 2025)

Table 4-30. Interchange bottleneck #3 merge delay (FAF 2040)

		Merge 1		Merge 2	
Bottleneck Name	Exiting Leg	AADT/C	Daily Delay Hours	AADT/C	Daily Delay Hours
	I-459 E	10.779 – 15.407	1,723.1 – 17,451.0	12.041	7,265.0
#0	I-65 S	*18*	25,349.3	17.739	58,907.2
#3	I-459 W	10.872 – 15.211	1,816.0 - 16,059.4	12.724	10,402.6
	I-65 N	11.185 – 15.587	2,200.1 - 18,613.5	13.785	17,435.7

Table 4-31 and Table 4-32 shows the total yearly hours of freight delay expected at interchange #3 for the FAF projections in 2025 and 2040 respectively.

Table 4-51. Interchange bottleneck #5 total height delay (FAF 2025)								
Bottleneck Name	Exiting Leg	Controlling Merge	Yearly Hours of Delay	Yearly Hours of Freight Delay	Total Yearly Hours of Freight Delay			
#3	I-459 E I-65 S I-459 W I-65 N	Merge 2 Merge 1 Merge 2 Merge 2	384,083 625,874 – 1,529,623 533,503 901,829	41,745 533,338 – 1,396,514 63,722 107,715	746,520 – 1,609,696			

Table 4-31. Interchange bottleneck #3 total freight delay (FAF 2025)

Table 4-32. Interchange bottleneck #3 total freight delay (FAF 2040)

Bottleneck Name	Exiting Leg	Controlling Merge	Yearly Hours of Delay	Yearly Hours of Freight Delay	Total Yearly Hours of Freight Delay
#3	I-459 E	Merge 2	2,651,739	307,619	
	I-65 S	Merge 2	21,501,137	3,225,348	4 927 291
	I-459 W	Merge 2	3,796,938	483,657	4,027,201
	I-65 N	Merge 2	6,364,048	810,657	

Notice that even though there is a range of projections in Table 4-31 (for 2025) there is not in Table 4-32 (for 2040). The reason is that merge 2 became the controlling merge instead of merge 1.

4.4.6 Interchange Bottleneck #3: Current Status of Improvements

Appendix B contains a road map of Interstate 65 extending from Jefferson County into Shelby County and shows the planned roadway improvements that would affect this interchange. Having this information available allows assessments of the benefits of these planned projects.

One project is underway. It involves ramp improvements and adding lanes south of the interchange. Two parts of this project will affect delay:

- Adding a second lane for merge of ramps before merging with I-65 S.
- Adding a fourth lane on I-65 south of the interchange.

These two improvements will change the controlling merge on this leg of the interchange from Merge 1 to Merge 2. It will also decrease the expected hours of delay for Merge 2. It will have a great impact on the hours of delay at the interchange.

4.4.7 Interchange Bottleneck #3: Benefits of Planned Improvements

The leg of the interchange that would be affected by the planned improvements described in Section 4.4.6 is the leg most in need of improvement and could account for anywhere between 45.1% and 89.5% of the total delay for the interchange, depending on which estimate of ramp volumes is used.

The improvements being made are beneficial to the overall efficiency of this interchange. Table 4-33 below shows that the interchange's I-65 S leg will experience large upgrades for present and future estimates.

Year	ATHD without	ATHD with	Absolute Change	Percentage Change					
	Improvement	Improvement	in Freight Delay	in Freight Delay					
2006	44,229 - 456,539	22,221	-22,008 - (-434,531)	-49.8% - (-95.2%)					
2025	533,338 - 1,396,514	97,971	-435,367 - (-1,298,543)	-81.6% - (-93.0%)					
2040	3,225,348	752,914	-2,472,434	-75.6%					

Table 4-33.	Interchange #3.	planned im	provement #1	(congested leg)
	interonange "o,	piurineu ini		(oongeotea leg)

Table 4-33 shows that a significant portion of delay on this congested leg was caused by two ramps merging into one leg instead of two legs. Table 4-34 shows the benefits that the entire interchange is expected to gain from these improvements.

Year	THD, without Improvement	THD, with Improvement	Absolute Change in Freight Delay	Percentage Change in Freight Delay	Value of Improvement (Freight \$ Saved Yearly)
2006	98,109 - 510,329	76,012	-22,008 - (-434,531)	-22.4% - (-85.1%)	\$689,731 - \$13,618,201
2025	746,520 - 1,609,696	311,152	-435,367 - (-1,298,543)	-58.3% - (-80.7%)	\$13,644,401 - \$40,696,338
2040	4,827,281	2,354,847	-2,472,434	-51.2%	\$77,486,081

Table 4-34. Interchange #3, planned improvement #1 (entire interchan	ge)
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The estimated delay reductions show that this improvement project is vital to the long-term health of the interchange. This project is expected to cut freight delay by more than half, even in 2040. This value is large compared to the estimates for the proposed improvements to interchange bottlenecks #1 and #2.

4.4.8 Interchange Bottleneck #3: Possible Future Improvements

The planned improvements to this interchange bottleneck will decrease the number of legs in this interchange experiencing an AADT/C greater than 8 from one to zero. Because of this current construction, there will not be a future improvement possibility analyzed for interchange bottleneck #3.

4.5 Interchange Bottleneck Ranking

Table 4-35 shows the ranking of the interchange bottlenecks by yearly freight hours of delay for 2006. For interchange bottleneck #3, which has a range of yearly hours of freight delay, the average of the range is used.

Table 4-35. Interchange bottleneck rankings						
Rank	Interchange	Total Annual Freight Hours of Delay				
#1	I-459 at I-65	304,174				
#2	I-20/59 at I-65	114,431				
#3	I-20/59 Diverge	54,653				

Nationally, the amount of freight delay at these interchanges is so low that they do not warrant further study. In the initial bottleneck report, interchanges were considered bottlenecks if their annual delay exceeded 250,000 hours (Cambridge Systematics 2005). The I-459/I-65 interchange meets that level according to this methodology, but may not truly meet it due to the uncertainty involved in the ramp-balancing procedures. Also, the methodology in the initial bottleneck report predates the methodology used in this report by several years.

In a later bottleneck study that uses the most up-to-date methodology for calculating delay at interchange bottlenecks, the bottleneck that experienced the least delay and warranted study still experienced freight delay exceeding 1,000,000 hours annually (Cambridge Systematics 2008). This level of delay is not expected on the interchanges studied in this report until roughly 2025.¹

The values shown in Table 4-35 show that the worst interchange in the state of Alabama when considering total delay occurs at the intersection of I-459 and I-65. However, the leg that causes most of the 304,174 hours of delay is on the southbound ramp before the merge into I-65. That number strongly depends on the number of vehicles using the ramp. The numbers used in this report are estimates and may not reflect the actual values. Also, there is work planned to improve the I-459/I-65 interchange that should reduce delay in the short term.

4.6 Future State of Interstate Interchange Bottlenecks

This chapter studied only three interchange bottlenecks because there are only three interchanges that meet the freight-bottleneck criteria. However, in the future, there will be several additional interchanges that can be classified as potential bottlenecks.

Table 4-36 shows the interchanges in the state of Alabama and shows whether each was studied in this bottleneck report. It also shows whether the projections for each interchange for 2025 and 2040 meet the bottleneck criteria. The table also shows the number of converging roadways to that interchange that experience congested conditions.

¹ The I-20/59 at I-65 interchange is projected to experience 1,201,844 hours of truck delay in 2025; the lowest value of freight delay in the bottleneck report [8] is 1,162,339 hours at the I-95 at I-495 interchange in Prince George's, Maryland.

(p							
Interchange	Converging Roadways	2006 Bottleneck?	2006 Congested Roadways	2025 Bottleneck?	2025 Congested Roadways	2040 Bottleneck?	2040 Congested Roadways
I-65/I-565	3	N	-	Y	1	Y	2
I-2059/I-65	4	Y	2	Y	4	Y	4
I-459/I-65	4	Y	1	Y	4	Y	4
I-65/I-85	3	N	-	Y	3	Y	3
I-165/I-65	3	N	-	N	-	Y	1
I-10/I-65	3	N	-	Y	2	Y	3
I-2059/I-359	3	N	-	N	-	Y	3
I-2059/I-459	3	N	-	Y	3	Y	3
I-2059 Div.	3	Y	1	Y	3	Y	3
I-20/I-459	4	N	-	Y	2	Y	4
I-459/I-59	3	N	-	Y	2	Y	3
I-59/I-759	3	N	-	N	-	N	-

Table 4-36. Alabama interchange bottleneck status (present, 2025, 2040)

In Table 4-36, interchanges that experience congestion (AADT/C > 8) from every direction are boldfaced and italicized. No interchanges experienced congestion from every direction in 2006, but FAF projections suggest five will in 2025 and nine in 2040.

4.7 Summary of Alabama Interchange Bottlenecks

Overall in the state of Alabama, the level of freight delay at the interchanges is low compared to the levels seen at interchange bottlenecks around the country. The initial national bottleneck report classified interchanges with 250,000 annual truck hours of delay as bottlenecks (Cambridge Systematics 2005).

There are no interchanges in the state of Alabama that even approach that level (taking into consideration the current improvement project on I-65, south of I-459). The closest interchange is I-65 and I-20/59, which is known statewide as "Malfunction Junction."

Although the interchanges in Alabama do not meet the national threshold for freight bottlenecks, they are expected to by 2040 (assuming FAF growth percentages). This means that there is a need for monitoring the levels of delay on the interchanges.

Projects that will monitor freight-interchange bottlenecks in Alabama need to address certain issues:

- Uncertainty regarding ramp volumes and turning percentages at interchanges in Alabama.
- The validity of using the FAF growth percentages in Alabama.
- Whether Alabama is using the same methodology as FHWA.

In Appendix B, a table shows every planned improvement to the Alabama interstate system over the next five years. This information was given by ALDOT and shows the large amount of work being performed to avert future delays.

Section 5 Alabama Capacity Bottlenecks

The methodology describing how capacity bottlenecks on Alabama interstates were identified and ranked can be found in Section 3.3. Using those methods, the researchers identified six freight-capacity bottlenecks using 2006 traffic data. This chapter will explain the results of those calculations and estimate future freight delay.

While the interchange bottlenecks studied for this report required separate calculations to estimate delay, capacity delay can be automated inside a database. The only required information for each roadway section is AADT, TADT, and Capacity. These are all found in the GIS database created for this report, along with the actual delay calculations.

For each of the six capacity bottlenecks identified in this section, an identical progression of headings is given. Standardizing the analysis of each interchange bottleneck into these sections allows for easy comparison for anyone reading this report. The headings for each bottleneck follow:

- 1. Profile
- 2. Delay Calculations
- 3. Planned Improvement Projects
- 4. Possible Future Improvement Projects

Profile contains location information for every segment of roadway in the bottleneck (roadway, beginning mile post, ending mile post, beginning exit, and ending exit). Also included are the average annual daily traffic (AADT), the truck average daily traffic (TADT), and the number of through lanes for the roadway segment.

Delay Calculations contains the calculations for the delay equation developed by Margiotta, Cohen, and Decorla-Souza for each bottleneck. These calculations include AADT/C, Delay, and Annual Truck Hours of Delay.

Planned Improvement Projects discusses ALDOT's planned projects that may affect the delay experienced for each bottleneck. If there is a planned improvement project, estimates of future benefits are produced.

Possible Future Improvement Projects discusses the benefits of a possible improvement project for each bottleneck. If the bottleneck already has an improvement project planned, no further calculations are performed here.

Satellite imagery and maps for all of the bottlenecks presented in this section may be found in Appendix A of this report.

5.1 Capacity-Bottleneck Locations

Table 5-1 shows the locations of the potential capacity bottlenecks that will be studied for this report. The table also provides the beginning and ending mile posts and the number of the roadway exits that encompass the bottleneck. Six segments of Alabama interstate warrant further study.

Capacity Bottleneck #	Interstate	Beginning MP	Ending MP	Beginning Exit #	Ending Exit #				
1	I-10	15.69	17.12	15B	17A				
2	I-10	25.96	27.08	26A	27				
3	I-20/59	123.14	130.29	123	130				
4	I-65	238.32	246.06	238	246				
5	I-65	247.26	250.08	247	250				
6	I-65	251.97	259.70	252	259B				

Table 5-1. Capacity bottleneck locations

Some capacity bottlenecks in this report cover multiple sections of roadway over the span of the bottleneck. For the sake of this study, the endpoints of the bottlenecks remain the same for future projections, even though adjacent roadways are expected to bottleneck.

The locations of the six capacity bottlenecks identified are shown in Figure 5-1.



Figure 5-1. Capacity bottleneck locations (GIS)

Because Figure 5-1 is shown on such a large scale and multiple capacity bottlenecks are found around Mobile and Birmingham, Figures 5-2 and 5-3 were created. Figure 5-2 shows the capacity bottlenecks in metropolitan Birmingham, and Figure 5-3 shows the capacity bottleneck locations in metropolitan Mobile.



Figure 5-2. Capacity bottleneck locations, Birmingham (GIS)



Figure 5-3. Capacity bottleneck locations, Mobile (GIS)

5.2 Capacity Bottleneck #1: I-10, Exit 15B to Exit 17A

This capacity bottleneck covers one exit-to-exit section of two-lane interstate west of the I-10/I-65 interchange in Mobile. This bottleneck is 1.53 miles in length.

5.2.1 Capacity Bottleneck #1: Profile

Table 5-2 profiles the sections of roadway encompassed by this capacity bottleneck. All of the profile information shown in this table can be taken from the GIS database created for this report.

Table 5-2. Capacity bottleneck #1: profile									
Section	Beg. MP	End MP	Beg. Exit	End Exit	AADT	TADT	Lanes		
1	15.69	17.12	15B	17A	65,660	0.18	4		

5.2.2 Capacity Bottleneck #1: Delay Calculations

Inside the GIS database created for this report, the calculations associated with freight delay have been performed for 2006, 2025, and 2040. Table 5-3 shows the delay results for this bottleneck for 2006. The calculations are in per-mile units.

Table 5-3. Capacity bottleneck #1: delay calculations (2006)									
Section	Beg. Exit	End Exit	AADTT	AADT/C	Delay	ATHD			
1	15B	17A	11,819	8.133	1.110	4,789			

Where:

- AADTT is the Average Annual Daily Truck Traffic (how many trucks travel the section of roadway daily).
- AADT/C is the value of the passenger-car equivalent traffic flow divided by the capacity of the roadway.
- *Delay* is the value determined by the delay equation (Eq. 4-4) and is given in units of hours of delay for every 1000 vehicle miles traveled.
- ATHD is the annual truck hours of delay experienced at this capacity bottleneck on a per-• mile basis.

The values found in Table 5-4 can be used to compare capacity bottlenecks or one bottleneck over time. Table 5-4 shows the same values found in Table 5-3 but projected out to 2025 using growth percentages from the FAF. The calculations are in per-mile units.

Table 5-4. Capacity bottleneck #1: delay calculations (2025)									
Section Beg. Exit		End Exit	AADTT	AADT/C	Delay	ATHD			
1	15B	17A	18,574	11.910	8.653	58,576			

Table 5-5 shows the same values found in Table 5-3 but projected out to 2040 using growth percentages from the FAF. The calculations are in per-mile units.

Tab	Table 5-5. Capacity bottleneck #1: delay calculations (2040)								
Section	Beg. Exit	End Exit	AADTT	AADT/C	Delay	ATHD			
1	15B	17A	26,472	16.115	28.021	270,747			

Table 5-5.	Capacity bottleneck #1: delay calculation	s (2040)
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5.2.3 Capacity Bottleneck #1: Planned Improvement Projects

There is a planned project that will directly impact the freight delay that occurs at this capacity bottleneck. The planned improvement includes adding an additional lane to I-10 in each direction between Exit 13 and Exit 17A, encompassing the entire length of this bottleneck. The project is scheduled for completion in summer 2013.

The effects of this improvement project can be calculated. Table 5-6 shows the reductions in freight delay expected for this capacity bottleneck for 2006. The calculations are in per-mile units.

	Beg. Exit	End Exit	Capacity	AADT/C	Delay	ATHD
W/O Improvements	15B	17A 8,800 8.133			1.110	4,789
W/ Improvements 15B 17A			13,200	5.422	0.664	2,864
	Percent Improvement ATHD:			40.2%		
		2006 Econ	omic Benefit	(Freight):	\$60	,330

Table 5-6. Capacity bottleneck #1: Planned improvement, delay calculations (2006)

Table 5-6 shows all the improvements this project will bring to this roadway. Tables 5-7 and 5-8 show the delay improvements that this project will bring to this roadway for 2025 and 2040, using growth estimates from the freight-analysis framework. The calculations are in per-mile units.

	Table 5-7. Capacit	y bottleneck #1	: planned im	provement, dela	ay calculations	(2025)
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	Beg. Exit	End Exit	Capacity	Delay	ATHD	
W/O Improvements	15B	17A 8,800 11.910			8.653	58,576
W/ Improvements	17A	13,200	7.940	1.010	6,847	
	Percent	Improvemen	88.3%			
	2025 Econ	omic Benefit	\$1,621,187			

Table 5-8. Capacity bottleneck #1: planned improvement, delay calculations (2040)

	Beg. Exit	End Exit	Capacity	AADT/C	Delay	ATHD
W/O Improvements	17A	8,800	16.115	28.021	270,747	
W/ Improvements	17A	13,200	10.743	4.976	48,084	
	Percent	Improvemen	82.2%			
	2040 Econ	omic Benefit	\$6,978,258			

The calculations in the last three tables show the economic benefits that can be realized with planned improvement projects. Though the effect will be minimal in the current year, reductions in freight delay are expected to exceed 80% in both 2025 and 2040.

5.2.4 Capacity Bottleneck #1: Possible Future Improvement Projects

Because there is a roadway-improvement project in the works that will eliminate freight bottlenecks, no calculations are needed for this roadway in this section.

5.3 Capacity Bottleneck #2: I-10, Exit 26A to Exit 27

This capacity bottleneck encompasses two sections of two-lane roadway in Mobile. The first section includes the area immediately west of the George C. Wallace Tunnel, which is west of the Mobile Bay Bridge and has a reputation for traffic problems. The second section is the tunnel itself. This bottleneck is 1.12 miles in length.

5.3.1 Capacity Bottleneck #2: Profile

Table 5-9 shows the profile information for both sections of roadway encompassed by this capacity bottleneck. All of the profile information shown in this table can be taken from the GIS database created for this report.

Table 5-5. Capacity bottleneck #2. profile									
Section	Section Beg. MP End MP Beg. Exit End Exit AADT								
1	25.96	26.51	26A	26B	73,790	0.13	4		
2	26.51	27.08	26B	27	66,110	0.15	4		

Table 5-9	Canacity	v bottleneck	#2·	nrofile
	Capacity	y Dollieneck	#4.	prome

The second section of this roadway is the George C. Wallace Tunnel and the Mobile Bay Bridge east of the tunnel. This is one particular bottleneck that would greatly benefit from having more accurate capacity information. The 2,200 pcphpl used for these calculations may not give an accurate picture of the true delay being experienced.

The Mobile Bay Bridge, which is east of this capacity bottleneck, needs "urgent capacity upgrades" (AASHTO 2010), but it was not studied because it did not meet the criteria in this report (using the 2,200 pcphpl capacity value).

5.3.2 Capacity Bottleneck #2: Delay Calculations

Inside the GIS database created for this report, all the calculations associated with freight delay have been performed for 2006, 2025, and 2040. Table 5-10 shows the delay calculations for this bottleneck for 2006. The calculations are in per-mile units.

Table 5-10. Capacity bottleneck #2: delay calculations (2006)							
Section	Beg. Exit	Beg. Exit End Exit		AADT/C	Delay	ATHD	
1	26A	26B	9,593	8.930	1.744	6,108	
2	26B	27	9,916	8.076	1.079	3,904	

Table 5.10 Conseity bettleneek #2, delay selevilations (2006)

The values found in Table 5-10 can be used to compare capacity bottlenecks or one bottleneck over time. Table 5-11 shows the same values found in Table 5-10 but projected out to 2025 using growth percentages from the FAF. The calculations are in per-mile units.

Table 5-11. Capacity bottleneck #2: delay calculations (2025)							025)
	Section	Beg. Exit	End Exit	AADTT	AADT/C	Delay	ATHD
	1	26A	26B	15,054	12.997	13.156	72,290
	2	26B	27	15,561	11.783	8.192	46,529

Table 5-12 shows the same values found in Table 5-10 but projected out to 2040 using growth percentages from the FAF. The calculations are in per-mile units.

Table 5-12. Capacity bottleneck #2: delay calculations (2040)								
Section	Beg. Exit	End Exit	AADTT	AADT/C	Delay	ATHD		
1	26A	26B	21,486	17.497	32.394	254,044		
2	26B	27	22,209	15.895	27.097	219,658		

5.3.3 Capacity Bottleneck #2: Planned Improvement Projects

There are no roadway-improvement projects planned that will improve capacity for this bottleneck. Because there are no planned improvements, no calculations of benefits need to be performed in this section.

5.3.4 Capacity Bottleneck #2: Possible Future Improvement Projects

Possible future improvements to this location are complicated by the fact that the tunnel cannot be expanded easily. The best alternative for this location may be for traffic that would usually take the tunnel to find an alternate route or to start making the commute in off-peak periods of the day.

Adding lanes to this location would almost certainly be excessively costly. Due to the economic constraints of possible capacity improvements, one alternative is to move traffic more efficiently through the tunnel. We might also provide drivers with information about traffic conditions in the tunnel to encourage them to use an alternate route at peak times. Another option would be to formulate alternative routes. Possibilities include building new roadway or upgrading alternative facilities.

Because of the extenuating circumstances that prevent improvement at this location, no calculations for decreases in delay were performed. The long-term solution for this location may be to take measures to decrease demand during peak hours of flow.

5.4 Capacity Bottleneck #3: I-20/59, Exit 123 to Exit 130

This capacity bottleneck contains six exit-to-exit segments of four-lane roadway in metropolitan Birmingham. The bottleneck starts west of the I-65 and I-20/59 interchange and continues east to the diverge of I-20/59 into I-20 and I-59. This bottleneck is 7.15 miles long.

5.4.1 Capacity Bottleneck #3: Profile

Table 5-13 profiles the sections of roadway encompassed by this capacity bottleneck. All of the profile information shown in this table can be taken from the GIS database created for this report.

Table 5-13. Capacity bottleneck #3: profile										
Section	Beg. MP	End MP	Beg. Exit	End Exit	AADT	TADT	Lanes			
1	123.14	124.35	123	124A/B	139,200	0.09	8			
2	124.35	126.03	124A/B	126A	159,820	0.10	8			
3	126.03	126.45	126A	126B	155,850	0.10	8			
4	126.45	128.26	126B	128	154,400	0.10	8			
5	128.26	129.59	128	129	143,130	0.11	8			
6	129.59	130.29	129	130	139,500	0.11	8			

	Table 5-13.	Capacity	bottleneck	#3:	profile
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5.4.2 Capacity Bottleneck #3: Delay Calculations

Inside the GIS database created for this report, the calculations associated with freight delay have been performed for 2006, 2025, and 2040. Table 5-14 shows the delay calculations for this bottleneck for 2006. The calculations are in per-mile units.

10.010								
Section	Beg. Exit	End Exit	AADTT	AADT/C	Delay	ATHD		
1	123	124A/B	12,528	8.265	1.190	5,439		
2	124A/B	126A	15,982	9.535	2.513	14,662		
3	126A	126B	15,585	9.298	2.179	12,394		
4	126B	128	15,440	9.211	2.068	11,652		
5	128	129	15,744	8.580	1.418	8,147		
6	129	130	15,345	8.362	1.254	7,023		

Table 5-14. Capacity bottleneck #3: delay calculations (2006)

The values found in this table can be used to compare capacity bottlenecks or one bottleneck over time. Table 5-15 shows the same values found in Table 5-14 but projected out to 2025 using growth percentages from the FAF. The calculations are in per-mile units.

Tab	Table 5-15. Capacity bottleneck #5. delay calculations (2025)								
Section	Beg. Exit	End Exit	AADTT	AADT/C	Delay	ATHD			
1	123	124A/B	19,660	11.967	8.865	63,612			
2	124A/B	126A	25,080	13.824	17.086	156,409			
3	126A	126B	24,457	13.480	15.415	137,604			
4	126B	128	24,230	13.355	14.817	131,039			
5	128	129	24,707	12.455	10.795	97,352			
6	129	130	24,081	12.139	9.523	83,703			

Table 5-15. Capacity bottleneck #3: delay calculations (2025)

Table 5-16 shows the same values that were found in Table 5-14 but projected out to 2040 using growth percentages from the FAF. The calculations are in per-mile units.

Iau	Table 3-10. Capacity bottleneck $\pi 3$. delay calculations (2040)								
Section	Beg. Exit	End Exit	AADTT	AADT/C	Delay	ATHD			
1	123	124A/B	28,060	16.040	27.713	283,831			
2	124A/B	126A	35,796	*18*	33.197	433,737			
3	126A	126B	34,906	*18*	33.197	422,953			
4	126B	128	34,582	17.920	33.101	417,825			
5	128	129	35,263	15.631	30.316	390,195			
6	129	130	34,369	16.307	28.786	361,108			

Table 5-16. Capacity bottleneck #3: delay calculations (2040)

As can be seen in Table 5-16, the AADT/C occasionally exceeds 18; however, the maximum possible value for AADT/C is only 18. Therefore, if the estimated AADT/C exceeds 18, 18 is assumed. We boldfaced and italicized the values where we made that change. An AADT/C value of 18 correlates to a delay value of 33.197 hours for every 1000 vehicle miles traveled.

5.4.3 Capacity Bottleneck #3: Planned Improvement Projects

No roadway projects that will improve capacity for this capacity bottleneck are planned. Because there are no planned improvements, no calculations of benefits need to be performed in this section.

5.4.4 Capacity Bottleneck #3: Possible Future Improvement Projects

In the case of this capacity bottleneck, one possible future improvement that can be calculated using the methodology is building additional lanes. Because this bottleneck is in metropolitan Birmingham and involves much elevated roadway, lane additions may quickly become cost prohibitive.

Table 5-17 shows the expected improvements in freight delay for this capacity bottleneck for 2006. The calculations are in per-mile units.

Table 5-17. Capacity bottleneck #3. possible improvement, delay calculations (2000)							
Beg. Exit	End Exit	End Exit Capacity AAD					
123	124A/B	17,600	8.265	1.190	5,439		
123	124A/B	22,000	6.612	0.694	3,172		
	Percent Impro	ovement AT	HD:	41	1.7%		
	2006 Economic	Benefit (Fre	eight):	\$7	1,048		
124A/B	126A	17,600	9.535	2.513	14,662		
124A/B	126A	22,000	7.682	0.884	5,154		
	Percent Impro	ovement AT	HD:	64	1.8%		
	2006 Economic	\$29	7,981				
126A	126B	17,600	9.298	2.179	12,394		
126A	126B	22,000	7.438	0.825	4,696		
Percent Improvement ATHD:					2.1%		
	2006 Economic	\$24	1,255				
126B	128	17,600	9.211	2.068	11,652		
126B	128	22,000	7.369	0.807	4,549		
	Percent Improvement ATHD:			61.0%			
	2006 Economic	Benefit (Fre	eight):	\$222,608			
128	129	17,600	8.580	1.418	8,147		
128	129	22,000	5.764	0.717	4,121		
	Percent Impro	ovement AT	HD:	49	9.4%		
	2006 Economic Benefit (Freight):				6,175		
129	130	17,600	8.362	1.254	7,023		
129	130	22,000	6.690	0.700	3,919		
	Percent Impro	vement ATI	ID:	44	.2%		
	2006 Economic	Benefit (Fre	ight):	\$97	7,279		
	Beg. Exit 123 123 124A/B 124A/B 124A/B 126A 126A 126B 126B 126B 128 128 128 129 129 129	Beg. Exit End Exit 123 124A/B 123 124A/B 123 124A/B 123 124A/B 123 124A/B 123 124A/B 124A/B 126A 124A/B 126A 124A/B 126A 124A/B 126A 124A/B 126A 124A/B 126A 126A 126B 126A 126B 126B 128 126B 128 126B 128 126B 128 126B 128 126B 128 128 129 128 129 129 130 129 130 129 130 129 130 129 130	Beg. Exit End Exit Capacity 123 124A/B 17,600 123 124A/B 17,600 123 124A/B 22,000 Percent Improvement ATI 2006 Economic Benefit (Free 124A/B 126A 17,600 124A/B 126A 17,600 124A/B 126A 17,600 124A/B 126A 22,000 Percent Improvement ATI 2006 Economic Benefit (Free 126A 126B 17,600 126A 126B 22,000 Percent Improvement ATI 2006 Economic Benefit (Free 126B 128 22,000 Percent Improvement ATI 2006 Economic Benefit (Free 128 129 17,600 128 129 17,600 128 129 22,000 Percent Improvement ATI 2006 Economic Benefit (Free 128 129 22,000 Percent Improvement ATI 2006 Economic Benefit (Free 129 130 17,600	Beg. Exit End Exit Capacity AADT/C 123 124A/B 17,600 8.265 123 124A/B 17,600 8.265 123 124A/B 22,000 6.612 Percent Improvement ATHD: 2006 Economic Benefit (Freight): 124A/B 126A 124A/B 126A 17,600 9.535 124A/B 126A 22,000 7.682 Percent Improvement ATHD: 2006 Economic Benefit (Freight): 126A 126B 12,000 126A 126B 17,600 9.298 126A 126B 17,600 9.298 126A 126B 12,000 7.438 Percent Improvement ATHD: 2006 Economic Benefit (Freight): 126B 128 22,000 7.369 126B 128 129 17,600 8.580 128 128 129 17,600 8.580 5.764 128 129 12006 Economic Benefit (Freight): 2006 E	Beg. Exit End Exit Capacity AADT/C Delay 123 124A/B 17,600 8.265 1.190 123 124A/B 17,600 8.265 1.190 123 124A/B 22,000 6.612 0.694 Percent Improvement ATHD: 41 2006 Economic Benefit (Freight): \$7 124A/B 126A 17,600 9.535 2.513 124A/B 126A 22,000 7.682 0.884 Percent Improvement ATHD: 64 2006 Economic Benefit (Freight): \$29 126A 126B 17,600 9.298 2.179 126A 126B 17,600 9.298 2.179 126A 126B 12,600 7.438 0.825 Percent Improvement ATHD: 62 2006 Economic Benefit (Freight): \$24 126B 128 12,600 7.369 0.807 126B 128 129 12,600 5.764 0.717 128 129		

Table 5-17 Canacity bottleneck #3: possible improvement delay calculations (2006)

Table 5-17 shows which sections of roadway would benefit most from lane additions. Roadway east of the I-65 and I-20/59 interchange to exit 126A would see an immediate benefit for truck flows of \$297,981 a year, while roadway west of the interchange would only see a benefit of \$71,048. Keep in mind that these calculations only account for improvements in capacity delay, not for the benefits that would accrue due to the improvement of interchange conditions.

Tables 5-18 and 5-19 show the delay improvements expected from these roadway improvements using growth estimates from the freight-analysis framework for 2025 and 2040. The calculations are in per-mile units.

Table 5-18 shows that, with the increases in traffic that are predicted in the Freight Analysis Framework, the benefit seen in 2025 from these improvements range from ten to twenty times the benefits that are seen from the improvements immediately. Benefits increase as traffic demand on the roadways gets larger and larger, as shown in Table 5-19 below.

I /						
	Beg. Exit	End Exit	Capacity	AADT/C	Delay	ATHD
W/O Improvements	123	124A/B	17,600	11.967	8.865	63,612
W/ Improvements	123	124A/B	22,000	9.574	2.573	18,461
		Percent	Improvemen	t ATHD:	71	.0%
		2025 Econ	omic Benefit	\$1,4	15,032	
W/O Improvements	124A/B	126A	17,600	13.824	17.086	156,409
W/ Improvements	124A/B	126A	22,000	11.059	5.844	53,498
		Percent Improvement ATHD:			65	5.8%
		2025 Economic Benefit (Freight):			\$3,2	25,231
W/O Improvements	126A	126B	17,600	13.480	15.415	137,604
W/ Improvements	126A	126B	22,000	10.784	5.083	45,373
		Percent	Improvemen	t ATHD:	67	7.0%
		2025 Economic Benefit (Freight):			\$2,890,520	
W/O Improvements	126B	128	17,600	13.355	14.817	131,039
W/ Improvements	126B	128	22,000	10.684	4.824	42,664
		Percent	Improvemen	t ATHD:	67	7.4%
		2025 Econ	omic Benefit	(Freight):	\$2,769,673	
W/O Improvements	128	129	17,600	12.455	10.795	97,352
W/ Improvements	128	129	22,000	9.964	3.238	29,203
	Percent Improvement ATHD:			t ATHD:	70).0%
		2025 Econ	omic Benefit	(Freight):	\$2,1	35,789
W/O Improvements	129	130	17,600	12.139	9.523	83,703
W/ Improvements	129	130	22,000	9.711	2.792	24,544
		Percent	Improvemen	t ATHD:	70).7%
		2025 Econ	omic Benefit	(Freight):	\$1,8	54,043

Table 5-18. Capacity bottleneck #3: possible improvement, delay calculations (2025)

Table 5-19. Capacity bottleneck #3: possible improvement, delay calculations (2040)

	Beg. Exit	End Exit	Capacity	AADT/C	Delay	ATHD
W/O Improvements	123	124A/B	17,600	16.040	27.713	283,831
W/ Improvements	123	124A/B	22,000	12.832	12.414	127,145
· · · ·		Percent	Improvemen	t ATHD:	55	.2%
		2040 Ecor	omic Benefit	(Freight):	\$4,9 ⁻	10,539
W/O Improvements	124A/B	126A	17,600	*18*	33.197	433,737
W/ Improvements	124A/B	126A	22,000	14.839	22.146	289,353
		Percent	Improvemen	t ATHD:	33	.3%
		2040 Ecor	omic Benefit	(Freight):	\$4,52	24,995
W/O Improvements	126A	126B	17,600	*18*	33.197	422,953
W/ Improvements	126A	126B	22,000	14.470	20.309	258,752
		Percent	Improvemen	t ATHD:	38	.8%
		2040 Econ	omic Benefit	(Freight):	\$5,14	46,059
W/O Improvements	126B	128	17,600	17.920	33.101	417,825
W/ Improvements	126B	128	22,000	14.336	19.636	247,857
		Percent	Improvemen	t ATHD:	40	.7%
		2040 Econ	omic Benefit	(Freight):	\$5,326,797	
W/O Improvements	128	129	17,600	15.631	30.316	390,195
W/ Improvements	128	129	22,000	13.385	14.959	192,535
		Percent	Improvemen	t ATHD:	50	.7%
		2040 Ecor	omic Benefit	(Freight):	\$6,19	94,664
W/O Improvements	129	130	17,600	16.307	28.786	361,108
W/ Improvements	129	130	22,000	13.046	13.376	167,797
		Percent	Improvemen	t ATHD:	53	.5%
		2040 Ecor	omic Benefit	(Freight):	\$6,0	58,367

Compared to other bottlenecks described, the "percent improvements" shown in Tables 5-17 to 5-19 are not as large. This result is evidence that, as the total through lane number gets larger, the benefits of improvement drop in effectiveness.

However, it can also be seen that, even with adding one lane in each direction, that delay is projected to far surpass the delay being experienced. Every segment of roadway in this bottleneck would likely still be a freight bottleneck in 2025 and 2040. Even if the roadway were

to be expanded to six lanes in both directions, the 2040 projections would still exceed the bottlenecking level (AADT/C > 8).

In congested areas such as this one, which services much of the daily traffic that travels through and around Birmingham, the long-term solution may not be improving roadway capacity but curbing traffic growth through alternative methods.

5.5 Capacity Bottleneck #4: I-65, Exit 238 to Exit 246

This capacity bottleneck contains two adjacent segments of two-lane roadway that service metropolitan Birmingham. The two segments are south of the I-459 and I-65 interchange. The bottleneck is 7.74 miles long.

5.5.1 Capacity Bottleneck #4: Profile

Table 5-20 profiles the sections of roadway encompassed by this capacity bottleneck. The profile information shown in this table can be taken from the GIS database created for this report.

Table 5-20.	Capacity	v bottleneck #	5: profile

Section	Beg. MP	End MP	Beg. Exit	End Exit	AADT	TADT	Lanes
1	238.32	241.85	238	242	69,180	0.17	4
2	241.85	246.06	242	246	82,140	0.16	4

5.5.2 Capacity Bottleneck #4: Delay Calculations

Inside the GIS database created for this report the calculations associated with freight delay have been performed for 2006, 2025, and 2040. Table 5-21 shows the delay calculations for this bottleneck for the year 2006. The calculations are in per-mile units.

Table 5-21. Capacity bottleneck #4: delay calculations (2006)							
Section	Beg. Exit	End Exit	AADTT	AADT/C	Delay	ATHD	
1	238	242	11,761	8.530	1.378	5,914	
2	242	246	13,142	10.081	3.463	16,612	

The values found in this table can be used to compare capacity bottlenecks or one bottleneck over time. Table 5-22 shows the same values found in Table 5-21 but projected out to 2025 using growth percentages from the FAF. The calculations are in per-mile units.

Table 5-22. Capacity bottleneck #4: delay calculations (2025)						
Section	Beg. Exit	End Exit	AADTT	AADT/C	Delay	ATHD
1	238	242	18,456	12.476	10.881	73,301
2	242	246	20,623	14.727	21.589	162,507

Table 5-23 shows the same values found in Table 5-21 but projected out to 2040 using growth percentages from the FAF. The calculations are in per-mile units.

Table 5-23.	Capacity	v bottleneck #4: dela	y calculations	(2040)
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Section	Beg. Exit	End Exit	AADTT	AADT/C	Delay	ATHD
1	238	242	26,342	15.764	30.743	295,586
2	242	246	29,435	*18*	33.197	356,661

Occasionally the AADT/C exceeds 18. When that happens, we assume the value is 18, and we indicate it by using an italicized and boldfaced 18. An AADT/C value of 18 correlates to a delay value of 33.197 hours for every 1000 vehicle miles traveled.

5.5.3 Capacity Bottleneck #4: Planned Improvement Projects

As shown in Appendix B, ALDOT plans an improvement project to add one lane per direction between Exit 242 and Exit 246. Table 5-24 shows the improvements in freight delay that would be expected for this capacity bottleneck in 2006. The calculations are in per-mile units.

	Beg. Exit	End Exit	Capacity	AADT/C	Delay	ATHD
W/O Improvements	242	246	8,800	10.081	3.463	16,612
W/ Improvements	242	246	13,200	5.621	0.702	3,369
	Percent	Improvemen	79	.7%		
		2006 Econ	\$41	5,035		

	able 5-24. Capacity	bottleneck #	4: planned	d improven	nent, delay	calculation	ons (2006
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The planned improvement project is expected to significantly reduce freight delay at this bottleneck. The \$415,035 of expected economic benefit from this reduction of freight delay is larger than any planned or possible future improvement projects at any bottlenecks studied.

Table 5-24 shows all of the improvements to this roadway that will come from finishing this roadway improvement project. Tables 5-25 and 5-26 show the reductions in delay that will come from these roadway improvements using growth estimates from the freight-analysis framework for 2025 and 2040. The calculations are in per-mile units.

Table 5-25. Capacity bottleneck #4: planned improvement, delay calculations (2025)
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	Beg. Exit	End Exit	Capacity	AADT/C	Delay	ATHD
W/O Improvements	242	246	8,800	14.727	21.589	162,507
W/ Improvements	242	246	13,200	9.818	2.974	22,387
		Percent Improvement ATHD:			86.2%	
		2025 Ecoi	nomic Benef	it (Freight):	\$4,39	91,361

	Beg. Exit	End Exit	Capacity	AADT/C	Delay	ATHD
W/O Improvements	242	246	8,800	*18*	33.197	356,661
W/ Improvements	242	246	13,200	13.257	14.357	154,245
		Percent Improvement ATHD:			55.7%	
	2040 Econ	omic Benefit	(Freight):	\$6,34	43,717	

The planned improvement project is expected to significantly reduce freight delay at this bottleneck in the future. With the improvements, freight delay levels are expected to be roughly the same in 2025 as before the improvements.

In 2040, however, congestion is expected to reach current levels. The 154,245 hours of delay expected far exceed the amount of delay experienced at this intersection in 2006.

5.5.4 Capacity Bottleneck #4: Possible Future Improvement Projects

In addition to the improvements that ALDOT plans from Exit 242 to Exit 246, one lane per direction could also be added between Exit 238 and Exit 242. Table 5-27 shows the reductions in freight delay that would be expected for this capacity bottleneck for 2006. The calculations are in per-mile units.

	Beg. Exit	End Exit	Capacity	AADT/C	Delay	ATHD
W/O Improvements	238	242	8,800	8.530	1.378	5,914
W/ Improvements	238	242	13,200	5.687	0.667	2,864
	Percent Improvement ATHD:			51.	6%	
	2006 Econ	omic Benefit	(Freight):	\$95	,587	

Table 5-27. Capacity Bottleneck #4: Possible Improvement, Delay Calculations (2006)

Table 5-27 shows what would be accomplished on this roadway by finishing this improvement project. Tables 5-28 and 5-29 show the delay reductions expected from these roadway improvements using growth estimates from the freight analysis framework for 2025 and 2040. The calculations are in per-mile units.

Table 5-20. Capacity	Dottieneck	#4. possib	ileni, delay	calculati	0115 (2025	
	Beg. Exit	Delay	ATHD			
W/O Improvements	238	242	8,800	12.476	10.881	73,301
W/ Improvements 238		242	13,200	8.317	1.224	8,243
	Percent Improvement ATHD:			88.8%		
	2025 Econ	omic Benefit	\$2,03	8,918		

Table 5-28. Capacity bottleneck #4: possible improvement, delay calculations (2025)

Table 5-29. Capacity bottleneck #4: possible improvement, delay calculations (2040)

	Beg. Exit	End Exit	Capacity	AADT/C	Delay	ATHD
W/O Improvements	238	242	8,800	15.764	30.743	295,586
W/ Improvements	238	242	13,200	11.243	6.392	61,457
		Percent Improvement ATHD:			79.2%	
	2040 Econ	omic Benefit	(Freight):	\$7,33	37,602	

This improvement project would likely reduce traffic delay by a significant amount, even in 2040 (with an expected improvement of 79.2% in ATHD).

The benefits from the possible improvement project are small compared to the benefits of the planned improvement project. While the economic benefit from the reduction in freight delay is expected to be around \$100,000 for the possible project, the benefit for ALDOT's project is expected to be about \$400,000 (four times as much). This may explain why this section of roadway was not included in ALDOT's improvement project.

5.6 Capacity Bottleneck #5: I-65, Exit 247 to Exit 250

This capacity bottleneck encompasses one segment of three-lane roadway that services metropolitan Birmingham and is part of the I-65 and I-459 interchange. The capacity delay is separate from the delay associated with the interchange. This bottleneck is 2.82 miles long.

5.6.1 Capacity Bottleneck #5: Profile

Table 5-30 profiles the section of roadway encompassed by this capacity bottleneck. The profile information in this table can be taken from the GIS database created for this report.

	Table 5-30. Capacity bottleneck #5: profile										
Section	Beg. MP	End MP	Beg. Exit	End Exit	AADT	TADT	Lanes				
1	247.26	250.08	247	250	112,220	0.13	6				

5.6.2 Capacity Bottleneck #5: Delay Calculations

Inside the GIS database created for this report, the calculations associated with freight delay have been performed for 2006, 2025, and 2040. Table 5-31 shows the delay calculations for this bottleneck for 2006. The calculations are in per-mile units.

Table 5-31. Capacity bottleneck #5: delay calculations (2006)										
Section	Section Beg. Exit End Exit AADTT AADT/C Delay ATHD									
1	247	250	14,589	9.054	1.880	10,009				

The values found in this table can be used to compare capacity bottlenecks or one bottleneck over time. Table 5-32 shows the same values found in Table 5-31 but projected out to 2025 using growth percentages from the FAF. The calculations are in per-mile units.

Table 5-32. Capacity bottleneck #5: delay calculations (2025)							
Section	Section Beg. Exit End Exit		AADTT	AADT/C	Delay	ATHD	
1	247	250	22,894	13.178	13.985	116,861	

Table 5-33 also shows the same values found in Table 5-31 but projected out to 2040 using growth percentages from the FAF. The calculations are in per-mile units.

Table 5-33.	Capacity	v bottleneck #5: dela	v calculations	(2040)	
	oupuon		y ouround to no i	2010/	

Section	Beg. Exit	End Exit	AADTT	AÁDT/C	Delay	ÁTHD
1	247	250	32,676	17.739	32.841	391,681

5.6.3 Capacity Bottleneck #5: Planned Improvement Projects

Planned improvements to this section of roadway include an additional lane for each direction of traffic. Too few lanes was the main constraining factor for this capacity bottleneck. When this improvement project is completed (expected summer 2011), this segment of roadway will no longer be a capacity bottleneck.

Table 5-34 shows the expected reductions in freight delay for this capacity bottleneck for the year 2006. The calculations are in per-mile units.

able 5-34. Capacity bottleneck #5: planned improvement, delay calculations (2006)								
	Beg. Exit	End Exit	Capacity	AADT/C	Delay	ATHD		
W/O Improvements	247	250	13,200	9.054	1.880	10,009		
W/ Improvements	247	250	17,600	5.691	0.709	3,776		
	Percent Improvement ATHD:			62.3%				
	2006 Economic Benefit (Freight):			\$195,342				

Table 5-34	Capacity	v bottleneck #5:	planned im	provement	delay	v calculations	(2006)
10010 0 04.	oupuon			provenient	, uciu	y culculations	12000

Table 5-34 shows the improvements this project would make to the roadway. Tables 5-35 and 5-36 show the reductions in delay these roadway improvements would bring using growth estimates from the freight analysis framework for 2025 and 2040. The calculations are in per-mile units.

	Tuble 5 00. Oupuell				calculati	0113 (2020)	
		Beg. Exit	End Exit	Capacity	AADT/C	Delay	ATHD
	W/O Improvements	247	250	13,200	13.178	13.985	116,861
	W/ Improvements	247	250	17,600	9.884	3.090	25,823
			Percent Improvement ATHD:			77.9%	
		2025 Economic Benefit (Freight):			\$2,8	53,131	

Table 5-35.	Capacity	v bottleneck #5:	planned im	provement, del	av calculations	(2025)
1 abie 5-55.	Oapacity	y bottleneck $\pi 3$.	planneu nn	provenient, dei	ay calculations	(2023)

Table 5-36. Capacity bottleneck #5: planned improvement, delay calculations (2040)

	Beg. Exit	End Exit	Capacity	AADT/C	Delay	ATHD
W/O Improvements	247	250	13,200	17.739	32.841	391,681
W/ Improvements	247	250	17,600	13.304	14.577	173,860
		Percent Improvement ATHD:			55.6%	
		2040 Economic Benefit (Freight):			\$6,826,510	

The expected improvement in delay from improvements at this bottleneck confirms the importance of the project. Using current traffic projections, delay is expected to be reduced by more than 60% for 2006 and almost 80% in year 2025 from what the expected delay would be with no roadway capacity improvements.

The benefits of this planned improvement project are expected to create a \$195,342 annual benefit to the economy with current traffic. By 2040, the expected benefit from this improvement would be almost \$7 million annually. At that point, with eight lanes of through traffic already, the addition of a lane in each direction may be considered.

5.6.4 Capacity Bottleneck #5: Possible Future Improvement Projects

Because there is a roadway improvement project in the works that will eliminate freight bottlenecks, there are no calculations that need to be performed for this roadway in this section.

5.7 Capacity Bottleneck #6: I-65, Exit 252 to Exit 259B

This capacity bottleneck encompasses seven adjacent segments of four-lane road that service metropolitan Birmingham. The bottleneck is south of I-20/59 and north of I-459. This bottleneck is 7.73 miles long.

5.7.1 Capacity Bottleneck #6: Profile

Table 5-37 profiles the sections of roadway encompassed by this capacity bottleneck. The profile information shown in this table can be taken from the GIS database created for this report.

5.7.2 Capacity Bottleneck #6: Delay Calculations

Inside the GIS database created for this report, the calculations associated with freight delay have been performed for 2006, 2025, and 2040. Table 5-38 shows the delay calculations for this bottleneck for the year 2006. The calculations are in per-mile units.

The values found in Table 5-38 can be used to compare capacity bottlenecks or one bottleneck over time. Table 5-39 shows the same values found in Table 5-38 but projected out to 2025 using growth percentages from the FAF. The calculations are in per-mile units.
Section	Beg. MP	End MP	Beg. Exit	End Exit	AADT	TADT	Lanes	
1	251.97	253.92	252	254	122,040	0.10	6	
2	253.92	255.22	254	255	125,610	0.10	6	
3	255.22	256.52	255	256A	126,590	0.10	6	
4	256.52	258.06	256A	258	133,360	0.10	6	
5	258.06	258.83	258	259	136,670	0.09	6	
6	258.83	259.55	259	259A	145,890	0.08	6	
7	259.55	259.70	259A	259B	145,890	0.08	8	

Table 5-37. Capacity Bottleneck #6: Profile

Table 5-38. Capacity bottleneck #6: delay calculations (2006)

Beg. Exit	End Exit	AADTT	AADT/C	Delay	ATHD		
252	254	12,204	9.708	2.787	12,413		
254	255	12,561	9.992	3.290	15,086		
255	256A	12,659	10.070	3.441	20,671		
256A	258	13,336	10.608	4.634	22,558		
258	259	12,300	10.820	5.177	23,244		
259	259A	11,671	11.494	7.195	30,650		
259A	259B	11,671	8.621	1.452	6,185		
	Beg. Exit 252 254 255 256A 258 259 259A	Beg. Exit End Exit 252 254 254 255 255 256A 256A 258 258 259 259 259A 259A 259A	Beg. ExitEnd ExitAADTT25225412,20425425512,561255256A12,659256A25813,33625825912,300259259A11,671259A259B11,671	Beg. ExitEnd ExitAADTTAADT/C25225412,2049.70825425512,5619.992255256A12,65910.070256A25813,33610.60825825912,30010.820259259A11,67111.494259A259B11,6718.621	Beg. ExitEnd ExitAADTTAADT/CDelay25225412,2049.7082.78725425512,5619.9923.290255256A12,65910.0703.441256A25813,33610.6084.63425825912,30010.8205.177259259A11,67111.4947.195259A259B11,6718.6211.452		

Table 5-39. Capacity bottleneck #6: delay calculations (2025)

Section	Beg. Exit	End Exit	AADTT	AADT/C	Delay	ATHD
1	252	254	19,151	14.074	18.329	128,122
2	254	255	19,712	14.486	20.388	146,690
3	255	256A	19,865	14.599	20.952	151,921
4	256A	258	20,928	15.380	24.765	189,176
5	258	259	19,302	15.666	26.085	183,777
6	259	259A	18,315	16.621	29.942	200,162
7	259A	259B	18,315	12.466	10.838	72,454

Table 5-40 also shows the same values found in Table 5-38 but projected out to 2040 using growth percentages from the FAF. The calculations are in per-mile units.

Tabl	Table 5-40. Capacity bottleneck #0. delay calculations (2040)						
Section	Beg. Exit	End Exit	AADTT	AADT/C	Delay	ATHD	
1	252	254	27,334	*18*	33.197	331,203	
2	254	255	28,133	*18*	33.197	340,885	
3	255	256A	28,353	*18*	33.197	343,551	
4	256A	258	29,869	*18*	33.197	361,920	
5	258	259	27,549	*18*	33.197	333,809	
6	259	259A	26,140	*18*	33.197	316,736	
7	259A	259B	26,140	16.690	30.178	287,928	

Table 5-40. Capacity bottleneck #6: delay calculations (2040)

As can be seen in Table 5-40, the AADT/C occasionally exceeds 18; however, the maximum possible value for AADT/C is only 18. Therefore, if the estimated AADT/C exceeds 18, 18 is assumed. We boldfaced and italicized the values where we made that change. An AADT/C value of 18 correlates to a delay value of 33.197 hours for every 1000 vehicle miles traveled.

5.7.3 Capacity Bottleneck #6: Planned Improvement Projects

Because there is no planned roadway improvement project that will eliminate the freight bottleneck, there are no calculations that need to be performed for this roadway in this section.

5.7.4 Capacity Bottleneck #6: Possible Future Improvement Projects

Table 5-41 shows the reductions in freight delay expected for this capacity bottleneck for 2006 if a travel lane were added in both directions. The calculations are in per-mile units.

	Beg. Exit	End Exit	Capacity	AADT/C	Delay	ATHD
W/O Improvements	252	254	13,200	9.708	2.787	12,413
W/ Improvements	252	254	17,600	7.281	0.787	3,504
	Percent Improvement ATHD: 71.8%		.8%			
		2006 Econ	omic Benefit	(Freight):	\$279	9,208
W/O Improvements	254	255	13,200	9.992	3.290	15,086
W/ Improvements	254	255	17,600	7.494	0.841	3,856
		Percent	Improvemen	t ATHD:	74	.4%
		2006 Econ	omic Benefit	(Freight):	\$35	1,948
W/O Improvements	255	256A	13,200	10.070	3.441	20,671
W/ Improvements	255	256A	17,600	7.553	0.859	3,968
		Percent	Improvemen	t ATHD:	80	.8%
		2006 Econ	omic Benefit	(Freight):	\$523	3,472
W/O Improvements	256A	258	13,200	10.608	4.634	22,558
W/ Improvements	256A	258	17,600	7.956	1.018	4,953
		Percent	Improvemen	t ATHD:	78.0%	
		2006 Econ	omic Benefit	(Freight):	\$55	1,741
W/O Improvements	258	259	13,200	10.820	5.177	23,244
W/ Improvements	258	259	17,600	8.115	1.100	4,939
		Percent	Improvemen	t ATHD:	78	.8%
		2006 Econ	omic Benefit	(Freight):	\$573	3,679
W/O Improvements	259	259A	13,200	11.494	7.195	30,650
W/ Improvements	259	259A	17,600	8.621	1.452	6,184
		Percent	Improvemen	t ATHD:	79	.8%
		2006 Econ	omic Benefit	(Freight):	\$76	6,764
W/O Improvements	259A	259B	17,600	8.621	1.452	6,185
W/ Improvements	259A	259B	22,000	5.797	0.721	3,072
		Percent	Improvemen	t ATHD:	50	.3%
		2006 Econ	omic Benefit	(Freight):	\$97	,561

Table 5-41. Capacity bottleneck #6: possible improvement, delay calculations (2006)

Table 5-41 shows the improvements to this roadway that finishing this roadway improvement project would bring. Tables 5-42 and 5-43 show the reductions in delay that these roadway improvements would bring using growth estimates from the freight analysis framework for 2025 and 2040. The calculations are in per-mile units.

Tables 5-42 and 5-43 show that, even with the additional lane, delay is projected to far surpass the delay being experienced today. The roadway would still be classified as a freight bottleneck on every segment of roadway in this bottleneck in 2025 and 2040. Even if the roadway were to be expanded to six lanes in each direction (from the current four lanes in each direction), the 2040 projections would still exceed the bottlenecking level of AADT/C > 8.

In congested areas such as this, which services much of the daily traffic that travels through and around Birmingham, the long-term solution may not be increasing roadway capacity but curbing traffic growth through alternative means.

•	Beg. Exit	End Exit	Capacity	AADT/C	Delay	ATHD
W/O Improvements	252	254	13,200	14.074	18.329	128,122
W/ Improvements	252	254	17,600	10.556	4.506	31,495
		Percent	Improvemen	t ATHD:	75	.4%
		2025 Econ	omic Benefit	(Freight):	\$3,02	28,290
W/O Improvements	254	255	13,200	14.486	20.388	146,690
W/ Improvements	254	255	17,600	10.865	5.298	38,118
		Percent	Improvemen	t ATHD:	74	.0%
		2025 Econ	omic Benefit	(Freight):	\$3,40	02,646
W/O Improvements	255	256A	13,200	14.599	20.952	151,921
W/ Improvements	255	256A	17,600	10.949	5.531	40,105
		Percent	Improvemen	t ATHD:	73	.6%
		2025 Econ	omic Benefit	(Freight):	\$3,50	04,313
W/O Improvements	256A	258	13,200	15.380	24.765	189,176
W/ Improvements	256A	258	17,600	11.535	7.331	56,000
		Percent	Improvemen	t ATHD:	70.4%	
		2025 Econ	omic Benefit	(Freight):	\$4,17	73,736
W/O Improvements	258	259	13,200	15.666	26.085	183,777
W/ Improvements	258	259	17,600	11.750	8.071	56,864
		Percent	Improvemen	t ATHD:	69	.1%
		2025 Econ	omic Benefit	(Freight):	\$3,97	77,453
W/O Improvements	259	259A	13,200	16.621	29.942	200,162
W/ Improvements	259	259A	17,600	12.466	10.839	72,459
		Percent	Improvemen	t ATHD:	63	.8%
	-	2025 Econ	omic Benefit	(Freight):	\$4,00	02,212
W/O Improvements	259A	259B	17,600	12.466	10.838	72,454
W/ Improvements	259A	259B	22,000	9.973	3.255	21,758
		Percent	Improvemen	t ATHD:	70	.0%
		2025 Econ	omic Benefit	(Freight):	\$1,58	38,813

Table 5-42.	Capacity	/ bottleneck #6:	possible im	provement, dela	y calculations ((2025)
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Table 5-43. Capacity bottleneck #6: possible improvement, delay calculations (2040)

	Beg. Exit	End Exit	Capacity	AADT/C	Delay	ATHD
W/O Improvements	252	254	13,200	*18*	33.197	331,203
W/ Improvements	252	254	17,600	14.165	18.778	187,351
		Percent	Improvemen	t ATHD:	43	3.4%
		2040 Econ	omic Benefit	(Freight):	\$4,5	08,322
W/O Improvements	254	255	13,200	*18*	33.197	340,885
W/ Improvements	254	255	17,600	14.579	20.850	214,095
		Percent	Improvemen	t ATHD:	37	'.2%
		2040 Econ	omic Benefit	(Freight):	\$3,9	73,599
W/O Improvements	255	256A	13,200	*18*	33.197	343,551
W/ Improvements	255	256A	17,600	14.693	21.418	221,653
		Percent	Improvemen	t ATHD:	35	.5%
		2040 Econ	omic Benefit	(Freight):	\$3,8	20,283
W/O Improvements	256A	258	13,200	*18*	33.197	361,920
W/ Improvements	256A	258	17,600	15.478	25.223	274,984
		Percent	Improvemen	t ATHD:	24	⊦.0%
		2040 Econ	omic Benefit	(Freight):	\$2,7	24,574
W/O Improvements	258	259	13,200	*18*	33.197	333,809
W/ Improvements	258	259	17,600	15.749	26.455	266,013
		Percent	Improvemen	t ATHD:	20).3%
		2040 Econ	omic Benefit	(Freight):	\$2,1	24,727
W/O Improvements	259	259A	13,200	*18*	33.197	316,736
W/ Improvements	259	259A	17,600	16.690	30.178	287,929
		Percent	Improvemen	t ATHD:	9.	.1%
		2040 Econ	omic Benefit	(Freight):	\$90	2,811
W/O Improvements	259A	259B	17,600	16.690	30.178	287,928
W/ Improvements	259A	259B	22,000	13.352	14.803	141,238
		Percent	Improvemen	t ATHD:	50	1.9%
		2040 Econ	omic Benefit	(Freight):	\$4,5	97,265

5.8 Capacity-Bottleneck Rankings

Bottlenecks are ranked based on the highest ATHD found on the roadway in 2006. Table 5-44 shows the ranking of the six bottlenecks identified by this methodology.

	16	Table 5-44. Oapacity-bottleneck fankings, ATTD								
Rank Interstate		Beg. Exit	End Exit	Maximum ATHD						
	1	I-65	252	259B	30,650					
	2	I-65	238	246	16,612					
	3	I-20/59	123	130	14,662					
	4	I-65	247	250	10,009					
	5	I-10	26A	27	6,108					
	6	I-10	15B	17A	4,789					

Table 5-44.	Capacity	y-bottleneck	rankings, ATHD

In the initial assessment of freight bottlenecks, the annual truck hours of delay must exceed 5,000 hours for a section of roadway to be categorized as a freight bottleneck. The top five bottlenecks in the state exceed this value.

We can also rank Alabama's capacity bottlenecks by the delay a vehicle experiences traveling through the bottleneck. Ranking them according to this criterion is different than ranking them by ATHD because the numbers are not skewed by the total number of trucks traveling the roadway.

Table 5-45 shows the ranking of the capacity bottlenecks in Alabama by the delay caused to an individual vehicle traveling through the bottleneck (on a per-mile basis).

16	Table 5-45. Capacity-bottleneck fallkings, delay								
Rank	Interstate	Beg. Exit	End Exit	Maximum Delay					
1	I-65	252	259B	5.177					
2	I-65	238	246	3.463					
3	I-20/59	123	130	2.513					
4	I-65	247	250	1.880					
5	I-10	26A	27	1.744					
6	I-10	15B	17A	1.110					

Table 5-45. Capacity-bottleneck rankings, delay

In this case, the ranking based on the maximum delay experienced is identical to the ranking of the capacity bottlenecks based on the annual total hours of delay by freight traffic.

5.9 Calculations for Improvement Projects

There is not a capacity-improvement project planned to accommodate freight flows for every capacity bottleneck in Alabama. However, calculations for every planned interstate-improvement project in Alabama are included in Appendix C. The projects were taken from the construction bulletin on ALDOT's website in June 2011 as well as projects on the "Progress 65," "Progress 20," or "Progress 59" websites maintained by ALDOT. The calculations in Section 5 include the expected improvements in delay and travel time and the economic benefits for each.

5.10 Summary of Alabama Capacity Bottlenecks

The delay-calculation procedure for capacity bottlenecks is well-established. While the interchange-bottleneck procedure contained uncertainty regarding the number of vehicles using

the ramps to make turning movements, capacity bottleneck delay is a function of volume and capacity, and this report had access to accurate volume data from ALDOT.

One way to improve the results of capacity bottleneck calculations in this report would be to obtain accurate capacities for the interstates in Alabama. In this report, 2,200 passenger cars per hour per lane was the assumed capacity for every interstate. This number may inaccurate for some locations. Improving the capacity estimations would lead to more accurate estimations of freight delay.

There are at least two ways that the future capacity problems and freight delay on Alabama interstates could be addressed. The addition of capacity of a roadway by adding lanes is one. Trying to reduce the number of vehicles that want to use these roadways at peak hours is another.

For five of the six capacity bottlenecks studied, there are only two through lanes running in each direction. These bottlenecks were in non-urban settings or at the edge of urban areas. The eventual switch of non-urban interstates from the typical four through lanes to six through lanes would significantly reduce delay outside urban areas.

However, lane addition in major urban areas may not be a long-term solution. Some roadways experiencing major delay include sections that already have four lanes of through traffic in each direction. Even with additional lanes, the amount of freight delay in these sections would be comparatively large.

For sections of major urban interstate that have a large number of through lanes, a better longterm solution may be the eventual decrease of traffic on the roadway. Adding a mass-transit system that efficiently moves people within the city is an example of a solution that could reduce congestion and benefit freight movements in, out, and through the city. Before a new masstransit system can be implemented, studies must be performed on a case-by-case basis for different types of mass transit systems, which might show that mass-transit systems are not the long-term solution. They need to be studied for cost effectiveness, feasibility, and other factors.

Table 2-3 shows different methods of addressing roadway demand and capacity besides lane addition. When addressing capacity bottlenecks, there are several measures from Table 2-3 that could be studied. Active roadway management techniques can lead to more efficient traffic flow through a city. In a city with large numbers of unfamiliar drivers, better roadway signage could improve traffic flow. Areas where traffic collisions occur regularly could benefit from a good incident-management plan. Table 2-3 shows several additional methods that could benefit traffic flow. The benefits of each are discussed in more detail in the source material, the *Congestion Mitigation Toolkit* (Denver Regional Council of Governments, 2008).

Section 6 Alabama Roadway-geometry bottlenecks

There are two criteria for a section of interstate to be classified as a roadway-geometry bottleneck:

- Grade exceeding 4.5%
- Length of at least one mile

6.1 Locations that Almost Qualify as Roadway-Geometry Bottlenecks

No Alabama interstates meet these criteria. Table 6-1 profiles the three one-mile sections of roadway in Alabama that have the highest average grade.

-	1. Locations that almost quality as roadway-geometry bott								
	Interstate	Beginning MP	Ending MP	Average Grade					
	I-65	252.5	253.5	4.20%					
	I-65	316.5	317.5	3.97%					
	I-20	153.6	154.6	3.75%					

Table 6-1. Locations that almost qualify as roadway-geometry bottlenecks

These three locations approach the 4.5%-grade threshold to be classified as a roadway-geometry bottleneck but do not reach it. Figure 6-1 shows their locations. Only the farthest-south section is in an area with relatively high traffic volumes.



Figure 6-1. Locations that almost qualify as roadway-geometry bottlenecks (GIS)

Section 7 Alabama Freight Delay Analysis

Integrating the National Highway Planning Network database with ALDOT's information allows further analysis of Alabama's patterns of freight delay. This section offers analysis of freight delay based on roadway in urban areas and analysis of entire roadways (e.g. the entirety of I-65) rather than by analyzing intersections or short roadway segments.

While the methods previously described can identify singular locations that deserve further analysis and possible improvements, there may be other issues of concern:

- How much delay would be expected for a truck traveling Interstate 65 from Mobile to the Tennessee state line?
- How does the delay on roadways in metropolitan Birmingham compare to delay on roadways in metropolitan Montgomery?

These questions can be answered conveniently when the roadway characteristics are maintained in a usable database. In this section, we analyze delay in Alabama beyond identifying bottlenecks and suggesting solutions.

Due to limitations with the GIS database created for this report, the analysis of statewide delay is limited to delay caused by capacity bottlenecks. If there were roadway-geometry bottlenecks, they could also be included.

7.1 Urban Areas of Alabama

Inside the NHPN database, there is a data column that includes a code that groups sections of roadway based on the urban area that the roadway is in. To qualify as an urban area, the city's population must exceed 50,000. In the NHPN database used for the new GIS database, there were eight urban areas that met the population criterion (since the most recent release, more cities qualify for an urban code number).

Table 7-1 shows the urban codes used by the NHPN. When creating the GIS database for this report, the same urban codes were used.

Table 7-1. Urban codes used in NHPN

Code	Urban Area
0	Outside urban area
35	Birmingham
67	Mobile
115	Montgomery
183	Tuscaloosa
184	Huntsville
192	Gadsen
254	Anniston
294	Auburn

By using these codes, traffic in urban areas can be analyzed, giving a more comprehensive view of delay statewide. Even though only capacity-bottleneck delay is included, it is still effective.

7.2 Distribution of Delay and Roadway in Alabama

The capacity delay experienced in each urban area can be compared to the capacity delay experienced in other areas, and the comparison can be used for policy decisions. This comparison can be analyzed in several ways.

7.2.1 Percentage of Total Delay

Table 7-2 shows the estimated total hours of delay for each urban area (and the total for "outside urban area"), its share of the statewide capacity delay, and its share of capacity delay experienced in urban areas. These values take into account the length of road inside an urban area, while Annual Truck Hours of Delay, which was used in much of this report, is in hours of delay per roadway mile.

	V		, ,
Urban Area	Delay Hours	Percentage of Statewide Delay	Percentage of Statewide Urban Delay
Outside urban area	1,071,585	55.4%	-
Birmingham	586,255	30.3%	67.8%
Mobile	91,095	4.7%	10.5%
Montgomery	76,603	4.0%	8.9%
Tuscaloosa	36,132	1.9%	4.2%
Huntsville	9,573	0.5%	1.1%
Gadsen	4,805	0.2%	0.6%
Anniston	20,261	1.0%	2.3%
Auburn	39,667	2.0%	4.6%
Total	1.935.976		

Table 7-2. Percentage of statewide capacity truck delay

Table 7-2 shows that trucks experienced roughly two million total capacity delay hours on Alabama's interstate roadways in 2006.

Most of the estimated delay occurs on interstates that fall outside the boundaries of a particular urban area. This probably occurs because we use one capacity value (2,200 pcphpl) for every situation. Rural interstates likely experience less constrained flow than urban areas, so rural areas should probably be assigned higher capacities. Making that change would lead to a smaller share of the delay occurring outside urban areas.

When delay outside of urban areas is not considered, Table 7-2 shows that Birmingham experiences roughly two-thirds of all capacity delay in urban areas.

7.2.2 Interstate Miles in Urban Areas

While Section 7.2.1 showed that Birmingham's urban area accounts for much of the state's capacity delay, the numbers may be skewed because Birmingham has a higher percentage of centerline miles of interstate highway than other urban areas.

Table 7-3 shows the amount of centerline miles in each urban area and compares the values to the number of centerline miles in other urban areas.

Urban Area	Centerline Miles	Percentage of Statewide Centerline Miles	Percentage of Statewide Urban Centerline Miles
Outside urban area	637.99	70.7%	-
Birmingham	130.47	14.5%	49.3%
Mobile	41.86	4.6%	15.8%
Montgomery	33.59	3.7%	12.7%
Tuscaloosa	11.12	1.2%	4.2%
Huntsville	8.32	0.9%	3.1%
Gadsen	11.33	1.3%	4.3%
Anniston	5.57	0.6%	2.1%
Auburn	22.24	2.5%	8.4%
Total	902.49		

Table 7-3. Miles of centerline in urban areas

Table 7-3 shows that a large percentage of Alabama's centerline miles lie outside urban areas and that almost half the state's urban centerline miles are in Birmingham. This may help explain why the total freight capacity delay in urban areas are so heavily weighted in Birmingham, which has roughly half the centerline miles and two-thirds of the delay.

Another way to view how the delay may heavily weigh urban areas would be to calculate each area's share of roadway based on total lane miles (centerline miles \times number of through lanes). Table 7-4 shows how urban areas compare to one another based on their lane-miles.

Urban Area	Lane-Miles	Percentage of Statewide Lane-Miles	Percentage of Statewide Urban Lane-Miles
Outside urban area	2,674.56	65.1%	-
Birmingham	735.72	17.9%	51.4%
Mobile	243.78	5.9%	17.0%
Montgomery	186.02	4.5%	13.0%
Tuscaloosa	52.14	1.3%	3.6%
Huntsville	58.52	1.4%	4.1%
Gadsen	45.32	1.1%	3.2%
Anniston	22.28	0.5%	1.6%
Auburn	88.96	2.2%	6.2%
Total	4.107.30		

Table 7-4. Lane-miles of freeways in urban areas

Table 7-4 shows similarities to Table 7-3. This is because most roadways in Alabama are four lanes wide: the average number of through lanes statewide is 4.55 lanes (4,107.30 lane-miles/902.49 centerline miles = 4.55 lanes/centerline mile).

Table 7-5 shows the number of lane miles in each urban area more than the typical four through lanes. For example, one mile of six-lane roadway adds two lane miles.

Table 7-5. Additional lane-times by diban area				
Urban Area	Additional Lane Miles	Percentage of Statewide Additional Lane-Miles	Percentage of Urban Additional Lane-Miles	
Outside urban area	122.6	24.7%	-	
Birmingham	213.84	43.0%	57.1%	
Mobile	76.34	15.3%	20.4%	
Montgomery	51.66	10.4%	13.8%	
Tuscaloosa	7.66	1.5%	2.0%	
Huntsville	25.24	5.1%	6.7%	
Gadsen	0	0.0%	0.0%	
Anniston	0	0.0%	0.0%	
Auburn	0	0.0%	0.0%	
Total	497.34			

Table 7-5. Additional lane-miles by urban area

Table 7-5 shows that most of Alabama's additional lane-miles are in Birmingham, which makes sense because Birmingham also contains the most centerline miles. This table does not necessarily contain any new information, but it is important for the next table.

Table 7-6 shows the average number of additional lane miles for urban areas based on the number of roadway miles in each section. It also gives the average number of through lanes for each urban area. This information is useful because it indicates level of development. As the average number of through lanes increases, it becomes more important to consider alternative congestion-mitigation methods beyond adding lanes because there is less land available to add right of way.

Urban Area	Average Additional Through Lanes	Average Number of Through Lanes		
Outside urban area	0.19	4.19		
Birmingham	1.64	5.64		
Mobile	1.82	5.82		
Montgomery	1.53	5.53		
Tuscaloosa	0.69	4.69		
Huntsville	3.03	7.03		
Gadsen	0	4.00		
Anniston	0	4.00		
Auburn	0	4.00		

 Table 7-6.
 Average additional lane-miles by urban area

We can infer lots of useful information from Table 7-6. We can also combine the information in Table 7-6 with information in other tables to draw additional inferences:

- Huntsville contains the highest average of additional through lanes of Alabama's urban areas. However, this may be due to Huntsville's small number of centerline miles servicing a large population.
- Huntsville contains the highest average of through lanes, and this may be why it accounts for only 1.1% of delay when it is the state's 3rd largest city.
- Gadsen, Anniston, and Auburn contain no additional through lanes. This leaves room for future development of the roadway when traffic volumes increase.

Additional inferences from the table are discussed in the remainder of Section 7.

7.3 Distribution of Statewide Capacity Delay

There has been discussion of the distribution of total delay by urban area and how the number of lanes in each urban area compares to other urban areas. That information is useful, but it can be further analyzed.

Table 7-7 shows the number of hours of delay both by centerline mile and lane-mile for several cities. High values indicate that the area experiences more intense delay.

	-1. Annual truck nouis of delay pe	er nine (capacity)
Urban Area	Hours of Delay per Centerline Mile	Hours of Delay per Lane-Mile
Outside urban area	1,679	401
Birmingham	4,493	797
Mobile	2,176	374
Montgomery	2,281	412
Tuscaloosa	3,249	693
Huntsville	1,151	164
Gadsen	424	106
Anniston	3,638	909
Auburn	1,784	446

Table 7-7. Annual truck hours of delay per mile (capacity)

Table 7-7 shows that Birmingham experienced the most hours of delay per centerline mile in 2006. Anniston also experienced relatively high delay per centerline mile and the highest delay per lane mile.

Table 7-8 shows that Birmingham endures more than double the expected delay and that Huntsville and Gadsen have lower levels of delay than even rural areas. When the rural areas are excluded, only Birmingham and Anniston exceed the expected amounts, primarily because Birmingham skews the average so far right.

•	. Onalo of aolay (po	room or total port	
	Urban Area	Statewide Ratio	Urban Ratio
	Birmingham	2.09	1.38
	Anniston	1.67	1.10
	Tuscaloosa	1.58	1.00
	Montgomery	1.08	0.70
	Mobile	1.02	0.66
	Auburn	0.80	0.55
	Huntsville	0.56	0.35
	Gadsen	0.15	0.14
	Outside urban area	0.78	-

Table 7-8. Share of delay (percent of total/percent of centerline miles)

,	Table 7-9	. Share of dela	y (percent of tota	l/percent of lane-miles)
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Urban Area	Statewide Ratio	Urban Ratio
Anniston	2.00	1.44
Birmingham	1.69	1.32
Tuscaloosa	1.46	1.17
Auburn	0.91	0.74
Montgomery	0.89	0.68
Mobile	0.80	0.62
Huntsville	0.36	0.27
Gadsen	0.18	0.19
Outside urban area	0.85	-

Table 7-9 considers lane miles instead of centerline miles, but it shows roughly the same results as Table 7-8. This time, however, Anniston has the highest ratio in both columns because all of Anniston's interstate has four lanes while Birmingham's is not.

The information calculated in these two tables provides a better picture about how the delay in each urban area should be viewed in comparison to statewide values. Birmingham has the most delay in the state, and that is shown by high values in these tables.

Anniston is the anomaly. No roadway in the Anniston urban area was found to be a capacity bottleneck, yet the delay there has been calculated to be well above the delay that would be expected if delay statewide were uniform. This is because there is far more freight traffic in this urban area than in other areas (one value for TADT in Anniston is 0.38 while it hovers around 0.10 in Birmingham).

If the same analysis done in this section were to include delay for vehicles other than trucks, Anniston would not demonstrate such high values and Birmingham would exhibit higher values.

7.4 Further Analysis of Capacity Bottlenecks

While Section 5 studied the capacity bottlenecks in Alabama to the same extent as other reports, further analysis will give a more thorough view.

Table 7-10 shows the total annual truck delay for each capacity bottleneck identified in Section 5. Delay values in the table differ from the value used to rank the bottlenecks because they use delay for the length of the segment as opposed to delay per mile. This analysis gives greater weight to the total annual truck delay on longer bottlenecks.

Table 7-10. Capacity bottlenecks, annual freight delay			lai ireigini uelay	
Roadway	Beginning MP	Ending MP	Length (mi)	Total Annual Truck Delay (hrs)
I-10	15.69	17.12	1.53	6,848
I-10	25.96	27.08	1.12	7,849
I-20/59	123.14	130.29	7.15	73,261
I-65	238.32	246.06	7.74	90,813
I-65	247.26	250.08	2.82	28,226
I-65	251.97	259.70	7.73	122,508

Table 7-10. Capacity bottlenecks, annual freight delay

Table 7-10 shows which bottleneck experiences the most freight delay overall. The results suggest I-65 has the most delay. Table 7-11 shows the intensity of each capacity bottleneck on a per-mile basis, allowing for direct comparison of bottlenecks. A I-65 shows the most delay.

Table 7-11. Capacity bottlenecks, annual freight delay per mile								
Roadway	Beginning MP	Ending MP	Length (mi)	Total Annual Truck Delay per Mile (hrs)				
I-10	15.69	17.12	1.53	4,476				
I-10	25.96	27.08	1.12	7,008				
I-20/59	123.14	130.29	7.15	10,246				
I-65	238.32	246.06	7.74	11,732				
I-65	247.26	250.08	2.82	10,009				
I-65	251.97	259.70	7.73	15,848				

Table 7-11. Capacity bottlenecks, annual freight delay per mile

The values in Table 7-11 are similar to the values found in Section 5. The differences that exist come from the fact that bottlenecks were ranked based on the most congested section of each roadway in Section 5 but a weighted average of all of its sections here.

7.5 Expected Delay Traveling the Length of Roadways

Table 7-12 shows the delay in 2006 for a vehicle traveling the entire length of each interstate highway in Alabama. For example, a vehicle traveling I-10 from Mississippi to Florida should expect 2.655 minutes of capacity delay while in Alabama. This may vary by the time of day, and vehicles traveling during peak periods should expect more delay.

Interstate	Length (mi)	Expected Delay (min)	Delay/mi. (min)
I-10	66.27	2.655	0.040
I-20/59	130.29	4.594	0.035
I-20	84.42	3.338	0.040
I-59	100.89	2.060	0.020
I-65	368.37	13.869	0.038
I-85	81.01	2.856	0.035
I-165	5.07	0.058	0.012
I-359	2.59	0.092	0.036
I-459	33.35	1.362	0.041
I-565	25.69	0.985	0.038
I-759	4.54	0.082	0.018

Table 7-12. Expected delay for vehicles traveling Alabama interstates (whole lengths)

Table 7-12 shows that congestion on I-65 tends to add the most travel time. However, this is partly a function of I-65's length. I-65 is tied for fourth highest expected delay per mile because much of I-65 lies outside urban areas. A larger proportion of other roadways is located in urban areas.

Another way to look at the total expected delay in 2006 would be to examine vehicles traveling through one of Alabama's urban areas. The following tables do that.

Table 7-13 shows the expected minutes of delay for a vehicle traveling through metropolitan Birmingham. The table also includes the length of the roadway within the urban area and the delay in minutes per mile traveled.

Interstate	Length (mi)	Expected Delay (min)	Delay/mi. (min)
I-20/59	33.15	1.854	0.056
I-20	9.81	0.401	0.041
I-59	17.22	0.695	0.040
I-65	36.94	3.803	0.103
I-459	33.35	1.362	0.041

Table 7-13. Expected delay for vehicles traveling Alabama interstates (Birmingham metro)

The portion of I-65 that runs through Birmingham experiences the most total delay and the most delay per mile.

Table 7-14 shows the expected delay in minutes for a vehicle traveling through metropolitan Mobile. The table also includes the length of the roadway within the urban area and the delay in minutes per mile traveled.

The portion of I-10 that runs through Mobile experiences the most total delay and the most delay per mile. I-65 also experiences high delay. However, the third roadway, I-165, has the lowest delay per mile for any interstates in urban Alabama. I-65 terminates inside metropolitan Mobile, and I-165 is completely contained within metropolitan Mobile.

Interstate	Length (mi)	Expected Delay (min)	Delay/mi. (min)
I-10	17.29	0.843	0.049
I-65	19.50	0.746	0.038
I-165	5.07	0.058	0.012

Table 7-14. Expected delay for vehicles traveling Alabama interstates (Mobile metro)

Table 7-15 shows the expected delay in minutes for a vehicle traveling through metropolitan Montgomery. The table also includes the length of the roadway within the urban area and the delay in minutes per mile traveled.

Table 7-15.	Expected	d delay	/ for vehicl	es traveling	Alabama i	nterstates	(Montgomery	metro)

Interstate	Length (mi)	Expected Delay (min)	Delay/mi. (min)
I-65	17.52	0.663	0.038
I-85	16.07	0.642	0.040

I-65 travels all the way through metropolitan Montgomery, while I-85 terminates at the I-85/I-65 interchange.

Table 7-16 shows the expected delay in minutes for a vehicle traveling through metropolitan Tuscaloosa. The table also includes the length of the roadway within the urban area and the delay in minutes per mile traveled.

Table 7-16. Expected delay for vehicles traveling Alabama interstates (Tuscaloosa metro)

Interstate	Length (mi)	Expected Delay (min)	Delay/mi. (min)
I-20/59	8.53	0.347	0.041
I-359	2.59	0.092	0.036

Table 7-17 shows the expected delay in minutes for a vehicle traveling through metropolitan Huntsville. The table also includes the length of the roadway within the urban area and the delay in minutes per mile traveled.

Table 7-17. Expected delay for vehicles traveling Alabama interstates (Huntsville metro)						
Interstate	Length (mi)	Expected Delay (min)	Delay/mi. (min)			
I-565	8.32	0.321	0.039			

Table 7-18 shows the expected delay in minutes for a vehicle traveling through metropolitan Gadsden. The table also includes the length of the roadway within the urban area and the delay in minutes per mile traveled.

Table 7 10	Exposted dala	. for vohioloo	trovaling	Alabama	interatotoo /	Cadadan	matra
	Expected dela	y ioi veincies	lavening	Alavailla	interstates (Gausuen	meno

Interstate	Length (mi)	Expected Delay (min)	Delay/mi. (min)
I-59	6.79	0.108	0.016
I-759	4.54	0.082	0.018

Table 7-19 shows the expected delay in minutes for a vehicle traveling through metropolitan Anniston. The table also includes the length of the roadway within the urban area and the delay in minutes per mile traveled.

Table 7-19 Expected delay for vehicles traveling Alabama interstates (Anniston metro)

Interstate	Length (mi)	Expected Delay (min)	Delay/mi. (min)
I-20	5.57	0.221	0.040

Table 7-20 shows the expected delay in minutes for a vehicle traveling through metropolitan Auburn. The table also includes the length of the roadway within the urban area and the delay in minutes per mile traveled.

Table 7-20	. Expected	delay fo	or vehicles	s traveling	Alabama	interstates	(Auburn metro)

Interst	ate	Length (mi)	Expected Delay (min)	Delay/mi. (min)
I-85		22.24	0.791	0.036

Many of the delay intensities experienced in Alabama's metro areas center around 0.040 minutes of delay per mile traveled. However, there are several cases that diverge from this value considerably. The expected delay on I-65 in Birmingham is more than double. Neither interstate in Gadsen approaches the 0.040 value.

7.6 Future Improvements to Alabama Freight-Delay Analysis

There are things that can be done to improve our freight-delay analysis. Using calculated capacity values instead of the uniform 2,200 pcphpl value can slightly increase the accuracy of our comparisons in this section. Separating the expected delay based on travel time can also increase accuracy. Margiotta provides equations to separate traffic delay based on time: peak period, peak hour, daily, weekend, or weekday (Margiotta, *et al.* 1998).

7.7 Summary of Alabama Freight-Delay Analysis

The analyses in Section 7 show that freight delay in Alabama can be analyzed beyond the techniques used in Sections 1-6.

The delay percentages found in Section 7.2 and the delay ratios found in Section 7.3 can shape long-term plans for construction on Alabama interstates. If an agency believes that Birmingham's share of urban delay—which is greater than 50%—is too high, greater infrastructure investment could be encouraged. However, many through lanes already run through metropolitan Birmingham. Thus, adding lanes might not be the best investment. The solution may include heavy investment in mass transit.

While it is reasonable for state transportation agencies to analyze delay by identifying bottlenecks and forming mitigation strategies, some of these methods may better suit freight companies looking for efficient shipping routes. For example, Section 7.5 shows time lost in urban areas, which can be used to plan truck routes. Freight shipments may want to avoid certain areas due to delay.

The key is to monitor the situation. Traffic projections can be unreliable, and maintaining an updated database or spreadsheet can help account for unforeseen population growth or decline.

Additional figures that present congestion information in GIS format can be found in Appendix D of this report.

Section 8 Conclusions/Recommendations

The primary purpose of this project was to identify interstate freight bottlenecks and present mitigation strategies. Another goal was to set the strategy for a more comprehensive freight-congestion analysis that can be used to form state transportation policy that uses roadway funds more efficiently (this report covers only interstates, but the methodology could be applied to other functional classes of roadways).

The methodology used in this report for classifying and inventorying freight bottlenecks on highways has been developed by Cambridge Systematics, an engineering firm that specializes in the policy, strategic planning, and management of transportation systems. This methodology was chosen over other bottleneck methodologies because of the relative ease of use and availability of data for study.

Three types of bottlenecks are of concern on Alabama interstates: roadway-geometry bottlenecks, interchange bottlenecks, and capacity bottlenecks. Roadway-geometry bottlenecks on interstates are steep-grade bottlenecks and have grade and length requirements. Interchange bottlenecks include interchanges involving two interstates with at least one ramp or approaching roadway that has insufficient capacity for the demand. Capacity bottlenecks include basic sections of roadways that have insufficient capacity to handle demand.

8.1 Summary of Results

This project used 2006 AADT data to identify nine bottlenecks on Alabama interstates, Including three interchange bottlenecks, six capacity bottlenecks, and zero roadway-geometry bottlenecks. A site qualified as a capacity bottleneck or an interchange bottleneck when the AADT to capacity ratio exceeded 8. A roadway-geometry bottleneck had to be one mile long and have a grade exceeding 4.5%, but no sections qualified. Table 8-1 below shows the nine identified bottlenecks and the annual truck hours of delay that were calculated for each.

Identifying congested locations and quantifying the freight delay at each can be useful when making funding decisions. Knowing the hours of delay experienced by vehicles traveling these roadways allow analyses of cost effectiveness to be performed when potential congestion mitigation projects are discussed.

This report also described strategies for identifying and predicting bottleneck locations using traffic projections out to 2025 and 2040. Such projections are also useful to long-range highway planners.

Table 8-1. Alabama-interstate bottlenecks						
	CAPACITY BOTTLENECK LOCATIONS					
Interstate	Beginning Exit #	Ending Exit #	Maximum ATHD			
I-65	252	259B	30,650			
I-65	238	246	16,612			
I-20/59	123	130	14,662			
I-65	247	250	10,009			
I-10	26A	27	6,108			
I-10	15B	17A	4,789			
	INTERCHANGE BOTTLENECK LOCATIONS					
Interc	hange	Total Annual Freight Hours of Delay				
I-459 at I-65		304,174				
I-20/59 at I-65		114,431				
I-20/59	Diverge	54,653				
ROADWAY-GEOMETRY BOTTLENECK LOCATIONS						
No roadway-geometry bottlenecks were identified on Alabama interstates in this report.						

8.2 Recommendations

There are two recommendation sections for this report. One recommendation section covers ways to improve the methodology used in this report. Another recommendation section includes possible uses of the methodology and future research avenues.

8.2.1 Recommendations for Methodology Improvement

There are separate delay-calculation methodologies for the two types of bottlenecks found on Alabama interstates. There are improvements that would provide more precise results for both types of bottlenecks:

- Determining accurate capacities for roadways on a case-by-case basis, as opposed to the current methodology, which uses a single value: 2,200 pcphpl.
- Determining the capacity benefits for more types of roadway-improvement projects.
- Creating adjustment factors for annual freight delay that take into account truck avoidance of congested roadways during peak periods.

Other projects could especially improve interchange bottlenecks. The most pressing improvement to the methodology concerns identifying site-specific values for ramp volumes and turning percentages at Alabama interstates.

There are also several improvements that could improve bottleneck monitoring but lie outside the methodology of this report:

- Use more specific growth percentages than the ones used in the FAF. Use values created specifically for Alabama.
- Use travel-demand modeling to help analyze the expected growth patterns of traffic.
- Update the methodology for monitoring bottlenecks whenever the Federal Highway Administration and Cambridge Systematics update their methodology.

The improvements described in this section will reduce uncertainty regarding the actual amount of bottleneck delay. When these improvements are made, a more credible system for identifying, mitigating, and projecting future bottlenecks can be produced and used in Alabama.

As described, the only mitigation projects this report considered involved adding lanes. This approach was used because the improvements from additional lanes are easily quantifiable. However, there are other types of potential improvement projects that can be performed:

- High Occupancy Vehicle (HOV) lanes
- High Occupancy Toll (HOT) lanes
- Creating additional roadways

Another way to address interstate bottlenecks involves addressing demand issues. Curbing demand and creating an environment where fewer passenger cars and freight vehicles are traveling on the roadways can greatly benefit future interstate delay conditions. There are multiple methods to curb the growth of interstate traffic:

- Ramp meters
- Roadway-signage improvements
- New fixed guideway transit travelways
- Transit-service expansion
- Telework and flexible work schedules

By trying to affect traffic congestion by addressing both capacity and demand concerns, it may be possible to avoid many the problems predicted for American roadways. At some point, the continued addition of lanes is not a practical solution, and demand concerns must be faced.

8.2.2 Recommendations for Future Projects

In addition to the improvements listed in Section 8.2.1, there are projects and research that can be performed to help make the freight-delay calculations more efficient and useful.

The methodology to identify freight bottlenecks on Alabama's interstates can be expanded to address freight movements on other functional classes of roadways. A methodology is available that would allow for the expansion of bottleneck identification to include those on major and minor arterial roadways. When monitoring other types of roadways, additional types of bottlenecking may be discovered.

In addition to expanding the monitoring to other functional roadway classifications, expanding the cost-benefit analysis would be beneficial. Studies on the effects of mitigation methods on capacity outside of lane addition need to be studied. Also, the effects of complex roadway geometry on capacity need to be studied.

A GIS database created for this report is useful for showing the current and projected state of delay conditions on Alabama interstates. ALDOT may wish to extend this database to other road

classifications or create a database based on this one that would fit their specific bottleneckmonitoring needs. The resulting database could become a useful tool for ALDOT.

Section 9 References

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Appendix A Imagery of Freight Bottlenecks in Alabama

The following pages in this appendix have satellite imagery for all of the freight bottlenecks in Alabama. Three interchange bottlenecks and seven capacity bottlenecks are highlighted in the images below. They are not listed in any particular order.

The satellite imagery was taken from the Alabama Department of Transportation website, which uses Google Maps as its source.

Also included for every bottleneck is an image from ALDOT's surveying maps. In these pictures, the interchange bottlenecks are highlighted by a black box and the capacity bottlenecks have arrows pointing to the beginning and end of the bottleneck. In some cases, the bottlenecks span two counties. When this happens, multiple images must be used.

Interchange Bottleneck #1 Interstate 20 – Interstate 59



Figure A-1. Interchange bottleneck #1 satellite image



Figure A-2. Interchange bottleneck #1 ALDOT map image

Interchange Bottleneck #2 Interstate 20/59 – Interstate 65



Figure A-3. Interchange bottleneck #2 satellite image



Figure A-4. Interchange bottleneck #2 ALDOT map image

Interchange Bottleneck #3 Interstate 459 – Interstate 65



Figure A-5. Interchange bottleneck #3 satellite image



Figure A-6. Interchange bottleneck #3 ALDOT map image

Capacity Bottleneck #1 Interstate 10 from Exit 15B to Exit 17A



Figure A-7. Capacity bottleneck #1 satellite image



Figure A-8. Capacity bottleneck #1 ALDOT map image

Capacity Bottleneck #2 Interstate 10 from Exit 26A to Exit 27



Figure A-9. Capacity bottleneck #2 satellite image



Figure A-10. Capacity bottleneck #2 ALDOT map image

Capacity Bottleneck #3 Interstate 20/59 from Exit 123 to Exit 130



Figure A-11. Capacity bottleneck #3 satellite image



Figure A-12. Capacity bottleneck #3 ALDOT map image

Capacity Bottleneck #4 Interstate 65 from Exit 238 to Exit 246



Figure A-13. Capacity bottleneck #4 satellite image



Figure A-14. Capacity bottleneck #4 ALDOT map image

Capacity Bottleneck #5 Interstate 65 from Exit 247 to Exit 250



Figure A-15. Capacity bottleneck #5 satellite image



Figure A-16. Capacity bottleneck #5 ALDOT map image (Jefferson County)



Capacity Bottleneck #6 Interstate 65 from Exit 252 to Exit 259 B



Figure A-18. Capacity bottleneck #6 satellite image



Figure A-19. Capacity bottleneck #6 ALDOT map image

Appendix B Current ALDOT Improvement Projects

Table B-1 below outlines the projects posted on the ALDOT construction bulletin. These do not include every project in the five-year plan. That information can be viewed in Table B-2.

US Route	Counties	Description	Estimated Completion Date
I-10	Baldwin	Road work between 0.14 mile east of CR 87 (MP 57.43) and one mile west of the Styx River (MP 59.50) consisting of slide corrections.	Spring 2011
I-20	Calhoun, Talladega	Road and bridge work consisting of additional lanes, grade, drain, base, pave and bridge raising from west of Bentley Parkway to east of Snow Creek in Oxford.	Spring 2013
I-20	Cleburne	Road work consisting of pavement rehabilitation from east of AL9 to east of AL 46 in Heflin including a portion of AL 46 at the I-20 interchange area. Length 5.668 miles.	Spring 2011
I-59	Etowah	Road and bridge work consisting of clearing, concrete pavement rehabilitation, guardrails, bridge raising and widening from 0.6 miles south of Attala north city limits to end of bridge over CR 276 at Duck Springs.	Fall 2012
I-65	Jefferson	Road work consisting of grade, drain, base and pave, signing and lighting from I-459 to US 31 in Vestavia Hills.	Winter 2012
Future I-22	Jefferson	Road and bridge work at I-65 in Birmingham and on I-65 from 41 st Ave to Walkers Chapel Road consisting of grade, drain, base, pave, signing, lighting, and ramp modifications.	Fall 2014
I-59	Jefferson	Road work consisting of pavement rehabilitation, planning, resurfacing, and guardrail from 11 th Street bridge to Fairfield Blvd. bridge in Bessemer.	Fall 2011
I-85	Lee	Road and bridge work at the Auburn Technology Park at (MP 50.00) and relocation of CR 10 (Beehive Road) consisting of grade, drain, base, pave, signing, bridge culverts and bridge.	Summer 2012
I-10	Mobile	Road and bridge work consisting of additional lanes, resurfacing, planning, grade, drain, base and pave, bridge widening and bridges from west of Carol Plantation Road to Halls Mill Creek in Mobile.	Summer 2013
I-85	Montgomery, Macon	Road work consisting of pavement rehabilitation, guardrails and ramp improvements from one mile east of AL 126 to east of Macon County line.	Fall 2011
I-65	Montgomery	Construction of additional lanes (grade, drainage, pavement, concrete pavement rubberization, bridge widening, lighting, signing, and signals) on I- 65 from the north end of the Catoma Creek Bridge to the south end of the Mill Street Bridge, and the Bridge widening on I-65 from north of Fairview Avenue to the Alabama River Bridge in Montgomery.	Spring 2011
I-65	Shelby, Jefferson	Road work north of CR 17 to south of I-459 in Hoover and at I-459 consisting of additional lanes, grade, drain, base, pave, signing and ramp modifications.	Summer 2011
I-65	Shelby	Road work consisting of pavement rehabilitation from the Chilton County line to exit 238.	Fall 2011
I-65	Shelby	Road and bridge work consisting of additional lanes, grade, drain, base, pave, bridge widening and raising, signing and traffic signals from CR 52 to CR 17.	Spring 2011
I-20	St. Clair	Road and bridge work consisting of additional lanes, grade, drain, base, pave, bridge widening and raising, signing and traffic signals from west of Kelly Creek in Moody to end of median barrier.	Summer 2013

Table B-1. Planned ALDOT improvement projects for AL interstates*

*Adapted from ALDOT website (http://aldotapps.dot.state.al.us/ConstructionBulletin/)

In addition to the improvement projects found in the construction bulletin, ALDOT maintains a five-year plan for improvement projects. This plan includes county, project cost range, target start date, and description of the work. The most recent release, the 2010 five-year plan, covers 10/1/2009 through 9/30/2014. The plan splits work by the county it is to be performed in.

The five-year plan for Alabama has been scanned for projects that will affect capacity on Alabama interstates. Table B-2 shows the projects from the 2010 five-year plan that will affect capacity. Notice there are multiple entries for the same projects. This is because work on these projects are split between the preliminary engineering (PE) and the construction (CN) phases.

The five-year plan notes projects that include construction of an additional lane. However, only projects designated "ADL" involve the addition of travel lanes.

Projects were found by searching for "ADD" in the pdf and recording the interstate projects that appeared. Some of the projects are listed multiple times because each phase of the projects is a separate entry in the five-year plan.

Project Number(s)	County	Location and Work Description	Length (Miles)	Project Cost Range (\$1,000s)	Target Start Date
100049343	Chilton	I-65 Add Lanes/Resurface from SR-3 (US-31) to SR- 145 (PE), RSF	6.536	458 to 688	FY 2010
100049344	Chilton	I-65 Add Lanes/Resurface from SR-3 (US-31) to SR- 145 (CN), RSF	6.536	9,150 to 13,724	FY 2012
100049321	Chilton	I-65 Add Lanes/Resurface from Autauga County Line to SR-3 (US-31, EXIT 205) (PE), RSF	7.319	514 to 772	FY 2011
100049322	Chilton	I-65 Add Lanes/Resurface from Autauga County Line to SR-3 (US-31, EXIT 205) (CN), RSF	7.319	10,629 to 15,943	FY 2013
100049347	Chilton	I-65 Add Lanes/Resurface from CR-51 to Shelby County Line (PE), RSF	5.224	374 to 562	FY 2011
100049348	Chilton	I-65 Add Lanes/Resurface from CR-51 to Shelby County Line (CN), RSF	5.224	7,592 to 11,388	FY 2013
100045873	Cullman	I-65 Reconstruct north and south bound lanes and additional lanes from Blount County line to 2.6 miles south of SR-69 and widen overpass SR-91 (CN), ADL	5.958	1,806 to 2,708	FY 2012
100045873	Cullman	I-65 Reconstruct north and south bound lanes and additional lanes from Blount County line to 2.6 miles south of SR-69 and widen overpass SR-91 (CN), ADL	5.958	23,987 to 35,981	FY 2012
100045871	Cullman	I-65 Reconstruct existing south bound lane and additional lanes north and south bound from 2.6 miles south of SR-69 to CR-222 (CN), ADL	7.825	27,027 to 40,541	FY 2013
100004982	Jefferson	I-59 Add Lanes from SR-7(US-11, 1 st Ave. N) to I-459 (CN), ADL	4.988	30,975 to 46,463	FY 2012
100045051	Jefferson	I-59 Add Lanes from SR-7(US-11, 1 st Ave. N) to I-459 (CN), UTL	4.988	97 to 145	FY 2012
100039738	Jefferson	Add Lanes I-59 from 18 th -19 th St. (EXIT 112) to Valley Road (EXIT 118) (RW), ADL	6.267	10 to 50	FY 2014
100047791	Jefferson	Add Lanes I-59 from 18 th -19 th St. (EXIT 112) to Valley Road (EXIT 118) (UT), UTL	6.388	53 to 79	FY 2014
100039738	Jefferson	Add Lanes I-59 from 18 th -19 th St. (EXIT 112) to Valley Road (EXIT 118) (RW), ADL	6.267	246 to 370	FY 2014
100044587	Jefferson	I-59 Add Lanes from SR-5 (US-11, EXIT 108) to CR-46 (18 th /19 th St., EXIT 112), PHASE II (PE), ADL	3.570	237 to 355	FY 2014
100047790	Jefferson	I-59 Add Lanes from SR-5 (US-11, EXIT 108) to CR-46 (18 th /19 th St., EXIT 112), PHASE II (UT), UTL	3.570	53 to 79	FY 2014
100044587	Jefferson	I-59 Add Lanes from SR-5 (US-11, EXIT 108) to CR-46 (18 th /19 th St., EXIT 112), PHASE II (PE), ADL	3.570	10 to 50	FY 2014

Table B-2. Capacity-improvement projects from ALDOT's five-year plan (2010)

Table B-2 (cont.)						
Project Number(s)	County	Location and Work Description	Length (Miles)	Project Cost Range (\$1,000s)	Target Start Date	
100037839	Lee	I-85 Additional Lanes and Bridge Replacement from MP 58.8 to MP 62.45 includes bridges: I85-41-12.2 #006495 & #006496, I85-41-13.2 #006497 & #006498, I85-41-13.3 #006499 & #006500 (CN), ADL	3.850	16,344 to 24,518	FY 2014	
100037839	Lee	I-85 Additional Lanes and Bridge Replacement from MP 58.8 to MP 62.45 includes bridges: I85-41-12.2 #006495 & #006496, I85-41-13.2 #006497 & #006498, I85-41-13.3 #006499 & #006500 (CN), ADL	3.850	13,835 to 20,753	FY 2014	
100037839	Lee	I-85 Additional Lanes and Bridge Replacement from MP 58.8 to MP 62.45 includes bridges: I85-41-12.2 #006495 & #006496, I85-41-13.2 #006497 & #006498, I85-41-13.3 #006499 & #006500 (CN), ADL	3.850	10,609 to 15,913	FY 2014	
100043151	Mobile	Adding lanes on I-65 from SR-158 to CR-41 (Celeste Rd) (PE), ADL	2.158	562 to 842	FY 2011	
100043152	Mobile	Adding lanes on I-65 from SR-158 to CR-41 (Celeste Rd) (CN), ADL	2.158	10,001 to 15,001	FY 2014	
100043178	Mobile	Add Lanes I-10 from CR-59 (Carol Plantation Rd) to Halls Mill Creek (UT), UTL	2.269	105 to 157	FY 2014	
100047484	Shelby	I-65 Add Lanes from ramps to SR-3 (US-31), north of Calera to Ramps south of CR-87 including interchange improvements and bridge widening @SR-3 (US-31) Calera (PE), ADL	2.738	1,215 to1,823	FY 2011	
100044672	Shelby	I-65 Add Lanes from SR-3 (US-31) to CR-52 (8-LN) (Phase 2) (CN), ADL	3.531	24,442 to 36,662	FY 2012	
100044672	Shelby	I-65 Add Lanes from SR-3 (US-31) to CR-52 (8-LN) (Phase 2) (CN), ADL	3.531	12,221 to 18,331	FY 2012	
100044678	Shelby	I-65 Add Lanes from Cahaba River Bridge to south end of CR-2310 (Wisteria Dr) Overpass (Phase 6) (PE), ADL	2.870	790 to 1,184	FY 2014	
100044963	Shelby	I-65 Add Lanes from 0.2 mile south of CR-87 to SR-3 (US-31) near Alabaster (Phase 3) (CN), ADL	4.520	29,477 to 44,215	FY 2014	
100044964	Shelby	I-65 Add Lanes from 0.2 mile south of CR-87 to SR-3 (US-31) near Alabaster (Phase 3) (CN), ADL	4.520	105 to 157	FY 2014	
100047970	Shelby	I-65 Add Lanes from south end of overpass @ CR-17 (Valleydale Rd) to south end of Cahaba River Bridge (Phase 5) (RW), ADL	1.180	53 to 79	FY 2014	
100050107	Talladega	I-20 Add Additional Lanes from Coosa River to 0.3 mile east of underpass CR-97 (Airport Rd) (PE), ADL	8.678	360 to 540	FY 2011	
100050108	Talladega	I-20 Add Additional Lanes from Coosa River to 0.3 mile east of underpass CR-97 (Airport Rd) (CN), ADL	8.678	12,000 to 18,000	FY 2012	
100049339	Tuscaloosa	I-359 Add Lanes/Resurface from SR-7 (US-11) to 0.3 mile south 35 th Street Underpass (CN), RSF	0.743	936 to 1,404	FY 2011	
100049339	Tuscaloosa	I-359 Add Lanes/Resurface from SR-7 (US-11) to 0.3 mile south 35 th Street Underpass (CN), RSF	0.743	467 to 701	FY 2011	
100042122	Tuscaloosa	I-59 Add Lanes from SR-6 (US-82; McFarland Blvd) to west of CR-32 (CN), ADL	8.818	22,270 to 33,404	FY 2013	
100039473	Tuscaloosa	I-59 Additional Lanes from south of CR-1900 (Black Warrior Pkwy) Interchange to SR-6 (US-82) Interchange (McFarland BLVD) GDBP BR (CN), ADL	4.499	13,159 to 19,739	FY 2014	

Where:

- PE=Preliminary Engineering
- CN=Construction
- ADL=Additional Lane
- RW=Right of Way
- UT=Utilities

Several maps available on ALDOT's website show projects from the construction bulletin in graphical form. The next several figures show the projects throughout the state that will affect capacity.

Figure B-1 shows current and planned I-65 construction projects in the Birmingham area. The projects extend from the Chilton County line on the southern edge of Shelby County to Exit 272 in Jefferson County.



Birmingham, AL Area I-65 Current and Planned Construction Projects

Figure B-1. Birmingham-area construction projects, I-65

The projects outlined in Figure B-1 show construction projects that will affect the following bottlenecks:

- Capacity bottleneck #5 (Exit 247 to Exit 250)
- Interchange bottleneck #3 (Intersection of I-459 and I-65)

Figure B-2 shows recently completed I-65 construction projects in the Montgomery area. The projects had a great effect on the traffic conditions in the Montgomery area. The improvements from these projects were already built into the GIS database.



Figure B-2. Montgomery-area construction project, I-65
Figure B-3 maps a project to add lanes on I-20 in St. Clair County planned for completion in the summer of 2013. While this has no effect on bottlenecks in the state, the I-20 corridor in east Alabama has high freight volumes, as it serves as the main freight line between Atlanta and Birmingham.



Figure B-3. St. Clair County construction project, I-20

Figures B-1, B-2, and B-3 are the only figures available from ALDOT. They do not cover every project in the construction bulletin that affects interstate capacity.

Appendix C Calculation of Benefits for Current ALDOT Improvement Projects

The projects analyzed in this appendix all tangibly improve roadway capacity because they all involve adding lanes to a roadway segment. The calculations shown include the improvement in current delay (2006 traffic volumes) and estimated improvements in 2025 and 2040. Also included will be the total economic benefit added by the roadway improvements.

These calculations give a quick picture of how much these projects reduce congestion and also assist in ranking projects by financial efficiency.

The analyses performed for each capacity-improvement project show how we can get a more complete idea of an improvement project's benefits. This analysis can be done for proposed projects to compare benefits. This will help allow for efficient allocation of resources.

Only included in this section are projects already on the construction bulletin in June of 2011 or were included in one of the "Progress" websites maintained by ALDOT (Progress 20, Progress 59, Progress 65).

ALDOT Project #1

I-20 - Calhoun/Talladega Counties

(Spring 2013)

Road and bridge work consisting of additional lanes, grade, drain, base, pave and bridge raising from west of Bentley Parkway to east of Snow Creek in Oxford.

This construction project does not affect any current bottleneck identified in this report for Alabama. However, this section identified has a relatively high percentage (38%) of trucks in the traffic stream.

This project includes the construction of additional lanes on a section of I-20 around Oxford, AL.

Table C-1 describes the capacity change the additional lanes will bring.

Table C-1. ALDOT project #1: capacity change									
Beginning Exit End Exit Previous Thru Lanes Finished Thru Lanes Change in Capacity New Capacity									
179	185	4	6	+4,400	13,200				

Table C-2 shows the AADT/C for the amount of capacity delay experienced on this section of roadway and the calculations for the amount of delay if the project were complete.

Table C-2. ALDOT project #1: AAD1/C calculations (2006)										
Status	Beg. Exit	End Exit	AADT	TADT	AADT (pce)	Capacity	AADT/C			
Before	179	185	38,340	0.38	45625	8,800	5.185			
After	179	185	38,340	0.38	45625	13,200	3.456			

Table C.O. ALDOT president #1. AADT/C coloulations (0000)

Table C-3 shows the Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the calculations for benefit of improvements (on a per-mile basis) for the current year.

Table C-3. ALDOT project #1: ATHD and benefit calculations (2006)										
Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit			
Before	179	185	9.129	1.967	19,284					
After	179	185	6.086	0.672	6,590	-12,694	\$397,822			

ALDOT president #1. ATUD and benefit colouisticne (0000)

Table C-4 shows the AADT/C for the amount of capacity delay expected in 2025 on this section of roadway and the future delay expected on the roadway section.

Table C-4. ALDOT project #1: AADT/C calculations (2025)										
Status	Beg. Exit	End Exit	AADT (pc)	AADTT	AADT (pce)	Capacity	AADT/C			
Before	179	185	33,991	22,864	68,287	8,800	7.760			
After	179	185	33,991	22,864	68,287	13,200	5.173			

Table C-5 shows the Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the expected project benefits (on a per-mile basis) for 2025.

Та	Table C-5. ALDOT project #1: ATHD and benefit calculations (2025)										
Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit				
Before	179	185	5.185	0.659	9,598						
After	179	185	3.456	0.477	6,945	-2,653	\$83,149				

Table O.F. Al DOT success #1. ATUD and has after a louistics a (2005)

Table C-27 shows the AADT/C for the amount of capacity delay expected in 2040 on this section of roadway and the delay expected on the roadway section.

Table C-6. ALDOT project #1: AADT/C calculations (2040)										
Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit			
Before	179	185	7.760	0.932	21,308					
After	179	185	5.173	0.658	15,055	-6,254	\$195,986			

Table C-6. ALDOT project #1: AADT/C calculations (2040)

Table C-28 shows the Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the project benefit (on a per-mile basis) expected for 2040.

Table C-7. ALDOT project #1: ATHD and benefit calculations (2040)

Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit
Before	179	185	10.685	4.826	157,493		
After	179	185	7.123	0.755	24,639	-132,854	\$4,163,656

ALDOT PROJECT #2

I-10 – Mobile County

(Summer 2013)

Road and bridge work consisting of additional lanes, resurfacing, planning, grade, drain, base and pave, bridge widening and bridges from west of Carol Plantation Road to Halls Mill Creek in Mobile.

Part of this planned project affects Capacity Bottleneck #1; the rest of this project does not affect current bottlenecks. This project includes the construction of additional lanes on a roughly fourmile-long section of I-10 west of Mobile heading toward the Mississippi state line.

Table C-8 describes the change in capacity expected from adding these lanes.

Table C-8. ALDOT project #2: capacity change											
Beginning Exit	End Exit	Current Thru Lanes	Finished Thru Lanes	Change in Capacity	New Capacity						
13	15B	4	6	+4,400	13,200						
15B	17A	4	6	+4,400	13,200						

Table C-8. ALDOT project #2: capacity change

Table C-9 shows the AADT/C estimates of capacity delay on this section of roadway and the estimates of delay expected if the project were complete.

Table C-9. ALDOT Project #2: AADT/C Calculations (2006)										
Status	Beg. Exit	End Exit	AADT	TADT	AADT (pce)	Capacity	AADT/C			
Before	13	15B	60,280	0.21	66610	8,800	7.569			
After	13	15B	60,280	0.21	66610	13,200	5.046			
Before	15B	17A	65,660	0.18	71570	8,800	8.133			
After	15B	17A	65,660	0.18	71570	13,200	5.422			

Table C-9. ALDOT Project #2: AADT/C Calculations (2006)

Table C-10 shows the calculations of the Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the calculations for benefit of improvements (on a per-mile basis) for the current year.

10											
Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit				
Before	13	15B	7.569	0.864	10,939						
After	13	15B	5.046	0.654	8,282	-2,657	\$83,280				
Before	15B	17A	8.133	1.110	13,121						
After	15B	17A	5.422	0.664	7,847	-5,274	\$165,284				

Table C-10. ALDOT project #2: ATHD and benefit calculations (2006)

Table C-11 shows the calculations of the AADT/C for the roadway being improved for both before and after ALDOT project #2 is completed (for year 2025).

	Table C-11. ALDOT project #2: AADT/C calculations (2025)										
Status	Beg. Exit	End Exit	AADT (pc)	AADTT	AADT (pce)	Capacity	AADT/C				
Before	13	15B	68,095	19,866	97,894	8,800	11.124				
After	13	15B	68,095	19,866	97,894	13,200	7.416				
Before	15B	17A	76,989	18,547	104,810	8,800	11.910				
After	15B	17A	76,989	18,547	104,810	13,200	7.940				

Table C-11. ALDOT project #2: AADT/C calculations (2025)

Table C-12 shows the calculations of the Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the calculations of improvement benefits (on a per-mile basis) for 2025.

Table C-12. ALDOT project #2: ATHD and benefit calculations (2025)									
Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit		
Before	13	15B	11.124	6.035	119,888				
After	13	15B	7.416	0.819	16,280	-103,608	\$3,247,083		
Before	15B	17A	11.910	8.654	160,497				
After	15B	17A	7.940	1.010	18,733	-141,764	\$4,442,875		

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Table C-13 shows the calculations of the AADT/C for the roadway being improved for both before and after ALDOT project #2 is completed (for year 2040).

Status	Beg. Exit	End Exit	AADT (pc)	AADTT	AADT (pce)	Capacity	AADT/C					
Before	13	15B	90,308	28,353	132,838	8,800	15.095					
After	13	15B	90,308	28,353	132,838	13,200	10.063					
Before	15B	17A	102,103	26,472	141,811	8,800	16.115					
After	15B	17A	102,103	26,472	141,811	13,200	10.743					

Table C-13. ALDOT project #2: AADT/C calculations (2040)

Table C-14 shows the calculations of the Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the calculations for improvement benefits (on a per-mile basis) for 2040.

Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit			
Before	13	15B	15.095	23.402	663,515					
After	13	15B	10.063	3.429	97,225	-566,290	\$17,747,526			
Before	15B	17A	16.115	28.021	741,782					
After	15B	17A	10.743	4.976	131,731	-610,052	\$19,119,015			

Table C-14. ALDOT project #2: ATHD and benefit calculations (2040)

ALDOT PROJECT #3

I-65 – Montgomery County

(Spring 2011)

Construction of additional lanes (grade, drainage, pavement, concrete pavement rubberization, bridge widening, lighting, signing, and signals) on I-65 from the north end of the Catoma Creek Bridge to the south end of the Mill Street Bridge, and bridge widening on I-65 from north of Fairview Avenue to the Alabama River Bridge in Montgomery.

This construction project was completed while we wrote the report. It addressed a major bottlenecking issue on I-65 in metropolitan Montgomery.

Figure B-2 is a map of this project.

Table C-15 describes the capacity increase brought by adding lanes.

			project "er capacity c	nango	
Beginning Exit	End Exit	Previous Thru Lanes	Finished Thru Lanes	Change in Capacity	New Capacity
167	168	4	6	+4,400	13,200
168	169	4	6	+4,400	13,200
169	170	4	6	+4,400	13,200
170	171	4	6	+4,400	13,200
171	173	4	6	+4.400	13.200

 Table C-15.
 ALDOT project #3: capacity change

Table C-16 shows the estimated capacity delay for this section of roadway before and after the project was completed.

	Table C-10. ALDOT project #5. AAD1/C calculations (2000)										
Status	Beg. Exit	End Exit	AADT	TADT	AADT (pce)	Capacity	AADT/C				
Before	167	168	68,010	0.16	73451	8,800	8.347				
After	167	168	68,010	0.16	73451	13,200	5.564				
Before	168	169	74,300	0.16	80244	8,800	9.119				
After	168	169	74,300	0.16	80244	13,200	6.079				
Before	169	170	75,430	0.14	80711	8,800	9.172				
After	169	170	75,430	0.14	80711	13,200	6.114				
Before	170	171	77,100	0.12	81726	8,800	9.287				
After	170	171	77,100	0.12	81726	13,200	6.191				
Before	171	173	75,130	0.12	79638	8,800	9.050				
After	171	173	75,130	0.12	79638	13,200	6.033				

Table C-16. ALDOT project #3: AADT/C calculations (2006)

Table C-17 shows the estimated Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the estimated project benefits (on a per-mile basis) for the current year.

Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit
Before	167	168	8.347	1.243	13,530		
After	167	168	5.564	0.666	7,246	-6,284	\$196,938
Before	168	169	9.119	1.955	23,236		
After	168	169	6.079	0.672	7,988	-15,248	\$477,863
Before	169	170	9.172	2.018	21,315		
After	169	170	6.114	0.673	7,103	-14,212	\$445,404
Before	170	171	9.287	2.165	20,026		
After	170	171	6.191	0.674	6,239	-13,787	\$432,095
Before	171	173	9.050	1.875	16,902		
After	171	173	6.033	0.671	6,051	-10,851	\$340,077

Table C-17. ALDOT project #3: ATHD and benefit calculations (2006)

Table C-18 shows the AADT/C capacity delay expected in 2025 on this section of roadway and the calculations for the future delay expected on the roadway section.

Status	Beg. Exit	End Exit	AADT (pc)	AADTT	AADT (pce)	Capacity	AADT/C
Before	167	168	81,689	17,077	107,305	8,800	12.194
After	167	168	81,689	17,077	107,305	13,200	8.129
Before	168	169	89,244	18,656	117,228	8,800	13.321
After	168	169	89,244	18,656	117,228	13,200	8.881
Before	169	170	92,759	16,572	117,617	8,800	13.366
After	169	170	92,759	16,572	117,617	13,200	8.910
Before	170	171	97,017	14,519	118,796	8,800	13.500
After	170	171	97,017	14,519	118,796	13,200	9.000
Before	171	173	94,538	14,148	115,760	8,800	13.155
After	171	173	94.538	14.148	115,760	13,200	8.770

Table C-18. ALDOT project #3: AADT/C calculations (2025)

Table C-19 shows the calculations of the Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the calculations of improvement benefits (on a per-mile basis) for 2025.

Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit		
Before	167	168	12.194	9.736	166,269				
After	167	168	8.129	1.108	18,922	-147,347	\$4,617,857		
Before	168	169	13.321	14.658	273,462				
After	168	169	8.881	1.693	31,592	-241,869	\$7,580,184		
Before	169	170	13.366	14.867	246,383				
After	169	170	8.910	1.724	28,564	-217,819	\$6,826,459		
Before	170	171	13.500	15.508	225,155				
After	170	171	9.000	1.819	26,408	-198,747	\$6,228,717		
Before	171	173	13.155	13.877	196,337				
After	171	173	8.770	1.585	22,421	-173,916	\$5,450,516		

Table C-19. ALDOT project #3: ATHD and benefit calculations (2025)

Table C-20 shows the calculations of the AADT/C for the roadway being improved for both before and after ALDOT project #2 is completed (for year 2040).

Status	Beg. Exit	End Exit	AADT (pc)	AADTT	AADT (pce)	Capacity	AADT/C		
Before	167	168	108,337	24,373	144,897	8,800	16.466		
After	167	168	108,337	24,373	144,897	13,200	10.977		
Before	168	169	118,357	26,627	158,298	8,800	17.988		
After	168	169	118,357	26,627	158,298	13,200	11.992		
Before	169	170	123,017	23,653	158,497	8,800	18.011		
After	169	170	123,017	23,653	158,497	13,200	12.007		
Before	170	171	128,665	20,723	159,750	8,800	18.153		
After	170	171	128,665	20,723	159,750	13,200	12.102		
Before	171	173	125,378	20,193	155,668	8,800	17.690		
After	171	173	125,378	20,193	155,668	13,200	11.793		

Table C-20. ALDOT project #3: AADT/C calculations (2040)

Table C-21 shows the estimated Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the improvement benefits (on a per-mile basis) estimated for 2040.

	Table C-21. ALDOT project #3. ATTID and benefit calculations (2040)										
Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit				
Before	167	168	16.466	29.386	716,236						
After	167	168	10.977	5.609	136,713	-579,523	\$18,162,253				
Before	168	169	17.988	33.184	883,597						
After	168	169	11.992	8.960	238,569	-645,028	\$20,215,175				
Before	169	170	18.011	33.210	785,504						
After	169	170	12.007	9.017	213,269	-572,235	\$17,933,859				
Before	170	171	18.153	33.346	691,020						
After	170	171	12.102	9.379	194,369	-496,650	\$15,565,024				
Before	171	173	17.690	32.758	661,483						
After	171	173	11.793	8.227	166,121	-495,362	\$15,524,641				

Table C-21. ALDOT project #3: ATHD and benefit calculations (2040)

ALDOT PROJECT #4

I-65 – Shelby/Jefferson Counties

(Summer 2011)

Road work from north of CR 17 to south of I-459 in Hoover and at I-459 consisting of additional lanes, grade, drain, base, pave, signing, and ramp modifications.

This construction project affects two bottlenecks identified in this report:

- Capacity Bottleneck #5
- Interchange Bottleneck #3

This project includes the construction of additional lanes on I-65 south of the I-459 interchange in Birmingham. This project is expected to be finished about the same time as this report.

Figure B-1 shows a map of this project.

Table C-22 describes the capacity increase expected from the additional lanes.

Table C-22. ALDOT project #4: capacity change								
Beginning Exit	End Exit	Previous Thru Lanes	Finished Thru Lanes	Change in Capacity	New Capacity			
247	250	4	6	+4,400	13,200			

Table C-23 shows the AADT/C capacity-delay estimates on this section of roadway with and without the improvement project.

	Table C-23. ALDOT project #4: AADT/C calculations (2006)										
Status	Beg. Exit	End Exit	AADT	TADT	AADT (pce)	Capacity	AADT/C				
Before	247	250	75,430	0.13	80333	8,800	9.129				
After	247	250	75,430	0.13	80333	13,200	6.086				

Table C-23. ALDOT project #4: AADT/C calculations (2006)

Table C-24 shows the estimated Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and estimated project benefits (on a per-mile basis) for the current year.

Та	Table C-24. ALDOT project #4: ATHD and benefit calculations (2006)										
Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit				
Before	247	250	9.129	1.967	19,284						
After	247	250	6.086	0.672	6,590	-12,694	\$397,822				

Table C-25 shows the calculations of the AADT/C for the roadway being improved for both before and after ALDOT project #2 is completed (for year 2025).

Table C-25. ALDOT project #4: AADT/C calculations (2025)									
Status	Beg. Exit	End Exit	AADT (pc)	AADTT	AADT (pce)	Capacity	AADT/C		
Before	247	250	93,837	15,389	116,921	8,800	13.286		
After	247	250	93,837	15,389	116,921	13,200	8.858		

Table C-26 shows the estimated Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the estimated project benefits (on a per-mile basis) for 2025.

Table C-26. ALDOT project #4: ATHD and benefit calculations (2025)								
Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit	
Before	247	250	13.286	14.494	223,042			
After	247	250	8.858	1.670	25,700	-197,342	\$6,184,712	

Table C-27 shows the calculations of the AADT/C for the roadway being improved for both before and after ALDOT project #2 is completed (for year 2040).

Table C-27. ALDOT project #4: AADT/C calculations (2040)										
Status	Beg. Exit	End Exit	AADT (pc)	AADTT	AADT (pce)	Capacity	AADT/C			
Before	247	250	124,448	21,963	157,393	8,800	17.886			

250 124,448 21,963 157,393 13,200 After 247 11.924

Table C-28 shows the calculations of the Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the calculations for benefit of improvements (on a per-mile basis) for 2040.

Table C-28. ALDOT project #4: ATHD and benefit calculations (2040)							
Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit
Before	247	250	17.886	33.057	726,028		
After	247	250	11.924	8.703	191,153	-534,875	\$16,762,983

In addition to the capacity-bottlenecking benefits seen for every other ALDOT construction project, this project also includes adding ramp lanes for one direction on the I-65 and I-459 interchange. Table C-29 is adapted from Table 4-33. It shows the benefits for the entire interchange with additional lanes between exits 247 and 250 and additional ramp lanes for Exit 250. It includes years 2006, 2025, and 2040.

Table C-29. ALDOT project #4 : ATHD and benefit calculations (interchange bottleneck #3	Table C-29. ALDOT project #4 : ATHD and benefit calculation	ns (interchange bottleneck #3)
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I able v	able C-29. AEDOT project #4 : ATTID and benefit calculations (interchange bottleneck #5)									
Year	ATHD, without Improvement	ATHD, with Improvement	Absolute Change in Freight Delay	Benefit						
2006	98,109 - 510,329	76,012	(-22,008) - (-434,531)	\$689,731 - \$13,618,201						
2025	746,520 - 1,609,696	311,152	(-435,367) - (-1,298,543)	\$13,644,401 - \$40,696,338						
2040	4,827,281	2,354,847	(-2,472,434)	\$77,486,081						

ALDOT PROJECT #5

I-65 – Shelby County

(Spring 2011)

Road and bridge work consisting of additional lanes, grade, drain, base, pave, bridge widening and raising, signing and traffic signals from CR 52 to CR 17.

Part of this planned project affects Capacity Bottleneck #4; the rest of this project was completed and built into the GIS database. This project includes the construction of additional lanes on a roughly five-mile-long section of I-65 south of I-459 south of Birmingham.

Table C-30 describes the increased capacity expected from the additional lanes.

Table C-30. ALDOT project #5: capacity change									
Beg. Exit	End Exit	Current Thru Lanes	Finished Thru Lanes	Change in Capacity	New Capacity				
242	246	4	6	+4,400	13,200				
246	247	4	6	+4,400	13,200				

Table C-31 shows the estimated AADT/C capacity delay on this section of roadway with and without the construction project.

	Table C-ST. ALDOT project #5: AADT/C calculations (2006)									
Status	Beg. Exit	End Exit	AADT	TADT	AADT (pce)	Capacity	AADT/C			
Before	242	246	68,010	0.16	73451	8,800	8.347			
After	242	246	68,010	0.16	73451	13,200	5.564			
Before	246	247	74,300	0.14	79501	8,800	9.034			
After	246	247	74,300	0.14	79501	13,200	6.023			

Table C-31 ALDOT project #5: AADT/C calculations (2006)

Table C-32 shows the estimated Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the estimated project benefits (on a per-mile basis) for the current year.

Id	Table C-52. ALDOT project #5. ATHD and benefit calculations (2000)									
Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit			
Before	242	246	8.347	1.243	13,530					
After	242	246	5.564	0.666	7,246	-6,284	\$196,938			
Before	246	247	9.034	1.857	19,318					
After	246	247	6.023	0.671	6,979	-12,339	\$386,701			

Table C-32, AI DOT project #5: ATHD and benefit calculations (2006)

Table C-33 shows the calculations of the AADT/C for the roadway being improved for both before and after ALDOT project #2 is completed (for year 2025).

	Table C-33. ALDOT project #5: AADT/C calculations (2025)									
Status	Beg. Exit	End Exit	AADT (pc)	AADTT	AADT (pce)	Capacity	AADT/C			
Before	242	246	81,689	17,077	107,305	8,800	12.194			
After	242	246	81,689	17,077	107,305	13,200	8.129			
Before	246	247	91,369	16,324	115,855	8,800	13.165			
After	246	247	91,369	16,324	115,855	13,200	8.777			

Table C-34 shows the estimated Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the estimated project benefits (on a per-mile basis) for 2025.

	Table C-34. ALDOT project #5: ATHD and benefit calculations (2025)									
Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit			
Before	242	246	12.194	9.736	166,269					
After	242	246	8.129	1.108	18,922	-147,347	\$4,617,857			
Before	246	247	13.165	13.927	227,351					
After	246	247	8.777	1.592	25,980	-201,371	\$6,310,963			

Table C-34. ALDOT project #5: ATHD and benefit calculations (2025)

Table C-35 shows the calculations of the AADT/C for the roadway being improved for both before and after ALDOT project #2 is completed (for year 2040).

	Table C-55. ALDOT project #5. AAD1/C calculations (2040)									
Status	Beg. Exit	End Exit	AADT (pc)	AADTT	AADT (pce)	Capacity	AADT/C			
Before	242	246	108,337	24,373	144,897	8,800	16.466			
After	242	246	108,337	24,373	144,897	13,200	10.977			
Before	246	247	121,175	23,298	156,122	8,800	17.741			
After	246	247	121,175	23,298	156,122	13,200	11.827			

Table C-35. ALDOT project #5: AADT/C calculations (2040)

Table C-36 shows the estimated Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the estimated project benefits (on a per-mile basis) for 2040.

Table C-30. ALDOT project #5. ATHD and benefit calculations (2040)										
Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit			
Before	242	246	16.466	29.386	716,236					
After	242	246	10.977	5.609	136,713	-579,523	\$18,162,253			
Before	246	247	17.741	32.844	765,193					
After	246	247	11.827	8.351	194,553	-570,640	\$17,883,862			

Table C-36. ALDOT project #5: ATHD and benefit calculations (2040)

ALDOT PROJECT #6

I-20 – St. Clair County

(Summer 2013)

Road and bridge work consisting of additional lanes, grade, drain, base, pave, bridge widening and raising, signing and traffic signals from west of Kelly Creek in Moody to end of median barrier.

This planned project does not affect the bottlenecks identified in this report. This project includes the construction of additional lanes on a roughly eight-mile-long section of I-20 between Birmingham and Atlanta, GA.

Table C-37 describes the increased capacity expected from additional lanes.

Table C-57. ALDOT project #6. capacity change											
Beginning Exit	End Exit	Current Thru Lanes	Finished Thru Lanes	Change in Capacity	New Capacity						
147	152	4	6	+4,400	13,200						
152	153	4	6	+4,400	13,200						
153	(Part.) 156	4	6	+4,400	13,200						

Table C-37. ALDOT project #6: capacity change

Table C-38 shows the estimated AADT/C capacity delay for this section of roadway with and without the project.

Status	Beg. Exit	End Exit	AADT	TADT	AADT (pce)	Capacity	AADT/C			
Before	147	152	51,180	0.28	58,346	8,800	6.630			
After	147	152	51,180	0.28	58,346	13,200	4.420			
Before	152	153	50,350	0.28	57,399	8,800	6.523			
After	152	153	50,350	0.28	57,399	13,200	4.348			
Before	153	(Part.) 156	49,920	0.28	56,969	8,800	6.467			
After	153	(Part.) 156	49,920	0.28	56,969	13,200	4.311			

Table C-38. ALDOT project #6: AADT/C calculations (2006)

Table C-39 shows the estimated Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the estimated project benefits (on a per-mile basis) for the current year.

Table C-39. ALDOT project #6: ATHD and benefit calculations (2006)											
Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit				
Before	147	152	6.630	0.695	9,959						
After	147	152	4.420	0.614	8,793	-1,166	\$36,535				
Before	152	153	6.523	0.688	9,696						
After	152	153	4.348	0.607	8,551	-1,145	\$35,885				
Before	153	(Part.) 156	6.467	0.685	9,570						

0.603

8,424

-1,146

\$35,914

Table C-39. ALDOT project #6: ATHD and benefit calculations (2006)

Table C-40 shows the calculations of the AADT/C for the roadway being improved for both before and after ALDOT project #2 is completed (for year 2025).

4.311

(Part.) 156

153

After

Table C-40. ALDOT project #6: AADT/C calculations (2025)										
Status	Beg. Exit	End Exit	AADT (pc)	AADTT	AADT (pce)	Capacity	AADT/C			
Before	147	152	52,692	22,489	86,426	8,800	9.821			
After	147	152	52,692	22,489	86,426	13,200	6.547			
Before	152	153	51,838	22,124	85,024	8,800	9.662			
After	152	153	51,838	22,124	85,024	13,200	6.441			
Before	153	(Part.) 156	51,395	21,935	84,298	8,800	9.579			
After	153	(Part.) 156	51,395	21,935	84,298	13,200	6.386			

Table C-40. ALDOT project #6: AADT/C calculations (2025)

Table C-41 shows the estimated Annual Truck Hours of Delay (ATHD) for each section (on a per-mile basis) and the estimated project benefits (on a per-mile basis) for 2025.

	rable of the Acborn project were Arrib and benefit dalcalations (2020)										
Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit				
Before	147	152	9.821	2.979	67,006						
After	147	152	6.547	0.689	15,501	-51,505	\$1,614,154				
Before	152	153	9.662	2.712	59,994						
After	152	153	6.441	0.683	15,119	-44,875	\$1,406,380				
Before	153	(Part.) 156	9.579	2.581	56,625						
After	153	(Part.) 156	6.386	0.681	14.935	-41.690	\$1.306.557				

Table C-41. ALDOT project #6: ATHD and benefit calculations (2025)

Table C-42 shows the calculations of the AADT/C for the roadway being improved for both before and after ALDOT project #2 is completed (for year 2040).

Table C-42. ALDOT project #6: AADT/C calculations (2040)

Status	Beg. Exit	End Exit	AADT (pc)	AADTT	AADT (pce)	Capacity	AADT/C
Before	147	152	69,881	32,097	118,027	8,800	13.412
After	147	152	69,881	32,097	118,027	13,200	8.941
Before	152	153	68,748	31,576	116,112	8,800	13.195
After	152	153	68,748	31,576	116,112	13,200	8.796
Before	153	(Part.) 156	68,160	31,307	115,121	8,800	13.082
After	153	(Part.) 156	68,160	31,307	115,121	13,200	8.721

1	Table C-43 shows the estimated Annual Truck Hours of Delay (ATHD) for each section (on a
	per-mile basis) and the estimated project benefits (on a per-mile basis) for 2040.

Table C-43.	ALDOT	project #6:	ATHD and	benefit	calculations	(2040)
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Status	Beg. Exit	End Exit	AADT/C	Delay	ATHD	Change	Benefit
Before	147	152	13.412	15.089	484,315		
After	147	152	8.941	1.756	56,366	-427,949	\$13,411,931
Before	152	153	13.195	14.063	444,059		
After	152	153	8.796	1.610	50,839	-393,220	\$12,323,513
Before	153	(Part.) 156	13.082	13.542	423,970		
After	153	(Part.) 156	8.721	1.540	48,213	-375,757	\$11,776,221

Appendix D Alabama Congestion GIS Maps

In addition to the GIS maps in the text, which show the locations of capacity and interchange bottlenecks and identify roadway sections that almost qualify as roadway-geometry bottlenecks, there is much information that can be presented in GIS format that gives a more comprehensive view of interstate congestion in Alabama.

In Appendix D, a series of maps are presented that include the following:

- NHPN urban codes
- Thru-lanes across the state
- AADTT across the state
- TADT across the state
- AADT/C ratios across the state
- AADT/C ratios in Birmingham area
- AADT/C ratios in Mobile area
- AADT/C ratios in Montgomery area
- ATHD across the state
- ATHD in Birmingham area

In the National Highway Planning Network database, each section of roadway is assigned an "urban code." These codes tell which urban area a section of roadway is in. Figure D-1 shows the roadways assigned to each of Alabama's urban areas.



Figure D-1. NHPN urban codes (GIS)

The number of thru-lanes on a section of roadway helps determine the capacity of the roadway. Figure D-2 shows the number of thru-lanes for each segment of roadway across the state.

Figure D-2 shows that most of the roadway sections with more than four thru-lanes are in urban areas. The main exception is Interstate 20/59 between Birmingham and Tuscaloosa, much of which has six lanes.



Figure D-2. Thru-lanes across the state (GIS)

Figure D-3 shows the Average Annual Daily Truck Traffic for every section of roadway in the state. This map shows that Interstate 20 is the main route for freight shipments across Alabama. Interstate 10 also has a substantial amount of freight traffic every day.



Figure D-3. AADTT across the state (GIS)

Figure D-4 shows the percentage of traffic that trucks comprise on interstate roadway in Alabama. Inside urban areas, passenger cars are a larger portion of the traffic flow. Outside urban areas, freight vehicles are a larger percentage. This is because intercity trips are more common for freight traffic and intra-city trips are more common for passenger-car traffic.



Figure D-4. TADT across the state (GIS)

Figure D-5 shows the Average Annual Daily Traffic to Capacity ratios statewide. This ratio is the sole factor in the equations used in this report to determine delay. This map shows that Birmingham has the majority of the worst traffic in the state.



Figure D-5. AADT/C across the state (GIS)



Figure D-6 focuses on metropolitan Birmingham. The main areas of concern here are the I-65 corridor that runs north-south through Birmingham and I-20/59 near the intersection with I-65.

Figure D-6. AADT/C in the Birmingham area (GIS)



Figure D-7 focuses on metropolitan Mobile. The main areas of concern here are I-10 west of Mobile, where there is a large freight flow, and I-10 in the George C. Wallace Tunnel.

Figure D-7. AADT/C in the Mobile area (GIS)

Figure D-8 focuses on metropolitan Montgomery. This map shows that Montgomery does not have many areas of concern for high values of AADT/C, partly thanks to a recently completed ALDOT project that added lanes to the I-65 corridor, which runs north-south through the city.



Figure D-8. AADT/C in the Montgomery area (GIS)

Figure D-9 shows the Annual Truck Hours of Delay for Alabama interstate. The areas with highest total hours of delay are in metropolitan Birmingham.



Figure D-9. ATHD across the state (GIS)



Figure D-10 focuses on metropolitan Birmingham because the roadways with highest annual truck delay are in this area.

Figure D-10. ATHD in the Birmingham area (GIS)

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