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Louisville / Jefferson County Hazardous Material Commodity Flow Analysis

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Final Report

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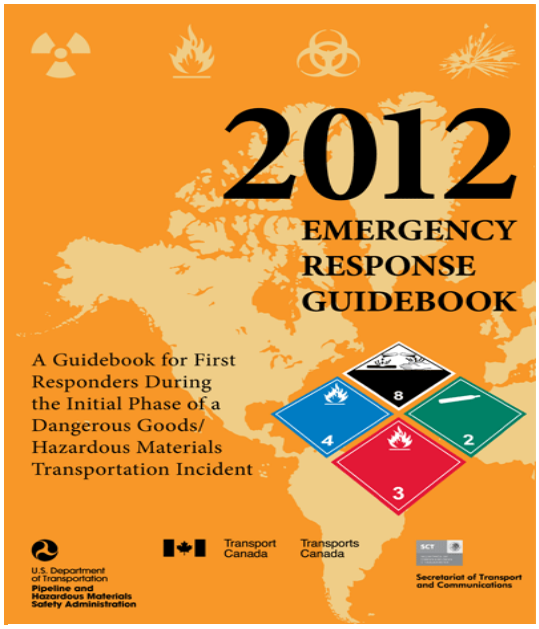

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Louisville/ Jefferson County Hazardous Material Commodity Flow Analysis

This project was completed by Western Kentucky University in partnership with

Louisville / Jefferson County, KY Emergency Management Agency

and the

Louisville / Jefferson County Local Emergency Planning Committee

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Louisville / Jefferson County Hazardous Material Commodity Flow Analysis

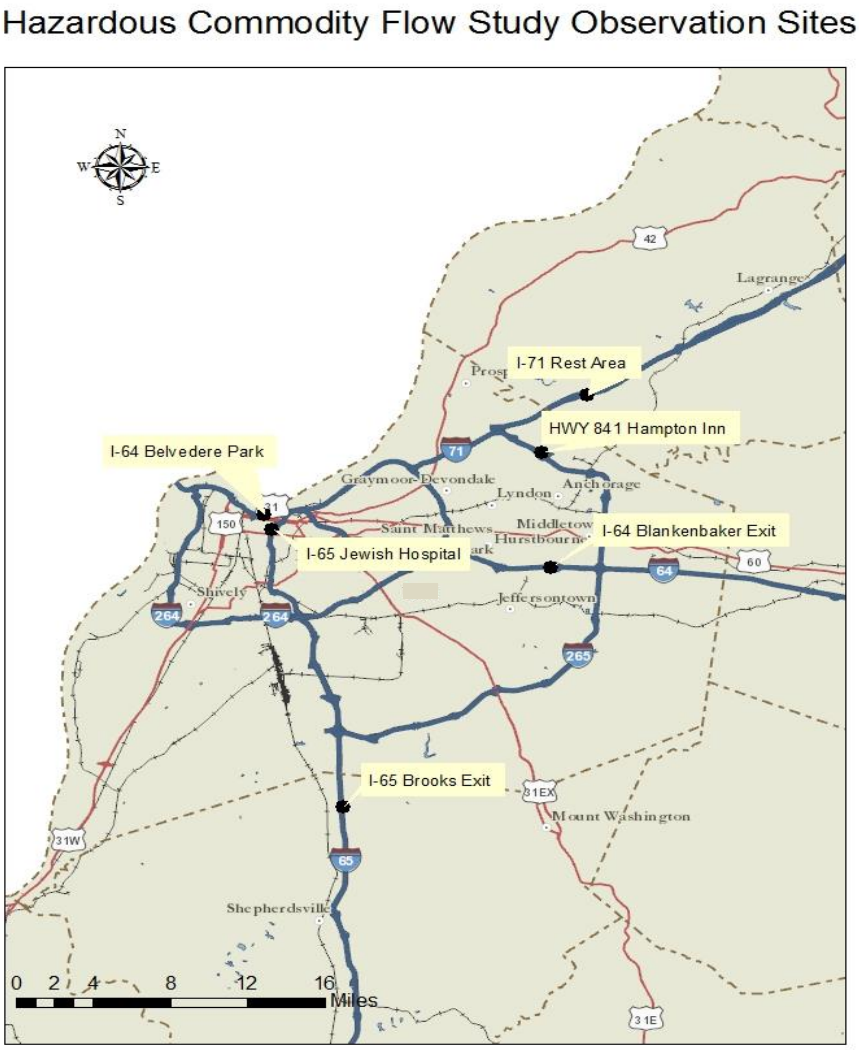
Chapter 1: Introduction

This report presents the results of a Hazardous Material Commodity Flow Analysis for the Louisville Metro area and Jefferson County. Study components were conducted by Western Kentucky University in partnership with Louisville / Jefferson County Emergency Management Agency. The study area was focused in Louisville and Jefferson County, Louisville Metro area, and included monitoring in Bullet County and Oldham County, as shown in Figure 1.1. As part of the study, hazardous material transport was monitored at the following sites:

- Interstate-64 (I-64), East and West bound lanes at The Belvedere
- I-64, East and West bound lanes at Blankenbaker exit location
- Interstate-65 (I-65), North and South bound lanes at the Jewish Hospital
- I-65, North and South bound lanes at Brooks, KY exit location
- Interstate-71 (I-71), North and South bound lanes at Oldham County rest areas
- Hwy 841, North and South bound Lanes at Westport Road

The purpose of this report is to present information on patterns of hazardous material commodity flow along I-64, I-65, I-71 and Highway 841, as observed from June 11, 2012 to August 2, 2012. This report also summarizes incidents involving hazardous materials over the previous 3 years, August 2008 to June 2011, in the Louisville Metro area. Finally, this report assesses survey information collected from fixed facilities that ship and receive hazardous materials in the Louisville Metro Area.

Figure 1.1 Location Sampling Sites within the Louisville Metro Area



The results obtained through this commodity flow analysis can serve as a source of information to increase hazardous material incident preparedness of the Louisville/Jefferson County Emergency Management Agency and community. Data collected will aid in the emergency planning and response process for specific hazardous material incidents. A critical

use of the information can be to forecast the risk of specific events to aid in development of contingency plans for emergency response.

i. Background

Commodity flow studies have a primary goal of identifying the transport of specific goods through the transportation system of a specific area (Taylor et al., 2010). Commodity, as defined by the EPA, is any physical good moving or any good being transported (U.S. EPA, 2010). In this particular study, hazardous materials are the commodities of interest and are defined in the following ways:

- U.S. Department of Transportation: "Any substance or material in any form or quantity which poses an unreasonable risk to safety and health and to property when transported in commerce," (U.S. DOT, 1991).
- U.S. EPA: "Any material, which when discharged into the environment, may be harmful to the public health or welfare of the United States," (U.S. EPA, 2010).

According to the U.S. EPA, a material is considered hazardous if it displays one or more of the following characteristics (U.S. EPA, 2010):

- Ignitability: Can create fires under certain conditions. e.g. fuels which catch fire, and friction-sensitive substances.
- Corrosivity: Is acidic and capable of corroding metal.
- Reactivity: Can create explosions or toxic fumes, gases, or vapors when exposed or mixed with water.
- Toxicity: Is harmful or fatal when ingested, breathed, or absorbed by the skin.

Hazardous material categories include:

- Explosive Substances: will release pressure, gas, and heat when exposed to sudden shock, heat, or high pressure. e.g. Explosives, fuel, ammonium nitrate.
- Flammable and Combustible Substances: either liquid or solid, that can be easily ignited. e.g. petroleum substances.
- Toxic Materials (Poisons): can cause injury or death when they enter the bodies of living organisms; can be classified by chemical nature or toxic action. e.g. heavy metals, cyanides, irritants.
- Oxidizers: supply oxygen to support normally non-flammable materials. e.g. fertilizers (oxides).
- Radioactive Materials: emit harmful rays and particles with their decay. e.g. plutonium, cobalt.
- Etiological Materials: cause disease or infection. e.g. microbes which cause rabies, botulism, tetanus.

ii. Interstates 64, 65, 71, and Hwy 841 within the Louisville Metro Area

Interstates were studied as part of the hazardous material commodity flow analysis. These roadways are part of the United States Interstate Highway System. One of the interstates studied, I-64, extends East to West across Kentucky for roughly 191 miles connecting through Louisville, Lexington and Frankfort. I-65, a major interstate highway in the U.S. running North/South, begins Southeast of Chicago and ends in Mobile, Alabama. In Kentucky, I-65 extends 137 miles, running through the cities of Louisville, Elizabethtown and Bowling Green. Interstate 71 runs North/South beginning outside of Cleveland, OH and its southern terminus ends at “Spaghetti Junction” in Louisville, KY. I-71 spans 97 miles in Kentucky. KY Hwy 841

spans 24 miles around the Louisville Metro area. Hwy 841 crosses both residential and industrial areas of the metro region.

A similar study, entitled Madison County, Kentucky: Hazardous Materials Commodity Flow Analysis was used as a basis for this study (Golla et al., 2011), as well as an earlier study conducted in Warren County, Kentucky (Taylor et al., 2010). The primary sources of data collection for the current study were a placard survey, transportation incident reports and a fixed facility survey. Data were collected on hazardous materials transported by motor vehicles via I-64, I-65, I-71, and Hwy 841.

iii. Data Collection Methods:

ROADWAY PLACARD SURVEY

Monitoring stations were established, as identified by WKU Faculty and Louisville / Jefferson County Emergency Management Agency. A total of eight locations included the major interstates and Hwy 841. The first monitoring station was set up at The Belvedere, in downtown Louisville, which served to monitor both east and westbound lanes on I-64. Jewish Medical Center served as the location to monitor the north and southbound lanes on I-65 in the northern corridor of the study area. A third monitoring station was delineated at Bluegrass Harley Davidson, Blankenbaker exit, to observe the westbound lane on East I-64. In conjunction with this site, a fourth station was founded at Microtel Inn, which served to monitor the eastbound lane on East I-64. In respect to I-71, the fifth and sixth monitoring stations were created at the Oldham County rest areas. These locations served to monitor the north and southbound lanes on I-71. A seventh monitoring station was developed at the Holiday Inn Express, Brooks, KY exit, which served to monitor the north and southbound lanes on South I-65. An eighth monitoring

station, at Hampton Inn near Westport Road, functioned to monitor the north and southbound lanes on Hwy 841.

With all necessary safety precautions, a team of two observers monitored each site for a five-day period. A typical monitoring day consisted of an 8-hour observation period. Observation times were adjusted as needed to avoid excessive heat. The monitoring periods totaled 537.5 observation hours. Monitoring dates and times for each site are presented in the list below:

- West I-64, east and westbound, at The Belvedere, June 11–15, 2012, Observation period 08:00 to 16:00 each day
- North I-65, north and southbound, at Jewish Medical Center, June 18–22, 2012, Observation period 07:00 to 15:00 each day
- East I-64, westbound, at Bluegrass Harley Davidson near Blankenbaker exit, June 25-29, 2012, Observation period 08:00 to 16:00 each day
- East I-64, eastbound, at Microtel Inn near Blankenbaker exit, June 25-29, 2012, Observation period 08:00 to 16:00 each day
- I-71, north and southbound, at Oldham County rest areas, July 9-13, 2012, Observation period 07:00 to 15:00 each day
- South I-65, north and southbound, at Holiday Inn Express near Brooks, KY exit, July 16-20, 2012, Observation period 8:00 to 17:00 each day
- Hwy 841, north and southbound, at Hampton Inn near Westport Road, July 23-27, 2012, Observation period 08:00 to 17:00 each day

During the monitoring hours the observers recorded the following variables: time of day, date, number of placarded vehicles, day of the week, location, Hazmat ID number, type of hazardous material transported and the state listed on the license plate, if possible.

TRANSPORTATION INCIDENT REPORTS

A complete history of transportation incidents for the previous three years, August 2008-June 2011, was obtained by Louisville / Jefferson County Emergency Management from the KY Department of Transportation. These were incidents involving commercial motor vehicles carrying hazardous material on I-64, I-65, I-71 and Hwy 841. This information was used to document the recent history of recorded incidents involving hazardous materials.

FIXED FACILITY SURVEY

A survey was administered to industries and facilities in the study area to assess transport of hazardous material. The fixed facility survey consisted of 35 response items designed to collect data from Metro Louisville area facilities that ship and receive hazardous materials. General information on the facility, trends in hazardous materials shipped and received, and frequency of specific hazardous materials shipped and received were the topics of interest.

iv. Report Organization

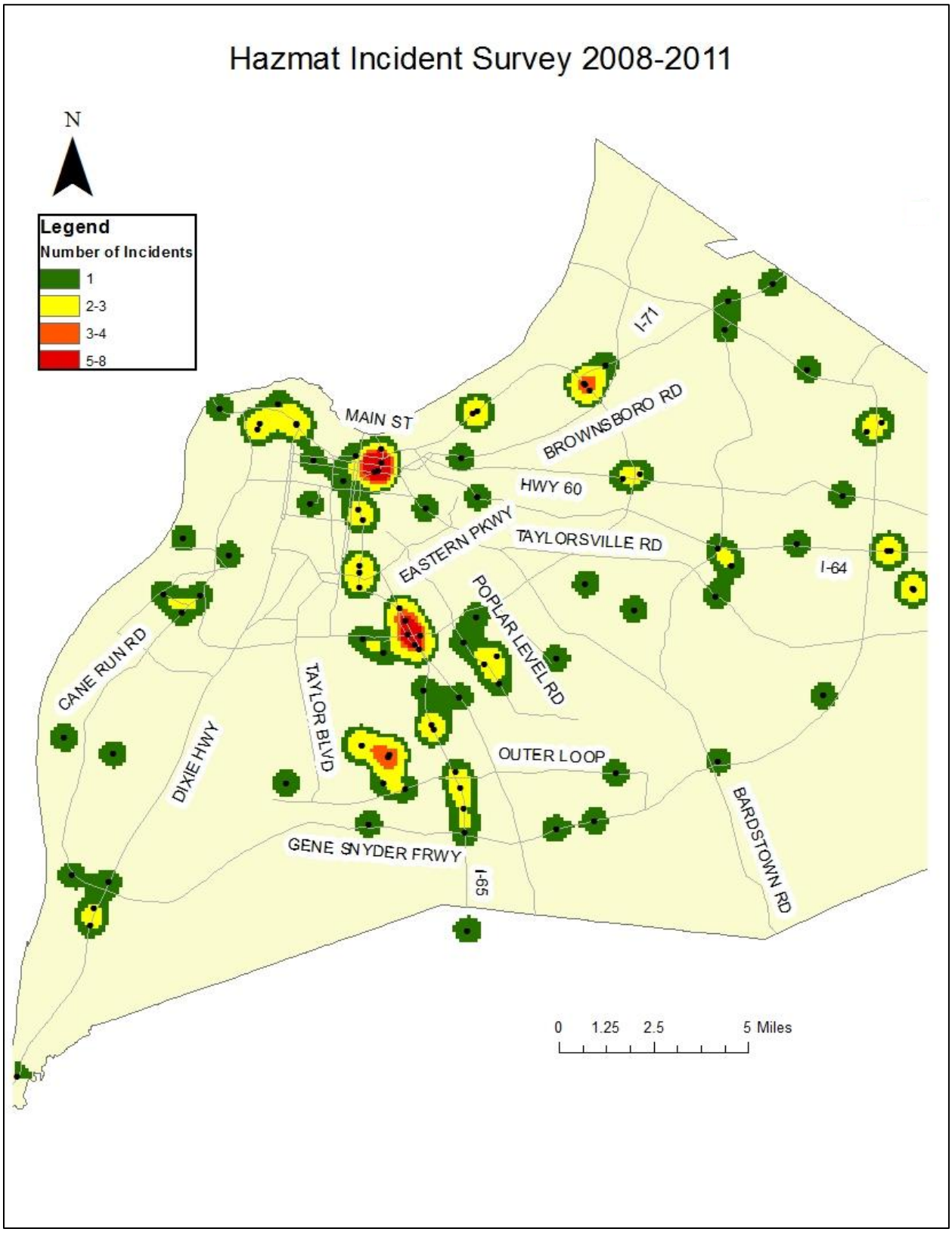
The first chapter of the report provides an introduction to the study, a description of methods, and other pertinent information. In the second chapter, a detailed summary of transportation incident reports is provided. Results from the placard survey are presented in the third, fourth, fifth and sixth chapters of this report. Chapter seven illustrates the results of the fixed facility survey, as well as describing the appropriate responses for incidents involving these materials. Chapter eight includes the summary of results and recommendations. Appendices include a copy of the survey that was sent to fixed facilities, a list of placard IDs observed, and a list of the most common roads used by facilities to reach/leave I-64, I-65, I-71 and Hwy 841.

Chapter 2: Analysis of Incident Reports for I-64, I-65, I-71 and Hwy 841 from August 2008 to June 2011

Analysis of incident reports indicates the history of accidents that took place between 2008 and 2011. This includes the patterns of occurrence and the identification of challenges in incident preparedness. Results of this analysis of the data provides emergency responders with information regarding the types of hazardous material commonly involved in commercial motor vehicle incidents. It also provides the most likely types of incidents such as spills, leaks, vehicle crashes, etc. A hotspot map of the data, utilizing ESRI ArcGIS Spatial Analyst software (2010), was created to elucidate areas that have a reoccurrence of incidents. Lastly the evaluation of incident data enables emergency responders to take certain precautions that are material specific.

Incident report data consisted of incidents, which were reported between 2008 and 2011 in the Louisville Metro Area. A total of 101 incidents were reported that required emergency response consisting of vehicle crashes, leaks, and spills. A hotspot map was produced through density analysis of incidents that occurred (Figure 2.1). This analysis creates a density surface based upon the number of incidents that occur in a defined area. The density model in the ArcGIS Spatial Analyst system was confined to create a layer spatially related to each transportation corridor. Density was color coded, in much the same way as the radar image of a storm, to provide a more accurate view of high-density incident areas. As shown in Figure 2.1, greater incident densities, areas with multiple incidents, primarily occurred near junctions of major highways. There is one hotspot in the southern portion of the study area that is not related to a roadway. These incidents were associated with a rail yard near Outer Loop.

Figure 2.1 Density map of hazmat incidents in the Louisville Metro Area from 2008-2009



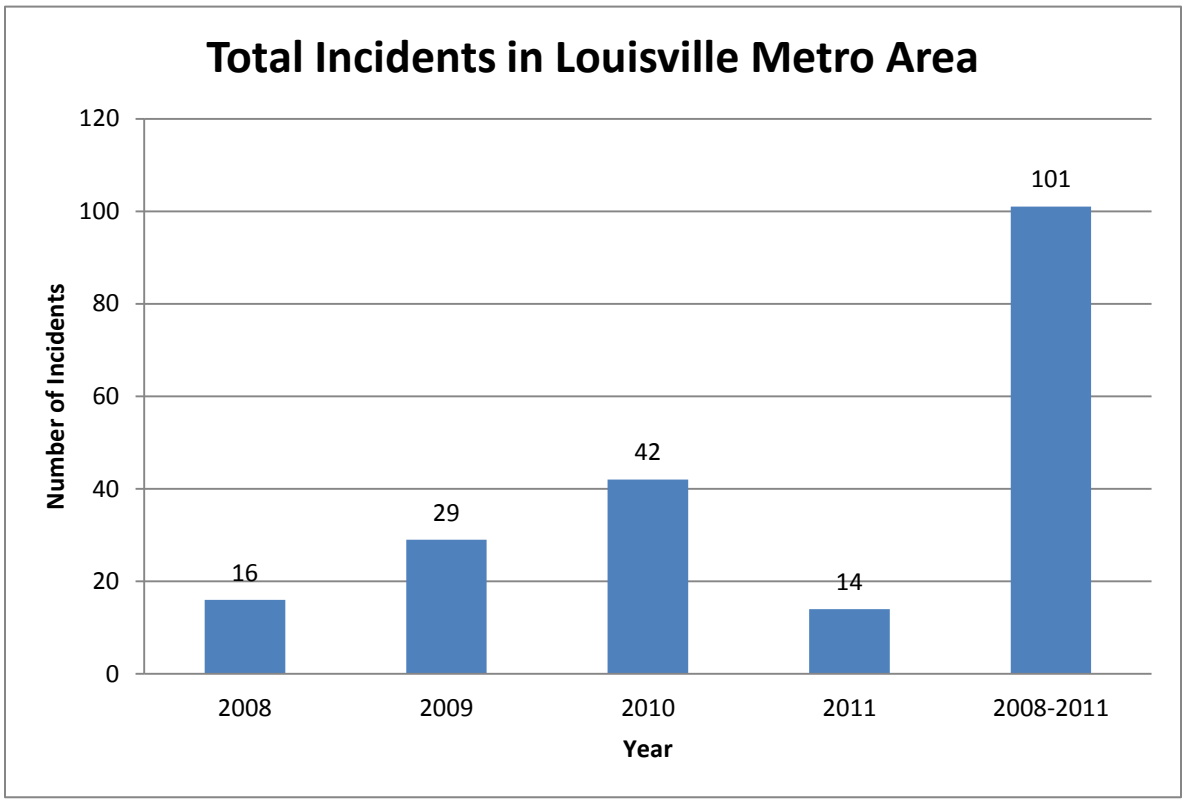
i. Comparison of Total Incidents from 2008-2011 to Hazardous Material Incidents from 2008 to 2011

To further evaluate the density of incidents, data were tabulated (Table 2.1) for the years 2008 to 2011. As presented in Figure 2.1, hazardous material incidents occurred along the I-65 corridor from near the Brooks, KY exit, to the interchange near Hospital Curve. Incidents in the Louisville Metro area increased from 16 in 2008 to 42 in 2010. Other problematic areas for hazardous material incidents include the rail yard proximate to Outer Loop, and the I-71/ Watterson interchange. The minimum number of incidents occurred in 2011 with a total of 14, while the maximum number occurred in 2010, with 42 incidents (Figure 2.2). An average of about 25 incidents per year occurred during the period of the incident data reviewed. Data were somewhat variable with a sample standard deviation of about 13. This indicates that from year to year incidents may vary considerably, as in the years 2010 to 2011. A note to make is that data for 2008 and 2011 do not represent entire annual periods. Therefore, if the data was analyzed for the entire year in 2008 and 2011, we would likely observe less variability.

Table 2.1: Frequency of incidents from the year 2008 - 2011

Year	Frequency
2008	16
2009	29
2010	42
2011	14
2008-2011	101

Figure 2.2: Total number of incidents in Louisville Metro Area



The type of emergency and hazardous material ultimately determines the appropriate emergency response. Four types of incidents were reported between 2008 and 2011 (Figure 2.3). Spills accounted for 54.46% of all incidents reported, followed by vehicle crashes (38.61%), while leaks and unspecified accounted for 6.93%. Numerous classes of materials were identified in the incident reports. As shown in Figure 2.3, the most common material classes identified were flammable products, such as diesel (44.55%), fuel (11.88%), and gasoline (7.92%). Unspecified materials accounted for 7.92% of reported incidents, while hydraulic fluid accounted for 3.96%. A combination of other materials accounted for 16.83%. A list of these materials can be found in Appendix 10, Table 1.

Figure 2.3: Types of incident occurrence from the year 2008 -2011

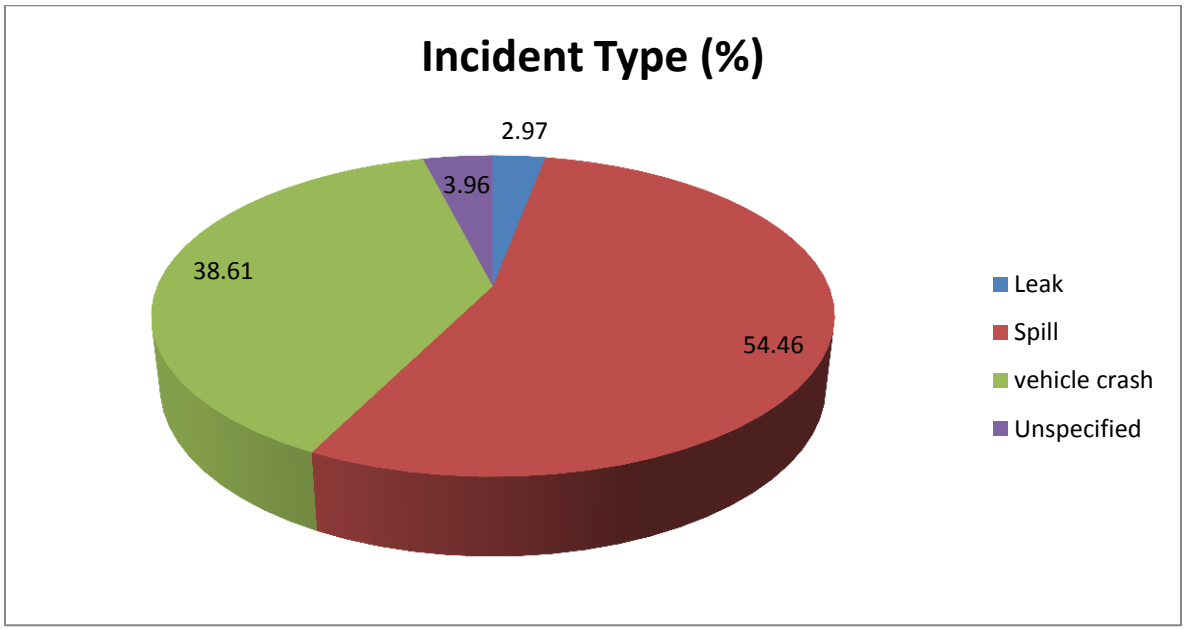
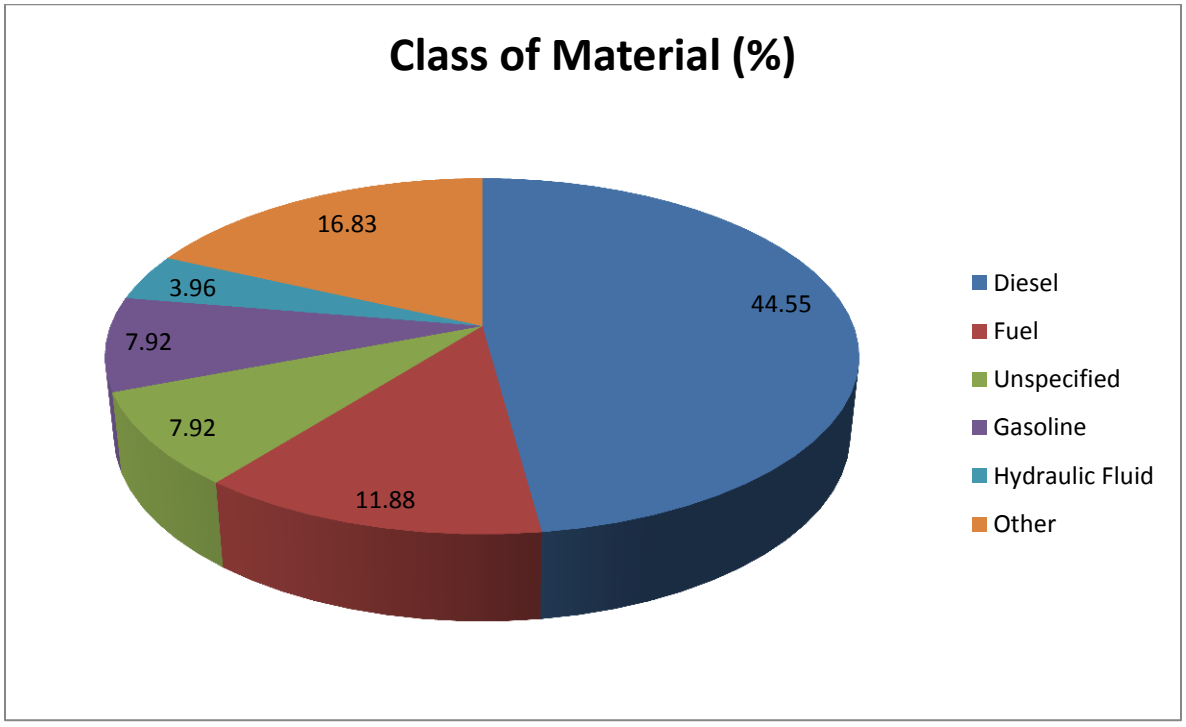


Figure 2.4: Various classes of materials identified in the incidents from the year 2008-2011



Chapter 3: Analysis of the I-64 Placard Survey

The placard survey for I-64 was conducted at three separate locations: East I-64, Blankenbaker Exit at Bluegrass Harley Davidson and Microtel Inn, and West I-64 at The Belvedere. The East I-64 eastbound monitoring station was located at Microtel Inn, Blankenbaker Exit. The East I-64 westbound monitoring station was located at Bluegrass Harley Davidson near the Blankenbaker Exit. The Belvedere in downtown Louisville was the monitoring location for both eastbound and westbound traffic of West I-64.

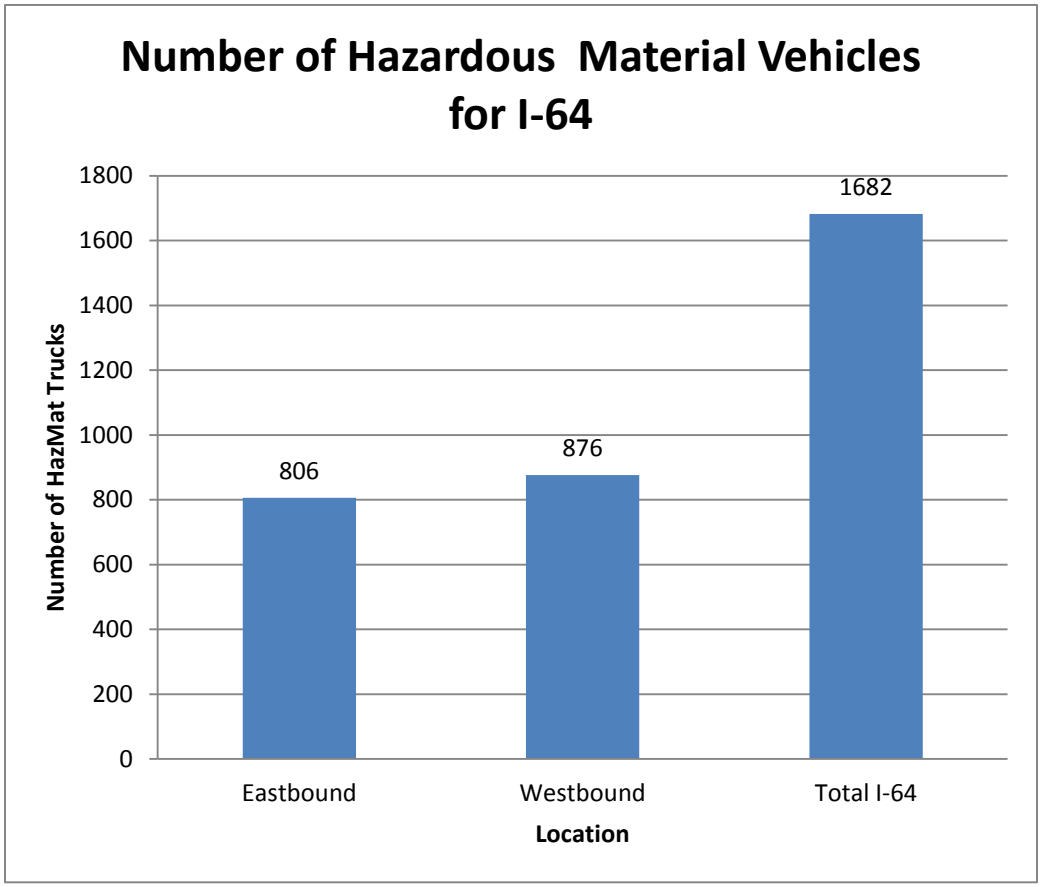
In total, the survey administered for this location included 169.5 monitoring hours. This survey was carried out during the month of June. Hours of observation were selected to note daily and temporal differences in the transportation of hazardous materials through the Louisville Metro area via I-64. Each observation period was conducted in shifts by graduate students of Western Kentucky University, Department of Public Health, Environmental Health Science program. Two observers were located at each monitoring site in order to avoid personal bias. At each of the three monitoring sites, both east and westbound lanes were monitored. Placard observations at monitoring sites consisted of recording the date, time, placard ID number, any other number on the placard, i.e. class number, state on the license plate, when possible, and Department of Transportation number, when possible, was noted.

i. Aggregate hazardous material truck frequencies on I-64

During the I-64 monitoring period, June 11-15, 2012 and June 25-29, 2012 the total number of placarded vehicles observed, on both eastbound and westbound lanes, was 1682 (Figure 3.1). Overall, there were a greater total number of vehicles transporting hazardous material on the westbound lane of I-64 (876) compared to the eastbound lane (807), representing

a 7.9% difference between westbound and eastbound lanes. Similarly, the average number of vehicles transporting hazardous material per hour was greater in the westbound lane (10.34 vehicles/hour) compared to the eastbound lane (9.51 vehicles/hour).

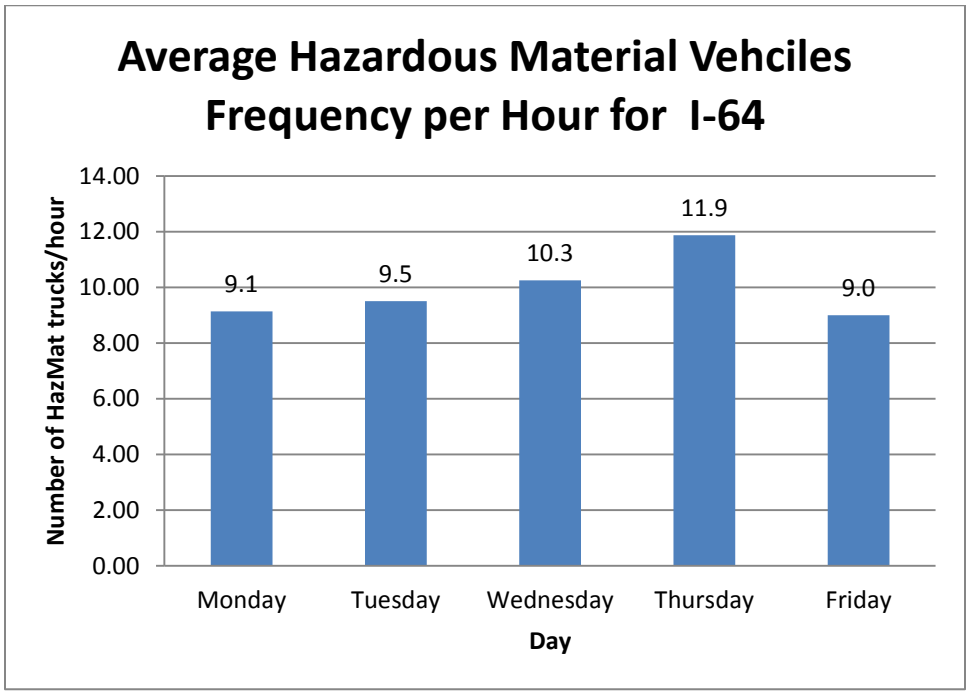
Figure 3.1: Placarded commercial vehicles observed on I-64



ii. Placarded vehicle frequencies by day of the week

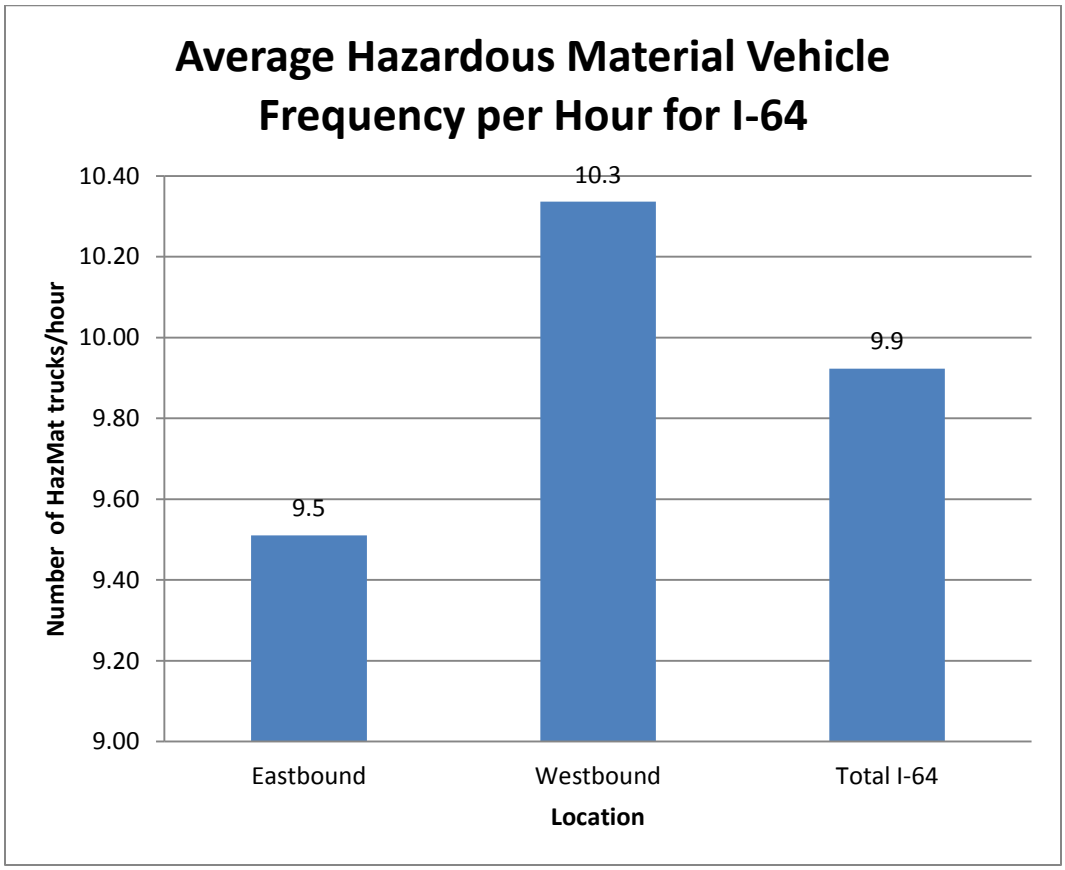
Hazardous material transportation frequency displayed differences throughout the week (Figure 3.2). Total hazardous material transport across I-64 peaked on Thursday, with an average of 11.9 vehicles/ hour. This peak is seen in both eastbound and westbound lanes of traffic (Figure 3.2). The lowest average rate was seen on Friday, with only 9.0 vehicles/ hour.

Figure 3.2: Placarded vehicle frequency per hour by day of the week



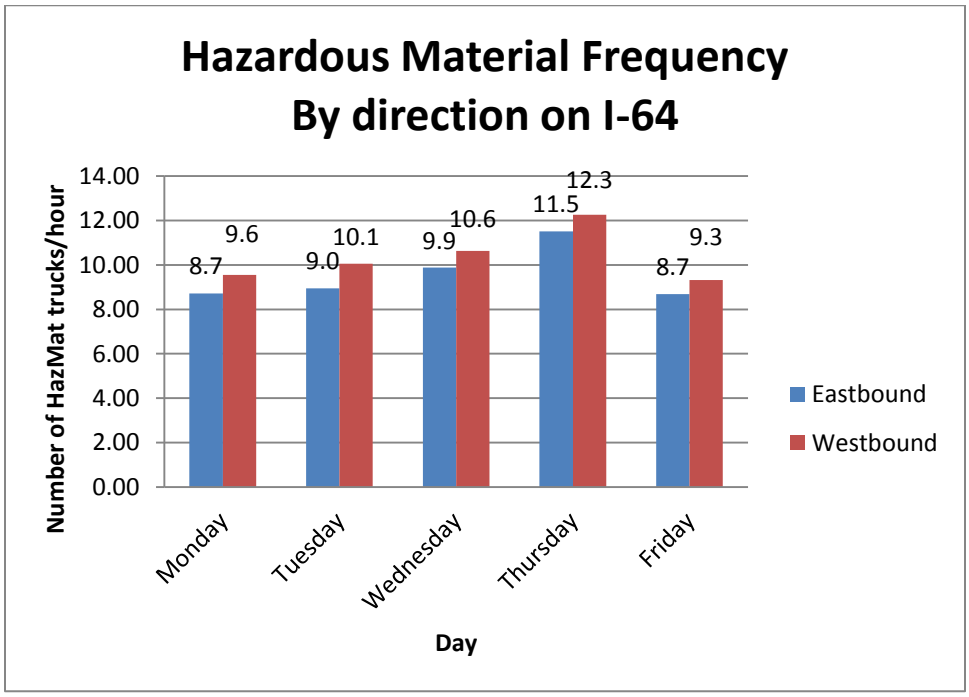
Again, this was also seen in both eastbound and westbound lanes as well. Placarded traffic increased from Monday (9.1 vehicles/hour) to Thursday (11.9 vehicles/hour), prior to the overall low on Friday. Though placarded traffic increased over the course of the week, Monday, Tuesday and Friday exhibited similar traffic (9.1 vehicles/hour, 9.5 vehicles/hour, and 9.0 vehicles/hour, respectively). The average number of placarded vehicles observed, on both eastbound and westbound I-64, was determined to be 9.9 or approximately 10 per hour (Figure 3.3).

Figure 3.3: Placarded vehicle *frequency per hour observed on I-64*



Eastbound and westbound weekly variation is noted in Figure 3.4. As previously noted, peak values were seen on Thursday for both northbound and southbound lanes, while low values were seen on Friday. Much like the overall I-64 trend, both eastbound and westbound traffic increased from Monday to Thursday, with Friday being the weekly minimum value. Eastbound traffic was similar Monday and Tuesday, 8.72 vehicles/hour and 8.95 vehicles/hour, respectively. Westbound traffic was similar Tuesday and Wednesday (10.05 vehicles/hour and 10.63 vehicles/hour, respectively).

Figure 3.4: Placarded vehicle frequency per hour by direction as observed on I-64



iii. Placarded vehicle frequency by time of day for I-64

Variations in frequency of hazardous material transport were determined with reference to the time of day. The time of day is important in order to correlate hazardous material vehicle movement with the expected times of traffic congestion and availability of emergency responders. By analyzing these variations, risk profiles for hazardous material transport can be projected by time of day.

In order to analyze the hourly frequency of hazardous material transport, the monitoring hours at each observation point were divided into three separate periods of four hours. This creates morning, afternoon, and evening scenarios:

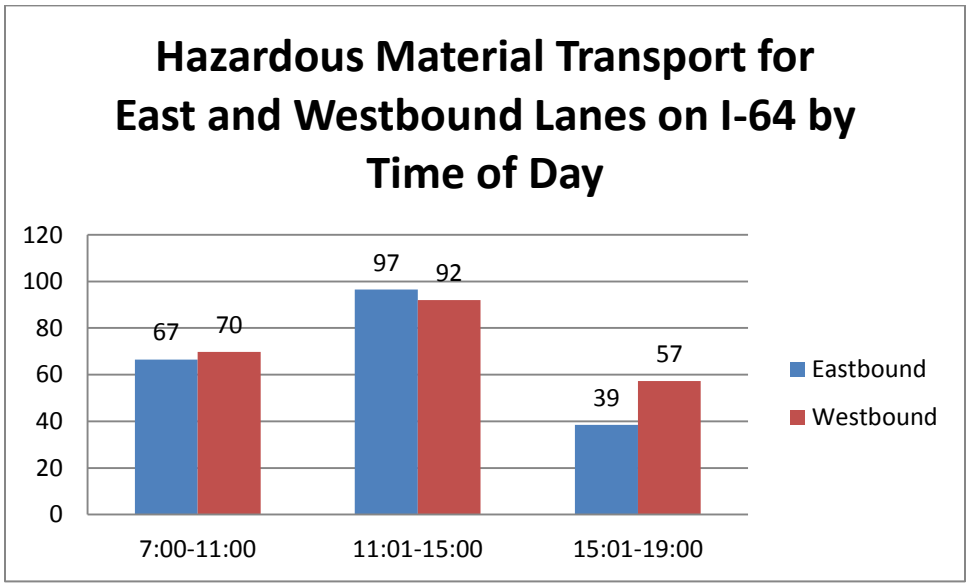
Period 1 (Morning): 07:00 to 11:00

Period 2 (Afternoon): 11:01 to 15:00

Period 3 (Evening): 15:01 to 19:00

As shown in Figure 3.5, the maximum frequency of hazardous material vehicle traffic was observed during the midday period for both eastbound and westbound lanes (97 vehicles/period and 92 vehicles/period). For both eastbound and westbound lanes, the lowest frequency of placarded truck traffic was seen in the evening period, with 39 vehicles/period and 57 vehicles/period for east and westbound lanes, respectively.

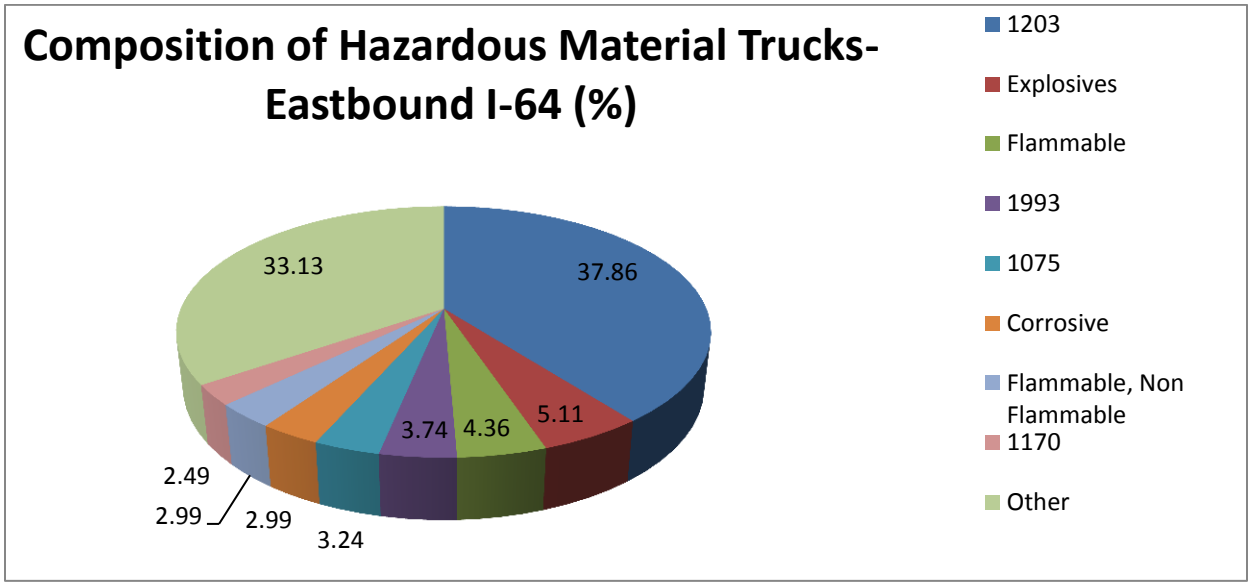
Figure 3.5: Frequency of Hazardous material by time of the day as observed on I-64



iv. Composition of Hazardous Material being transported

The composition (%) of hazardous material transported by vehicles on eastbound I-64 is displayed in Figure 3.6. Gasoline (Placard ID 1203) was the most frequently transported material on eastbound I-64, accounting for 304 (37.9%) of the total hazardous material observed. Other commonly observed materials included explosives (5.1%), flammable substances (4.4%), and

Figure 3.6: Composition of hazardous material being transported on eastbound I-64 by percentage of total load



combustible liquids (Placard ID 1993: 3.7%). Table 3.1 shows frequencies of other materials transported; the "Other" category indicates all other observed materials, which account for less than 2% of the observations. A list of these materials can be found in Appendix (2 & 3).

As shown in Figure 3.7, gasoline (Placard ID: 1203) was the most frequently transported hazardous material on westbound I-64, with 306 (35.5%) of the total hazardous material observed. Other commonly observed materials included flammables (7.8%), corrosive substances (5.9%), and combustible liquids (Placard ID 1993: 3.3%). Table 3.2 shows frequencies of other materials transported; the "Other" category indicates all other observed materials that account for less than 2% of the observations. A list of these materials can be found in Appendix (2).

Table 3.1: Types of hazardous material transported on eastbound I-64

Material Type	Frequency (%)
1203	304 (37.86)
Explosives	41 (5.11)
Flammable	35 (4.36)
1993	30 (3.74)
1075	26 (3.24)
Corrosive	24 (2.99)
Flammable, Non-Flammable	24 (2.99)
1170	20 (2.49)
Other	266 (33.13)

Figure 3.7: Composition of hazardous material as observed on westbound I-64 by percentage of total load

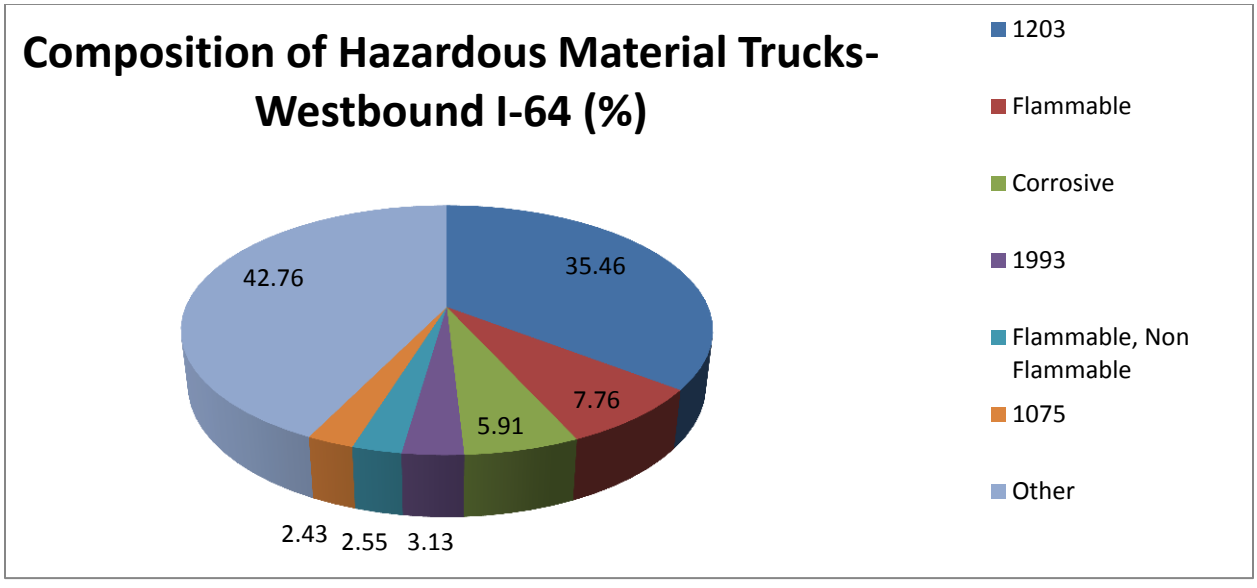


Table 3.2: Frequency of hazardous material transported through I-64

Material Type	Frequency (%)
1203	306 (35.46)
Flammable	67 (7.76)
Corrosive	51 (5.91)
1993	27 (3.13)
Flammable, Non-Flammable	22 (2.55)
1075	21 (2.43)
Other	369 (42.76)

West I-64

v. Aggregate frequency of placarded vehicles West I-64

During the West I-64 monitoring period, the total number of placarded vehicles observed that transported hazardous materials, on both northbound and southbound lanes, was 857 (Figure 3.8). Monitoring of west I-64 occurred at The Belvedere in Downtown Louisville from June 11-15, 2012. The average number of vehicles containing hazardous material observed on both eastbound and westbound I-64 per hour was determined to be 10.32 and 10.59 vehicles/hour, respectively (Figure 3.9). Overall, there was a greater total vehicles transporting hazardous material on westbound West I-64 (434 vehicles compared to eastbound (423 vehicles), though the totals are similar, with only a 2.5% difference between west and eastbound lanes. The average number of vehicles, transporting hazardous material per hour, were greater westbound (10.6 vehicles/hour) compared to eastbound (10.3 vehicles/hour). This represents a 2.5% difference between west and eastbound traffic.

Figure 3.8: Total number of placarded vehicles *observed on West I-64*

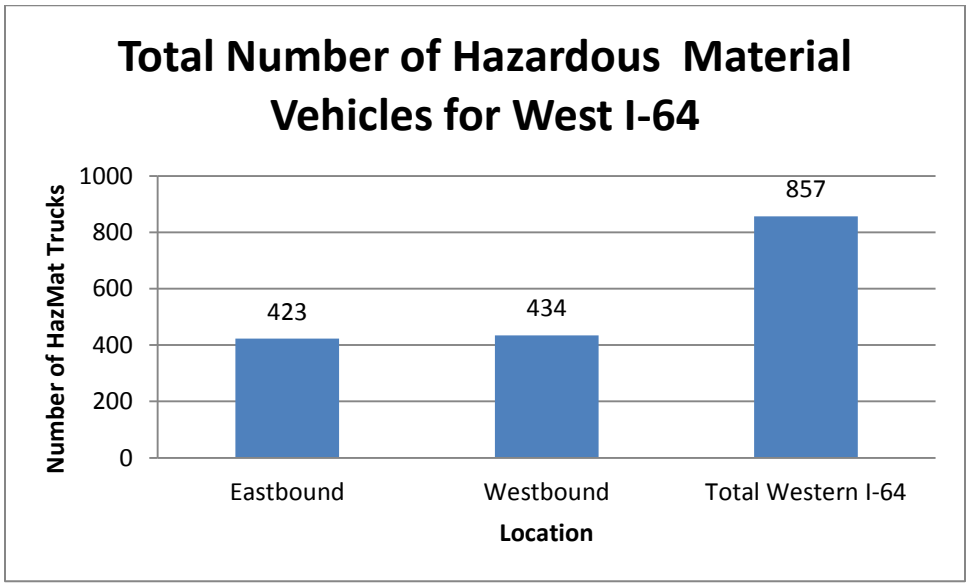
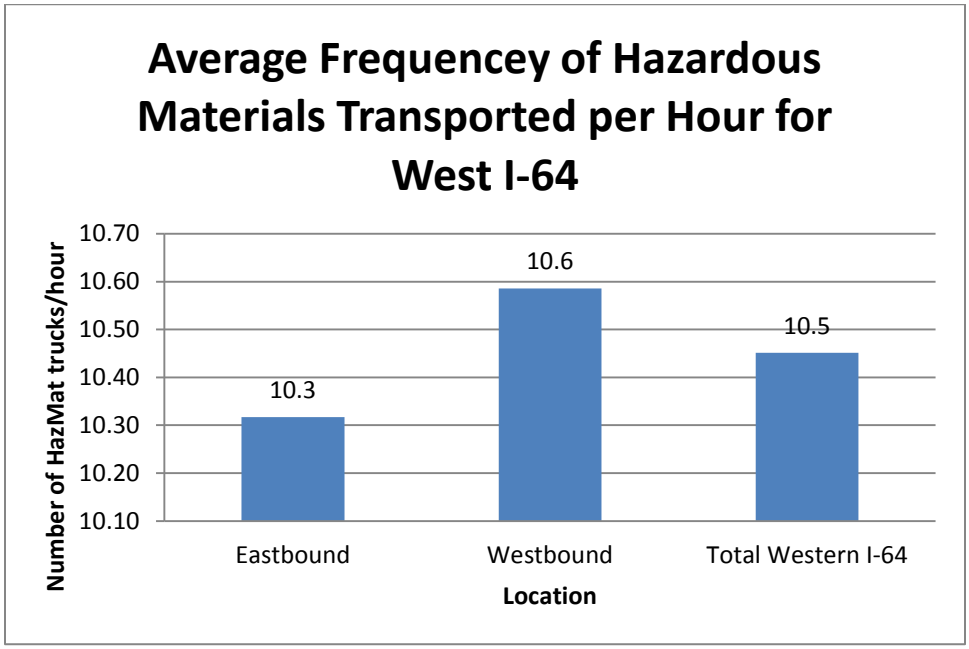


Figure 3.9: Average Frequency of Hazardous Materials per Hour for West I-64



vi. Placarded vehicle frequencies by day of the week for West I-64

Observation hours at the west I-64 monitoring sites were scheduled to detect differences in the frequency of hazardous material traffic during the week. Students made observations at The Belvedere, located in downtown Louisville, KY.

Hazardous material transportation displayed differences throughout the week (Figure 3.10). Total hazardous material transport across west I-64 peaked on Thursday, with an average 13.0 vehicles/hour. This peak is seen in both eastbound and westbound lanes of traffic (Figure 3.11). The lowest average rate was seen on Monday, with only 8.1 vehicles/hour. This was seen in both eastbound and westbound lanes as well, with 8.4 vehicles/hour in the eastbound lane, and 7.7 vehicles/hour in westbound lane. Traffic increased from Monday (8.1 vehicles/hour) to Thursday (13.0 vehicles/hour), prior to a decrease on Friday. This trend is similar to that seen in the overall I-64 trend.

Eastbound and westbound weekly variation is noted in Figure 3.11. As previously stated, peak values were seen on Thursday for both eastbound and westbound lanes, while low values were seen on Friday. Much like the overall I-64 trend, both eastbound and westbound traffic increased from Monday to Thursday, with an end of the week (Friday) decrease. Eastbound traffic was similar Monday and Tuesday (8.4 vehicles/hour and 8.9 vehicles/hour, respectively). Westbound traffic was similar Tuesday and Friday (9.9 vehicles/hour and 9.6 vehicles/hour, respectively).

Figure 3.10: Frequency of placarded vehicles through the week on West I-64

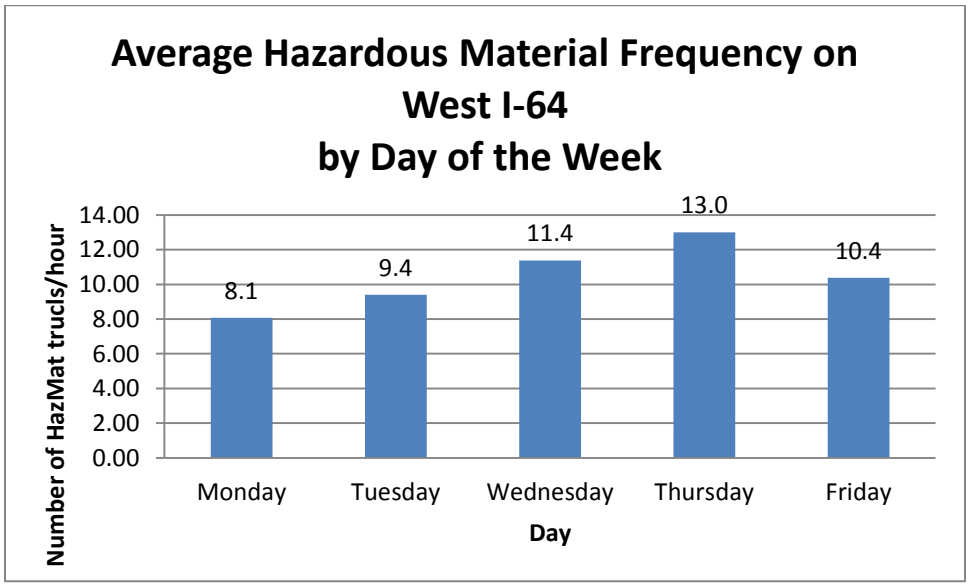
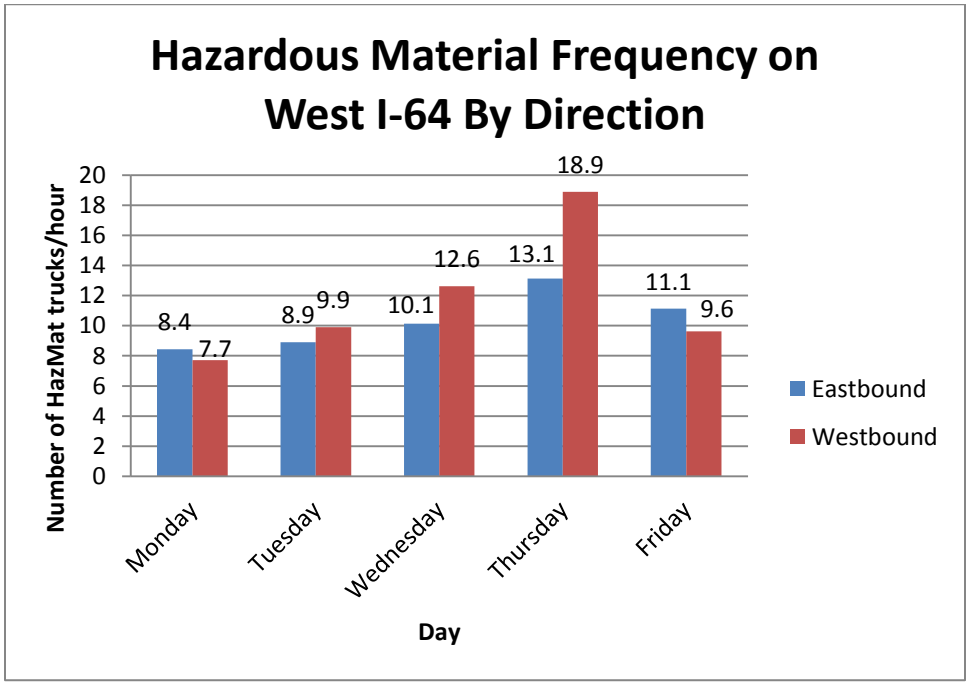


Figure 3.11: Hazardous material frequency on east and westbound directions



vii. Placarded vehicle frequency by time of the day West I-64

Again, in order to analyze the hourly frequency of hazardous material transport, the monitoring hours at each observation point were divided into three separate periods of four hours. This creates the following three time periods:

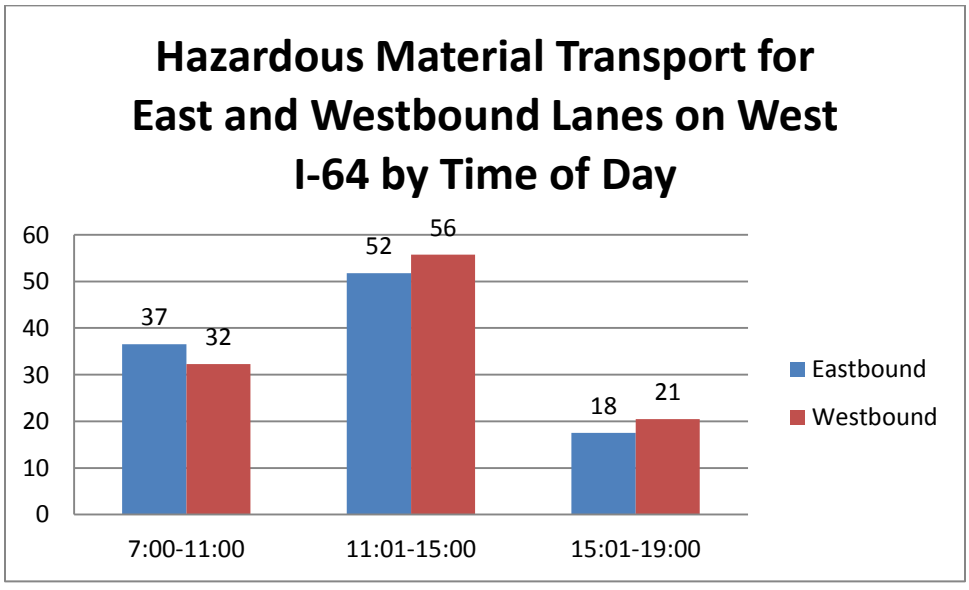
Period 1 (Morning): 7:00 to 11:00

Period 2 (Afternoon): 11:01 to 15:00

Period 3 (Evening): 15:01 to 19:00

As shown in Figure 3.12, the maximum frequency of vehicles transporting hazardous material was observed during the midday period for both east and westbound lanes (51.7 vehicles/period and 55.8 vehicles/period). For both east and westbound lanes, the lowest frequency of placarded vehicle traffic was seen in the evening period, with 17.5 vehicles/period and 20.5 vehicles/period, for east and westbound lanes, respectively.

Figure 3.12: Hazardous material frequency by time of the day



East I-64

viii. Aggregate Frequency of placarded vehicles East I-64

Monitoring of East I-64 occurred at Microtel Inn and Bluegrass Harley Davidson (Blankenbaker Exit) in Louisville, KY from June 25-29, 2012. For the East I-64 monitoring period, there were a total of 825 placarded vehicles observed (Figure 3.13). The average number of placarded vehicles on east I-64 per hour was 9.3 vehicles/hour (Figure 3.14). In comparison, there were a greater number of hazardous material transporting vehicles westbound on east I-64 (442 vehicles) compared to eastbound (383 vehicles), a 13% difference between west and eastbound lanes. Similarly, the average number of hazardous material transporting vehicles per hour was greater westbound (10.1 vehicles/hour) compared to eastbound (8.8 vehicles/hour), a 13.4% difference between west and eastbound traffic.

Figure 3.13: Frequency of hazardous material as observed on East I-64

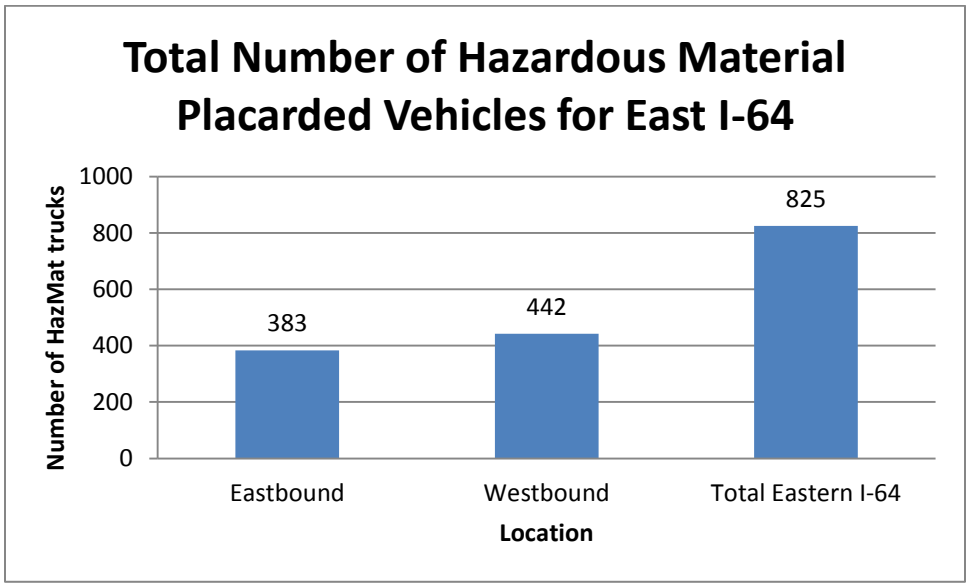
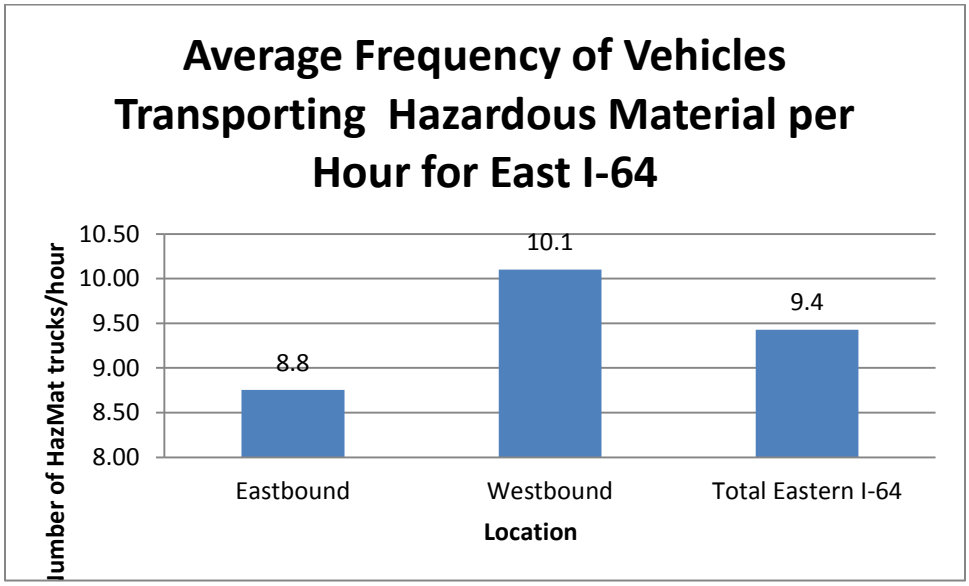


Figure 3.14: Frequency of hazardous materials per hour on East I-64



ix. Placarded vehicle frequencies by day of the week East I-64

Observation hours at the East I-64 monitoring sites were scheduled to detect differences in the frequency of hazardous material traffic during the week. Much like West I-64, hazardous material transportation displayed differences throughout the week (Figure 3.15). Total hazardous material transport across east I-64 peaked on Thursday, with an average rate of 10.8 vehicles/hour. This peak is seen in both east and westbound lanes of traffic (Figure 3.16). The lowest average rate was seen on Friday, with only 7.6 vehicles/hour. This was seen in the eastbound lane as well, with 6.3 vehicles/hour. Commodity flow was reduced for the westbound lane on Wednesday, with 8.6 vehicles/hour. Unlike east I-64, overall traffic decreased on East I-64 from Monday (9.9 vehicles/hour) to Wednesday (9.1 vehicles/hour), prior to the peak on Thursday and the low on Friday.

East and westbound weekly variation is depicted in Figure 3.16. As previously noted, peak values were seen on Thursday for both east and westbound lanes, while low values were

Figure 3.15: Frequency of placarded vehicles by day of the week on East I-64

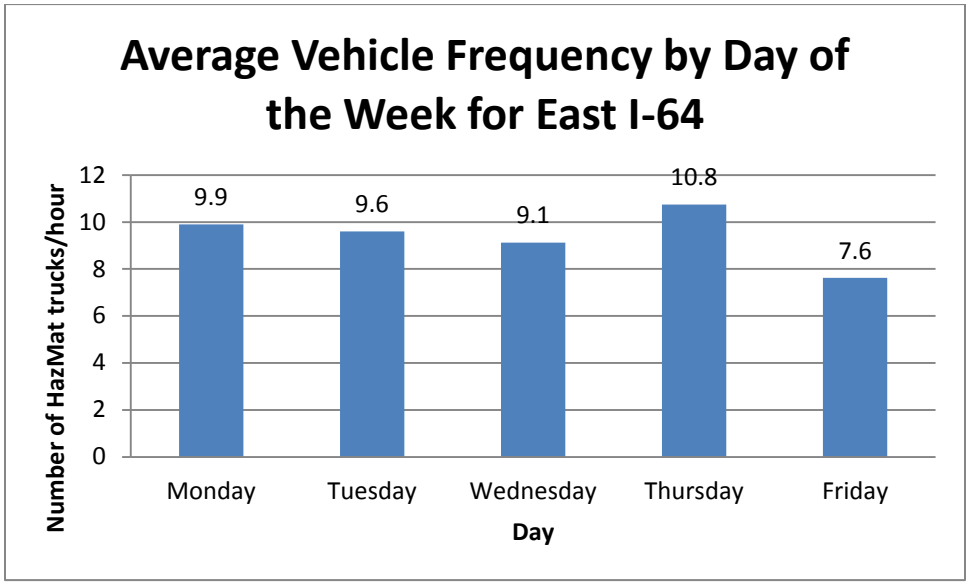
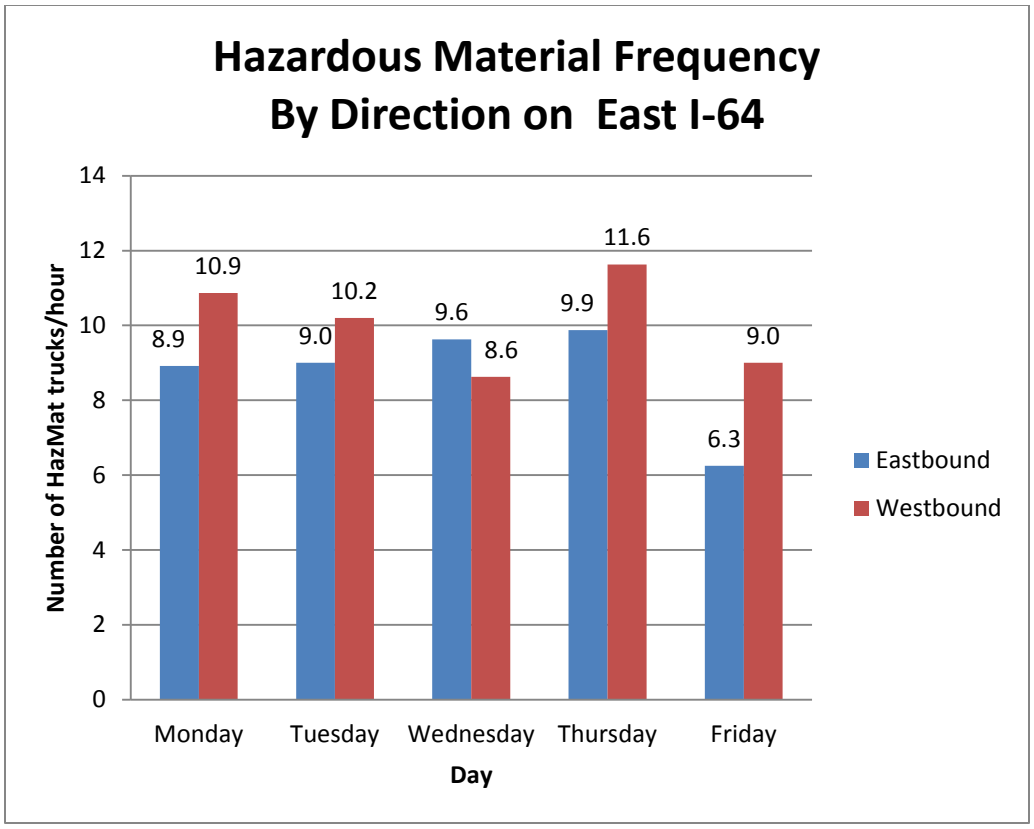


Figure: 3.16: Frequency of hazardous material as observed on East I-64



seen on Friday for eastbound traffic, and Wednesday for westbound traffic. Much like the overall I-64 trend, eastbound hazardous material traffic increased from Monday to Thursday, with an end of the week (Friday) decrease. Westbound traffic decreased from Monday to Wednesday, with the peak on Thursday. Eastbound placarded truck traffic showed a similar pattern from Monday through Thursday at approximately 9 vehicles/hour.

x. Placarded vehicle Frequency by time of the day for East I-64

To analyze the hourly frequency of hazardous material transport, the monitoring hours at each observation point were divided into three separate periods of four hours. This creates the following three periods of the day:

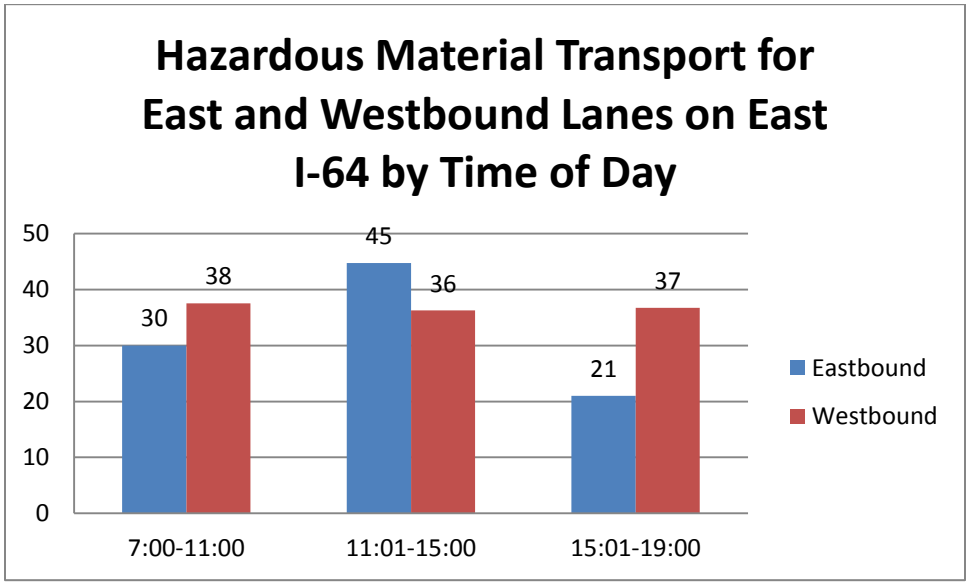
Period 1 (Morning): 7:00 to 11:00

Period 2 (Afternoon): 11:01 to 15:00

Period 3 (Evening): 15:01 to 19:00

As shown in Figure 3.17, the maximum frequency vehicles hazardous material commodity flow was observed during the midday period for the eastbound lane, with 44.8 vehicles/period, while westbound traffic was greatest in the evening, with 36.8 vehicles/period. The lowest period for the westbound lane was determined to be midday, with 36.3 vehicles/period, while the eastbound lane was lowest in the Evening, with 21.0 vehicles/period.

Figure 3.17: Frequency of hazardous material by time of the day on East I-64



Chapter 4: Analysis of the I-65 Placard Survey

i .Aggregate frequency of placarded vehicles I-65

Observations on I-65 were made to determine the frequency of hazardous material transport, for the monitoring period June 18-22 and July 16-20, 2012. Total placarded vehicles observed that transported hazardous materials, on both north and southbound lanes, were 2477 (Figure 3.18). The average number of vehicles observed on both north and southbound per hour was approximately 14 vehicles/hour (Figure 4.2). Overall, there were a greater number of vehicles transporting hazardous material on southbound I-65 (1243 vehicles) compared to northbound, 1234 vehicles, representing a 0.7% difference between lanes. Similarly, the average number of placarded vehicles per hour was slightly greater on southbound, 14.13 vehicles /hour, compared to northbound, 13.87 vehicles/hour, lanes. This constitutes a 1.8% difference between north and southbound traffic. It should be noted that during the time of observation of North I-65, truck traffic was detoured to I-264, 71 or 64 due to bridge construction and maintenance.

Figure 4.1: Frequency of hazardous material as observed on I-65

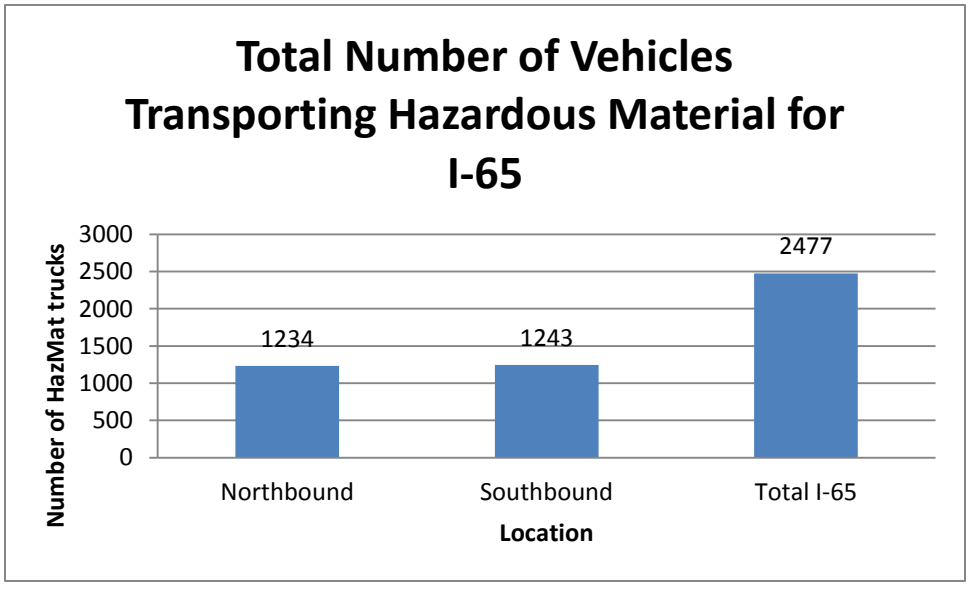
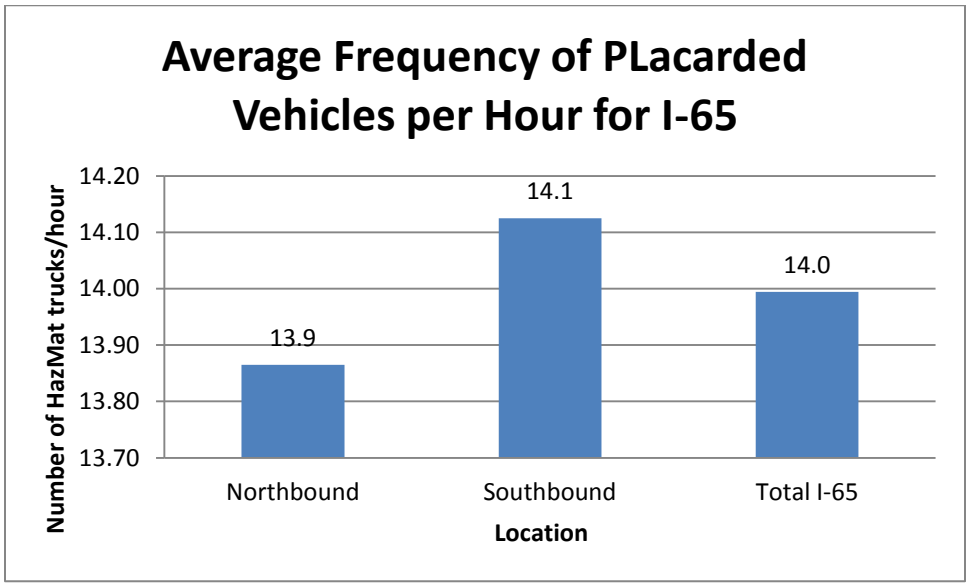


Figure 4.2: Frequency of hazardous material per hour as observed on I-65



ii. Placarded vehicle frequencies by day of the week on I-65

The observation hours for I-65 sites were scheduled to identify differences in the frequency of hazardous material traffic during the week. Students made observations at Jewish Medical Center in downtown Louisville, KY for North I-65 and Holiday Inn Express near the Brooks, KY Exit for South I-65.

Hazardous material transport showed differences throughout the week (Figure 4.3). Total hazardous material transport across I-65 peaked on Wednesday, with an average 16.6 vehicles/ hour. This peak was seen in the southbound lane, while the peak in the northbound lane was observed on Thursday (Figure 4.4). The lowest average commodity flow rate was witnessed on Monday with 12.4 vehicles /hour. The low for both north and southbound lanes was seen on Monday. Traffic increased from Monday, 12.4 vehicles/hour, to Wednesday, 16.6 trucks/hour,

Figure: 4.3: Frequency of hazardous material by day of the week on I-65

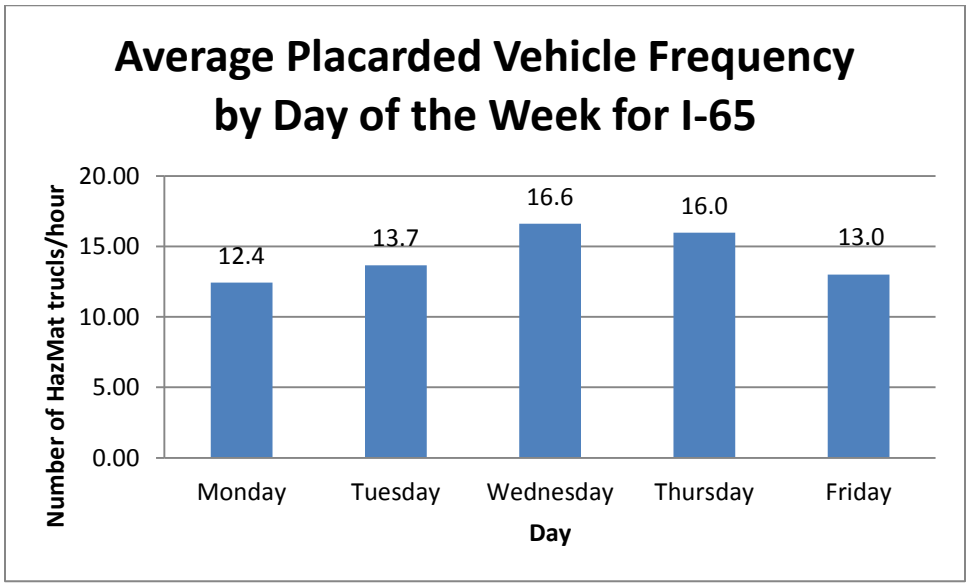
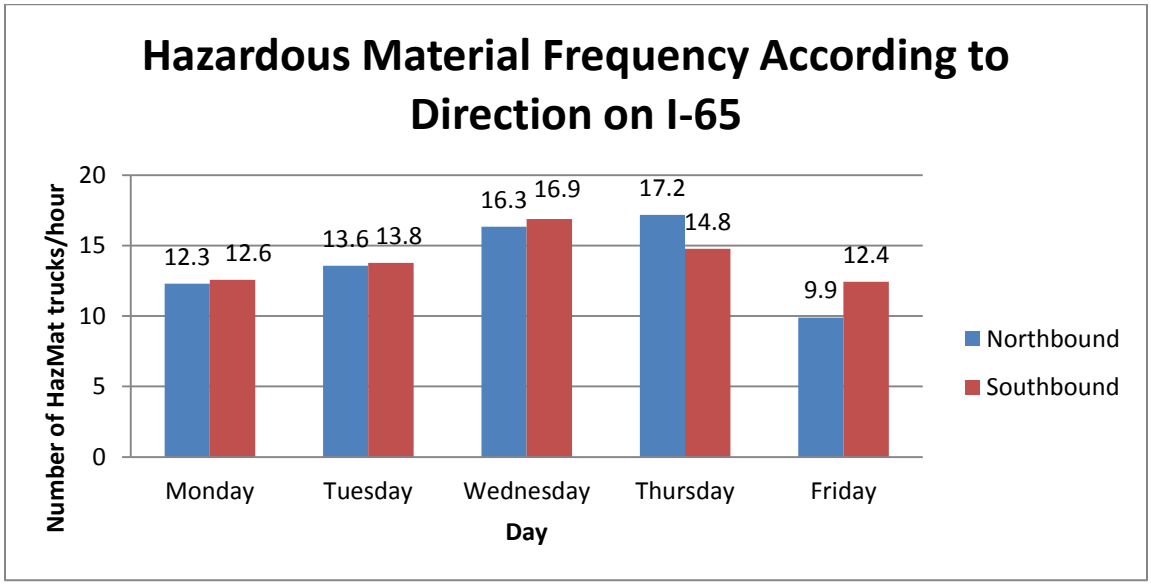


Figure 4.4: Frequency of hazardous material as observed on I-65



then decreased from Thursday, 16.0 vehicles/hour, to Friday, 13.0 vehicles/hour. Though traffic increased over the course of the week, Tuesday and Friday exhibited similar placarded traffic, 13.7 vehicles/ hour and 13.0 vehicles/hour, respectively.

North and southbound weekly variation is shown in Figure (4.4). A consistent trend was observed for the hazardous material commodity flow rate on both north and southbound, increasing through midweek and decreasing from that point to a low on Friday. As previously noted, peak values were seen on Thursday for the northbound lanes and Wednesday for the southbound lanes, while low values were seen on Friday. Much like the overall I-65 trend, southbound traffic increased from Monday to Wednesday, with a decrease from Thursday to Friday. Northbound traffic increased from Monday to Thursday.

iii. Placarded vehicle Frequency by time of the day on I-65

In order to analyze the hourly frequency of hazardous material transport, the monitoring hours at each observation point were divided into three separate periods of four hours. This creates the following three time periods:

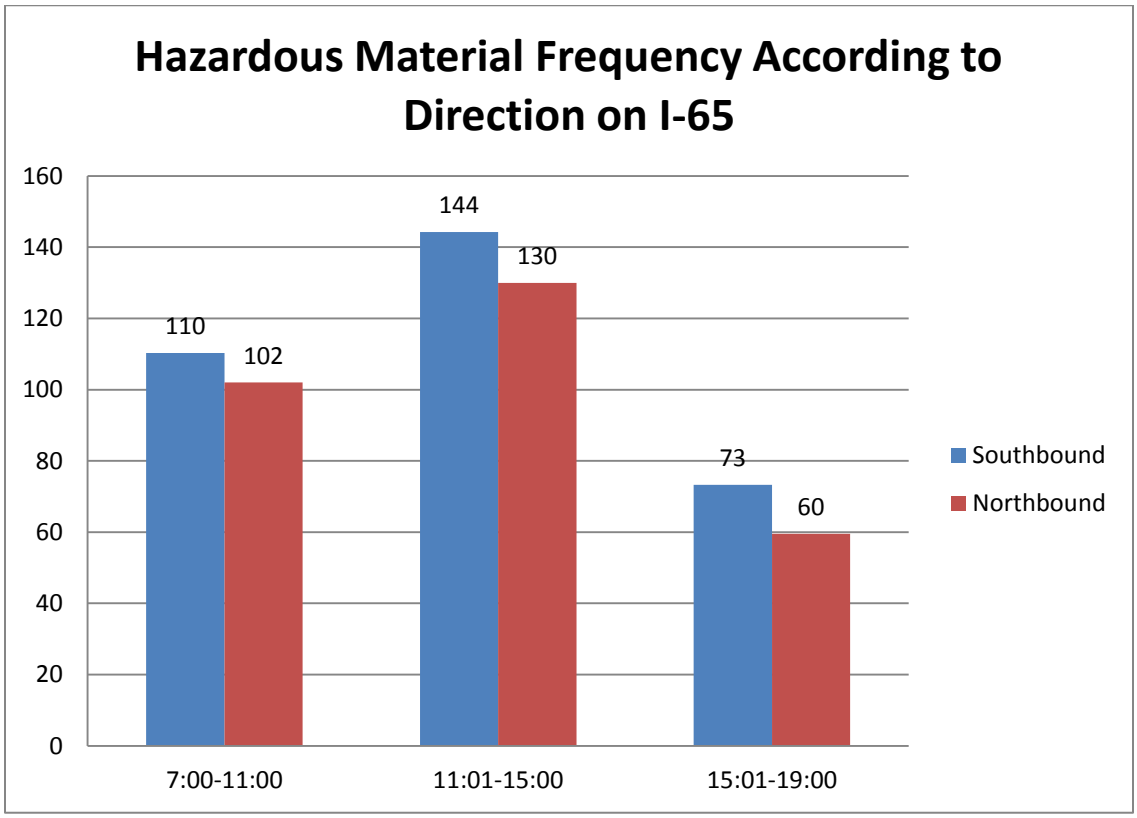
Period 1 (Morning): 7:00 to 11:00

Period 2 (Afternoon): 11:01to 15:00

Period 3 (Evening): 15:01 pm to 19:00

As shown in Figure 4.5, the maximum frequency of placarded vehicles was observed during the midday period for both north and southbound lanes, 130 vehicles/period and 144 vehicles/period. For both north and southbound lanes, the lowest frequency of truck traffic was seen in the evening period, with 59 vehicles/period and 73 vehicles/period respectively.

Figure 4.5: Frequency of hazardous material as observed on I-65



iv. Composition of Hazardous Material being transported on I-65

Analysis of the placard data was used to assess the materials being transported on both northbound and southbound lanes of I-65. As shown in Figure 4.6, gasoline, Placard ID 1203, was the most frequently transported material on northbound I-65, accounting for 25% of the total hazardous material observed during the observation period. Other commonly observed materials included flammables, 11.6%, corrosives, 6.7%, and combustible liquids, Placard ID 1993: 5.7%.

Figure 4.6: Composition of placarded vehicles as observed on northbound I-65 by percentage of total load

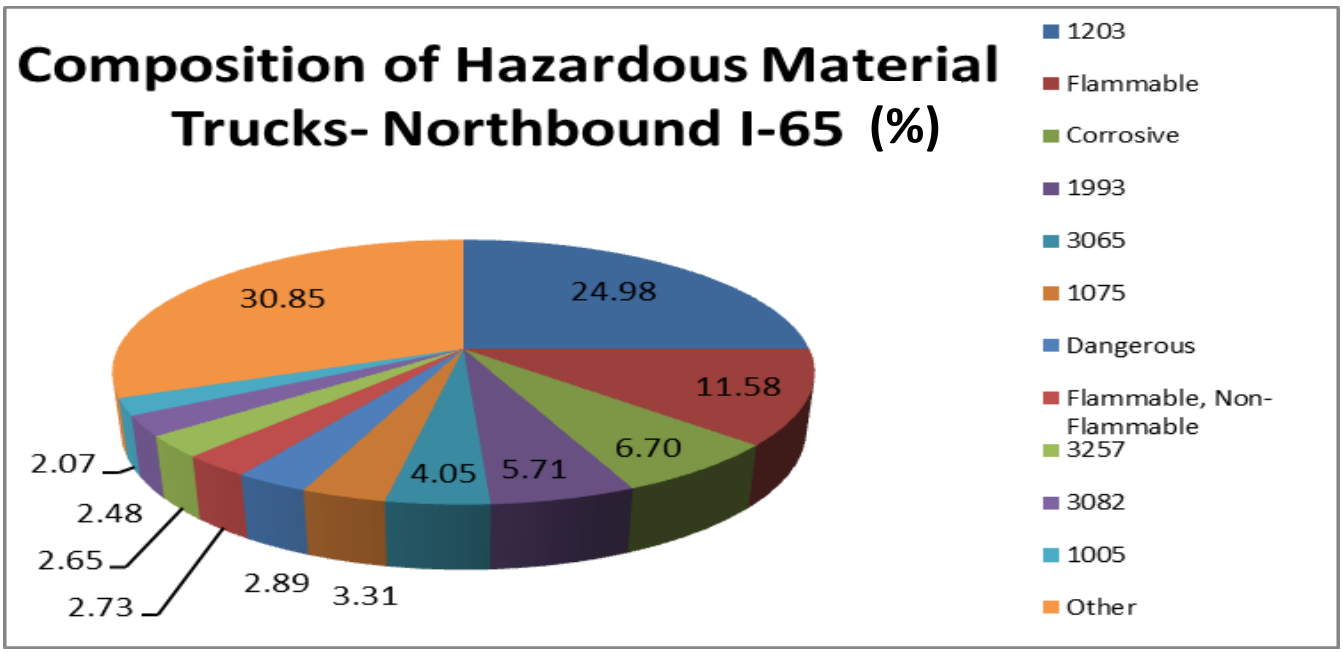


Table 4.1 shows frequencies of hazardous material transported that was observed during the study period; the "Other" category indicates all other observed hazardous material, which account for less than 2% of the observations and can be found in Appendix (4 & 5).

Like northbound I-65, gasoline (Placard ID 1203) was the most frequently transported material on southbound I-65, accounting for 21.8% of the total hazardous material observed (Figure 4.7). Other frequently observed materials included flammables (12.2%), corrosives (9.8%), and elevated temperature substances (Placard ID 32573: 4.2%). Table 4.2 shows frequencies of hazardous material observed to be transported during the study period; the "Other" category indicates all other observed materials which account for less than 2% of the observations and can be found in Appendix (4).

Table 4.1: Frequency of hazardous material transported on northbound I-65

Material Type	Frequency (%)
1203	302 (24.98)
Flammable	140 (11.58)
Corrosive	81 (6.70)
1993	69 (5.71)
3065	49 (4.05)
1075	40 (3.31)
Dangerous	35 (2.89)
Flammable, Non-Flammable	33 (2.73)
3257	32 (2.65)
3082	30 (2.48)
1005	25 (2.07)
Other	373 (30.85)

Figure 4.7: Composition of placarded vehicles southbound as observed on southbound I-65 by percentage of total load

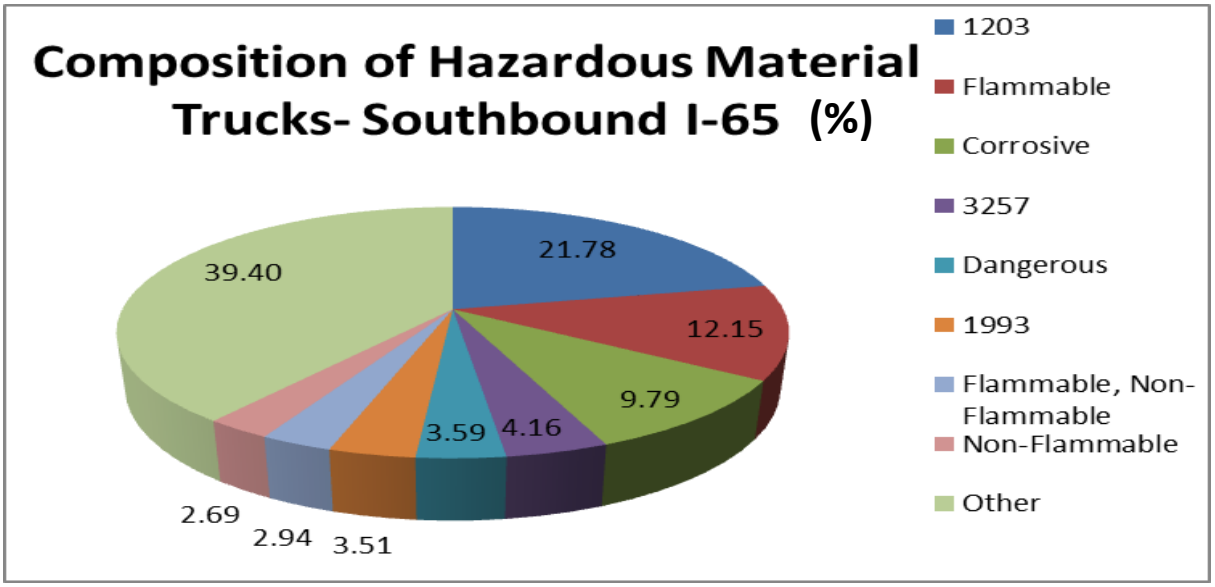


Table 4.2: Frequency of hazardous material transported on southbound I-65

Material Type	Frequency (%)
1203	267 (21.78)
Flammable	149 (12.15)
Corrosive	120 (9.79)
3257	51 (4.16)
Dangerous	44 (3.59)
1993	43 (3.51)
Flammable, Non-Flammable	36 (2.94)
Non-Flammable	33 (2.69)
Other	483 (39.40)

North I-65 (Near Downtown Louisville)

v. Aggregate frequencies of placarded vehicles North I-65

There were a total of 537 placarded vehicles observed on North I-65 during the monitoring period June 18-22, 2012 (Figure 4.8). The average number of vehicles observed on both north and southbound North I-65 was determined to be 6.8 vehicles/hour (Figure 4.9). Overall, there were a greater total number of vehicles transporting hazardous material southbound on I-65, 307 vehicles, compared to northbound, 230 vehicles, representing a 25% difference between north and southbound lanes. Similarly, the average number of trucks transporting hazardous material per hour was greater southbound, 7.8 vehicles/hour, compared to northbound, 5.8 vehicles/hour. This represents a 25% difference between north and southbound traffic. It should be noted that during the North I-65 observation period, placarded vehicle traffic was detoured to I-264, 71, or 64 due to bridge construction and maintenance.

Figure 4.8: Total number of hazardous material on north I-65

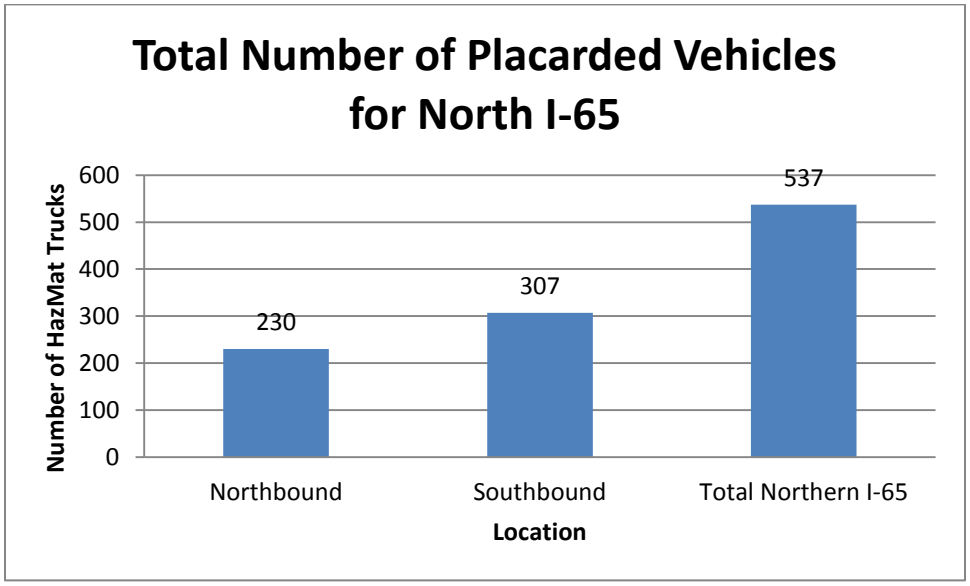
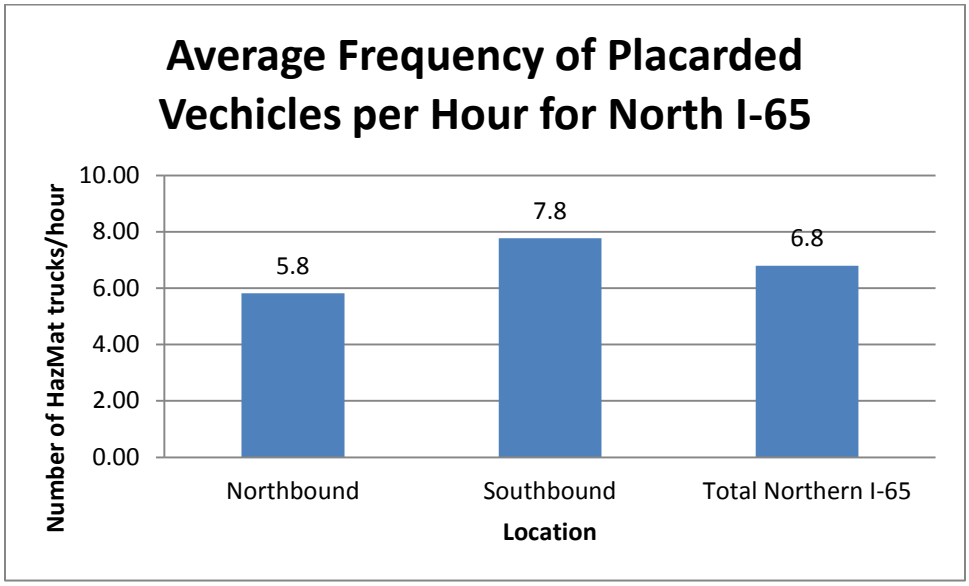


Figure 4.9: Frequency of hazardous material per hour on north I-65



vi. Placarded vehicle frequencies by day of the week on north I-65 near downtown Louisville

The observation hours for North I-65, near downtown Louisville, sites were scheduled to detect differences in the frequency of hazardous material traffic during the week. In order to analyze the hourly frequency of hazardous material transport, the monitoring hours at the observation point were typically from 08:00 to 17:00. Students made observations at Jewish Hospital near downtown Louisville.

Hazardous material transportation displayed differences throughout the week (Figure 4.10). Total hazardous material transport through the North I-65 observation site peaked on Wednesday, with an average 8.9 vehicles/hour. This peak is seen in both the southbound and northbound lanes (Figure 4.11). The lowest average rate was seen on Friday with 3.38 vehicles/hour. The low for both north and southbound lanes was seen on Friday. Placarded

Figure 4.10: Frequency of hazardous material by day of the week on north I-65

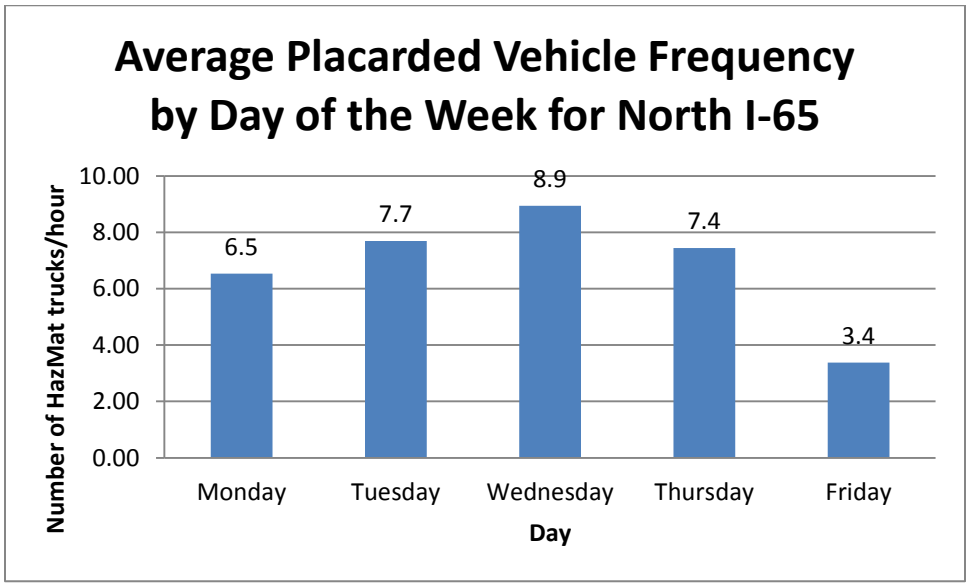
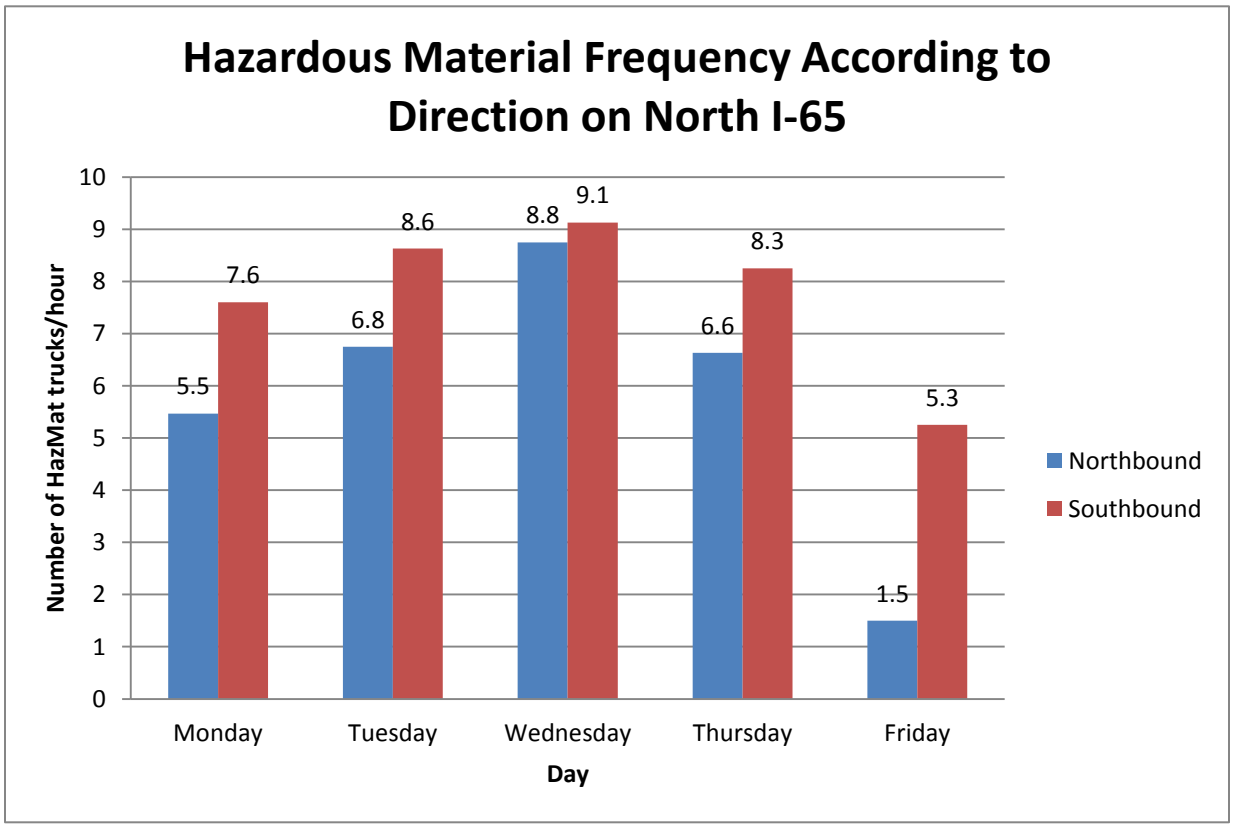


Figure 4.11: Frequency of hazardous material as observed on North I-65



traffic increased from Monday, 6.5 vehicles/hour, to Wednesday, 8.9 vehicles/hour, then decreased from Thursday, 7.4 vehicles/hour, to Friday, 3.4 vehicles /hour. Although traffic increased over the course of the week, Tuesday and Thursday exhibited similar traffic, 7.7 vehicles/hour and 7.4 vehicles/hour, respectively.

North and southbound weekly variation is shown in Figure 4.11. Peak hazardous material commodity flow rates were seen on Wednesday for north and southbound lanes, while decreased rates were observed on Friday. Much like the overall I-65 trend, southbound and northbound traffic increased from Monday to Wednesday, with a decrease from Thursday to Friday. It should be documented that in addition to bridge construction and maintenance, occurring during the observation period, a diesel spill occurred on Thursday near the North I-65 observation point causing northbound traffic to stop from 14:22 through the end of the observation period.

vii. Placarded vehicle frequency by time of the day North I-65

To assess the hourly frequency of hazardous material transport, the monitoring hours at each observation point were divided into three separate periods of four hours. This creates the following divisions of a day:

Period 1 (Morning): 7:00 to 11:00

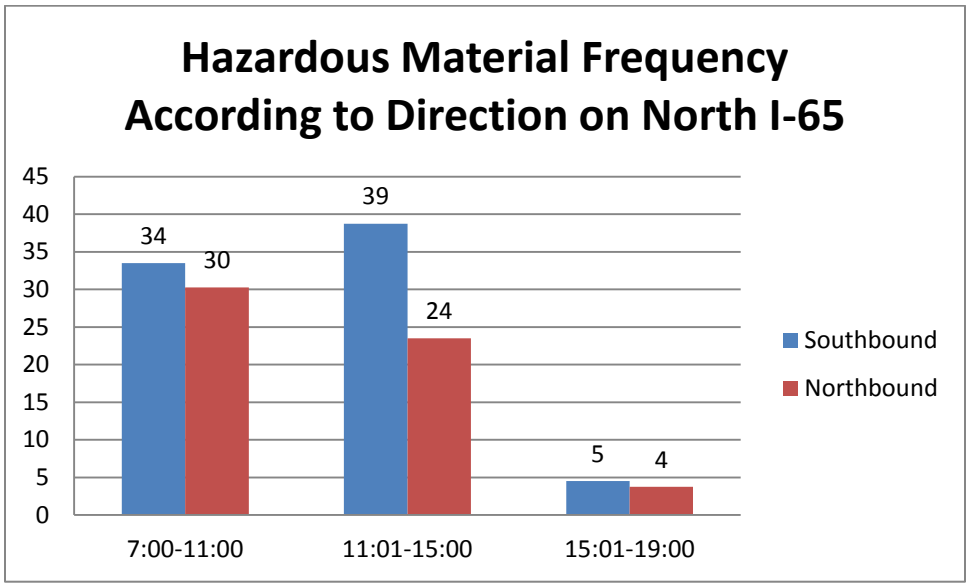
Period 2 (Afternoon): 11:01 to 15:00

Period 3 (Evening): 15:01 to 19:00

As shown in Figure 4.12, the maximum frequency of hazardous material traffic was observed during the midday period for the southbound lane (38.8 vehicles /period), and morning

for the northbound lane (30.3 vehicles /hour). The lowest frequency of placarded traffic was seen in the evening period, with 3.8 vehicles/period 4.5 vehicles /period, for north and southbound lanes, respectively.

Figure 4.12: Frequency of hazardous material by time of the day on north I-65



South I-65 (near Brooks, KY)

viii. Aggregate frequency of placarded vehicles on south I-65

There were a total of 1940 placarded vehicles observed at the South I-65 commodity flow monitoring site during the observation period, July 16-20, 2012 (Figure 4.13). The average number of placarded vehicles observed on both north and southbound I-65 per hour was determined to be 19.8 vehicles/hour (Figure 4.14). Overall, there were a greater total number of vehicles transporting hazardous material northbound on I-65, 1004 vehicles, than southbound, 936 vehicles, representing a 6.8% difference between north and southbound lanes. Similarly, the average number of placarded vehicles per hour was greater northbound, 20.3 vehicles/hour,

Figure 4.13: Total number of placarded vehicles *with hazardous material on South I-65*

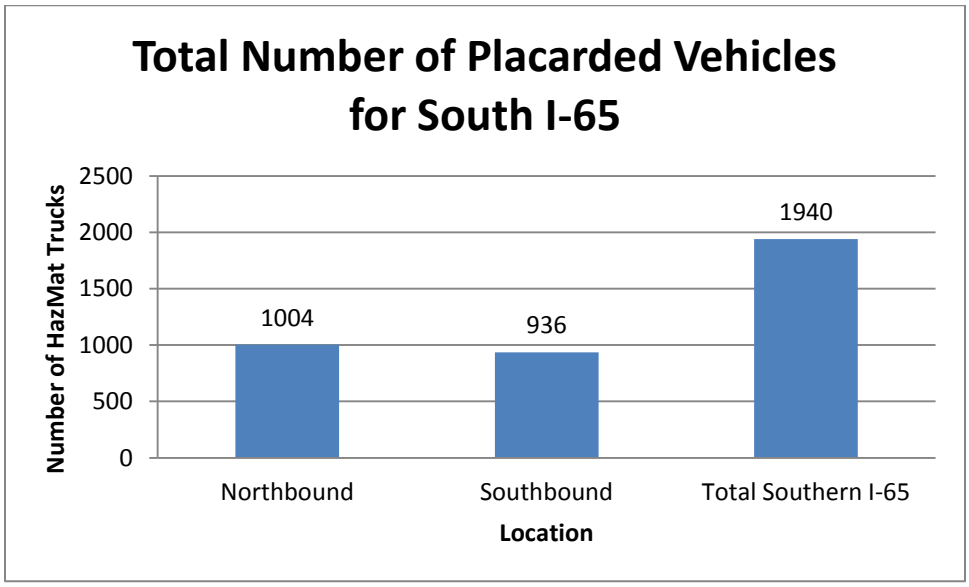
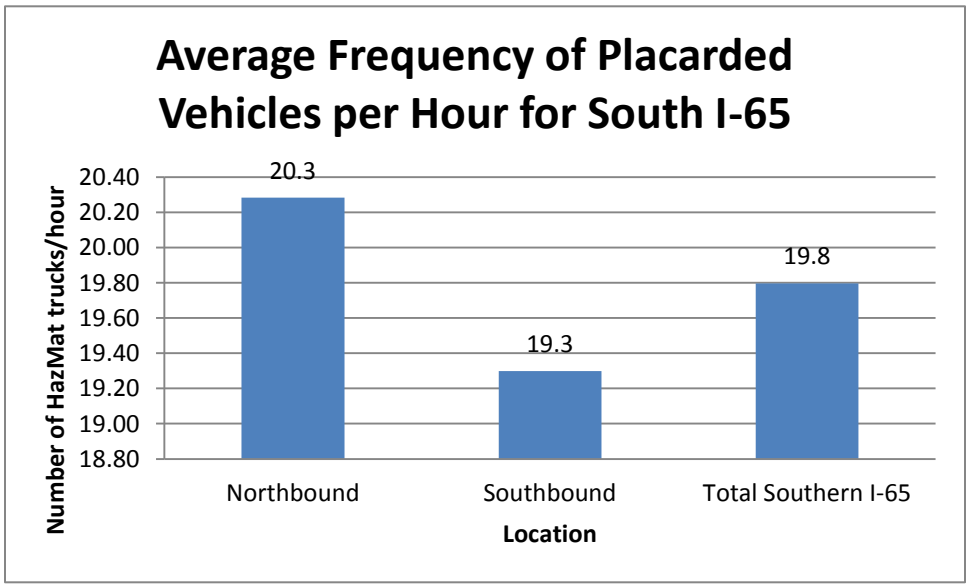


Figure 4.14: Frequency of hazardous material per hour on South I-65



compared to southbound, 19.3 vehicles/hour. This represents a 4.8% difference between north and southbound traffic.

ix. Placarded vehicle frequencies by day of the week on South I-65

The observation hours for the South I-65 monitoring site was scheduled to detect differences in the frequency of hazardous material traffic during the week. Observations occurred from 07:00 until 18:00 each day. Students made observations at Holiday Inn Express near the Brooks, KY Exit.

Total hazardous material transport along South I-65 peaked on Thursday, with an average of 25.6 vehicles/hour, as shown in Figure 4.15. This peak was detected in the northbound lane, while the southbound lane peak was observed on Wednesday (Figure 4.15). The lowest average rate occurred on Friday, with 16.6 vehicles/hour. The low for the northbound lane was found to be Friday, and Monday for the southbound lane. Traffic increased from Monday, 17.7 vehicles/hour, to Thursday, 25.6 vehicles/hour, for the site, then decreased on Friday, 16.6 vehicles /hour.

South I-65, north and southbound, weekly variation is shown in Figure 4.16. As previously noted, peak values were seen on Thursday for the northbound lane and Wednesday for the southbound lane. Decreased hazardous material commodity flow was observed on Friday for the northbound lane and Monday for the southbound lane. In agreement with the overall I-65 trend, northbound placarded traffic increased from Monday to Thursday, with a decrease on Friday. Southbound placarded traffic showed an increased from Monday to Wednesday, and decreased Thursday and Friday.

Figure 4.15: Frequency of hazardous material by day of the week on south I-65

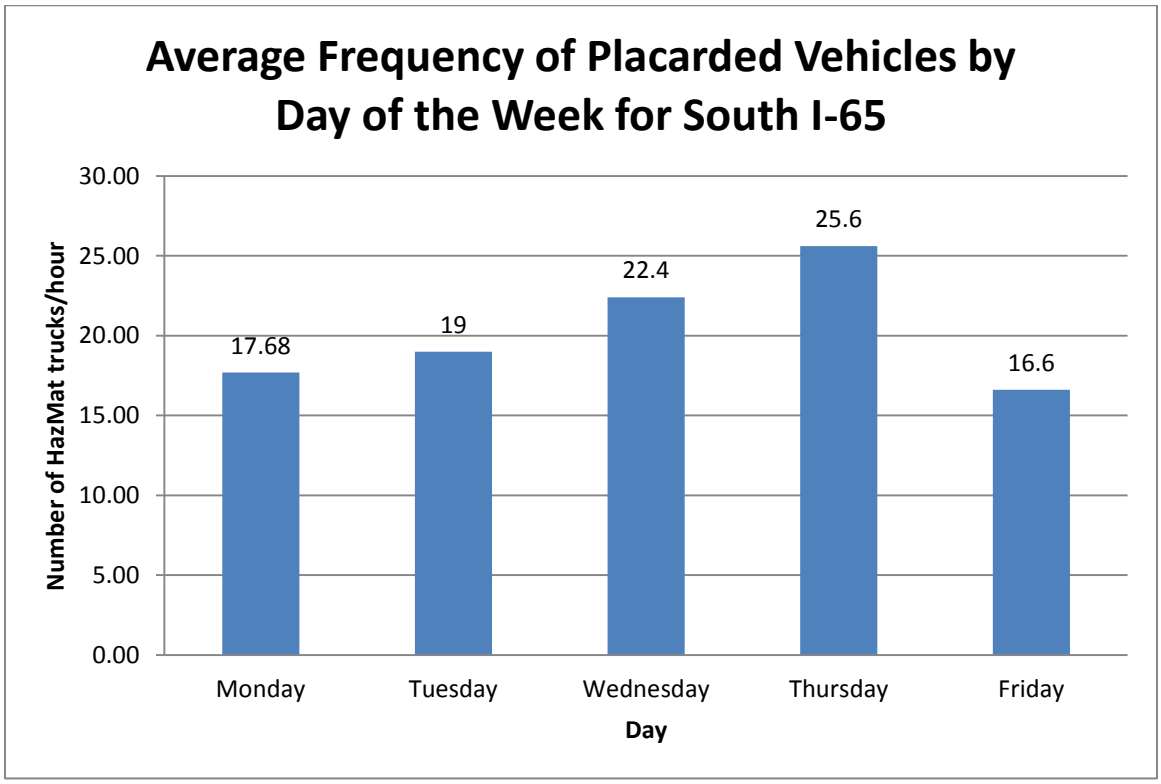
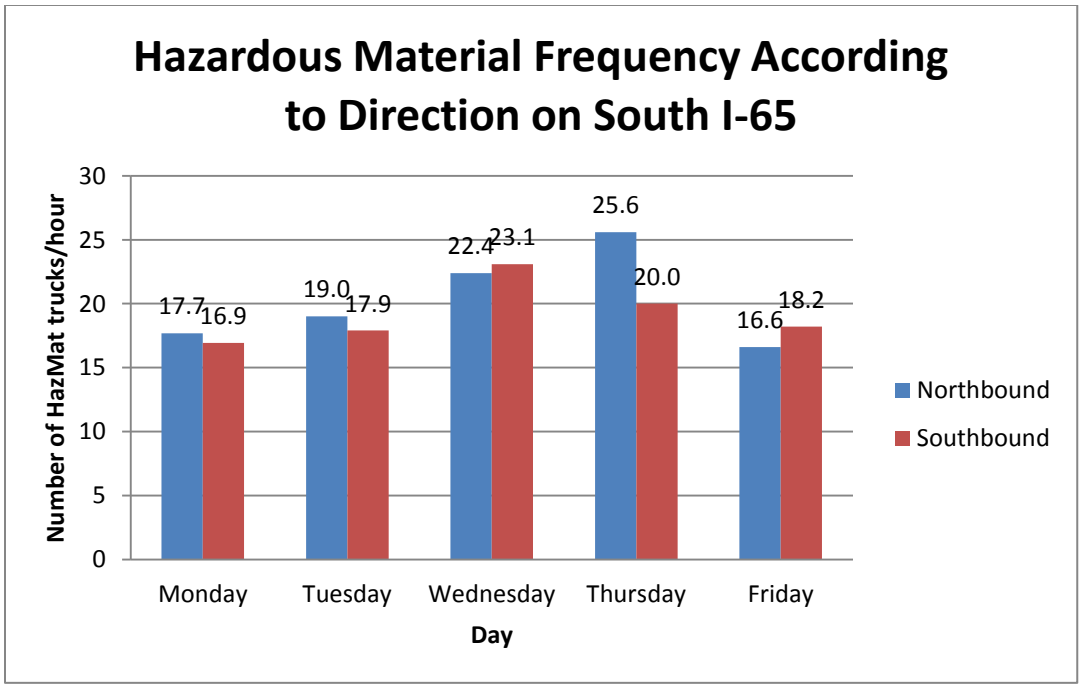


Figure 4.16: Frequency of hazardous material on South I-65



x. Placarded vehicle frequency by time of the day on South I-65

Monitoring data were divided into daily periods to evaluate the daily frequency of hazardous material commodity flow. Monitoring hours at each observation point were divided into three separate periods of four hours. This created the following three time periods:

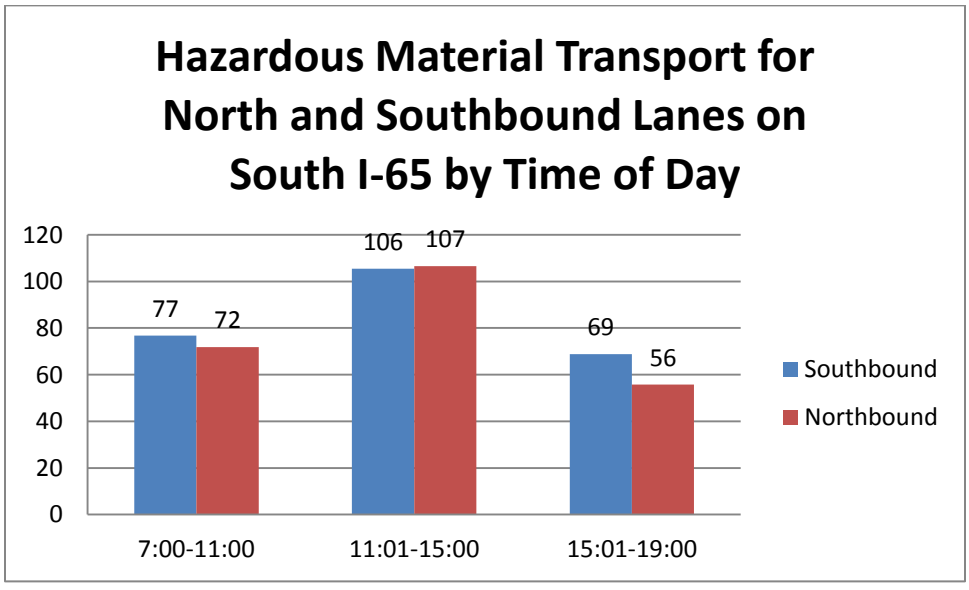
Period 1 (Morning): 7:00 to 11:00

Period 2 (Afternoon): 11:01 to 15:00

Period 3 (Evening): 15:01 to 19:00

As shown in Figure 4.17, the maximum frequency of vehicles transporting hazardous material was observed during the midday period, southbound and northbound lanes, 105.5 vehicles/period and 106.5 vehicles /period, respectively. Observations of placarded vehicles produced the lowest frequency in the evening period, with 55.8 vehicles/period and 68.8 vehicles/period, for north and southbound lanes, respectively.

Figure 4.17: Frequency hazardous material transport by time of the day on South I-65



Chapter 5: Analysis of the I-71 Placard Survey

i .Aggregate frequency of placarded vehicles I-71

A total of 1588 placarded hazardous material vehicles were observed during the I-71 monitoring period, July 9-13, 2012 (Figure 5.1). The average commodity flow rate observed on both north and southbound I-71 per hour was determined to be 17.5 vehicles/hour (Figure 5.2). A greater number of placarded vehicles were observed transporting hazardous material on southbound I-71, 831, than northbound, 757, representing a 9.6% difference between south and northbound lanes. Similarly, the rate of placarded vehicles was greater southbound,18.26 vehicles/hour, compared to northbound, 16.64 vehicles/hour.

ii. Placarded vehicle ***frequencies by day of the week on I-71***

The observation hours for the I-71 sites were scheduled to detect differences in the frequency of hazardous material traffic during the week. Students made observations at north and southbound rest areas near Crestwood, KY from 07:00 to 16:00 each day.

Total hazardous material transport at the I-71 observation sites peaked on Thursday, with an average rate of 18.62 vehicles/hour (Figure 5.3). This trend was detected in the southbound lane, while the peak commodity flow rate for the northbound lane was seen on Tuesday (Figure 5.3). The lowest average rate was witnessed on Friday, with 15.7 vehicles/hour. Minimum commodity flow rates were observed on Friday for the northbound lane, 15.5 vehicles/hour, and Tuesday for the southbound lane, 15.6 vehicles/hour (Figure 5.4).

Figure 5.1: Total number of placarded vehicles on I-71

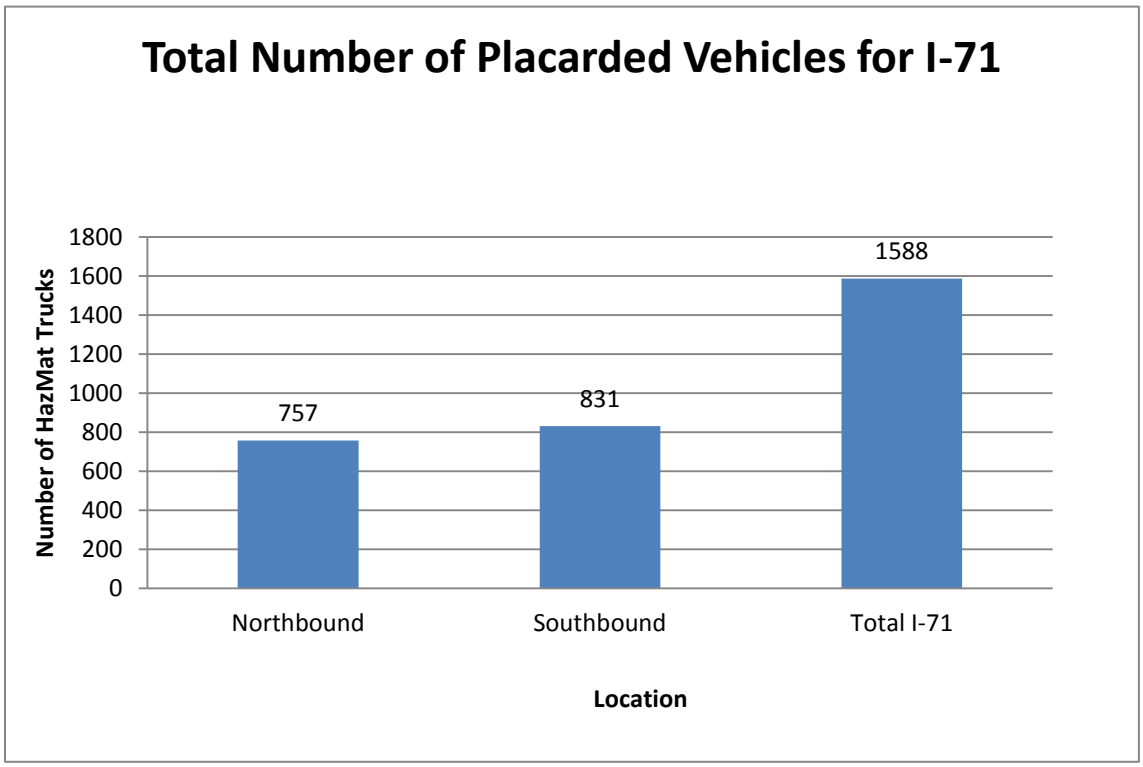


Figure 5.2: Frequency of placarded vehicles *per hour on I-71*

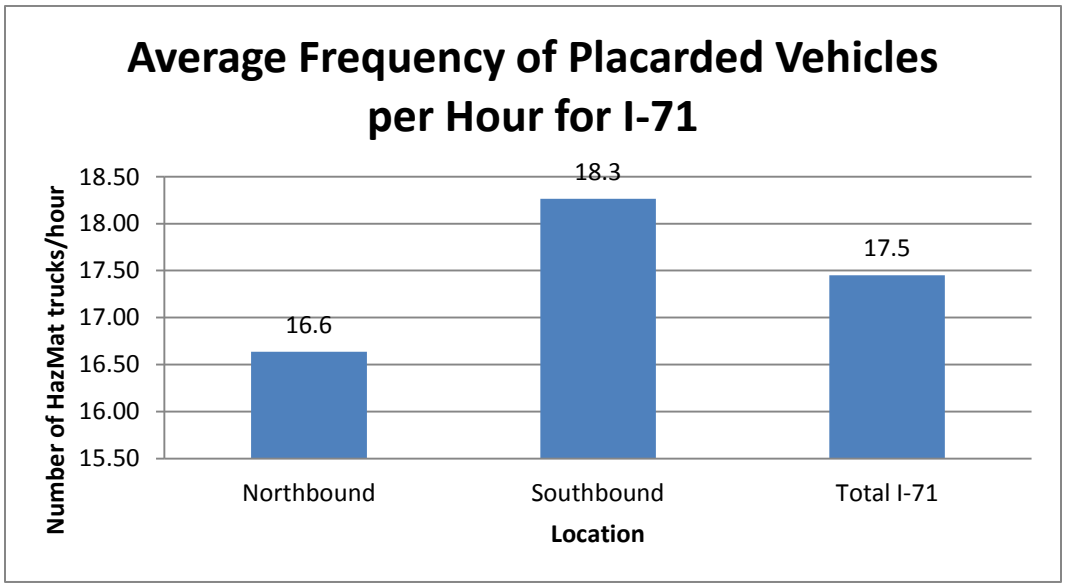


Figure 5.3: Frequency of placarded vehicles *by day of the week on I-71*

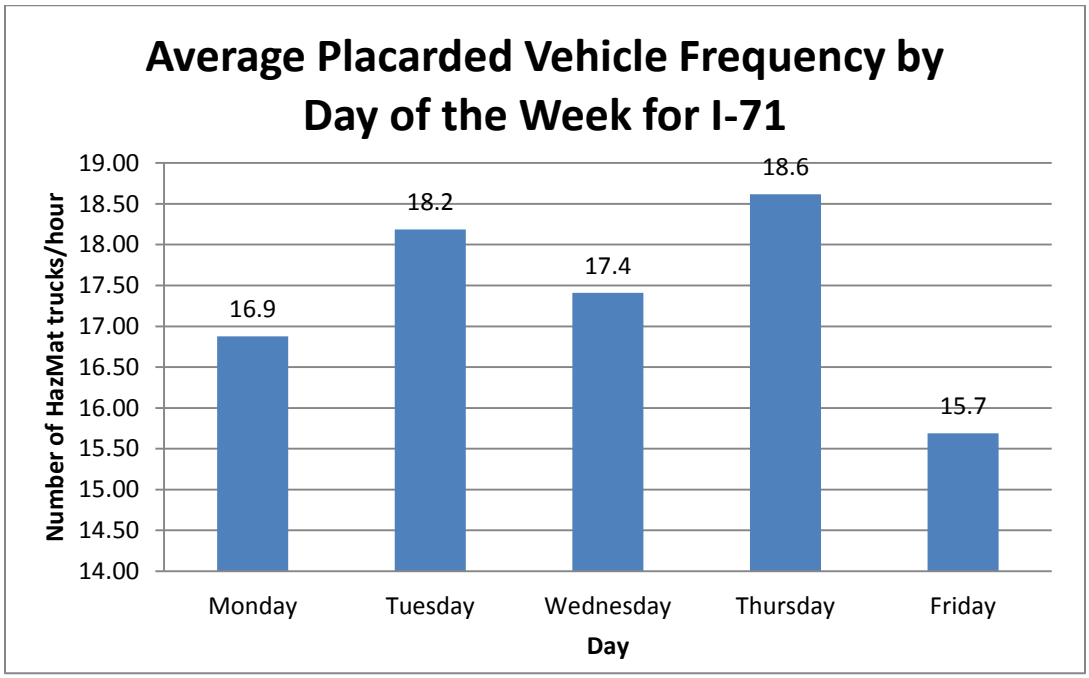
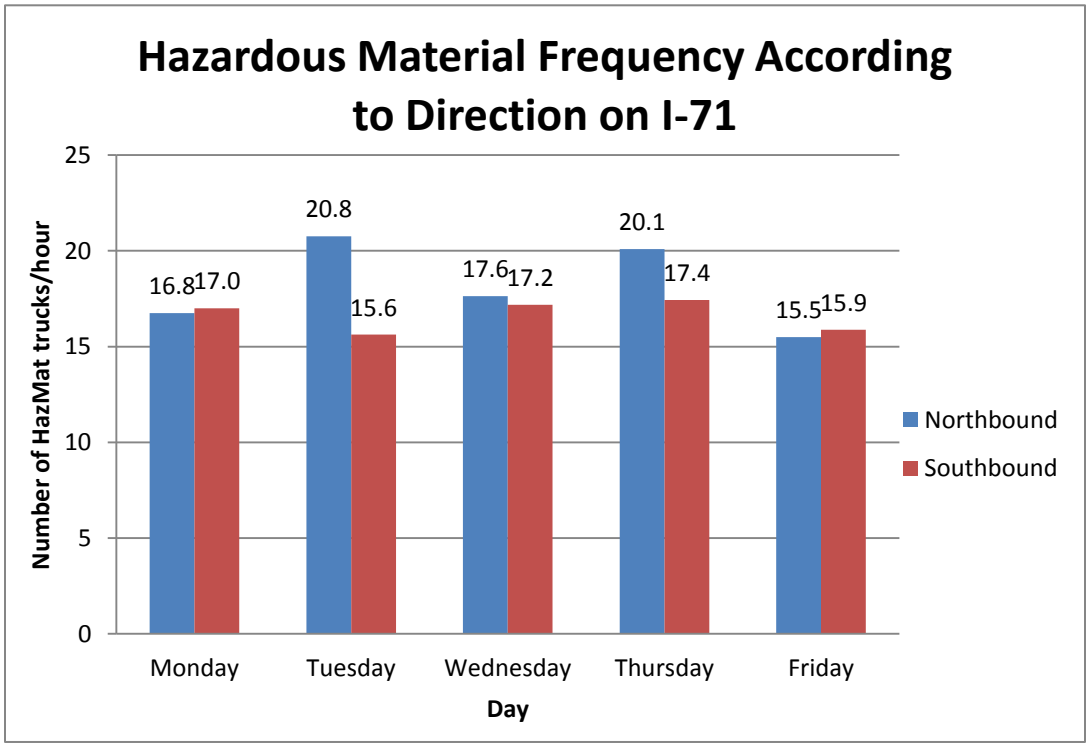


Figure 5.4: Frequency of hazardous material on I-71



iii. Placarded vehicle frequency by time of the day on I-71

To appraise the hourly variation of hazardous material commodity flow, data collected was divided into monitoring periods. This analysis provides a picture of the heaviest loads of commodities. In this manner, time periods with heaviest loads of commodities were determined. Time periods were assigned as follows:

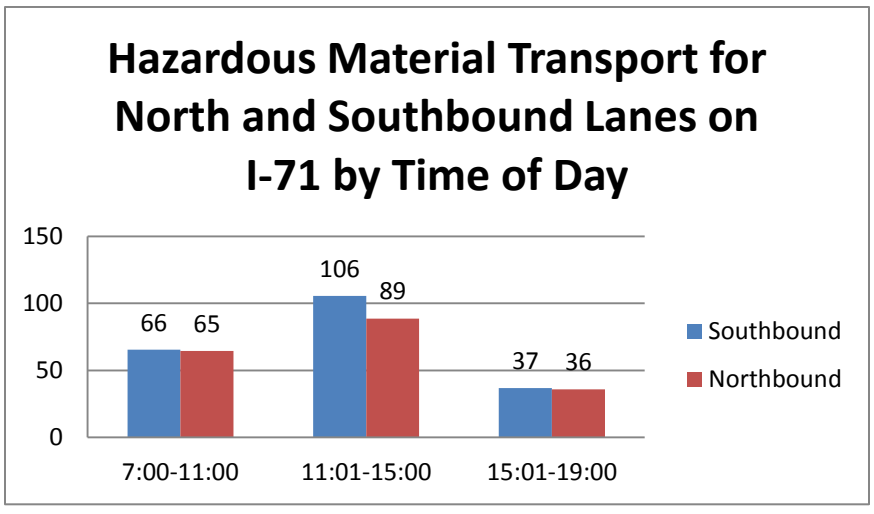
Period 1 (Morning): 7:00 to 11:00

Period 2 (Afternoon): 11:01 to 15:00

Period 3 (Evening): 15:01 to 19:00

As shown in Figure 5.5, the maximum frequency of hazardous material traffic was observed during the midday period for southbound and northbound lanes, 105.5 vehicles/period and 88.8 vehicles/period, respectively. Minimum hazardous material transport rates were identified in the evening period for north and southbound, with 36.0 vehicles/period and 36.7 vehicles/period, respectively.

Figure 5.5: Frequency of hazardous material by time of the day on I-71



iv. Composition of Hazardous Material being transported on I-71

Analysis of the placard data was used to assess the materials being transported on both northbound and southbound I-71. As shown in Figure 5.6, gasoline, Placard ID 1203, was the most frequently transported material on northbound I-71, with 13.3% of the total hazardous material observed. Other frequently observed materials included flammables, 6.8%, corrosives, 3.8%, and combustible liquids, Placard ID 1993: 3.6%. Frequencies of hazardous materials transported are shown in Table 5.1; the "Other" category indicates all other observed materials, which account for less than 2% of the observations. A list of these materials can be seen in Appendix (6 and 7).

Figure 5.6: Composition of hazardous material on northbound I-71 by percentage of total load

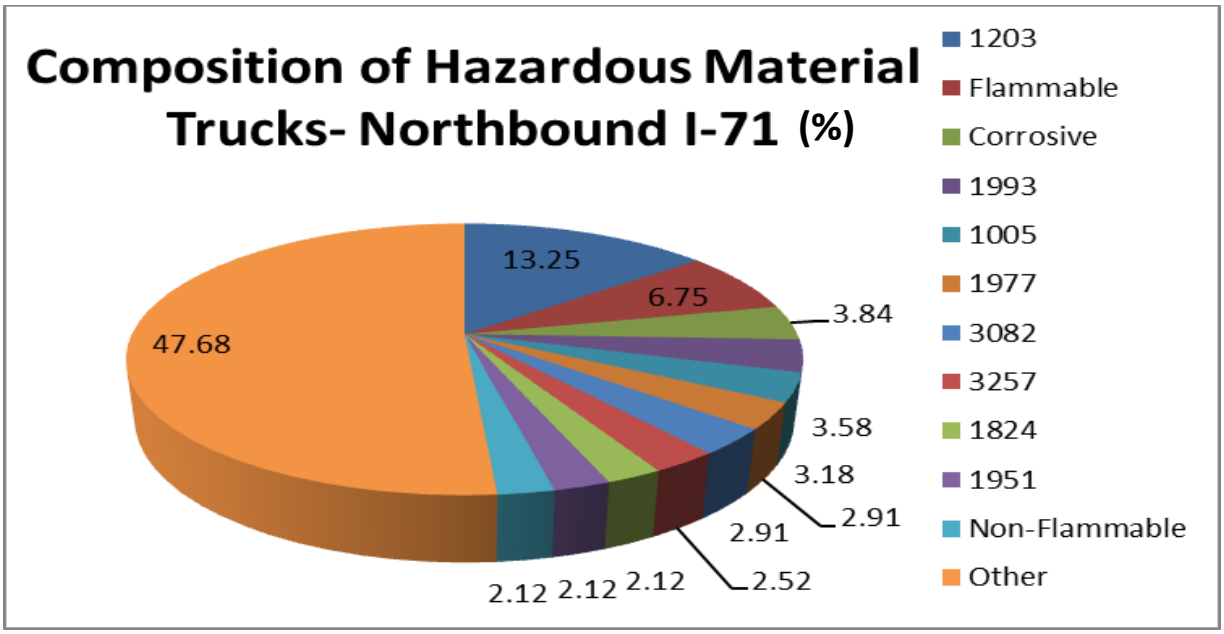


Table: 5.1: Frequency of hazardous material transported on northbound I-71

Material Type	Frequency (%)
1203	100 (13.25)
Flammable	51 (6.75)
Corrosive	29 (3.84)
1993	27 (3.58)
1005	24 (3.18)
1977	22 (2.91)
3082	22 (2.91)
3257	19 (2.52)
1824	16 (2.12)
1951	16 (2.12)
Non-Flammable	16 (2.12)
Other	360 (47.68)

Composition of the hazardous material commodity flow for southbound I-71 is shown in Figure 5.7. Gasoline, Placard ID 1203, was the most frequently detected material during the placard survey on southbound I-71, accounting for 11.1% of the total hazardous material observed. Other commonly observed materials include flammables, 8.45%, corrosives, 6.6%, and environmentally hazardous substances, liquids, Placard ID 3082: 5.2%. Frequencies of hazardous commodities observed are presented in Table 5.2. “Other” indicates all other observed materials, which account for less than 2% of the observations Appendix (6).

Figure 5.7: Composition placarded vehicles on southbound I-71 by percentage of total load

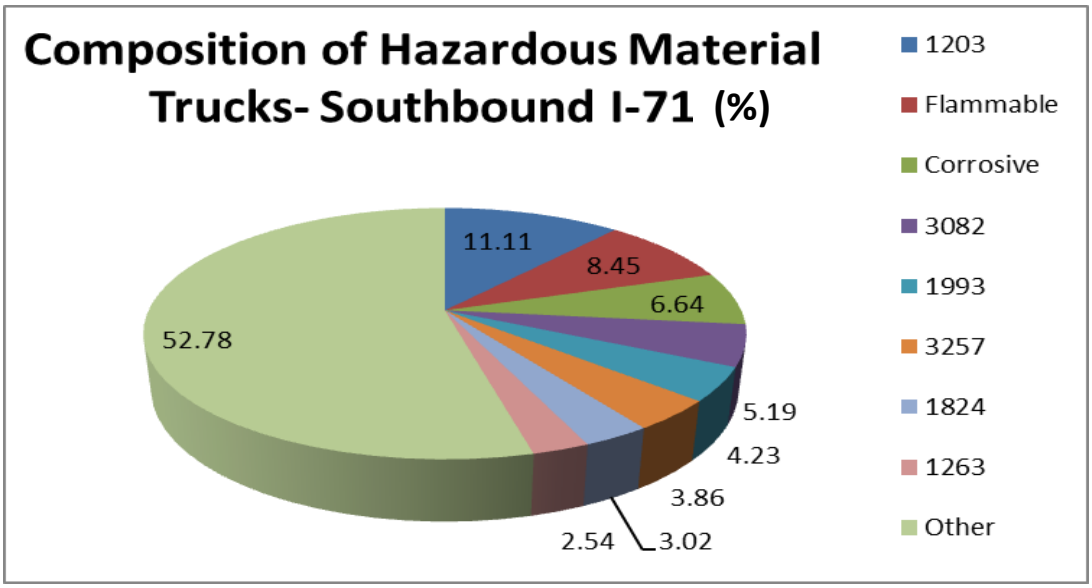


Table 5.2: Frequency of hazardous material transported on southbound I-71

Material Type	Frequency (%)
1203	92 (11.11)
Flammable	70 (8.45)
Corrosive	55(6.64)
3082	43 (5.19)
1993	35 (4.23)
3257	32 (3.86)
1824	25 (3.02)
1263	21 (2.54)
Other	437 (52.78)

Chapter 6: Analysis of Hwy 841 Placard Survey

***i .Aggregate* frequency of placarded** vehicles **Highway 841**

A total of 410 placarded vehicles were observed during the Hwy 841 observation period, July 23-27, 2012 (Figure 6.1). The average number of placarded vehicles observed on both north and southbound Hwy 841 per hour was determined to be 4.1 vehicles/hour (Figure 6.2). There were a greater number of vehicles transporting hazardous material on northbound Hwy 841, 225 vehicles, than southbound, 185 vehicles, representing a 17.8% difference. The average number of placarded vehicles transporting hazardous material per hour was greater northbound, 4.50 vehicles/hour, compared to southbound, 3.70 vehicles/hour.

Figure 6.1: Total number of hazardous material as observed on Hwy-841

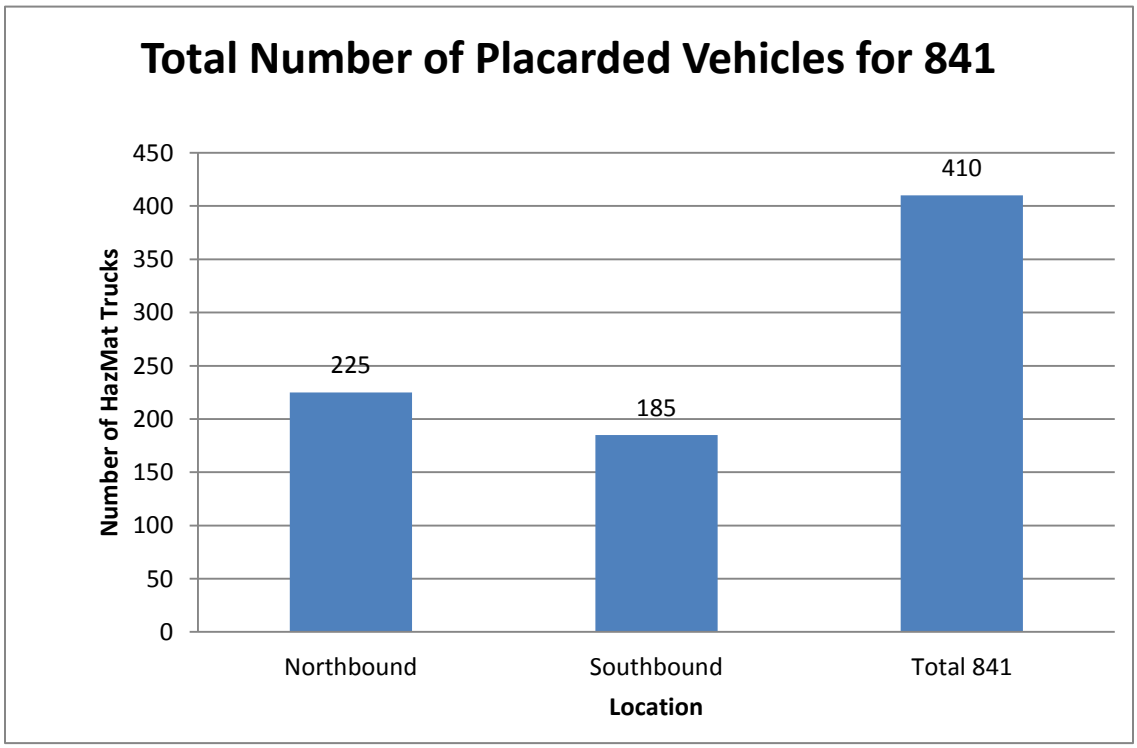
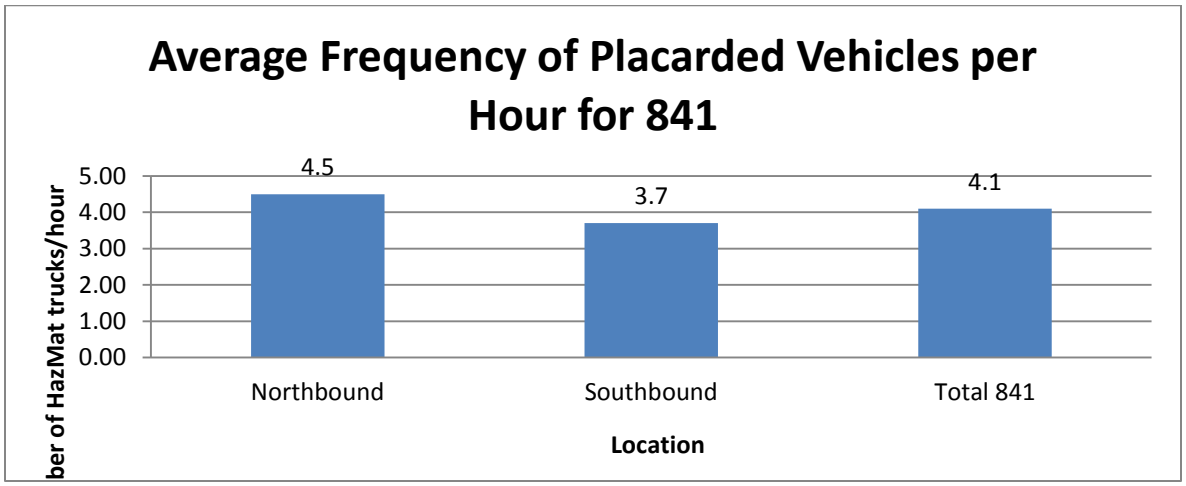


Figure 6.2: Frequency of hazardous material per hour as observed on Hwy 841



ii. Placarded vehicle frequencies by day of the week on Hwy 841

The observation hours for the Hwy 841 monitoring site was scheduled to detect differences in the frequency of hazardous material traffic during the week. Observations occurred from 08:00 to 17:00 each day of the monitoring period. Students made observations from the Hampton Inn (Westport Road), Louisville. Placarded truck flow was conducted for the north and southbound lanes, requiring two observation teams of two students each.

Total hazardous material transported along Hwy 841 peaked on Friday, with an average 4.5 vehicles/hour (Figure 6.3). This pattern was observed in the northbound lane, while the southbound lane peaked on Thursday (Figure 6.4). The lowest average rate was seen on Monday, with 3.40 vehicles/hour. Minimum hazardous material flow rates for the northbound and southbound lanes were detected on Monday. Overall averages were similar for Wednesday, Thursday, and Friday, with values of 4.4 vehicles/hour, 4.5 vehicles/hour, and 4.5 vehicles/hour. Additionally, Monday and Tuesday exhibited similar values, 3.4 vehicles/hour and 3.8 vehicles/hour, respectively.

Figure 6.3: Frequency of hazardous material by day of the week as observed on Hwy-841

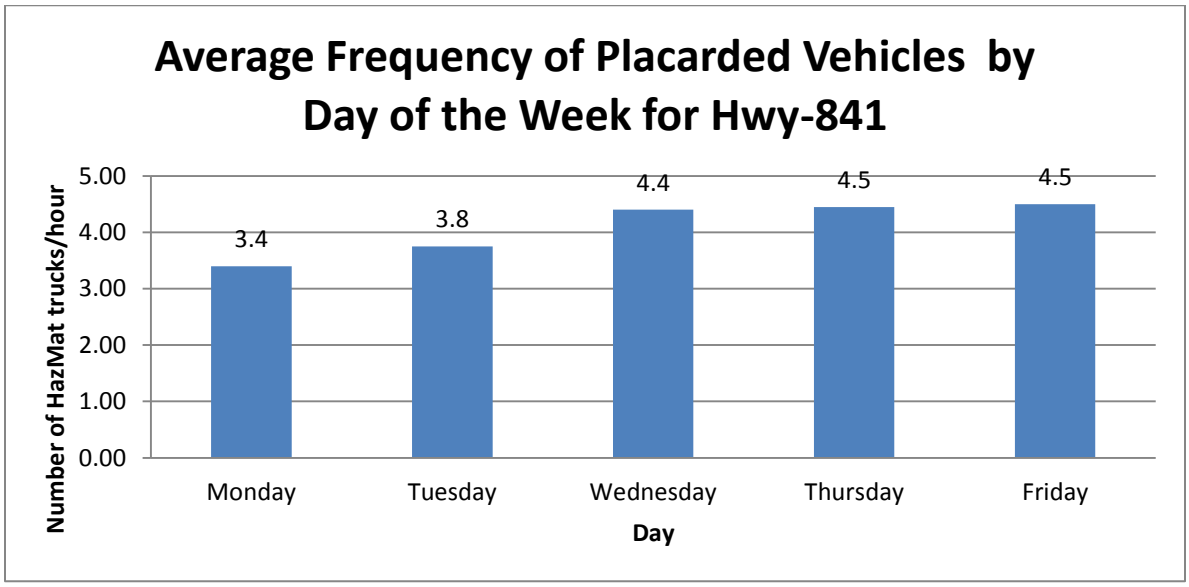
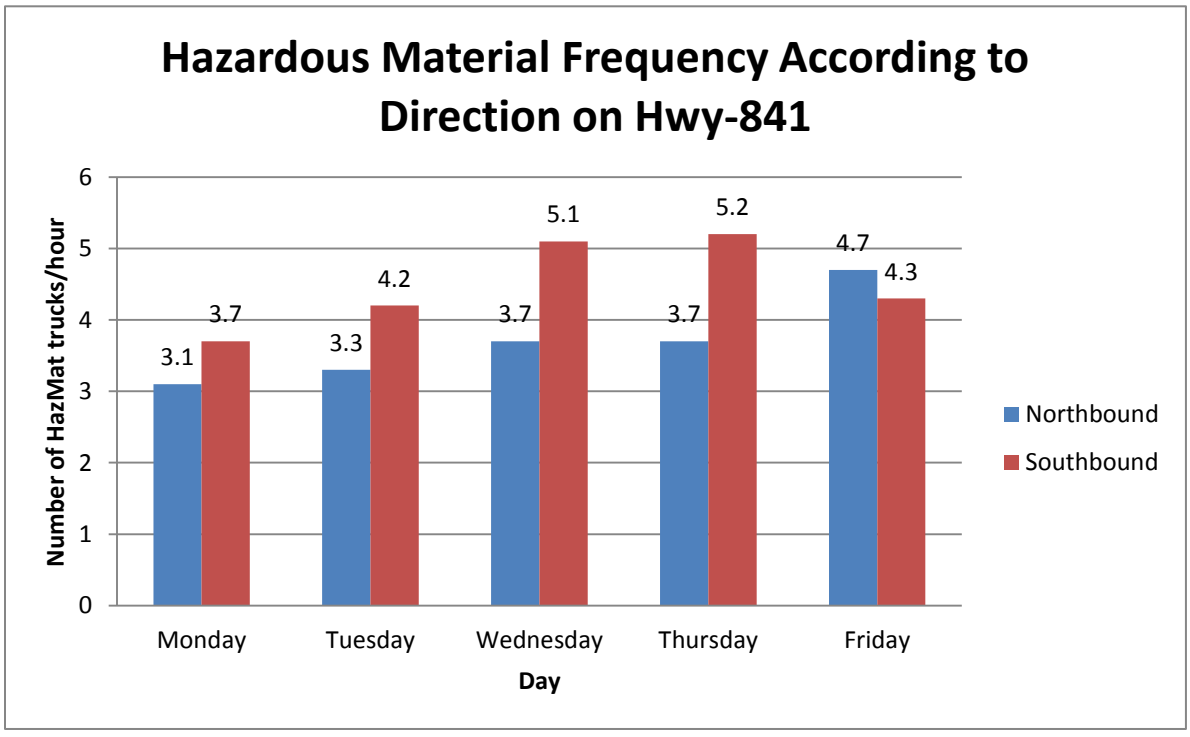


Figure 6.4: Frequency of hazardous material according to direction on Hwy-841



iii. Placarded vehicle frequency by time of the day on Hwy 841

Again, in order to analyze the hourly frequency of hazardous material transport, the monitoring hours at each observation point were divided into three separate periods of four hours. This creates the following three time periods:

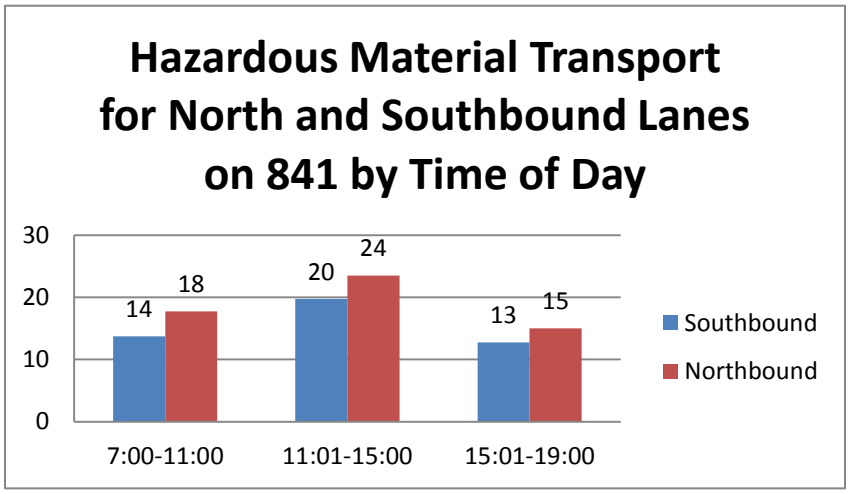
Period 1 (Morning): 7:00 to 11:00

Period 2 (Afternoon): 11:01 to 15:00

Period 3 (Evening): 15:01 to 19:00

As displayed in Figure 6.5, the maximum frequency of hazardous material traffic was observed during the midday period for the southbound and northbound lanes, 19.8 vehicles/period and 23.5 vehicles/period, respectively. The lowest frequency of hazardous material commodity flow was found to occur in the evening period, with 15.0 vehicles/period and 12.8 vehicles/period, for north and southbound lanes, respectively.

Figure 6.5: Transport of hazardous material by time of the day on Hwy-841



iv. Composition of Hazardous Material being transported on Hwy 841

Analysis of the placard data was also used to assess the materials being transported on both northbound and southbound Hwy 841. Gasoline, Placard ID 1203, was the most frequently transported material on southbound 841with 18.4% of the total hazardous material observed (Figure 6.6). Other commonly observed materials included corrosives, Class 8: 14.1%, flammables, 9.7%, and environmentally hazardous substances, liquids, Placard ID 3082: 8.1%. Table 6.1 provides frequencies of hazardous materials transported; the "Other" category indicates all other observed materials, which account for less than 2% of the observations and can be found in Appendix (8 and 9).

Figure 6.6: Composition of hazardous material for placarded vehicles on southbound Hwy-841 by percentage of total load

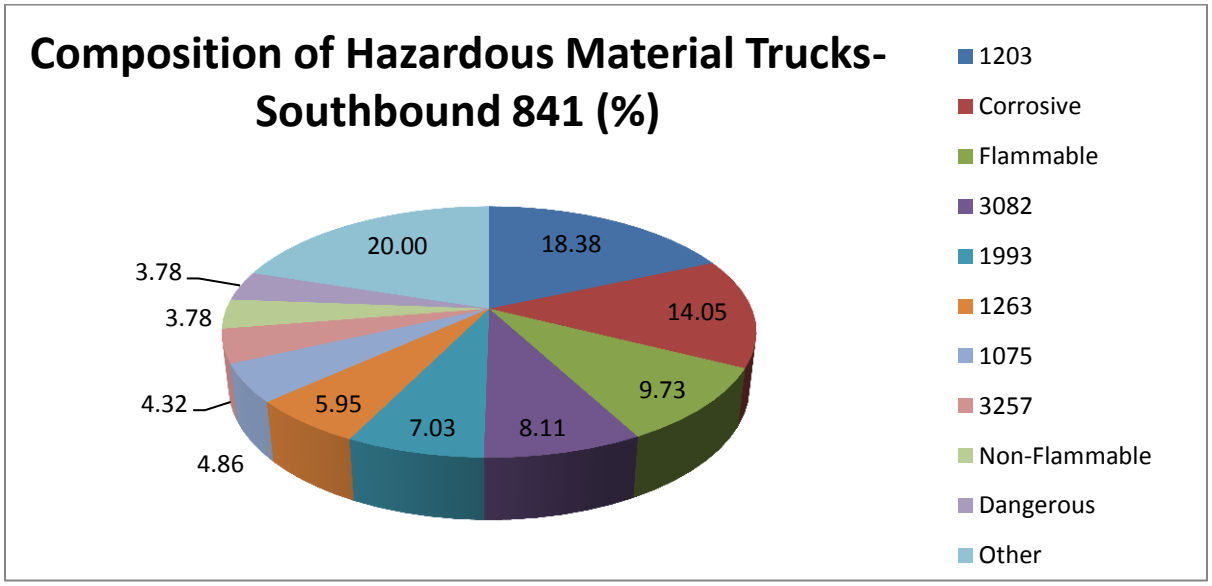


Table 6.1: Frequency of hazardous material transported on Hwy-841 southbound

Material Type	Frequency (%)
1203	34 (18.38)
Corrosive	26 (14.05)
Flammable	18 (9.73)
3082	15 (8.11)
1993	13 (7.03)
1263	11 (5.95)
1075	9 (4.86)
3257	8 (4.32)
Non-Flammable	7 (3.78)
Dangerous	7 (3.78)
Other	37 (20.00)

As shown in Figure 6.7, gasoline, Placard ID 1203, was also the most frequently transported material on northbound Hwy 841, accounting for 12.9% of the total hazardous material. Other commonly observed materials included flammables, 9.8%, environmentally hazardous substances, liquids, Placard ID 3082: 6.2%, and elevated temperature liquids, placard ID 3257: 5.8%. Table 6.2 shows frequencies of hazardous materials transported; the "Other" category indicates all other observed materials, which account for less than 2% of the observations and can be found in Appendix (9).

Figure 6.7: Composition of hazardous material placarded vehicles on northbound Hwy 841 by percentage of total load

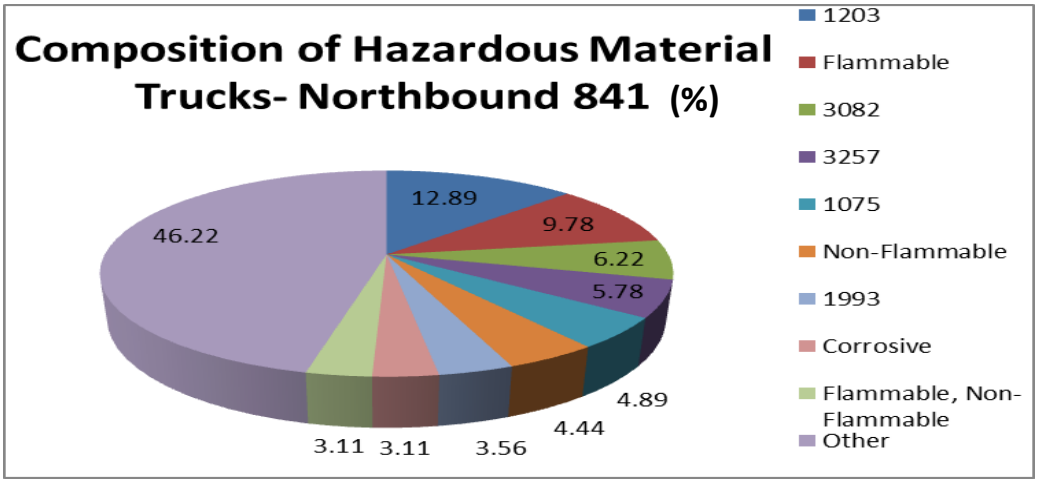


Table 6.2: Frequency of hazardous material transported on northbound Hwy-841

Material Type	Frequency (%)
1203	29 (12.89)
Flammable	22 (9.78)
3082	14 (6.22)
3257	13 (5.78)
1075	11 (4.89)
Non-Flammable	10 (4.44)
1993	8 (3.56)
Corrosive	7 (3.11)
Flammable, Non-Flammable	7 (3.11)
Other	104 (46.22)

Chapter 7: Fixed Facilities Hazardous Commodity Transport Survey

A fixed facilities hazardous commodity transport survey was administered through Jefferson County/Louisville Emergency Management Agency, Appendix (10). Survey data was collected from 54 fixed facilities within the Louisville Metro study area. The Kentucky Emergency Response Commission monitors these facilities as they store large amounts of hazardous materials. In some instances, hazardous material exceeds the threshold planning capacity of the EPA's "Extremely Hazardous Materials". Emergency planning for future hazardous material incidents should be based upon knowledge of fixed facilities use of trucking, both timing and routes, although other modes of transportation such as rail and barge may be used.

In order to investigate the travel of hazardous materials to and from fixed facilities, the survey consisted of a voluntary questionnaire. Surveys were mailed to environmental health and safety managers in July 2012. The questionnaire was designed to document the origins and destinations of hazardous material commodities interacting with fixed facilities, within the study corridor. Surveys were returned to Jefferson County/Louisville Emergency Management Agency. The results were assessed to portray the types of hazardous material transport within the study area.

Information requested in the questionnaire included:

- Frequency of Hazmat shipments
- Routine of hazmat shipments

- Total quantities of hazardous materials
- Origins/Destinations of shipments
- Timing of Hazmat shipments
- Composition of Hazmat shipments
- Recent trends

i. Fixed facilities and hazardous materials

A total of 54 industrial facilities responded to the survey. Most of the responding industries ship and receive hazardous materials. It is essential to know the type of hazardous materials transported, as well as their regular periods of shipment. Survey results evaluate the most common substances transported, their origins and destinations, as well as trend of transportation over the last four years, i.e. 2008-2011. Jefferson County/Louisville Emergency Management Agency can utilize the fixed facility survey results, in conjunction with the commodity flow survey, to assess preparedness for hazardous material incidents within the study region. An important aspect of this survey was to determine if facilities transport hazardous materials on legal holidays. Facilities, which indicated that they do not carry hazardous materials, were discarded from the results.

ii. Fixed Facility Locations

Survey questions, regarding the location of facilities based on city, state and county, were provided to local industries. This data was used to assess hazardous material commodity imports and exports in the Louisville Metro study area. All 54 facilities that responded to the survey were based in Kentucky, with some having corporate offices in other states.

Questions in the survey addressed the most common mode of transportation of hazardous material to and from the facilities. All 54 facilities reported using trucks as a major source of

hazardous material transport. None of the facilities reported using railroad as a means of transportation. The survey included questions requiring the facilities to give information about the number of placarded trucks that leave or arrive at their facilities. Routes of hazardous material transport were requested in the questionnaire. Location, by zip code, of the 54 facilities is shown in Figure 7.1. Approximately, 20% of the facilities reporting were located in zip code 40258. At least 30% of all responding facilities were located between the 40258 and 40214 zip codes. Frequency data for facility location is presented in Table 7.1. The "Other" category indicates all other observed hazardous materials, which account for less than 2% of the total observations.

Figure 7.1: Fixed facility location by zip code

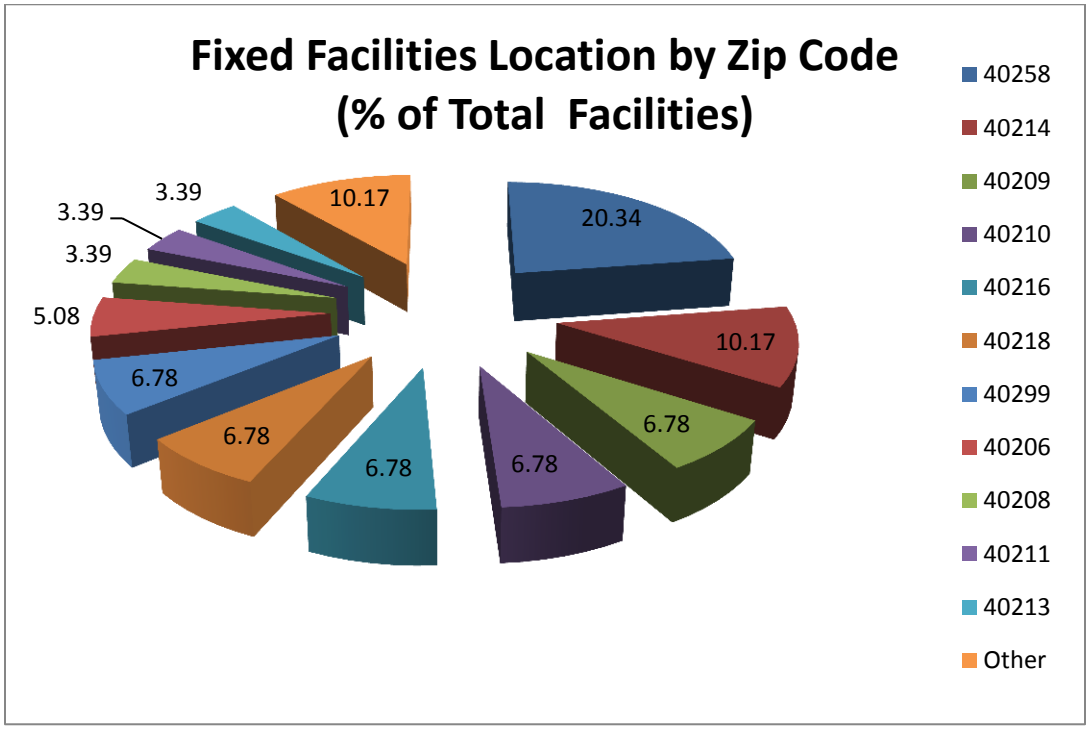


Table 7.1: Fixed Facility Location by Zip Code

Unique Zip Codes	Frequency	Percentage
40258	12	20.34
40214	6	10.17
40209	4	6.78
40210	4	6.78
40216	4	6.78
40218	4	6.78
40299	4	6.78
40206	3	5.08
40208	2	3.39
40211	2	3.39
40213	2	3.39
40124	1	1.69
40203	1	1.69
40219	1	1.69
40229	1	1.69
40231-9366	1	1.69
40245	1	1.69

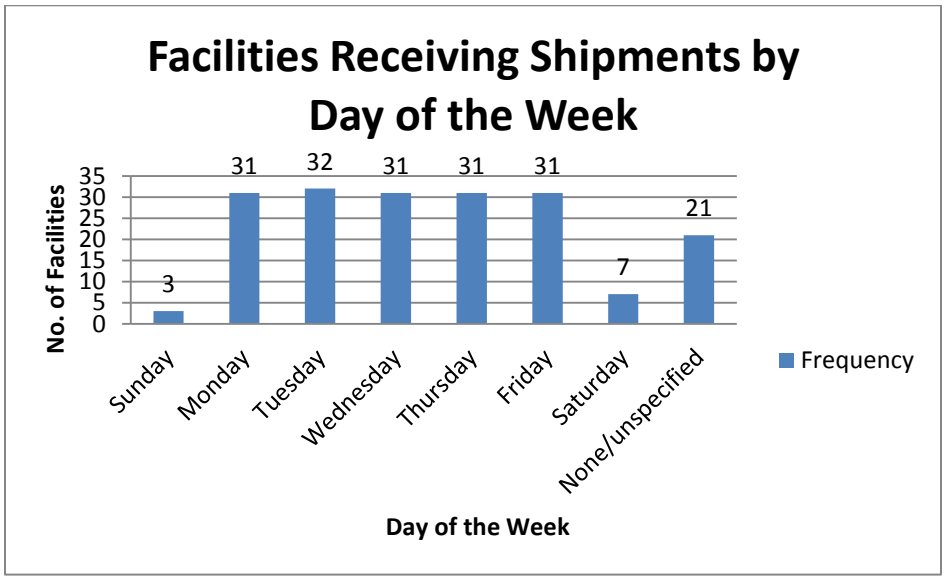
iii. Time pattern for receiving hazardous materials shipments

One of the questions in the survey asked the facilities to give information regarding the number of placarded vehicles that arrived and departed from their facilities. Table 7.2 gives an overview of the movement of these vehicles, by frequency for receiving. When we compare the tonnage of materials received over the past four years, we observe that the bulk of receiving is during the week or Monday through Friday (Figure 7.2), as reported by the facilities.

Table 7.2: Time pattern, by day, for receiving hazardous materials

Day	Frequency
Sunday	3
Monday	31
Tuesday	32
Wednesday	31
Thursday	31
Friday	31
Saturday	7
None/unspecified	21

Figure 7.2: No. of facilities receiving shipments by day of the week

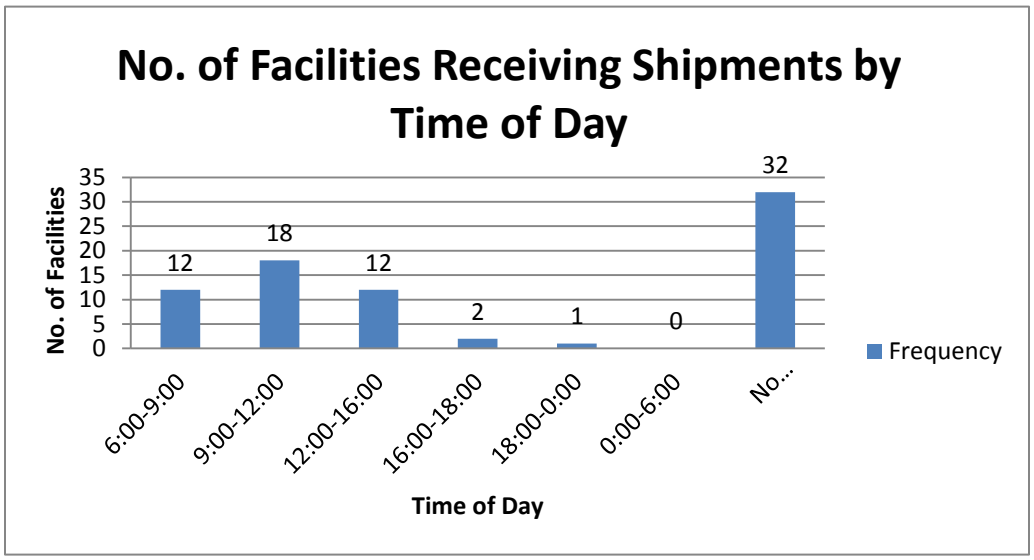


Fixed facilities were also asked to give information on the most common shipment periods. Results are shown in Table 7.3 and Figure 7.3. Information submitted indicated that 32 facilities had no routine time of shipment. The most common time of day for shipments of hazardous materials was during normal working hours, between 06:00 – 16:00.

Table 7.3: Frequency of truck based hazardous material shipments received by time of the day

Time of Day	Frequency
6:00-9:00	12
9:00-12:00	18
12:00-16:00	12
16:00-18:00	2
18:00-0:00	1
0:00-6:00	0
No Routine/Not Specified	32

Figure 7.3: No. of Facilities receiving shipments by time of the day



The facilities were asked if they received or shipped hazardous materials on legal holidays. Twelve facilities, which make up 22% of all responding facilities, ship or receive hazardous materials on legal holidays. This may be a contingency to plan for as altered traffic patterns may change the operation parameters of placarded vehicles, thus increasing the chances of incidents.

iv. Time pattern for shipments from facilities

Facilities were asked to report on time patterns for shipping hazardous materials. Six facilities reported Saturday and three facilities reported Sunday as routine shipment days (Table 7.4). Thirty-six facilities reported that they had no routine period of shipment by day. The typical shipment pattern reported (Figure 7.4) by day was during the work week, Monday through Friday. Time of day patterns for hazardous material shipments showed a trend towards standard work hours, between 06:00 and 16:00 (Table 7.5 and Figure 7.5). At least 21 facilities reported that there was no routine day for shipments and 22 reported there was no routine time of day.

Table 7.4: Time Pattern by day for Shipping from facilities

Day	Frequency
Sunday	3
Monday	26
Tuesday	27
Wednesday	26
Thursday	28
Friday	26
Saturday	6
None/Unspecified	21

Figure 7.4: No. of Facilities sending shipments by day of the week

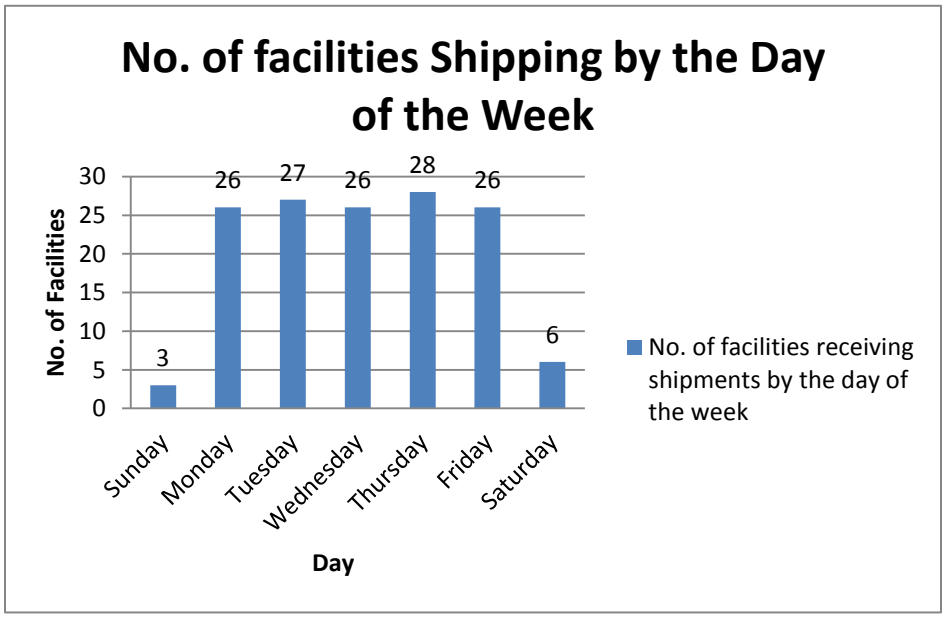
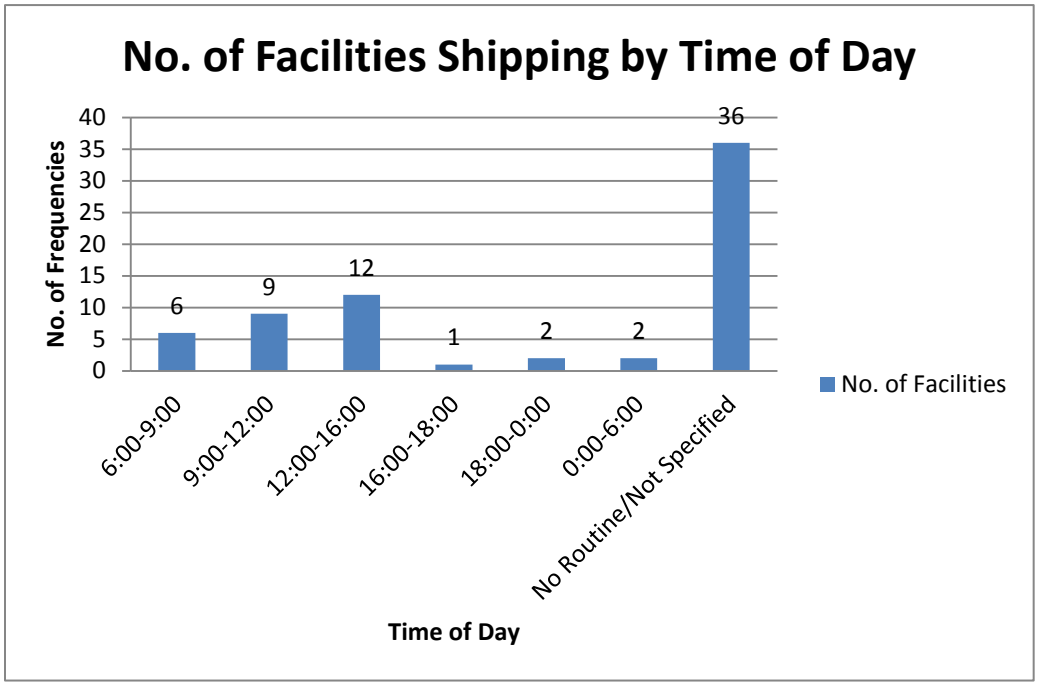


Table 7.5: Frequency of movement of trucks by facilities by time of the day

Time of Day	No. of Facilities
6:00-9:00	6
9:00-12:00	9
12:00-16:00	12
16:00-18:00	1
18:00-0:00	2
0:00-6:00	2
No Routine/Not Specified	22

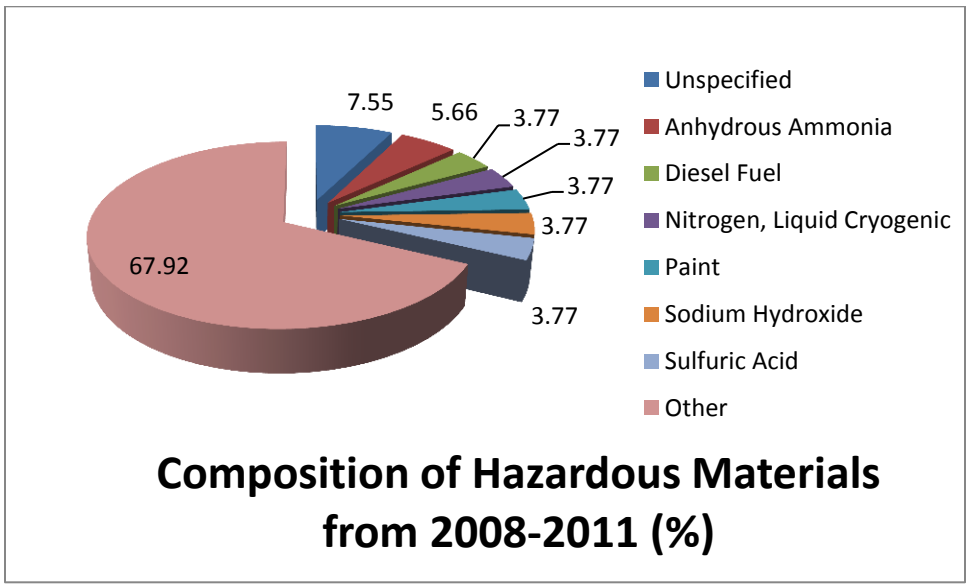
Figure 7.5: No. of facilities shipping by time of the day



v. Material Data Analysis

Survey questions were designed to elicit information about the five most frequently shipped hazardous materials from each facility. Respondents listed a total of 38 hazardous materials that were transported during the three-year period, August 2008 through June 2011. Survey questions addressed the most common cities and states the materials are transported to, including seasonal transportation. Out of the 38 hazardous materials listed, Anhydrous Ammonia, Diesel fuel, Paint, and Acids (which include sulfuric acid, glacial acetic acid, lead acid batteries) formed approximately 32% of the hazardous material composition (Figure 7.6). Other hazardous materials that were transported included ammonium nitrate, aerosol, caustic soda, ammonium hydroxide, calcium nitrate, flammable solids and liquids, and others together formed the 68% of the total of hazardous materials.

Figure 7.6: Composition of hazardous materials shipped and received by facilities from 2008 - 2011

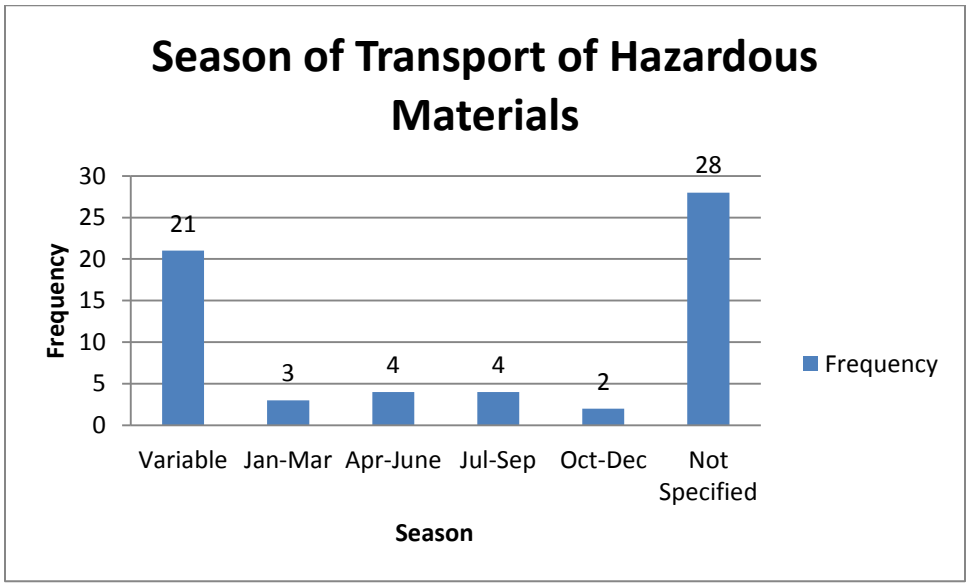


Seasonal transport was another series of questions in the survey, including the season during which hazardous material is most frequently transported. Facilities provided the most common seasons of the year during which they transport hazardous materials (Table 7.6 and Figure 7.7). For the facilities that responded, 45% reported that they had no particular season for transportation of hazardous materials. Whereas, 33% responded that the seasons when they transport material varied throughout the year. The supply period is based upon demand for their produced materials. The distribution of supply slightly decreases from October to December.

Table 7.6: Frequency of transport of material according to seasons

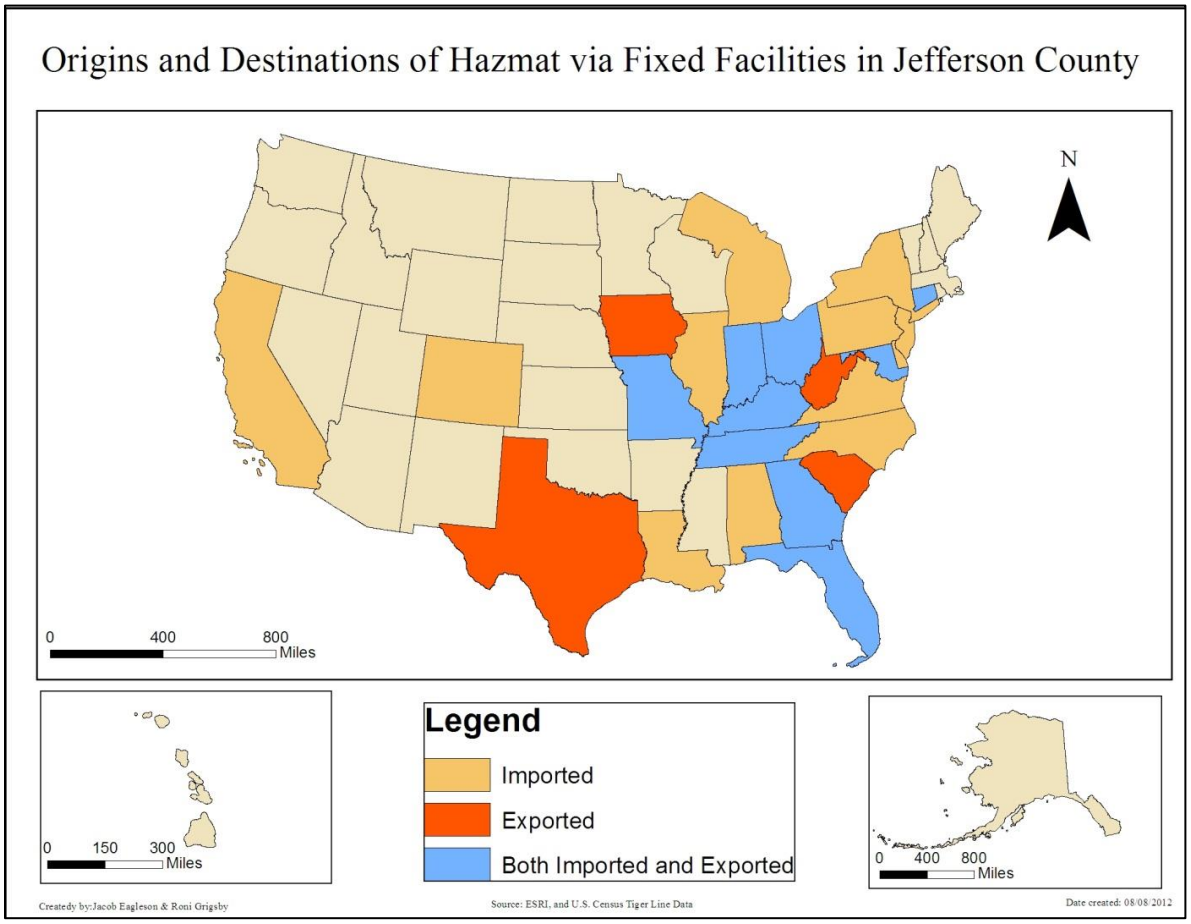
Season of Transport	**Frequency**
Variable	21
Jan-Mar	3
Apr-June	4
Jul-Sep	4
Oct-Dec	2
Not Specified	28

Figure 7.7: Frequency of seasons of shipments on the Louisville Metro area



Survey results also included information as to the origin and destination of hazardous materials, to and from the responding facilities. States that hazardous materials were both imported to and exported from included: Tennessee, Indiana, Ohio, Missouri, and four other states (Figure 7.7). Hazardous materials were imported from the reporting facilities as far away as California. A total of 24 states were reported as the origins of hazardous materials coming into the study area (Figure 7.8). More facilities receive shipments from the states of Tennessee, Kentucky, Indiana, Ohio and Illinois, than all others.

Figure 7.8: Origins and Destinations of Hazardous Material



Destination states were indicated in the survey by the reporting facilities. Figure 7.9 shows the states that were indicated to send shipments of hazardous materials to the Jefferson County/Louisville study area. Survey responses indicated that Kentucky, Indiana, and Ohio were reported as the most frequent ship from states by facilities in the study area. Likewise, these states were the highest frequency for receiving shipments from facilities in the study area (Figure 7.10). Two facilities also reported shipping hazardous materials to the states of Georgia, Texas, and West Virginia. The spatial patterns of shipment and receiving provide an indication of the probable travel routes for hazardous material commodity transport.

Figure 7.9: States that ship hazardous materials to Jefferson County, KY

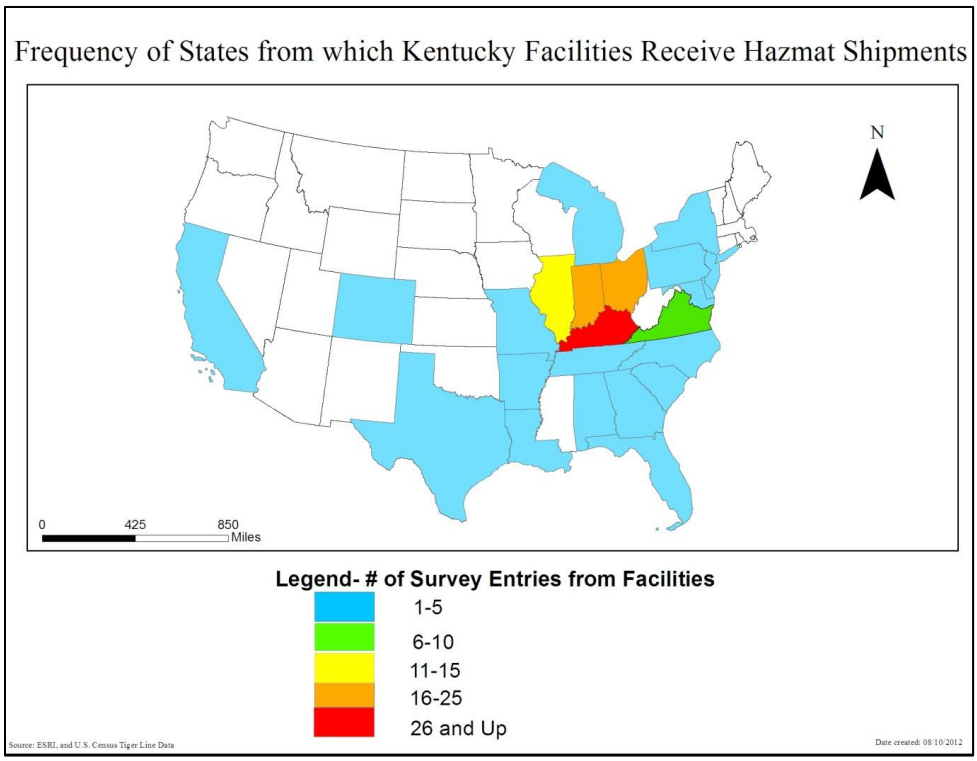
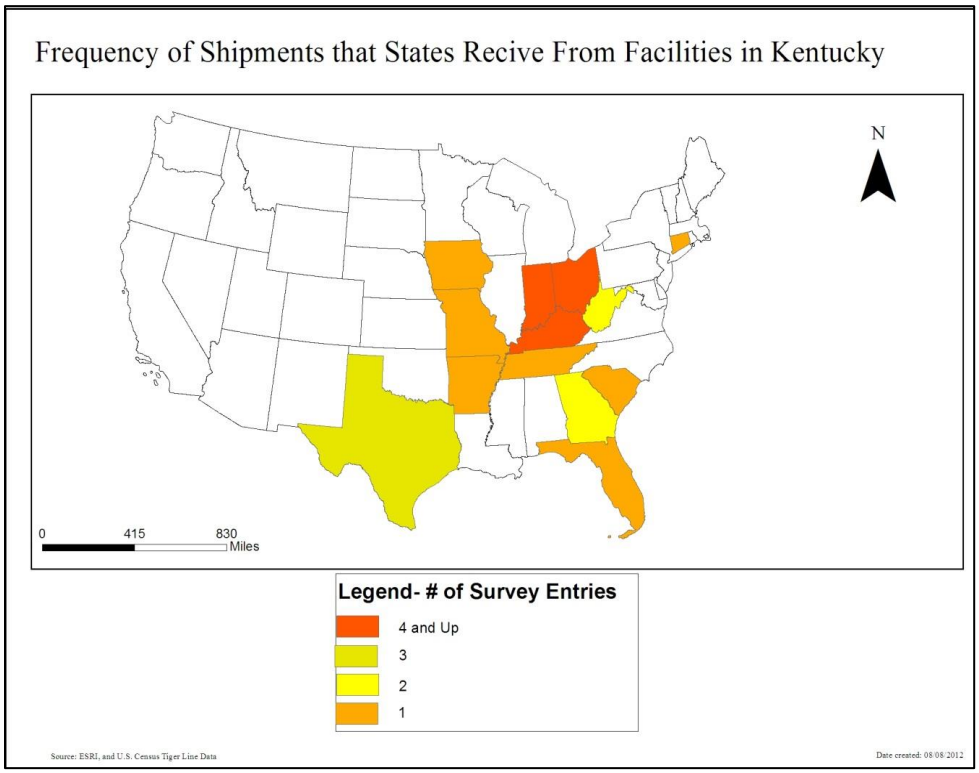


Figure 7.10: States that receive shipments from Jefferson County, KY



Chapter 8: Summary and Recommendations

Hazardous materials are an important part of contemporary American society. As with other commodities, hazardous materials are produced, transported, stored, used and discarded. Hazardous materials that are released due to highway, railway, and other incidents pose a threat to environment and human health. Incidents with hazardous materials can take place at any time, from their production to their disposition. This study clarifies the quantities and types of hazardous materials that are transported on I-65, I-64, I-71 and Hwy 841 in the Louisville Metro area of Kentucky. Likewise, information is provided on the timing of transport, which is critical for emergency preparedness.

It is essential to prepare communities, both large and small, for the potential of hazardous material incidents. Hence, it is important to initiate construction of a knowledge base that concerns types of hazardous materials being transported to, from, and through a respective jurisdiction. In addition to their relative frequencies, the timings and routes of hazardous materials increase emergency response preparedness. Emergency response planning should be predicated on an adequate portrayal of these elements of hazardous material movements. The adequacy of emergency response organizational schemes, contingency plans, equipment inventories and purchases, and personal training must be assessed in the light of this type of information.

This report creates an accurate starting point, and begins the development of the necessary knowledge for the commodity flow of hazardous materials through the study corridor in Louisville Metro. Communicating this information to emergency responders will generate an initial line of incident response before such an event occurs. Coordination of emergency response

will be critical to adequately protect human health and environment from the potential impacts of the hazardous materials documented. It is hopeful that results and recommendations of this report will be a useful guide in preparing emergency responders.

This study provides focus on highway transportation. The empirical results that are summarized below are based on the following:

- A three-year hazardous material incident history from August 2008 – June 2011, which was reported to the Jefferson County Emergency Management Agency.
- A fixed facility survey sent out to facilities in the Louisville Metro area.
- Commodity flow data was collected by placard surveys on I-65, I-64, I-71 and Hwy 841. Monitoring was conducted by Western Kentucky University students from the Department of Public Health, Environmental Health Science program. Student work was supervised by Dr. Vijay Golla and Dr. Ritchie Taylor of Western Kentucky University and by Mr. Jim Bottom with Jefferson County/Louisville Emergency Management.

The following section summarizes the results obtained in chapters 2, 3, 4, 5, 6 and 7, and gives recommendations which can be used as a guidance tool for emergency preparedness related to hazardous material incidents:

Result 1:

During the period of August 2008 – June 2011 a total of 101 incidents were reported to the Jefferson County/Louisville Emergency Management. Most hazardous material incidents occurred on the I-65 corridor from the Brooks, KY Exit, to the interchange near Hospital Curve. Incidents in the metro area increased from 16 in 2008 to 42 in 2010. Other problematic areas for hazardous material incidents included the rail yard off near Outer Loop, and the I-71/ Watterson

Expressway interchange. USDOT placard ID number 1993 (Diesel/Oil) was the most common hazardous material involved in incidents, accounting for 44.55% of total emergency incidents. Current data for 2011 indicates a greater rate of incidents than in 2010.

Recommendation 1.1:

The emergency response committee should index general economic activity as a predictor of commodity transport. Data shows that transport volume corresponds to the number of incidents. Periods of recovery after a sustained economic lull may be particularly dangerous periods in the study corridor.

Recommendation 1.2:

Jefferson County/Louisville Emergency Management should inform local emergency responders as to the most detected placard ID numbers in surveys, incidents, and from other data sources. This would ensure that responders are prepared for hazardous materials incidents that are likely to occur. Also, emergency management planning should take all hazardous materials observed into account.

Recommendation 1.3:

A more extensive analysis of the incidents in the Metro Louisville study area should be undertaken for the last ten years of record. Density maps should be completed to elucidate patterns of incidents or hot spots.

Result 2:

Majority of incidents include spills and vehicular accidents along the study corridor.

Recommendation 2:

It is important to update the drivers about the current rules and regulations and safety norms. Strict rules should be implemented for speed control in this corridor. Logbooks should be thoroughly checked to make sure the drivers do not overwork, and speed limits for trucks should be restricted to 60 mph or less. Trucks overtaking other vehicles on highways should be fined. A system of automated signage may improve safety.

Result 3:

Diesel, placard ID 1993, is the most common hazardous material released in hazardous material incidents. The Response guide that should be used for this substance is 128.

Recommendation 3:

It is important for local emergency responders to be properly trained for response Guide No. 128. They should be updated with any changes that are made to this guide. Annual training for emergency responders should include a refresher on application of response guide 128 under various scenarios.

Result 4:

The greatest frequency of hazardous material imports/exports was reported to arrive from and ship to Kentucky and the surrounding states: Indiana, Ohio, Tennessee and Missouri.

Recommendation 4:

This warrants an increased need for the emergency responders to be vigilant around the interstate corridors, which connect these states, since these will be popular routes for hazardous materials.

Additional emergency crossover points should be provided along I-65, I-64, I-71, and Hwy 841 that allows emergency vehicles increased access for incidents. Additionally, the density of incidents should be studied to prepare contingency plans for the areas with the greatest pattern of past incidents.

Result 5:

Commodity flow rates of hazardous materials were greatest during mid week and during normal work hours.

Recommendation 5:

It is extremely important for emergency responders to be familiar with the peak days and times with reference to the transportation of hazardous materials. This will ensure better alertness and preparedness in case an incident occurs during these time periods. Extra emergency responders should be on call during the aforementioned peak timing in order to ensure efficient response. One potential problem in areas with volunteer emergency responders is that these responders are usually working other jobs during these peak times for hazardous material transport. A system needs to be devised to improve incident response in these areas.

Result 6

The most common type of hazardous material that is transported across the study corridor varies by Interstate. On I-64 gasoline, ID 1203, is most commonly transported. Corrosives and gasoline, ID 1203, are most commonly transported on I-65. I-71 and Hwy 841 both varied greatly in which hazardous material was most commonly detected. They each ranked highest in the "other

category" followed by corrosives and gasoline respectively. A review of the list of the "other category" in the appendices of this report is needed.

Recommendation 6:

Responders should review the most common types of hazardous material that is transported via each study corridor and develop emergency response plans for the related materials. It is extremely important to train emergency responders with reference to these materials. Annual training should be established for incidents involving ID 1203, 3257, corrosives, and 1075. Additionally, contingency plans should be developed in the areas with the greatest densities of incidents in case an evacuation or extensive response is in order.

Result 7:

From chapter 7, Fixed Facilities Survey, it is clear that the greatest numbers of facilities are located in the Louisville Metro area

Recommendation 7:

It is very important for local responders in the Louisville Metro area to be trained to deal with a range of hazardous material incidents. Proper training equipment and PPE should be kept in place. Each responder should review the hazardous materials that have been observed in this report and be trained and prepared to respond to each one. Additionally, scenarios with multiple hazmats should be practiced.

Result 8: Transportation of the majority of hazardous materials was observed to take place during weekdays, and between working hours of 6 am-4 pm. This corresponds to the morning and evening rush hours of public traffic. Additionally, this corresponds to school bus transport.

Recommendation 8: Facilities should be requested to change their hours of shipments to mid-day, early morning or early evening. This will limit the risk to the public during traffic rush hour.

Result 9: Monitoring was constrained to daylight hours due to budget and time restrictions for the project. Additionally, rail and barge commodity loads of hazardous material were not included for the aforementioned reasons.

Recommendation 9: A placard survey should be completed in the Louisville Metro area that includes monitoring during the late evening, 18:00-22:00, through the night, 22:00-02:00, and into the early morning hours, 02:00-06:00. Currently, the rate of commodity flow is unknown for these time periods in the Louisville Metro area. A daylight rail and barge commodity flow pilot study should be completed to begin to assess the load of hazardous materials transported by these modes of transport.

Chapter 9: References

Golla, V. (2011). Madison County, Kentucky, Hazardous Materials Commodity Flow Analysis, Final Report, August 2011. *Public Health Faculty Publications.* Paper 2. http://digitalcommons.wku.edu/public_hlth_fac_pub/2.

Taylor, R. (2010). Warren County, Kentucky Hazardous Materials Commodity Flow Analysis. Final Report, August 12, 2010. http://digitalcommons.wku.edu/public_hlth_fac_pub/1/.

U.S. Department of Transportation. (2010). *U.S Department of Transportation Federal Motor Carrier Safety Administration*. Retrieved August 26, 2012, from DOT: http://www.fmcsa.dot.gov/safety-security/hazmat/hm-theme.htm

U.S. Environmental Protection Agency. (2010, March 10). *Wastes-Hazardous Wastes*. Retrieved August 26, 2012, from U.S.Environmental Protection Agency: http://www.epa.gov/osw/hazard/