U.S. Department of
Homeland Security

U.S. Department of Transportation
Federal Highway Administration

WYOMING COMMODITY FLOW STUDY

FOR GOSHEN COUNTY

By:

Mohamed M. Ahmed, PhD, PE

Department of Civil & Architectural Engineering
University of Wyoming
1000 E. University Avenue, Dept. 3295
Laramie, Wyoming 82071
Phone: 307-766-5550
Fax: 307-766-2221
mahmed@uwyo.edu

March 2019

DISCLAIMER

Notice

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The U.S. Government assumes no liability for the use of the information contained in this document.

The U.S. Government does not endorse products or manufactures. Trademarks or manufacturers' names appear in this report only because they are considered essential to the objective of the document.

Quality Assurance Statement

The Federal Highway Administration (FHWA) provides high-quality information to serve Government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. FHWA periodically reviews quality issues and adjusts its programs and processes to ensure continuous quality improvement.

Technical Report Documentation Page

1. Report No.	**2. Government Accession No.**	**3. Recipient's Catalog No.**	
4. Title and Subtitle Wyoming Commodity Flow Study – Goshen County		**5. Report Date** March 2019 **6. Performing Organization Code**	
7. Author(s) Irfan Uddin Ahmed, B.Sc. (University of Wyoming) Sherif Gaweesh, Ph.D., P.E. (University of Wyoming) Mohamed Ahmed, Ph.D., P.E. (University of Wyoming)		**8. Performing Organization Report No.**	
9. Performing Organization Name and Address Department of Civil & Architectural Engineering University of Wyoming 1000 E. University Avenue, Dept. 3295 Laramie, Wyoming 82071		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.**	
12. Sponsoring Organization Name and Address Wyoming Office of Homeland Security 5500 Bishop Blvd, East Door Cheyenne, WY 82002		**13. Type of Report and Period Covered** Final Report March 2019 **14. Sponsoring Agency Code**	
15. Supplementary Notes			
16. Abstract			
A hazardous materials (HAZMAT) commodity flow study is a transportation analysis study identifying the types and amounts of hazardous materials being transported through a specified geographic area by analyzing current traffic patterns. Transportation of hazardous materials may pose a great danger to the public and environment if an incident occurred. The main objectives of this study were to identify what, where and when hazardous material is being transported in Goshen County. Due to a lack of HAZMAT transportation information within this jurisdiction, collecting new original HAZMAT data was needed. Two locations were identified by the Wyoming State Emergency Response Commission (SERC) in conjunction with the Wyoming Office of Homeland Security (WOHS) and Goshen County Emergency Management Agency to collect HAZMAT data from highway intersections in Goshen County. The selected study locations 1&2 were intersections of US-85 and US-26 in Torrington and Lingle cities, and location 3 was on US-85 in Torrington. Data analysis showed that the most common HAZMAT being transported is class 3 (flammable liquids) in location 1 and 2, and class 2 (gases) in location 3. It also showed that truck-trailer is the most common type used to transport HAZMAT in all the study locations. This study provides emergency responders, community planners and organizations with information that may aid in enhancing emergency preplanning.			
17. Key Words Hazardous Materials, HAZMAT, Commodity Flow Study, HMCRP, ERG		**18. Distribution Statement**	
19. Security Classification (of this report) Non-Classified	**20. Security Classification (of this page)** Non-Classified	**21. No. of Pages** 46	**22. Price**

Form DOT F 1700.7 (8-72) Reproduction of form and completed page is authorized

ACKNOWLEDGEMENTS

The authors of this report would like to extend their gratitude to the Wyoming Office of Homeland Security (WOHS), Wyoming State Emergency Response Commission (SERC) and Pipeline and Hazardous Materials Safety Administration (PHMSA) for funding this research project. All statements and opinions presented in this expert system are the sole responsibility of the authors and may not necessarily reflect those of the SERC or of WOHS.

METRIC CONVERSION FACTORS

SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

EXECUTIVE SUMMARY

A hazardous materials (HAZMAT) commodity flow study (CFS) is a transportation analysis study identifying the types and amounts of hazardous materials being transported through a specified geographic area by analyzing current traffic patterns. Hazardous materials are substances that would threaten human safety, health, the environment, or property if released. Hazardous materials are classified into nine classes according to the emergency response guide 2016. Transportation of hazardous materials may pose a great danger to the public and environment if an incident occurred. One HAZMAT incident could affect a circle of diameter ranging from 0.5 to 5 miles. Using the data collected in the commodity flow study, emergency responders and community planners will be able to enhance emergency planning capabilities and continue to support existing emergency response organizations.

The objectives of this study were to identify what, where and when hazardous materials are being transported in Goshen County, identify most likely hazard scenarios that may be expected in that jurisdiction, provide information about the amount of HAZMAT being transported and provide responders, community planners, and organizations information that enhances emergency preplanning.

There is a lack of HAZMAT transportation information in Wyoming. Prior HAZMAT studies in the same geographic area are important as they provide a baseline information for the current situation. Unfortunately, no previous studies were conducted in Goshen County. Although, several studies were conducted in Wyoming in other counties. The first HAZMAT CFS was conducted back in 1986 in Albany County. A large gap separates the first conducted study and the following conducted studies in Wyoming. The Wyoming State Emergency Response Commission (SERC), in conjunction with the Wyoming Office of Homeland Security (WOHS), has identified the need to conduct HAZMAT CFS in Wyoming to fill in this huge gap. In 2015, a HAZMAT commodity flow study was conducted in Campbell and Converse Counties, followed by more CFS in Laramie County and Albany County in 2016, Natrona County and Sweetwater County in 2017, and Johnson County in 2018. For Campbell and Converse counties two intersections on WY59 were chosen to collect HAZMAT data. For Laramie County, HAZMAT data was collected from four locations around Cheyenne city. The four locations were: 1) US 85 MP 5, 2) US 85 MP 25, 3) I-80 MP 345,

and 4) HW 210 MP 18. For Albany the locations studied were: 1) I-80 MP 307, 2) I-80 MP 333 and 3) US287 at MP 405. The Natrona County CFS locations included: 1) US-220 MP 108, 2) US-20/26 MP 12, 3) I-25 South MP 182.06 and 4) I-25 North MP 192. The Sweetwater County CFS included the following locations: 1) I-80 MP 66, 2) US-30 MP100 and 3) US-191 MP5. The locations selected for the CFS in Johnson County included: 1) I-25 MP 295, 2) I-90 MP 60, and 3) US-16 MP 5.

Collecting new original HAZMAT data was needed in this study to achieve the required objectives. Data collection was the major task in this study. In consultation with the Emergency Management Coordinator from Goshen County (Shelly Kirchhefer), the roadways (intersections) chosen for the proposed commodity flow study are: intersections of US-85 and US-26 in Torrington and Lingle. Additionally, the data collection team from the University of Wyoming decided to collect data from US-85 in Torrington which is a straight highway segment. In total, three locations were selected and the exact locations were:

1. The intersection of U.S. Highway 85 and State Highway 26 in Torrington
2. The intersection of U.S. Highway 85 and State Highway 26 in Lingle
3. US-85 near Americas Best Value Inn- Torrington

Eight graduate students from the University of Wyoming volunteered to carry out the road network HAZMAT data collection. Three days during the winter break were selected to collect field data for the selected locations. Field data was collected for the two identified locations and an additional location on a straight highway segment. Field data collection periods consisted of 3 consecutive days with 10 hours per day of data collection, forming a total of 30 hours of counting for each of the first two locations. For the locations on US-85 field data was collected for two days forming a total of 20 hours of data collected.

Descriptive analysis of the collected HAZMAT data was performed to clarify the distribution of HAZMAT trucks according to its destination and the different types of HAZMAT being transported at the four study locations according to the placard class and ID. Amounts of HAZMAT being shipped were estimated according to the different body configurations, under the assumption that all the counted HAZMAT trucks are loaded with hazardous materials. The HAZMAT amount was calculated according to the minimum and maximum amount of shipment each body configuration can hold. It should be noted that the only way to obtain the accurate amount of shipped HAZMAT, is by checking the shipment documents, which was not feasible to obtain.

Data analysis showed that the most common HAZMAT class being transported is class 3 and class 2 which are flammable liquids and gas, respectively. Accordingly, it would indicate that the most likely HAZMAT incident could happen would involve a class 3 or class 2 HAZMAT.

While the exact truck payload of HAZMAT being transported cannot be identified from a field data collection, truck body configuration is a good indication of the amount of HAZMAT being transported. Analysis showed that truck-trailers (TT) are the most common types used to transport HAZMATs in the studied locations. The truck-trailer can transport from 5,500 to 9,500 US gallons. The estimated minimum/maximum amounts of the transported HAZMATs were 127,290/218,034 US gallons/day for the intersection of US-85 and US-26 in Torrington, 176,105/300,185 US gallons/day for the intersection of US-85 and US-26 in Lingle, and 81,169/137,679 for US-85 in Torrington. It should be noted that these numbers were estimated without taking seasonal variation into account due to a lack of seasonal factors for HAZMAT transportation in Wyoming.

This study provides responders, community planners and organizations information that could help in enhancing emergency preplanning also to adjust and schedule the resources to support emergency response capabilities for potential incidents to protect the environment and people.

Table of Contents

List of Figures

List of Tables

WYOMING COMMODITY FLOW STUDY
GOSHEN COUNTY

Final Draft Report
March 2019

Principal Investigator
Mohamed M. Ahmed, Ph.D., PE
Associate Professor
Department of Civil and Architectural Engineering, University of Wyoming

Graduate Research Assistant
Irfan Uddin Ahmed
Department of Civil and Architectural Engineering, University of Wyoming
Sherif M. Gaweesh
Department of Civil and Architectural Engineering, University of Wyoming

Authors
Irfan Uddin Ahmed, M.Sc., Sherif Gaweesh, Ph.D., and Mohamed M. Ahmed, Ph.D., PE

Sponsored by
Pipeline and Hazardous Materials Safety Administrations (PHMSA)

A report from
Department of Civil and Architectural Engineering, University of Wyoming
1000 E. University Ave, Laramie, WY 82071
Phone: 307-766-5550
Fax: 307-766-2221
mahmed@uwyo.edu

LIST OF ACRONYMS/ABBREVIATIONS

AADT	:	Annual Average Daily Traffic
CFS	:	Commodity Flow Study
DHS	:	Department of Homeland Security
ERG	:	Emergency Response Guide
FHWA	:	Federal Highway Administration
HAZMAT	:	Hazardous Materials
HMCFS	:	Hazmat Commodity Flow Study
HMCRP	:	Hazardous Materials Cooperative Research Program
HRs	:	Hours
HW	:	Highway
I	:	Interstate
ID	:	Identification Number
IR	:	Infra-Red
LED	:	Light-Emitting Diode
LPG	:	Liquefied Petroleum Gases
MADT	:	Monthly Average Daily Traffic
MAWDT	:	Monthly Average Week Day Traffic
MAWET	:	Monthly Average Weekend Traffic
MP	:	Milepost
MT	:	Multi-Trailer
n.o.s	:	not otherwise specified

PHMSA	:	Pipeline and Hazardous Materials Safety Administration
SERC	:	State Emergency Response Commission
ST	:	Straight Truck
TT	:	Truck Trailer
US	:	United States
V	:	Volts
vpd	:	Vehicles Per Day
WHP	:	Wyoming Highway Patrol
WOHS	:	Wyoming Office of Homeland Security
WYDOT	:	Wyoming Department of Transportation

CHAPTER 1- INTRODUCTION

A hazardous materials (HAZMAT) commodity flow study (CFS) is a transportation analysis study identifying the types and amounts of hazardous materials being transported through a specified geographic area. The CFS clarifies the flow of hazardous materials through a certain area by analyzing current traffic patterns. It provides a reference to match planning programs to existing needs within communities and reduce the occurrence of risky incidents[1].

Hazardous materials are substances that are flammable, explosive, toxic or any substance that would threaten human safety, health, the environment, or property if released. The effect of the increase in transportation of hazardous materials poses safety, security and environmental issues on all the road users[2].

Transportation of hazardous material poses a great danger to the public and environment if an incident takes place. Responding to these danger kinds of incidents should be fast and appropriate in order to contaminate the dangerous effect on public and environment and to reduce the produced risk. Necessary equipment and safety precautions are the controlling rules to adequately contaminate the incident released danger. Dealing with different hazardous materials incidents requires different safety precautions and different equipment. Mitigating the danger requires a previous knowledge regarding the nature of HAZMAT in transit through the roads network.

Hazardous materials are classified into 9 classes according to the emergency response guide 2016 (ERG)[3].

Table 1 shows the different classes and divisions for the hazardous materials.

By using the data collected in the commodity flow study, emergency responders and community planners will be able to enhance emergency planning capabilities and continue to support existing emergency response organizations.

Hazardous Materials Cooperative Research Program (HMCRP) introduced six main steps identifying the commodity flow study process[2]. Figure 1 shows these six steps for the commodity flow study process. This report will discuss the different steps and how they were applied in this study.

Table 1: Hazardous Materials Classes and Divisions (ERG 2016[3])

Class 1 - Explosives
Division 1.1 Explosives with a mass explosion hazard
Division 1.2 Explosives which have a projection hazard but not a mass explosion hazard
Division 1.3 Explosives which have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard
Division 1.4 Explosives with no significant blast hazard
Division 1.5 Very insensitive explosives with a mass explosion hazard
Division 1.6 Extremely insensitive articles which do not have a mass explosion hazard
Class 2 - Gases
Division 2.1 Flammable gases
Division 2.2 Non-flammable, non-toxic* gases
Division 2.3 Toxic* gases
Class 3 - Flammable liquids (and Combustible liquids [U.S.])
Class 4 - Flammable solids; substances liable to spontaneous combustion; substances which, on contact with water, emit flammable gases
Division 4.1 Flammable solids, self-reactive substances and solid desensitized explosive
Division 4.2 Substances liable to spontaneous combustion
Division 4.3 Substances which in contact with water emit flammable gases
Class 5 - Oxidizing substances and Organic peroxides
Division 5.1 Oxidizing substances
Division 5.2 Organic peroxides
Class 6 - Toxic substances and Infectious substances
Division 6.1 Toxic substances
Division 6.2 Infectious substances
Class 7 - Radioactive materials
Class 8 - Corrosive substances
Class 9 - Miscellaneous dangerous goods/hazardous materials and articles

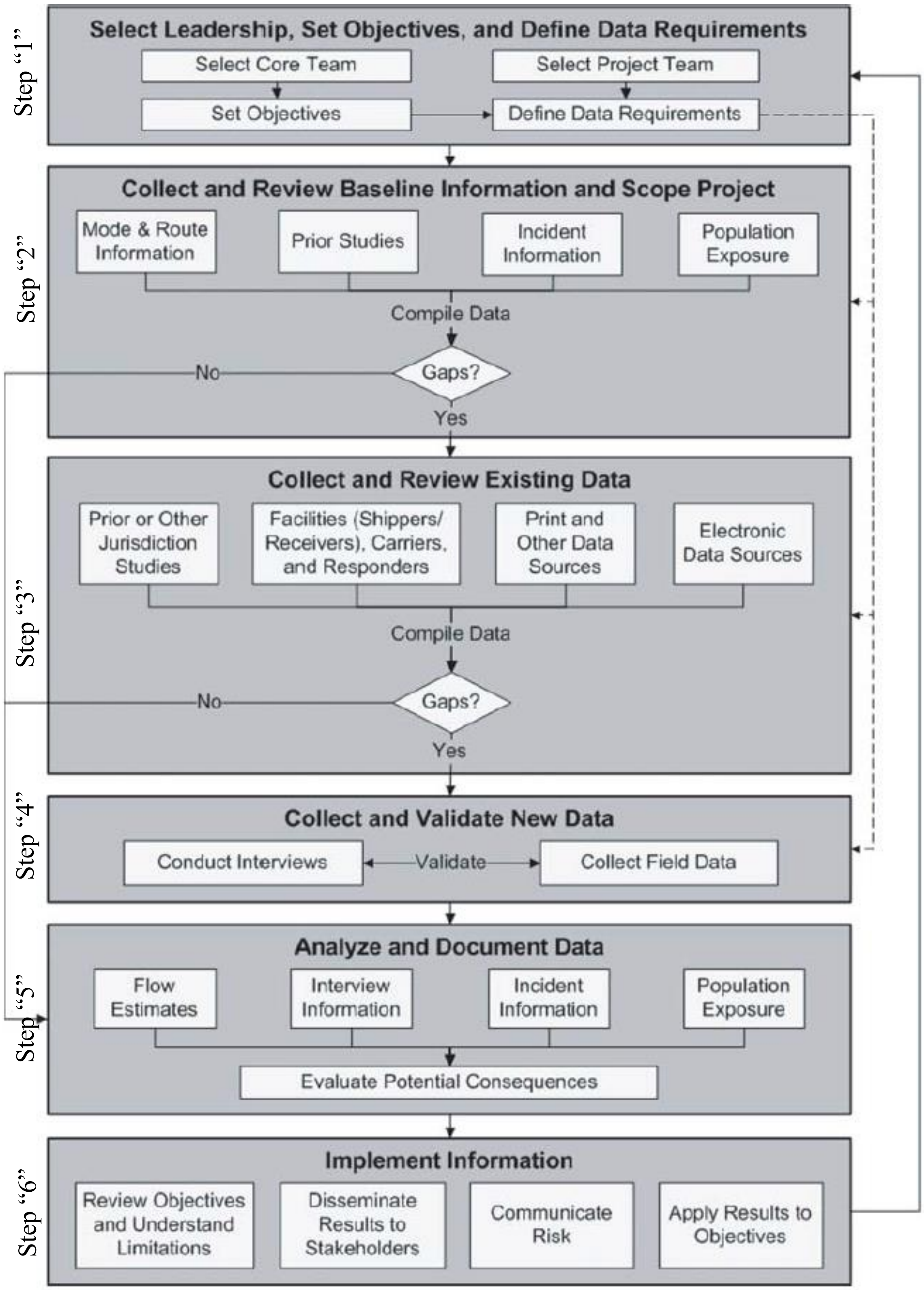


Figure 1: The HAZMAT Commodity Flow Study (HMCFS) Process[2]

CHAPTER 2- OBJECTIVES AND PROJECT OUTLINES

GENERAL

The Wyoming State Emergency Response Commission (SERC), in conjunction with the Wyoming Office of Homeland Security (WOHS) has identified the need to conduct a study of the flow of all HAZMAT commodities in Goshen County. In consultation with the Emergency Management Coordinator from Goshen County, Shelly Kirchhefer, the following roadways (intersections) are chosen for the commodity flow study: the intersection of U.S. Highway 85 and State Highway 26 in Torrington, and the intersection of U.S. Highway 85 and State Highway 26 in Lingle. Another location on U.S. Highway 85 in Torrington was selected by the data collection team in order to estimate the amount of HAZMAT transported through the Torrington city.

OBJECTIVES

The main goal of the study is to identify hazardous materials transportation patterns on Goshen County primary highways to provide help for emergency management agencies to allocate resources and enhance the emergency preplanning.

The tasks of the Wyoming commodity flow study in Goshen County are as follows:

- Determine the amount of commercial truck traffic moving through certain Goshen County Highways
- Identify the truck and container types in order to estimate the amount of HAZMAT being transported.
- Determine the type of hazardous materials being transported along the roadways designated in the commodity flow study.
- Determine the types and quantities of hazardous materials going through Goshen County.
- Analyze and document the collected data.

DATA REQUIREMENTS

To achieve the above objectives, a sampling framework was adopted. The data requirements should include the data collection plan and the required level of precision of the data. HAZMAT data was collected during January 2019 for three days from 7:00 am to 5:00 pm forming a total of 30 counting hours per location. One weekend day and two weekdays were considered for the data collection. For the first location (intersection of US-85/US-26 in Torrington) and second location (intersection of US-85/US-26 in Lingle) data was collected for one weekend (Sunday, 6th of January 2019) and two weekdays (Monday and Tuesday, 7th and 8th of January 2019). For the third location (US-85 in Torrington), data collection was scheduled for two weekdays (Monday and Tuesday, 7th and 8th of January 2019). More information about data collection plan is provided in "Data Collection Plan" section.

According to the Guidebook for Conducting Local Hazardous Materials Commodity Flow Studies[2], Sampling framework is divided into 6 levels. Table 2 shows the different sampling framework used in HAZMAT Commodity Flow Studies (CFSs). HAZMAT truck survey can be done in seven different methods. It depends on the level of data collected about the HAZMAT trucks. Table 3 shows the seven different methods to conduct a HAZMAT placard survey. According to Table 2 and Table 3, data collection in this study can be classified as directional and intersectional surveys with a representative sampling framework.

Table 2: Sampling frameworks, examples, advantages and disadvantages[2]

Sampling Framework	Sampling Examples	Advantages	Disadvantages
Convenience	As available for data collectors	Easiest for data collectors; minimum scheduling management	Difficult to reliably identify traffic patterns at any one location or timeframe
Representative	One location per major roadway, at different times of day on any given weekday, during any season	Easy to conduct over time for data collectors; moderate scheduling management; moderate degree of information about traffic patterns for roadway; low–to moderate level of data collection resources required	Cannot be used to reliably characterize traffic on different segments of same road or other roads, determine seasonal traffic patterns, or transport patterns throughout a network
Cluster	Multiple locations per major roadway, at different times of day, on multiple days of week, during multiple seasons	High degree of information about traffic patterns throughout a transportation network	High degree of scheduling management; may require high level of time commitment from data collectors or other data collection resources
Stratified or Proportional	Dependent on traffic characteristics on given network segment; less data is required for low traffic volumes, and more data for high traffic volumes	Very high degree of information about traffic patterns throughout a transportation network; focuses effort on high-priority segments	Requires statistical calculations to determine sampling requirements; extremely high degree of scheduling management; may require high level of data collection resources
Random	At random times of day, days of week, seasons of year, for a specific network segment	Very high degree of information about traffic patterns on sampled network segment	Requires statistical calculations to determine sampling requirements; extremely high degree of schedule management; requires high level of data collection resources

Census	All traffic data for all times of day, days of week, and seasons of year, for specific network segment or entire network	Complete information about traffic patterns at sample locations	Nearly impossible to attain with current systems; requires an extreme degree of data reduction

Table 3: Traffic and Hazmat placard survey methods

Survey Method	Description	What It Provides	What It Requires
Total Truck Surveys	A count of the total number of observed trucks	Information about overall truck traffic levels during sampled time periods	Assumptions about hazmat transported on observed trucks (e.g., that hazmat transport conforms to national averages); assumptions about types and configurations of trucks used to transport hazmat
Truck Type and Configuration Surveys	A count of observed trucks by truck type and configuration	Information about truck traffic levels, by type and configuration, during sampled time periods	Assumptions about hazmat transported on observed trucks by type and configuration (e.g., that hazmat transport conforms with national averages)
UN/NA Placard ID Surveys	ID and count of observed hazmat placards	Information about the number and types of hazmat placards present during sampled time periods	Assumptions about truck traffic patterns and the types and configurations of trucks used to transport hazmat
Total Truck Combined with UN/NA Placard ID Surveys	A count of the total number of observed trucks and ID and count of observed hazmat placards	Information about overall truck traffic levels and the number and types of hazmat placards present during sampled time periods	Assumptions about types and configurations of trucks used to transport hazmat; data collectors who can record truck count information and placard information
Truck Type and Configuration Combined with UN/NA Placard ID Surveys	A count of observed trucks by truck type and configuration and ID and count of observed hazmat placards	Information about truck traffic levels by type and configuration and the number and types of hazmat placards present during sampled time periods	Data collectors who can record truck type and configuration and placard information; may require more training of volunteers on data collection process and monitoring of collected data to ensure consistency
Directional and Intersection Surveys	Observation of trucks and/or placards on multiple road directions or at intersections at the same time	Information for more than one roadway lane collected at a single location; may reduce number of data collectors needed	Experienced data collectors; more training of volunteers on data collection process, and monitoring of collected data to ensure consistency
Manifest Surveys	Review of information found on shipping papers and interviews of truck drivers	Highly specific information about hazmat shipment content for both placarded and un-placarded loads	Coordination with local, state, or federal license and weigh stations or patrol units; potentially, a very intensive data collection process for high-traffic roadways

CHAPTER 3- BACKGROUND AND BASELINE INFORMATION

GENERAL

The scope of this study focuses on collecting information on HAZMAT transportation on major highways in and around Torrington and Lingle in Goshen County, Wyoming. These major highways are U.S. Highway 85 and State Highway 26. US-85 is a north-south United States highway that travels through Mountain-Northern Plains states. It enters Wyoming from Colorado, 8 miles south of Cheyenne. In Torrington it meets with US-26 and runs concurrently with US-26 for 10 miles until Lingle from where it separates and run northbound. US-26 is an east-west United States highway and passes through Guernsey, Fort Laramie, Lingle and Torrington before entering Nebraska. Both highways are two-lane two-way.

According to the Pipeline and Hazardous Materials Safety Administration (PHMSA) Incident Reports Database, incidents in highways in and around Torrington, Goshen County amounts to 4 HAZMAT incidents from 1990 to 2018[4]. Total losses from the HAZMAT incidents was approximately $30,000. Moreover, weather plays a major role in increasing the possibility of having a HAZMAT incident. Adverse weather conditions (rain, snow, fog, and blowing snow) may cause reduction in visibility, which is an important factor that affects the risk of road crashes.

Wyoming's energy industries, oil and gas, uranium, coal and other extracted minerals, are the main sources of HAZMAT materials being transported in Wyoming[5]. It was reported in the Wyoming state emergency response commission report that 33 facilities in Goshen County store HAZMATs[5].

BASELINE DATA

Prior HAZMAT studies in the same geographic area are important as they provide a baseline information for the current situation. However, no CFS was available or carried out previously for the Goshen County. The first HAZMAT study in Wyoming was previously conducted in Albany County, Wyoming back in 1986[6]. The objectives of the study were to:

- Determine the effect of different seasons on truck and railroad traffic volumes.
- Determine the percentage of traffic transporting HAZMAT.

- Classify the HAZMAT being transported.
- Determine the accuracy of the HAZMAT placards.
- Determine the condition of the trucks and trains transporting HAZMAT.
- Determine the amount of HAZMAT being transported in Albany County.

The study identified the major arterials used to transport HAZMAT within Albany County. The data was collected for 48 hours in different weekdays. Data were collected for 3 hours per day in the morning and afternoon. The study showed that 5.25% of the truck traffic contained hazardous materials. It was also stated that 73% of the trucks were out of service, and the remaining were in good condition. The study stated that the accuracy of placard system is approximately 50%, this accuracy was roughly estimated by the Wyoming Highway Patrol (WHP) with no supporting data presented in the report.

It is worth mentioning that in previous years several CFSs were carried out by the Department of Civil & Architectural Engineering, University of Wyoming. The study locations included Campbell and Converse counties in 2015, Laramie County and Albany County in 2016, Natrona and Sweetwater County in 2017, and Johnson County in 2018. Two intersections on WY 59 were chosen to collect HAZMAT data for Campbell and Conserve counties Commodity Flow Study[7]. The locations studied for the Laramie County Commodity Flow study[8] were: 1) US 85 MP 5, 2) US 85 MP 25, 3) I-80 MP 345, and 4) HW210 MP18 and for the Albany County Commodity Flow Study[9] the locations were: 1) I-80 MP 307, 2) I-80 MP 333 and 3) US287 at MP 405. The Natrona County Commodity Flow Study[10] locations included: 1) US-220 MP 108, 2) US- 20/26 MP 12, 3) I-25 South MP 182.06 and 4) I-25 North MP 192. The Sweetwater County Commodity Flow Study[11] included the following locations: 1) I-80 MP 66, 2) US-30 MP100 and 3) US-191 MP5. The locations studied for the Johnson County CFS[12] were: 1) I-25 MP 295, 2) I-90 MP 60, and 3) US-16 MP 5.

In addition to the HAZMAT data collected on the roadway sections mentioned above, HAZMAT transportation using the railroad via Union Pacific Railroad was analyzed as well in the Albany County Commodity Flow Study.

CHAPTER 4- COLLECTING AND REVIEW EXISTING DATA

As mentioned earlier, no prior hazardous material commodity flow study was conducted in Goshen County, Wyoming. However, several HAZMAT CFSs were conducted in other counties in Wyoming, as previously mentioned.

Due to a lack of information about the HAZMAT transportation in Goshen County, collecting new data was needed to achieve the study objectives. Manual Data collection was the primary method used to collect HAZMAT data in this study. However, other data collection techniques were utilized in data collection. Eight graduate students from the University of Wyoming volunteered to carry out the data collection. Raw data for the study is presented in Appendix C.

CHAPTER 5- NEW DATA COLLECTION

An essential task of this study was to collect HAZMAT traffic data from the 2 main locations on Goshen County highways. As previously mentioned, the two intersections of US-85 and US-26 (near Torrington and Lingle) were determined by the Wyoming State Emergency Response Commission (SERC) in consultation with the Emergency Management Coordinator from Goshen County, Shelly Kirchhefer. Furthermore, the data collection team selected another location on the US-85 near Torrington to estimate HAZMAT being transported through the city.

Eight graduate students from the University of Wyoming volunteered to carry out the HAZMAT data collection. A total of 3 days of HAZMAT data collection were conducted during the period from 6^{th} to 8^{th} of January 2019.

DATA COLLECTION LOCATIONS

The two proposed data collection locations were on intersections of Goshen County highways and the other location was on a straight segment (US-85 in Torrington) as shown in Figure 2. Figure 2 shows general map of the data collection locations along with the inset maps showing detailed view of the study locations. Location 1 and 2 are 3 leg-intersections of two-lane two-way highways (US-85 and US-26) with traffic movements in 6 directions (Figure 2). Location 3 is a straight segment of a two-lane two-way state highway with traffic movements in 2 directions.

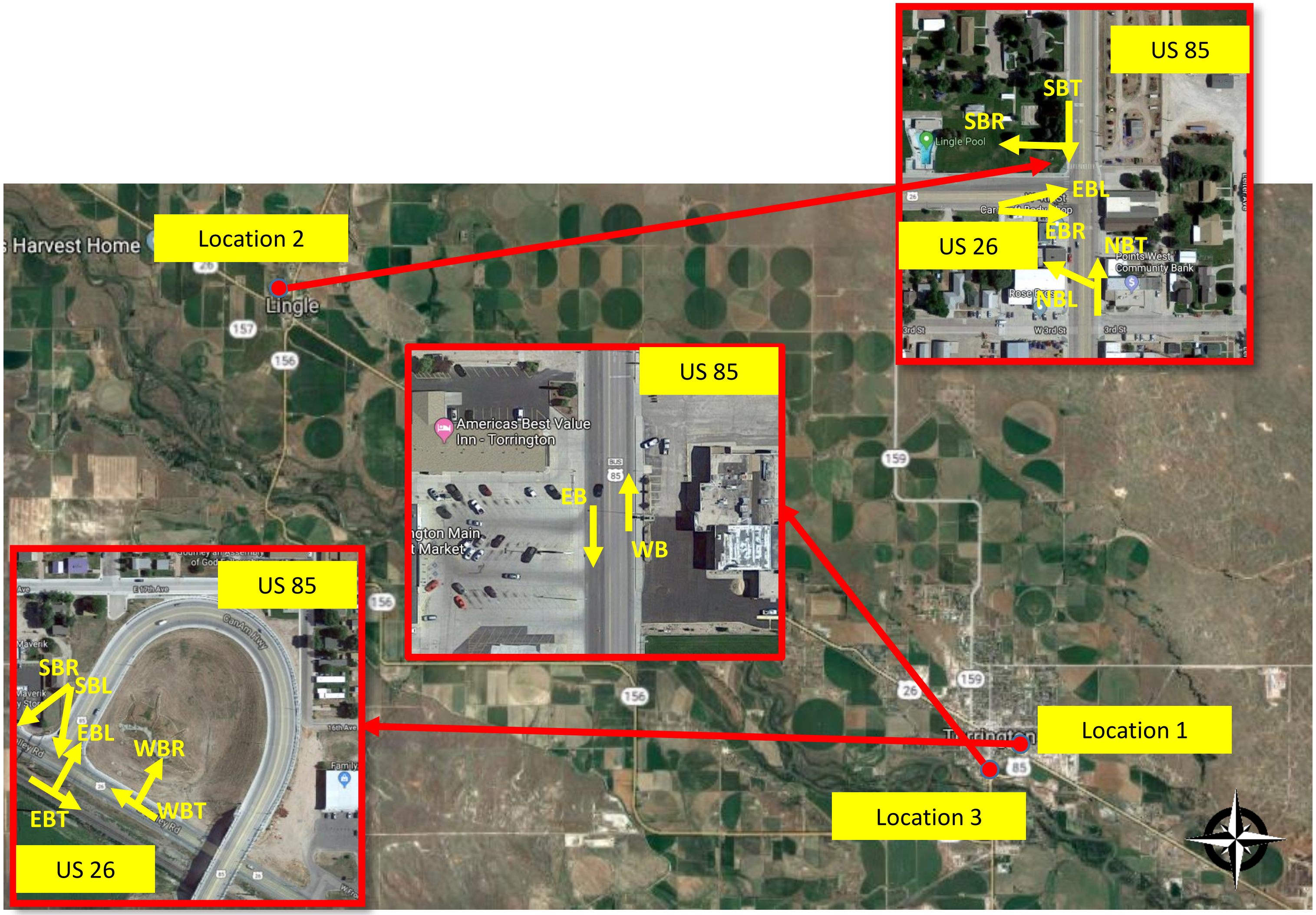


Figure 2: Data collection locations in Goshen County

DATA COLLECTION PLAN

Most of the Hazardous Material Commodity Flow Study (HMCFS) use volunteers in order to collect required information about HAZMAT trucks passing at a certain route. In this study, the level of data collection is classified as directional and intersectional surveys with a representative sampling framework[2]. Count data for all vehicle types and HAZMAT trucks data were collected for all the directions for each of the locations as shown in Figure 2.

A data collection sheet, shown in Appendix “A”, was designed to collect Placard ID, Placard Class, Truck Body Configuration, Cargo Type, and Direction. Due to the high speed limit on the study locations, 2 to 3 seconds was the available time to collect all the aforementioned data. Moreover, a truck count was conducted so as to estimate the percentage of HAZMAT trucks passing through each location. Truck count sheets are provided in Appendix A. Another challenge faced during the data collection was the multiple trucks passing at the same time. Due to these issues, volunteers participated in this study received training in order to be able to capture the correct information on the placard and the truck in few seconds.

Data from the location 2 was collected by 2 volunteers, 1 per 5-hour shift. For the first day, 4 volunteers were assigned to location 1 with 2 volunteers collecting data in each 5-hour shift. However, it was observed that only 1 volunteer per shift was needed at location 1 and from the second day 2 volunteers were assigned to location 3 to collect data for the additional location. Data collection in location 2 was carried out by 2 volunteers on the second and third day. As shown in Table 4 data collection periods consisted of 3 consecutive days; one weekend and two weekdays. HAZMAT traffic counts were conducted for 10 hours per day. Due to the short duration of daylight data could not be collected for 12 hours each day according to the initial plan.

Table 4: Scheduled Data Collection Plan for Goshen County

Location		Day	Date	Time		Total Number of (HRs)
				From	To	
1	Intersection of US-85/US-26 in Torrington	Sunday, Monday, Tuesday	6^{th}, 7^{th}, and 8^{th} of January 2019	7:00am	5:00pm	10hr×3d = 30
2	Intersection of US-85/US-26 in Lingle	Sunday, Monday, Tuesday	6^{th}, 7^{th}, and 8^{th} of January 2019	7:00am	5:00pm	10hr×3d = 30
3	US-85 in Torrington	Monday, Tuesday	7^{th}, and 8^{th} of January 2019	7:00am	5:00pm	10hr×2d = 20

AVERAGE DAILY TRAFFIC

Traffic pneumatic tube counters can be used to collect annual average daily traffic (AADT), truck percentage, and vehicle classification. Installing pneumatic traffic tubes on the study locations were impossible due to the high traffic volumes and high operating speeds and accordingly they were not used to collect ADTs for the study locations. The Wyoming Department of Transportation (WYDOT) has several automatic traffic recorders, classifiers and count sites that provide the ADT for Wyoming's highways. However, there were no traffic recorders placed nearby the study locations in Goshen County. As a result, ADTs and truck counts had to be done manually. Table 5 shows the traffic data for the selected study locations.

Table 5: Traffic Data for the three data collection locations

Location	MADT	MAWDT	MAWET	% of trucks	% of HAZMAT trucks from truck traffic
Intersection of US-85/US-26 in Torrington	16,662	18,968	10,320	3.68%	4.46%
Intersection of US-85/US-26 in Lingle	4,719	5,196	3,408	17.89%	4.88%
US-85 in Torrington	9,720	-	-	5.22%	4.05%

The HAZMAT truck percentages were calculated based on the percentage of HAZMAT trucks collected from the field data collection

Where:

MADT : Monthly Average Daily Traffic.

MAWDT : Monthly Average Week Day Traffic.

MAWET : Monthly Average Weekend Traffic.

CHALLENGES AND DATA COLLECTION DIFFICULTIES

Many difficulties were faced by the data collection team while collecting the data. Some of these difficulties can be summarized as follows:

- Due to the high operating speed, errors in collecting data might occur.
- Due to the high speed, missing data may be presented when having more than two placards mounted on the same truck.
- In some cases, errors in data collection might happen as more than one HAZMAT truck pass at the same time.
- When trucks or other vehicles are present on both lanes, this might block the vision to collect placard data on HAZMAT trucks.
- There is no fixed location for the HAZMAT placard on the truck body, which represents a challenge to trace its location for each truck as shown in pictures in Appendix B.
- Due to the short duration of daylight it was difficult to collect data for 12 hours per day since it was impossible to collect data in the dark.

CHAPTER 6- DATA ANALYSIS

This section provides descriptive analysis of the collected HAZMAT data. It presents the distribution of HAZMAT trucks according to its destination, and the different types of HAZMAT being transported at the study locations according to the placard class and ID. Moreover, it shows the different amounts of HAZMAT being shipped according to the different body configurations.

HAZMAT TRANSPORTATION USING GOSHEN COUNTY HIGHWAYS

HAZMAT DIRECTIONAL DISTRBUTION

As mentioned earlier, the study locations were at intersections of US-85 and US-26 in Torrington and Lingle, and straight highway segment on US-85 in Torrington. Directional distribution provides the information about the percentage of HAZMAT trucks moving in each direction. Table 6 shows the HAZMAT directional distribution for five of the six study locations.

Table 6: Directional Distribution for HAZMAT trucks for each study location

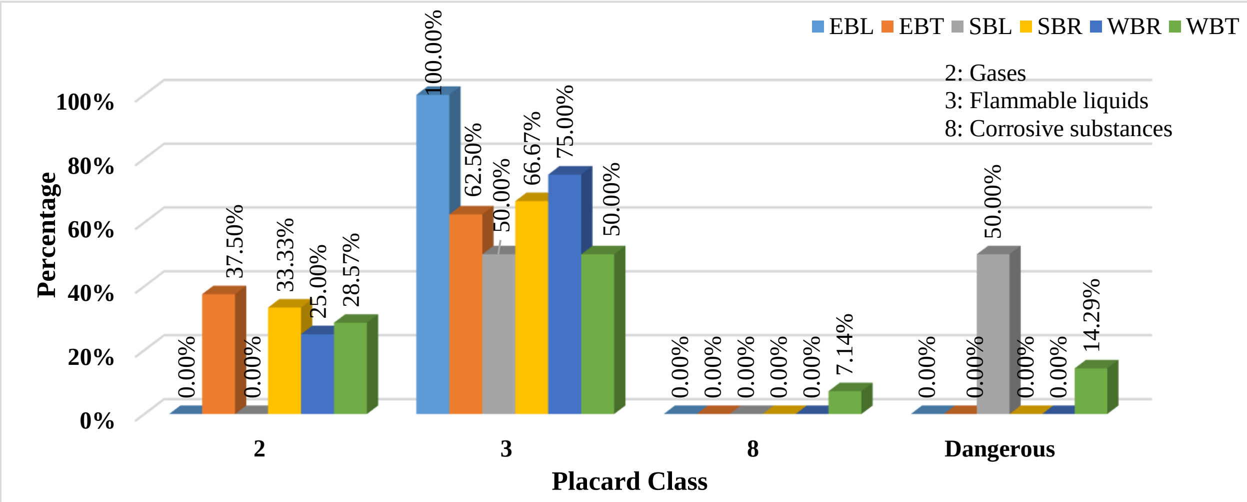
#	Location	Direction	Percentage of HAZMAT trucks for each direction and its count
1	Intersection of US-85/US-26 in Torrington	EBL EBT SBL SBR WBR WBT	6.06%- 2 24.24%- 8 6.06%- 2 9.09%- 3 12.12%- 4 42.42%- 14
2	Intersection of US-85/US-26 in Lingle	EBR NBL NBT SBL SBT	32.56%- 14 39.53%- 17 11.63%- 5 2.33%- 1 13.95%- 6
3	US-85 in Torrington	EB WB	68.75%- 11 31.25%- 5

Data represents percentage of total HAZMAT counted for each direction in the study locations and its percentage

HAZMAT CLASS DISTRIBUTION

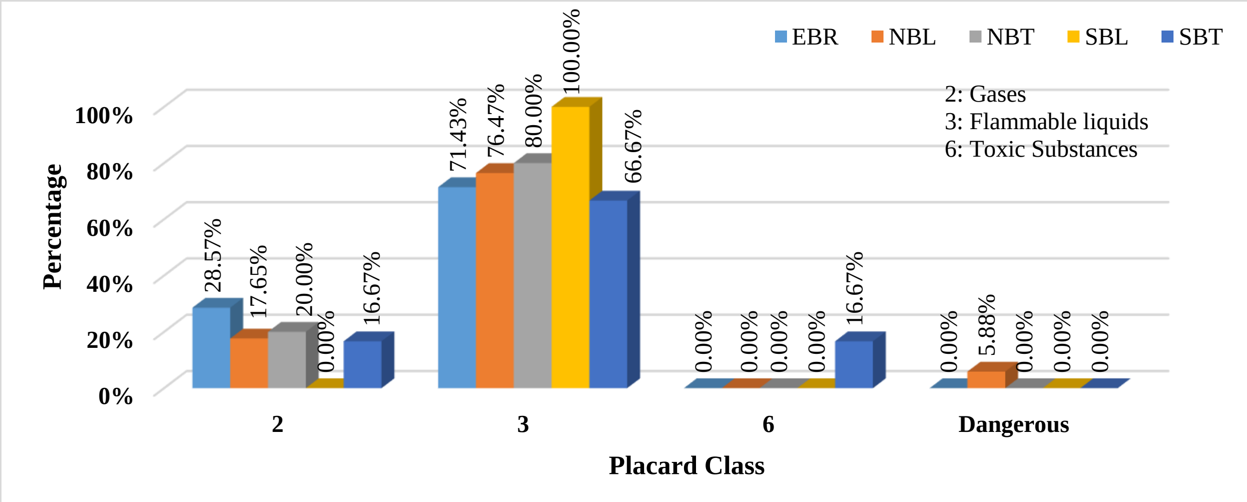
Figure 3 to Figure 5 show how the different percentages of the HAZMAT class being transported in the study locations per direction. Flammable liquids (Class 3) HAZMAT has the highest percentage among the transported HAZMAT classes in location 1 and location 2, averaged for all directions. It represents 67% of transported HAZMAT through the 1st location (Figure 3), and 79%

through the 2nd location (Figure 4). It was observed that the highest percentage among the transported HAZMAT classes in location 3 was gas (Class 2) which represents 53% transported HAZMAT (Figure 5), averaged for all directions.



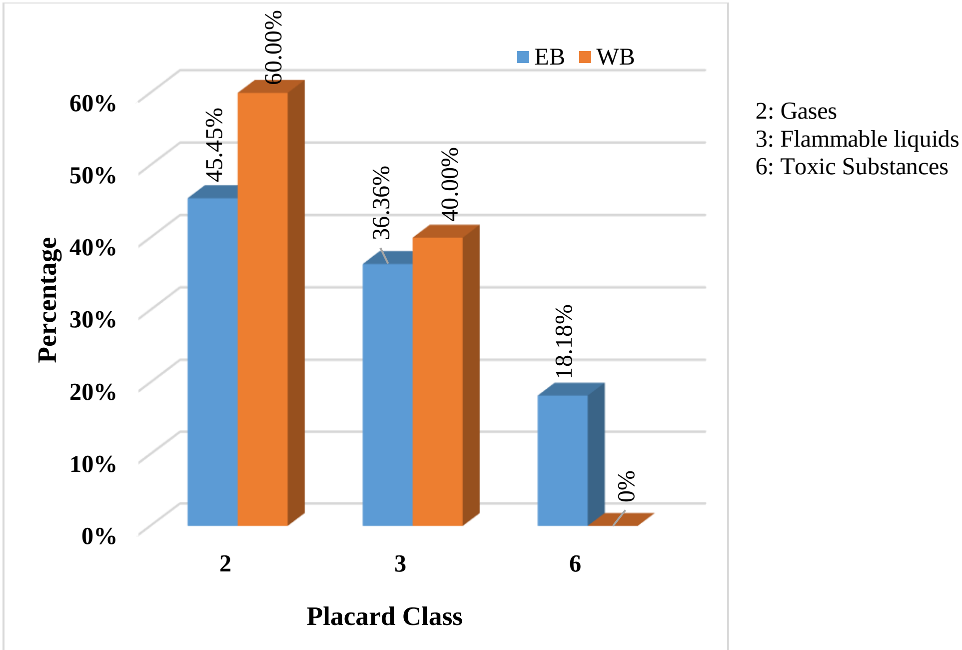
Data represents the percentage of HAZMAT classes from the total HAZMATs shipped in a certain direction

Figure 3: HAZMAT placard class percentages for the intersection of US-85/US-26 in Torrington



Data represents the percentage of HAZMAT classes from the total HAZMATs shipped in a certain direction

Figure 4: HAZMAT placard class percentages for the intersection of US-85/US-26 in Lingle



Data represents the percentage of HAZMAT classes from the total HAZMATs shipped in a certain direction

Figure 5: HAZMAT placard class percentages for US-85 in Torrington

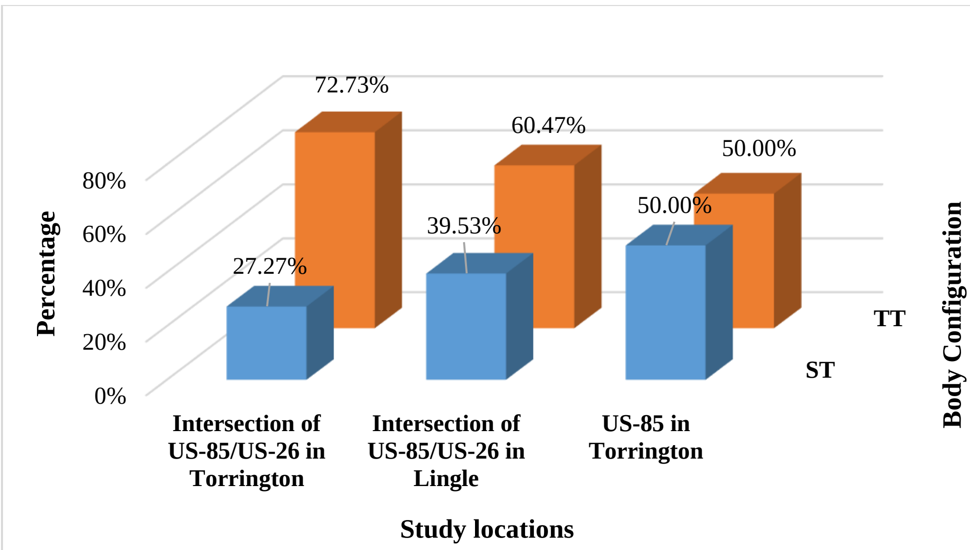
ESTIMATION OF HAZMAT AMOUNT BEING TRANSPORTED

Collecting the body configuration information in the data provides a rough estimate of the HAZMAT amount being transported. Straight truck may have a capacity ranging from 2,400 to 3,900 US gallons. A truck-trailer may have a capacity of 5,500 to 9,500 US gallons while a multi-trailer may have a capacity of 9,500 to 19,000 US gallons. Two main underline assumptions were considered to estimate the amount of HAZMAT being transported in the study locations. The two assumptions are as follows:

1) All the counted HAZMAT trucks, trucks with placards, are considered to be loaded with its minimum or maximum capacity.
2) The estimated minimum and maximum amounts are based on the body configuration not the body type.

According to the two assumptions, partially loaded trucks might be counted and included in the estimated amounts as a fully loaded truck. Also, different body types were not considered in the calculations of the HAZMAT amounts (e.g. a semi-trailer with a high-pressure tank or a mixed cargo were considered as a truck trailer body configuration with the same min/max amount of HAZMAT). It should be noted that the only way to obtain the accurate amount of shipped HAZMATs is by checking the shipment documents, which was not feasible to perform in this study.

While truck-trailer (TT) is the most common body configuration used for transporting HAZMAT in all the study locations, multi-trailer (MT) was not observed in any of the locations. Figure 6 shows the different percentages of body configuration for HAZMAT trucks in the study locations.



Data represents the percentage of different truck body configurations from the total trucks passing at each study location separately.

Figure 6: Percentage of HAZMAT trucks by body configuration for the study locations

Table 7 shows an estimation of the amount of HAZMAT being transported on the study locations in the US gallons per day. The minimum and maximum amounts were calculated using the following equations:

Total min amount = MADT ×% of trucks × % of HAZMAT trucks × body config. × min capacity

Total max amount = MADT ×% of trucks × % of HAZMAT trucks × body config. × max capacity

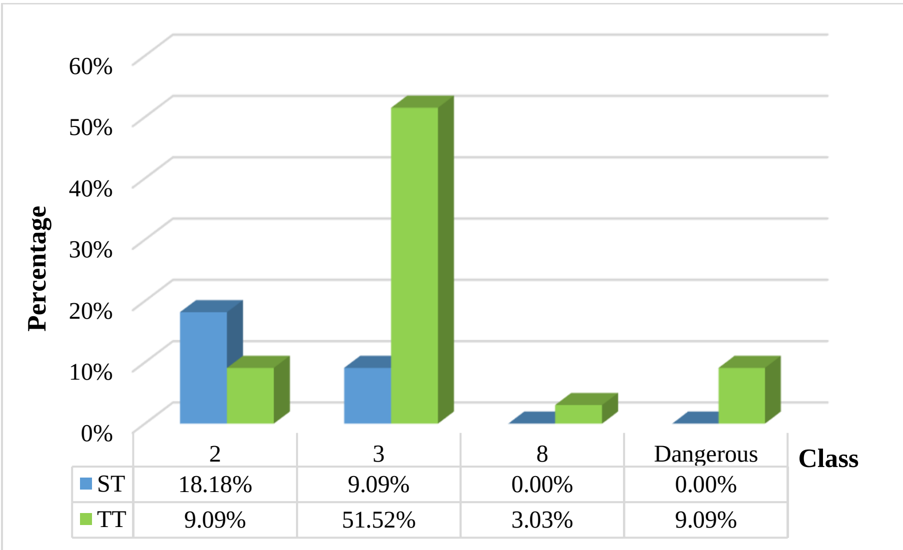
Where:

MADT : Monthly Average Daily Traffic.

Table 7: Estimation of the amount of HAZMAT transported in the study locations

Study Locations	MADT	% of trucks	% of HAZMAT trucks	Number of HAZMAT trucks per day (Monthly average)	HAZMAT trucks body configuration Percentages		Min. Capacity per truck type (US gallons)	Max. Capacity per truck type (US gallons)	Total Min. amount (US gallons / day)	Total Max. Amount (US gallons / day)	Total amount (US gallons / day) Min/ Max
Intersection of US-85/US-26 in Torrington	16,662	3.68%	4.46%	27.35	TT	72.73%	5,500	9,500	109,392	188,950	127,290/ 218,034
					ST	27.27%	2,400	3,900	17,898	29,084	
Intersection of US-85/US-26 in Lingle	4,719	17.89%	4.88%	41.20	TT	60.47%	5,500	9,500	137,020	236,670	176,105/ 300,185
					ST	39.53%	2,400	3,900	39,086	63,514	
US-85 in Torrington	9,720	5.22%	4.05%	20.55	TT	50%	5,500	9,500	56,510	97,608	81,169/ 137,679
					ST	50%	2,400	3,900	24,659	40,071	

Figure 7 to Figure 9 show the different percentages of truck body configuration used to transport different HAZMAT classes. The percentages provided in the figures are calculated from the grand total of the HAZMAT trucks.

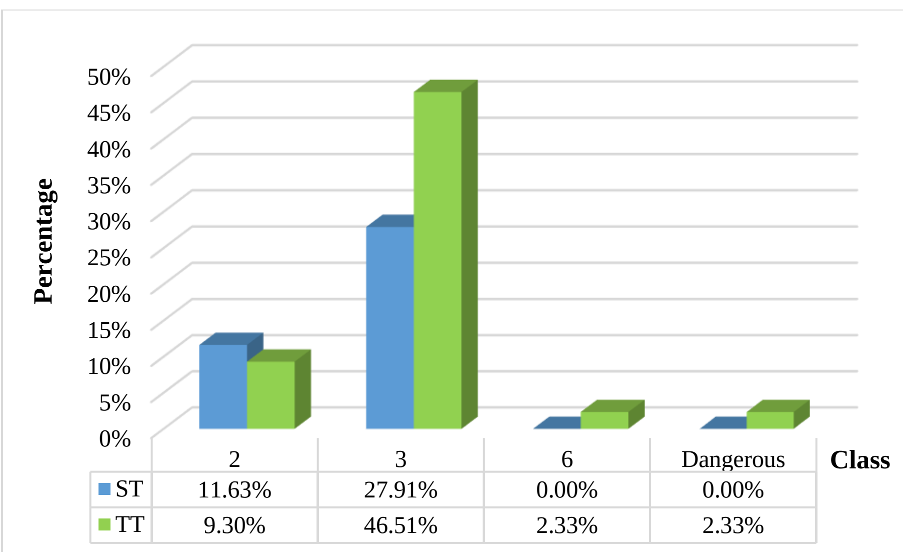


	2	3	8	Dangerous
ST	18.18%	9.09%	0.00%	0.00%
TT	9.09%	51.52%	3.03%	9.09%

2: Gases
3: Flammable liquids
8: Corrosive substances

Data represents the percentage of different body configurations transporting different HAZMAT classes from the total HAZAMTs transported at a certain study location.

Figure 7: Body configuration percentages by HAZMAT classes for the intersection of US-85/US-26 in Torrington

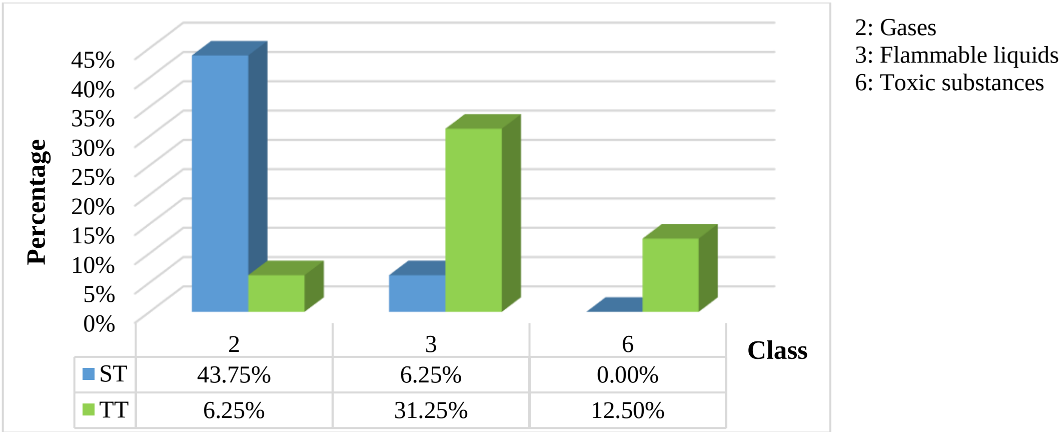


	2	3	6	Dangerous
ST	11.63%	27.91%	0.00%	0.00%
TT	9.30%	46.51%	2.33%	2.33%

2: Gases
3: Flammable liquids
6: Toxic substances

Data represents the percentage of different body configurations transporting different HAZMAT classes from the total HAZAMTs transported at a certain study location.

Figure 8: Body configuration percentages by HAZMAT classes for the intersection of US-85/US-26 in Lingle



Data represents the percentage of different body configurations transporting different HAZMAT classes from the total HAZAMTs transported at a certain study location.

Figure 9: Body configuration percentages by HAZMAT classes for US-85 in Torrington

Each placard ID refers to the material being shipped. Figure 10 and Figure 11 show that at location 1 and 2 (intersection of US-85 and US-26 in Torrington and Lingle) majority of the HAZMATs transported were Gasoline, motor spirit, or petrol (HAZMAT placard with ID number 1203). At the 3rd location (US-85 in Torrington), Petroleum gases, liquefied or liquefied petroleum gas (HAZMAT placard with ID number 1075) was transported the most as shown in Figure 12.

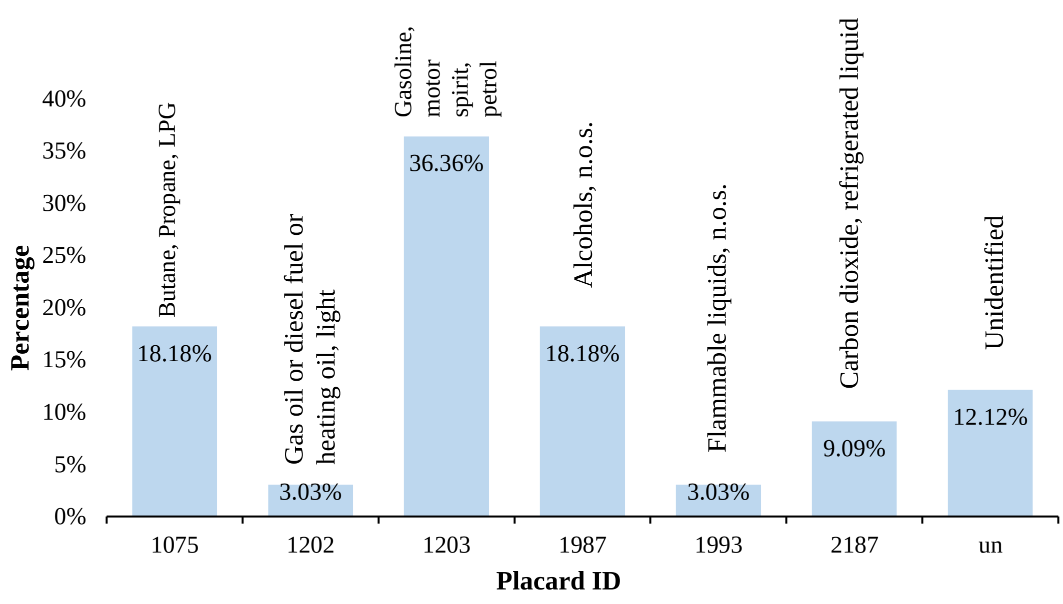


Figure 10: Placard ID number percentages at 1st location (Intersection of US-85/US-26 in Torrington)

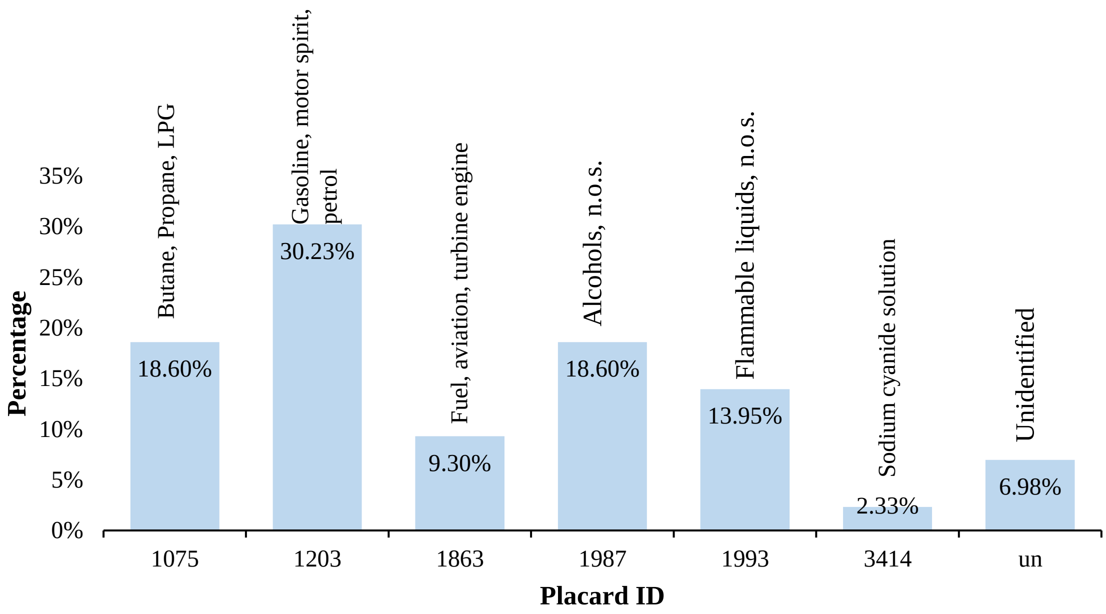


Figure 11: Placard ID number percentages at 2nd location (Intersection of US-85/US-26 in Lingle)

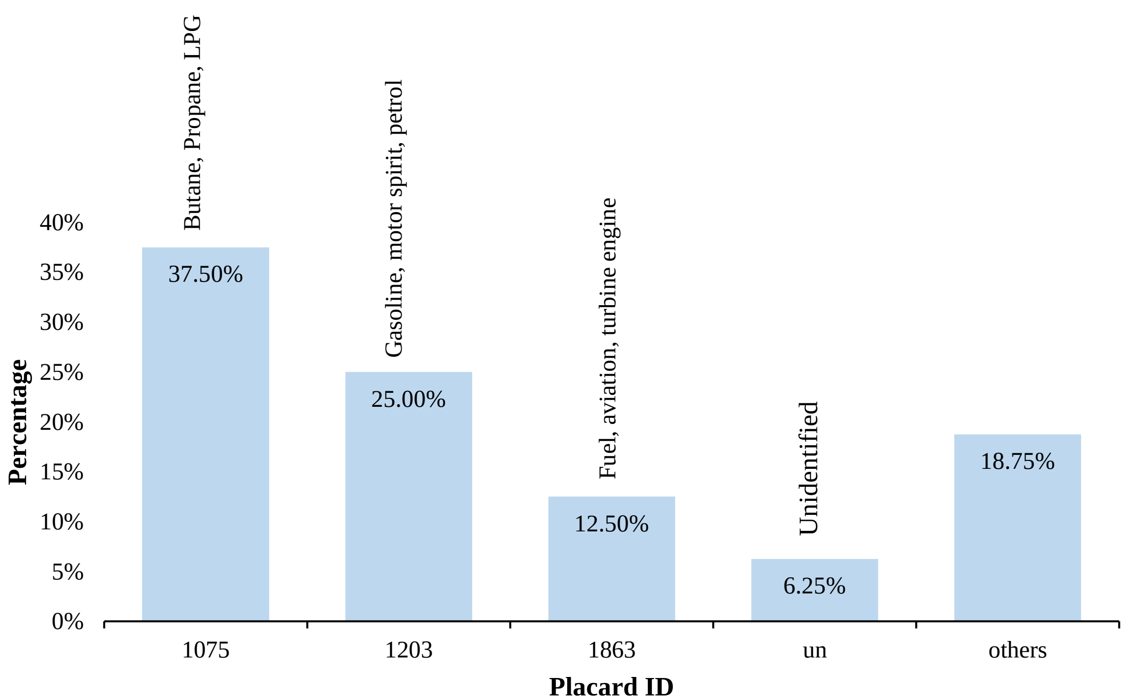


Figure 12: Placard ID number percentages at 3rd location (US-85 in Torrington)

CHAPTER 7- CONCLUSIONS

Hazardous material commodity flow studies are studies identifying what, where and when HAZMAT is being transported in a certain jurisdiction. In 2011, Hazardous Materials Cooperative Research Program (HMCRP) published the guidebook for conducting local hazardous materials commodity flow studies. Six main steps were identified by the guidebook. One important step is to collect and review existing HAZMAT data. There is a lack of previous HAZMAT commodity flow studies in Wyoming. No commodity flow study was performed in Goshen County, Wyoming previously. One commodity flow study was performed in 1986 in Albany County. In Wyoming, commodity flow studies were conducted in Campbell and Converse Counties in 2015, Laramie County and Albany County in 2016, Natrona County and Sweetwater County in 2017, and Johnson County in 2018.

Collecting new data was essential for this study due to the absence of any CFS within the jurisdiction. The purpose of this commodity flow study was to identify and provide information about the different types and amounts of hazardous materials being transported in Goshen County. Providing such critical information will help emergency responders and community planners to enhance emergency planning and capabilities, mitigating the dangerous effect associated with any HAZMAT incident. A comprehensive three days (one weekend day and two weekdays) of data collection was performed to fulfill the study objectives. Manual data collection was performed by eight volunteered graduate students from the University of Wyoming.

Two locations determined by the SERC, in consultation with the Emergency Management Coordinator from Goshen County, Shelly Kirchhefer, were investigated in the study. Furthermore, another location was selected by the data collection team. Two of the locations were on intersections of highways in Torrington and Lingle and another location was on a straight highways segment in Torrington. The two locations determined by the SERC are at intersections of US-85 and US-26 in Torrington and Lingle. Additionally, the data collection team studied the movement of HAMZAT trucks on the straight segment of US-85 in Torrington.

Table 8 shows a summary for all the data analysis provided in this report for the two highway intersections and the additional location on the straight segment studied.

Table 8: Summary of data analysis for Goshen County HAZMAT study

<table>
<tr><th rowspan="2">Location</th><th rowspan="2">Direction</th><th colspan="2">% of HAZMAT by class</th><th colspan="2">% of Body configuration used to transport Hazmat</th><th colspan="2">Estimated Min. and Max. Amounts of HAZMATs (US gallons/day)</th><th colspan="3">% of most common transported HAZMAT</th></tr>
<tr><th>Class</th><th>%</th><th>Body Config.</th><th>%</th><th>Min.</th><th>Max.</th><th>Placard ID</th><th>Material</th><th>%</th></tr>
<tr><td rowspan="12">Intersection of US-85/US-26 in Torrington</td><td rowspan="2">EBL</td><td>3- Flammable Liquids</td><td>100%</td><td rowspan="6">TT</td><td rowspan="6">72.73%</td><td rowspan="12">127,290</td><td rowspan="12">218,034</td><td rowspan="6">1203</td><td rowspan="6">Gasoline, motor spirit, petrol</td><td rowspan="6">36.36%</td></tr>
<tr><td>Others</td><td>0%</td></tr>
<tr><td rowspan="2">EBT</td><td>3- Flammable Liquids</td><td>62.50%</td></tr>
<tr><td>Others</td><td>37.5%</td></tr>
<tr><td rowspan="2">SBL</td><td>3- Flammable Liquids</td><td>50%</td></tr>
<tr><td>Others</td><td>50%</td></tr>
<tr><td rowspan="2">SBR</td><td>3- Flammable Liquids</td><td>66.67%</td><td rowspan="6">ST</td><td rowspan="6">27.27%</td><td rowspan="6">1075
1987</td><td rowspan="6">Butane, Propane, LPG
Alcohols, n.o.s.</td><td rowspan="6">18.18%</td></tr>
<tr><td>Others</td><td>33.33%</td></tr>
<tr><td rowspan="2">WBR</td><td>3- Flammable Liquids</td><td>75%</td></tr>
<tr><td>Others</td><td>25%</td></tr>
<tr><td rowspan="2">WBT</td><td>3- Flammable Liquids</td><td>50%</td></tr>
<tr><td>Others</td><td>50%</td></tr>
<tr><td rowspan="10">Intersection of US-85/US-26 in Lingle</td><td rowspan="2">EBR</td><td>3- Flammable Liquids</td><td>71.43%</td><td rowspan="5">TT</td><td rowspan="5">60.47%</td><td rowspan="10">176,105</td><td rowspan="10">300,185</td><td rowspan="5">1203</td><td rowspan="5">Gasoline, motor spirit, petrol</td><td rowspan="5">30.23%</td></tr>
<tr><td>Others</td><td>28.57%</td></tr>
<tr><td rowspan="2">NBL</td><td>3- Flammable Liquids</td><td>76.47%</td></tr>
<tr><td>Others</td><td>23.53%</td></tr>
<tr><td rowspan="2">NBT</td><td>3- Flammable Liquids</td><td>80%</td></tr>
<tr><td>Others</td><td>20%</td><td rowspan="5">ST</td><td rowspan="5">39.53%</td><td rowspan="5">1075</td><td rowspan="5">Butane, Propane, LPG</td><td rowspan="5">18.60%</td></tr>
<tr><td rowspan="2">SBL</td><td>3- Flammable Liquids</td><td>100%</td></tr>
<tr><td>Others</td><td>0%</td></tr>
<tr><td rowspan="2">SBT</td><td>3- Flammable Liquids</td><td>66.67%</td></tr>
<tr><td>Others</td><td>33.33%</td></tr>
<tr><td rowspan="4">US-85 in Torrington</td><td rowspan="2">EB</td><td>3- Flammable Liquids</td><td>66.67%</td><td rowspan="2">TT</td><td rowspan="2">50%</td><td rowspan="4">81,169</td><td rowspan="4">137,679</td><td rowspan="2">1075</td><td rowspan="2">Butane, Propane, LPG</td><td rowspan="2">37.50%</td></tr>
<tr><td>Others</td><td>33.33%</td></tr>
<tr><td rowspan="2">WB</td><td>3- Flammable Liquids</td><td>33.33%</td><td rowspan="2">ST</td><td rowspan="2">50%</td><td rowspan="2">1203</td><td rowspan="2">Gasoline, motor spirit, petrol</td><td rowspan="2">25%</td></tr>
<tr><td>Others</td><td>66.67%</td></tr>
</table>

REFERENCES

1. Guidance for Conducting Hazardous Materials Flow Surveys. U.S. Dep. Transp. (1995).
2. Bierling, D. H. et al. Guidebook for Conducting Local Hazardous Materials Commodity Flow Studies. (2011).
3. Emergency Response Guidebook. (2012).
4. Hazmat Intelligence Portal, U.S.Department of Transportation. Available at: https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/IncrSearch.aspx. (Accessed: June 6, 2018)
5. Wyoming State Emergency Response Commission. (2004).
6. A Study of the Hazardous Material Problem Related to Transportation for Albany Count Wyoming. (1986)
7. Gaweesh, S. & Ahmed, M. WYOMING COMMODITY FLOW STUDY. (2015)
8. Gaweesh, S. & Ahmed, M. WYOMING COMMODITY FLOW STUDY FOR LARAMIE COUNTY. (2016).
9. Gaweesh, S. & Ahmed, M. WYOMING COMMODITY FLOW STUDY FOR ALBANY COUNTY. (2016).
10. Gaweesh, S., Ahmed, I. U., & Ahmed, M. WYOMING COMMODITY FLOW STUDY FOR NATRONA COUNTY. (2017).
11. Ahmed, I. U., Gaweesh, S., & Ahmed, M. WYOMING COMMODITY FLOW STUDY FOR SWEETWATER COUNTY. (2017)
12. Ahmed, I. U., Gaweesh, S., & Ahmed, M. WYOMING COMMODITY FLOW STUDY FOR JOHNSON COUNTY. (2018)

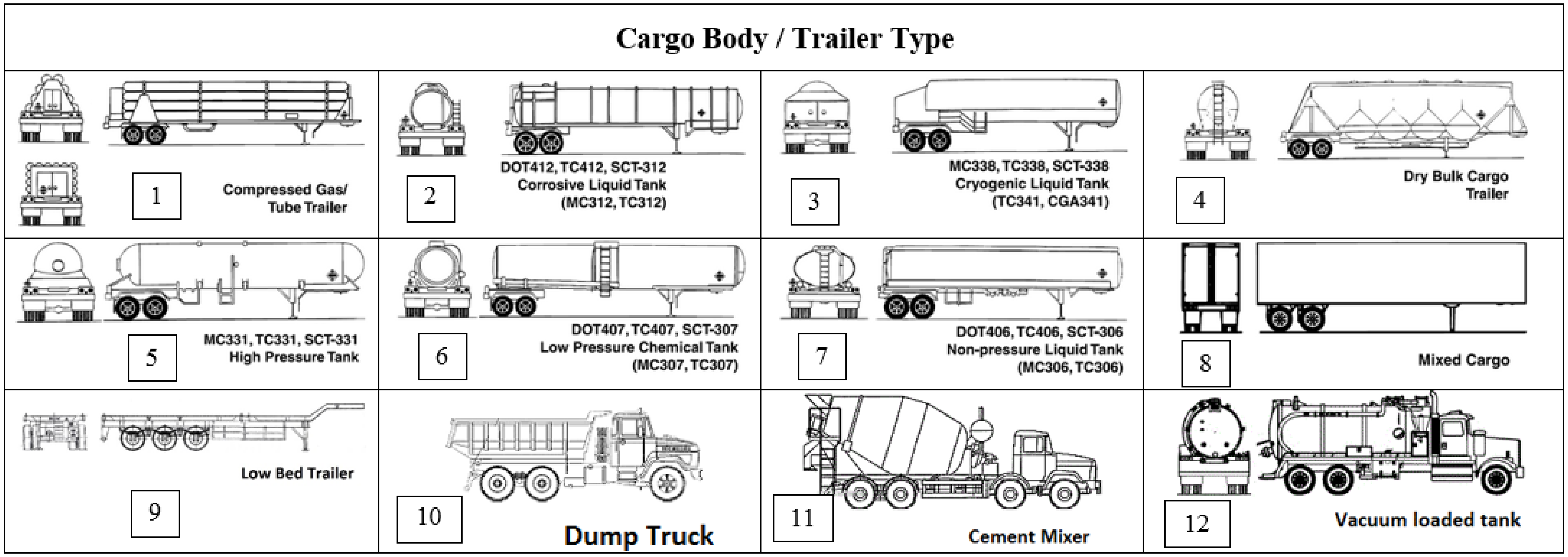
APPENDIX A: DATA COLLECTION SHEETS

HAZMAT Commodity Flow Study - Data Collection Sheet

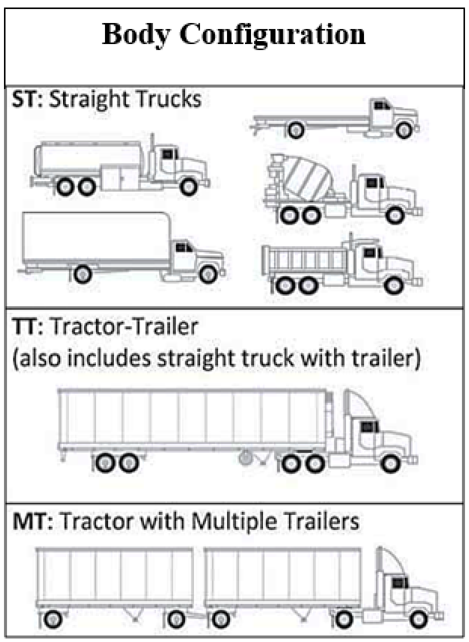
Name: ______ Location: ______ Weather: ______ Page Number: ______

Day: ______ Date: ______ Start Time: ______ End Time: ______

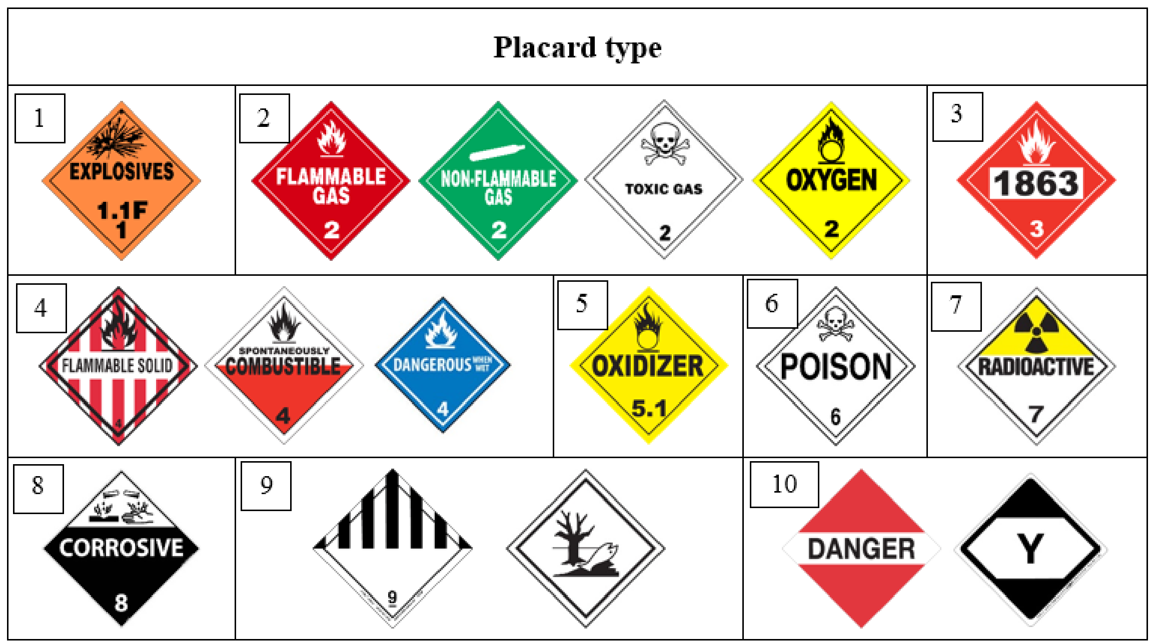
No.	Time	UN Placard ID					Placard type	Body Configuration				Cargo Body / Traier Type													Direction
1						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
2						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
3						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
4						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
5						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
6						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
7						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
8						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
9						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
10						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
11						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
12						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
13						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
14						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
15						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
16						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
17						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
18						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
19						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
20						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
21						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
22						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
23						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
24						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
25						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
26						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
27						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
28						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
29						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	
30						Un		ST	TT	MT	Un	1	2	3	4	5	6	7	8	9	10	11	12	Un	



Cargo Body / Trailer Type
1
Compressed Gas/
Tube Trailer
2
DOT412, TC412, SCT-312
Corrosive Liquid Tank
(MC312, TC312)
3
MC338, TC338, SCT-338
Cryogenic Liquid Tank
(TC341, CGA341)
4
Dry Bulk Cargo
Trailer
5
MC331, TC331, SCT-331
High Pressure Tank
6
DOT407, TC407, SCT-307
Low Pressure Chemical Tank
(MC307, TC307)
7
DOT406, TC406, SCT-306
Non-pressure Liquid Tank
(MC306, TC306)
8
Mixed Cargo
9
Low Bed Trailer
10
Dump Truck
11
Cement Mixer
12
Vacuum loaded tank



Body Configuration
ST: Straight Trucks
TT: Tractor-Trailer
(also includes straight truck with trailer)
MT: Tractor with Multiple Trailers



Placard type
1
EXPLOSIVES
1.1F
1
2
FLAMMABLE GAS
2
NON-FLAMMABLE GAS
2
TOXIC GAS
2
OXYGEN
2
3
1863
3
4
FLAMMABLE SOLID
SPONTANEOUSLY COMBUSTIBLE
4
DANGEROUS WHEN WET
4
5
OXIDIZER
5.1
6
POISON
6
7
RADIOACTIVE
7
8
CORROSIVE
8
9
9
10
DANGER
Y

Truck Count Sheet

Name: Location: Start Time:

Day: Date: End Time:

APPENDIX B: PHOTOS

APPENDIX C: RAW DATA FOR HIGHWAY MODE OF TRANSPORTATION

LOCATION 1: INTERSECTION OF US-85/US-26 IN TORRINGTON

Serial	Time	Date	Day	Direction	Placard #	Class	Body Config	Cargo Type
1	10:00	01/06/19	Sunday	WBT	1987	3	TT	7
2	16:11	01/06/19	Sunday	SBL	1203	3	TT	7
3	8:32	01/07/19	Monday	EBT	1987	3	TT	7
4	9:25	01/07/19	Monday	WBT	1075	2	TT	8
5	9:48	01/07/19	Monday	WBR	1987	3	TT	7
6	10:12	01/07/19	Monday	EBL	1203	3	ST	10
7	10:58	01/07/19	Monday	EBT	1203	3	TT	7
8	11:19	01/07/19	Monday	SBR	1075	2	ST	6
9	11:30	01/07/19	Monday	WBT	1987	3	TT	7
10	12:07	01/07/19	Monday	WBT	1987	3	TT	7
11	15:12	01/07/19	Monday	EBT	1075	2	ST	5
12	15:44	01/07/19	Monday	SBR	1202	3	TT	7
13	16:13	01/07/19	Monday	WBT	1075	2	ST	5
14	7:40	01/08/19	Tuesday	EBT	1075	2	TT	8
15	9:10	01/08/19	Tuesday	WBR	2187	2	ST	8
16	9:25	01/08/19	Tuesday	WBT	1993	3	TT	6
17	9:36	01/08/19	Tuesday	EBT	1203	3	TT	7
18	9:39	01/08/19	Tuesday	SBL	un	10	TT	8
19	9:55	01/08/19	Tuesday	WBT	un	10	TT	8
20	9:58	01/08/19	Tuesday	WBT	1203	3	TT	7
21	10:19	01/08/19	Tuesday	EBT	2187	2	ST	8
22	10:22	01/08/19	Tuesday	WBT	un	10	TT	8
23	10:28	01/08/19	Tuesday	WBT	1075	2	TT	5
24	10:37	01/08/19	Tuesday	WBT	1987	3	TT	7
25	11:16	01/08/19	Tuesday	EBT	1203	3	ST	7
26	11:18	01/08/19	Tuesday	EBT	1203	3	TT	7
27	11:35	01/08/19	Tuesday	SBR	1203	3	TT	7
28	11:36	01/08/19	Tuesday	WBT	un	8	TT	8
29	11:51	01/08/19	Tuesday	WBR	1203	3	TT	7
30	11:54	01/08/19	Tuesday	WBR	1203	3	TT	7
31	12:17	01/08/19	Tuesday	EBL	1203	3	TT	5
32	13:11	01/08/19	Tuesday	WBT	1203	3	ST	7
33	13:42	01/08/19	Tuesday	WBT	2187	2	ST	7

LOCATION 2: INTERSECTION OF US-85/US-26 IN LINGLE

Serial	Time	Date	Day	Direction	Placard #	Class	Body Config	Cargo Type
1	7:45	01/06/19	Sunday	NBT	1075	2	ST	6
2	8:31	01/06/19	Sunday	NBT	1993	3	ST	un
3	10:16	01/06/19	Sunday	NBL	1987	3	TT	7
4	11:04	01/06/19	Sunday	SBT	1993	3	ST	un
5	13:41	01/06/19	Sunday	SBT	1863	3	TT	7
6	8:20	01/07/19	Monday	EBR	1987	3	TT	7
7	9:30	01/07/19	Monday	NBT	1863	3	TT	7
8	10:05	01/07/19	Monday	NBL	1987	3	TT	7
9	10:15	01/07/19	Monday	NBL	1987	3	TT	7
10	10:28	01/07/19	Monday	EBR	un	3	ST	8
11	11:05	01/07/19	Monday	NBL	1987	3	TT	7
12	11:45	01/07/19	Monday	NBL	1987	3	TT	7
13	13:23	01/07/19	Monday	EBR	un	2	TT	8
14	13:33	01/07/19	Monday	NBL	1203	3	ST	un
15	14:48	01/07/19	Monday	SBT	3414	6.1	TT	un
16	15:33	01/07/19	Monday	EBR	1203	3	ST	un
17	15:38	01/07/19	Monday	EBR	1203	3	TT	7
18	16:09	01/07/19	Monday	EBR	1075	2	ST	5
19	16:23	01/07/19	Monday	NBL	1863	3	ST	un
20	7:27	01/08/19	Tuesday	EBR	1075	2	ST	un
21	8:15	01/08/19	Tuesday	NBL	1075	2	TT	5
22	8:45	01/08/19	Tuesday	NBL	1203	3	ST	un
23	9:43	01/08/19	Tuesday	NBL	1993	3	TT	6
24	9:57	01/08/19	Tuesday	NBL	1075	2	ST	5
25	10:16	01/08/19	Tuesday	SBL	1993	3	TT	un
26	10:24	01/08/19	Tuesday	EBR	1203	3	ST	un
27	10:38	01/08/19	Tuesday	NBL	un	10	TT	8
28	10:41	01/08/19	Tuesday	NBL	1993	3	TT	un
29	10:45	01/08/19	Tuesday	NBL	1075	2	TT	5
30	10:55	01/08/19	Tuesday	NBL	1987	3	TT	7
31	11:05	01/08/19	Tuesday	EBR	1203	3	TT	7
32	11:41	01/08/19	Tuesday	SBT	1203	3	TT	7
33	13:10	01/08/19	Tuesday	NBT	1203	3	ST	8
34	13:20	01/08/19	Tuesday	NBT	1203	3	TT	7
35	14:22	01/08/19	Tuesday	NBL	1203	3	ST	7
36	15:18	01/08/19	Tuesday	SBT	1075	2	ST	5
37	15:40	01/08/19	Tuesday	EBR	1075	2	TT	5
38	15:45	01/08/19	Tuesday	EBR	1993	3	TT	6
39	15:47	01/08/19	Tuesday	SBT	1863	3	TT	6

40	15:50	01/08/19	Tuesday	EBR	1203	3	ST	7
41	16:11	01/08/19	Tuesday	EBR	1203	3	ST	7
42	16:31	01/08/19	Tuesday	NBL	1203	3	TT	7
43	16:31	01/08/19	Tuesday	EBR	1987	3	TT	7

LOCATION 3: US-85 IN TORRINGTON

Serial	Time	Date	Day	Direction	Placard #	Class	Body Config	Cargo Type
1	8:02	01/07/19	Monday	EB	1075	2	ST	5
2	10:10	01/07/19	Monday	WB	1203	3	TT	7
3	13:08	01/07/19	Monday	WB	1075	2	ST	5
4	15:00	01/07/19	Monday	EB	3414	6	TT	2
5	16:22	01/07/19	Monday	EB	1203	3	TT	6
6	8:12	01/08/19	Tuesday	EB	1075	2	ST	5
7	8:16	01/08/19	Tuesday	EB	1075	2	ST	6
8	10:11	01/08/19	Tuesday	WB	un	2	ST	8
9	12:08	01/08/19	Tuesday	EB	1863	3	TT	7
10	12:32	01/08/19	Tuesday	WB	1203	3	TT	7
11	13:59	01/08/19	Tuesday	EB	2187	2	ST	6
12	14:04	01/08/19	Tuesday	EB	1203	3	ST	6
13	14:28	01/08/19	Tuesday	WB	1075	2	ST	6
14	15:54	01/08/19	Tuesday	EB	1075	2	TT	6
15	16:00	01/08/19	Tuesday	EB	1863	3	TT	7
16	16:23	01/08/19	Tuesday	EB	3291	6	TT	7