Hazardous materials data from business and industrial chemical information and incident databases were analyzed to study the types of chemicals located in Linn, Benton, and Lincoln Counties, Oregon. Federal and Oregon Department of Transportation data were analyzed to study traffic patterns and truck and railroad traffic levels. Results indicate more than 2,000 chemical products are reported by businesses and industries in the three counties, with about 1,000 hazardous ingredients. The primary hazard Classes for these chemicals are flammable fuels, corrosives, and poisonous materials. Diesel, heating fuel, gasoline, and related fuels comprised more than 50% of the materials transported in the study area.

A Geographic Information System (GIS) was used to input industrial and business locations of hazardous materials, historic hazardous materials incidents, traffic densities, population centers, and traffic network intersections. These metrics were modeled as risk factors for potential hazardous materials transportation risks. For Benton County, these factors were combined with population density and critical facilities themes to provide the basis for overlay and proximity analysis for the purpose of facilitating emergency planning and to foster public awareness.

Located on the Interstate 5 corridor, Linn County uses and transports a greater variety of hazardous materials than Benton or Lincoln Counties. For example, fifty-one of fifty-five extremely hazardous substances found in the three county area were reported in Linn County, with 24 reported in Benton County, and 6 reported in Lincoln County.

Data from Oregon Department of Transportation were extracted to assess accident and traffic patterns and integrate these risk factors with hazardous materials information.
One federal and one state database reporting hazardous materials incidents were analyzed. Although traffic increased on study area roads more than 25% in the last decade, two hazardous materials incidents databases did not indicate an increasing number of emergency spill responses. The Oregon State Fire Marshall’s incident database indicated an average of 34 per year between 1988-1997. Linn County averaged 18 per year during this time period, Benton County averaged 13, and Lincoln County averaged 3. Fuels were the primary chemical type responded to. The federal Hazardous Materials Information Reporting System database reported 40 incidents in the highway category and 11 railway incidents. Both types of incidents were dominated by corrosive materials in this database, which does not include fuels as defined hazardous materials.

Traffic data on the roads used for hazardous materials transport show much higher traffic densities near intersections with other major roadways and in urban areas. Incident reports followed this pattern, primarily occurring in the major cities and towns of the three counties. Estimated daily numbers of trucks carrying hazardous materials ranged from 6 per day on the coastal portion of Oregon 34, to almost 700 on the section of I-5/99E between Albany and the Linn-Marion County border. Rail data studied indicate the highest quantities of materials designated hazardous were also transported on the main north-south corridor of Linn County, implicating this central area in the three counties has the highest density of the risk factors studied.
HAZARDOUS MATERIALS COMMODITY FLOW STUDY FOR LINN, BENTON, AND LINCOLN COUNTIES, OREGON

By

Bryan E. Wemple

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Bryan E. Wemple, Author
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LIST OF TERMS

ADT..............................Average Daily Traffic
ArcInfo®..........................Geographic Information System software by ESRI, Inc.
ArcView®..........................Geographic Information System software by ESRI, Inc.
ATR...............................Automatic Traffic Recorder
ATSDR.............................Agency for Toxic Substances and Disease Registry
CAA.................................Clean Air Act (Federal)
CAER..............................Community Awareness and Emergency Response (group)
CAS.................................Chemical Abstracts Service (identification numbering system for chemicals)
CERCLIS...........................CERCLA Information System
CFR.................................Code of Federal Regulations
CR2K...............................Community Right-to-Know
CROET.............................Center for Research on Occupational and Environmental Toxicology (Oregon Health Sciences University)
Commodity Flow Study...........An analysis of the movement of materials or commodities
CWA.................................Clean Water Act (Federal)
DOT.................................Department of Transportation
EHS..................................Extremely Hazardous Substances
EPA.................................Environmental Protection Agency
EPCRA...............................Emergency Planning and Community Right-to-Know Act of 1986
ESRI...............................Environmental Systems Research Institute, Inc.
FEMA...............................Federal Emergency Management Agency
FIFRA...............................Federal Insecticide, Fungicide, and Rodenticide Act
Fixed Facility.......................Industrial, business, or governmental facility location
Geocoding.........................GIS process of adding point locations by geographic referencing data
GIS.................................Geographic Information System
HMIRs...............................Hazardous Materials Information Reporting System
HMTA...............................Hazardous Materials Transportation Act (Federal)
HSEES..............................Hazardous Substances Emergency Event Surveillance System
HSIS...............................Hazardous Substance Information Survey (or System)
Hazmat.............................Hazardous Material(s)
LEPC...............................Local Emergency Planning Committee
LEPD...............................Local Emergency Planning District
Line.................................A line of any shape or length in GIS
Milepost inventory...............A list of hazardous materials shipment information
MP.............................Milepost
MSDS..........................Material Safety Data Sheet
NOS............................Not Otherwise Specified
NPL.............................National Priorities List
NRC.............................National Response Center (Federal)
OAR.............................Oregon Administrative Rule
ODOT............................Oregon Department of Transportation
OEM.............................Oregon Emergency Management
OERS............................Oregon Emergency Response System
ORM.............................Other Regulated Material
OSFM...........................Office of the State Fire Marshall (Oregon)
OPA.............................Oil Pollution Act of 1990
OSH Act..........................Occupational Safety and Health Act (Federal)
OSHA...........................Occupational Safety and Health Administration (Federal)
PAA.............................Pollution Prevention Act (Federal)
Point............................A single point location in GIS
Polygon.........................A closed shape comprised of lines in GIS
R2K.............................Right-to-know (reference to part of SARA Title III)
RCRA............................Resource Conservation Recovery Act
Road tube count...............A measure of average daily traffic by temporary mechanical counter
RQ...............................Reportable Quantity
PUC.............................Public Utilities Commission
RCRA............................Resource Conservation and Recovery Act
RHMT...........................Regional Hazardous Materials Team
RP...............................Reportable quantity
RTK.............................Right to know (reference to part of SARA Title III)
SARA...........................Superfund Amendments and Reauthorization Act of 1986
SDWA...........................Safe Drinking Water Act
SERC...........................State Emergency Response Council
SFM.............................State Fire Marshall
STCC............................Standard Transportation Commodity Code
Theme......................a coverage, topic, or map layer in ArcView® GIS software
TIGER..........................Topologically Integrated Geographic Encoding and Referencing [digital database]
TPQ.............................Threshold Planning Quantity
TRI.............................Toxics Release Inventory
TSCA...........................Toxic Substances Control Act
UN/NA............United Nations or North American chemical identification number followed by a DOT identification number
USCG..........................United States Coast Guard
USDOT..........................United States Department of Transportation
USGS...........................United States Geological Survey
HAZARDOUS MATERIALS COMMODITY FLOW STUDY FOR LINN, BENTON, AND LINCOLN COUNTIES, OREGON

1 INTRODUCTION

The study of hazardous materials in the environment is of significant importance to the field of public health. Critical information about the types, locations, and movement of these materials provides the community, the private sector, and emergency response and management personnel with effective planning and response capabilities in the event of rare, but potentially significant releases of hazardous substances.

The transportation of these materials across the landscape is of concern in the context of planning and response, and in support of public awareness and community right-to-know issues. In 1996, 14 states reported 5,502 total hazardous substance incidents, of which 1,150 (20%) were transportation related. Incidents are defined as releases or threatened releases of hazardous substances. Oregon had a total of 211 reported incidents in 1996, including 76 (30%) in transportation (ATSDR, 1996).

Commodity flow study methodology for hazardous materials has been developed through community right-to-know laws in the federal Superfund Amendments and Reauthorization Act (SARA) Title III and similar state regulations to analyze transportation risks from hazardous materials. These studies are part of the overall planning process for emergency management as part of hazards analysis at the local and regional planning scales.

This study was designed to provide a characterization of hazardous material commodity flow through Linn, Benton, and Lincoln Counties in western Oregon. Relevant and available information from federal, state, and county sources was integrated to study the range of hazardous materials present within the three adjacent counties. Three primary objectives were to: 1) identify hazardous materials present and transported in the study area; 2) evaluate and analyze factors that contribute to geographic vulnerability from hazardous materials transport; and 3) provide a basis for the integration of these factors for emergency planning and public awareness. While most commodity flow studies conducted to date have come from hazardous materials truck placard surveys,
this study incorporates methodology that can be used where placard surveys cannot reasonably characterize primary risk factors for hazardous materials incidents.

The Federal Emergency Management Agency (FEMA) and the Mid-Valley Community Awareness and Emergency Response (CAER) group have sponsored this study. The CAER group is a non-profit community organization, comprised of community, industry, and government members that promotes emergency planning, training, and emergency response awareness at the local and regional level. The group’s mission is to coordinate and unify emergency response activities between private industry, emergency managers and responders, critical government services (e.g. fire and road departments, medical facilities), and all potentially affected community members. The findings of this study are intended to enhance the planning and management activities of the Mid-Valley CAER group and the emergency managers of the three counties that comprise the study area.
2 BACKGROUND

2.1 Regulatory Framework for Commodity Flow Studies

Oregon’s Community Right to Know Protection Act of 1985 was enacted to “provide the public, emergency responders, emergency planners and local and state agencies with hazardous substance information...to make informed decisions...to protect life, property and the environment from releases of hazardous substances” (ORS 453.307-453.414). As a result of this legislation, the Oregon Office of the State Fire Marshall (OSFM) established a statewide Hazardous Substance Information System (HSIS), which required Oregon’s 37,000 businesses and governmental facilities to provide annual reports regarding specific hazardous substances used at these sites.

In the federal context, hazardous materials are regulated and defined by a fragmented patchwork of federal agencies and laws. Community right-to-know laws provide for public disclosure and emergency planning information for hazardous materials incidents. The federal Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act (SARA) Title III of 1986 contain what is known as the Emergency Planning and Community Right-to-Know Act, or EPCRA (Laitos and Tomain, 1992). This federal act mandates tracking and disclosure of hazardous substances to protect humans and the environment from releases of hazardous materials (STP, 1996). Title III specifically defines the federal mandate to states and local governments to plan for spills caused by toxic or hazardous material releases and to provide information for the public. Governors were required to create State Emergency Response Commissions (SERCs). The SERCs, in turn, were mandated to designate Local Emergency Planning Districts (LEPDs) and appoint Local Emergency Planning Committees (LEPCs) to coordinate local agencies, community groups, and law enforcement together in tracking and planning emergency responses to environmental releases of hazardous materials (Hickok, 1996).
This commodity flow study is by definition part of a hazard analysis process for emergency planning originally defined and mandated by SARA Title III EPCRA requirements. Title III requires LEPCs to provide emergency planning for hazardous chemicals at regional and local scales. LEPCs were created to include representation from governmental groups, medical and health organizations, community groups, and private sector businesses and industries. In Oregon, there is one LEPC for the entire state, located in Salem.

In the three-county study area, the Mid-Valley Community Awareness and Emergency Response group (CAER) acts as the local planning group, along with county emergency managers. The CAER group model was originally developed by the Chemical Manufacturers Association after the SARA Title III regulations of 1986. Similarly to the LEPCs, CAER groups encourage representation from all groups and individuals that have an interest in the emergency planning process.

One of the requirements of the SERC/LEPC system was to identify transportation routes for Extremely Hazardous Substances (EHS), defined by the Environmental Protection Agency (STP, 1996). The Hazardous Materials Transportation Act of 1974 (HMTA), and subsequent amendments in the Hazardous Materials Transportation Uniform Safety Act of 1990 (HMTUSA) provided funding to include the consideration of transportation risks into emergency planning efforts and to support implementation of SARA Title III and EPCRA. Federal regulation 49 CFR Part 110 specifically provides funding through grants for "[a]n assessment to determine flow patterns of hazardous materials within a State, between a State and another State or Indian country, and development and maintenance of a system to keep such information current." (ICF, 1995).

2.2 Guidance Framework for Commodity Flow Studies

Several guidance documents have been published to define principles, objectives, and methods for conducting commodity flow studies. US Environmental Protection Agency (EPA), US Department of Transportation (DOT), and FEMA have provided somewhat conflicting frameworks for these studies, although common tenets for commodity flow studies are found in the existing guidance.
In *Technical Guidance for Hazards Analysis* (also known as the "Green Book") produced in 1987 by a joint effort of the EPA, FEMA, and DOT, hazard analysis is described as a community level process, to develop and/or revise emergency planning and to encourage public awareness and involvement. The process includes three steps: hazard identification, vulnerability analysis, and risk analysis (Figure 1). Hazard identification includes information on the type, location, quantity, storage conditions, and specific hazards posed by materials manufactured, transported, stored, or processed in the community. This phase of the framework usually comprises commodity flow study objectives. Vulnerability analysis is focused on identification and location of sensitive areas or populations that may be affected by a release of a hazardous material. Risk analysis, the final step in this framework, allows for the ranking of specific types of releases, based on potential severity and likelihood of releases (EPA, 1987).

The commodity flow study is generally defined as part of the hazards identification step in the hazards analysis process, providing information on the types and volumes of hazardous materials moving through a community or state. These assessments are then used to identify priority planning and potential danger areas. Finally, they can be used to designate transportation network components for hazardous materials movements and to enhance emergency planning and response actions, highway safety activities, and public awareness regarding these movements.

In 1995, the Research and Special Programs Administration division of the US Department of Transportation published *Guidance for Conducting Hazardous Materials Flow Surveys*. This document is specifically tailored to the regulatory framework that provides funding opportunities for jurisdictions interested in conducting these studies. Primarily focused on truck transportation as the primary mode of hazardous material movement, it provides stepwise guidance for conducting commodity flow studies using a number of metrics. Information gathered and analyzed for these studies can include:

- Major traffic corridors used;
- primary origins and destinations;
- primary hazard Classes transported;
- actual materials transported;
• hazardous materials tonnages or volumes shipped;
• number of hazardous materials trucks;
• percentage of hazardous materials traffic in all traffic;
• truck and container types used for hazardous materials;
• driver training and awareness;
• degree of regulatory compliance;
• temporal variations in hazardous materials transport (i.e., times of day, days of week, seasonal).

Figure 1: Hazard Analysis Model

Hazard Analysis

Hazard Identification

Vulnerability Analysis

Risk Analysis

Emergency Planning,
Emergency Response,
and Public Awareness
Some combination of these metrics are used in application to site-specific commodity flow study objectives. According to the US DOT guidance, designation of transportation routes and planning program development for hazardous materials movements are the primary uses of these studies. Hazardous material surveys and analysis of highway and accident data are recommended as primary methodologies for commodity flow studies (ICF, 1995).

The scope and range of commodity flow studies varies with time and resource allotment and objectives in a given study area, as well as the availability and quality of existing information. Several methods that have been used in commodity flow studies are listed in Table 1, with primary advantages and disadvantages of each.

Table 1: Common Methods for Commodity Flow Studies

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>Review and analysis of existing data</td>
<td>Inexpensive, details major routes of potential concern; good starting point</td>
<td>No single source for all existing data; transportation specifics are not quantified for hazardous materials</td>
</tr>
<tr>
<td>Placard survey</td>
<td>Approximate counts for trucks on major routes; can be combined with existing data to estimate % of trucks carrying hazardous materials</td>
<td>Limited number of routes can be surveyed; limited spatially and temporally to locations and times studied</td>
</tr>
<tr>
<td>Shipping manifest survey</td>
<td>Provides specific detailed data on volumes and nature of hazardous materials shipped</td>
<td>Shipping papers are not standardized (requires lengthy review process), high costs; also limited spatially and temporally</td>
</tr>
<tr>
<td>Fixed facility survey</td>
<td>Data on routing, volume, and nature of hazardous materials</td>
<td>Only covers shipments originating or terminating locally; requires voluntary reporting by facilities</td>
</tr>
<tr>
<td>Weigh station survey</td>
<td>Data on routing, volume, and nature of hazardous materials</td>
<td>Only covers portion of shipments on selected highways at times and places studied</td>
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Adapted from: EPA 550-F-93-004 (1993)
2.3 **Public Health Perspective**

In a public health perspective, commodity flow studies are applicable to primary, secondary, and tertiary prevention methods and the goal of mitigating public hazards (Turnock, 1997). Absolute prevention of chemical spills with the use of knowledge gained from commodity flow studies would be defined as primary prevention. The designation of a highway “chemical safety corridor” on a road segment considered high risk for transportation spills would be an example of primary prevention.

Secondary prevention in the context of hazardous materials transportation involves the mitigation of effects and consequences of hazardous materials incidents by early and efficient response. In some cases, early actions may prevent an incident threat from turning into a hazardous materials release. Increased training by emergency responders for particularly high risk or high probability scenarios would be an example of secondary prevention. Commodity flow studies provide the information required to plan for and to minimize spills of hazardous materials.

Tertiary prevention in the public health context would include the mitigation of effects from transportation related incidents with hazardous materials. Given a situation where a major incident or multiple hazard events did occur, information from a commodity flow study facilitates efficient mitigation and remediation actions after a major environmental release. A reduction of further exposures or complications from exposures would constitute tertiary prevention. Using historic information from previous incidents provides an effective mode for tertiary prevention efforts in this context.

While the ultimate goal of primary prevention from a community-based public health perspective is ideal, several factors determine the level of prevention applicable to commodity flow studies. Effective emergency planning and public awareness regarding hazardous material transportation incidents depends on the level of information attainable on hazardous material transport risk, the resources applied to the problems and data gaps, and the efficiency of potential avoidance and mitigation measures. In the event of unavoidable or compound crises involving hazardous materials transportation emergencies, secondary and tertiary preventive measures are the only options (Turnock, 1997).
2.4 Definition of Hazardous Materials

Because hazardous materials are regulated by a patchwork of legislation and agencies, definitions of these substances vary considerably. Effective hazardous materials management requires the synthesis of these definitions for effective risk assessment, planning, and public awareness issues. Federal, state, and local governments collectively provide the regulatory contexts for hazardous materials.

The US EPA provides definitions and regulatory requirements for a variety of hazardous substances. US DOT mandates shipping and labeling requirements and has its own classification system for these materials. The Nuclear Regulatory Commission (NRC) controls the transportation of certain types of ionizing radiation materials, including special packaging and transportation container requirements. Specific laws are administered by different agencies, including the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the Toxic Substances Control Act (TSCA), the Hazardous Substances Act (HSA), the Resource Conservation and Recovery Act (RCRA), the Pollution Prevention Act (PPA), and the Hazardous Materials Transportation Act, or HMTA (Blackman, 1995). As with most federal laws, states are allowed to further define and regulate hazardous materials, given that state regulations substantially follow federal standards (STP, 1996).

Oregon’s Hazardous Substance Information System, created by Oregon’s Community Right-to-Know Act, designated the state Office of the Fire Marshall (OSFM) to compile records on these substances. The act defined hazardous materials specifically for the purposes of its tracking system. These definitions will be used as the benchmark for classifications of hazardous materials in this study. Hazardous substances are defined by OSFM and the Oregon Department of Consumer Affairs as:

- substances for which manufacturers are required to develop Material Safety Data Sheets (MSDS);
- materials including toxic, poisonous, explosive, radioactive, flammable, combustible, reactive, corrosive, biologically hazardous, asphyxiant, or materials that create health and/or physical hazards to humans and the environment;
any waste substance that presents hazards to emergency responders or the public under normal conditions or during emergency situations.

OSFM uses Reportable Quantities (RQs) for environmental tracking and release information. RQs for poisons, explosives, or dangerous labeled products are ≥ 5 gallons, ≥ 10 pounds, or ≥ 20 cubic feet for liquids, solids, and gases, respectively. For all other hazardous substances, the RQs are ≥ 50 gallons, ≥ 500 pounds, or ≥ 200 cubic feet, dependent on the chemical phase of the material (Upson and O'Brien, 1998).

The international or United Nations hazard classification system is commonly used to group general categories of chemicals by type. The DOT uses this system for classification and placarding of all transported hazardous materials. Several of the numbered Classes are further classified into divisions for more accuracy. The nine general Classes and their divisions are listed in Table 2. The UN/DOT hazard Class and division number is required on the lower part of placards and labels and on shipping papers for hazardous materials during transport.

A sub-classification of about 400 hazardous materials with severe potential human and environmental effects in the event of a spill incident are the extremely hazardous substances, or EHS, defined by the EPA. This designation was initiated by section 302 of SARA Title III and is based on a combination of acute toxicity and potential of substances to become airborne (CFR 40, Part 355, Appendix A). As of 1996, 356 chemicals were listed in this category. Reporting of these chemicals is required when threshold planning quantities (TPQ) are met or exceeded by weight in 1, 10, 100, 500, 1,000, and 10,000 pound increments, dependent on the particular chemical and form (STP 1996). Liquids and gases must be converted to pounds in this classification system. As the EHS designation specifically addresses potential human and environmental consequences in the event of environmental releases, it provides a relevant metric for fixed facility and transportation incidents and their possible environmental effects. The Hazardous Substance Information System (HESIS) in Oregon also categorizes and tracks EHS chemicals.
Table 2: United Nations/Dept. of Transportation Hazard Classification System

<table>
<thead>
<tr>
<th>Class name</th>
<th>Divisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1: Explosives</td>
<td>Division 1.1 With a mass explosion hazard</td>
</tr>
<tr>
<td></td>
<td>Division 1.2 With a projection hazard</td>
</tr>
<tr>
<td></td>
<td>Division 1.3 With a predominant fire hazard</td>
</tr>
<tr>
<td></td>
<td>Division 1.4 With minor explosion hazard</td>
</tr>
<tr>
<td></td>
<td>Division 1.5 Very insensitive explosives</td>
</tr>
<tr>
<td></td>
<td>Division 1.6 Extremely insensitive detonating substances</td>
</tr>
<tr>
<td>Class 2: Gases</td>
<td>Division 2.1 Flammable gases</td>
</tr>
<tr>
<td></td>
<td>Division 2.2 Non-flammable, non-poisonous gases</td>
</tr>
<tr>
<td></td>
<td>Division 2.3 Poisonous gases</td>
</tr>
<tr>
<td>Class 3: Flammable Liquids</td>
<td>Flashpoint &lt; -18°C (0°F)</td>
</tr>
<tr>
<td></td>
<td>Flashpoint ≥ -18°C - 23°C (73°F)</td>
</tr>
<tr>
<td></td>
<td>Flashpoint 23°C - 61°C (141°F)</td>
</tr>
<tr>
<td>Class 4: Flammable solids; Spontaneously combustible materials; and Materials dangerous when wet</td>
<td>Division 4.1 Flammable solids</td>
</tr>
<tr>
<td></td>
<td>Division 4.2 Spontaneously combustible materials</td>
</tr>
<tr>
<td></td>
<td>Division 4.3 Materials dangerous when wet</td>
</tr>
<tr>
<td>Class 5: Oxidizers and Organic peroxides</td>
<td>Division 5.1 Oxidizers</td>
</tr>
<tr>
<td></td>
<td>Division 5.2 Organic peroxides</td>
</tr>
<tr>
<td>Class 6: Poisonous and Etiologic (infectious) materials</td>
<td>Division 6.1 Poisonous materials</td>
</tr>
<tr>
<td></td>
<td>Division 6.2 Etiologic materials</td>
</tr>
<tr>
<td>Class 7: Radioactive Materials</td>
<td></td>
</tr>
<tr>
<td>Class 8: Corrosives</td>
<td></td>
</tr>
<tr>
<td>Class 9: Miscellaneous hazardous materials</td>
<td></td>
</tr>
<tr>
<td>ORM-D (Other regulated material)</td>
<td>Consumer commodities</td>
</tr>
</tbody>
</table>

Adapted from Varela et al, 1996

2.5 Previous Commodity Flow Studies

Several commodity flow studies have been conducted at the state and regional scales, and at least one study has been conducted in Oregon (PUC and ODOT, 1988). Most are from placard or photocopy survey information, and some important generalizations about hazardous material truck transportation can be made. Information relevant to the three-county study area has been synthesized and provides a starting point from which to conduct site-specific analysis. Table 3 compares some key metrics the surveys had in common.

In addition to providing general information on percentages of truck traffic as part of total traffic and hazard Class information, review and analysis of previous studies
<table>
<thead>
<tr>
<th>State/Scope/ Number of Trucks in survey</th>
<th>Hazardous Materials Movement as Percent of Total Truck Traffic</th>
<th>Hazardous Materials Truck Traffic Breakdown by Hazard Class and Percent</th>
</tr>
</thead>
</table>
| Colorado-Statewide (1988) Placard and manifest n=? | 10%                                                          | Class 3 63%  
Class 2 31%  
Class 8 3%  
Class 5 1%  
Class 9 2%  
Class 4 1%  
ORM-E 4%  
ORM-A 0.5%  
ORM-C 2%  
ORM-D 1% |
| Idaho-Statewide (1988) Truck and placard survey n=11,335 total trucks | 4-6% (range 1.9%-9.2%)                                               | Class 3 29%  
Class 8 10%  
Class 5 4%  
Class 6 1%  
ORM-E 4%  |
| Nevada-Statewide (1993) Truck and placard survey n=19,838 total trucks | 3.6% (range 3.1%-6%)                                               | Class 3 59%  
Class 8 22%  
Class 2 7%  
Class 5 2%  
Class 1 2%  
Class 6 1%  
ORM-E 4%  |
| Oregon-North Part of State (1988) Weigh station and placard n=2,511 placarded trucks | 5.5% (range 2.1%-12.9%)                                               | Class 3 54%  
Class 8 16%  
Class 2 10%  
ORMs 9%  |
| Texas-Dallas Central Business District, local (1985) Placard and facility survey n=? | 5.2%                                                          | N/A  |
| Virginia-Statewide (avg. of 1977, 1978) Weigh station and placard n=? | 10%                                                          | Class 3 64%  
Class 2 13%  
Class 8 12%  
Class 5 1.3%  
Class 1 1%  
Class 6 1%  
Class 7 1%  
ORM-C 2%  
ORM-A 0.5%  |
| West Virginia-two county Kanawha Valley area (1994) Analysis of existing data, facility and placard surveys n=4,000 | 6%                                                          | Class 3 50%  
Class 2 18%  
Class 8 16%  
Class 9 5%  
Class 5 5%  
Class 6 3%  
Class 4 1%  
Class 7 1%  
Class 1 1%  |
provides relevant applications to this analysis. A large percentage of hazardous materials transported are hazard Class 3 (Flammable liquids, primarily fuels); Class 2 (Gases, again largely comprised of fuel gases); and Class 8 (Corrosives, for example Sodium Hydroxide). This correlates well with nationwide figures from DOT. Of approximately 1.5 billion tons of hazardous materials transported between 1982-1993, almost 50% of shipments were gasoline and other petroleum products (ICF, 1995).

Several other findings are significant to commodity flow study work in general, and to this study specifically. These include several commonalities in variation of seasonal and daily truck flow of hazardous materials, variation by type and size of roadways, and origin and destination information.

In the Oregon and Virginia studies, there was an increase in hazardous materials truck traffic in the Spring and Summer seasons. Oregon’s study indicated a strong increase in hazardous materials traffic in the summer months at all of the surveyed sites, and the Virginia studies indicated highest levels in the Spring. The Idaho, Oregon, Texas, Virginia, and West Virginia studies all had the highest frequency of hazardous materials traffic in the daytime hours. Seventy % of the hazardous materials movements in the Oregon study were between 6 a.m. and 6 p.m.

The studies from Nevada, Oregon, Virginia, and West Virginia had the highest frequencies of hazardous materials traffic on Interstate routes, compared to US and state routes. Most hazardous materials traffic had origins and destinations in the state of the study, with the exception of the Texas and Virginia studies. Origins and destinations of hazardous materials truck shipments from out of the state were destined for the states themselves or close neighboring states. In Oregon, 16% of trucks surveyed were going through Oregon for destination in another state; in the Colorado study, 3% were going through the state for destinations elsewhere.

While truck transport of hazardous materials was the primary mode of concern in the studies reviewed, rail transport was investigated in the West Virginia study. By tonnage in the Kanawha Valley study area, hazardous materials transport by rail and by truck were approximately equal, about 600,000 tons each (37% each by weight) for the reporting year. Barge transport was about 300,000 tons (18%) and pipeline transport
made up the remaining 120,000 tons (8%). These figures assumed an average truck load weight of 20,000 lbs. While tonnage and hazard Classes are measures of concern for emergency planning and public awareness issues, frequency of shipments was the metric most emphasized in the studies reviewed.

Several issues arise from a comparative view of truck and rail transportation in the context of hazardous materials, both from historic incident data and from a brief review of the differences between the modes of transportation. Long-term statistics analyzed by Blackman (1985) compared railroad and truck incident data from the late 1970s to the early 1980s. In that time period, truck hazardous materials incidents occurred at twelve times the rate of rail incidents, four times the rate of fatalities in accident comparisons, and twice the rate of injuries compared to those in rail transportation accidents. Blackman also noted that rail accidents released about 50% more hazardous materials than highway accidents.

Approximately 8% of total tonnage of hazardous materials is transported by railway on a nation-wide basis, but 57% by ton/miles (US Office of Technology Assessment, 1986). This difference in percentage between weight and distance is probably a function of bigger rail tank sizes (130 ton capacity vs. 40 ton capacity for trucks) and longer haul distances. Higher rail tank capacities and the possibility of mixing large quantities of incompatible materials can cause severe, if rare, accidents (Blackman, 1995).

In terms of percentages transported nationwide, hazard Classes shipped by rail are predominantly 2, 3, and 8 (gases, flammable/combustible liquids, and corrosives, respectively). Table 4 shows the relative percentages of hazardous materials shipped by rail by types of materials and their hazard Classes (Assoc. of American Railroads, 1992).

With 30% of the hazardous materials shipped in the Class 3 category (flammable and combustible liquids) and about 34% in Class 2 and 24% Class 8 corrosives, the hazard Classes were almost evenly distributed by rail. These percentages by hazard Classes indicated a slightly higher percentage of materials in the Class 2 and Class 8 categories than by truck transport, where the Class 3 flammable liquid fuels were dominant.
Table 4: Hazardous Materials Shipped by Rail, 1992

<table>
<thead>
<tr>
<th>Type of material and hazard Class</th>
<th>Percentage of total hazardous materials by rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flammable liquid (Class 3)</td>
<td>20%</td>
</tr>
<tr>
<td>Combustible liquid (3)</td>
<td>10%</td>
</tr>
<tr>
<td>Flammable gas (2)</td>
<td>20%</td>
</tr>
<tr>
<td>Non-flammable gas (2)</td>
<td>8%</td>
</tr>
<tr>
<td>Poison gas (2)</td>
<td>6%</td>
</tr>
<tr>
<td>Corrosives (8)</td>
<td>24%</td>
</tr>
<tr>
<td>All others</td>
<td>12%</td>
</tr>
</tbody>
</table>

Source: Association of American Railroads, 1992

2.6 Oregon Commodity Flow Study

Although the 1988 Oregon hazardous materials commodity flow study is over 10 years old, several specific analyses can be drawn from this information (PUC and ODOT, 1988). The percentage of truck traffic that moved hazardous materials averaged 5.5% and this was combined with current ODOT data to project the number of hazardous materials movements per day in the study area. However, the range of percentage of truck traffic at the 11 sites surveyed in the Oregon study was between 2.1% and 12.9%. This spatial variation in percentage of truck traffic provides an indication of the difficulty of generating accurate numbers for this metric. Clearly, truck traffic varies considerably between locations, both between different roads and by milepost on the same roads. There was also significant variation of numbers of hazardous materials movements on a seasonal and on a daily basis. The Oregon study indicated hazardous material movements increased at seven sites surveyed in March and in August by 44%. While part of the increase observed in the study was due to a large hazardous waste movement from a Superfund site cleanup in Washington State, the difference indicates a probable seasonal component to hazardous material truck traffic.

On a daily basis, the Oregon survey recorded about 70% of hazardous materials truck shipments in the daytime, with one notable exception. While the flammable/combustible group of materials (hazard Classes 3 and 4) followed this pattern, dangerous placarded truck shipments containing a combination of materials (commonly both flammables and corrosives) were surveyed in night hours. Flammable solids (Class
4), Poisons (Class 6), and Oxidizers (Class 8) were often observed between 6PM and 6AM, indicating a variability in time of day for different types of hazardous material movement. However, time of day of movement may be more closely related to origin and destination of shipments than consistent time-of-day variation (PUC and ODOT, 1988).

By hazard Classes, as in studies conducted elsewhere, flammable/combustible materials (Classes 3 and 4) comprised more than 50% of the total number of shipments surveyed in the study. The next highest percentage hazard Class was the corrosive category (Class 8) at 16%. The third highest percentage of truck transported materials was hazardous waste, although it was primarily bound from the Portland area to Arlington, Oregon, on Highway 84. By shipping name, the most common commodities were fuels, paint, hazardous waste, and corrosives. By chemical shipping name, 208 different hazardous materials were identified in the study area.

The Oregon study synthesized numbers of shipments by county and city destinations and by general hazard Class. It also generated raw numbers of trucks passing through the counties as well as those with destinations in each county. Table 5 summarizes these data. Linn County, as would be expected, had the highest percentage of through traffic for hazardous materials as well as the most shipment destinations in the three counties. Linn County also had the highest number of commodities surveyed, with 47. Note that the Class 3 materials (flammable/combustible liquids) comprised the highest percentage of exposure in Lincoln County. Both Linn and Benton counties had higher percentages of exposure to the other classifications used in the study. Dangerous placards indicated combination loads of hazardous materials and the Other category combined materials not otherwise classified. At the time of the Oregon study, ORM or “Other Regulated Materials” had several sub-classifications. Today, the designation is still used for mixed loads of standard consumer commodities.
Table 5: Hazardous Materials Flow, Oregon Commodity Flow Study

<table>
<thead>
<tr>
<th></th>
<th>Linn</th>
<th>Benton</th>
<th>Lincoln</th>
</tr>
</thead>
<tbody>
<tr>
<td># of trucks surveyed</td>
<td>830</td>
<td>80</td>
<td>68</td>
</tr>
<tr>
<td># of different</td>
<td>47</td>
<td>33</td>
<td>14</td>
</tr>
<tr>
<td>commodities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common commodities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>destined for county</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(in order of # of</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>shipments)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>Gas/diesel</td>
<td>Gas/diesel</td>
</tr>
<tr>
<td></td>
<td>Sodium hydroxide (liq.)</td>
<td>Nitrogen (liq. refrig.)</td>
<td>Sodium hydroxide</td>
</tr>
<tr>
<td></td>
<td>Corrosive liq. n.o.s.</td>
<td>Sulfuric acid</td>
<td>Corrosive liq. n.o.s.</td>
</tr>
<tr>
<td></td>
<td>Diesel</td>
<td>Sodium hydroxide</td>
<td>Diesel</td>
</tr>
<tr>
<td></td>
<td>Methyl alcohol</td>
<td>Helium</td>
<td>Methyl alcohol</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Helium</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% with destination in</td>
<td>21%</td>
<td>63%</td>
<td>93%</td>
</tr>
<tr>
<td>county</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% through traffic</td>
<td>79%</td>
<td>36%</td>
<td>7%</td>
</tr>
<tr>
<td>% exposure to county</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>by hazard Class (combined trucks surveyed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 3</td>
<td>41%</td>
<td>49%</td>
<td>63%</td>
</tr>
<tr>
<td>Class 8</td>
<td>30%</td>
<td>21%</td>
<td>19%</td>
</tr>
<tr>
<td>Dangerous</td>
<td>10%</td>
<td>11%</td>
<td>7%</td>
</tr>
<tr>
<td>Class 2</td>
<td>6%</td>
<td>10%</td>
<td>6%</td>
</tr>
<tr>
<td>Other</td>
<td>9%</td>
<td>9%</td>
<td>4%</td>
</tr>
<tr>
<td>ORM</td>
<td>4%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from: PUC and ODOT, 1988
3 METHODOLOGY

3.1 Conceptual Framework

To date, most commodity flow studies have been done using placard surveys as a basis for characterizing hazardous materials movements. Placard surveys provide critical information on specific materials transported and can be used to estimate percentages of truck traffic carrying hazardous materials. However, where placard surveys alone have served as commodity flow studies, they have been limited both spatially and temporally, providing a snapshot in one time and place when and where a survey is conducted. Because placard surveys are conducted in specific locations on road networks, they cannot offer information on the spatial variability of traffic patterns. They also are limited to the time of survey and are only rarely conducted repeatedly in the same locations to analyze temporal changes in traffic patterns. This project presents a new approach that can be used with, or in lieu of, placard surveys to achieve commodity flow study goals.

The approach taken in this study includes elements of all three components of the hazards analysis process (Figure 2). In addition to identifying hazardous materials in the study area, this study integrates GIS to evaluate the primary transportation corridors and geographic and demographic factors that may influence exposure risks, classified in hazards analysis as vulnerability analysis. Hazard identification and vulnerability factors are combined in this study to provide a basis for risk analysis in the study area, in the context of hazardous materials.

The three specific objectives of this study were:

1) To identify hazardous materials present and transported in the study area;
2) To evaluate and analyze factors that contribute to geographic vulnerability from hazardous materials transport; and
3) To provide a basis for integrating these factors for emergency planning and public awareness.
Figure 3 shows the combination of types of information gathered and analyzed to meet these objectives. Facilities that use or produce hazardous materials were investigated, and these materials were assumed to be transported in the study area. Hazardous materials incidents databases were queried to investigate reported numbers and locations of historic incidents, and to see if trends existed, either in numbers over time or types of materials involved.

To investigate transportation of these materials, traffic information was analyzed, including reported average traffic levels, percentages of traffic that were truck traffic, and estimated percentages and numbers of trucks carrying hazardous materials. A Geographic Information System (GIS) was then used to place locations and types of hazardous
materials in the study area and incidents that have occurred in the past, and to model the information as risk factors for potential future accidents with these materials.

Figure 3: Information Types for this Commodity Flow Study

3.2 Study Area

3.2.1 Geography

Linn, Benton, and Lincoln counties, located in northwest Oregon, comprise the study area. This region is a cross-section of western Oregon, from sea level on the coast of Lincoln County to the Pacific Crest of the Cascade Range in Linn County (Figure 4). Lincoln County is a 992 mi$^2$ area and has approximately 60 miles of Pacific shoreline. The
Figure 4: Linn, Benton, and Lincoln Counties, Oregon
coastal mountain range in Lincoln County is drained by the Salmon, the Siletz, the Yaquina, the Alsea, and the Yachats Rivers (listed north to south). With the exception of the Yachats, these rivers all have significant bay systems, ranging inland from one to several miles. Towns and cities include Lincoln City, Newport, Toledo, Waldport and Yachats. All of these are on the coast except Toledo, the original location of the Lincoln County seat. With a population of about 42,000, Lincoln is the least populated county in the study area.

Benton County is located between Lincoln and Linn Counties, extending from the eastern slope of the coast range to the Willamette River. Other significant waterways within the county boundaries include the Mary's River, the Long Tom, and the Luckiamute River. The Alsea River runs westward from Benton County into Lincoln County and to the Pacific Ocean. Mary's Peak (elevation 4097 ft.) is the highest mountain in the Oregon Coast Range. At 679 mi², Benton County is the smallest county within the study area, but it has the highest population density of the three counties. Cities and towns in Benton County include Corvallis, Philomath, Alsea, and Monroe.

Linn County is bounded by the western shore of the Willamette River and extends across its eastern floodplain, through the foothills of the Cascade Range, to the highest point in the county, Mt. Jefferson, at 10,495 feet. The high Cascade peaks of Mount Jefferson, Three Fingered Jack (7841 ft.), and Mt. Washington (7794 ft.) bound the eastern border of Linn County. Three federal Wilderness Areas define this eastern boundary of the study area. Cities and towns in the county include Albany, Lebanon, Sweet Home, Brownsville, and Halsey. With about 2,300 square miles, Linn County is more than twice the size of Lincoln County and more than three times the size of Benton County. Table 6 shows several physical and demographic aspects of the three counties in the study area.

The three-county area borders six other Oregon counties. From north to east to south, these include Tillamook, Polk, Marion, Jefferson, Deschutes, and Lane Counties. Tillamook is a coastal county north of Lincoln County in the study area. Marion County to the north includes the capital city of Salem. Jefferson and Deschutes Counties to the
Table 6: Physical and Demographic Features, Linn, Benton, and Lincoln Counties

<table>
<thead>
<tr>
<th></th>
<th>Linn County</th>
<th>Benton County</th>
<th>Lincoln County</th>
<th>Study area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mi²</td>
<td>2,297</td>
<td>679</td>
<td>992</td>
<td>3,968</td>
</tr>
<tr>
<td>km²</td>
<td>5,949</td>
<td>1,759</td>
<td>2,569</td>
<td>10,277</td>
</tr>
<tr>
<td><strong>Elevation range (&gt;msl)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>feet</td>
<td>210 - 10,495</td>
<td>200 - 4,097</td>
<td>0 - 3,359</td>
<td>0 - 10,495</td>
</tr>
<tr>
<td>meters</td>
<td>64 - 3,199</td>
<td>61 - 1,249</td>
<td>0 - 1,024</td>
<td>0 - 3,199</td>
</tr>
<tr>
<td><strong>Average Temperature</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January °F (°C)</td>
<td>39 (4)</td>
<td>39 (4)</td>
<td>43 (6)</td>
<td></td>
</tr>
<tr>
<td>July °F (°C)</td>
<td>66 (19)</td>
<td>66 (19)</td>
<td>57 (14)</td>
<td></td>
</tr>
<tr>
<td><strong>Population</strong></td>
<td>100,000</td>
<td>76,000</td>
<td>42,200</td>
<td>218,200</td>
</tr>
<tr>
<td><strong>Principle Industries</strong></td>
<td>Agriculture, Food and Wood Products, Rare Metals, and Manufacturing</td>
<td>Agriculture, Lumber, Research and Development, Electronics, and Wineries, University</td>
<td>Lumber, Fishing, Agriculture, and Tourism</td>
<td></td>
</tr>
</tbody>
</table>

east are considered part of Central Oregon. Lane County, south of the study area, includes the city of Eugene.

The study area represents a significant physiographic portion of Western Oregon and of the Northwest. It is within the Cascadia geologic province, that extends from British Columbia, Canada, to Northern California. The landscape has been shaped by tectonic activity, and the Cascade Crest is part of the "Ring of Fire" that extends through much of the Pacific Ocean. The subduction zone of the Juan de Fuca plate and the North American plate is the western boundary of the Cascadia province (Alt and Hyndman, 1990).

Volcanic eruptions, lava floods, tsunamis, mud flows, and river flooding have been common in recent geologic history in this part of Oregon. Along with the tectonic activity that visibly dominates in the Cascade Range, the Willamette Valley has experienced periodic and continuous winter flooding, providing fertile valley soils in eastern Benton
and western Linn Counties. Three physiographic provinces are represented in the study area, including the Coast Range, the Willamette Valley, and the Western Cascades physiographic provinces (Hulse, 1998).

Maritime influence is pronounced in western Oregon, with warm moist Pacific Ocean air from the southwest combining with cold dry continental air masses. Proximity to the Pacific Ocean, topography, and exposure to mid-latitude westerly winds are the primary climatic controls (Frank, 1974). The temperate marine climate produces relatively warm dry summers and cool wet winters in the lower elevations. Annual precipitation ranges from about 40 inches in the Willamette Valley to more than 100 inches in the mountain areas, most occurring between October and April. A transient snow zone with intermittent snow and rain occurs between 1,300 and 4,000 feet, with a permanent snow zone in the Cascades above 4,000 feet (Harr, 1981). The seasonality of precipitation and winter snowfall in the higher elevations applies a strong influence on transportation and related transportation incidents in the study area.

Forest products and agriculture are primary industries in the study area. Large portions of Linn and Lincoln counties are in Willamette and the Siuslaw National Forests, respectively. Heavily forested landscape is dominant throughout the region. Deep, fertile soils are found in all the major river corridors in the region, supporting extensive crop varieties, including grass seed, grains, tree fruits, nuts, and vegetables. The growing season in the Willamette Valley is about 200 days (Frank, 1974). Agriculture-related industries include food- and meat-processing plants. These industries utilize a wide variety of chemical mixtures, including fertilizers, pesticides, and chemicals used in pulp and paper manufacturing.

A general trend from a primarily resource-based economy (e.g., agriculture and wood products) to a high technology and manufacturing economy is distinctly evident in Linn and Benton Counties, and to a lesser degree in Lincoln County. As the economic base of the area has diversified, urban and surrounding areas have experienced a corresponding increase in population densities. Significant newer industries in the study area include primary and fabricated metals and electronics manufacture, transportation, communication and utilities, wholesale and retail trade, and services (Rothlein, 1996).
3.2.2 The Transportation Network

The transportation network in the study area is a result of the physiography and demographic features of the region. The north-south orientation of both the Coast and the Cascade Mountains, the number of rivers in the study area, and the relative historic ease of travel along floodplains contributed to population growth along rivers and at the confluence of major rivers. A number of dams have decreased the intensity of flooding in the valley areas, and many of these confluences have become the urban centers of the region. Correspondingly, many of the major transportation routes in the region are located adjacent to waterways.

Transportation modes for hazardous materials may include roadways, railroads, navigable waterways, pipeline, and air transport. Truck and rail transportation are considered of primary concern for emergency planning and public awareness issues for the study area in the context of hazardous materials transportation.

Major north/south roads in the study area include the US Hwy 101 on the coast in Lincoln County, Oregon 99W in Benton County, and Oregon 99E and Interstate 5 in Linn County. Major east west routes include Oregon 18 in the northern portion of Lincoln County, US Highway 20 spanning all three counties, Oregon 34 spanning from the coast in Lincoln County, through Benton County, and extending into Linn County to Lebanon, and Oregon 22, 226, and 228 in Linn County (Figure 5). The ten roads analyzed in the study area total about 517 miles. Santiam Pass on Highway 20 (4817 ft.) traverses the eastern barrier of the study area.

As designated nation-wide, the odd-numbered routes in the study area run generally north/south and even-numbered routes run east/west. ODOT uses its own numbering system for highways in Oregon and data they produce is organized by these numbers rather than the traditional highway numbering system (Figure 5). Table 7 summarizes several attributes of the study area road network.
Figure 5: Study Area Roads with ODOT Numbers

- OR 18 (ODOT 39)
- US 101 (ODOT 9)
- OR 22 (ODOT 162)
- OR 22/34 (ODOT 212)
- OR 99W (ODOT 1W)
- OR 99E (ODOT 58)
- OR 34 (ODOT 27)
- US 20 (ODOT 16)
- US 20 (ODOT 33)
- OR 34 (ODOT 210)
- OR 226 (ODOT 211)
- I-5 (ODOT 1)
- Lincoln City
- Newport
- Salem
- Corvallis
- Albany
- Lyons
- Eugene
- Junction City
- Halsey
- Sweet Home
- Yachats
- Waldport
- Toledo
Table 7: Study Area Road Network Attributes

<table>
<thead>
<tr>
<th>Road Name</th>
<th>ODOT road segment number and milepost range</th>
<th>Road Length in Study Area</th>
<th>Functional Classification*</th>
<th>Cities and Towns Served (major cities in adjoining counties)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interstate 5</td>
<td>No. 1 (~204-240)</td>
<td>36 miles</td>
<td>Interstate</td>
<td>Albany (Salem, Eugene-north and south of study area)</td>
</tr>
<tr>
<td>Oregon Hwy 18</td>
<td>No. 39 (0-10.27)</td>
<td>10 miles</td>
<td>Principal Arterial</td>
<td>Otis, Rose Lodge</td>
</tr>
<tr>
<td>US Hwy 20</td>
<td>No. 33 (0-56.70)</td>
<td>149 miles</td>
<td>Principal Arterial</td>
<td>Newport, Toledo, Eddyville, Burnt Woods, Blodgett, Wren, Philomath, Corvallis, North Albany, Albany, Lebanon, Sweet Home</td>
</tr>
<tr>
<td></td>
<td>No. 31 (0.1-11.15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. 16 (0-80.77)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oregon Hwy 22</td>
<td>No. 162 (~22-81.44)</td>
<td>59 miles</td>
<td>Principal Arterial</td>
<td>Mehama, Lyons, Mill City, Gates, Detroit, Idanha</td>
</tr>
<tr>
<td>Oregon Hwy 34</td>
<td>No. 27 (0-58.46)</td>
<td>84 miles</td>
<td>Minor Arterial</td>
<td>Waldport, Tidewater, Alsea, Philomath, Corvallis, Tangent, Lebanon</td>
</tr>
<tr>
<td></td>
<td>No. 33 (49.66-56.70)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. 210 (0-18.12)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oregon Hwy 99E</td>
<td>No. 58 (0-29.09)</td>
<td>35 miles</td>
<td>Minor Arterial</td>
<td>Albany, Tangent, Shedd, Halsey, Lebanon</td>
</tr>
<tr>
<td></td>
<td>No. 1 (233.73-240)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oregon Hwy 99W</td>
<td>No. 1W (72.33-104.36)</td>
<td>32 miles</td>
<td>Minor Arterial</td>
<td>Camp Adair, Lewisburg, Corvallis, Greenberry, Alpine Junction, Monroe</td>
</tr>
<tr>
<td>US Hwy 101</td>
<td>No. 9 (102.8-167.61)</td>
<td>65 miles</td>
<td>Principal Arterial</td>
<td>Neotsu, Lincoln City, Depoe Bay, Otter Rock, Newport, Waldport, Yachats</td>
</tr>
<tr>
<td>Oregon Hwy 226</td>
<td>No. 211 (0-25.70)</td>
<td>26 miles</td>
<td>Minor Arterial</td>
<td>Crabtree, Scio, Lyons, Mehama</td>
</tr>
<tr>
<td>Oregon Hwy 228</td>
<td>No. 212 (0-21.39)</td>
<td>21 miles</td>
<td>Minor Arterial</td>
<td>Halsey, Brownsville, Crawfordsville, Holley, Greenville, Sweet Home</td>
</tr>
</tbody>
</table>

*Functional Classification: Road groups based on type of services provided by roads. Operating speeds, trip travel times, and degree of property access are examples of services provided. For example, large cities that generate many trips are usually connected by arterial highways. Arterials emphasize high levels of mobility and shortest trip travel times between destinations.
Railroads located within the study area include the Burlington Northern/Santa Fe, Union Pacific, Albany & Eastern, and Willamette Valley railroads in Linn County, and the Willamette & Pacific in Lincoln and Benton Counties (Table 8).

Table 8: Study Area Rail Network

<table>
<thead>
<tr>
<th>Railroad Name</th>
<th>Functional Use</th>
<th>Track Length in Study Area</th>
<th>Cities and Towns Served</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burlington Northern Santa Fe (BNSF)</td>
<td>Freight</td>
<td>~50 miles (2 lines)</td>
<td>Harrisburg, Albany, Millersburg, Dever</td>
</tr>
<tr>
<td>Union Pacific (UP, historically Southern Pacific)</td>
<td>Freight &amp; Passenger</td>
<td>~34 miles (2 lines)</td>
<td>Harrisburg, Halsey, Shedd, Tangent, Albany, N. Albany, Millersburg, Jefferson</td>
</tr>
<tr>
<td>Willamette Valley Railway (WVRY, now becoming part of A&amp;E)</td>
<td>Freight</td>
<td>~40 miles (1 line)</td>
<td>Lebanon, Griggs, Crabtree, Shelburn, Kingston, Lyons, Mill City</td>
</tr>
<tr>
<td>Albany &amp; Eastern (A&amp;E)</td>
<td>Freight</td>
<td>~17 miles (1 line)</td>
<td>Albany, Lebanon, Sweet Home, Foster</td>
</tr>
</tbody>
</table>

The Burlington Northern/Santa Fe and Union Pacific routes run north-south along the I-5, 99E, and 99W corridor in the center of the Willamette Valley. Willamette & Pacific has a north-south route from Monroe through Corvallis and to Adair Village in Benton County and two east-west routes: one from the coast at Toledo to Albany, and a short run between Alpine Junction and Dawson in southern Benton County. The Albany & Electric railroad runs between Albany and Foster and Willamette Valley Railway has a line between Lebanon and Mill City (Figure 6).
3.3 Methods

Because hazardous materials in transport are not specifically tracked in the public sector, multiple sources of information were gathered and analyzed to present a picture of these materials in the context of transportation flow. Table 9 shows the types of data that were assembled to analyze in this study.

Table 9: Data Sources for Linn, Benton, and Lincoln Counties

<table>
<thead>
<tr>
<th>Information category</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous material information</td>
<td>♦ Fire Marshall databases (fixed facilities and incident databases)</td>
</tr>
<tr>
<td></td>
<td>♦ Hazardous Materials Information Reporting System (HMIRS)</td>
</tr>
<tr>
<td></td>
<td>♦ SARA Title II and III information</td>
</tr>
<tr>
<td>Transportation network data</td>
<td>♦ Average daily traffic data (ATRs and road tube counts)</td>
</tr>
<tr>
<td></td>
<td>♦ Railroad milepost inventories</td>
</tr>
<tr>
<td>Demographic/geographic data</td>
<td>♦ Population centers</td>
</tr>
<tr>
<td></td>
<td>♦ Waterways</td>
</tr>
<tr>
<td></td>
<td>♦ Critical facilities</td>
</tr>
<tr>
<td></td>
<td>♦ County and State GIS data</td>
</tr>
<tr>
<td>Existing hazardous material commodity flow guidance and studies</td>
<td>♦ State and Federal government documents and publications</td>
</tr>
<tr>
<td></td>
<td>♦ Existing CFSs and surveys</td>
</tr>
</tbody>
</table>

3.3.1 Characterization of Hazardous Materials

Identification of the types and quantities of hazardous materials within the study area was accomplished with analysis of two databases maintained by the Office of the State Fire Marshall (OSFM), and one federal database from DOT. The two OSFM databases were the fixed facility database, which inventories the types of materials present at individual locations, and the incident database, which tracks spills or threatened hazardous materials releases. Both OSFM databases were obtained in Microsoft Access® format (Diane Henry, personal communication, Dec. 1998). The federal database used is
called the Hazardous Materials Information Reporting System (HMIRS) and was received in Microsoft Excel® format (Joanne Williams, personal communication, Oct. 1998).

3.3.1.1 Fixed Facilities

Fixed facilities are defined as industrial, commercial or service establishments where raw and refined materials are produced, used, and/or stored. As such, these facilities are origin and destination points for hazardous materials that are conveyed through the transportation network. It has been inferred that materials located at fixed facilities are transported through the road and railroad network, either as raw materials or as produced commodities.

Fixed facilities data from the OSFM for 1998 were used for analysis in this study. The data set includes information on the numbers and locations of facilities with reportable quantities of hazardous materials, descriptions of the materials, and a range of quantities at the sites. Hazardous materials are listed in the database by chemical trade name or product, most hazardous ingredient, and hazard Class. Chemical trade named materials are often complex mixtures of chemicals, so the most hazardous ingredient and hazard Class listings provide more information on the actual chemical names and hazards presented by products. Multiple hazard Classes are commonly recorded for chemical products and most hazardous ingredients, where hazard Class 1 indicates the hazard that presents the highest physical danger to emergency response personnel. Hazard Class 2 and hazard Class 3 may provide better descriptions of potential health hazards of listed materials. Extremely Hazardous Substances (EHS) are also identified in this database, indicating materials on the US EPA list of 356 chemicals defined for their high toxicity and environmental risks.

3.3.1.2 Incidents

Two databases were used to characterize incidents: the OSFM database and DOT’s Hazardous Materials Information System (HMIRS) database. Both databases were received and queried in Microsoft Access® for total numbers of incidents involving hazardous materials.
The HMIRS database includes threats or releases of defined hazardous materials, death or injury, more than $50,000 monetary damage, evacuation or closure of transportation facilities equal to or more than 1 hour, or the diversion of aircraft or restriction of aircraft routes. Due to the stringency of these reporting requirements, fewer incidents were reported in the federal database than were reported in the state Fire Marshall’s incident database. HMIRS data for the period 1971-1997 were analyzed (Joanne Williams, personal communication, Oct. 1998).

The 1998 OSFM incident database include reported environmental releases or potential releases where any of the 15 statewide hazardous materials teams, fire departments, or police respond to incidents involving hazardous materials. Within this database, the ten-year period from 1988 through 1997 was used to review incidents that may have involved hazardous materials releases. Chemical/Biological/Technologic and Radiation incidents were extracted for the ten year period. These two categories of incidents comprise the two classifications of potential hazardous material responses in the database.

3.3.2 Characterization of Transportation Corridors and Traffic Levels

3.3.2.1 Highways

ODOT data were analyzed to characterize the general traffic flows in the transportation network roads of interest. Permanent traffic recorders, called Automatic Traffic Recorders (ATRs), are in place on major roads in each county in Oregon. These data indicate normalized average traffic in one location per road per county (ODOT, 1998). Traffic data from ATRs also include average daily traffic by month of year and comparison of average weekday traffic and average daily traffic. These permanent recorders also provide percentages of traffic by vehicle classification.

Along with permanent ATRs (one per road per county), ODOT also collects average daily traffic figures by milepost (ODOT, 1998). Temporary road tubes are placed in variable locations and the figures generated provide a view of the variation of traffic along ODOT road segments. These data provide site-specific traffic information at a number of locations along each road.
3.3.2.2 Railroads

Hazardous materials rail information is reported by hazard Classes and by Standard Transportation Commodity Codes (STCC) or "stick codes." These codes and hazard Classes of materials are tracked by ODOT's rail division of hazardous materials. Railroad milepost inventories provide information on hazard Classes and STCC codes and the number of train carloads transported by milepost range by year.

Milepost inventories were requested for the rail lines in the study area and were acquired for what used to be Southern Pacific's (now Union Pacific and run by CORP) main line from the Eugene to Portland, and Burlington Northern Santa Fe's lines between Eugene and Albany. This information was received for 1993 for the Union Pacific line and for 1995 for the Burlington Northern Santa Fe lines (Michael Eyer, personal communication, Oct. 1998). Information on Albany & Eastern's line between Albany and Foster and Willamette Valley's line between Lebanon and Mill City was obtained verbally from a company representative of Albany & Electric (Jim Krueger, personal communication, April, 1999).

3.3.2.3 Estimation of Hazardous Materials Traffic

Truck traffic percentages of total traffic are provided by ODOT's permanent automatic traffic recorders. Fourteen vehicle classifications are designated in these data, ranging from motorcycles and scooters, buses, passenger cars, and a variety of truck classifications (ODOT, 1998). Ten of the 14 classifications are summed by ODOT to calculate estimated truck traffic as a percentage of total traffic, including:

- Single unit 2 axle 6 tire;
- single unit 3 axle;
- single unit 4 axle or more;
- single trailer truck 4 axle or less;
- single trailer truck 5 axle;
- single trailer truck 6 axle or more;
- dbl-trailer truck 5 axle or less;
- dbl-trailer truck 6 axle;
• dbl-trailer truck 7 axle or more;
• triple trailer trucks.

To estimate daily truck traffic (ADT\textsubscript{truck}) for ODOT road segments, the following formula was used:

\[ \text{ADT}_{\text{truck}} = \text{ADT}_{\text{total}} \times P_{\text{truck}} \]  \hspace{1cm} (1)

Where \text{ADT}_{\text{total}} is the average daily traffic value taken from the ODOT road tube count data and \( P_{\text{truck}} \) is the percentage of total traffic estimated as truck traffic. The number of trucks transporting hazardous materials (\( \text{ADT}_{\text{haztrucks}} \)) was computed using the following formula:

\[ \text{ADT}_{\text{haztrucks}} = \text{ADT}_{\text{truck}} \times P_{\text{haz}} \]  \hspace{1cm} (2)

Where \( P_{\text{haz}} \) is the average percent of hazardous materials traffic taken from the Oregon study as 5.5%. Minimum and maximum possible values of \( P_{\text{haz}} \) were also used in equation (2) to compute possible ranges of hazardous materials truck traffic as percentages of truck traffic. The range of percentages for hazardous truck traffic from the Oregon study was from 2.1% to 12.9%.

### 3.3.3 GIS Mapping

Oregon county boundary lines were obtained from Benton County GIS and from Oregon GIS Services. Road and rail networks were edited from Tiger/Line files (State Service Center for GIS, 1999). These are developed by the USGS for the US Census Bureau to provide mapping and related geographic capabilities for the decennial census. Geographic and demographic features are provided by the Tiger/Line files in a digital database format. Tiger/Line files (1992) were originally drafted at 1:100,000. Census block data was obtained tiled by county, and was produced with 1990 Tiger/Line data (scale of drafting varied). Stream coverage was obtained from USGS maps and was originally drafted 1:2,000,000. These files were downloaded from the State GIS website in Arc/Info\textsuperscript{®} export format with the file extension E00 (State Service Center for GIS, 1999). E00 files were unzipped with Winzip software from Microsoft and were then converted to shape files in Arc/Info\textsuperscript{®} for input into ArcView GIS software. After re-projecting them for the county projection parameters, they were placed as themes in an
ArcView project file. Appendix 1 shows the projection parameters for the state GIS Services group and for Benton County.

Road traffic levels were placed as a new field in the roads theme, showing three magnitude ranges of average daily traffic from 2,000-10,000; 10,001-16,000; and 35,000-49,000. A theme produced by Benton County was added for critical facilities, which were subdivided into seven classifications: educational facilities; health facilities; fire and law enforcement; government facilities; utilities and communications; airport; and other. Several other existing coverages were modeled for potential inclusion in this project, including the 1996 flood polygon area, the Corvallis fault system, potential landslide areas, and potential tree blowdown areas.

Geocoding, the process by which point locations are added to a GIS map defined by street address, was conducted to place the two Fire Marshall databases into the project. Geocoding was conducted in ArcView® to match address fields between the Tiger road files and the Fire Marshal databases, both for fixed facilities and for historic hazardous materials incident locations. The Fire Marshall’s databases were received in MS Access® format, were converted first into MS Excel® format, and then exported as dBase IV (.dbf extension) into ArcView®. Fixed facility information for Linn and Lincoln Counties was queried in MS Access to separate company listings from chemical listings because many of the facilities use multiple chemicals which stacked geocoded points in ArcView®. The Fire Marshall’s historic hazardous materials incidents database was similarly geocoded with the Tiger road files after conversion from MS Access, through MS Excel®, and into dBase IV format for inclusion into ArcView®.

Geocoding in ArcView was done by the batch-matching process, with matching based on “US streets with zone.” Default matching parameters were used for the initial geocoding, with spelling sensitivity, 80%; minimum match score, 60; and minimum score for candidate consideration, 30 (ESRI, 1996). The geocoding process provided low total matching percentages at these settings so the data were re-matched with lowered matching parameters; spelling sensitivity, 30%; minimum match score, 30; and minimum score for candidate consideration, 30. For consistency, all final geocoding was done using the above parameters.
Maps were then developed in ArcView by placing themes for each of the factors on the study area basemap, allowing for inclusive and/or selective overlays of the factors, called themes in ArcView®. Two categories of map themes were produced for this project; specific hazardous materials information, and geographic/demographic information. These map themes then could be superimposed on one another in any desired combination.
4 RESULTS

4.1 Hazardous Materials

4.1.1 Fixed Facilities

Data compiled from the OSFM indicate that there were 2,426 separate facilities that produced or used hazardous materials in the study area, with Linn County reporting the highest number of facilities (Table 10). Linn County also reported the greatest variety of chemical products, with 2,261 chemical trade names, while Benton County reported 838 chemical trade names, and Lincoln County reported 444. Hazard Classes were provided for all but four of the product listings in both Linn and Lincoln Counties, and for about 75% (643 of 838) of the product listings in Benton County. Among the hazard Classes, roughly 70-75% of the products were in Classes 2 (gases), 3 (flammable liquids), 4 (flammable solids), and 6 (poisonous/infectious substances). In Linn County, hazard Class 8 (corrosives) also made up almost 10% of the products listed. Less than 1% of the products were in Classes 1 and 7 (explosive and radioactive, respectively), with 2 - 3% in Class 5 (oxidizers and organic peroxides).

It is important to note that many of these products occurred more than once in the database for the study area, and that many of the product listings assigned different chemical trade names to the same product. For example, gasoline was listed as several different trade names (gasoline vs. regular gasoline vs. premium gasoline), even though the materials described would be very similar. Among these product names occurring at fixed facilities in the study area, there were relatively fewer most hazardous ingredients that comprise these products. There were about 973 most hazardous ingredients in the 2,261 products in Linn County. Benton County reported 439 most hazardous ingredients among the 838 products listed, and Lincoln County reported 233 most hazardous ingredients for the 444 products listed.
Table 10: Fixed Facilities and Reported Products in the Study Area

<table>
<thead>
<tr>
<th></th>
<th>Linn County</th>
<th>Benton County</th>
<th>Lincoln County</th>
<th>totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed facilities reported</td>
<td>1093</td>
<td>614</td>
<td>528</td>
<td>2426</td>
</tr>
<tr>
<td>Chemical trade name listings</td>
<td>2261</td>
<td>805</td>
<td>444</td>
<td></td>
</tr>
<tr>
<td>Products with hazard Class listings</td>
<td>2257</td>
<td>643</td>
<td>440</td>
<td></td>
</tr>
<tr>
<td>hazard Class:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 1. explosives</td>
<td>9</td>
<td>9</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Class 2. gases</td>
<td>134</td>
<td>83</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Class 3. flammable liquids</td>
<td>328</td>
<td>117</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>Class 4. flammable solids</td>
<td>453</td>
<td>133</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>Class 5. oxidizers and organic peroxides</td>
<td>42</td>
<td>20</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Class 6. poisonous/infectious substances</td>
<td>626</td>
<td>136</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>Class 7. radioactive materials</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Class 8. corrosives</td>
<td>200</td>
<td>48</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Class 9. miscellaneous</td>
<td>457</td>
<td>89</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>Products with 2nd hazard Class listings</td>
<td>982</td>
<td>285</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td>Total “most hazardous ingredients” reported</td>
<td>973</td>
<td>439</td>
<td>233</td>
<td></td>
</tr>
<tr>
<td>Extremely hazardous substances (EHS) - by unique chemical trade names</td>
<td>118</td>
<td>46</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Extremely hazardous substances (EHS) – by unique “most hazardous ingredient”</td>
<td>51</td>
<td>24</td>
<td>6</td>
<td>55</td>
</tr>
</tbody>
</table>

Of the more than 900 most hazardous ingredients reported, 55 met the SARA Title III criteria of Extremely Hazardous Substances (EHS) by most hazardous ingredients (Table 11). Fifty-one of these were in Linn County, with 24 in Benton County, and six in Lincoln County. Although the listed EHS for Lincoln and Benton Counties were almost a perfect subset of Linn Counties listed EHS, the hazard Class breakdown between the counties was slightly different. There were more different hazard Classes of EHS in Linn County than in Benton or Lincoln Counties, but the number of EHS by hazard Class was dominated by the Class 6 (poisonous/infectious substance) category. No EHS were reported in any of the counties for the Class 1 (explosives) or the Class 7 (radioactive) categories. Appendix 2 lists the EHS for each county and for the three county study area by chemical names.
Table 11: Extremely Hazardous Substances (EHS) by County

<table>
<thead>
<tr>
<th>EHS breakdown by hazard Class</th>
<th>Linn</th>
<th>Benton</th>
<th>Lincoln</th>
<th>Total # of EHSs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>hazard Class:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 1. explosives</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Class 2. gases</td>
<td>10</td>
<td>5</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Class 3. flammable liquids</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Class 4. flammable solids</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Class 5. oxidizers and organic peroxides</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Class 6. poisonous/infectious substances</td>
<td>37</td>
<td>12</td>
<td>0</td>
<td>59</td>
</tr>
<tr>
<td>Class 7. radioactive materials</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Class 8. corrosives</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Class 9. miscellaneous</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>51</td>
<td>24</td>
<td>6</td>
<td>55</td>
</tr>
</tbody>
</table>

4.1.2 Incidents

The federal Hazardous Materials Information Reporting System (HMIRS) data indicated 40 incidents in the highway category and 11 railway incidents between 1971 and 1997. Of the 40 highway incidents listed, 35 of the recorded incidents were in Linn County, with 20 of those recorded in the city of Albany. Benton County had 4 listings, and only 1 was recorded for Lincoln County. The 11 recorded rail incidents were all reported in Linn County.

Over the 26 year reporting period, the HMIRS did not show a pattern of increase of incidents either by rail or by highway. By both modes of transportation (highway and railway), the majority of incidents involved materials in the Class 8 and Class 3 categories, 34 out of 40 (85%) of highway incidents, and 10 of 11 (91%) of the rail incidents reported (Table 12). HMIRS data lists the chemicals involved, the number of releases for each chemical and the hazard Class.

The OSFM data produced were a complete summary of hazardous materials incidents during the ten year period from 1988 through 1997. Chemical, Biological, and Technologic and Radiation incidents included 181 in Linn County, 132 in Benton County, and 28 in Lincoln County. The average for the study area was 34 incidents per year, with
an average of 18 per year in Linn County, 13 in Benton, and 3 in Lincoln. The number of occurrences per year did not appear to be increasing through the ten-year time period studied in the Fire Marshall’s incident database. Table 13 summarizes total numbers and averages per year, number of chemicals reported per county in the study area, with city locations where incidents occurred most often and the chemicals of most common occurrence. Lists of the chemicals involved in these incidents are provided in Appendix 3.

Table 12: HMIRS Summary

<table>
<thead>
<tr>
<th>Highway incidents (# of incidents)</th>
<th>Railroad incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Highway incidents (# of incidents)</strong></td>
<td><strong>Railroad incidents</strong></td>
</tr>
<tr>
<td><strong>Sulfuric acid (8)</strong></td>
<td>Ammonium nitrate (4)</td>
</tr>
<tr>
<td>Sodium hydroxide (8)</td>
<td>Sodium hydroxide solution (3)</td>
</tr>
<tr>
<td>Hydrochloric acid (6)</td>
<td>Sulfuric acid (1)</td>
</tr>
<tr>
<td>Corrosive liquid (2)</td>
<td>Methyl alcohol (2)</td>
</tr>
<tr>
<td>Carbon tetrachloride (1)</td>
<td>Liquid petroleum gas (1)</td>
</tr>
<tr>
<td>Hydrofluoric acid (1)</td>
<td></td>
</tr>
<tr>
<td>Trichloroisocyanuric dry (1)</td>
<td></td>
</tr>
<tr>
<td>Gasoline (2)</td>
<td></td>
</tr>
<tr>
<td>Acetone (1)</td>
<td></td>
</tr>
<tr>
<td>Isopropyl alcohol (1)</td>
<td></td>
</tr>
<tr>
<td>Naptha petroleum (1)</td>
<td></td>
</tr>
<tr>
<td>Compressed gases (1)</td>
<td></td>
</tr>
<tr>
<td>Anhydrous ammonia (1)</td>
<td></td>
</tr>
<tr>
<td>Nitric acid (1)</td>
<td></td>
</tr>
<tr>
<td>Sodium chlorate (1)</td>
<td></td>
</tr>
<tr>
<td>III-trichloroethane (1)</td>
<td></td>
</tr>
<tr>
<td>Chlorpyrifos (1)</td>
<td></td>
</tr>
<tr>
<td>Petroleum distillate (1)</td>
<td></td>
</tr>
<tr>
<td>Hazardous substance (1)</td>
<td>NOS ORM-E</td>
</tr>
</tbody>
</table>

Differentiating between fixed and transportation hazardous material incidents was complex in the database. One hundred and seven incidents were in the fixed facility category, but transportation information was found in several fields within the database. One hundred thirty of the total 341 incidents analyzed were listed in a public road classification; commercial vehicles were listed as involved in 75 of the incidents; 40 were listed as “in transit” in the “cause of incident” field; 19 are listed in a “during delivery”
category; and 16 are classified as “material involved – cargo.” Eight incidents flag the “train” field, with four in the “train derailment” field. Thirty-eight % (130 of 341 incidents) were on the public road network, and 2% (8 of 341) involved rail transport, indicating that more than 40% of these incidents reported were in transportation categories.


<table>
<thead>
<tr>
<th></th>
<th>Linn</th>
<th>Benton</th>
<th>Lincoln</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of incidents</td>
<td>181</td>
<td>132</td>
<td>28</td>
<td>341</td>
</tr>
<tr>
<td>Average # reported incidents per year</td>
<td>18</td>
<td>13</td>
<td>3</td>
<td>34</td>
</tr>
<tr>
<td>Number of different chemicals reported</td>
<td>66</td>
<td>61</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Cities where incidents occurred most often</td>
<td>Albany (121)</td>
<td>Corvallis (100)</td>
<td>Newport (19)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lebanon (27)</td>
<td>Philomath (28)</td>
<td>Lincoln City (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Halsey (11)</td>
<td></td>
<td>Waldport (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Harrisburg (5)</td>
<td></td>
<td>Toledo (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tangent (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Brownsville (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Millersburg (2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most common chemicals involved</td>
<td>Diesel (38)</td>
<td>Diesel (26)</td>
<td>Anhyd. Ammonia (5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gasoline (20)</td>
<td>Unknown (18)</td>
<td>Natural gas (3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown (19)</td>
<td>Gasoline (17)</td>
<td>Calcium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chlorine (11)</td>
<td>Natural gas (9)</td>
<td>hypochlor. (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drug lab chems. (5)</td>
<td>Unknown (2)</td>
<td></td>
</tr>
</tbody>
</table>

4.2 Transportation Corridors and Traffic Levels

4.2.1 Highways

Ten years of Average Daily Traffic (ADT) figures from the study area roads showed an average increase of 28% in traffic for the 10 highways in this study, although there was wide variability among these highways (Figure 7). Between 1988 and 1997 average daily traffic increased 11% on Highway 34 and 70% on Highway 18. Interstate 5, US 20 and 101, and Oregon highways 18 and 226 all experienced increases in the ten year period of
Figure 7: Average Daily Traffic for Study Area Roads, 1988-1997
Figure 7: continued
more than 25% (ODOT, 1998). Automatic Traffic Recorders (ATRs) at Oregon
highways 22, 34, 99E, and 99W showed increases of 20% or less in the same ten year
period. There is not currently an ATR on Oregon 228 so there were no numbers for this
road. These increasing traffic levels reflect trends at one location for each road in the
study area, since the ATRs are placed one location, per county, per road.

Road tube data present a more detailed view of the spatial variability in traffic
levels for each road in the study area (Figure 8). Computed average daily traffic from
road tube count data indicates a strong pattern of higher average traffic levels at
intersections between major roadways and in urban areas. The spatial variation of the
traffic is also apparent over each road segment. These traffic “spikes” are evident from
these data throughout the entire road network in the study area.

Comparison of traffic levels from the two data sources indicates distinct
differences in reported average daily traffic levels (Table 14). Note that the ATR station
for Interstate 5 is located at milepost 214, nineteen miles north of Eugene, about fourteen
miles south of Highway 34 at Tangent. Recordings for the ATR are taken at the lowest
traffic area of I-5 in the study area. Higher levels of traffic south closer to Eugene and the
much higher traffic levels at the northern portion of the road segment are not accounted
for in the permanent ATR locations. For this reason, road tube count data rather than
ATR data were used to calculate traffic and truck loads relevant to hazardous materials
traffic.

I-5 carries more than double the traffic volume of its neighbor roads. The next tier
of roads by average daily traffic volumes are US 101, 99E and 99W, and the US 20 east-
west corridor. The lowest average traffic roads include the US 101 to Philomath section
of 34, Oregon 226 and 228, and the sections of Oregon 18 and 20 at the northern border
of the study area. Average daily traffic numbers divide the roads in the study area into
three orders of magnitude of traffic; from 2,000-10,000 per day; from 10,001-16,000; and
for I-5, 35,000-50,000 (Figure 9).

Based on estimates of truck traffic and hazardous materials truck traffic as a
percentage of total traffic, I-5 carries between 500 and 700 hazardous materials trucks
daily, and as few as 6 per day west of Philomath on Oregon 34 (Table 15).
Figure 8: Variation of Average Daily Traffic by Road Tube Count

a) Oregon 99E, I-5 Section, Average 48,800 (S - N)

b) Interstate 5, Average 42,727 (S - N)
Figure 8, continued

c) US 20/Ore 34/ODOT 33, Average 15,564 (W - E)

![Graph showing average daily traffic for US 20/Ore 34/ODOT 33.]

- 20/34 "Y" Philomath Intersection
- 53rd St., Corvallis
- Ore 99W at Bypass

- ODOT milepost
- Average daily traffic


d) US 20/ODOT 31, Average 14,393 (W - E)

![Graph showing average daily traffic for US 20/ODOT 31.]

- Circle Blvd. Corvallis
- Independence Hwy. Scenic Dr. Albany
- Ore 99E

- ODOT milepost
- Average daily traffic
Figure 8, continued

e) Oregon 99E, not including section of I-5, Average 13,732 (N - S)

f) US 101, Average 13,313 (N - S)
Figure 8, continued

g) Oregon 99W (N-S), Average 12,706

h) Ore 34/ODOT 210, Average 11,643 (W-E)
Figure 8, continued

i) **US 20/ODOT 16**, Average 10,478 (W - E)

![Graph showing traffic distribution with key points like Lebanon, ATR MP 19.07, Sweet Home, Quartzville Rd., Linn-Jefferson County Line, and others.]  

j) **US 20/ODOT 33**, Average 10,030 (W - E)

![Graph showing traffic distribution with key points like US 101 Int., Ore 229 Int., Union with Ore 34, Philomath Int., and others.]
Figure 8, continued

k) Oregon 18, Average 9,383 (W - E)

![Graph of Oregon 18 traffic]

l) Oregon 22, Average 4,175 (W - E)

![Graph of Oregon 22 traffic]
Figure 8, continued

m) Oregon 228, Average 3,950 (W - E)

n) Oregon 226, Average 3,250 (W - E)
Figure 8, continued

o) Ore 34/ODOT 27, Average 2,223 (W - E)
Note in Table 15 that the roads have been re-ordered by decreasing daily traffic based on the road tube counts, rather than from the ATRs in one location for each road in the study area.

Table 14: ODOT Average Daily Traffic

<table>
<thead>
<tr>
<th>Road name</th>
<th>ODOT number</th>
<th>ATR location</th>
<th>1997 Average Daily Traffic</th>
<th>Average daily traffic range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>By ATR</td>
<td>By road tube</td>
</tr>
<tr>
<td>Interstate 5</td>
<td>No. 1</td>
<td>19 miles north of Eugene</td>
<td>33,445</td>
<td>42,727</td>
</tr>
<tr>
<td>US 20</td>
<td>No. 31</td>
<td>No ATR</td>
<td>17,881</td>
<td>9,383</td>
</tr>
<tr>
<td>Oregon 18</td>
<td>No. 39</td>
<td>East boundary of Lincoln County</td>
<td>11,929</td>
<td>10,478</td>
</tr>
<tr>
<td>US 20</td>
<td>No. 16</td>
<td>3 miles east of Lebanon</td>
<td>9,625</td>
<td>13,313</td>
</tr>
<tr>
<td>US 101</td>
<td>No. 9</td>
<td>Otter Rock</td>
<td>5,425</td>
<td>3,250</td>
</tr>
<tr>
<td>Oregon 226</td>
<td>No. 211</td>
<td>Intersection w/ US 20</td>
<td>5,167</td>
<td>12,706</td>
</tr>
<tr>
<td>Oregon 99W</td>
<td>No. 1W</td>
<td>6 miles north of Monroe</td>
<td>4,760</td>
<td>4,175</td>
</tr>
<tr>
<td>Oregon 22</td>
<td>No. 162</td>
<td>Gates</td>
<td>4,471</td>
<td>10,030</td>
</tr>
<tr>
<td>Oregon 228</td>
<td>No. 212</td>
<td>No ATR</td>
<td>3,369</td>
<td>13,732</td>
</tr>
<tr>
<td>Oregon 99E</td>
<td>No. 58</td>
<td>Halsey</td>
<td>48,800</td>
<td>37,900-50,000</td>
</tr>
<tr>
<td></td>
<td>No. 1 (I-5 section)</td>
<td>No ATR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oregon 34</td>
<td>No. 27</td>
<td>5 miles west of Philomath</td>
<td>11,643</td>
<td>4,700-21,000</td>
</tr>
<tr>
<td></td>
<td>No. 210</td>
<td>No ATR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No 33 (US 20 section)</td>
<td>No ATR</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An increase in average daily traffic during the summer and early fall months was also evident from ODOT data. For 1997, the study area roads all experienced a larger share of total traffic from June through September on a consistent basis. Both average weekday traffic and average daily traffic (including weekends in the average) recordings were elevated during the summer months, with more than 100% of the average daily traffic for these times. The portion of US 20 from Albany east to the Linn-Jefferson county line
Figure 9: Average Daily Traffic Magnitudes

Average vehicles per day:
- 2,000-10,000
- 10,001-16,000
- 35,000-50,000
(ODOT No. 16), and Oregon 99E and 226 had noticeably higher average daily traffic levels for an extended season from about March through November (ODOT, 1998). It is not known if truck traffic, and more importantly, hazardous materials truck traffic, is similarly higher during these months. However, given the study area climate, there may be some seasonal component to the amount of hazardous materials traffic.

Table 15. Estimated Number of Hazardous Materials Trucks, Average Daily Basis

<table>
<thead>
<tr>
<th>Road name ODOT No.</th>
<th>Estimated daily traffic, by road tube ADTs (ADT&lt;sub&gt;total&lt;/sub&gt;)</th>
<th>Truck traffic percentage multiple from ATR locations (P&lt;sub&gt;truck&lt;/sub&gt;)</th>
<th>Estimated daily truck traffic from road tube counts (ADT&lt;sub&gt;truck&lt;/sub&gt;)</th>
<th>Estimated number of trucks carrying hazardous materials, average daily basis and range estimate (ADT&lt;sub&gt;trucks&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oregon 99E (I-5 section, No. 1)</td>
<td>48,800</td>
<td>25.37%</td>
<td>12,380</td>
<td>681 (260-1597)</td>
</tr>
<tr>
<td>Interstate 5 (excluding 99E section, No. 1)</td>
<td>35,600</td>
<td>25.37%</td>
<td>9,032</td>
<td>497 (190-1165)</td>
</tr>
<tr>
<td>US 20 (No. 33)</td>
<td>15,564</td>
<td>16.54%</td>
<td>2,574</td>
<td>142 (54-332)</td>
</tr>
<tr>
<td>Oregon 99E (No. 58)</td>
<td>13,732</td>
<td>15.44%</td>
<td>2,120</td>
<td>117 (45-273)</td>
</tr>
<tr>
<td>US 101 (No. 9)</td>
<td>13,313</td>
<td>7.7%</td>
<td>1,025</td>
<td>56 (22-132)</td>
</tr>
<tr>
<td>Oregon 99W (No. 1W)</td>
<td>12,706</td>
<td>11.19%</td>
<td>1,421</td>
<td>78 (30-183)</td>
</tr>
<tr>
<td>Oregon 34 (No. 210)</td>
<td>11,643</td>
<td>4.73%</td>
<td>551</td>
<td>30 (12-71)</td>
</tr>
<tr>
<td>US 20 (No. 16)</td>
<td>10,478</td>
<td>7.71%</td>
<td>808</td>
<td>44 (17-104)</td>
</tr>
<tr>
<td>US 20 (No. 33)</td>
<td>10,030</td>
<td>4.73%</td>
<td>474</td>
<td>26 (10-61)</td>
</tr>
<tr>
<td>Oregon 18 (No. 39)</td>
<td>9,383</td>
<td>8.64%</td>
<td>811</td>
<td>45 (17-105)</td>
</tr>
<tr>
<td>Oregon 22 (No. 162)</td>
<td>4,175</td>
<td>15.98%</td>
<td>667</td>
<td>37 (14-86)</td>
</tr>
<tr>
<td>Oregon 228 (No. 212)</td>
<td>3,950</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Oregon 226 (No. 211)</td>
<td>3,250</td>
<td>7.7%</td>
<td>250</td>
<td>14 (5-32)</td>
</tr>
<tr>
<td>Oregon 34 (No. 27)</td>
<td>2,223</td>
<td>4.73%</td>
<td>105</td>
<td>6 (2-14)</td>
</tr>
</tbody>
</table>


4.2.2 Railroads

Both the Burlington Northern Santa Fe and the Union Pacific (formerly Southern Pacific) carry the majority of all rail shipments on the north-south lines. From the milepost inventories analyzed, the Southern Pacific line carried two orders of magnitude more hazardous materials than the Burlington Northern Santa Fe lines in the milepost inventories studied. The Burlington Northern Santa Fe lines had a noticeably different mix of materials, with a significant percentage (40%) of hazard Class 6 poison carloads. Table 16 summarizes the railroad milepost data received from the Oregon Department of Transportation, and verbal information received for Willamette & Pacific and Albany & Eastern lines (personal communication, David Hiser, W&P and Jim Krueger, A&E. March 1999). The Southern Pacific line, now Union Pacific and run by CORP, carried a large share of Classes 2, 3, and 8 (gases, flammable liquids, and corrosives, respectively), with relatively small quantities of Classes 1 and 4 (explosives and flammable solids, respectively). A relatively large portion of these materials (13%) are classified as “mixed loads,” Classes 1.1-8. The exact composition of these materials is not specifically tracked in the public sector (Michael Eyer, ODOT, personal communication, Oct. 1998).

4.3 GIS Mapping of Selected Risk Factors

Mapping the geographic distributions of the fixed facility database, EHS present in the study area, the incident database, and highways railroads and traffic levels provided information within the hazard analysis process defined as vulnerability assessment. The geographic placement of these risk factors allowed an analysis of the compounding of risks due to proximity, intersection, or overlap. Although the address matching procedure only geocoded a subset of each of the databases, maps produced showed strong and distinct spatial patterns in the study area.

The geographic distribution of fixed facilities showed a strong clustering effect in the city locations of the study area (Figure 10). Particularly evident was the clustering of facilities around the cities of (from west to east): Newport, Toledo, Philomath, Corvallis, Albany, Lebanon, and Sweet Home. This clustering is notably all on US 20, the primary east-west route in the study area.
Table 16: Summary of Railroad Milepost Data

<table>
<thead>
<tr>
<th>Commodity hazard Class and STCC</th>
<th>Number of carloads transported annually</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Burlington Northern Santa Fe (1995), Albany-Eugene line</strong></td>
<td></td>
</tr>
<tr>
<td>Class 6.1, Poison, #49212</td>
<td>84</td>
</tr>
<tr>
<td>Class 2.1, Flammable gases, #49054-49058</td>
<td>66</td>
</tr>
<tr>
<td>Class 3, Flammable and combustible liquids, #49060-49155</td>
<td>42</td>
</tr>
<tr>
<td>Class 9, Miscellaneous, #49403,49601,49621,49633</td>
<td>14</td>
</tr>
<tr>
<td>Class 2.3, Poison gas, #49205</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>210</strong></td>
</tr>
<tr>
<td><strong>Burlington Northern Santa Fe (1995), Albany-Foster line</strong></td>
<td></td>
</tr>
<tr>
<td>Class 9, Corrosive, #49300</td>
<td>2</td>
</tr>
<tr>
<td>Class 2.3, Poison gas, #49205</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3</strong></td>
</tr>
<tr>
<td><strong>Southern Pacific RR, Main line Eugene to Portland (1993)</strong></td>
<td></td>
</tr>
<tr>
<td>Class 3.1-3.3, Flammable liquids, #49060-49155</td>
<td>2,020</td>
</tr>
<tr>
<td>Class 2.1, Flammable compressed gases, #49054-49058</td>
<td>2,000</td>
</tr>
<tr>
<td>Class 2.2 &amp; 2.4, Nonflammable compressed gases, #49040-49048</td>
<td>1,820</td>
</tr>
<tr>
<td>Class 8, Corrosives, #49300-49365</td>
<td>1,800</td>
</tr>
<tr>
<td>Classes 1.1-8, “Mixed loads”, #49501,</td>
<td>1,350</td>
</tr>
<tr>
<td>Class 6.1, Class B Poisons, #4210-49239</td>
<td>940</td>
</tr>
<tr>
<td>Class 5.1, Oxidizing materials, #49181-49189</td>
<td>220</td>
</tr>
<tr>
<td>Class 1.3, Class B Explosives, #49021-49028</td>
<td>45</td>
</tr>
<tr>
<td>Class 6.2, Irritating materials &amp; etiologic agents, #49251-49259</td>
<td>44</td>
</tr>
<tr>
<td>Class 1.4, Class C Explosives, #49031-49036</td>
<td>25</td>
</tr>
<tr>
<td>Class 4.1-4.3, Flammable solids, #49161-49174</td>
<td>16</td>
</tr>
<tr>
<td>Class 1.1-1.2, Class A Explosives, #49011-49108</td>
<td>8</td>
</tr>
<tr>
<td>Empty tank cars w/ 1%-3% residues of hazardous materials</td>
<td>8,710</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18,998</strong></td>
</tr>
<tr>
<td><strong>Willamette &amp; Pacific (1998)</strong></td>
<td></td>
</tr>
<tr>
<td>Class 5.1, Oxidizing materials, #49183, Ammonium Nitrate</td>
<td>18</td>
</tr>
<tr>
<td>Class 5.1, Oxidizing materials, #49188, Ammonium Nitrate</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>25</strong></td>
</tr>
<tr>
<td><strong>Albany &amp; Eastern (1998), Albany-Foster line</strong></td>
<td></td>
</tr>
<tr>
<td>Class 9, Corrosive, #49365, Metam sodium</td>
<td>100</td>
</tr>
<tr>
<td>Tetrachloride</td>
<td>200</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>200</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>500</strong></td>
</tr>
</tbody>
</table>
The highest concentration of facilities occurs in two locations: at the intersection of 99W with US 20/OR 34 in Corvallis, and at the intersection of 99E with I-5 in Albany. The fixed facilities shown on this map are a partial set of the full group of the facilities. Of the 805 facilities in Benton County, 502 (62%) were successfully geocoded using the ArcView address matching procedure. For Linn and Lincoln Counties, 1,071 (56%) of the 1,887 facilities were successfully geocoded.

Smaller clusters of fixed facilities are observable at Waldport (south of Newport of US 101), Siletz north of US 20 just inland from the coast, the Alpine Junction/Bellfountain/Dawson area (in the southern 99W region of the study area), Lyons and Scio (both on Oregon 226), and Halsey and Brownsville (on Oregon 228). These clustered locations of fixed facilities are all, with the exception of Newport on the coast, on the rail routes of the study area. There is also an observable, relatively even distribution of facilities between Depoe Bay and the northern study area boundary on the coast, north of Lincoln City. These fixed facility locations are concentrated in close proximity to US 101.

The fixed facilities locations were then subdivided to look at those that reported EHS (Figure 11). This map shows the locations of 31 facilities with EHS of the 81 EHS containing facilities in the database. With 38% of these EHS matched to locations in the GIS, there is a notable pattern with EHS in the city locations of Newport, Toledo, Philomath, Corvallis, Albany and Lebanon on the US 20 and Oregon 34 east-west corridor. Scio, Halsey, Harrisburg, and Alpine Junction also have EHS in their facilities and these are also on the road and rail network of the study area. Only three of the EHS matched in the GIS are not located on the primary road and rail network designated for hazardous materials transportation.

Almost all of the incidents occurred on major roadways and along the rail network. A clear pattern of clustering is evident in the city and town areas. Lincoln City and Newport on the coast, and Toledo, Philomath, Corvallis, Albany, and Lebanon all have had multiple historic incidents, with Corvallis and Albany the most prominent clusters. Seventy-four percent (252 of 341) of the incidents in the OSFM database were successfully geocoded (Figure 12).
Figure 11: EHS Chemicals at Fixed Facilities
Figure 12: Historic Hazardous Materials Incidents
Along with chemical and historic incident data for the study area, several other potential risk factors for hazardous materials transportation incidents were modeled in the GIS for Benton County. Critical facilities, including schools, hospitals, fire and law enforcement facilities, government offices, utilities, communications facilities, and airports are of primary interest to emergency planners. This theme was already produced by Benton County personnel and these critical facilities were selected to illustrate how overlay and proximity analysis may be used with hazardous materials data. Fixed facility locations and historic incident locations were combined with the critical facilities theme to observe how close these factors might be in a geographic context (Figure 13). It was immediately evident there is a significant amount of both overlap and close proximity between industrial facilities, historic hazardous material incidents, and the critical facilities of particular concern to county emergency and planning staff. Both the road and rail network and the urban center of Corvallis is dominated by these locations. Similarly to the other hazardous materials and traffic information features in the GIS, the location of these facilities provides an observed linear co-incidence with the major transportation routes through the north-south 99W corridor and on the US 20 east-west corridor.

Population density was also modeled, with dominant overlap between the urban Corvallis area, fixed facilities, and historic incidents (Figure 14). Another example of overlap between themes in the GIS was average annual income, which was placed with the two types of hazardous materials information (Figure 15). These three illustrations indicate the diversity of information that can be inputted and analyzed in the GIS platform. Benton County currently has several other themes with hazard information, including the Corvallis fault system, slide and tree blow-down risk areas, and the 1996 flood footprint. These may be incorporated by Benton County Emergency Planning staff with risk factors modeled in this study for future overlay analysis.
Figure 13: Benton County Critical Facilities
Figure 14: Benton County Population Density

Persons/square mile:
- 0 - 250
- 250 - 500
- 500 - 1000
- 1000 - 2000
- 2000 - 5000

• Incidents
• Fixed facilities
Figure 15: Benton County Average Annual Income

Annual average income:
- $8,500 - 17,000
- $17,001 - 23,000
- $23,001 - 30,000
- $30,001 - 40,000
- $40,001 - 50,000

- Incidents
- Fixed facilities
4.4 Limitations

Limitations in this study included the temporal limits of collected data, data that was requested but not received by the time of this study, and several specific aspects of methods used to input and analyze it. Although the most current available data was used, it represents past years information and therefore is limited to the times it was collected. OSFM data and ODOT data were obtained for 1998, but railroad and federal data years varied considerably. Years analyzed were cited in tables and figures.

Several data sources requested during this study were not received by the deadline for inclusion. While the applicability of outstanding data sources is not known, new information may augment and perhaps modify the conclusions made in this project. Available study area data does not include specific quantitative tracking information for hazardous material transportation at this time. Because of this, other risk factors that contribute to the potential for transportation incidents should continue to be analyzed in the context of commodity flow in the study area.

Data on hazardous materials truck traffic as part of total traffic was estimated using the average and range of percentages from the Oregon commodity flow study from 1988. As stated, placard surveys such as the Oregon commodity flow study, are limited to the times and places the data was collected, and may not represent current conditions. More current information was not available to estimate truck flows with hazardous materials.

Railroad milepost data was neither complete nor specific for chemical products. Data received was categorized by hazard Class and by STCC codes which are not specifically identifiable. Some of the information used for this study that was not available through standard public sector reporting systems was obtained by personal communication.

This study focused on road and rail transportation of hazardous materials in the three-county area. It was directed to these modes of transportation because they are thought to be the most significant among the transportation types with hazardous
materials risks. Ship, pipeline, and air transport were not included in this study. Although it appears that truck and rail hazardous materials transport are the two most significant modes of transportation in this context, these other modes were not studied.

The data acquired for this study was converted from MS Access to Microsoft Excel to dBase IV (.dbf extension) format for inclusion in the GIS. It is not known if this process may truncate or otherwise limit the usefulness of the information. While it appears this information is complete, refinement of the address-matched databases may show some errors in the methods used to input these data.

Tiger/Line files used as the basis for geocoding have some known problems with address matching capability, and this was evidenced in this project. The matching parameters were set low to obtain the highest percentage of successfully geocoded points, and there may be incorrect matching in the study. The percentage matching average for the fixed facility database was approximately 60% and approximately 74% for the incident database.
5 DISCUSSION AND CONCLUSIONS

The data analyzed have shown the types of hazardous materials that are present in the study area, the traffic patterns that hazardous materials transportation must necessarily be a part of, and the general numbers and types of hazardous materials incidents that have occurred. Geographic, demographic, and hazardous materials data have been integrated to refine planning efforts, to provide information for emergency responders, and to foster public knowledge about these materials and the associated risks of transporting them. The combined analyses present several significant conclusions about hazardous materials transport in the study area.

For 1996 in the United States, ATSDR reported about 20% of hazardous materials incidents in transportation (ATSDR, 1996). Data collected by ATSDR for the same year indicated about 30% of hazardous materials incidents in Oregon were in the transportation sector. However, the OSFM incident database analyzed indicated more than 40% of these incidents in the transportation category in the study area. Whether due to industrial characteristics or other geographic/demographic factors, this indicates the significance of transportation incidents involving hazardous materials in the three county area.

There is clearly a large variety of hazardous materials on the road and rail networks. By inference, the same products and materials used by local industry and agriculture travel on this transportation network. Through traffic is assumed to follow a similar pattern, with movements of a variety of hazardous materials through the region. Due to the growth of new industries, the types of hazardous materials moving on the network has changed and is expected to continue to change over time. Yet materials such as fuels, corrosives, and poisons have been the types of materials identified most commonly.

A specific list of hazardous materials has been generated for the three-county area, including categories of chemicals by hazard Classes and extremely hazardous substances (EHS). Primary hazard Classes within and transported in the study areas are, as found in other commodity flow studies, dominated by the flammable fuels and gases (hazard
Classes 2, 3, and 4), with strong representation by the poisonous/infectious materials (hazard Class 6). Corrosive materials (hazard Class 8) represent almost 10% of the materials in Linn County. This entire group of hazard Classes (2, 3, 4, 6, and 8) represent more than 75% of the materials reported by fixed facilities in study area. Explosive materials (hazard Class 1) and radioactives (Class 7) are nearly non-existent in the reported hazard Classes for the three counties. Fifty-five of the almost 400 defined EHS are found in the study area, and locations and reported quantities of these materials are contained in the GIS theme for fixed facilities. By definition, these materials are particularly dangerous in situations where they are released into the environment.

The highest traffic levels in the study area are on the primary north-south routes in the study area, primarily on the I-5/99E corridor through Linn County. Traffic levels on this main corridor are in the range of 30,000-50,000 per day. An estimated average of between 500-700 hazardous materials trucks travel this route daily. The primary east-west corridor, US 20, carries about half of this traffic, and intersects with I-5 in Albany. Railroad traffic volumes mirror the dominance of north-south movement of hazardous materials, with two orders of magnitude more hazardous materials traffic than the east-west rail lines in the study area carry. This knowledge underscores the importance of the central region of the study area regarding its vulnerability to hazardous materials incidents.

This study focused on materials defined, regulated, and reported as hazardous materials. While defined hazardous materials may themselves not be tracked accurately and comprehensively, many substances that are not defined as hazardous may become so in situations when they are released into the environment. Densely populated areas or environmentally-sensitive areas are vulnerable to these materials not classified or regulated as hazardous, as well as defined hazardous materials. For a hypothetical example, a milk tanker truck accident on US 20 and I-5, with the release of 8,000 gallons, would represent a serious environmental hazard that would threaten Albany's water supply. The South Santiam River, running parallel to US 20 between Lebanon and Upper Soda in the Cascades, is the water supply for the city of Albany. While milk is obviously not classified as a hazardous material, it would indeed be hazardous in such a transportation incident.
Effective emergency planning needs to address these materials as well as specifically defined hazardous materials.

Increasing road traffic has been consistent through the three-county area over the last decade, paralleling state trends. These increases in traffic may correlate with higher numbers of hazardous materials shipments. However, incident databases do not indicate an increasing trend in the number of hazardous materials incidents in the study area. This finding indicates there may be some mechanisms that have made hazardous materials traffic safer. On the other hand, there may be some critical amount of hazardous material and general traffic movement where the number of these incidents may increase significantly.

Critical clustering of hazardous materials in the study area has been perhaps the most important insight gained through this study. In combination with high traffic, intersections, and densely populated urban areas, these clusters of fixed facilities and hazardous materials incidents emphasize the need for planning in those areas most likely to experience environmental releases of these materials. Both fixed facility locations, where hazardous materials are used and produced, and historic incidents with these materials are highly concentrated in the urban areas within the three counties. In addition, critical government, communication, and educational facilities are typically located in close proximity to these same areas. As a result, geographic areas where vulnerable populations or other sensitive resources and high traffic levels coincide with facilities and incidents are areas of key focus for successful planning, prevention, and mitigation efforts.

It is necessary to update, expand, and refine the information applicable to the study area as new data become available. The continued relevance and usefulness of this commodity flow study is dependent on the application of new information and refining the information that has been synthesized. Improvements and/or changes in tracking systems and monitoring, both by the private and government sectors, will continue to provide more and improved data on the transportation of hazardous materials. Other possible risk factors should be analyzed and included in this work as they become available.

In summary, effective emergency planning for hazardous materials transportation incidents needs to focus on geographic corridors and areas of vulnerability as well as on
specific hazardous materials. Because roads in the study area parallel or intersect with surface waters, these areas represent highly vulnerable risk factors to consider. While high traffic areas are obvious corridors of concern in this perspective, the data analyzed indicate that densely populated urban areas require direct attention as risk factors. In addition, critical facilities, such as schools and hospitals, are also in close proximity to other risk factors, compounding the potential for serious implications of hazardous materials releases in these areas. Without completely tracking all materials that may represent hazards, the risk factors that present vulnerable corridors and vulnerable areas in the study area can be used for a central focus of emergency planning efforts and for public knowledge of what and where hazardous materials incidents may occur.
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Oregon Department of Transportation (1998). Website. Avail HTTP: www.odot.state.or.us/tdb/traffic_monitoring/97tvt/97index.htm


State Service Center for Geographic Information Systems, Oregon (1999). Website. Avail HTTP: www.ssgis.state.or.us


APPENDICES
Appendix 1: Projection Parameters
Coordinate System Description – Projection Parameters

State of Oregon Projection:

Projection: Lambert
Datum: NAD83
Units: International Feet, 3.28084 (.3048 meters)
Spheroid: GRS1980
Parameters:
1st standard parallel 43 00 0.000
2nd standard parallel 45 30 0.000
Central meridian -120 30 0.00
Latitude of projection origin 41 45 0.000
False easting (meters) 400000.00000 (1,312,335.958 Feet)
False northing (meters) 0.00000

Benton County:

Output
Projection: State Plane
Units: Feet
FIPSZONE: 3601
Datum: NAD83 NADCON
Parameters
End
Appendix 2: EHS Chemicals, by County, and EHS List for Study Area
Linn County EHS by most hazardous ingredient – 51

ACRYLAMIDE
ALDICARB
ALUMINUM PHOSPHIDE
AMMONIA
AZINPHOS METHYL
BENZYL CHLORIDE
CARCIUM NAPHTHALENE SULFONATE
CARBOFURAN
CHLORINE
CHLOROPHACINONE
CHLOROPHACINONE 2 PHENYLACETY[L]
DIMETHOATE
DIMETHOATE 30.5%
DIPHACINONE
DISULFOTON
ENDOSULFAN
ETHOPROP
FONOFOS
FORMALDEHYDE
FORMALDEHYDE SOLUTION
HYDROFLUORIC ACID
HYDROGEN CHLORIDE
HYDROGEN PEROXIDE
HYDROGEN SULFIDE
HYDROQUINONE
MERCURIC CHLORIDE
METHOMYL
METHYL BROMIDE
Linn County EHS by most hazardous ingredient – 51, continued

NITRIC ACID
NITRIC OXIDE
OXAMYL
PARAQUAT DICHLORIDE
PHENOL
PHOSGENE
PHOSMET
PHOSPHINE
PHOSPHORUS PENTOXIDE
PYRIDINE
SODIUM HYPOCHLORITE
STRYCHNINE
SULFUR DIOXIDE
SULFURIC ACID
THIOPHENOL
TITANIUM TETRACHLORIDE
TRIETHANOLAMINE
UREA FORMALDEHYDE POLYMER
VANADIUM PENTOXIDE
VINYL ACETATE
VINYL ACETATE MONOMER
WARFARIN
ZINC PHOSPHIDE
Benton County EHS by most hazardous ingredient – 24

AMMONIA
BORON TRICHLORIDE
CHLORINE
CHLOROFORM
CHLOROPHACINONE
CHLOROPHACINONE 2 PHENYLACETYL
DIPHACINONE
ENDOSULFAN
ETHOPROP
ETHYLENE OXIDE
FONOFOS
FORMALDEHYDE
HYDROFLUORIC ACID
HYDROGEN PEROXIDE
NITRIC ACID
NITRIC OXIDE
PARAQUAT DICHLORIDE
PHENOL
SILANE
STRYCHNINE
SULFURIC ACID
VINYL ACETATE
WARFARIN
ZINC PHOSPHIDE
Lincoln County EHS by most hazardous ingredient – 6

AMMONIA
CHLORINE
ETHYLENE OXIDE
FORMALDEHYDE
SODIUM HYPOCHLORITE
SULFURIC ACID
ACRYLAMIDE
ALDICARB
ALUMINUM PHOSPHIDE
AMMONIA
AZINPHOS METHYL
BENZYL CHLORIDE
BORON TRICHLORIDE
CALCIUM NAPHTHALENE SULFONATE
CARBOFURAN
CHLORINE
CHLOROFORM
CHLOROPHACINONE
CHLOROPHACINONE 2 PHENYLACETYL
DIMETHOATE
DIMETHOATE 30.5%
DIPHACINONE
DISULFOTON
ENDOSULFAN
ETHOPROP
ETHYLENE OXIDE
FONOFOS
FORMALDEHYDE
FORMALDEHYDE SOLUTION
HYDROFLUORIC ACID
HYDROGEN CHLORIDE
HYDROGEN PEROXIDE
HYDROGEN SULFIDE
HYDROQUINONE
MERCURIC CHLORIDE
METHOMYL
METHYL BROMIDE
NITRIC ACID
NITRIC OXIDE
OXAMYL
PARAQUAT DICHLORIDE
PHENOL
PHOSGENE
PHOSMET
PHOSPHINE
PHOSPHORUS PENTOXIDE
PYRIDINE
SILANE
SODIUM HYPOCHLORITE
STRYCHNINE
SULFUR DIOXIDE
SULFURIC ACID
THIOPHENOL
TITANIUM TETRACHLORIDE
TRIETHANOLAMINE
UREA FORMALDEHYDE POLYMER
VANADIUM PENTOXIDE
VINYL ACETATE
VINYL ACETATE MONOMER
WARFARIN
ZINC PHOSPHIDE
Appendix 3: Historic Incident Chemicals, by County
Historic Incident Chemicals, Linn County – 66

ACETYLENE
AMMONIA
ANHYDROUS AMMONIA
ARGON
BORANE-PYRADINE COMPLEX
CALCIUM CARBIDE
CAPELLA OIL WF
CHLORINE
CHLOROPICRIN
COPPER SULFATE
DATA MISSING
DIESEL
DIESEL #2
DIESEL FUEL
DIESEL FUEL #1
DIESEL FUEL #2
DIESEL OIL
DIURON 4L
DRUG LAB CHEMICALS
EPICHLOROHYDRIN
FUEL OIL
GASOLINE
GUN POWDER
HERBICIDE
HYDRAULIC FLUID
HYDROCHLORIC ACID
HYDROFLUORIC ACID
HYDROFLUORIC ACID 70%
LACQUER
LATEX
LATEX PAINT
LIGHT OIL
LIME
LIQUIFIED PETROLEUM GAS
LUBE OIL
MAGNISIUM
MALATHION
MERCURY
METHANE
MOTOR FUEL
NATURAL GAS
NITROGEN DIOXIDE
OIL
OXYGEN
PERCHLOROETHYLENE
PETROLEUM
PETROLEUM NAPHTHA
PETROLEUM OIL
PETROLEUM PRODUCT
PHENOL
PROPANE
REDICOAT ASPHALT PRIMER
SILICON TETRACHLORIDE
STD FERROMANGANESE 4X1
SULFURIC ACID
TITANIUM SPONGE
TRANSMISSION OIL
UNKNOWN CHEMICAL
UNLEADED GAS
UNLEADED GASOLINE
UREA
UREA NITRATE
USED MOTOR OIL
VARIOUS CHEMICALS
WASTE PETROLEUM
XYLENE
AMMONIUM NITRATE
ANTIFREEZE
AROMATIC SOLVENTS
AUTOMATIC TRANSMISSION FLUID
BROMINE
CALCIUM HYPOCHLORITE
CARB CLEANER
CARBON MONOXIDE
CHLORINE BLEACH
COPPER NAPHTHENATE
COPPER OCTUATE
CROSSBOW WEED & BRUSH KILLER
CYANIDE
DATA MISSING
DIAZINON
DIESEL
DIESEL #2
DIESEL FUEL
DRAGNET ® FT TERMITICIDE
DRUG LAB CHEMICALS
DYE
EVANITE GLASS MICROFIBER
FORMALDEHYDE
FUEL
FUEL OIL
GASOLINE
GASOLINE UNLEADED
GLASS FIBERS
HYDRAULIC FLUID
HYDRAULIC OIL
HYDROCHLORIC ACID
JET A AVIATION FUEL
KEROSENE
METHOXYCHLOR TECH-20%
METHYL ETHYL KETONE
METHYLAMINE
MILK
MINERAL OIL
MOTOR OIL
NATURAL GAS
OIL
PETROLEUM HYDROCARBONS
PHENOL
PHOSPHORUS OXYCHLORIDE
PROPANE
REFRIGERANT
ROCK SALT
SAE 90 GEAR LUBE
SHEEP FAT ASPHALT ADDITIVE
SHERWIN WILLIAMS A-100 ACRYLIC LATEX
SILICON TETRACHLORIDE
SODIUM HYPOCHLORITE BLEACH 12.5%
TELAS 46 US HYDRAULIC OIL
TRICHLOROETHYLENE
UNKNOWN CHEMICAL
UNLEADED GAS
UNLEADED GASOLINE
WASTE MOTOR OIL
WASTE OIL
WASTE OIL PRODUCTS
ZEP SEWER CLEANER
AMMONIA
ANYDROUS AMMONIA
ANTIFREEZE
CALCIUM HYPOCHLORITE
CHLORDANE
FUEL
FUEL OIL
GASOLINE
GREEN LIQUOR
METHANE
NATURAL GAS
NITRIC ACID
OIL
OXYGEN LIQUID
PETROLEUM OIL
PROPANE
SODIUM DYDROXIDE LIQUID
UNKNOWN CHEMICAL
USED OIL