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Hazardous Materials Flows By Rail

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Final Report

U.S. Department of Transportation
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16. Abstract

This report presents a quantitative overview of the movement of hazardous materials by rail in the United States. The data used is a hazardous materials rail waybill sample developed at TSC from the 1983 Rail Waybill Sample. The report examines (1) the Rail Waybill Sample, (2) the characteristics of hazardous materials rail transport, (3) non-interchange versus interchange hazardous materials traffic, (4) the origins and destinations of hazardous materials traffic, and (5) specific information on the rail flows of STCC 289--Misc. Chemical Products, STCC 287--Agricultural Chemicals, STCC 291--Products of Petroleum Refining, and STCC 281--Industrial Organic Chemicals. The basic purpose of the report is to provide analysts and policymakers with information on the movement of hazardous materials by rail that can be used in the decision-making process.

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PREFACE

This report, prepared by the Economic Analysis Division, the Transportation Systems Center, Research and Special Programs Administration, U.S. Department of Transportation, with contractor support by Dr. Frederick Beier, University of Minnesota, and EG&G Dynatrend, provides a broad overview of the transportation of hazardous materials by rail in the U.S. The basic purpose of the report is to provide analysts and policymakers in government and industry with comprehensive information on the movement of hazardous materials by rail that can be used in the decision-making process.

METRIC / ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in) = 2.5 centimeters (cm)
1 foot (ft) = 30 centimeters (cm)
1 yard (yd) = 0.9 meter (m)
1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2) = 0.09 square meter (m^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)
1 acre = 0.4 hectares (he) = 4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gr)
1 pound (lb) = .45 kilogram (kg)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
1 tablespoon (tbsp) = 15 milliliters (ml)
1 fluid ounce (fl oz) = 30 milliliters (ml)
1 cup (c) = 0.24 liter (l)
1 pint (pt) = 0.47 liter (l)
1 quart (qt) = 0.96 liter (l)
1 gallon (gal) = 3.8 liters (l)
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x - 32) (5/9)] °F = y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
1 centimeter (cm) = 0.4 inch (in)
1 meter (m) = 3.3 feet (ft)
1 meter (m) = 1.1 yards (yd)
1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
1 hectare (he) = 10,000 square meters (m^2) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gr) = 0.036 ounce (oz)
1 kilogram (kg) = 2.2 pounds (lb)
1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

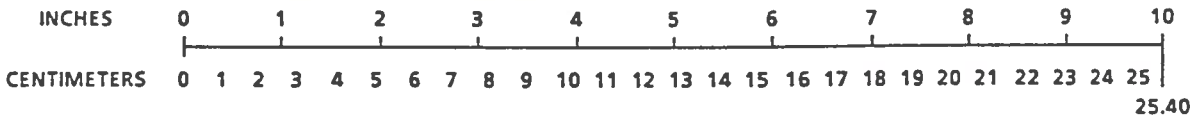
VOLUME (APPROXIMATE)

1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 liter (l) = 2.1 pints (pt)
1 liter (l) = 1.06 quarts (qt)
1 liter (l) = 0.26 gallon (gal)
1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)

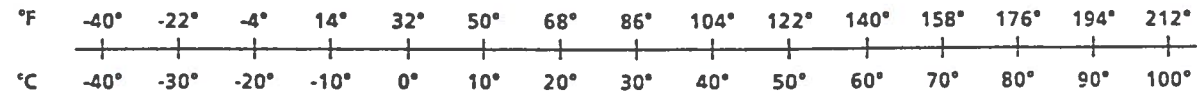
TEMPERATURE (EXACT)

[(9/5) y + 32] °C = x °F

QUICK INCH-CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT-CELCIUS TEMPERATURE CONVERSION



For more exact and/or other conversion factors, see NBS Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50. SD Catalog No. C13 10 286.

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EXECUTIVE SUMMARY

This report represents the culmination of a research effort by the U.S. Department of Transportation's Transportation System Center (TSC) in support of the Research and Special Programs Administration's Office of Hazardous Materials Transportation. The purpose of the effort was twofold: (1) to enumerate and assess the Rail Waybill Sample's capabilities as an analytical tool; and (2) to quantify rail flows as a preliminary means of evaluating the risk associated with the rail transportation of hazardous materials.

The report presents a quantitative overview of the movement of hazardous materials by rail. Based on the hazardous materials rail waybill sample developed at TSC from the 1983 Rail Waybill Sample, an estimated 51 million tons of hazardous materials were moved by rail in the U.S. in 1983. This material moved in an estimated 691 thousand carloads approximately 34 billion ton-miles. These estimates differ from those reported in a recent Office of Technology Assessment (OTA) study which also documented the movement of hazardous materials. In that study, 73 million tons and 53 billion ton-miles were reported. The discrepancy in figures would appear to be the result of an apparent misunderstanding of the intent and utilization of the hazardous materials commodity coding scheme used in the rail waybills by those who prepared the OTA figures.

Four commodity groups compose the majority of all hazardous materials movements in 1983. These are Standard Transportation Commodity Code (STCC) 281 (Industrial Organic Chemicals), STCC 291 (Products of Petroleum Refining), STCC 287 (Agricultural Chemicals), and STCC 289 (Miscellaneous Chemical Products). Combined, these four commodity groups represent 94 percent of the total tonnage shipped in 1983. The top four 7-digit STCC within each of these commodity groups were found to be (1) STCC 2819315, sulfuric acid or oil of vitriol, accounting for approximately 3.8 million tons shipped; (2) STCC 2912190, liquefied petroleum gas, accounting for almost 2.7 million tons shipped; (3) STCC 2871450, phosphatic fertilizer solution, accounting for 2.4 million tons shipped; and (4) STCC 2899991, chemicals not elsewhere classified, accounting for 1.1 million tons.

Based on flow analyses conducted for the four primary commodities, significant differences in the direction, gateway cities used for interchange, routing characteristics, use of multiple cars, density of loads, and other characteristics were found to exist. It would appear, therefore, to be inaccurate to generalize across all hazardous materials shipments.

Nine states--Texas, Louisiana, Illinois, Alabama, Tennessee, North Carolina, West Virginia, Mississippi, and Florida--accounted for approximately 62 percent of the tonnage of hazardous materials shipped by rail in 1983. In general, hazardous materials shipments by rail demonstrate intrastate or intra-regional characteristics: most shipments move to destinations within the originating state or region. Texas may be an exception to this in that it is also the origin for much national traffic. Florida, on the other hand, appears to epitomize the local nature of shipments in that the vast majority of its shipments of hazardous materials are intrastate.

Almost 55 percent of the shipments in the hazardous materials rail waybill sample developed for this study were interchanged between at least two rail carriers. Interchange data is critical to the accurate estimation of the total volume of hazardous materials moving through a particular city as opposed to the volume that is originating or terminating there. Moreover, interchanging may pose an extra dimension of risk, since the shipment is handled at least one more time than it would have been had it not been interchanged. Such additional handling obviously increases the risk of damage to the car and/or its contents.

In assessing the risk associated with rail shipments of hazardous materials, tons shipped may not always be an adequate measure of such risk. In the case of lightly loaded shipments, for example, cars may be a more accurate measure of the level of exposure than tons. While the number of tons of a commodity passing a point may be one-half that of similar commodity (similar in terms of the type of hazard of the commodity), the number of cars may be the same. It can then be argued that the probability of an incident is also the same, i.e., it is the car, or the interface of the car with its "environment" that usually cause incidents, not the lading. The amount of

lading may be at least a partial measure of the potential severity of an incident, but it may not be the best measure of the probability of one. Hybrid measures, such as loaded car-miles, may also be useful in measuring aggregate system risk.

1. INTRODUCTION

1.1 PURPOSE AND SCOPE

Well over a billion tons of hazardous materials move through the U.S. by truck, rail, water, and air every year. Given the potentially disastrous consequences of a hazardous material accident, assuring the safe transport of these materials is an important concern of the government at Federal, state, and local levels as well as of the general public. To support this goal of safe transport, information is needed on the pattern of movement of hazardous materials throughout the country. The purpose of this report is to develop such information by documenting the flow patterns of hazardous materials moved by rail in the U.S. This information can then be used by policymakers and analysts in the evaluation of the risk of such flows.

This report represents the culmination of an effort by the U.S. Department of Transportation's Transportation Systems Center (TSC) in support of the Research and Special Program Administration's Office of Hazardous Materials Transportation. The goal of the effort was twofold: (1) to enumerate and assess the Rail Waybill Sample's capabilities as an analytical tool, and (2) to quantify rail flows.

This report presents a quantitative overview of the movement of hazardous materials by rail.[1] There is a strong need for such information. In recent years, only two other major studies have attempted to evaluate aggregate rail flows of hazardous materials in a meaningful way. The first, sponsored by the U.S. Department of Transportation's Federal Railroad

[1]This report is the second in a series prepared by the U.S. Department of Transportation examining the flows of hazardous materials in the U.S. The first, "Truck Transportation of Hazardous Materials: A National Overview" by D. Maio and T.K. Liu, examined the movement of hazardous materials on the nation's highways.

Administration (FRA)[2], was performed in the late 1970s and early 1980s and used Rail Waybill Sample data for the late 1970s and 1980. To be of use to analysts and policymakers interested in hazardous materials movements today, the FRA study results need to be updated with more current data. While the second study, sponsored by the Office of Technology Assessment (OTA)[3], uses more current Rail Waybill Sample data (1983) than the FRA study, it appears to have significantly overestimated the level of rail transport of hazardous materials in the U.S. by misinterpreting the commodity coding supplied in the waybills.

The present report complements or improves upon the previous work of earlier studies in a number of ways. First, it provides another data point in estimating the aggregate flows of hazardous materials by rail (a data point more current than that of the FRA study and of the same year, 1983, as the OTA study). Second, it provides substantial background on the nature of waybill statistics, benchmark information on aggregate national volumes, and regional distribution patterns of specific hazardous materials transported by rail. Third, unlike the OTA study, it provides flow estimates derived using the commodity coding of the waybills correctly. In addition, it examines specific routing characteristics of different commodity groups. This report also supplies insight into how the risks of such movements can be assessed for the

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[2]Federal Railroad Administration, Office of Safety, Rail Hazard Analysis project, 1978-1982. This effort was performed, in large part, at the Transportation Systems Center by research teams headed by Ronald Mauri and Theodore Glickman. A large number of reports on the rail movement of hazardous materials resulted from this work, including the FRA annual, "Railroad Safety Statistics: Accident Locations/Hazardous Material Flows/ Accident Rates," which detailed and presented on maps the freight accidents occurring and hazardous materials carloads moving by railroad per year.

[3] U.S. Congress, Office of Technology Assessment, Transportation of Hazardous Materials, OTA-SET-304 (Washington, DC: U.S. Government Printing Office, July 1986). The background analysis for this report was performed, in large part, by Mark Abkowitz and George List of the Department of Civil Engineering, Rensselaer Polytechnic Institute at Troy, New York. Primary among the reports prepared by List and Abkowitz for the OTA study was "Hazardous Materials Transportation: Commodity Flow and Incident/Accident Information Systems," submitted in January 1986.

purposes of developing routing alternatives. Given the importance of accurate information regarding hazardous materials transport and the need to assess its risks, the detailed information in this report can be very useful to DOT policymakers and analysts, as well as to others interested in the transport of hazardous materials by rail.

2. THE HAZARDOUS MATERIALS DATABASE

2.1 BACKGROUND

The Transportation Systems Center (TSC) Hazardous Materials Waybill File, "Hazway," uses 1983 data from the Rail Waybill Sample,[4] which was collected for the Interstate Commerce Commission (ICC) and the Federal Railroad Administration (FRA).[5] Hazway is a subset of the Waybill Sample containing only observations on hazardous materials shipments. The identification of the relevant observations from the 1983 Rail Waybill Sample was based upon the existence of a STCC[6] Section 49 Series code number on the waybill. The Waybill Sample contains approximately 230,000 observations representing 2.4 percent of all rail shipments in 1983.[7] Hazway contains a total of 11,091 observations (i.e., waybills) on hazardous materials shipments, or approximately 4.8 percent of the total 1983 Rail Waybill Sample.

The choice of the year of the sample, 1983, was arbitrary. The use of 1983 for the analysis, it might be noted, does allow the findings of the analysis to be compared with those presented in the OTA report and supporting documentation, since the OTA also used data from the 1983 Rail Waybill Sample.

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[4]For an excellent discussion of the background and methodology of waybill sampling see K. Eric Wolfe, "The Carload Waybill Statistics: A Content Analysis," Proceedings-Twenty-seventh Annual Meeting, (Washington DC: Transportation Research Forum, 1986), pp. 244-252.

[5]The contractor who prepared the 1983 Waybill Sample was Price Williams. The current contractor is the Association of American Railroads.

[6]Standard Transportation Commodity Code (STCC). For a listing of the codes, see an STCC tariff, such as Standard Transportation Commodity Code Tariff STCC 6001-N. For a history of each of the STCC, see Association of American Railroads, "STCC Numeric File Historical Summary."

[7]See Wolfe, p. 249.

2.2 THE RAIL WAYBILL SAMPLE

The Rail Waybill Sample is an annually collected, stratified sample of national rail flows in the U.S. that has been collected by the ICC since 1946. The original intent of this data collection was to achieve a one percent sample of rail movements by requiring submission of all Class I terminated waybills whose numbers were "1" or ended in the numbers "01." It was discovered, however, that this procedure yielded a true sampling rate more on the order of 0.8 or 0.9 percent. To correct for this undersampling, the ICC instituted a new reporting procedure in 1981.

Unlike the old procedure, which based reporting requirements on revenue, the new procedure is based on a rail carrier's annual operations. Under this procedure, any railroad terminating 4,500 or more carloads during any one of the previous three years or transporting five percent or more of the traffic terminated in any one state during any one of the previous three years is required to submit a sample of its waybills. Although Class Is still constitute the overwhelming majority of the reporting rail carriers, some Class IIs and Class IIIs are now represented as well.[8]

Another major difference in the new procedure is the use of two sets of stratified sampling rates, one for railroads supplying machine readable input (MRI) and the other for railroads supplying hardcopy information. Under MRI submission, railroads must report between 2.5 and 50 percent of their waybills according to the strata as defined in Table 1. Railroads unable to submit the waybill data in MRI format are required to report according to the hardcopy requirements listed in Table 2.

Of the approximately 230,000 waybills sampled in 1983, nearly 70 percent were submitted in the MRI format. The ICC, DOT, and AAR (Association

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[8]Effective January 1, 1982, the Interstate Commerce Commission adopted a procedure to adjust the definition of Class I status for inflation by restating it in constant 1978 dollars. The 1983 basis for Class I railroads was $83.5 million or more in operating revenues. Railroads with less than this are Class II or III.

TABLE 1.

MRI SAMPLING STRATA

Number of Carloads Listed on the Waybill	Sampling Rate	Sample Percent
1-2	1 of 40	2.5%
3-15	1 of 12	8.3%
16-60	1 of 4	25.0%
61-100	1 of 3	33.3%
101 or more	1 of 2	50.0%

Source: Eric K. Wolfe, "The Carload Waybill Statistics: A Content Analysis," In Transportation Research Forum, "Proceedings of the Twenty-seventh Annual Meeting", Volume 27, Number 1, 1986, p. 247.

TABLE 2.

HARDCOPY SAMPLING STRATA

Number of Carloads Listed on the Waybill	Ending Waybill Serial Number	Sampling Rate	Sample Percent
1-5	01 or just 1	1 of 100	1.0%
6-25	1	1 of 10	10.0%
26 or more	1 or 7	1 of 5	20.0%

Source: Wolfe, p. 247.

of American Railroads) encourage MRI reporting since this improves the sampling rate (the proportion of the population sampled), which ensures more thorough reporting of all strata. Additionally, MRI reporting reduces processing cost due to the increased accuracy with which the data are submitted.

It should be noted that, since 1983, many railroads that had been submitting hardcopy have begun submitting machine readable waybills. Thus, as the data become more current, there should be fewer inconsistencies caused by multiple methods of data submission.

2.2.1 Statistical Accuracy of the Waybill Sample

The Waybill Sample is recognized for its high level of detail and statistical accuracy. This accuracy is the result of adherence to an ICC mandate that the sample contain less than one percent error and that this error be of a non-repetitive, or non-serial nature.[9] There are, however, several practices that may affect the reliability of inferences made from Waybill Sample data.[10] While it is unlikely that these practices have severely impacted the results of this analysis, each is briefly discussed to provide a context for their interpretation.

The exact waybill sampling rate (i.e., proportion of the population that is included in the sample) is a function not only of the waybill submission method, but also of the particular billing method chosen by the railroad. For example, a railroad may bill or rebill local or interline multiple car movements as a series of single car moves, which reduces the sampling rate for the multiple carload strata by an unknown factor. While this billing practice may distort Waybill information on revenues, it will not alter the quality of the overall population estimate since the one-to-two carload population will necessarily increase under such circumstances.

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[9]See Wolfe, pp. 248-249. A non-serial error is random and not systematic within the sample.

[10]See Wolfe.

Consequently, the larger sample drawn from the latter stratum will roughly counterbalance a reduction in sampling rates from multiple carload strata.

Another practice that may have some effect concerns estimated weights of shipments. Freight weight statistics in the Waybill are based on billed rather than actual lading weights. While billed weights differ from actual weights on average by only a little more than two percent, there appears to be considerable variation among individual commodities. In general, use of the ton-mile statistics (mileage divided by billed weight) will result in larger than actual aggregates. Unfortunately, there seems to be no way of controlling this bias.

2.2.2 Using the Waybill Sample

Based on the method used to collect the waybill sample, each stratum has a different sampling rate that varies with the form of waybill submission. Therefore, to permit aggregate analysis, a weighting or expansion factor defined as the inverse of the sampling rate must be applied to cars, tons, and revenue. In this way, estimates about the total annual cars, tons, and revenue can be calculated.

While it is possible to derive estimates of the total tonnage, carloads, and ton-miles being moved by rail using the Waybill Sample, it is impossible to calculate an accurate estimate of the number of annual rail shipments by applying the expansion factor to the sample waybill count. To understand the reason for this, it is first important to clarify the definition of a waybill. As defined by 49 CFR 1244, a waybill is "the document or instrument prepared from the bill of lading contract or shipper's instructions as to the disposition of the freight, and used by the railroad(s) involved as the authority to move the shipment and as the basis for determining the freight charges and interline settlements." Viewed in its most practical sense, then, a waybill is a function of the particular billing practice of the railroad; it does not necessarily imply that for each shipment there is only one corresponding waybill. In addition to the billing practices discussed in the previous section, two other practices are relevant here since

they both cause the creation of at least two waybills for the same shipment. First, since "piggyback" shipments involving highway tractors or containers on flatcars (commonly referred to as TOFC--trailer-on-flatcar--and COFC--container-on-flatcar) are frequently rebilled, a count of these intermodal waybills will overstate the number of shipments. Second, Accounting Rule 11, which permits shippers to rebill deregulated traffic, also results in at least two waybills and a consequent overstatement of the estimated number of shipments. Thus, due to various methods of legal rebilling, it is impossible to expand the number of sample waybills to calculate an accurate estimate of the number of shipments.

2.3 THE HAZARDOUS MATERIALS RAIL WAYBILL SAMPLE

The hazardous materials rail waybill sample was developed from the Rail Waybill Sample in a very straightforward manner. The Rail Waybill Sample database, obtained from the Federal Railroad Administration, contained a variable indicating whether the product listed in a database record had a 49 Series STCC code number (i.e., a hazardous materials STCC number), as well as a regular STCC code number, assigned to it. If it did, the record represented the movement of a hazardous material by rail and, therefore, was included in the hazardous materials rail waybill sample; if it did not, the record was not included, since the record did not represent a hazardous materials movement.

It should be noted that a STCC-49 code is assigned to all proper shipping names listed in DOT's Hazardous Materials Table (49 CFR 172.101). The proper shipping names are also matched to the appropriate "STCC Product Class Tariff description" (i.e., the regular STCC code). This dual matching is necessary since there is no one-to-one correspondence between regular STCC codes used for shipping and the STCC-49 code. The approach should result in the assignment of STCC-49 codes to only those commodities deemed hazardous by DOT rather than a whole range of commodities having a similar name. For example, while antifreeze is classified under 21 different regular STCC product class descriptions, only 19 of these are classified as hazardous under STCC-49. The remaining two classifications are <u>not</u> deemed hazardous. Without the use of STCC-49 bridging, the two latter non-hazardous antifreeze

classifications would be erroneously included as hazardous in rail transportation statistics.[11]

Table 3 contains a breakdown of selected characteristics of the hazardous materials rail waybill sample by two-digit (regular) STCC. As can be seen in the table, the waybill sample contains data for sixteen two-digit STCC. Of these, as might be expected, STCC 28 (Chemicals and Allied Products) and STCC 29 (Petroleum or Coal Products) are, respectively, the first and second most important. These two STCC, with a total of 302 different 7-digit STCC, have the majority of the sampled waybills, sample tonnage, sample carloads, unique 6-digit origin SPLC[12], and unique 6-digit termination SPLC. The least important two-digit STCC would appear to be STCC 14 (Nonmetallic Minerals, Exc. Fuels), followed by STCC 35 (Machinery, Exc. Electrical), and then by STCC 33 (Primary Metal Products, Including Galvanized, Exc. Coating or Other Allied Processing) and STCC 37 (Transportation Equipment).

In total, as shown in Table 3, the 1983 hazardous materials rail waybill sample--"Hazway"--contains 11,091 records (waybills), 1,436,117 short tons, 19,448 carloads, 345 different 7-digit STCC, 761 unique 6-digit origin SPLC, and 1,870 unique 6-digit termination SPLC.

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[11]There is at least one additional caveat regarding the traffic contained in "Hazway." In accordance with Title 49 of the Code of Federal Regulations (49 CFR Part 171), rail carriers are required to use STCC-49 when an interstate shipment contains a hazardous commodity. While Title 49 does not regulate reporting of intrastate shipments of hazardous materials, it does regulate shipments of hazardous substances and wastes (that is, hazardous materials on the CERCLA, or "Superfund", list). Consequently, the Waybill permits an accurate estimate of interstate hazardous commodity rail flows but underreports intrastate flows by an unknown factor.

[12]Standard Point Location Codes (SPLC). These are published in Rail Stations by Standard Point Location Codes, (Washington DC: Transportation Codes Section, Economics and Finance Department, Association of American Railroads).

TABLE 3. SELECTED CHARACTERISTICS OF THE HAZARDOUS MATERIALS RAIL WAYBILL SAMPLE BY TWO-DIGIT STCC

2-Digit STCC	No. of Records (Waybills)	Sample Tonnage	Sample Carloads	Number of Different 7-Digit STCC	Number of Different 6-digit Origin SPLC	Number of Different 6-digit Termination SPLC
13	132	58,235	700	2	14	13
14	1	14	1	1	1	1
19	40	3,792	69	6	16	9
20	70	5,193	87	10	27	42
26	47	2,192	47	2	26	10
28	8,008	1,002,920	11,788	271	541	1,533
29	1,884	339,061	5,258	31	227	529
33	3	61	3	2	2	2
35	2	24	2	1	2	2
36	33	1,313	62	3	14	21
37	3	92	3	2	2	2
39	17	487	28	3	15	12
40	34	2,428	34	8	21	22
44	155	3,497	231	1	21	37
45	51	840	54	1	10	20
46	611	15,968	1,081	1	45	76
Total for Sample	11,091	1,436,117	19,448	345	761	1,870

Source: TSC hazardous materials waybill database.

3. CHARACTERISTICS OF HAZARDOUS MATERIALS RAIL TRANSPORT

3.1 INTRODUCTION

The following discussion examines some of the salient shipping characteristics of the various hazardous materials moving in the U.S. by rail. The discussion moves from a general description of national flows of aggregated hazardous materials to an analysis of specific commodity group between origins and destinations defined at the two-digit SPLC level.[13] The shipping characteristics used to distinguish between commodity groups include distance, shipment size, whether the shipment is interchanged between rail carriers, as well as state or regional differences in origin and destination.

3.2 NATIONAL PATTERN OF HAZARDOUS MATERIALS SHIPMENTS

A number of characteristics of the national pattern of hazardous materials shipments by rail are of interest. Included among these are the total amounts of hazardous materials moving by rail, the hazardous commodities being shipped, the length of haul observed, and the types of cars used in the transport of the hazardous materials.

3.2.1 Estimates of Total Tonnage, Carloads, and Ton-Miles

Based on the 1983 hazardous materials rail waybill sample, an estimated 51,082,075 short tons of hazardous materials were moved by rail in the U.S. in 1983. This hazardous materials tonnage moved in an estimated 691,023 carloads, a total of 34,351,955,646 ton-miles. On average, each carload contained approximately 74 tons. The average length of haul per ton for hazardous materials moved by rail in 1983 was 672 miles.

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[13]The greater the number of digits in the SPLC code the greater precision in defining a location, e.g., 38 represents northern Illinois while 380000 represents Chicago.

The tonnage and carload estimates were derived by multiplying the sample tons and sample carloads for each record in the hazardous materials rail waybill database by the expansion factor for the record[14]. The expanded numbers for cars and tons represent annual estimates of movements based on the data reported in the waybill. The ton-mileage estimates included in the table were derived from the sample tonnage, the expansion factor, and the trip mileage for each waybill in the sample, all multiplied together. Because of the use of the expansion factor in the derivation of the estimates of tonnages, carloads, or ton-mileages, the estimates of these are sometimes referred to in this report as expanded tons, expanded carloads, and expanded ton-miles.

Total 1983 shipments of hazardous materials by rail, as stated above, were estimated to be in excess of 51 million tons and 34 billion ton-miles. The previously cited work for the U.S. Office of Technology Assessment, which was performed by G. List and M. Abkowitz of Renssellaer Polytechnic Institute and which, like the present report, used the 1983 Rail Waybill Sample, estimated the total tonnage of hazardous material shipped by rail to be approximately 73 million in 1983 and the total ton-mileage of hazardous material shipped by rail to be about 53 billion in 1983.[15] Due to an apparent misunderstanding of the intent and utilization of STCC Section 49 Series Codes and the assignment of hazardous status to numerous observations of non-hazardous shipments, the rail flows reported by List and Abkowitz appear to be significantly overstated. In constructing their rail flows database for the OTA study, List and Abkowitz first identified all records in the 1983 Rail Waybill Sample with STCC-49 coded commodities and then added to this all records for non-49 coded commodities where the STCC code used had one or more

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[14]The appropriate expansion factor is included with each waybill and depends on the sampling rate. If, for example, the waybill was for a single car, which was to be sampled at the rate of 2.5%, the expansion factor would be 40. That is, the tonnage and carload data on the waybill would be multiplied (expanded) by 40 in order to convert it to an annual number.

[15]OTA, p. 4. See also G. List and M. Abkowitz, "Estimates of Current Hazardous Materials Flow Patterns," Transportation Quarterly, October 1986, pp. 483-502 and especially p. 497.

STCC-49 "equivalents".[16] The addition of all records for non-49 coded commodities for which there was a STCC-49 "equivalent" to the records for STCC-49 coded commodities was incorrect.[17] This mistaken coding assumption resulted in an approximately 43 percent overstatement of the aggregate tonnage of hazardous materials hauled and 56 percent overstatement of the total ton-miles. Clearly, this level of overestimation is not trivial. Any rail risk analyses performed using the OTA aggregates would tend to significantly overstate the true situation.

3.2.2 The Commodities Moving by Rail

Table 4 contains the estimated annual tonnage, carloads, and ton-mileage moving by rail in the U.S. in 1983 by two-, three-, five- and seven-digit STCC. As can be seen in the table, there are four primary 3-digit STCC codes that represent the major portion of all hazardous materials movements in the 1983 database. These are STCC 281 (Industrial Organic Chemicals), 291 (Products of Petroleum Refining), 287 (Agriculture Chemicals), and 289 (Miscellaneous Chemical Products). These four 3-digit STCC are the top four hazardous materials in terms of movements in the database. They represent almost 94 percent of total tonnage in the database. Consequently, they are the focus of the detailed discussion of commodity flows presented later in this report.

It is interesting to note that three of the top four 3-digit STCC are part of the same 2-digit STCC, STCC 28 (Chemical or Allied Products). The fourth, perhaps not surprisingly, is part of STCC 29 (Petroleum or Coal Products). In total, almost 75 percent of the total tonnage and 79 percent of the total ton-mileage were classified under STCC 28 (Chemical or Allied Products). STCC 29 (Petroleum or Coal Products) accounted for nearly 20

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[16]See List and Abkowitz, January 1986, pp. 88-91.

[17]Telephone conversations with K. Eric Wolfe, Manager, Transportation Data Base & Special Studies, and Luray McHargue, Manager, Transportation Codes, both of the Association of American Railroads' Economic and Finance Division, in January 1987.

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
13	Crude petroleum, natural gas or gasoline	911945	10732	353023087
131	Crude petroleum or natural gas	726089	8812	249602660
13111	Crude petroleum	726089	8812	249602660
1311110	Petroleum oil or shale oil, crude	726089	8812	249602660
132	Natural gasoline, exc. liquefied petroleum gases	185856	1920	103420427
13211	Natural gasoline, exc. liquefied petroleum gases	185856	1920	103420427
1321110	Gasoline, natural (casinghead), suitable only for blending, mixing or refining	185856	1920	103420427
14	Nonmetallic minerals, exc. fuels	1416	100	3136360
147	Chemical or fertilizer minerals	1416	100	3136360
14719	Chemical or fertilizer minerals, nec, exc. ground or otherwise treated	1416	100	3136360
1471990	Cyanides, crude, nec, or cyanogen salts, crude, nec	1416	100	3136360
19	Ordinance or accessories	110269	2052	114101300
192	Ammunition, over 30mm (1.18 inch),exc. for small arms	75044	1304	68738897
19291	Artillery ammunition or related parts	72606	1264	63925066
1929110	Ammunition, fixed, cannon, with empty inert-loaded or solid projectile	15320	280	13268001
1929135	Projectiles for cannon, explosive	43958	784	40803297
1929191	Ammunition, fixed, nec, for cannon	13328	200	9853768
19293	Military bombs, mines or related parts	2438	40	4813831
1929310	Bombs, mines or depth charges, explosive, explosive torpedoes, nec, gas, incendiary, smoke or tear producing bombs	2438	40	4813831
196	Small arms ammunition, 30mm or under (1.18 inch or under)	35225	748	45362403
19611	Small arms ammunition, 30mm or under (1.18 inch or under), exc. blasting or detonating caps or safety fuses or fireworks	35225	748	45362403
1961110	Cartridges, small arms, blank or loaded, nec, or small arms ammunition	33075	708	42566328
1961111	Cartridges, small arm, loaded with explosive projectiles, or 20 mm with incendiary projectiles	2150	40	2796075
20	Food or kindred products	341819	4710	392371104
208	Beverages or flavoring extracts	340881	4670	392056499

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
20841	Wine, brandy or brandy spirits or fruit spirits	85925	1100	98501395
2084120	Wines, nec	20925	280	10602320
2084135	Brandy, alcoholic	2762	80	2697922
2084137	Alcohol or spirits, grape, neutral, in bond	48723	600	71658279
2084150	Alcohol or spirits, fruit, except grape, neutral, in bond	13515	140	13542874
20851	Distilled, rectified or blended liquors, exc. brandy, brandy spirits or fruit spirits	253290	3460	291188693
2085120	Alcohol, in bond (free of internal revenue tax), other than denatured alcohol or methanol (methyl or wood alcohol)	171265	2040	225858399
2085125	Spirits, alcoholic, whiskies, rum other than denatured	9140	240	8346487
2085136	Spirits, grain, neutral, in bond	55431	640	35252856
2085190	Liquors or liqueurs, alcoholic, nec	17454	540	21730951
20871	Miscellaneous flavoring extracts, syrups or compounds, exc. chocolate syrups	1666	110	2366411
2087125	Flavoring compound, nec, liquid or paste, flavoring extracts or imitation flavors, nec, dry	1666	110	2366411
209	Miscellaneous food preparations or kindred products	938	40	314605
20942	Marine oil mill by-products, viz. meal, scrap or tankage	938	40	314605
2094231	Fish tankage, nec, dry, not ground, pulverized nor screened	938	40	314605
26	Pulp, paper or allied products	99036	2120	59691334
261	Pulp or pulp mill products	99036	2120	59691334
26112	Pulp mill by-products	99036	2120	59691334
2611220	Pulp mill liquid	78964	1880	51367474
2611233	Waste liquor, consisting of not less than 50 percent by weight of water, resulting from sulphate or soda pulping process	20072	240	8323860
28	Chemicals or allied products	38338109	463546	26585283681

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
281	Industrial inorganic or organic chemicals, exc. pesticides, drugs, medicinal chemicals or medicines, naval stores or wood distillation products or cosmetics, glycerin or soap	32035944	376973	21942692855
28121	Inorganic bleaching compounds, exc. chlorine	18049	696	25697645
2812120	Lime, chlorinated (chloride of lime), dry, (chloride of lime bleach, nec, dry, chloride of lime bleaching powder, nec, dry, or calcium hypochlorite (calcium oxychloride), dry)	18049	696	25697645
28122	Sodium alkalies	5813667	62894	2581880582
2812210	Sodium (soda), caustic (sodium hydroxide) and potassium (potash), caustic, mixed, in solution	8074	250	3796713
2812220	Sodium (soda), caustic (sodium hydroxide)	2560694	28772	991510014
2812225	Caustic sodium (soda) (sodium hydroxide) containing not less than 48 percent water by weight, in solution	3244899	33872	1586573855
28123	Sodium compounds, exc. sodium alkalies	200278	2960	147614580
2812328	Sodium cyanide	9014	300	9014489
2812330	Dibasic sodium phosphate, disodium orthophosphate or phosphate or hydrosodium phosphate, or tribasic sodium phosphate, trisodium ortho-phosphate or phosphate or tertiary sodium phosphate	10000	100	2680000
2812333	Sodium hydrosulfate (sodium hydro-sulfide or sodium sulphydrate)	86471	940	28035988
2812336	Sodium (soda) nitrate (chile saltpeter, caliche or soda niter)	79534	1300	90772143
2812341	Sodium nitrite	11585	200	10506395
2812363	Sodium dichloro-s-triazinetrione (sodium dichloroisocyanurate)	850	40	939930
2812367	Sodium hydroxide and sodium borohydride solution	2824	80	5665635
28124	Potassium alkalies	191848	2320	102622300
2812410	Potassium hydroxide (caustic potassium)	191848	2320	102622300

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
28125	Potassium compounds, exc. potassium alkalies	71035	1060	67761773
2812536	Potassium nitrate (saltpeter), other than crude	58817	860	59888725
2812538	Potassium perchlorate	10000	100	6353000
2812542	Potassium persulfate	2218	100	1520048
28126	Barium, calcium, magnesium or strontium compounds, exc. bleaches	44582	860	57649396
2812629	Calcium carbide	41738	660	52554148
2812690	Calcium or lime salts, nec	2844	200	5095248
28128	Chlorine	3011255	35188	1218190303
2812815	Chlorine gas, liquefied	3011255	35188	1218190303
28133	Carbon dioxide	400312	5156	196286896
2813315	Carbon dioxide-air mixture	13406	160	5759877
2813320	Carbon dioxide gas, liquefied or carbonic acid gas	386906	4996	190527019
28134	Elemental gases	4750	300	5614965
2813410	Air, compressed	750	100	368325
2813445	Helium gas, compressed	4000	200	5246640
28139	Industrial gases, nec, compressed, solid or liquefied, exc. chemical warfare gases, ammonia or ammonia compounds or chlorine or fluorine	1995141	24370	1948007263
2813914	Methyl bromide	14828	300	18454291
2813922	Hydrogen chloride, anhydrous, liquefied	34961	460	31303266
2813934	Dimethylamine, monomethylamine or trimethylamine, anhydrous	57702	1340	51993410
2813944	Ethylene oxide-dichlorodifluoromethane mixture	3098	200	3037961
2813946	Hydrogen sulfide	2594	40	1804905
2813950	Methyl mercaptan gas	6165	140	1440722
2813960	Oxygen gas, compressed	1200	40	778680
2813966	Vinyl chloride (chloroethane or chloroethylene)	1691315	18990	1694337672
2813979	Refrigerants, nec, gas or liquid, nonflammable	13307	180	12230018
2813984	Fluoroethane gases, flammable, viz. difluoroethane or difluoromonochloroethane (chlorodifluoroethane or difluorochloroethane)	2408	40	2614847

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
2813987	Fluoromethane gases, nonflammable viz. dichlorodifluoromethane (difluorodichloromethane), dichloromonofluoromethane (dichlorofluoromethane or fluorodichloromethane), monochlorodifluoromethane (chlorodifluoromethane or difluorochloromethane) or monofluorotrichloromethane (fluorotrichloromethane or trichlorofluoromethane)	134416	1600	92400589
2813988	Fluoroethane and fluoromethane gas, mixtures, nonflammable, viz. dichlorodifluoromethane-dichlorotetrafluoroethane (difluorodichloromethane-tetrafluorodichloroethane) mixture or dichlorodifluoromethane-monofluorotrichloromethane (difluorodichloromethane) fluorotrichloromethane or trichlorofluoromethane) mixture	3455	180	2857643
2813990	Compressed gases, nec, other than poison	27220	780	32574525
2813992	Hydrocarbon gas, nec	2472	80	2178734
28141	Crude products from coal tar, natural gas or petroleum, exc. asphalt, pitches or tar	781400	10172	502333367
2814115	Amylenes (pentenes), viz. alpha-n-amylene (1-pentene or propylethylene), beta-n-amylene (sym-methylethylethylene or 2-pentene) or isoamylene (isopentene)	3310	40	1006240
2814116	Benzene (benzol)	185528	2200	78238737
2814125	Coal tar creosote (creosote or dead oil) or distillate or solution, coal tar and coal tar creosote (creosote or dead oil)	110950	1540	69333523
2814134	Coal tar naphtha and light oil of coal tar crude	3504	40	6783043
2814137	Coal tar oil, crude, nec	18088	200	18570140
2814142	Crude light oil of coal tar	15694	260	7788082
2814145	Heptane	39260	600	35884361
2814158	Refinery cracking stock	27407	340	15436805

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	CARLOADS	TON-MILES
2814167	Toluene (toluol or methylbenzene) (methylbenzol or phenylmethane)	105734	1444	81003564
2814170	Xylene (dimethylbenzene or xylol)	177727	2208	134996865
2814175	Isobutane for further refinery processing	94198	1300	53292007
28151	Cyclic intermediates from benzene, toluene, naphthalene, anthracene, pyridine, carbazole or other cyclic chemical products	1461785	17188	1381354838
2815108	Amyl phenol	1200	40	1198200
2815111	Carbolic acid (phenol)	515335	5760	556006099
2815112	Aniline (aminobenzene, aniline oil or phenylamine)	93591	1128	48500841
2815119	Chlorobenzene (chlorobenzol) or monochlorobenzene (monochlorobenzol)	84999	940	76979606
2815122	Cumene	3338	100	7551988
2815132	Dinitrotoluene (dinitrotoluol), other than dry	75590	800	22042044
2815139	Naphthalene, other than crude (naphthalin or tar camphor, other than crude)	8081	100	3726727
2815141	Maleic acid or maleic anhydride	61180	700	77674900
2815142	Benzyl chloride	3600	100	3636720
2815143	Benzoyl chloride	8521	100	6377969
2815147	Nitrobenzene (nitrobenzol) (oil mirbane)	9154	120	7604841
2815152	Orthodichlorobenzene (orthodichlorobenzol) or orthodichlorobenzene orthodichlorobenzol) emulsified	11578	200	20722598
2815158	Polyethylbenzene or diethylbenzene or ethylbenzene	138515	1500	158396513
2815159	Pyridine	1932	100	1459865
2815165	Butyl phenol	800	40	878160
2815166	Toluene diisocyanate	219969	2840	243507543
2815174	Tetrahydrofuran	13450	140	20941530
2815177	Paraxylene	176676	2100	90142991
2815179	Cyclohexanone	12382	140	20751213
2815186	Para-nitrochlorobenzene	21894	240	13254490
28181	Miscellaneous acyclic organic chemical products, exc. organic dyes	2895212	35222	3030389305
2818101	Acrolein (acraldehyde, acrylic or allyl aldehyde, or propenol)	7000	100	9839900
2818102	Acrylonitrile (vinyl cyanide)	378391	4984	377654073
2818103	Acetaldehyde (acetic aldehyde, aldehyde, ethanal or ethyl aldehyde)	294805	3620	243692186

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
2818105	Acetone, nec, synthetic, viz. acetone (dimethylketone, ketopropane, pyroacetic ether, or 2-propanone)	177813	2300	165518412
2818107	Ethyl acrylate	81828	988	115313459
2818110	Methyl acrylate	17358	200	29426377
2818112	Methyl methacrylate monomer	218804	2760	312042577
2818113	Allyl chloride	20030	220	23781650
2818115	Acrylates, butyl, ethylhexyl, hydroxyethyl, hydroxypropyl or isobutyl	125804	1580	196065646
2818117	Di-n-propylamine	14584	200	5777906
2818118	Butyraldehyde	41455	560	44586715
2818119	Carbon tetrachloride	152500	1600	152664255
2818127	Diethanolamine, monoethanolamine, triethanolamine or ethanolamine still bottom mixtures	20172	240	38811849
2818129	Diisobutyl ketone	6750	100	5708475
2818130	Dimethylamine, monomethylamine, trimethylamine or trimethylamine hydrochloride, aqueous	8375	100	13384925
2818131	Dimethylsulfate	5000	100	3288000
2818136	Ethyl acetate	37195	460	28939839
2818137	Ethyl chloride	98441	1080	123562054
2818140	Ethylene dichloride	17708	200	2931700
2818143	Formaldehyde, dry	34456	500	60159987
2818144	Formaldehyde, liquid	268592	2920	145557677
2818148	Ethylamines, viz. diethylamine, monoethylamine or triethylamine	10676	180	5504556
2818149	Isobutyl aldehyde (isobutyradehyde)	5416	80	7451339
2818150	Methyl butyl ketone, methyl ethyl ketone, methyl isobutyl ketone, methylpropyl ketone, ethyl amyl ketone or mesityl oxide	113051	1590	114536792
2818158	Propyl aldehyde	31256	400	27785282
2818161	Ethylenediamine (1,2-diaminoethane)	1700	40	1066750
2818162	Diethyl ketone	5320	80	4098528
2818164	Glycol ethers	55066	700	59576620
2818169	Hexamethylenediamine (1,6-diaminohexane or 1,6-hexanediamine) solution	399685	4340	488234792
2818175	Trichloroethylene	7840	80	8282960
2818184	Ethylene dibromide (bromoethene, bromoethylene, dibromoethane, ethylene bromide or vinyl bromide)	39338	540	28037989

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
2818190	Chloroform (trichloromethane), nec, other than technical grade	7715	100	3572045
2818192	Diisobutylamine or ethyl-n-butylamine	2092	40	925082
2818195	Isoprene	67330	820	88186982
2818196	Isopropylamines, viz. diisopropyl-amine or monoisopropylamine	8615	100	8615
2818197	Chloroprene (chlorobutadiene)	69068	880	56621946
2818199	Chloroform (trichloromethane), nec, technical grade	43983	440	37791365
28182	Miscellaneous acyclic organic chemical products, exc. organic dyes	1019710	12580	887947937
2818220	Dichloroethyl ether (dichloroether, dichloroethyl oxide, or sym-di-chloroethyl or 2,2-dichloroethyl ethers)	780	40	552786
2818222	Diethylenetriamine	9110	100	3429004
2818226	Dimethylaminoethanol	2954	40	1378041
2818228	Dimethyldichlorosilane	10812	120	5264394
2818235	Ethyl ether, other than anesthesia grade (ether, diethyl or sulfuric ether, or diethyl or ethyl oxide)	13356	240	12680342
2818237	Ethyl hexaldehyde	29032	400	25806235
2818239	Ethylene oxide	432408	5400	400010333
2818265	Propylene oxide	428122	5160	326352954
2818276	Vinylidene chloride, inhibited	80136	880	112291848
2818280	Vinyl methyl ether (methyl vinyl ether or mve)	13000	200	182000
28183	Miscellaneous cyclic chemical products	750585	9036	693953997
2818331	Hexachlorocyclopentadiene	2070	80	1134000
2818340	Pentachlorophenol	1778	80	4650696
2818342	Styrene, liquid	525209	6000	564421429
2818347	Vinyl toluene, inhibited, liquid	4000	40	5498000
2818359	Chlorinated diphenyl	9458	200	6485648
2818362	Isopropyltoluene (isopropyltoluol, methylpropylbenzene, paracymene or paracymol)	5327	100	844830
2818368	Furfural (furfural, artificial ant oil, pyromucic aldehyde or furfuraldehyde)	9826	120	7955212
2818370	Cyclohexane	185067	2276	90780862
2818385	Morpholine	7850	140	12183320
28184	Alcohols	2498320	30384	1903977681
2818412	Alcohol distillates, synthetic	1450	40	1236560

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
2818416	Butyl alcohols, viz. n-butyl alcohol (butyric alcohol or 1-butanol), sec-butyl alcohol (methylethylcarbinol or 2-butanol) or tert-butyl alcohol (trimethylcarbinol or 2-methyl-2-propanol)	145631	1920	156358190
2818419	Denatured alcohol or denatured ethyl or grain alcohol, liquid	236799	3440	127745416
2818422	Furfuryl alcohol (furyl carbinol)	9581	100	3467527
2818424	Hexyl alcohol, other than perfumery grade (amyl carbinol or 1-hexanol)	23447	300	45707442
2818425	Isobutyl alcohol (isobutanol, isopropylcarbinol or 2-methylpropanol-1)	50626	660	46520978
2818426	Methanol (methyl or wood alcohol), liquid	932930	10220	695554803
2818427	Octyl alcohol (2-ethylhexanol, or 2-ethylhexyl alcohol), isoctyl alcohol, primary normal octyl alcohol (alcohol c-8, capryl alcohol, caprylic alcohol, heptyl carbinol, octoic alcohol, octylic alcohol or 1-octanol) or sec-normal octyl alcohol (inactive secondary capryl alcohol, methylhexylcarbinol or 2-octanol), other than perfumery grade	144708	1940	149287046
2818428	Octyl alcohol (2-ethylhexanol, or 2-ethylhexyl alcohol), isoctyl alcohol, primary normal octyl alcohol (alcohol c-8, capryl alcohol, caprylic alcohol, heptyl carbinol, octoic alcohol, octylic alcohol or 1-octanol) or sec-normal octyl alcohol (inactive secondary capryl alcohol, methylhexylcarbinol or 2-octanol), perfumery grade	3192	40	2356654
2818429	Propyl alcohol (n-propyl alcohol or 1-propanol) or isopropyl alcohol (dimethylcarbinol, ipa, isopropanol, sec-propyl alcohol or 2-propanol)	202587	2600	148058154
2818430	Tetrahydrofurfuryl alcohol (tetrahydrofuryl carbinol)	838	40	932107

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
2818438	Isopropanol and methanol mixture (methyl alcohol or wood alcohol mixed with dimethylcarbinol, ipa, isopropyl alcohol, sec-propyl alcohol or 2-propanol)	13190	180	11285684
2818443	Methyl isobutyl carbinol	2602	40	2323066
2818445	Ethyl alcohol (cologne spirits, ethanol, ethyl hydroxide, fermentation alcohol, grain alcohol or spirits of wine)	34305	480	54128577
2818446	Ethyl alcohol, anhydrous denatured in part with petroleum products and/or chemicals, petroleum products and/or chemicals not to exceed five percent	458717	5584	304381623
2818458	Methanol, contaminated, having value only for refining	162504	1880	43735680
2818490	Alcohols, nec, other than alcoholic liquors	75213	920	110898174
28186	Organic acids or salts, exc. acid dyes or fatty acids	1585179	18000	1856439187
2818610	Acetic acid, glacial or liquid	263558	3240	295758449
2818616	Formic acid	41616	400	53566087
2818619	Trichloro-s-triazinetrione (trichloro-isocyanuric acid)	7500	400	10565400
2818632	Methyl acetoacetate	8924	160	6743359
2818634	Acid, propionic (methylacetic or propanoic)	11348	120	17482970
2818644	Acetic anhydride (acetic or acetyl oxide)	175102	1640	207551932
2818652	Butyl acetate	49657	580	30218235
2818658	Isopropyl acetate	2950	40	1955850
2818662	Adipic acid (hexanedioic acid) (1,4-butanedicarboxylic acid)	568249	6100	713906269
2818664	Propyl acetate	25352	320	38454437
2818668	Vinyl acetate	307100	3380	367053969
2818675	Isobutyric acid	632	40	419016
2818690	Acid, nec, dry, organic	1586	80	3243741
2818691	Acid, nec, liquid, organic	43950	740	48133272
2818692	Acrylic acid	77655	760	61386201

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
28189	Industrial organic chemicals, nec, exc. grain alcohol for beverage purposed, paints or allied products, plastic materials, synthetic fibres, resins, rubber, or nonvulcanizable elastomers, or specialty cleaning, polishing, or sanitation preparations	244635	3395	213277192
2818915	Acetone cyanohydrin	2922	80	3185988
2818930	Mercaptans, petroleum	5280	80	5364216
2818947	Methyl chloride	103390	1220	133453566
2818961	Carbon bisulphide	122719	1740	59792759
2818967	Plasticizers, paint, lacquer, varnish, gum, plastic, resin or adhesive	10324	275	11480663
28191	Ammonia or ammonium compounds, exc. anhydrous ammonia	346770	4700	225487704
2819110	Ammoniacal liquor, nec	12135	140	6084241
2819111	Aqua ammonia, nec	19524	480	7954568
2819131	Ammonium nitrate	258477	3080	136538396
2819137	Ammonium nitrate, sodium nitrate mixture	1498	140	2736881
2819140	Ammonium perchlorate	13444	240	7160274
2819164	Ammonium sulfide solution	21262	240	50972962
2819170	Ammonium thiocyanate liquor (ammonium sulphocyanate liquor)	14698	300	9863818
2819173	Ammonium thiosulphate solution	5732	80	4176564
28192	Nitric acid	54606	680	31060332
2819210	Nitrating acid (mixed nitric and sulfuric)	28622	360	17438052
2819215	Nitric acid	25984	320	13622280
28193	Sulfuric acid	4102466	42240	1668191235
2819315	Sulfuric acid or oil of vitriol	3817034	38960	1534702808
2819325	Sulphur trioxide, stabilized	2446	40	465229
2819330	Acid, sulfuric, spent	282986	3240	133023198
28194	Industrial inorganic acids, exc. nitric or sulfuric	1761577	20280	1566445721
2819411	Phosphoric anhydride	886	40	655640
2819414	Arsenic acid, other than fused	3164	40	2507154
2819415	Phosphorus chloride or trichloride	34952	420	32975981
2819416	Phosphorus oxychloride or phosphoryl chloride	2640	100	2663760
2819422	Chlorosulfonic acid	18635	360	27537004
2819423	Phosphorus pentasulfide	21132	300	16848141
2819426	Chromic acid	24676	360	53377667

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
2819434	Hydrocyanic acid	40684	1100	21636448
2819438	Hydrofluoric acid	217142	2700	221255223
2819446	Hydrofluorosilicic acid	118736	1220	136232719
2819450	Muriatic (hydrochloric) acid	849729	9120	528478312
2819454	Phosphoric acid	72680	1000	58986069
2819462	Phosphorus, nec	348376	3340	456008401
2819491	Acids, inorganic, nec, liquid	8145	180	7283202
28195	Cobalt, copper, iron, nickel or zinc compounds	181658	2000	85083405
2819523	Iron chloride, crude, liquid, not less than 50 percent water	158464	1680	67625493
2819542	Zinc chloride, liquid	9642	160	10764579
2819568	Ferrous sulphate (sulfate) (copperas, green copperas or vitriol, iron sulphate (sulfate), iron vitriol or sal chalybis), containing not less than 40 percent water	13552	160	6693333
28196	Aluminum compounds	39582	520	21528630
2819628	Aluminum chloride, dry	1888	100	3975939
2819655	Aluminum sulphate (sulphate of alumina), or paper makers alum, liquid	37694	420	17552691
28197	Radio-active or nuclear chemicals	20756	600	11349277
2819710	Fuel elements, nuclear reactor, irradiated and requiring protective shielding, or irradiated parts or constituents	970	40	760674
2819711	Radioactive materials, articles or isotopes, nec	5174	160	2956779
2819720	Uranium fluorides, oxides, salts or uranates, not irradiated nor requiring protective shielding	14612	400	7631824
28198	Anhydrous ammonia	2149335	28276	1131914109
2819815	Ammonia, anhydrous	2149335	28276	1131914109
28199	Industrial inorganic chemicals, nec, exc., mining, milling or otherwise preparing natural boron, sodium or potassium compounds or household bleaches	391451	5896	380633235
2819901	Metallic sodium	37589	740	34918646
2819903	Potassium permanganate	520	40	166192
2819917	Arsenic, white (arsenic trioxide)	2208	40	1967328
2819919	Bromine	5848	320	4619473
2819924	Sodium chlorate	96279	980	66345369

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
2819931	Hydrogen peroxide (hydrogen dioxide)	89319	1220	130264978
2819934	Lead peroxide, ground, dry	4060	100	2956086
2819939	Lead sulphate, refined	1765	100	1617040
2819957	Silicon chloride	24063	360	34480847
2819960	Strontium nitrate	4040	200	9151812
2819962	Sulphur chloride	8790	100	3918582
2819990	Sodium salts, nec	9060	100	5496702
2819997	Sulphur dioxide (sulphurous acid anhydride)	107910	1596	84730180
282	Plastic materials or synthetic fibres, resins or rubber, exc. glass, plastic or rubber products or knitting, spinning, throwing or weaving fibres	26343	700	22942354
28211	Plastic materials or synthetic resins or nonvulcanizable elastomers, exc. fabricated plastic products	24754	600	20048740
2821143	Plastics, resins or gums, nec, other than liquids	24754	600	20048740
28213	Synthetic fibers, exc. glass	1589	100	2893614
2821345	Rayon or synthetic fibre, nec	1589	100	2893614
284	Soap or other detergents, cleaning preparations, cosmetics, perfumes or other toilet preparations	78436	2190	77655618
28419	Soap or other detergents, exc. shampoos or shaving products, specialty cleaners or synthetic organic detergents	47766	1490	33347577
2841920	Compounds, cleaning, scouring or washing, nec, liquid	47766	1490	33347577
28422	Specialty cleaning, polishing or sanitation preparations, or household bleaches, exc. pesticidal preparations	28132	500	41212583
2842240	Cleaning compounds, iron or steel, dry	4598	200	10185472
2842245	Cleaning compounds, iron or steel, nec, liquid	4980	80	2980804
2842255	Lye, concentrated, nec	18554	220	28046307
28423	Waxes or polishing preparations or related products	488	40	1670278
2842319	Dressing or blacking, automobile top, curriers, harness, shoe, including shoe whitener (cleaner), stove (stove polish) or leather, other than belt	488	40	1670278

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
28441	Cosmetics, perfumes or other toilet preparations, exc. essential oils or synthetic flavoring or perfume materials	2050	160	1425180
2844190	Toilet preparations, nec, or depilatory, nec	2050	160	1425180
285	Paints, enamels, lacquers, shellacs or varnishes, or allied products, exc. bone, carbon or lamp blacks, caulking compounds or printers ink, inorganic or organic color pigments or plastic materials	158658	4510	214877203
28511	Paints, enamels, lacquers, shellacs or or varnishes	17898	900	29072275
2851118	Tire lacquer, paint or shellac, rubber	5807	380	5742300
2851126	Asphaltum or coal tar paint or varnish	2735	140	4166209
2851172	Enameling compounds, glass and clay, consisting of ground or powdered glass and clay and water	754	40	824876
2851176	Aluminum paint	8602	340	18338890
28512	Paint oils, solvents or thinners, paint drying ingredients or related products	119724	2420	159557087
2851210	Epichlorohydrin or glycerol-dichloro-hydrin	48041	700	64304688
2851215	Paint oils, nec	8289	480	9954174
2851220	Solvents, adhesive, gum, lacquer, paint, plastic, resin or varnish	37961	520	46867585
2851221	Compounds, paint, lacquer, varnish, adhesive, or rust preventive pipe line coating increasing, reducing, removing or thinning, nec	16565	580	19895246
2851230	Paint or varnish driers, nec	8600	100	17988620
2851270	Paint oil compounds	268	40	546774
28519	Paints, enamels, lacquers, shellacs or or varnishes or allied products, nec, including mixed shipments, exc. bone, carbon or lamp blacks, caulking compounds, inorganic color pigments, organic color pigments, plastic materials, or printers ink	21036	1190	26247841
2851930	Paints, stains or varnishes, nec, bronzing liquids, lacquers or shellacs, liquid or paste	21036	1190	26247841

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
286	Gum or wood chemicals	81806	1340	74839023
28612	Gum or wood chemicals, exc. synthetic dyes or synthetic organic chemicals or tanning materials	81806	1340	74839023
2861231	Pine oil	12581	260	6473899
2861241	Rosin liquor (rosin and not more than 40 percent alcohol or mineral spirits)	1280	40	1882240
2861250	Rosin solution	63897	960	64398230
2861268	Turpentine, spirits of (oil of turpentine, or turps)	4048	80	2084654
287	Agricultural chemicals	4497379	49742	2806729384
2871244	Ammonium nitrate fertilizer	1874777	20880	843687700
28713	Ammoniating fertilizer solution or nitrogen fertilizer solution	52957	800	37288818
2871315	Nitrogen fertilizer solution or fertilizer ammoniating solution, consisting of water and agricultural nitrogen salts, ammoniated or not ammoniated, total free ammonia content not to exceed 50 percent by weight	37401	540	34587104
2871316	Fertilizer manufacturing solution, blend of anhydrous ammonia and agricultural nitrogen salts and water	15556	260	2701714
28714	Miscellaneous fertilizer compounds	2444849	25322	1791620654
2871430	Fertilizing compounds (manufactured fertilizers), nec, dry, or plant food, dry	27456	300	13539652
2871433	Fertilizer solution, consisting of water, free ammonia and sulphur, total ammonia content not to exceed 30 percent by weight	10013	100	8743916
2871440	Nitrate of soda-potash	21451	280	31473934
2871450	Phosphatic fertilizer solution, containing not more than 77 percent of phosphoric anhydride by weight	2385929	24642	1737863152

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
28799	Agricultural chemicals, nec, fungicides, herbicides or plant hormones, household or industrial pesticidal preparations, or agricultural disinfectants, insecticides or pesticides, exc. pest control chemicals not formulated or agricultural lime products	124796	2740	134132212
2879931	Insecticides, insect repellents, animal repellents or vermin exterminators, nec, other than agricultural insecticides	21134	280	21247596
2879934	Insecticides, agricultural, nec, liquid	19649	680	23747966
2879936	Insecticides, agricultural, nec, other than liquid	19031	720	31974427
2879951	Insecticides, nitrotrichloromethane (chloropicrin, nitrochloroform or trichloronitromethane insecticides), or mixtures of nitrotrichloromethane (chloropicrin , nitrochloroform or trichloronitromethane) and methyl chloride (chloromethane)	2702	80	3688255
2879958	Tree or weed killing compounds, nec	51509	840	32699072
2879960	Methyl parathion or parathion	906	40	368833
2879964	Nematocide, liquid, viz. dichloropropene-dichloropropane mixture	9865	100	20406063
289	Miscellaneous chemical products	1459543	28091	1445547244
28911	Adhesives, cements, glues, sizes, caulking compounds or sealants, exc. asbestos cement	26627	840	22067877
2891114	Cement, bonding, embedding or sealing, nec, consisting of sulphur with sand, coke breeze or other inert material	1092	80	831230
2891116	Cement, carpet, linoleum, wallboard, acoustical tile or pad or facing tile or linoleum paste	2094	100	1575585
2891124	Adhesives, nec, adhesive cements, nec, adhesive glues, nec, or adhesive pastes, nec, or rubber cement	686	40	230084
2891134	Glue catalyst, nec	3838	40	4409094
2891190	Cement, nec, liquid	18917	580	15021884
28921	Explosives, exc. ammunition, fireworks or pyrotechnics	31174	768	26724235

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
2892113	Explosive igniters, nec, class b or c	796	40	771881
2892125	High explosives, nec, or dynamite, guncotton or tetryl	11694	248	8720109
2892151	Propellant explosives, class b or c, viz. smokeless powder for cannon or small arms, or solid fuel for missiles, rockets or other devices	14354	280	7985391
2892164	Nitrocellulose (colloided, non fibrous, granular or flaked, wet with alcohol or solvent, or not less than 20 percent of water	2030	100	1860678
2892167	Nitrocellulose (collodion cotton, fibrous), wet	2300	100	7386176
28931	Printing ink	1416	100	1452120
2893125	Ink, printing, nec, or brush or stencil marking ink	1416	100	1452120
28993	Fireworks or pyrotechnics	23467	968	42839338
2899320	Fireworks or pyrotechnics, nec	23467	968	42839338
28995	Water treating compounds	11963	300	19911675
2899550	Compounds, water treating, industrial, liquid, containing fungicides, bateriacides, corrosion inhibitors, or dispersants	11963	300	19911675
28998	Miscellaneous chemical compounds, exc. sealants	65366	1660	46525881
2899807	Compounds, waterproofing, cement, concrete or masonry, liquid or paste	600	40	1524960
2899826	Compounds, water system rust or scale preventing, dry, other than boiler cleansing, preserving, scale preventing or removing compounds	802	40	751955
2899871	Compounds, resin, not commercially suitable for extruding or molding purposes, in flake, liquid, lump, powder, or solid mass form, resin content not exceeding 50 percent by weight	54616	1320	36889527
2899877	Carbon, gum or sludge removing compounds, nec, designed to remove, loosen, soften or retard the formation of carbon, gum or sludge in internal combustion engines	520	40	562120

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
2899885	Additives, fuel oil, gasoline, or lubricating oil, containing less than 50 percent by weight of petroleum	6318	80	1087547
2899887	Engine starting compounds or fluids, diesel or internal combustion engine	2510	140	5709772
28999	Chemical products, nec, exc. sealants	1299530	23455	1286026118
2899936	Ink materials, nec, viz. plasticizers, solvents, varnishes, driers, extenders, color bases, or reducing, thickening or thinning compounds	2000	100	4773000
2899951	Sodium chlorate and sodium chloride, in water solution, consisting of not exceeding 50 percent by weight sodium chlorate and sodium chloride	8750	100	3483375
2899986	Hexane	102705	1560	87526692
2899990	Acids, chemicals and other articles, in mixed loads	66977	1980	83678429
2899991	Chemicals, nec	1116215	19575	1100171229
2899993	Electrolyte acid, containing not to exceed 47 percent sulfuric acid	2883	140	6393393
29	Petroleum or coal products	10166167	146220	5366549765
291	Products of petroleum refining	9965038	142660	5219670138
29111	Gasoline or jet or high volatile petroleum fuels, exc. natural gas or gasoline	948641	16296	331709020
2911130	Jet fuel	424229	8704	241137381
2911135	Gasolines, blended, consisting of motor fuels containing 50 percent or more of gasolines	192961	2964	33600694
2911190	Gasoline, nec	331451	4628	56970945
29112	Kerosene, exc. jet fuels	126417	3284	5717810
2911225	Refined oil, burning or illuminating (kerosene or coal oil)	126417	3284	5717810
29113	Distillate fuel oil	1570527	22464	254735712
2911315	Petroleum distillate fuel oil, diesel oil or gas oil, not suitable for illuminating purposes	1570527	22464	254735712
29114	Petroleum lubricating or similar oils, compounds or derivatives	2096	80	1510976
2911415	Petroleum lubricating oil	2096	80	1510976

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983
BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
29116	Asphalt pitches or tars, from petroleum, coal tar, coke oven or natural gas	135249	1780	84999670
2911634	Tar or pitch, coal or petroleum	57151	700	42722243
2911670	Asphalt, petroleum, liquid, and tall oil pitch, mixed	53098	800	27916827
2911692	Tar, nec, or paving tar	25000	280	14360600
29117	Petroleum residual fuel oils or other low volatile petroleum fuels	809118	9972	313295281
2911715	Petroleum residual fuel oil or diesel oil	563521	6452	134534333
2911735	Petroleum, partially refined for further processing	6118	80	10471568
2911740	Petroleum oil residuum	24468	320	18847942
2911791	Oil, petroleum, nec	215011	3120	149441438
29119	Petroleum refining products, nec, exc. liquefied petroleum gases or petroleum coke	1901592	26098	1305522442
2911931	Waste, petroleum by-product, consisting of impure butane, butylenes or butadienes for further refining	489349	6618	231028912
2911950	Petroleum road oil or carbon black oil	3780	40	2383668
2911976	Petroleum condensate	14642	360	15884454
2911982	Petroleum naphtha, naphtha distillate or naphtha solvents	764332	10540	706383211
2911985	Butadiene from petroleum	623898	8140	347551667
2911987	Mixed loads of petroleum oil or products	5591	400	2290530
29121	Liquefied gases, coal or petroleum	4471398	62686	2922179227
2912110	Butane gas, liquefied	289282	3900	137917826
2912111	Propane gas, liquefied	743995	10540	429345299
2912112	Isobutane gas, liquefied	369141	4980	219166208
2912120	Ethylene, cryogenic liquid	5442	80	2133808
2912122	Butene (butylene) gas, liquefied, or isobutene (isobutylene), liquefied	315135	4500	167349882
2912125	Petroleum isopentane or pentane	39829	580	36818447
2912131	Pintsch gas	10297	140	6665413
2912190	Liquefied petroleum gas, nec, compressed	2698277	37966	1922782344
295	Paving or roofing materials	20412	200	10375753
29522	Asphalt or tar cements or coatings or roofing cements or pitches, exc. linoleum or tile cement	20412	200	10375753
2952220	Asphalt pavement surface sealer, asphalt, coal tar or petroleum base	20412	200	10375753
299	Miscellaneous coal or petroleum products	180717	3360	136503874

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
29912	Lubricants or similar compounds, exc. petroleum refinery	176387	3260	126737992
2991240	Motor fuel, nec, liquid (blends of alcohol and petroleum or tar products)	708	40	1597956
2991245	Motor fuel anti-knock compounds, nec	175679	3220	125140036
29919	Coal or petroleum products, nec, exc. dyes, dye (cyclic) intermediates or petroleum refinery	4330	100	9765882
2991926	Coal spraying oil, petroleum	4330	100	9765882
33	Primary metal products, including galvanized, exc. coating or other allied processing	3739	180	9104255
339	Miscellaneous primary metal products, exc. coating or other allied processing	3739	180	9104255
33991	Metal powder, flakes or paste	3739	180	9104255
3399119	Aluminum or aluminum alloy powder, nec	1614	80	5297955
3399183	Aluminum or bronze powders or flitters	2125	100	3806300
35	Machinery, exc. electrical	1570	140	1222572
359	Miscellaneous machinery or parts, exc. electrical	1570	140	1222572
35999	Machinery or parts, nec, exc. electrical or carburetors, pistons, rings or valves	1570	140	1222572
3599937	Shock absorbers, nec, machine	1570	140	1222572
36	Electrical machinery, equipment or supplies	76495	2450	89593267
369	Miscellaneous electrical machinery, equipment or supplies	76495	2450	89593267
36911	Storage batteries or plates	6752	200	14568140
3691110	Storage batteries, electric, assembled, nec	6752	200	14568140
36921	Primary batteries (dry or wet)	69743	2250	75025127
3692112	Batteries, electric, nec	67651	2150	70745941
3692115	Battery sets for wet batteries, consisting of battery oil, battery zincs, carbon electrodes or copper oxide, caustic potash, without liquids or caustic soda, and insulators	2092	100	4279186
37	Transportation equipment	6590	240	15764240
372	Aircraft or parts	4916	200	13018210
37222	Missile or space vehicle engines or parts	4916	200	13018210

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
3722211	Rocket or missile-propelling units (rocket motors), or jet thrust (jato) units, other than jet type engines, class b explosives	4916	200	13018210
376	Guided missile or space vehicle parts, nec, or auxiliary equipment	1674	40	2746030
37691	Guided missile or space vehicle parts, nec, or auxiliary equipment	1674	40	2746030
3769125	Rocket heads, explosive, or war heads	1674	40	2746030
39	Miscellaneous products of manufacturing	22938	1240	44588308
399	Miscellaneous manufactured products	22938	1240	44588308
39961	Matches	4914	300	7820760
3996110	Matches	4914	300	7820760
39991	Chemical fire extinguishing equipment or parts	4617	380	8692757
3999115	Fire extinguishers, chemical, hand or stationary, metal, other than wheeled	4617	380	8692757
39995	Tobacco pipes, cigarette holders, accessories or parts	13407	560	28074791
3999515	Lighters, cigar, cigarette or pipe, nec	13407	560	28074791
40	Waste or scrap materials not identified by producing industry	169668	2320	118314054
402	Waste or scrap, exc. ashes	169668	2320	118314054
40251	Chemical or petroleum waste, including spent	169668	2320	118314054
4025132	Sodium solution waste	19740	200	8440264
4025133	Waste materials, radioactive, having no reclamation value, requiring protective shielding, or requiring radioactive-materials labeling, marking or placarding	2388	120	3799786
4025160	Petroleum refinery sulfide waste	21170	220	24649683
4025163	Muriatic acid, spent	5936	80	2082724
4025177	Aromatic concentrates, by-product obtained in production of ethylene, suitable only for further processing	39948	500	26909023
4025180	Sulphide waste, chemical plant	12248	180	10158976
4025187	Caustic soda solution, spent (an unrefined waste obtained in refining petroleum oil)	15845	240	10816856
4025190	Chemical plant waste, nec	52393	780	31456742
44	Freight forwarder traffic	169349	10433	273798457
441	Freight forwarder traffic	169349	10433	273798457

TABLE 4. ESTIMATED HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983 BY TWO-, THREE-, FIVE-, AND SEVEN-DIGIT STCC (CONT.)

STCC	DESCRIPTION	EXPANDED TONS	EXPANDED CARLOADS	EXPANDED TON-MILES
44111	Freight forwarder traffic	169349	10433	273798457
4411110	Freight forwarder traffic	169349	10433	273798457
45	Shipper association or similar traffic	75561	4688	78986316
451	Shipper association or similar traffic	75561	4688	78986316
45111	Shipper association or similar traffic	75561	4688	78986316
4511110	Shipper association or similar traffic	75561	4688	78986316
46	Miscellaneous mixed shipments	587404	39852	846427546
461	Miscellaneous mixed shipments, exc. forwarder or shipper association	587404	39852	846427546
46111	All freight rate shipments, nec, or trailer-on-flat-car (tofc) shipments, exc. where identified by commodities, then code by commodity	587404	39852	846427546
4611110	All freight rate shipments, nec, or trailer-on-flat-car shipments, commercial (except where identified by commodities, then code by commodity)	587404	39852	846427546

percent of the total tonnage and 15 percent of the ton-miles. The remaining 5 percent of the tonnage and 6 percent of the ton-mileage is attributable to the 14 other 2-digit STCC in the hazardous materials database.

Tables 5, 6, and 7 rank the top twenty-five 7-digit STCC by tons, carloads, and ton-miles, respectively. As can be seen, there is some variation of relative positions of hazardous commodities among the tables. For example, while sulfuric acid is first in tonnage, it is second in carloads, and does not even appear on the list for ton-mileage. As the level of STCC aggregation is increased, the variation decreases. At the 3-digit level of STCC aggregation, the top four hazardous commodities are the same for both tons and ton-miles, as can be seen in Table 8.

A comparison of Tables 5 and 7 illustrates some of the difficulties in using ton-miles as a factor in assessing the risks of transporting hazardous materials. While there are differences in the average shipment distances between commodity groups, the use of ton-miles as a factor in assessing risks of hazardous materials shipments requires some interpretation. For example, ton-miles may be a good measure of aggregate risk for an entire system, but it is a difficult concept to apply when assessing the risk to a specific community (i.e., a single fixed point), since the added distance dimension has little meaning when assessing the exposure risk of a particular point. Ton-miles is more a measurement of the carrying capacity of the system or the total amount of work performed by a carrier. Volume of tons, on the other hand, does allow a specific point to evaluate its exposure to something going wrong.

There are situations, however, where tons may also be inadequate in measuring risk. In the case of lightly loaded shipments, cars may be a more accurate measure than tons. For example, while the number of tons of a commodity passing a point may be one-half that of other commodities, the number of cars may be the same. It can be argued that the probability of an incident is also the same, i.e., it is the car, or the interface of the car with its environment, which causes incidents and not the lading. The amount

TABLE 5. TOP TWENTY-FIVE SEVEN-DIGIT STCC MOVING BY RAIL RANKED BY TONNAGE

Rank	STCC	Description	Tonnage
1.	2819315	Sulfuric acid or oil of vitriol	3,817,034
2.	2812225	Caustic sodium (soda) (sodium hydroxide) containing not less than 48 percent water by weight, in solution	3,244,899
3.	2812815	Chlorine gas, liquefied	3,011,255
4.	2912190	Liquefied petroleum gas, nec, compressed	2,698,277
5.	2812220	Sodium (soda), caustic (sodium hydroxide)	2,560,694
6.	2871450	Phosphatic fertilizer solution, containing not more than 77 percent of phosphoric anhydride by weight	2,385,929
7.	2819815	Ammonia, anhydrous	2,149,335
8.	2871244	Ammonium nitrate fertilizer	1,874,777
9.	2813966	Vinyl chloride (chloroethane or chloroethylene)	1,691,315
10.	2911315	Petroleum distillate fuel oil, diesel oil or gas oil, not suitable for illuminating purposes	1,570,527
11.	2899991	Chemicals, nec	1,116,215
12.	2818426	Methanol (methyl or wood alcohol), liquid	932,930
13.	2819450	Muriatic (hydrochloric) acid	849,729
14.	2911982	Petroleum naphtha, naphtha distillate or naphtha solvents	764,332
15.	2912111	Propane gas, liquefied	743,995
16.	1311110	Petroleum oil or shale oil, crude	726,089
17.	2911985	Butadiene from petroleum	623,898
18.	4611110	All freight rate shipments, nec, or trailer-on-flat-car shipments, commercial (except where identified by commodities, then code by commodity)	587,404
19.	2818662	Adipic acid (hexanedioic acid) (1,4-butanedicarboxylic acid)	568,249
20.	2911715	Petroleum residual fuel oil or diesel oil	563,521
21.	2818342	Styrene, liquid	525,209
22.	2815111	Carbolic acid (phenol)	515,335
23.	2911931	Waste, petroleum by-product, consisting of impure butane, butylenes or butadienes for further refining	489,349
24.	2818446	Ethyl alcohol, anhydrous denatured in part with petroleum products and/or chemicals, petroleum products and/or chemicals not to exceed five percent	458,717
25.	2818239	Ethylene oxide	432,408

TABLE 6. TOP TWENTY-FIVE SEVEN-DIGIT STCC MOVING BY RAIL RANKED BY CARLOADS

Rank	STCC	Description	Carloads
1.	4611110	All freight rate shipments, nec, or trailer-on-flat-car shipments, commercial (except where identified by commodities, then code by commodity)	39,852
2.	2819315	Sulfuric acid or oil of vitriol	38,960
3.	2912190	Liquefied petroleum gas, nec, compressed	37,966
4.	2812815	Chlorine gas, liquefied	35,188
5.	2812225	Caustic sodium (soda) (sodium hydroxide) containing not less than 48 percent water by weight, in solution	33,872
6.	2812220	Sodium (soda), caustic (sodium hydroxide)	28,772
7.	2819815	Ammonia, anhydrous	28,276
8.	2871450	Phosphatic fertilizer solution, containing not more than 77 percent of phosphoric anhydride by weight	24,642
9.	2911315	Petroleum distillate fuel oil, diesel oil or gas oil, not suitable for illuminating purposes	22,464
10.	2871244	Ammonium nitrate fertilizer	20,880
11.	2899991	Chemicals, nec	19,575
12.	2813966	Vinyl chloride (chloroethane or chloroethylene)	18,990
13.	2911982	Petroleum naphtha, naphtha distillate or naphtha solvents	10,540
14.	2912111	Propane gas, liquefied	10,540
15.	4411110	Freight forwarder traffic	10,433
16.	2818426	Methanol (methyl or wood alcohol), liquid	10,220
17.	2819450	Muriatic (hydrochloric) acid	9,120
18.	1311110	Petroleum oil or shale oil, crude	8,812
19.	2911130	Jet fuel	8,704
20.	2911985	Butadiene from petroleum	8,140
21.	2911931	Waste, petroleum by-product, consisting of impure butane, butylenes or butadienes for further refining	6,618
22.	2911715	Petroleum residual fuel oil or diesel oil	6,452
23.	2818662	Adipic acid (hexanedioic acid) (1,4-butanedicarboxylic acid)	6,100
24.	2818342	Styrene, liquid	6,000
25.	2815111	Carbolic acid (phenol)	5,760

TABLE 7. TOP TWENTY-FIVE SEVEN-DIGIT STCC MOVING BY RAIL RANKED BY TON-MILES

Rank	STCC	Description	Ton-Miles
1.	2912190	Liquefied petroleum gas, nec, compressed	1,922,782,344
2.	2871450	Phosphatic fertilizer solution, containing not more than 77 percent of phosphoric anhydride by weight	1,737,863,152
3.	2813966	Vinyl chloride (chloroethane or chloroethylene)	1,694,337,672
4.	2812225	Caustic sodium (soda) (sodium hydroxide) containing not less than 48 percent water by weight, in solution	1,586,573,855
5.	2812815	Chlorine gas, liquefied	1,218,190,303
6.	2819815	Ammonia, anhydrous	1,131,914,109
7.	2899991	Chemicals, nec	1,100,171,229
8.	2812220	Sodium (soda), caustic (sodium hydroxide)	991,510,014
9.	2871244	Ammonium nitrate fertilizer	843,687,700
10.	2818662	Adipic acid (hexanedioic acid) (1,4-butanedicarboxylic acid)	713,906,269
11.	2911982	Petroleum naphtha, naphtha distillate or naphtha solvents	706,383,211
12.	2818426	Methanol (methyl or wood alcohol), liquid	695,554,803
13.	2818342	Styrene, liquid	564,421,429
14.	2815111	Carbolic acid (phenol)	556,006,099
15.	2819450	Muriatic (hydrochloric) acid	528,478,312
16.	2818169	Hexamethylenediamine (1,6-diaminohexane or 1,6-hexanediamine) solution	488,234,792
17.	2819462	Phosphorus, nec	456,008,401
18.	2912111	Propane gas, liquefied	429,345,299
19.	2818239	Ethylene oxide	400,010,333
20.	2818102	Acrylonitrile (vinyl cyanide)	377,654,073
21.	2818668	Vinyl acetate	367,053,969
22.	2911985	Butadiene from petroleum	347,551,667
23.	2818265	Propylene oxide	326,352,954
24.	2818112	Methyl methacrylate monomer	312,042,577
25.	2818446	Ethyl alcohol, anhydrous denatured in part with petroleum products and/or chemicals, petroleum products and/or chemicals not to exceed five percent	304,381,623

TABLE 8.

TOP FOUR THREE-DIGIT STCC TRANSPORTED BY RAIL IN 1983
RANKED BY TOTAL TONS AND TON-MILES

3-Digit STCC	Commodity	Tons (000)	Percent	Ton-Miles (000,000)	Percent
281	Ind. Inorganic Chemicals	32,036	63	21,943	64
291	Prod. of Petrol. Refining	9,965	20	5,220	15
287	Agricultural Chemicals	4,497	9	2,807	8
289	Misc. Chemical Products	1,460	3	1,446	4

Source: TSC Hazmat Waybill File "Hazway"

of lading may be at least a partial measure of the potential severity of an incident but it will not generally be a measure of the probability of one.

Hybrid measures, such as loaded car-miles, may also be useful in measuring aggregate system risk.

3.2.3 Length of Haul

Table 9 shows total carloads and tons of hazardous materials rail shipments by length of haul. To highlight trends for shipments hauled as little as one and as many as 3,500 miles, shipment lengths in the table are expressed by six incremental mileage ranges. As measured by both carloads and tons, shipment lengths are distributed fairly regularly along a bell-shaped curve. The bulk of the carloads are moved between 500 and 1,000 miles (27.9%), while the largest percentage of tons are moved between 200 and 500 miles (28.2%). Approximately half of the carloads and tons are shipped less than 500 miles.

Individual distributions for STCC 28 (Chemical and Allied Products) and STCC 29 (Petroleum or Coal Products) and all other 2-digit STCC combined tend to conform to the distribution for all commodities combined. The only exception is that the predominance of STCC 29 tonnage (30%) is hauled between 50 and 200 miles. This appears to be primarily due to numerous, relatively short-haul gasoline shipments.

3.2.4 Car Types in Use in Hazardous Materials Movements

As shown in Table 10, tank cars are by far the predominant type of car used for the rail transportation of hazardous materials. In 1983, shipments of hazardous materials in tank cars accounted for approximately 90 percent of the tonnage, 81 percent of the carloads, and 86 percent of the ton-miles for all car types. The primary types of tank car when measured by tonnage, carloads, or ton-miles are steel pressured cars (DOT container specifications 105A300, 105A300W, 109A300W, and 120A300W), steel pressured insulated cars (105, 105A500, 105A500W, and 120A500W), and steel pressured non

TABLE 9. LENGTH OF HAUL OF RAIL HAZARDOUS MATERIALS SHIPMENTS

Length of Shipment (Miles)	Expanded	
	Carloads (Percent of Total in Parenthesis)	Tons (Percent of Total in Parenthesis)
0 to 50	32,874 (4.8)	2,392,085 (4.8)
50.1 to 200	108,380 (15.7)	8,767,874 (17.2)
200.1 to 500	179,268 (25.9)	14,396,354 (28.2)
500.1 to 1000	192,894 (27.9)	13,867,681 (27.1)
1000.1 to 1500	85,376 (12.4)	6,081,159 (11.9)
1500.1 and greater	92,231 (13.3)	5,576,922 (10.9)

TABLE 10.

CAR TYPES USED FOR HAZARDOUS MATERIALS RAIL TRANSPORT IN 1983

Car Type	Tons	Carloads	Ton-Miles
Equipped Boxcars	282,508	4,832	277,563,871
Unequipped Boxcars	195,033	4,804	160,034,131
Covered Hopper Cars	16,420	180	12,992,426
Flat Cars	1,287,046	75,653	1,831,124,707
Gondolas	6,634	400	10,863,419
Equipped Hopper Cars	8,814	90	3,763,685
Special Cars			
Special Boxcars	10,336	160	4,303,463
Special Hopper Cars	2,929,924	31,216	1,953,988,032
Special Flat Cars	24,796	540	35,904,008
Total Special	2,965,056	31,916	1,994,196,503
T/COFC Cars*	168,967	9,970	259,345,907
Refrigerator Cars	162,184	2,796	136,500,927
Tank Cars	45,853,875	558,402	29,564,469,650
Rack Cars	2,000	100	1,977,200
Unspecified/Unknown	133,538	1,880	99,123,220
Total	51,082,075	691,023	34,351,955,646

*Includes items specified as "Containers" and "Trailers".

insulated cars (112A340W). It should be noted, however, that identification of these specific tank car types is based on just over half of all tank car observations in "Hazway." Due to contractor error during preparation of the 1983 Rail Waybill Sample for the ICC, approximately 45 percent of the waybills reporting a shipment by tank car lack the codes needed to assign the specific tank car type.

Representing much smaller proportions of the rail car types used in 1983, flatcars and special hopper cars are the only other car types of any significance in the transportation of hazardous materials. Special hopper cars accounted for roughly 6 percent of the tons and ton-miles and 5 percent of the carloads. Flatcars, however, represented a substantial 11 percent of the carloads but only 3 percent of the tons and 5 percent of the ton-miles. Flat cars are typically utilized for freight forwarder or shipper association traffic in addition to miscellaneous mixed shipments.

Railcar ownership data suggests a trend towards either leasing by the railroad or supply by the hazardous materials manufacturer. Less than 7 percent of the cars sampled in "Hazway" were owned by the rail carrier. Even fewer tank cars (less than one percent) were railroad-owned. The high cost of maintaining cars is a primary reason for this trend towards private ownership.

3.2.5 Intrastate and Interstate Movement of Hazardous Materials

Table 11 contains information on the aggregate tonnage and carloads of hazardous materials that moved by rail in 1983 that (1) did not leave the state of origin, (2) moved from the state of origin to an adjacent state, or (3) moved from the state of origin to a non-adjacent state. As can be seen in the table, slightly more than half (52 percent) of the tonnage and slightly less than half of the carloads moved did not leave the state of origin or moved from the state of origin to an adjacent state. This traffic could be considered to be internally generated. Traffic from the state of origin to an adjacent state was a little greater, in terms of both tonnage and carloads moved, than traffic whose destination was the origin state. Slightly less than half (48 percent) of the tonnage and slightly more than half (52 percent)

TABLE 11. INTRASTATE AND INTERSTATE MOVEMENTS OF HAZMAT BY RAIL IN 1983

Type of Movement	Expanded (Percent of Total in Parenthesis)	
	Tons	Carloads
To Origin State	12,585,662 (24.6)	158,278 (22.9)
To Adjacent State	13,806,446 (27.0)	171,748 (24.9)
To Non-Adjacent State*	24,689,967 (48.3)	360,997 (52.2)
Total	51,082,075	691,023

*Represents pass-through traffic to states other than the origin and destination states.

of the carloads moving went to a nonadjacent state. This represents the total aggregate level of hazardous materials pass-through (i.e., externally generated) traffic that the various states in the U.S. experienced in 1983.

3.3 NON-INTERCHANGE VERSUS INTERCHANGE TRAFFIC

A useful means of classifying the data is in terms of the number of times the shipment is interchanged between railroads. Such interchanged traffic allows a more precise routing description by including the junction points at which the transfers take place in addition to origin and destination of the shipment. This information is useful to determine the total volume moving through a city as opposed to the volume that is merely originating or terminating there. Interchanging, it should be noted, may also include an extra dimension of risk since the shipment is handled at least one additional time. For example, an interchange generally means the freight car moves from one carrier's classification yard to another. It will involve additional switching through either a flat (level) or a "hump" yard.[18] Such additional handling obviously increases the risk of damage to the car and/or its lading.

Of the 11,091 hazardous materials shipments (waybills) in "Hazway," 6,086 (i.e., 55 percent) were interchanged. The total breakdown of sampled shipments by the number of junctions used in moving the shipment is contained in Table 12.

All four top 3-digit hazardous materials commodity groups are similar to the "Hazway" average of interchange traffic. Fifty-nine percent of the sampled shipments for both STCC 281 (Industrial Inorganic Chemicals) and STCC 287 (Agricultural Chemicals) were interchanged at least once. Likewise, STCC 291 (Products of Petroleum Refining) and STCC 289 (Miscellaneous Chemical Products) conform to the overall average, with 56 percent and 57 percent of

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[18]These are rail yards where a string of freight cars are driven up an incline and then allowed to coast down the other side through a preset maze of classification tracks. In level yards, cars are pushed or pulled by switch engines and propelled down tracks by a technique known as "kicking," i.e., the car is allowed to coast after the engine comes to a stop.

TABLE 12.

FREQUENCY DISTRIBUTION OF THE NUMBER OF INTERCHANGED HAZARDOUS MATERIALS SHIPMENTS

Number of Junctions	Sampled Shipments (Waybills)	Percent
0	5005	45
1	4781	43
2	1135	10
3	162	1
4	6	-
5	2	-

Source: TSC Hazmat File "Hazway"

their respective sampled shipments being interchanged at least once. For the four commodity groups, five points handled 60 percent of all interchanged shipments. These were Chicago, East St. Louis, Memphis, New Orleans, and Shreveport. Approximately 20 percent of the hazardous materials shipments that were interchanged were interchanged through New Orleans. The other cities each handled approximately 10 percent of such shipments. The interchange pattern noted above is driven by commodity group STCC 281 (Industrial Inorganic Chemicals), since it is the largest of the commodity groups. There are some differences with respect to other commodity groups, and these are discussed later in this report. The point of this observation on the interchanging of hazardous materials shipments is that effective monitoring and enforcement activity could focus on a small number of interchange points.

3.4 ORIGIN AND DESTINATION DATA

The following discussion moves from broad regional analysis to a more specific state-to-state discussion of flows. More detailed analysis is possible using 4- or 6-digit SPLC codes, but such precision generates an enormous amount of data and makes interpretation difficult, and, as a result, has not been undertaken here.

3.4.1 Regional Sources and Terminations

Table 13 lists the percentage of total expanded tons originated and terminated by Census Region.[19] Over 39 percent of all hazardous material rail flows originated in the West South Central region. This region is the origin for more than twice the volume of any other region.[20] Regarding the termination of shipments, the South Atlantic and West South Central regions are the primary termination regions. Twenty-three percent of all shipments terminated in the South Atlantic region, while 21 percent terminated in the West South Central region.

3.4.2 State or Subregional Flows

The database, "Hazway", contains 761 unique origins. Of these, the top 115 (listed in Table 14) were the source of 69 percent of all shipments in the database. Appendix A contains a series of maps which graphically depict destination states for all hazardous material shipments from the top nine originating states, i.e., Texas, Louisiana, Illinois, Alabama, Tennessee, North Carolina, West Virginia, Mississippi, and Florida. These states were

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[19]The U.S. Census Regions are defined as follows:

New England --Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut;
Middle Atlantic --New York, New Jersey, and Pennsylvania;
East North Central--Ohio, Indiana, Illinois, Michigan, and Wisconsin;
West North Central--Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas; (Continued on Page 51)
(Continued from Page 49)
South Atlantic --Delaware, Maryland, the District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, and Florida;
East South Central--Kentucky, Tennessee, Alabama, and Mississippi;
West South Central--Arkansas, Louisiana, Oklahoma, and Texas;
Mountain --Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, and Nevada; and
Pacific --Washington, Oregon, California, Alaska, and Hawaii.

[20]Of the four states in the region--Texas, Oklahoma, Louisiana, and Arkansas--Arkansas, as might be expected, accounted for the least number of shipments. Of the sampled shipments, from this region, Arkansas accounted for around one percent.

TABLE 13.

PERCENT OF ORIGIN AND DESTINATION RAIL FLOWS

Census Region	Percent of Tons Originated	Percent of Tons Terminated
New England	2	4
Middle Atlantic	6	9
East North Central	10	13
West North Central	5	6
South Atlantic	15	23
East South Central	12	13
West South Central	39	21
Mountain	6	5
Pacific	5	8

Source: TSC Hazmat Waybill File "Hazway"

TABLE 14. TOP 115 ORIGIN SPLCS

SPLC	Station Name	State	Sampled Shipments	Expanded Tons	Expanded Carloads
380000	Chicago	IL	272	299,847	15,072
645172	Geismar	LA	268	1,324,670	14,800
684800	Houston	TX	219	1,287,254	15,990
479473	McIntosh	AL	200	968,127	10,348
686297	Freeport	TX	193	1,119,921	13,120
658671	West Lake	LA	192	1,095,267	12,804
665450	Longview	TX	184	704,177	8,960
645340	Plaquemine	LA	170	847,120	9,320
427770	Copperhill	TN	170	648,256	6,860
298810	Calvert	KY	160	650,118	7,760
117165	Searsport	ME	151	638,117	10,212
883000	Los Angeles	CA	137	155,045	10,446
645343	Allemania	LA	136	752,906	8,208
272997	Natrium	WV	133	555,464	6,432
684790	Bayport	TX	130	674,117	8,500
185180	Niagara Falls	NY	120	711,729	7,808
277618	South Charleston	WV	120	425,991	5,164
846200	Tacoma	WA	98	410,708	4,780
646123	Norco	LA	92	474,267	6,200
684150	Orange	TX	91	443,864	4,780
686152	Texas City	TX	90	491,741	6,180
646143	Taft	LA	90	588,122	6,828
457210	Augusta	GA	89	296,576	3,560
427910	Charleston	TN	89	385,205	4,240
688278	Bloomington	TX	87	418,780	4,440
403896	Lee Creek	NC	84	477,020	4,828
488680	Pascagoula	MS	78	380,470	4,840
346740	Lima	OH	77	267,744	3,940
488223	Dragon	MS	75	272,042	3,720
221268	Reybold	DE	75	408,554	4,680
644772	North Baton Rouge	LA	74	339,843	4,640
684777	Strang	TX	74	404,742	4,640
647000	New Orleans	LA	73	285,157	4,524
405320	Beaufort	NC	72	370,442	7,604
684745	Channelview	TX	72	415,522	4,980
391350	Tuscola	IL	72	278,239	3,600
684415	Dowling	TX	69	256,080	3,540
644800	Baton Rouge	LA	68	375,475	4,452
473344	Evans City	AL	66	256,260	3,048
485730	Yazoo City	MS	62	273,638	3,140
465590	Brunswick	GA	60	219,630	2,460
173360	Albany	NY	59	627,917	7,930
461457	Savannah LS	GA	58	201,063	2,600
456200	Atlanta	GA	58	45,000	2,500
671685	Borger	TX	58	333,408	4,360
567500	St. Louis	MO	57	127,326	4,308

TABLE 14. TOP 115 ORIGIN SPLCS (CONT.)

SPLC	Station Name	State	Sampled Shipments	Expanded Tons	Expanded Carloads
686225	Chocolate Bay	TX	57	304,946	3,840
492172	Occidental	FL	56	778,982	8,184
479947	Lemoyne	AL	56	216,532	2,536
684775	Pasadena	TX	56	303,330	3,800
836311	Don	ID	56	265,696	2,600
409160	Wilmington	NC	54	190,692	2,340
281435	Catlettsburg	KY	53	152,499	2,356
646528	Avondale	LA	53	250,530	3,380
380646	Englewood TVT	IL	52	65,859	5,200
494887	Pace	FL	51	175,153	2,400
396640	East St. Louis	IL	51	241,456	2,640
381364	Lemont	IL	49	199,870	2,680
381230	Chicago Interm EX	IL	48	25,518	1,920
396246	Roxana	IL	46	137,284	1,900
461413	Port Wentworth	GA	46	157,306	1,840
787196	Separ	NM	45	441,054	4,380
671867	Kings Mill	TX	45	267,286	2,460
534450	Clinton	IA	45	232,218	2,908
645547	Uncle Sam	LA	45	262,915	2,580
849652	Columbia Junction	WA	45	193,438	2,100
421350	Kingsport	TN	43	182,155	2,620
392200	Decatur	IL	43	210,325	2,528
380415	Wood Street, Chicago	IL	42	29,320	2,040
617740	El Dorado	AR	42	291,705	3,180
497777	Sutton	FL	42	158,658	1,680
447850	Charleston	SC	42	138,510	2,000
286550	Louisville	KY	41	150,521	2,120
684569	Bishop	TX	41	276,755	3,080
384842	Seneca	IL	41	164,380	1,820
652322	Sterlington	LA	41	195,180	2,456
581520	Kansas City	KS	40	40,341	2,765
686732	South Bay City	TX	39	228,146	2,820
684771	Baytown	TX	39	266,925	3,660
584130	Lawrence	KS	38	222,818	2,480
277592	Belle	WV	36	166,779	2,220
439900	Memphis	TN	36	76,404	1,975
688875	Gregory	TX	36	229,135	2,640
557463	Hoag	NE	36	143,029	1,680

TABLE 14. TOP 115 ORIGIN SPLCS (CONT.)

SPLC	Station Name	State	Sampled Shipments	Expanded Tons	Expanded Carloads
686293	Sweeny	TX	36	140,034	2,100
343100	Toledo	OH	35	146,243	1,760
494945	Gonzalez	FL	35	148,118	1,760
588250	El Dorado	KS	34	168,587	2,020
489493	North Lumberton	MS	33	106,490	1,320
853470	Portland	OR	33	48,930	1,680
645364	St. Gabriel	LA	32	119,304	1,400
846777	Hoquiam	WA	32	122,834	1,280
645191	Donaldsonville	LA	32	168,893	2,044
657846	West Erath	LA	31	96,131	1,300
439844	Woodstock	TN	31	104,036	1,660
588440	Wichita	KS	31	292,178	3,110
762928	Garfield	UT	30	228,373	2,360
645523	Gramercy	LA	30	172,703	1,864
182367	Solvay	NY	30	239,023	2,640
478968	Flomaton	AL	29	86,324	1,220
457250	Nixon	GA	29	107,774	1,220
744300	Denver	CO	29	201,241	2,240
257663	Bellwood	VA	28	88,430	1,120
647011	Michoud	LA	28	86,032	1,084
632440	Woodward	OK	28	171,270	2,128
534960	Muscatine	IA	28	150,419	1,780
497800	Tampa	FL	28	90,894	1,120
564119	South River	MO	27	113,613	1,260
357998	Haverhill	OH	27	114,453	1,380
696900	El Paso	TX	27	230,440	2,520
648115	Chalmette	LA	26	85,251	1,024
513942	Tioga	ND	26	81,069	1,080
264448	Thaxton	VA	26	41,590	1,040
491200	Jacksonville	FL	26	72,121	1,380
784181	Zuni	NM	26	373,891	4,470

the source of approximately 62 percent of the expanded tons of hazardous materials shipped by rail. With the exception of shipments originating in Texas, hazardous materials shipments from the nine states demonstrate a distinct intrastate or intra-regional nature. Texas shipments, of course, serve both the immediate region and the national market (i.e., reach both east and west coasts with heavy volumes of products).

A more detailed way of analyzing the data is to consolidate the most often cited origins in the database by 2-digit SPLC code. This results in some of the states being divided into subregions. A partial list of these origins is contained in Table 15, which is organized in descending order of the number of sampled shipments (waybills) originated. The number of counties included in the two-digit SPLC code is also included in Table 15.

Note that there is a significant amount of concentration in a small number of origins. Specifically, the top 20 origins (73 counties) in Table 15 were the source of almost 60 percent of all hazardous materials shipments. Looking at counties provides a clue as to how dispersed the origins may be within the 2-digit code. In many cases there are only one or two counties involved, and the general level of coding does not lose any detail. In the case of Southeast Texas, which includes 10 counties, as well as of eastern Louisiana and northern Illinois, this may not be true.

A similar listing of destination points for all sampled rail hazardous materials shipments is contained in Table 16. These data are substantially more dispersed than the origin data. In this case, the first 20 most popular terminations (covering 160 counties) were the destinations of approximately 49 percent of all shipments in the database. Note, however, that 13 of the top 20 termini are also among the top 20 origins. This suggests either a significant amount of intrastate traffic and/or a balance of inbound and outbound movements.

TABLE 15.

MOST OFTEN CITED ORIGINS FOR HAZARDOUS MATERIALS
BASED ON NUMBER OF SAMPLED SHIPMENTS (WAYBILLS)
IN 1983 WAYBILL DATA

2-Digit SPLC Code	Region Name	No. of Shipments Sampled	No. of Counties in Sample
68	Southeast Texas	1329	10
64	Eastern Louisiana	1217	9
38	Northern Illinois	504	6
47	Alabama	351	4
42	Eastern Tennessee	302	3
27	West Virginia	289	3
65	Western Louisiana	264	3
48	Mississippi	248	4
49	Florida	238	6
39	Southern Illinois	212	4
40	Eastern North Carolina	210	3
66	Northeast Texas	184	1
45	North Georgia	176	2
84	Washington	175	3
46	South Georgia	164	2
29	Southern Kentucky	160	1
43	Western Tennessee	156	2
18	Western New York	150	2
58	Eastern Kansas	143	4
88	Southern California	137	1
34	Northern Ohio	112	2
67	Northwest Texas	103	2
28	Northern Kentucky	94	2
56	Northern Missouri	84	2
22	Delaware	75	1
53	Iowa	73	2
78	New Mexico	71	2
11	Maine	62	1
17	Eastern New York	59	1
83	Idaho	56	1
61	Arkansas	42	1
44	South Carolina	42	1
55	Nebraska	36	1
85	Oregon	33	1
76	Utah	30	1

Source: TSC Hazmat File "Hazway"

TABLE 16.

MOST OFTEN CITED TERMINATION POINTS FOR HAZARDOUS MATERIALS BASED ON SAMPLED SHIPMENTS (WAYBILLS) IN 1983 WAYBILL DATA

2-Digit SPLC Code	Region Name	No. of Shipments Sampled	No. of Counties in Sample
49	Florida	532	13
68	Southeast Texas	525	12
38	Northern Illinois	423	10
64	Eastern Louisiana	403	7
42	Eastern Tennessee	399	5
44	South Carolina	307	9
47	Alabama	307	15
45	Northern Georgia	295	6
40	Eastern North Carolina	285	11
84	Washington	259	10
48	Mississippi	209	8
29	Southern Kentucky	182	10
39	Southern Illinois	174	7
34	Northern Ohio	172	8
31	Southern Michigan	171	5
28	Northern Kentucky	167	4
27	West Virginia	159	5
25	Northern Virginia	151	7
19	New Jersey	151	5
88	Southern California	136	3
43	Western Tennessee	133	4
26	Southern Virginia	131	6
35	Southern Ohio	128	7
46	Southern Georgia	116	6
56	Northern Missouri	115	3
85	Oregon	99	2
23	Maryland	96	3
76	Utah	83	1
21	Western Pennsylvania	78	3
41	Western North Carolina	70	4
87	Northern California	69	2
66	Northeast Texas	64	3
74	Eastern Colorado	63	2
69	Southwest Texas	63	3
11	Maine	62	3

Source: TSC Hazmat File "Hazway"

3.4.3 The Railroads Originating Hazardous Materials Movements

Originating traffic is concentrated in 14 Class I railroads[21]. These railroads originated approximately 92 percent of the hazardous materials shipments in 1983.

Examination of data for specific carriers reveals significant differences in the volume and type of hazardous materials which they carry. To a large extent, these differences reflect the geographic orientation of carriers, e.g., western carriers carry a larger share of STCC 289, Miscellaneous Chemical Products, while southern carriers dominate STCC 287, Agricultural Chemicals.

The ability of the Waybill Sample to identify specific carriers can allow the monitoring of individual carrier performance over time. For example, a simple carrier performance index could be developed where the denominator would be a measure of overall hazardous materials transportation delivered, such as ton-miles, and the numerator would be incidents. Such an index would allow comparison of carriers so that good performance, relative to the overall amount of work performed, could be isolated and used as a model for other members of the industry.

The differences in the commodities carried among carriers suggest the possibility of establishing a system of relative expertise for purposes of education and training other carriers and relevant municipalities. Specifically, the Southern may have a good deal of resident expertise on agricultural chemicals that could be transformed into educational and training programs for its connections and communities through which the traffic is flowing. Likewise, other carriers are knowledgeable about the specific hazardous materials they customarily transport.

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[21]There were 32 Class I railroads, 26 Class II railroads, and 412 Class III railroads in 1983. In 1983, Class I railroads were defined by the ICC as those carriers with annual operating revenues equal to or exceeding $83.5 million.

3.5 COMMODITY-SPECIFIC FLOWS

From this point, the analysis of the flows of hazardous materials by rail narrows its focus to specific commodities between more precisely defined origins and destinations. In order to reduce the amount of data that needed to be manipulated, the specific flows analysis undertaken focused on the most often cited 115 origins (69 percent of all sampled shipments), and the 4 primary commodity codes, which accounted for 87 percent of all sampled shipments. The result of combining these two simplifying assumptions was that the specific flow analysis covered approximately 62 percent of all sampled shipments in the database.

3.5.1 STCC 289--Miscellaneous Chemical Products

This STCC is the least significant of the four primary commodities in terms of expanded tonnage and expanded carloads. A breakdown of the shipping characteristics for STCC 289 for all origins and for the 115 most often cited origins in "Hazway" is presented in Table 17. Note that the carloads per sampled shipment for this commodity grouping, overall, is 1.18, and for the 115 most often cited origins is 1.02. Given that these figures are fairly close to 1.00 (i.e., one carload per shipment), this indicates that shippers of this commodity group do not rely much on multiple car shipments (i.e., multiple carloads specified on the same waybill). Those multiple car shipments that are made are not generally interchanged. The percentages of interchanged STCC 289 shipments reported in "Hazway" for all origins and for the 115 major origins are roughly the same, 59 percent and 58 percent respectively.

Using shipments or cars as a measure, no single interchange point dominates this commodity grouping. East St. Louis/St. Louis, handling 20 percent of the interchanged shipments, is the most often cited. Chicago, Cincinnati, Kansas City (both Missouri and Kansas), Memphis, and New Orleans are each used for about 15 percent of the sampled shipments.

TABLE 17.

SHIPPING CHARACTERISTICS OF STCC 289
ALL ORIGINS AND 115 MOST OFTEN CITED ORIGINS

	All Origins	115 Origins	Percent of Total in 115
Sampled Shipments	421	216	51.3
Sample Cars	495	220	44.4
Sample Tons	24,188	12,218	50.5
Expanded Cars	28,091	14,380	51.2
Expanded Tons	1,459,543	821,877	56.3
Cars/Shipment	1.18	1.02	
Tons/Car	48.86	55.54	

Source: TSC Hazmat File "Hazway"

The tons/carload ratio for all sampled shipments of STCC 289 was found to be 48.86, while somewhat heavier loadings, 55.54 tons/carload, were found to come from the top 115 origins. This commodity group represents the lightest loadings of any of the four major groups. The significance of this is that aggregate tons may not be a reasonable measure of risk for shipments in this category and the number of cars should be used for this, either in place of or in addition to tons.

A more specific analysis of the origins of STCC 289 indicates that six regions account for approximately 38 percent of the cars and 43 percent of the tons shipped. These are (1) Southeast Texas (SPLC 68), (2) northern Texas (SPLC 66 and 67), (3) West Virginia (SPLC 27), (4) Louisiana east of the Mississippi River (SPLC 64), (5) Tennessee (SPLC 42 and 43), and (6) northern Illinois (SPLC 38). A detailed set of tables was created for these origins, measuring the sampled shipments, sample carloads, sample tons, expanded carloads and expanded tons to major destinations (see Appendix B). On examining this data, it was noted that northern Illinois originates a disproportionate share of cars relative to tons. Northern Illinois, which includes the Chicago area, originates 19 percent of the cars, but only 5.8 percent of the tons. Chicago is apparently where the light loadings are originating for this commodity group. An examination of the detailed flows data in Appendix B also indicates that there is no significant intrastate traffic from any of the six regions presented.

3.5.2 STCC 287--Agricultural Chemicals

STCC 287 was the second major commodity group analyzed in detail. It presents some interesting contrasts to the previous discussion. Selected shipping characteristics of STCC 287 are presented in Table 18. The carloads per sampled shipment calculated indicate a greater use of multiple cars in this commodity grouping than in STCC 289. The 115 top origins represent an even greater use of multiple cars per shipment. The tons per carload calculation suggests that tons and carloads are possible surrogates for each other in the measurement of exposure to risk.

TABLE 18.

SHIPPING CHARACTERISTICS OF STCC 287
ALL ORIGINS AND 115 MOST OFTEN CITED ORIGINS

	All Origins	115 Origins	Percent of Total in 115
Sampled Shipments	858	579	67.5
Sample Cars	2,914	2,486	85.3
Sample Tons	273,386	234,626	85.8
Expanded Cars	49,742	34,992	70.3
Expanded Tons	4,497,379	3,250,713	72.3
Cars/Shipment	3.4	4.3	
Tons/Car	93.82	94.38	

Source: TSC Hazmat File "Hazway"

This commodity grouping is dominated by shipments originating in Florida. A possible explanation of this is that the large amount of phosphates that move out of the state by water may be travelling from the production site to the port via intrastate rail movement. Approximately 78 percent of both sampled cars and tons originate in Florida (SPLC 49). Of those originated cars and tons, 98 percent move intrastate. Other significant intrastate movements occur in Nebraska, Mississippi, eastern Kansas, and eastern North Carolina. Almost 80 percent of all STCC 287 cars and tons move intrastate. However, only 24 percent of the waybills and approximately 33 percent of both expanded cars and tons represent intrastate shipments.

Florida intrastate transport also dominates the use of multiple cars with an average of 20.5 cars per record (interstate shipments originating in Florida average 1 car per sampled shipment). The only other substantial movements of multiple car shipments originate in eastern North Carolina and are destined for Ohio and northern Indiana and Illinois.

Approximately 84 percent of cars and 46 percent of the shipments of STCC 287 are not interchanged. The array of major interchange points for this commodity grouping is somewhat different from STCC 289. There is clear dominance of Chicago in terms of number of sampled shipments. Chicago handles 18 percent of all STCC 287 interchanged shipments, nearly twice as high as the next most often cited junction, Cincinnati, where 9.5 percent of the sampled shipments were found to be interchanged. The shipments moving through Chicago are predominately single car shipments, as is the case also with shipments moving through East St. Louis, Kansas City, and Memphis. Multiple car shipments, i.e., more than one car moving from an origin to a destination as part of a single shipment, appear to be flowing through a limited number of junction cities rather than being distributed across the country. As examples, New Orleans is used as a junction on 4 percent of interchange shipments but handles 12 percent of the cars, while Richmond accounts for 6 percent of interchange shipments and 17 percent of the cars. This suggests that multiple car shipments are carrier-, and therefore, interchange-specific. This reinforces the suggestion made earlier that monitoring could concentrate on a few strategic interchange points rather than all possible locations.

A detailed set of flow matrices for this commodity group is given in Appendix C. It represents movements to and from a sample of major origins and destinations.

3.5.3 STCC 291--Products of Petroleum Refining

This STCC was the next largest commodity group. Its salient shipping characteristics are presented in Table 19. The use of multiple cars is substantial for all movements of STCC 291 and even greater for movements from the 115 most often cited origins. Tons per carload are relatively low and suggest that the number of cars should be factored into any risk calculation for this commodity.

Approximately 59 percent of all sampled STCC 291 shipments were interchanged. New Orleans is the dominant junction point. East St. Louis handles one-half as many shipments as New Orleans. Shreveport and Chicago trail both New Orleans and East St. Louis in the number of STCC 291 shipments interchanged.

There is a much lower incidence of intrastate traffic in this grouping than in other commodity groups. Viewing the 115 origins, only 33 percent of the shipments were intrastate. These shipments involved 43 percent of expanded carloads and 40 percent of expanded tons, however.

3.5.4 STCC 281--Industrial Inorganic or Organic Chemicals

STCC 281 is the largest of the four most important commodity groups. Selected shipping characteristics are detailed in Table 20. Sample carloads per sampled shipment suggest a modest use of multiple car shipments while sample tons per sample carload suggest that cars or tons may be reasonable surrogates for evaluating risks. The sampling of 115 origins appears to be a good fit to the entire population of STCC 281.

Approximately 60 percent of all sampled STCC 281 shipments were interchanged, but there is nothing that appears to distinguish interchange

TABLE 19.

SHIPPING CHARACTERISTICS OF STCC 291
ALL ORIGINS AND 115 MOST OFTEN CITED ORIGINS

	All Origins	115 Origins	Percent of Total in 115
Sampled Shipments	1,837	1,073	58.4
Sample Cars	5,211	3,650	70.0
Sample Tons	336,648	228,437	67.9
Expanded Cars	142,660	79,318	55.6
Expanded Tons	9,965,038	5,396,555	54.2
Cars/Shipment	2.84	3.40	
Tons/Car	64.60	62.59	

Source: TSC Hazmat File "Hazway"

TABLE 20.

SHIPPING CHARACTERISTICS OF STCC 281
ALL ORIGINS AND 115 MOST OFTEN CITED ORIGINS

	All Origins	115 Origins	Percent of Total in 115
Sampled Shipments	6,588	5,023	76.2
Sample Cars	8,201	6,347	77.4
Sample Tons	698,999	547,700	78.4
Expanded Cars	376,973	281,475	74.7
Expanded Tons	32,035,944	24,229,478	75.6
Cars/Shipment	1.24	1.26	
Tons/Car	85.23	86.29	

Source: TSC Hazmat File "Hazway"

from non-interchange traffic. New Orleans is the dominant junction point. It handles twice as many shipments as the other major junctions, which were found to be Shreveport, Memphis, East St. Louis, and Chicago, in that order.

Only about 19 percent of the shipments in this commodity grouping are intrastate movements. Approximately 23 percent of this total is represented by intrastate movements within the state of Texas; no other state comes close to the magnitude of intrastate shipments of STCC 281 (e.g., 1,829,384 forecasted tons in 1983 versus 308,862 forecasted tons for Alabama, the next closest state). The magnitude of shipments within Texas provides a good indication of why this state demonstrates both a regional and national shipping pattern for hazardous materials.

4. SUMMARY AND CONCLUSIONS

Accurate information on the shipment patterns of hazardous materials in the U.S. is needed by policymakers and analysts to support their evaluation of the risks associated with such shipments. In response to that need, an effort was undertaken by the Department of Transportation's Transportation Systems Center to assess the Rail Waybill Sample's capabilities as an analytical tool in the evaluation of risks posed by the rail transportation of hazardous materials. To provide the basis for that assessment, hazardous materials data from one of the annual Waybill Samples was identified and examined in considerable detail.

4.1 CAPABILITY OF THE RAIL WAYBILL SAMPLE

It was determined that the Rail Waybill Sample is a detailed yet flexible resource which enables the quantification of rail flows in support of rail transportation risk assessments. Specifically, the Sample is capable of providing commodity flow estimates for the movement of hazardous materials. The levels at which these commodity flows can be calculated range from broad industry grouping (e.g., chemicals or allied products) to detailed article description (e.g., methyl chloride). Commodity flows between specific origins and destinations can also be estimated. The Sample allows aggregation of commodity flows at the national, regional, state, county, and city level.

Overall, the Waybill Sample is a valuable analytical tool in the evaluation of risks arising from hazardous materials moved by rail. Because of its detail and flexibility, the volume and flow patterns of hazardous materials can be easily estimated. Moreover, there appears to be sufficient data available in the Sample to construct a reliable index of risk using car and tons broken down either by carrier, geographic region, and/or other variables.

4.2 FINDINGS FOR 1983

The basic source of data used in the analysis was the 1983 Rail Waybill Sample. Although the choice of 1983 data was arbitrary, it permits comparison with earlier work conducted by the Office of Technology Assessment (OTA) on aggregate rail flows of hazardous materials. Moreover, the conclusions documented from 1983 data are applicable to other years as well.

Based on a hazardous materials rail waybill sample developed from the Rail Waybill Sample at TSC, aggregate figures for tonnage, carloads, and ton-miles were estimated for hazardous materials rail traffic in the U.S. in 1983. These were found to be (1) 51 million short tons, (2) 691 thousand carloads, and (3) 34 billion ton-miles, respectively.

The estimated aggregate levels of movement calculated for this study differ significantly from those reported in a recent OTA study which also analyzed 1983 rail shipments of hazardous materials. In the OTA study, it was estimated that 73 million tons of hazardous materials were moved a total of 53 billion ton-miles. The differences between the estimates are the result of an apparent misunderstanding by those who prepared the OTA figures, of the intent and utilization of the hazardous materials commodity coding scheme used in the rail waybills. Given the high level of overestimation, any rail risk analyses performed using OTA aggregates would consequently overstate the true situation.

Four commodity groups were found to compose the majority of all hazardous materials tonnage moved by rail in 1983. These are STCC 281 (Industrial Organic Chemicals), which accounted for 63 percent of all tons moved; STCC 291 (Products of Petroleum Refining), which accounted for 20 percent of the tons; STCC 287 (Agricultural Chemicals), which accounted for 9 percent of the tons; and STCC 289 (Miscellaneous Chemical Products), which accounted for 3 percent of the tons moved. The top 7-digit STCC by tons for each of these four commodity groups is, respectively, (1) STCC 2819315, sulfuric acid or oil of vitriol, accounting for approximately 3.8 million tons shipped; (2) STCC 2912190, liquefied petroleum gas, accounting for almost 2.7

million tons shipped; (3) STCC 2871450, phosphatic fertilizer solution, accounting for 2.4 million tons shipped; and (4) STCC 2899991, chemicals not elsewhere classified, accounting for 1.1 million tons.

Based on flow analyses conducted for the four primary commodities, significant differences in the direction, gateway cities used for interchange, routing characteristics, use of multiple cars, density of loads, and other characteristics were found to exist. It would appear, therefore, to be inaccurate to generalize across all hazardous materials shipments.

It was determined that 14 railroads accounted for 92 percent of the hazardous materials shipments in 1983. An examination of these railroads revealed differences in the volumes and types of hazardous materials carried that prohibit making generalizations about rail carriers of hazardous materials.

It was found that approximately 62 percent of the tonnage of hazardous materials shipped by rail in 1983 was accounted for by just nine states (Texas, Louisiana, Illinois, Alabama, Tennessee, North Carolina, West Virginia, Mississippi, and Florida). In general, it was found that rail shipments of hazardous materials are intrastate or intra-regional in nature. Most traffic appears to be that with destinations within the originating state or region. Texas may be an exception to this in that it also originates much national traffic. Florida, on the other hand, appears to epitomize the local nature of shipments in that the vast majority of its shipments of hazardous materials are intrastate.

Two considerations for the assessment of risk associated with the rail movement of hazardous materials were discussed. First, it was noted that almost 55 percent of the shipments in the hazardous materials rail waybill sample were interchanged between at least two rail carriers. Interchange data is critical to the accurate estimation of the total volume of hazardous materials moving through a particular city as opposed to the volume that is originating or terminating there. Moreover, interchanging may represent an extra dimension of risk since the shipment is handled at least one more time

than it would have had it not been interchanged. It appears that the additional handling required by interchanging may increase the risk of damage to the car and/or its contents.

Second, it was argued that tons shipped may not always be an adequate measure of the risk associated with hazardous materials rail shipments. In the case of lightly loaded shipments, for example, cars may be a more accurate measure of the level of exposure than tons. While the number of tons of a commodity passing a particular point may be one-half that of a similar commodity (similar in terms of the type of hazard of the commodity), the number of cars may be the same. It can then be argued that the probability of an incident is also the same; that is, it is the car, or the interface of the car with its "environment," that usually causes incidents, not the lading. The amount of lading may be a partial measure of the potential severity of an incident, but it will not generally be a measure of the probability of one. Hybrid measures, such as loaded car-miles, may also be useful in measuring aggregate system risk.

APPENDICES

APPENDIX A

MAPS OF SELECTED STATE-TO-STATE FLOWS OF HAZARDOUS MATERIALS

Note: the following maps reflect expanded tons. Although each map legend has a consistent interval between classifications, the size of the interval varies according to the map. For example, the intervals on the legend for the Louisiana map are twice as large as those for the Texas map and so on. The reason for this is that the scale of volume is very different across the states. This is illustrated by the data presented in Table A.1. The states selected were those originating the largest quantities of hazmat. The total expanded tons for each of the mapped states are given in Table A.1.

TABLE A.1

EXPANDED TONS OF HAZARDOUS MATERIALS FOR NINE MOST IMPORTANT ORIGIN STATES

State	Expanded Tons of Hazmat
Texas	10,480,701
Louisiana	8,707,554
Illinois	2,381,180
Alabama	1,847,624
Tennessee	1,788,083
North Carolina	1,157,451
West Virginia	1,579,317
Mississippi	1,332,306
Florida	2,174,203
Total	31,448,419*

*62% of total expanded tons for hazmat.

APPENDIX B

SELECTED FLOWS OF STCC 289, MISC. CHEMICAL PRODUCTS

Appendix B contains flows of STCC 289, Misc. Chemical Products, from the 6 two-digit origin SPLCs that generated the greatest number of sampled shipments. The origin territories are West Virginia, Northern Illinois, Tennessee, eastern Louisiana, and Texas.

TABLE B.1

STCC 289--MISC. CHEMICAL PRODUCTS
FROM OL2=27--WEST VIRGINIA

TO Term SPLCS (2-digit)	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
23	MD	1	1	43	40	1708
25	N.VA	1	1	99	40	3954
27	WVA	1	1	64	100	6420
38	N.IL	1	1	77	40	3094
40	E.NC	2	2	126	80	5046
41	W.NC	2	2	89	80	3576
44	SC	2	2	192	80	7672
45	N.GA	2	2	110	80	4404
49	FL	1	1	77	40	3074
56	N.MO	3	3	231	120	9238
67	NW.TX	1	1	50	100	5010
68	SE.TX	3	3	257	300	25675
Totals		20	20	1415	1100	78871

Source: TSC Hazmat File "Hazway"

TABLE B.2

STCC 289--MISC. CHEMICAL PRODUCTS
FROM OL2=38--NORTHERN ILLINOIS

TO Term SPLCS (2-digit)	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
14	MA	2	2	40	200	4025
29	S.KY	1	1	60	40	2400
45	N.GA	13	13	201	520	7840
49	FL	8	8	115	320	4560
50	MN	4	4	50	400	4978
66	NE.TX	1	1	14	100	1416
84	WA	1	1	13	40	510
85	OR	1	1	15	40	598
87	N.CA	6	8	132	800	13158
88	S.CA	3	3	73	300	7257
Totals		40	42	713	2760	46742

Source: TSC Hazmat File "Hazway"

TABLE B.3

STCC 289--MISC. CHEMICAL PRODUCTS
FROM OL2=42/43--E & W TENNESSEE

TO Term SPLCS (2-digit)	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
19	NJ	2	2	116	200	11648
27	WVA	4	4	125	160	5000
31	S.MI	1	1	20	100	1957
38	N.IL	2	2	170	80	6372
39	S.IL	1	1	37	40	1498
42	E.TN	2	2	45	80	1784
43	W.TN	2	4	262	160	10494
44	SC	1	1	39	40	1544
46	S.GA	1	1	30	40	1188
56	N.MO	1	1	34	40	1354
87	N.CA	1	1	22	100	2189
Totals		18	20	900	1040	45028

Source: TSC Hazmat File "Hazway"

TABLE B.4

STCC 289--MISC. CHEMICAL PRODUCTS FROM OL2=64--EASTERN LOUISIANA

TO Term SPLCS (2-digit)	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
19	NJ	1	1	80	100	8000
21	W.PA	3	3	238	300	23805
38	N.IL	3	3	186	180	13954
42	E.TN	1	1	92	40	3666
47	AL	1	1	38	40	1538
61	S.AR	1	1	88	100	8750
64	E.LA	2	2	171	140	12058
68	SE.TX	3	3	277	300	27750
87	N.CA	5	5	94	500	9401
Totals		20	20	1264	1700	108922

Source: TSC Hazmat File "Hazway"

TABLE B.5

STCC 289--MISC. CHEMICAL PRODUCTS
FROM OL2=66/67--NORTHERN TEXAS

TO Term SPLCS (2-digit)	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
19	NJ	1	1	96	100	9636
29	S.KY	1	1	66	40	2644
34	N.OH	1	1	99	40	3960
38	N.IL	1	1	99	100	9900
39	S.IL	4	4	205	220	14128
42	E.TN	6	6	492	240	19706
45	N.GA	1	1	66	40	2640
47	AL	1	1	100	40	4000
53	E.IA	2	2	179	80	7132
68	SE.TX	3	3	227	300	25647
Totals		21	21	1629	1200	99393

Source: TSC Hazmat File "Hazway"

TABLE B.6

STCC 289--MISC. CHEMICAL PRODUCTS
FROM OL2=68--SOUTHEAST TEXAS

TO Term SPLCS (2-digit)	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
16	CT	1	1	90	100	9000
17	E.NY	2	2	180	200	18000
19	NJ	2	2	157	200	15665
20	E.PA	1	1	89	100	8911
23	MD	1	1	27	40	1070
26	S.VA	1	1	80	40	3200
27	WVA	2	2	129	140	10591
28	N.KY	3	3	193	120	7710
31	S.MI	2	2	189	140	12926
34	N.OH	4	4	147	220	8460
36	N.IN	2	2	188	200	17791
38	N.IL	9	9	716	540	41825
42	E.TN	1	1	44	40	1774
44	SC	2	2	138	80	5484
45	N.GA	1	1	66	40	2636
47	AL	4	4	262	160	10454
49	FL	2	2	136	80	5438
61	S.AR	1	1	88	100	8845
62	E.OK	1	1	86	100	8600
64	E.LA	4	4	324	340	26759
68	SE.TX	13	13	880	1300	87618
85	OR	1	1	40	40	1600
87	N.CA	1	1	86	100	8565
88	S.CA	3	3	236	300	10100
Totals		64	64	4571	4720	333022

Source: TSC Hazmat File "Hazway"

APPENDIX C

SELECTED FLOWS OF STCC 287, AGRICULTURAL CHEMICAL PRODUCTS

Appendix C contains flows of STCC 287, Agricultural Chemical Products from the 11 origin SPLCs which generated the greatest number of shipments. The origin territories are Northern Illinois, eastern North Carolina, northern Georgia, Mississippi, Florida, Nebraska, northern Missouri, eastern Kansas, southern Arkansas, eastern Louisana, and Idaho. In addition to sample cars, sample tons, expanded carloads, and expanded tons, the number of sampled shipments (waybills) is also recorded in the following tables.

TABLE C.1

STCC 287--AGRICULTURAL CHEMICALS
FROM OL2=38--NORTHERN ILLINOIS

TO Term. SPLC	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
21	W.PA	2	2	196	80	7848
27	West VA	6	6	586	240	23422
28	N.KY	13	13	1155	520	46178
29	S.KY	7	7	533	280	21346
30	N.MI	1	1	100	100	9980
34	N.OHIO	1	1	100	100	9995
35	S.OHIO	7	7	656	280	26194
37	S.IN	1	1	100	40	4000
40	E.NC	1	1	62	40	2460
47	AL	1	1	83	40	3312
49	FL	1	1	13	40	534
53	E.IA	1	1	96	100	9645
Totals		42	42	3680	1860	164914

Source: TSC Hazmat File "Hazway"

TABLE C.2

STCC 287--AGRICULTURAL CHEMICALS
FROM OL2=40--EASTERN NORTH CAROLINA

TO Term. SPLC	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
18	W. NY	1	1	99	100	9912
23	MD	3	3	299	120	11952
25	N.VA	2	2	202	80	8040
26	S.VA	4	4	298	160	11906
28	N.KY	3	7	595	140	9988
31	S.MI	1	1	100	40	3992
34	N.OHIO	1	23	2297	92	9187
35	S.OHIO	5	14	1400	280	27879
36	N.IN	11	31	3072	836	82770
37	S.IN	4	4	396	160	15852
38	N.IL	6	44	4318	320	31500
39	S.IL	3	3	298	120	11944
40	E.NC	15	15	1448	600	57886
41	W.NC	3	3	249	120	9948
44	SC	3	3	274	120	10928
46	S.GA	1	1	97	40	3880
49	FL	3	3	295	120	11810
50	MN	1	1	99	40	3962
51	ND	3	3	295	240	23723
53	E.IA	3	3	300	240	24061
54	W.IA	1	1	100	40	4014
55	NE	9	9	888	840	82693
63	W.OK	2	2	194	80	7762
64	E.LA	1	1	102	40	4086
67	NW.TX	2	2	192	140	13301
Totals		91	184	17907	5108	492976

Source: TSC Hazmat File "Hazway"

TABLE C.3

STCC 287--AGRICULTURAL CHEMICALS
FROM OL2=45--NORTHERN GEORGIA

TO Term. SPLC	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
26	S.VA	9	9	724	360	28948
27	West VA	3	3	271	120	10830
28	N.KY	18	18	1635	720	65268
29	S.KY	8	8	704	320	28160
34	N.OHIO	1	1	99	40	3960
40	E.NC	1	1	51	40	2020
41	W.NC	1	1	51	40	2020
42	E.TN	6	6	549	240	21982
44	SC	2	2	168	80	6682
45	N.GA					
46	S.GA	2	2	147	80	5900
47	AL	13	13	1217	320	46634
48	MS					
49	FL	13	13	899	520	35976
Totals		77	77	6515	2880	258380

Source: TSC Hazmat File "Hazway"

TABLE C.4

STCC 287--AGRICULTURAL CHEMICALS
FROM OL2=48--MISSISSIPPI

TO Term. SPLC	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
19	NJ	1	1	51	100	5100
28	N.KY	2	2	160	80	7490
29	S.KY	2	2	198	80	7920
40	E.NC	2	2	190	80	6024
41	W.NC	1	1	61	40	2440
42	E.TN	2	2	112	80	4444
43	W.TN	4	4	322	160	12848
44	SC	2	2	136	80	5424
45	N.GA	3	3	231	120	9240
46	S.GA	5	5	398	200	15896
47	AL	10	10	957	400	38248
48	MS	11	11	961	440	38440
49	FL	4	4	397	160	15868
66	NE.TX	6	6	589	600	56784
68	SE.TX	2	2	161	200	16050
69	SW.TX	1	1	100	100	10000
Totals		58	58	5024	2920	252216

Source: TSC Hazmat File "Hazway"

TABLE C.5

STCC=287--AGRICULTURAL CHEMICALS
FROM OL2=49--FLORIDA

TO Term. SPLC	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
28	N.KY	1	1	77	40	3060
33	S.WI	2	2	194	200	19400
36	N.IN	1	1	97	40	3880
37	S.IN	1	1	51	40	2020
38	N.IL	1	1	99	40	3960
39	S.IL	1	1	97	40	3880
40	E.NC	1	1	98	40	3920
43	W.TN	1	1	98	40	3930
45	N.GA	1	1	98	40	3936
46	S.GA	3	3	240	120	9596
47	AL	6	6	540	240	21576
49	FL	93	1906	181063	9484	900690
53	E.IA	2	2	197	200	19700
56	N.MO	1	1	97	40	3882
67	NW.TX	1	2	44	80	1742
Totals		116	1930	183090	10684	1005172

Source: TSC Hazmat File "Hazway"

TABLE C.6

STCC 287--AGRICULTURAL CHEMICALS
FROM OL2=55--NEBRASKA

TO Term. SPLC	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
50	MN	1	1	100	40	4012
52	SD	1	1	99	40	3972
54	W.IA	2	2	198	140	13851
55	NE	5	5	486	260	25370
59	W. KS	1	1	97	40	3892
74	E.CO	1	1	99	40	3954
Totals		11	11	1079	560	55051

Source: TSC Hazmat File "Hazway"

TABLE C.7

STCC 287--AGRICULTURAL CHEMICALS
FROM OL2=56--NORTHERN MISSOURI

TO Term. SPLC	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
21	W.PA	1	1	96	40	3852
28	N.KY	5	5	470	200	18788
29	S.KY	3	3	291	120	11648
34	N.OHIO	1	1	95	40	3814
35	S.OHIO	2	2	190	80	7618
43	W.TN	1	1	98	40	3906
49	FL	1	1	21	40	820
53	E.IA	2	2	94	200	9378
62	E.OK	1	1	95	100	9525
Totals		17	17	1450	860	69349

Source: TSC Hazmat File "Hazway"

TABLE C.8

STCC 287--AGRICULTURAL CHEMICALS
OL2=58--EASTERN KANSAS

TO Term. SPLC	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
31	S.MI	1	1	99	100	9900
36	N.IN	1	1	99	100	9900
50	MN	1	1	98	100	9751
53	E.IA	1	1	51	100	5050
54	W.IA	1	1	81	40	3234
55	NE	3	3	296	120	11844
57	S.MO	8	8	739	380	35466
58	E.KS	5	5	489	380	37287
59	W. KS	1	1	98	100	9831
60	N.AR	1	1	98	100	9770
62	E.OK	1	1	93	100	9326
66	NE.TX	1	1	97	100	9708
67	NW.TX	1	1	97	100	9714
68	SE.TX	1	1	97	100	9747
74	E.CO	2	2	153	80	6100
Totals		28	29	2685	2000	186628

Source: TSC Hazmat File "Hazway"

TABLE C.9

STCC 287--AGRICULTURAL CHEMICALS
FROM OL2=61--SOUTHERN ARKANSAS

TO Term. SPLC	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
29	S.KY	2	2	199	80	7950
35	S.OHIO	1	1	61	40	2420
36	N.IN	1	1	91	40	3638
43	W.TN	1	1	98	40	3936
47	AL	1	1	98	40	3930
48	MS	1	1	98	40	3934
57	S.MO	7	7	692	640	63295
65	W.LA	2	2	199	200	19980
66	NE.TX	10	10	993	820	81446
68	SE.TX	1	1	98	100	9820
73	W.WY	1	1	99	40	3952
Totals		28	28	2726	2080	204301

Source: TSC Hazmat File "Hazway"

TABLE C.10

STCC 287--AGRICULTURAL CHEMICALS
FROM OL2=64--LOUISIANA, EAST OF MISSISSIPPI RIVER

TO Term. SPLC	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
31	S.MI	1	1	100	40	4016
38	N.IL	3	3	306	180	18253
47	AL	1	1	103	40	4132
53	E.IA	21	21	2158	1260	128616
54	W.IA	3	3	302	300	30178
55	NE	6	6	486	300	25620
56	N.MO	9	9	919	360	36784
61	S.AR	1	1	91	100	9065
68	SE.TX	2	2	202	200	20245
69	SW.TX	1	1	104	100	10383
88	S.CA	1	1	99	100	9865
Totals		49	49	4870	2980	297157

Source: TSC Hazmat File "Hazway"

TABLE C.11

STCC 287--AGRICULTURAL CHEMICALS
FROM OL2=83--IDAHO

TO Term. SPLC	Region	Sample			Expanded	
		Shipments	Cars	Tons	Cars	Tons
50	MN	2	2	198	80	7914
51	ND	1	1	101	40	4048
52	SD	2	2	195	80	7810
55	NE	14	14	1388	560	55552
58	E.KS	1	1	100	100	9965
63	W.OK	1	1	100	40	4016
66	NE.TX	1	1	100	40	3982
70	MT	3	3	298	120	11938
74	E.CO	2	2	198	80	7930
84	WA	10	10	983	400	39254
87	N.CA	2	2	197	200	19661
Totals		39	39	3858	1740	172070

Source: TSC Hazmat File "Hazway"

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