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Truck Transportation of Hazardous Materials
A National Overview

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Final Report
December 1987

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16. Abstract

The primary objective of this effort has been to provide Government regulators and policy-makers with a) an estimate of the aggregate national volume of hazardous chemical and petroleum products transportation in trucks, b) a profile of the truck fleet involved in hazardous materials transport, and c) the geographical distribution of this transport activity.

After defining data sources and methods, hazardous chemical and petroleum products transport is quantified in terms of total tons, ton-miles, and haul distances. Truck transport categories include domestic production from U.S. plants, imports from ports of entry, and distribution from regional storage facilities. Next, the report characterizes the truck fleet involved in hazardous materials transport in terms of truck size, type, and placarded operations. Geographical distribution of truck transport of hazardous materials is then presented graphically, with traffic patterns mapped in terms of major highway corridors. Finally, trends in truck transport of hazardous chemical and petroleum products since 1977 are analyzed. The appendices detail the methods and data used in making specific estimates.

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PREFACE

This report is the culmination of an effort by the Transportation Systems Center (TSC) that began in 1983 in support of the Research and Special Programs Administration (RSPA), Office of Hazardous Materials Transportation. This report quantifies the magnitude of hazardous chemical and petroleum products transported by truck and characterizes the vehicle fleet involved in this transportation activity. The effort has been sponsored and guided by the Office of Hazardous Materials Transportation as the research progressed from preliminary estimates of national total shipment tons to graphical displays of regional distribution patterns of the truck activity. The objective of this research effort has been to analyze certain publicly available data in sufficient depth to provide government regulators and policy makers with a perspective on the distribution patterns of hazardous chemical and petroleum products truck shipments and the activities of the fleet that transports them.

This report supersedes the previous TSC staff study by the same title, dated May 1984, which contained national level estimates only. This report refines the previous national total estimates, particularly those for truck transport from regional storage facilities, and extends the analysis to geographical distribution patterns. The analysis has been constrained by the data available; 1977 was the latest year for which comprehensive data on both the origin/destination commodity flows and the truck fleet size, mix and activity were available. The analysis does shed some light on the trends between 1977 and 1982, using 1982 truck fleet data and some statistics on aggregate national domestic production and foreign imports.

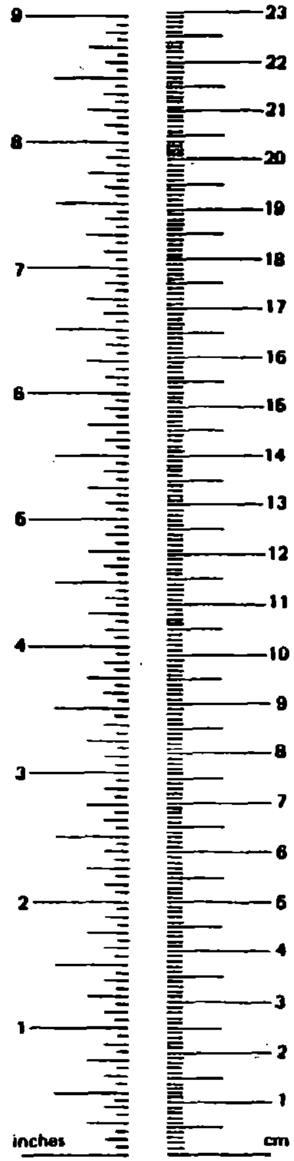
The authors wish to acknowledge the guidance provided throughout the conduct of this research and documentation effort by Sherwood C. Chu, Richard C. Hannon, Robert A. McGuire and Joseph S. Nalevanko of RSPA's Office Of Hazardous Materials Transportation.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

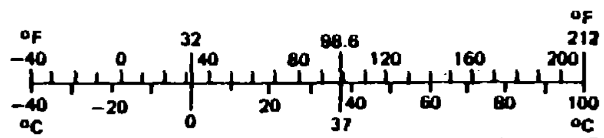
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in. = 2.54 cm (exactly). For other exact conversions and more detail tables see NBS Misc. Publ. 286. Units of Weights and Measures. Price $2.25 SD Catalog No. C13 10 286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1. INTRODUCTION

1.1 PURPOSE AND SCOPE

This report presents a quantitative overview of the movement of hazardous chemical and petroleum products in highway freight transportation. Hazardous waste materials are not included. Waste shipments by truck have been estimated at less than 1 percent of the chemical and petroleum ton-miles.* The primary purpose of this report is to provide the Research and Special Programs Administration, Office of Hazardous Materials Transportation, with a) an estimate of the aggregate national volume of hazardous chemical and petroleum products transportation in trucks, b) a profile of the truck fleet involved in hazardous materials transport and its total activity, and c) the geographical distribution of this truck activity.

This report focuses on national total estimates of specific dimensions of the truck traffic (e.g., truck fleet size, annual miles of truck travel, freight shipment tonnage, ton-miles of transportation, etc.) that could be constructed from the data available from the U.S. Department of Commerce, supplemented by data extracted from a U.S. Department of Transportation highway traffic forecasting model system and U.S. Department of Energy publications, as well as chemical and petroleum industry sources.

The analysis of truck transportation of hazardous chemical and petroleum products and the development of this report have proceeded incrementally over a period of time. It began with national level estimates of total truck activity associated with hazardous chemical and petroleum products, progressed to regional distributions focusing on the split between regionally generated traffic and regional pass-through traffic, then to mapping of major highway corridors to determine geographical concentrations and dispersions of flows, and ended with an assessment of trends.

Earlier TSC staff studies (November 1983 and May 1984) with the same title are superseded by this report.

*The Office of Technology Assessment, in its July 1986 report "Transportation of Hazardous Materials," p. 41, estimated that hazardous wastes represent about one precent of the hazardous materials (tons) shipped annually.

The volumes of truck transport of hazardous chemical and petroleum products and their respective distribution patterns presented in this report are based on 1977 data, the latest year for which comprehensive coverage of truck activity is available. One subset of data, the U.S. Bureau of the Census' Truck Inventory and Use Survey, was available for both 1977 and 1982. This data subset, coupled with U.S. Department of Commerce national production and imports data, permitted inference of possible changes in truck patterns in the transport of hazardous chemical and petroleum products since 1977. Therefore, this report first presents a basic picture of truck transportation of hazardous chemical and petroleum products in the data base year, then uses the more recent data, with its limited scope, to suggest possible trends. As additional data become available, the base-year truck volumes and distribution patterns can be adjusted.

The analysis indicates that there are three distinct sources of truck traffic: 1) transport of U.S. domestic production from manufacturing plants, 2) transport of foreign imports from ports of entry into the U.S., and 3) transport from regional storage facilities. The last involves distribution of both domestic production and imported materials throughout regional service areas. Sections 2 and 3 are therefore structured to present national information on truck transport of hazardous chemical products and hazardous petroleum products from each of these sources separately before presenting the aggregate national totals. Section 4 characterizes the truck fleet involved in transport of these hazardous materials. Section 5 then proceeds to the geographical distribution of these national totals using three analytical approaches. The first approach to analyzing the geographical distribution patterns is heavily oriented toward and driven by data on transport from U.S. domestic production plants.

The second approach focuses on the split between internally generated traffic within regions and traffic that passes through regions en route between two other regions. The second approach includes movements from ports and regional storage facilities. The third approach, which produced the highway corridor maps, is limited to the transport from U.S. domestic production plants only. The highway corridor maps were prepared from origin/destination flow data and a highway network minimum path assignment model. Actual truck routings are unknown, and these maps are presented to indicate only the regional concentrations and national dispersion patterns of selected hazardous materials commodity groupings. They do not represent the actual flows of specific hazardous materials on specific highway segments. Section 6 analyzes limited time series data in an attempt to infer whether or not there have been significant changes in the truck distribution patterns described in the first five sections.

1.2 SUMMARY OF FINDINGS

This report provides a national level overview of the volume of hazardous chemical and petroleum products shipments transported by trucks and the geographical distribution patterns of shipments. It also characterizes the truck fleet involved and the magnitude of its activity.

In 1977 there were 200 million truck-trips generating 11.4 billion truck-miles while transporting 1.1 billion tons of hazardous chemical and petroleum products on the nation's highways, roads and streets. Single unit trucks hauling an average of 1.2 tons of these hazardous materials a distance of 33 miles were responsible for 74 percent of the truck-trips and 53 percent of the truck-miles generated. Distribution from regional storage facilities accounted for 74 percent of the hazardous chemical and petroleum products tonnage loaded into both single unit and combination trucks. Local and regional markets are responsible for 92 percent of this hazardous materials tonnage in trucks; on average, only 8 percent can be attributed to traffic that simply passed through a region using the region's road system en route between two other regions. Obviously these statistics vary by region.

In terms of total ton-miles of truck transportation, chemical and petroleum products are about equally split (i.e., 52 percent chemicals and 48 percent petroleum products). In terms of truck-trips, chemicals produce only 33 percent of the total, but in terms of truck-miles, chemicals dominate with 65 percent of the total, due to the longer average hauls of chemical shipments.

Trucks operating in placarded services may be divided into those that have a high percentage of their annual miles dedicated to placarded services and those that are placarded for only a small percentage of their activity. Trucks that are essentially dedicated to placarded services may be characterized as single unit tank body trucks carrying petroleum products in local services for the wholesale and retail trade. Trucks that have only a small portion of their total activity in placarded service may be characterized as combination van body trucks carrying mixed shipments of packaged chemical and petroleum products and other nonhazardous commodities in local and short haul for-hire services.

From the observations above, one would expect that the number of highway traffic accidents involving hazardous materials trucks and spills would be more heavily represented by single unit trucks in local or regional distribution services, and less heavily represented by combination trucks in over-the-road service. One would also expect that there would be approximately equal representation between chemicals and petroleum products and between tank trucks and van body trucks in the highway accidents involving hazardous materials. If this is not the case, then attention might be productively focused on the over-represented group(s) of truck activities.

There are indications of moderate increases between 1977 and 1982 in the activity of trucks transporting chemicals. These increases, however, were countered by decreases in petroleum products truck activity. In both commodity markets, some shift from smaller, single unit trucks to larger, combination trucks took place, which translated into fewer truck miles and fewer truck trips for the volume of freight transported. While this internal shift among vehicle classes tended to reduce the truck traffic, a concurrent shift from the rail mode to highway was tending to increase the truck traffic. There apparently was a small shift from rail to over-the-road truck combinations for both chemicals and petroleum. These changes occurred in a period of economic recession, which suggests that increased truck activity can be expected with future increases in economic activity. The increase in foreign imports of chemicals has had little effect on the total truck activity because of the small import component of the total chemical truck traffic. Petroleum products truck activity is so dominated by transport from regional storage facilities (86 percent of tons and 60 percent of the ton-miles) that changes in total consumption of petroleum products have a greater effect than shifts between domestic and foreign sources.

2. DATA SOURCES AND METHODS OF ANALYSIS

Current data defining the total volume of trucking activity, the characteristics of the truck fleet, the areas served, the freight shipments hauled and their geographical distribution patterns are very sparse. Data which permit the segregation of hazardous materials transport from other freight transported by truck are sparser still. This report is the result of a very laborious process involving the synthesis of publicly available data, primarily from government sources. The statistical reliability of some of the estimates presented in this report is uncertain because of the assumptions that had to be made throughout the process, but the description that follows and the audit trail provided by the appendices should permit readers to judge for themselves the utility of the statistics.

2.1 TRUCK TRANSPORT OF DOMESTIC PRODUCTION FROM PLANTS

One U.S. Department of Commerce data source, the Bureau of the Census' Commodity Transportation Survey (CTS),[1] was the basis for the estimates of total national tonnage of hazardous chemical and petroleum products shipments of domestic production from manufacturing plants. The 1977 CTS (the latest year available) is the only comprehensive source of origin/destination flow data of freight shipments by commodity, principal mode of transport and shipment weight distributions. This survey covers all shipments of manufactured and processed goods, except waste materials, from U.S. manufacturing establishments and processing plants. It does not include inland transportation of foreign imports from ports of entry into the U.S. or truck transport from nonproduction places such as warehouses and regional storage facilities. Except for a few materials (e.g., sulfuric acid), the data are not sufficiently disaggregated by product to permit identification of specific hazardous materials listed in the CFR 49 Table of Hazardous Materials.[2] It nevertheless represents the only comprehensive source of data on truck shipment flow patterns by commodity group. The CTS data does include some local as well as intercity shipments from places of manufacture or production. Local traffic has been defined as shipments within approximately a fifty-mile radius from the point of origin. The CTS volumes are measured in terms of shipment tons and ton-miles calculated by the PICADAD system, which is based on the great circle mileage between the longitude and latitude coordinates of the origin and destination points. The ton-miles reported in the CTS files, therefore, understate by a significant percentage the actual ton-miles generated by even the most direct truck routing. To obtain a more realistic estimate of truck ton-miles, a circuity factor must be applied to the CTS ton-mile values. For this study, a truck route circuity factor of 1.167 was estimated. This circuity factor was estimated by comparing truck average haul distances calculated from the CTS data with those derived from computer model runs of another TSC project. The latter figures were inter-BEA* truck freight flow assigments on a highway network routing model that is part of the Federal Highway Administration's (FHWA) Highway Traffic Forecasting System (HTFS).[3]

The estimates of total national tons of hazardous chemical and petroleum products transported by truck were derived from the CTS records at the 5-digit TCC commodity code level. These were identified by matching STCC 49 Hazardous Materials (HAZMAT) codes in the Standard Transportation Commodity Code Tariff STCC 6001-H, Section 3, Part II.[4] A data base containing the 7-digit STCC commodity codes was used to bridge the STCC 49 codes to the CTS commodity groupings. A file of abbreviated 5-digit HAZMAT codes was created because the CTS contained TCC codes no finer than the 5-digit level. These 5-digit HAZMAT codes were then used to match the 5-digit CTS commodity codes to determine whether or not a shipment record contained some volume of hazardous materials. The percent of the total shipment tonnage that is hazardous within a selected shipment record is not known. Conversely, any hazardous material that would be classified under a 5-digit commodity group other than one of those shown in this report is not included because no shipment tonnage is given in the CTS files. The magnitude of these discrepancies is unknown.

2.2 TRUCK TRANSPORT OF FOREIGN IMPORTS FROM PORTS OF ENTRY

Imports of hazardous chemical and petroleum products have been estimated using U.S. Department of Commerce statistics on imports. The annual publication

*BEA - Economic areas delineated by the Regional Economics Division, Bureau of Economic Analysis, U.S. Department of Commerce. See Appendix J for a full description of the 173 regions delineated prior to the revision of December 1977.

of the U.S. General Imports, Schedule A,[5] was the primary source for the total volume of imports by vessel and by air of all commodities. The country of origin and the U.S. port of entry are indicated, but the level of commodity detail is less than that offered by the CTS. The inland transport mode and destination cannot be identified by this source. The U.S. General Imports for Calender Year 1977, Table 1, Schedule A, Commodity Groupings and Method of Transport[5] provides the total shipping weight by vessel and by air into the U.S. Hazardous chemical commodity groups were selected at the 2-digit level and petroleum commodity groups were selected at the 3-digit level. These volumes were transported inland by various modes. The percent of the total volume transported by truck was estimated using percent distributions derived from another Bureau of the Census survey, Domestic and International Transportation of U.S. Foreign Trade: 1976, Part B, Imports, Tables 7, 11 and 15.[6] This is the only source addressing the distribution of imports among the domestic transport modes and their respective inland destinations or haul distances. This survey included chemical products and petroleum products, but not crude petroleum or partly refined petroleum. The latter were assumed to be transported inland by modes other than truck.

The Schedule A imports statistics represent imports by vessel and by air from all foreign countries, but they do not include land mode imports from Canada or Mexico. Another annual report of the U.S. Department of Commerce segregated imports from Canada and Mexico - namely, U.S. Imports for Consumption and General Imports, TSUSA Schedule, Microfiche FAS 236, Canada and Mexico, 1978.[7] Only vessel and air modes are explicitly segregated from total imports; ground modes are not. No record is retained by the Bureau of the Census (or the U.S. Customs district that collected the original data) of the distribution of imports among truck, rail and pipeline. Pipeline can be essentially ignored as an import mode except for crude petroleum from Canada*, leaving the hazardous chemical and petroleum products to be shared by rail and truck. In the absence of any other data to the contrary, an assumption was made that the truck and rail shares of imported chemical and petroleum products would

*Based on telephone conversations with representatives of the Federal Energy Regulatory Commission and the Association of Oil Pipelines.

approximate those from U.S. domestic production plants as reported by the CTS. Appendix A describes in detail how the truck imports from Canada and Mexico were estimated.

2.3 TRUCK TRANSPORT FROM REGIONAL STORAGE FACILITIES

The data extracted from the Department of Commerce sources provided coverage of truck transport of domestic production of hazardous chemical and petroleum products from U.S. plants and their associated primary storage facilities. These sources also provided coverage of truck transport of imports from ports of entry into the U.S. The major deficiency of these data is the exclusion of truck transport of hazardous chemical and petroleum products from secondary storage or regional storage facilities and warehouses used for local distribution.

At the start of this investigation, it was believed that transport from regional storage facilities was a very large portion of the total truck transport of hazardous chemical and petroleum products, and that local and regional distribution of gasoline and heating oil would dominate the total volume of hazardous materials movement by truck. A rather involved process of data synthesis, assumptions and calculations has confirmed the early hypothesis. Appendix B documents the elaborate method of estimating truck transport of petroleum products and Appendix C documents the relatively simple method of estimating truck transport of chemical products from regional storage facilities. The estimating process for chemicals is simpler than that for petroleum products because there is much less information and fewer controls with which to work.

The national total volume (tonnage) of petroleum products delivered for domestic consumption was derived from the Annual Energy Review, April 1983,[8] published by the Energy Information Administration of the U.S. Department of Energy. The patterns of local and regional distribution (i.e., truck loads and service areas) of gasoline and home heating oil were derived from information obtained from the Oil Jobbers Council. Oil jobbers, sometimes referred to as "marketers", "distributors" or "resellers", acquire the petroleum products (motor fuel and heating oil) at the refinery or pipeline storage facility (primary storage) and load it in large tank trucks and transport it to their own bulk storage facilities where it is unloaded and stored again (secondary storage) for later loading into other trucks for regional and local distribution. Oil jobbers are responsible for approximately 85 percent of the heating oil distribution to final consumers, while the major producers transport 15 percent of the total directly to large end users in their own truck-trailer combinations. Oil jobbers are responsible for regional and local distribution of approximately 46 percent of the gasoline, while the major producers transport the other 54 percent in their own large combination trucks directly to major oil company service stations. Although the data are scarce, there is sufficient information to conclude that most of the hazardous petroleum products delivered for final consumption in the U.S. are ultimately delivered to the consumer by truck, regardless of the transport mode from primary to secondary storage. The truck ton-miles for each product during distribution from regional storage facilities were estimated by multiplying the annual tons shipped by an estimated average haul for each. Appendix B shows how these two sources of data and several specific assumptions were used to derive estimates of truck transport tons, ton-miles and average hauls from regional storage facilities.

The patterns of distribution from regional storage facilities of hazardous chemical products are more sketchy, as the rough estimating procedure of Appendix C indicates. The starting point of that estimate is the total payload ton-miles for all chemicals in single unit trucks and in combination trucks assigned to "local service" as estimated by the 1977 Master Traffic File, of the FHWA, HTFS.[3] The average haul distance was calculated assuming a uniform distribution of activity over a 50 mile radius service area. The total shipment tons were calculated by dividing the ton-miles by the average haul. The hazardous chemicals tons in all trucks were estimated as a percent of all chemicals tons, based on the percent of chemicals from manufacturing plants that are hazardous as determined by the CTS data analysis.

2.4 TRUCK FLEET CHARACTERISTICS AND TOTAL VEHICLE MILES

The primary source of data defining the size of the truck fleet, the mix of vehicle types and sizes, the areas of operation, the products carried and the total annual vehicle miles of travel (VMT) is the 1977 Bureau of the Census' Truck Inventory Use Survey (TIUS).[9] These data also identify the trucks that operated while displaying hazardous materials placards some portion of the time. The 1977 TIUS data file was used for the estimates presented in Section 4 of this report because the commodity flow data was from 1977; and at the beginning of this study the 1982 TIUS was not available. The 1982 TIUS[10] was subsequently analyzed along with other more recent aggregate production and imports data to determine trends in hazardous materials truck activity patterns since 1977. The latter is the subject of Section 6 of this report.

The 1977 TIUS used for this study was the FHWA version, which was the DOT's basic source for truck fleet data, and was available on the TCC and TSC computers. All trucks registered in the U.S., regardless of their ownership and use, are represented by the TIUS. It is the only comprehensive data source for truck fleet characteristics and activity. The FHWA version of the 1977 TIUS contains adjustments to the Bureau of the Census' public use tape file. These adjustments reconcile the fleet population and VMT with other DOT and industry sources.[11] The TIUS was a basic source in the development of the FHWA HTFS, which was used in this study as a source for certain key inputs. Its use in this study provides results that are comprehensive and consistent with other DOT studies and reports on truck operations.

3. NATIONAL TOTAL TONS, TON-MILES AND HAUL DISTANCES

This section presents estimates of the quantity of hazardous chemical and petroleum products transported by truck from each of the three types of origination points: plants, ports and regional storage facilities. Two units of measurement are used to indicate shipment volume. The quantity of product shipped and transported is measured in tons loaded onto trucks. However, volume of transportation service provided by the trucks is usually measured in ton-miles (the tons times the miles traveled). A given ton of product may be shipped (or loaded) twice - once from the initial source of supply (domestic production plant or foreign import port of entry) and again from a regional storage facility or warehouse. Therefore tons shipped or loaded may legitimately be counted twice in this context to estimate the exposure to potential incidents (such as spills) during loading/unloading operations. Where tons may be a good measure of exposure to incidents during loading and unloading at either end of the trip, ton-miles is a better measure of exposure to potential en route highway traffic accidents. Average haul distance is an indicator of the size of the market service area or the geographic operating range of the trucks.

3.1 TRUCK TRANSPORT OF DOMESTIC PRODUCTION FROM PLANTS

Table 3-1 shows the total of all commodities, the total of all chemical products and all petroleum products, and the total of the 5-digit commodities in the 1977 CTS that were identified as encompassing some hazardous materials. It shows the tons shipped from the origin plants and the ton-miles generated by this traffic, calculated by the CTS PICADAD system[1] and subsequently adjusted by TSC for truck routing circuity. The average haul distance shown results from dividing the ton-miles by the tons. Table 3-1 indicates that the total shipment tons of chemical and petroleum products combined was 402 million tons in 1977, which was approximately 21 percent of the total tons of all commodities transported by truck from manufacturing plants. The weighted average haul distance of chemical and petroleum products combined, 212 miles, was only slightly greater than the average haul for all commodities (172 miles). Commodity groups encompassing hazardous materials equaled 252 million tons,

TABLE 3-1. NATIONAL TRUCK TRANSPORT OF HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS FROM MANUFACTURING PLANTS

	TONS (Millions)	TON-MILES[2] (Millions)	AVERAGE HAUL[3] (Miles)
1. Total Truck Transport, All Commodities	1,894[1]	326,689	172
2. TCC 28 Chemical Prod. in Trucks	152.7[1]	41,466	271
3. TCC 29 Petroleum Prod. in Trucks	249.5[1]	27,198	111
4. Hazardous Chem. Prod. in Trucks	146.5[4]	37,689	257
5. Hazardous Pet. Prod. in Trucks	105.9[4]	15,813	149
6. Total Hazardous Chem. & Pet. Products in Trucks	252.4	53,502	212

Notes:

1 1977 Commodity Transportation Survey (CTS) National Summary, Table 7

2 CTS Ton-Miles x 1.167 To adjust PICADAD miles to truck route miles

3 Ton-Miles/Tons

4 Table 3-2

constituting 63 percent of the total chemical and petroleum products tons shipped by truck. The average haul distance of these hazardous materials was 212 miles, suggesting that an average hazardous materials shipment from a plant traveled farther than the average of all other commodities. Therefore, the hazardous materials as a group represented 13 percent of the tons and 16 percent of the ton-miles of all commodities shipped by truck from plants. The hazardous chemical products represented 58 percent of the total hazardous materials tons but 70 percent of the ton-miles. This suggests that chemicals represented a slightly greater risk of terminal area incident than petroleum products but substantially greater risk of en route highway accident than petroleum products.

Table 3-2 provides a detailed listing of the 5-digit CTS commodity groups identified as encompassing some hazardous materials. The shipment tons, ton-miles and average haul distances of each commodity group and the subtotals at the 3-digit level indicate the varied distribution of the totals among the groups. The average haul distances vary significantly among the groups indicating that the products with the largest quantity were shipped by truck the shortest distances, while those with the smallest quantities were shipped the longest distances. This is consistent with the fact that large quantities shipped long distances usually go by rail.

The wide range of average haul distances among the chemicals effectively changes the risk exposure ranking of individual commodity groups when ranked first by tons and then by ton-miles. This phenomenon is evident in the chemicals but not in the petroleum products, as Table 3-3 illustrates. The top five hazardous chemical products and the top five hazardous petroleum products are ranked first by tons and then by ton-miles. The first observation to be made from Table 3-2 is that there are about four times as many 5-digit hazardous chemical commodity groups as hazardous petroleum product groups, which leads one to anticipate the first observation to be made from Table 3-3. The total hazardous chemical tons are more dispersed by product than are the total petroleum products tons. The last column of Table 3-3 is the 5-digit commodity group percentage of the total hazardous chemical or the total hazardous petroleum products. The fact that the top five commodity groups were responsible for 35.6 percent of the total chemical tons and the top five commodity groups were responsible for 92.9 percent of the petroleum tons

TABLE 3-2. FIVE-DIGIT COMMODITY GROUPS ENCOMPASSING HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS IN TRUCK TRANSPORT FROM MANUFACTURING PLANTS

TCC CODE		SHIPMENT TONS (Thousands)	SHIPMENT TON-MILES (Millions)	AVERAGE HAUL (Miles)
28121	Inorganic Bleaching Comp., Exc. Chlorine	766	85	111
28122	Sodium Alkalies	4355	1092	251
28123	Sodium Compounds	1795	589	328
28124	Potassium Alkalies	216	53	245
28125	Potassium Compounds	46	35	761
28128	Chlorine	735	154	210
28133	Carbon Dioxide	2322	680	293
28134	Elemental Gases	4503	567	126
28139	Industrial Gases, NEC	4496	927	206
28141	Crude Products of Coal & Petroleum Tar	1274	376	295
28151	Cyclic Intermediates from Benzene	4136	1097	265
28156	Organic Dyes	165	67	406
28182	Misc. Acyclic Organic Chem. Prod.	3509	779	222
28183	Misc. Cyclic Organic Chem. Prod.	57	27	474
28184	Alcohols	1942	335	173
28185	Glycols and Glycerines	942	709	753
28186	Organic Acids and Salts	693	392	566
28189	Industrial Organic Chem., NEC	3133	1470	469
28191	Ammonia & Ammonia Comp., Exc. Anhydrous Ammonia	4108	821	200
28192	Nitric Acid	794	177	223
28193	Sulfuric Acid	13838	1753	127
28194	Industrial Inorganic Acids, Exc. Nitric & Sulfuric	10068	1160	115
28195	Cobalt, Copper, Iron, Nickel & Zinc Comp.	763	230	301
28196	Aluminum Compounds	7460	386	52
28198	Anhydrous Ammonia	2799	551	197
28199	Industrial Inorganic Chem., NEC	4146	1381	333
	Subtotal	79061	15893	201
28211	Plastics Materials	10544	4847	460
28212	Synthetic Rubbers	1781	966	542
28213	Synthetic Fibers	3293	1063	323
	Subtotal	15618	6876	440
28311	Drugs For Human Use	2587	1407	544
28419	Soap and Other Detergents	3346	1118	334
28422	Specialty Cleaning	5912	1775	300
28423	Waxes and Polishing Preparations	442	215	486
28441	Cosmetics and Perfumes	1484	1032	695
	Subtotal	11184	4140	370
28511	Paints, Enamels, Lacquers & Shellacs	4546	1573	346
28512	Paint Oils, Solvents, & Thinners	769	308	401
	Subtotal	5315	1881	354

TABLE 3-2. FIVE-DIGIT COMMODITY GROUPS ENCOMPASSING HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS IN TRUCK TRANSPORT FROM MANUFACTURING PLANTS, (CONT.)

TCC CODE		SHIPMENT TONS (Thousands)	SHIPMENT TON-MILES (Millions)	AVERAGE HAUL (Miles)
28612	Gum and Wood Chemicals	1104	422	382
28712	Superphosphate	2772	473	171
28713	Ammoniating & Nitrogen Fertilizer Solution	2169	284	131
28714	Misc. Fertilizer Compounds	10090	1258	125
28799	Agricultural Chemicals, NEC	7597	1932	254
	Subtotal	22628	3947	174
28911	Adhesive, Cement, Sealant, Glue & Sizes	3141	1206	384
28921	Explosives	772	373	483
28931	Printing Ink	789	197	250
28995	Water Treating Compounds	428	160	374
28996	Blacks	356	301	846
28999	Chemical Products NEC, Exc. Sealants	3505	886	253
	Subtotal	8991	3123	347
	Total Hazardous Chemical Products	**146488**	**37689**	**257**
29111	Gasoline and Jet Fuel	40594	6837	168
29112	Kerosene	217	15	69
29113	Distillate Fuel Oil	19691	2674	136
29116	Asphalt Pitches and Tars from Petroleum	19593	2741	140
29117	Petroleum Residual Fuel Oils	12772	1193	93
29119	Petroleum Refining Prod., NEC	5803	1220	210
29121	Liquified Petroleum & Coal Gases	4913	581	118
	Subtotal	103583	15261	147
29522	Asphalt & Coal Tar Cements and Coatings	700	189	270
29911	Coal and Coke Briquettes	113	44	389
29912	Lubricants other than Petroleum	1396	304	218
29919	Petroleum and Coal Product, NEC	124	15	121
	Subtotal	1633	363	222
	Total Hazardous Petroleum Products	**105916**	**15813**	**149**
	TOTAL HAZARDOUS CHEM. & PET. PROD.	**252404**	**53502**	**212**

Source: Bureau of the Census, "1977 Census of Transportation - Commodity Transportation Survey - Summary." Five digit groups identified as hazardous by Standard Transportation Commodity Code Tariff STCC 6001-H, Section 3, Part III. Ton-miles are adjusted by a circuity factor of 1.167.

Table 3-3. TOP FIVE 5-DIGIT HAZARDOUS CHEMICAL AND PETROLEUM COMMODITY GROUPS - RANKED BY TONS AND BY TON-MILES

Rank by Tons			TONS (Thousands)	AVER. HAUL MILES	%
Hazardous Chemicals					
1	28193	Sulfuric Acid	13,838	127	9.4
2	28211	Plastics Materials	10,544	460	7.2
3	28714	Misc. Fertilizer Compounds	10,090	125	6.9
4	28194	Industrial Inorganic Acids, Except Nitric & Sulfuric	10,068	127	6.9
5	28799	Agricultural Chemicals, NEC	7,597	254	5.9
		Subtotal	52,137		35.6
Petroleum Products					
1	29111	Gasoline and Jet Fuel	40,594	168	38.3
2	29113	Distillate Fuel Oil	19,691	136	18.6
3	29116	Asphalt Pitches & Tars	19,593	140	18.5
4	29117	Petroleum Residual Fuel	12,772	93	12.0
5	29119	Petroleum Refining Prod., NEC	5,803	210	5.5
		Subtotal	98,453		92.9

Rank by Ton-Miles			TON-MILES (Millions)	AVER. HAUL MILES	%
Hazardous Chemicals					
1	28211	Plastics Materials	4,847	460	12.9
2	28799	Agricultural Chemicals, NEC	1,932	254	5.1
3	28422	Specialty Cleaning Compounds	1,775	300	4.7
4	28193	Sulfuric Acid	1,753	127	4.6
5	28189	Indus. Organic Chemicals, NEC	1,470	469	3.9
		Subtotal	11,777		31.2
Petroleum Products					
1	29111	Gasoline and Jet Fuel	6,837	168	43.2
2	29116	Asphalt Pitches & Tars	2,741	140	17.3
3	29113	Distillate Fuel Oil	2,674	136	16.9
4	29119	Petroleum Refining Prod., NEC	1,220	210	7.7
5	29117	Petroleum Residual Fuel Oils	1,193	93	7.5
		Subtotal	14,665		92.7

Source: Table 3-2

illustrates that the hazardous chemicals were more dispersed by product. The average hauls of two of the top five chemical commodity groups by shipment tons (miscellaneous fertilizer compounds and industrial inorganic acids, except nitric and sulfuric) were 125 miles and 127 miles respectively. These low average hauls drop them out of the top five by ton-miles. Two other commodity groups (agricultural chemicals, NEC, and industrial organic chemicals, NEC), having average hauls of 254 miles and 460 miles respectively, replaced them. The ranking of the top five petroleum commodity groups changed only slightly, because the range of average hauls was not as great as for the chemical groups.

3.2 TRUCK TRANSPORT OF IMPORTS FROM PORTS OF ENTRY

In Section 2 it was indicated that foreign imports of hazardous chemical and petroleum products entered the U.S. by way of vessel, air, rail and truck. All four modes were used for imports from Canada and Mexico and the first two modes were used for imports from all other countries of origin. Table 3-4 shows that 10.4 million tons of hazardous chemicals and 90.1 million tons of hazardous petroleum products were imported by vessel and air from all countries and that 13.6 million tons of chemicals and 3.0 million tons of petroleum products were imported by railroad and truck from Canada and Mexico.

Of the total 24 million tons of hazardous chemical products and 94 million tons of hazardous petroleum products imported, 17 million and 6 million respectively were estimated to be transported inland from ports and border entry points by truck. There was no clear indication of the average truck hauls for these inland movements, so it was assumed that the average truck hauls would be approximately the same as for domestic production from plants. Using these average hauls of 257 miles for hazardous chemicals and 149 miles for hazardous petroleum products produced estimates of 4.4 billion and 0.9 billion ton-miles respectively.

It appears that in the transport of foreign imports, hazardous chemicals generated 10 times the truck ton-miles that petroleum products generated, whereas in the transport of domestic production from plants the ratio is 2.4:1. Imported petroleum products were far less important in truck transport than domestic petroleum or imported chemicals.

TABLE 3-4. NATIONAL TRUCK TRANSPORT OF IMPORTED HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS FROM PORTS OF ENTRY

	TONS (Millions)	**TON-MILES (Millions)**	**AVERAGE HAUL (Miles)**
1. Inland Transport (All Modes) Imported Hazardous Chem. Prod.			
Imported via Vessel & Air[1]	10.4	--	--
Imported via Rail & Truck[2]	13.6	--	--
	24.0	--	--
2. Inland Transport (All Modes) Imported Hazardous Pet. Prod.			
Imported via Vessel & Air[1]	90.1	--	--
Imported via Rail & Truck[2]	3.0	--	--
	93.1	--	--
3. Inland Transport (Truck) Imported Hazardous Chem. Prod.			
Imported via Vessel & Air	6.1[5]	1,574[4]	257
Imported via Truck	10.9[2]	2,797[4]	257
	17.0	4,371	257
4. Inland Transport (Truck) Imported Hazardous Pet. Prod.			
Imported via Vessel & Air	4.0[3]	596[4]	149[4]
Imported via Truck	1.8[2]	270[4]	149
	5.8	866	149

Notes:

[1] U.S. General Imports, Schedule A Commodity Groups
[2] From Canada and Mexico, Appendix A
[3] 4.4% of Total Bulk Vessel Shipments, Domestic & International Transportation of U.S. Foreign Trade: 1976, Table 3, Part B
[4] Tons multiplied by Appropriate Average Hauls from Table 3-2
[5] 59% of Chemical Product Tons Transported Inland by All Modes, Domestic & International Transportation of U.S. Foreign Trade: 1976, Table 15

3.3 TRUCK TRANSPORT FROM REGIONAL STORAGE FACILITIES

In Section 2 it was indicated that a highly involved calculation process was required to obtain estimates of the quantity of truck transport of hazardous chemical and petroleum products from regional storage facilities. Table 3-5 shows the result of the calculation process that is fully documented in Appendices B and C. Petroleum products dominate the local and regional distribution of hazardous products transported by truck with 88 percent of both the tons and ton-miles. Gasoline was by far the single largest commodity group, with 45 percent of the tons and 40 percent of the ton-miles. The 701 million tons of hazardous petroleum products reflects double handling of gasoline and heating oil, first in combination trucks and then in single unit trucks in the regional distribution pattern.

3.4 TOTAL TRUCK TRANSPORT FROM ALL SOURCES

Table 3-6 presents a comprehensive summary of hazardous chemical and petroleum products from all three sources (plants, ports, and regional storage). The relative importance of these sources varied, depending on whether tons of shipments loaded into trucks or ton-miles of transportation service was used as the measure of risk exposure. Regional storage was responsible for 74 percent of the 1.1 billion tons of material loaded for truck transport, and 88 percent of this was attributed to petroleum products. Domestic production from plants was responsible for 61 percent of the 87.3 billion ton-miles of total truck transport of hazardous products, and 70 percent of this was attributed to hazardous chemical products.

TABLE 3-5. NATIONAL TRUCK TRANSPORT OF HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS FROM REGIONAL STORAGE FACILITIES

	TONS (Millions)	TON-MILES (Millions)	AVERAGE HAUL (Miles)
Hazardous Chemical Products[1]			
Hazardous Chem. Prod.	99.4	3,520	35
Hazardous Petroleum Products[2]			
Gasoline	359.1[3]	11,447	32
Heating Oil	176.0[3]	5,300	30
Other Petroleum Prod.	166.2	8,310	50
Total	701.3	25,057	36
Hazardous Chem. and Pet. Prod.	800.7	28,577	36

Notes:

1 Appendix C
2 From Appendix B-2
3 Reflects double handling of product in combination trucks and in single unit trucks

TABLE 3-6. NATIONAL TRUCK TRANSPORT OF IMPORTED HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS FROM PLANTS, PORTS AND REGIONAL STORAGE FACILITIES

	TONS (Millions)	TON-MILES (Millions)	AVERAGE HAUL (Miles)
Hazardous Chemical Products			
From Plants[1]	146.5	37,689	257
From Ports[2]	17.0	4,371	257
From Regional Storage[3]	99.4	3,520	35
Subtotal	262.9	45,580	
Hazardous Petroleum Products			
From Plants[1]	105.9	15,813	149
From Ports[2]	5.8	866	149
From Regional Storage[4]	701.3	25,057	36
Subtotal	813.0	41,736	
Hazardous Chemical and Petroleum Products			
From Plants	252.4	53,502	212
From Ports	22.8	5,237	230
From Regional Storage	800.7	28,577	36
Total	1,075.9	87,316	

Notes:

[1] Table 3-1
[2] Table 3-4
[3] Table 3-5

4. CHARACTERISTICS OF THE TRUCK FLEET TRANSPORTING HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS

Section 3 discussed the characteristics of the hazardous products flow from the three sources to the final consumer, and the measurement of risk exposure to potential loading spills or incidents and highway accidents. Measurement was in terms of tons of hazardous products loaded into trucks and ton-miles of transportation service provided by the trucks. This section discusses the physical and operational characteristics of the truck fleet that provides the transportation service. It first examines the shipment size distributions of hazardous chemical and petroleum products and relates them to truck sizes and types used. Then it examines the split of the tons and ton-miles presented in Section 3 between two classes of trucks - single unit trucks and combination trucks. This section also provides a look at a profile of the truck fleet involved in placarded services in terms of the number of vehicles by vehicle class, body type, area of operation, operator class, principal products carried and major use. It closes with estimates of annual vehicle miles, average truck loads, average haul distances and number of annual truck trips of each truck type hauling hazardous chemical and petroleum products.

4.1 SHIPMENT SIZE AND TRUCK SIZE

Size of shipment is one dimension available, in the CTS, for domestic products transported from plants but not available for foreign imports transported from ports or for transport from regional storage facilities. Together with the physical state (that is, solid, liquid, packaged, bulk, etc.), shipment size determines the body type and size of the truck used (for example, van or tank, single unit or combination). Large bulk shipments tend to be transported in large combination trucks, one commodity at a time, whereas small bulk shipments or packaged shipments tend to be transported in smaller single unit trucks or are combined with other small shipments (that may or may not be hazardous) in large single unit or combination trucks (that may or may not be placarded).

Figure 4-1 displays the distribution of hazardous chemical products and hazardous petroleum products total shipment tons by weight of individual shipment. Unfortunately, the CTS data show a large portion of the total tons of each commodity group not disaggregated by shipment weight. However, unless the unknown portions were concentrated in one or two of the weight blocks shown, the distribution picture would not be substantially changed.

The major observation to be made here is that approximately two-thirds of the hazardous chemical tons moved in truck-load (TL) quantities (that is, greater than 20,000 pounds), with the remaining one-third moving as less-than-truck-load (LTL) shipments (less than 10,000 pounds) and partial-truck-load (PTL) shipments (10,000 - 20,000 pounds). Approximately 80 percent of the hazardous petroleum products moved as TL, with 20 percent moving as LTL and PTL. Truck shipments greater than 50,000 pounds tend to be those in tractor and multiple trailer combinations or truck-trailer combinations. They may also be moved as single shipments in more than one truck under a single bill of lading. PTL shipments may be transported in either single unit trucks or they may share space with other shipments in larger combination trucks. LTL shipments, unless moved in company (private) trucks, may be loaded and unloaded several times at origin and destination terminals, as well as at intermediate break-bulk terminals of general commodity carriers.

The U.S. CFR 49 indicates that shipments of less than 1,000 pounds each may be transported in a truck that is not placarded for hazardous materials, although the individual packages in each shipment must be properly labeled. Figure 4-1 suggests that these small shipments of hazardous chemical and petroleum products were a small portion of their respective totals (1.6 percent of chemicals and 0.3 percent of petroleum products), unless the unknown tonnage hid a sizeable quantity of these small shipments.

One could infer from these data that, in truck transport of domestic production from plants, the heavier single unit and combination trucks (those capable of carrying more than 20,000 pounds) displaying a hazardous materials placard were roughly evenly divided between chemical and petroleum products. The chemicals had a 14 percent greater volume than the petroleum products. One could also infer from these data that, in truck transport from plants, the

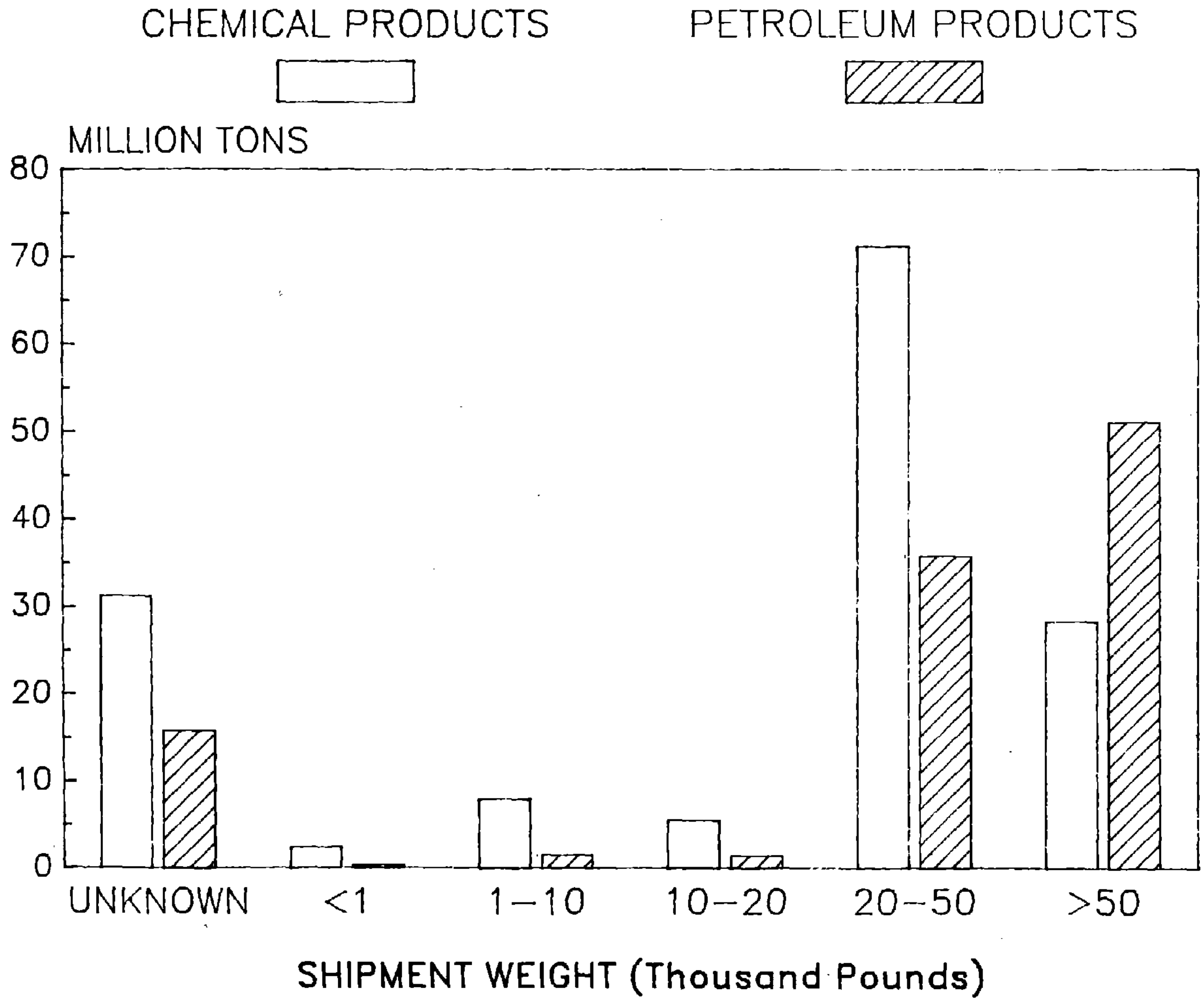


FIGURE 4-1. HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS FROM PLANTS - 1977 (ANNUAL TONS BY SHIPMENT SIZE)

smaller trucks (single units with less than 20,000 pound capacity) transporting hazardous materials were nearly five times as likely to be hauling chemicals as petroleum products. In the case of the LTL and small shipments, it was not clear whether they were transported in small single unit trucks or transported together in larger single units and combination trucks.

4.2 SINGLE UNIT AND COMBINATION TRUCK ACTIVITY

Single unit trucks (sometimes referred to as straight trucks) are characterized by a single chassis carrying the power plant and the cargo container between the steering axle and the single rear axle or tandem or tridem axle group. The combination truck is characterized by a prime mover on a separate chassis from the cargo container. The most common configuration of combination truck is a tractor-semi-trailer combination. A less common combination truck is a single unit truck, with its own cargo container, pulling a short full trailer. The least common combination configuration is a tractor-semi-trailer and full trailer combination. These last two configurations are sometimes referred to as doubles combinations.

In order to estimate the split of the total shipment tons and ton-miles of hazardous chemical products and hazardous petroleum products between these two classes of trucks, and to estimate their respective total vehicle miles and total truck trips generated during 1977, it was necessary to estimate fleet average hauls and fleet average loads for each vehicle class when hauling each commodity.

Table 4-1 displays the resultant truck fleet mix and activity in transporting hazardous chemical and petroleum products. The starting point for the chemicals was the 45.6 billion shipment ton-miles (from Table 3-6) by all trucks from all sources. It was estimated that 85 percent of the chemical products shipment ton-miles was transported in combination trucks with an overall average haul distance from all sources estimated at 215 miles. Appendix E shows the calculation process for the average hauls. Transport from plants dominated the total hazardous chemical ton-miles, so that the average haul for the combination trucks was greater than that for the single unit trucks. The

TABLE 4-1. TRUCK FLEET MIX AND ACTIVITY TRANSPORTING HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS FROM PLANTS, PORTS AND REGIONAL STORAGE FACILITIES

	SINGLE UNIT TRUCKS	COMBINATION TRUCKS	ALL TRUCKS
Chemical Products			
Shipment Tons[1] (Millions)	83.3	181.0	264.3
Shipment Ton-Miles[1] (Millions)	6,746	38,834	45,580
Average Haul[1] (Miles)	81.0	214.6	---
Adjusted Average Load[2] (Tons)	1.52	13.76	---
Vehicle Miles Traveled[3] (Millions)	4,438	2,822	7,260
Annual Truck Trips[4] (Millions)	54.7	13.2	67.9
Petroleum Products			
Shipment Tons[1] (Millions)	249.2	564.7	813.9
Shipment Ton-Miles[1] (Millions)	4,257	37,479	41,736
Average Haul[1] (Miles)	17.1	66.4	---
Adjusted Average Load[2] (Tons)	2.64	14.84	---
Vehicle Miles Traveled[3] (Millions)	1,613	2,526	4,139
Annual Truck Trips[4] (Millions)	94.4	38.1	132.5

Notes:

1 Appendix E
2 The average load is from 1977 MTF (see Appendix F). The empty truck miles factors (40.2% for combination trucks and 24.2% for single unit trucks, see Table VI, "Empty/Loaded Truck Miles on Interstate Highways During 1976," I.C.C., April 1977)[12] were used to calculate these adjusted average loads for loaded trucks only.
3 Shipment ton-miles/adjusted average load
4 Shipment tons/adjusted average load

single unit trucks were calculated to produce 6.7 billion ton-miles with an average haul of approximately 81 miles. This difference in average hauls between the two truck classes explains the large apparent discrepancy between the combination truck's 85 percent of the ton-miles and 69 percent of the tons.

In order to estimate the number of vehicle miles driven by each class of truck in transporting hazardous chemicals from the ton-mile values already established, an average load per loaded vehicle mile for each class was needed. Average loads of 1.5 tons and 13.8 tons were estimated for single unit and combination trucks respectively. Appendix F shows the calculation process for these average loads. The apparently small loads in single unit trucks reflect the range of truck sizes and the large number of light (two axles, four tires) trucks used within this class, the number of partial loads, and the quantity of packaged shipments in vans.

Dividing the shipment ton-miles by the average load yielded the estimated 7.3 billion truck miles traveled hauling hazardous chemicals. Dividing the total shipment tons by the average load yielded the 68 million truck trips to transport the hazardous chemical products in 1977.

Table 4-1 also displays the truck fleet mix and activity in transportation of hazardous petroleum products. The starting point for petroleum products was the 41.7 billion shipment ton-miles by all trucks from all sources. It was estimated that 90 percent of this was transported in combination trucks. The residual 4.2 billion ton-miles in single unit trucks was estimated to have an average haul distance of 17 miles, the calculation for which is shown in Appendix E. This means that 31 percent of the shipment tons of petroleum products were transported by single unit trucks. Table 4-1 indicates that the average haul for combination trucks would have been 66 miles. These average hauls for combination trucks and single unit trucks transporting petroleum products from all sources were considerably shorter than transportation of chemical products because transport from regional storage facilities dominated the hazardous petroleum products, whereas transport from plants dominated chemical products.

In order to estimate the number of truck miles driven by each class of truck in the transport of hazardous petroleum products, the average payload per truck mile was estimated at 2.6 tons and 14.8 tons for single units and combinations respectively. The calculation of average loads for petroleum products is shown in Appendix F. These average loads (somewhat heavier than for chemicals) reflect the physical density of bulk fuel shipments and the more frequent use of tank trucks of higher weight capacity. Appendix H indicates that the use of tank trucks for petroleum products was greater than that for chemical products. These averages were well below the average load capacity of trucks typically used. These load factors reflect the mix of equipment types and sizes within each class and number of the miles traveled empty.

Dividing the shipment ton-miles by the average load yielded the estimated 4.1 billion truck miles traveled in hauling hazardous petroleum products. Dividing the shipment tons by the average load yielded the estimated 132 million truck trips to transport hazardous petroleum products.

Summing the estimates for chemicals and petroleum products yielded a total of 11.4 billion truck miles and 200 million truck trips in transporting these hazardous materials. This was approximately 6 percent of the estimated total 1977 truck miles and 15 percent of the estimated total 1977 ton-miles for all truck freight. Hazardous materials truck trips, as a percent of total truck trips for all freight, could not be estimated because the total number of tons of all freight loaded into trucks at all sources is unknown.

4.3 PROFILE OF PLACARDED TRUCK OPERATIONS

All trucks are required by CFR 49 to display an appropriate hazardous materials placard when transporting hazardous materials shipments larger than 1,000 pounds. Of the estimated 26.2 million trucks in the 1977 TIUS total truck fleet, 1.3 percent reported that a hazardous materials placard was displayed some portion of the time during the trucks' operations in 1977. The TIUS characterized all trucks by a number of attributes, the most significant of which are: vehicle class, body type, area of operation, principal product carried, and major use (or industry served). Table 4-2 displays the

TABLE 4-2. PROFILE OF TRUCK FLEET PLACARDED FOR TRANSPORT OF HAZARDOUS MATERIALS - 1977

	PLACARDED	<75% OF TIME		75-100% OF TIME	
	NUMBER	NUMBER[1]	%	NUMBER[1]	%
Fleet Total	351,089	202,138	100.0	108,408	100.0
Vehicle Class					
Single- Units	185,555	75,307	37.3	71,837	66.3
Combinations	165,534	126,831	62.7	36,571	33.7
Unknown	0	0	0	0	0
Body Type					
Vans	126,052	121,295	60.0	3,286	3.0
Tanks	112,821	22,949	11.4	88,045	81.2
Pickup, Panel, Walk-in	68,644	30,844	15.2	7,411	6.8
Other	43,572	27,050	13.4	9,666	8.9
Unknown	0	0	0	0	0
Area of Operation					
Local	209,310	107,812	53.3	68,383	63.1
Over-The-Road <200 Miles	73,882	41,990	20.8	28,296	26.1
Over-The-Road >200 Miles	53,671	47,549	23.5	5,695	5.2
Off-Road	13,278	4,348	2.2	5,677	5.2
Unknown	948	439	0.2	357	0.3
Principal Product Carried					
Chemical Prod.	32,733	20,495	10.1	11,952	11.0
Petroleum Prod.	103,187	14,702	7.3	87,151	80.4
Mixed Shipments	127,211	125,136	61.9	460	0.4
Other	87,688	41,805	20.7	8,678	8.0
Unknown	270	0	0	167	0.2
Major Use / Industry					
Wholesale/Retail Trade	110,035	27,802	13.8	74,220	68.5
For-Hire Transport	151,136	136,572	67.5	12,610	11.6
Other	89,396	37,764	18.7	21,411	19.7
Unknown	522	0	0	167	0.2

Note: [1] Excludes respondents who gave no percent of time placarded distribution of the 351,089 vehicles reporting placarded operations among the categories of greatest interest to this study. Table 4-2 also shows the distribution of each category's subtotal into two classes of operations: those placarded more than 75 percent of the time (that is, dedicated trucks or those usually in placarded service) and those placarded less than 75 percent of the time (that is, those occasionally in placarded service; approximately half of these were placarded less than 25 percent of the time).

These data indicate that single unit trucks represented 53 percent of the placarded fleet. This is consistent with Table 4-1, which indicated that single unit trucks generated 53 percent of the truck VMT for hazardous chemical and petroleum products. Single unit trucks were about equally split between usually placarded service and occasionally placarded service, whereas only 22 percent of the combination trucks were in placarded service more than 75 percent of the time. Van body trucks had 96 percent of their number in placarded service on an occasional basis, whereas tank body trucks had 75 percent of their number in placarded service on an essentially dedicated basis. Local service occupied 60 percent of the total placarded trucks, with an additional 21 percent in over-the-road service of less than 200 mile hauls. The local fleet reported only 33 percent of its number in placarded service more than 75 percent of the time and 52 percent in placarded service less than 75 percent of the time.

Mixed shipments (packaged small shipments of hazardous materials) sharing a truck with nonhazardous shipments were reported by 36 percent of the total placarded trucks as the principal product carried. Chemical and petroleum products together represented only 39 percent of the total placarded trucks. If it could be assumed that the placarded mixed shipment operations were mostly chemical and petroleum products, then the combined total would be 75 percent. Mixed shipments and chemical products were transported mostly (98 percent and 63 percent respectively) in vehicles that displayed placards less than 75 percent of the time, while petroleum products were transported mostly (84 percent) in trucks that displayed placards greater than 75 percent of the time. It is interesting to note that 25 percent of the total placarded trucks were carrying hazardous materials other than chemicals, petroleum products or mixed shipments.

For-hire transport accounted for 43 percent of the total placarded trucks, while wholesale and retail trade activities accounted for an additional 31 percent. The wholesale and retail trade was mostly (67 percent) in trucks displaying placards greater than 75 percent of the time, while the for-hire trucks were mostly (90 percent) displaying placards less than 75 percent of the time.

Scanning the two columns of percentage distributions within each truck attribute provides a quick profile of the truck fleet that appears to have been essentially dedicated to hazardous material placarded services and the truck fleet that was only partially involved. The essentially dedicated fleet consisted mostly of single unit tank body trucks in local service carrying bulk shipments of petroleum products for the wholesale and retail trade. The partially involved fleet consisted mostly of combination van body trucks in local service and short haul over-the-road service carrying mixed package shipments in for-hire operations.

5. GEOGRAPHICAL DISTRIBUTION OF TRUCK TRANSPORT OF HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS

5.1 ANALYSIS OF REGIONAL TRAFFIC PATTERNS

The geographical distribution patterns of truck activity in transport of chemical and petroleum products is the focus of this section. Three analytical approaches were taken to determine the traffic concentrations and dispersion patterns. The first two approaches involved clustering states into regions and segregating traffic that was internally generated from traffic that was externally generated. The third approach involved highway route mapping of origin to destination flows to identify regional concentrations in highway corridors and/or dispersions over the national highway system, and to suggest the operating range of traffic in selected hazardous commodity groups.

The first approach was a region by region assessment of the truck shipments of chemical and petroleum products from manufacturing plants. The distribution of each region's total shipments in trucks was categorized into intra-region and inter-region traffic. It provided a picture of the national distribution and regional concentrations of the truck activities for domestically produced chemical and petroleum products. The results are presented in tabular and map forms that define the regional boundaries and display the distribution of shipment tonnage from origins. However, this approach was limited in scope to regional traffic originations only and the comparative shares in intra-region and inter-region activities. The direction and destination of traffic moving beyond the regional boundaries and the secondary movements generated by regional storage facilities were not included in this simple analysis.

The second approach attempted to identify traffic inbound to and outbound from each region, as well as the traffic that passed through each region on the way between two other regions. It also included the movements from regional storage facilities. It provides a more detailed analysis of the regional traffic mix than the first approach. The second approach involved the use of the FHWA HTFS abstract highway network and minimum path assignment models.[3] The flows over the highway network links were aggregated into four traffic categories and reported by region. The four traffic categories were: a) shipments that originated and terminated within the region, b) shipments that originated in the region but terminated outside the region, c) shipments that originated outside the region but terminated in the region, and finally d) shipments that neither originated nor terminated in the region but used a route that passed through the region. Only domestic production from plants was represented in the network traffic assignment, because the CTS BEA-to-BEA origin-destination flows at the 2-digit code level were the only suitable data source. National totals of truck movements from regional storage facilities (presented in Section 3) were allocated to the regions and added to the intra-region totals. The results are presented in tabular and map forms showing the percent of the total regional chemical and petroleum truck traffic that passed through (that is, not the result of economic activity within the region).

The third approach provided a mapping of the origin/destination (o/d) shipment flows of chemical and petroleum products transported from plants by truck. It graphically displays the distribution and shipping range of selected groups of commodities and truck types. The highway routing maps produced by this approach make apparent the regional concentrations of some commodities and the dispersions of others over the national highway system. The same basic o/d commodity flow data used in the second approach were prepared by TSC in somewhat more disaggregate commodity groups and the o/d trip tables were sent to Oak Ridge National Laboratories for use with their HIGHWAY model.[13] The latter incorporates a detailed map of all major truck routes, a minimum path assigment algorithm, and a map plotting capability. The ORNL model routes each o/d flow over the minimum time route, aggregates the flows on each highway link and plots the total flows to scale on large multi-colored maps. Although actual highway route alignments and origin/destination points are plotted in fine detail, these maps are only suggestive of the actual origin and destination points within the states and the actual truck routes, especially for the selected commodity groups for which origin/destination points were reported at the state level only. These maps graphically depict the concentrations of truck activity in the transport of some hazardous materials and the much dispersed nature of some other hazardous materials. Figure 5-1 provides an overview of the data sources and steps involved in each of the three approaches to produce the results

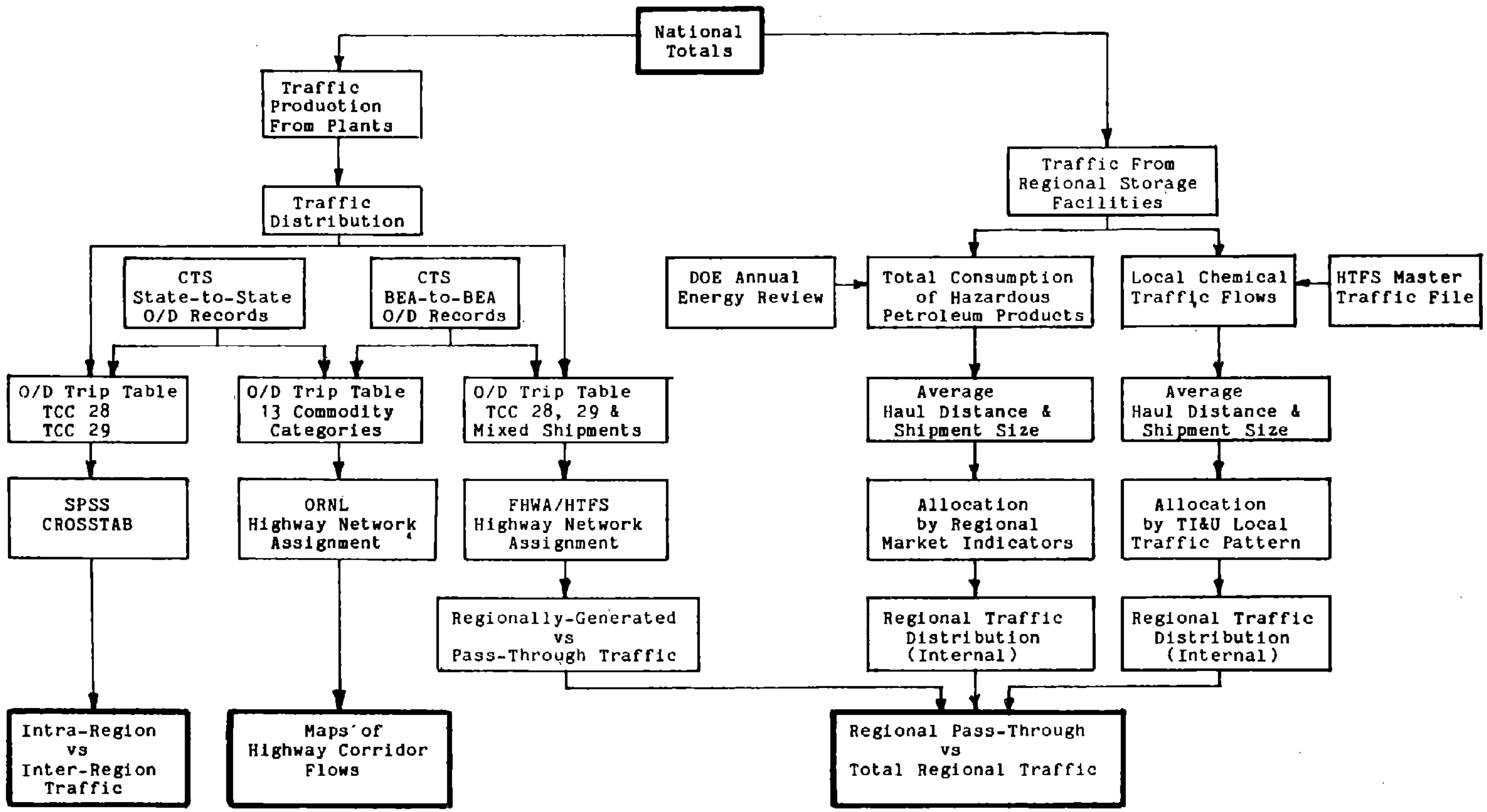


FIGURE 5-1. SOURCES OF DATA AND PROCESS FOR GENERATING REGIONAL DISTRIBUTIONS OF HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS TRUCK TRAFFIC

presented in this section. Each final product will be analyzed later in this section. The methods used in each step of the data manipulation are explained more fully in Appendix G.

The objective of this complex process has been to use three separate and somewhat overlapping views to provide a kind of collage that conveys a reasonable perspective of the national and regional patterns. The deficiencies in the available data files preclude more direct and more accurate portrayal of national and regional truck traffic patterns. To illustrate the loss of coverage by the data associated with the levels of representation of origin/destinations and commodity groups, Table 5-1 lists selected commodity groups from the CTS, with the national total shipment tons taken from Table 3-1 and the shipment tons represented by the CTS o/d data records. It is apparent in Table 5-1 that the 5-digit commodity groups suffer greater losses when shifting from national totals to specific state-to-state o/d data than do the 2-digit commodity groups. Table 5-1 also shows the 2-digit commodity shipment tonnages available in the TSC BEA-to-BEA o/d data file[14] that was used as a guide for the distribution of the more complete state-to-state flows among BEAs before building the BEA-to-BEA o/d trip tables for the network assigments. These data deficiencies motivated the pursuit of several data adjustments in the second and third approaches to produce the very rough but comprehensive traffic representation of national flow patterns.

5.2 REGIONAL PRODUCTION PATTERNS

The first approach described in Section 5.1 involved an origin/destination cross-region tabulation designed to indicate the national distribution of the origins of truck shipments of chemical and petroleum products from manufacturing plants. The results of this analysis indicate that the truck activity is highly concentrated for petroleum products. The truck shipments of domestic production transported by truck from production plants were concentrated in a few regions and the regional totals were dominated by intra-regional shipments. Conversely, the truck shipments of chemical products tended to be dispersed across the nation and were fairly evenly distributed between intra-region and inter-region trips.

TABLE 5-1. SHIPMENT TONNAGE DISCREPANCIES BETWEEN NATIONAL TOTALS AND REGIONAL O/D FLOWS

TCC CODE		NATIONAL SHIPMENT TOTALS	STATE-TO-STATE O/D FLOWS	BEA-TO-BEA O/D FLOWS
			(1000 Tons)	
28	Chemical Products	152,742	148,252 (97.1%)	148,605 (97.3%)
28128	Chlorine	735	428 (58.2%)	---
28151	Cyclic Intermediates From Benzene	4,136	2,853 (69.0%)	---
28193	Sulfuric Acid	13,838	611 (4.4%)	---
28198	Anhydrous Ammonia	2,799	1,193 (42.6%)	---
28921	Explosives	772	142 (18.4%)	---
29	Petroleum Products	249,490	175,671 (70.4%)	169,546 (67.9%)
29111	Gasoline & Jet Fuel	40,594	22,278 (54.9%)	---
29121	Liquified Petroleum and Coal Gases	4,913	3,495 (71.1%)	---

Notes:

National totals for 2 digit groups from Table 3-1
National totals for 5 digit groups from Table 3-2
State-to-State totals from 1977 CTS public use tape
BEA-to-BEA totals from TSC special CTS tape

Table 5-2 lists the twenty-two regions (into which the 48 states were grouped) ordered by total tons of chemical products originated by truck (column 1). The percent of the national total represented by this data file is shown for each region (column 2). The last two columns indicate the intra-region tons in absolute terms and as a percent of the total originated tons.

The top five regions accounted for 52 percent of the total truck originations of chemical products. The intra-region shares of the region totals ranged from 51 percent to 66 percent for four of the top five regions. The fourth placed region (California and Nevada) shows that 93 percent of the total was intra-region shipping.

Table 5-3 lists the twenty-two regions ordered by total tons of petroleum products originated by truck. The top three regions accounted for 66 percent of the national total originations of petroleum products. The top five regions accounted for 78 percent of the total. The intra-region shares of their respective totals ranged between 86 and 98 percent in the top three regions and between 55 and 100 percent in the top ten, with one exception: The fourth placed region shows only 33 percent intra-region activity. This concentration of intra-regional truck activity in petroleum products was suggested in Section 3 by the relatively short average haul distance. Table 3-1 indicated that the average haul for petroleum products was 111 miles, in contrast to 271 miles for chemical products.

In interpreting the regional patterns of originating shipments of chemical and petroleum products by truck, the total volumes transported by other modes should also be considered as an influencing factor. Up to this point, the discussion has been restricted to only the regional volumes of transport by truck while other modes (e.g., pipelines and waterways, which were the primary modes for petroleum products from plants) have been excluded. For example, Louisiana and Texas (regions 14 and 15) originated 42 percent of the national total shipment tons, but their combined tonnage by truck was only 6 percent of the national total by truck. Table 5-4 shows the national aggregate modal distribution of chemical and petroleum products in shipment tons originated from plants. It indicates that trucks played a greater role in the transport of chemical products than in the transport of petroleum products from domestic plants. Pipeline and water dominated the petroleum products transport of

TABLE 5-2. REGIONAL DISTRIBUTION OF CHEMICAL PRODUCTS TRANSPORTED BY TRUCK (DOMESTIC PRODUCTION FROM PLANTS ONLY)

REGION	STATES	ORIGINATED TONS (1000)	% OF NATIONAL TOTAL TONS	INTRA-REGION TONS (1000)	% OF ORIGINATED TONS
3	N.York, Penn., N.Jersey, Del.	17,467	11.8	9,120	52.2
9	Illinois, Indiana, Ohio	17,005	11.5	9,105	53.5
15	Texas	16,417	11.1	10,870	66.2
21	California, Nevada	13,821	9.3	12,893	93.3
4	Maryland, Vir., W.Vir., N.Car.	12,867	8.7	6,591	50.8
14	Louisiana	12,302	8.3	4,392	35.7
10	Michigan	11,218	7.6	3,969	35.4
5	S.Carolina, Georgia	7,896	5.3	4,798	60.8
8	Kentucky, Tennessee	7,440	5.0	2,787	37.5
6	Florida	6,837	4.6	5,706	83.5
7	Alabama, Mississippi	5,448	3.7	3,084	56.6
2	Ver., N.Ham., Mass., Conn., R.I.	4,456	3.0	2,374	53.3
13	Missouri, Arkansas	3,487	2.4	878	25.2
16	Kansas, Oklahoma	2,966	2.0	976	32.9
22	Oregon, Washington	2,487	1.7	1,994	80.2
19	Utah, Colorado	2,096	1.4	979	46.7
18	Montana, Idaho, Wyoming	1,253	0.8	247	19.7
20	Arizona, New Mexico	1,183	0.8	801	67.7
11	Wisconsin	874	0.6	282	32.3
12	Minnesota, Iowa	586	0.4	242	41.3
17	Nebraska, N.Dakota, S.Dakota	145	0.1	10	6.8
1	Maine	--	0.0	--	0.0
TOTAL		148,250	100.0	82,098	55.4

TABLE 5-3. REGIONAL DISTRIBUTION OF PETROLEUM PRODUCTS TRANSPORTED BY TRUCK (DOMESTIC PRODUCTION FROM PLANTS ONLY)

REGION	STATES	ORIGINATED TONS (1000)	% OF NATIONAL TOTAL TONS	INTRA-REGION TONS (1000)	% OF ORIGINATED TONS
3	N.York, Penn., N.Jersey, Del.	40,449	23.0	38,019	94.0
9	Illinois, Indiana, Ohio	38,447	21.9	35,274	86.0
21	California, Nevada	36,912	21.0	36,044	97.6
16	Kansas, Oklahoma	11,215	6.4	3,684	32.8
8	Kentucky, Tennessee	10,363	5.9	7,361	71.0
15	Texas	8,988	5.1	7,021	78.1
13	Missouri, Arkansas	8,328	4.7	4,590	55.1
22	Oregon, Washington	6,305	3.6	6,290	99.8
10	Michigan	4,187	2.4	2,853	68.1
2	Ver., N.Ham., Mass., Conn., R.I.	3,530	2.0	3,354	95.0
7	Alabama, Mississippi	3,062	1.7	627	20.5
14	Louisiana	1,972	1.1	1,085	55.3
18	Montana, Idaho, Wyoming	1,763	1.0	1,419	80.5
19	Utah, Colorado	120	0.1	75	62.1
4	Maryland, Vir., W.Vir., N.Car.	29	0.0	--	0.0
1	Maine	--	0.0	--	0.0
5	S.Carolina, Georgia	--	0.0	--	0.0
6	Florida	--	0.0	--	0.0
11	Wisconsin	--	0.0	--	0.0
12	Minnesota, Iowa	--	0.0	--	0.0
17	Nebraska, N.Dakota, S.Dakota	--	0.0	--	0.0
20	Arizona, New Mexico	--	0.0	--	0.0
TOTAL		175,670	100.0	147,696	84.1

Source: 1977 CTS, National Summary

TABLE 5-4. SHIPMENT TONS BY MODE FROM MANUFACTURING ESTABLISHMENTS

MODE OF TRANSPORT	**CHEMICAL PRODUCTS (1000 Tons)**	**PETROLEUM PRODUCTS (1000 Tons)**
TRUCK	152,743 (47.2%)	249,489 (25.0%)
RAIL	107,602 (33.3%)	67,495 (6.8%)
PIPELINE	35,059 (10.8%)	426,422 (42.7%)
WATER	23,215 (7.2%)	236,393 (23.7%)
OTHER & UNKNOWN	4,680 (1.5%)	17,932 (1.8%)
TOTAL	323,299 (100.0%)	997,731 (100.0%)

Source: 1977 CTS National Summary

domestic production with 66 percent of the total shipment tons. Truck was the dominant mode of transport for chemical products with a 47 percent share of the national total, compared to the 33 percent share of the rail mode.

The above observations are somewhat uncertain because of the data deficiencies noted earlier, particularly the 30 percent of the national total petroleum products (TCC 29) shipment tons missing from the state-to-state o/d flow files, as indicated in Table 5-1. It is not clear how truck flow patterns of petroleum products would differ if a larger portion of the total traffic were represented by these o/d data files.

5.3 REGIONALLY GENERATED AND REGIONAL PASS-THROUGH TRAFFIC

The second approach described in Section 5.1 involved assigning domestic production o/d flows to an abstract highway network to identify not only regionally originated but regionally terminated as well as regional pass-through traffic. It also added truck movements from regional storage facilities. The results of this analysis show that when all these traffic flows are accumulated for each region, the pass-through traffic was about 19 percent of the total traffic from plants on average, and it dropped to 8 percent when the traffic from regional storage facilities was added to the total. It goes without saying that there was substantial variation among regions.

Table 5-5 sums the truck traffic from plants and the traffic from regional storage facilities. The 22 regions were ordered by regional total tons of the aggregate of chemical and petroleum products. The traffic from regional storage was allocated using regional petroleum consumption rates derived from DOE statistics and regional fleet ton-miles distribution derived from TIUS. Appendix G documents the sources and the details of the calculation of regional shipment tons of products from production plants and from regional storage facilities. This somewhat imperfect aggregation was based on the assumption that all shipments from the regional storage facilities were intra-region distribution. The pass-through traffic was generated by shipments from plants and was routed over the highway network. The pass-through (or externally generated) traffic is presented in ton-miles and as a percent of total regional traffic. Figure 5-2 graphically displays the total tons of chemical and petroleum products

TABLE 5-5. REGIONAL PASS-THROUGH TRAFFIC AS PERCENT OF REGION TOTAL - CHEMICAL AND PETROLEUM PRODUCTS FROM PLANTS AND FROM REGIONAL STORAGE

REGION	REGION TOTAL TONS (1000)	REGION PASS-THRU TONS (1000)	REGION PASS-THRU PERCENT OF TONS	REGION TOTAL TON-MILES (1000)	REGION PASS-THRU TON-MILES (1000)	REGION PASS-THRU PERCENT OF TON-MILES
3	244,700	6,326	2.6	12,310,201	768,221	6.2
21	137,445	74	0.0	6,847,905	11,620	0.2
9	129,256	9,822	7.6	11,505,677	2,623,903	22.8
4	125,181	18,366	14.7	6,985,244	1,670,903	23.9
15	89,517	874	0.9	6,630,396	575,610	8.7
2	70,700	2,783	3.9	2,975,366	176,031	5.9
5	62,642	9,322	14.9	4,473,132	1,428,355	31.9
7	47,198	13,967	29.6	4,111,233	1,892,250	46.0
13	47,052	8,068	17.1	3,334,120	1,113,480	33.4
14	46,906	7,352	15.7	2,687,433	791,514	29.4
6	46,799	26	0.0	2,343,691	2,369	0.1
10	43,026	1,381	3.2	2,496,023	292,940	11.7
12	41,648	2,086	5.0	2,305,878	537,781	23.3
16	38,942	2,906	7.5	4,220,213	839,845	19.9
8	36,230	3,761	10.4	2,906,494	936,164	32.2
22	33,052	20	0.1	1,570,643	2,118	0.1
19	21,433	3,930	18.3	2,023,192	894,000	44.2
20	17,796	1,479	8.3	1,368,645	669,958	49.0
18	17,605	5,549	31.5	2,308,879	1,643,706	71.2
17	16,021	4,297	26.8	1,390,388	941,730	67.7
11	13,568	0	0.0	484,488	0	0.0
1	6,656	0	0.0	258,400	0	0.0
TOTAL	1,333,373	102,389	7.7	85,537,642	17,812,498	20.8

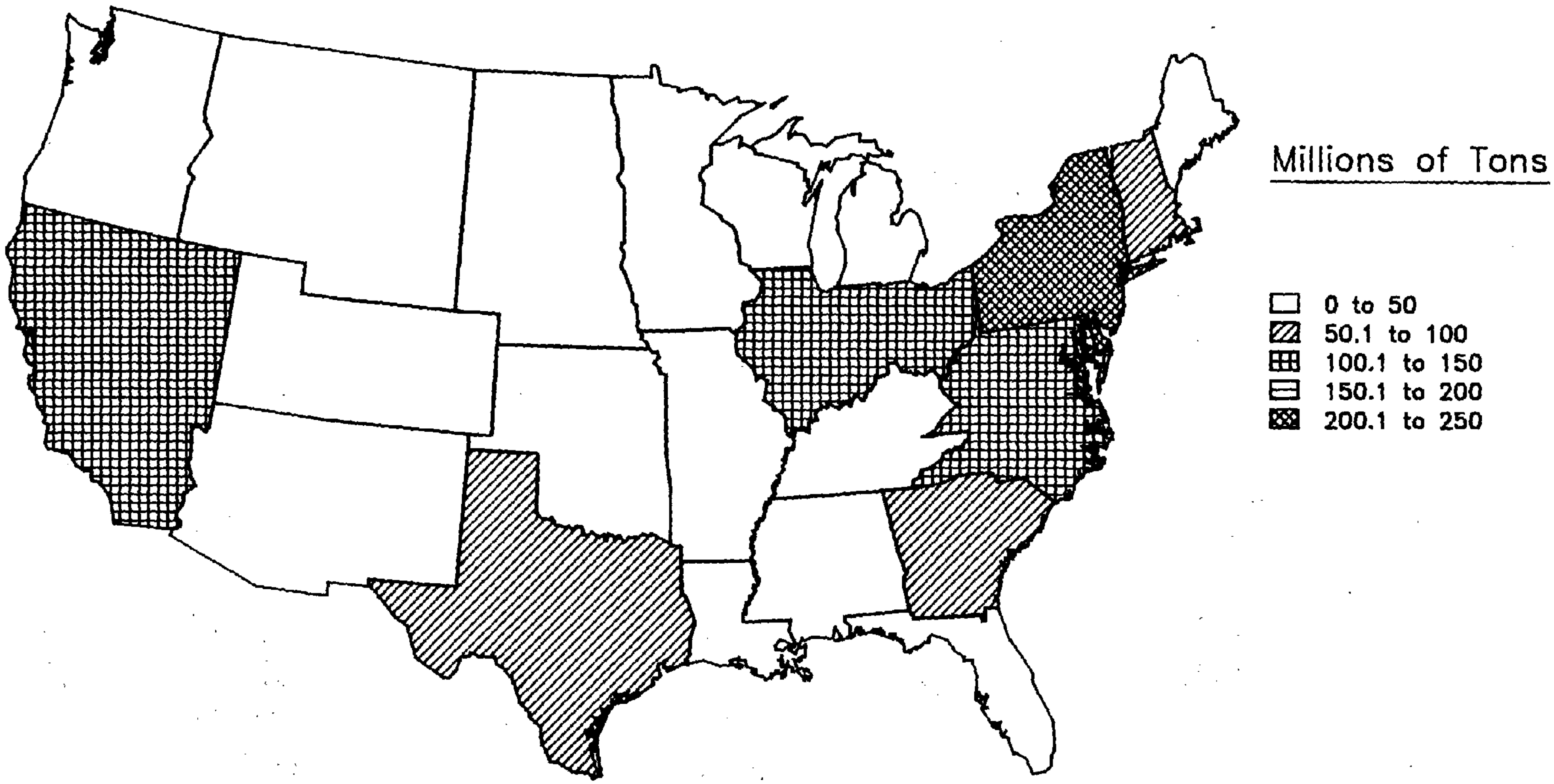


FIGURE 5-2. REGIONAL TOTAL SHIPMENT TONS OF CHEMICAL AND PETROLEUM PRODUCTS BY TRUCK

originated within each of the 22 regions. Although this is not perfect, it displays the relative magnitude of the traffic that was not internally generated by the regional economy. It is believed to be an adequate representation of the real traffic distribution patterns. Table 5-5 displays five additional columns of statistics: tons of pass-through traffic, pass-through tons as percent of regional total, total ton-miles generated within the region, ton-miles of pass-through traffic, and pass-through ton-miles as percent of regional total. Figure 5-3 graphically displays the truck pass-through traffic in each of the twenty-two regions as a percent of the regional total truck tonnage. Figure 5-4 shows the parallel pass-through as a percentage of total regional ton-miles. The longer hauls across a region of the pass-through traffic increases its percentage share of the regional total when measured in ton-miles.

Several observations may be made from the results. The percent of pass-through tons out of a region's total tonnage varied between 0 and 31 percent, with a weighted national average of 8 percent. The three regions responsible for the highest pass-through percentages - region 17 (Nebraska, North Dakota and South Dakota) with 27 percent; region 7 (Alabama and Mississippi) with 30 percent; and region 18 (Montana, Idaho and Wyoming) with 31 percent - had rather low levels of total regional traffic. Together they represented approximately 6 percent of the national total shipment tons of chemical and petroleum products by truck. If ton-miles are a more significant measure of exposure on the regions' highways, then the longer distances covered by the pass-through traffic within the region inflate the pass-through traffic's importance. The percent of a region's total ton-miles that were pass-through ranges between 0 and 71 percent, with a weighted national average of 21 percent.

Table 5-6 shows the same ordering of the 22 regions as in Table 5-5, but it segregates the regionally generated traffic (i.e., shipment origin or destination, or both, within the region) from the pass-through traffic (i.e., shipment origin and destination outside the region but routed over highways within the region). The regionally generated tons plus the regional pass-through tons in Table 5-6 equal the regional total tons in Table 5-5. The shipment tons are derived from the CTS o/d flow data and are counted in each region en route, so that multiple counting is present in the national totals. The ton-miles are the

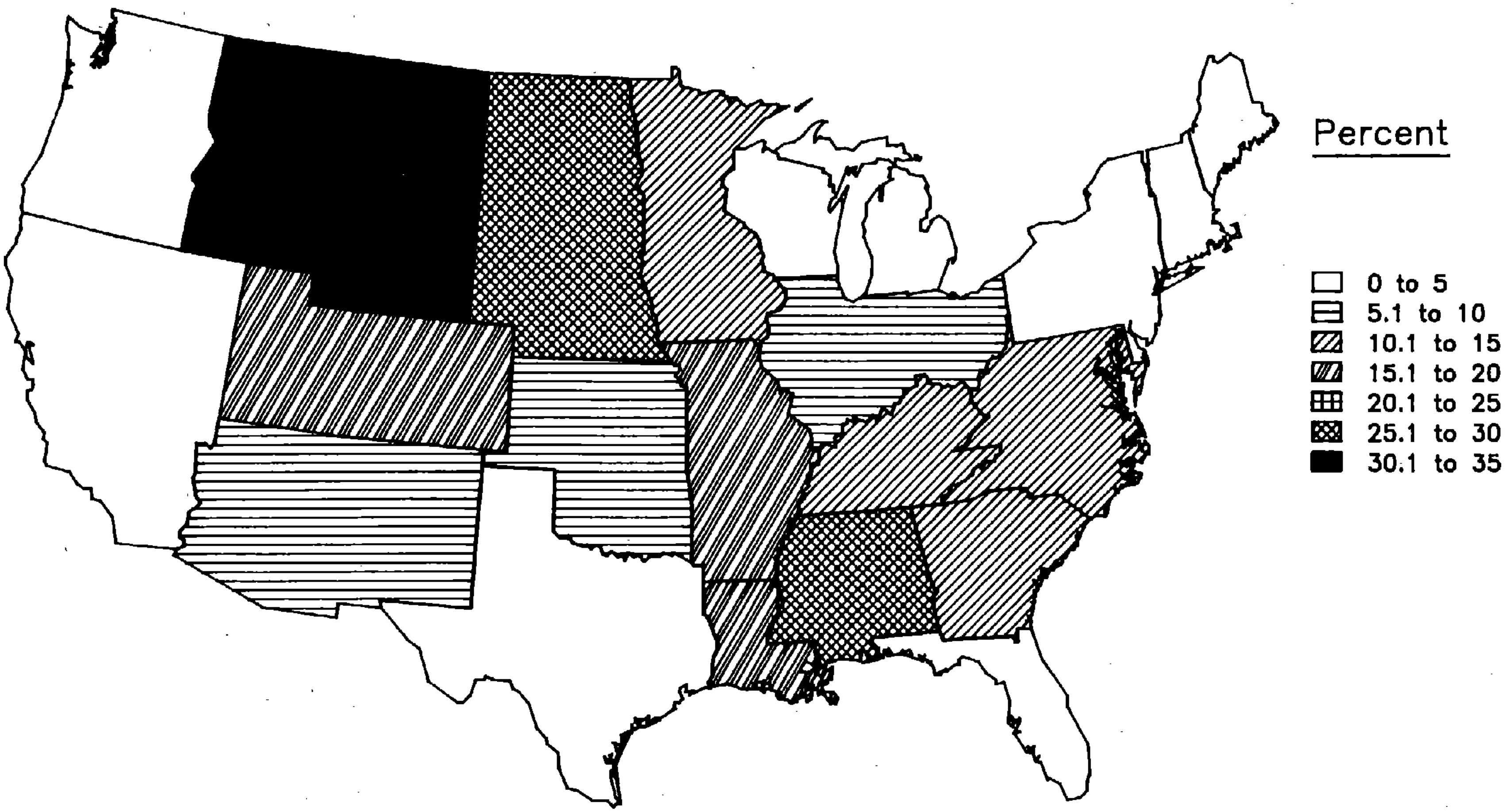


FIGURE 5-3. TRUCK PASS-THROUGH TRAFFIC AS A PERCENT OF REGIONAL TOTAL TONS

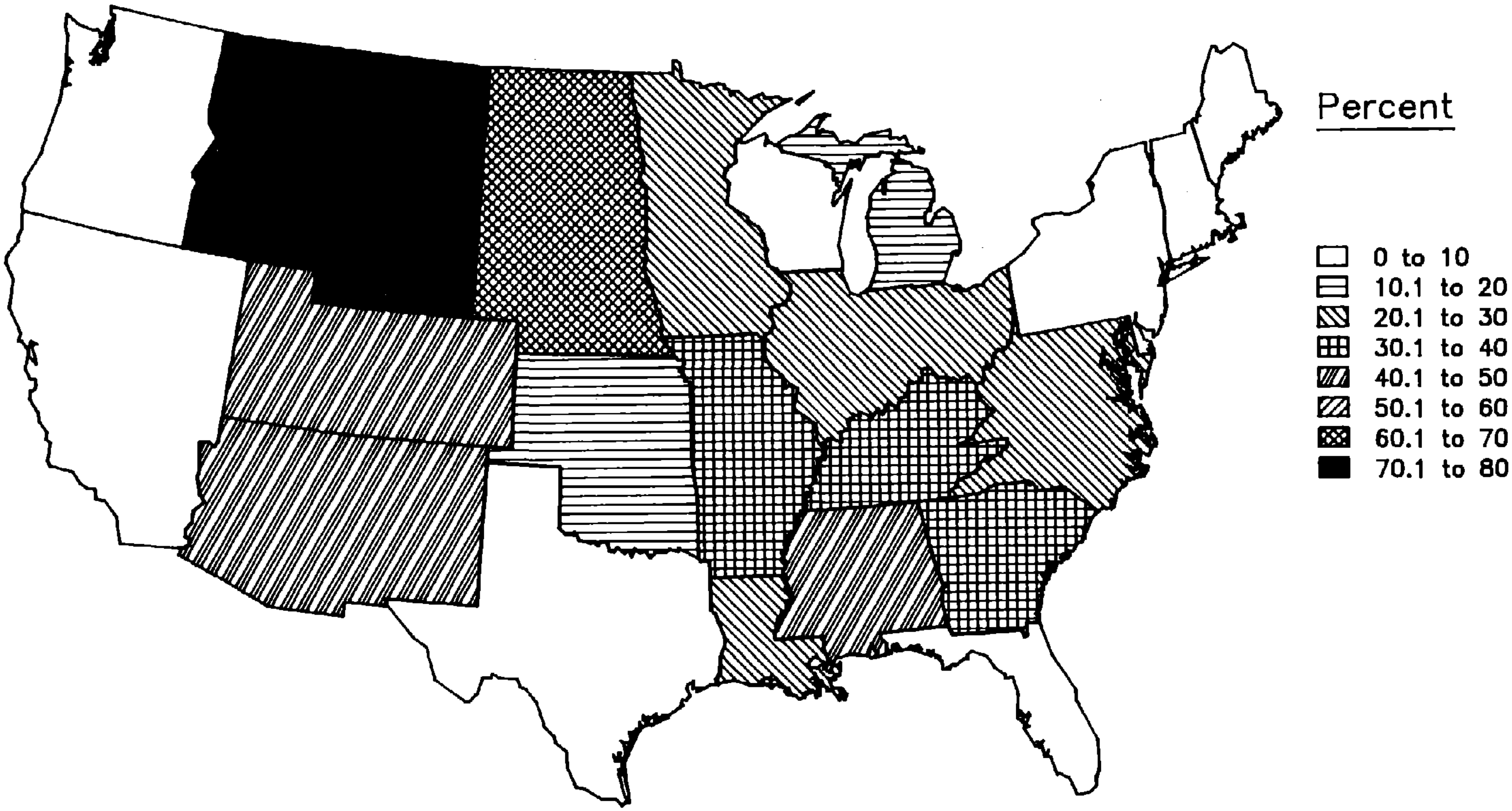


FIGURE 5-4. TRUCK PASS-THROUGH TRAFFIC AS A PERCENT OF REGIONAL TOTAL TON-MILES

TABLE 5-6. AVERAGE HAUL DISTANCE OF REGIONALLY GENERATED AND PASS-THROUGH TRAFFIC - CHEMICAL AND PETROLEUM PRODUCTS FROM PLANTS AND FROM REGIONAL STORAGE

REGION	REGIONALLY GENERATED TRAFFIC			REGION PASS-THROUGH TRAFFIC		
	REGION TOTAL TONS (1000)	**REGION TOTAL TON-MILES (1000)**	**REGION AVERAGE HAUL (Miles)**	**REGION PASS-THRU TONS (1000)**	**REGION PASS-THRU TON-MILES (1000)**	**PASS-THRU AVERAGE HAUL (Miles)**
3	238,374	11,541,980	48	6,326	768,221	121
21	137,371	6,836,285	50	74	11,620	157
9	119,434	8,881,774	74	9,822	2,623,903	267
4	106,815	5,314,341	50	18,366	1,670,903	91
15	88,643	6,054,786	68	874	575,610	658
2	67,917	2,799,335	41	2,783	176,031	63
5	53,320	3,044,777	57	9,322	1,428,355	153
7	33,231	2,218,983	67	13,967	1,892,250	135
13	38,984	2,220,640	57	8,068	1,113,480	138
14	39,554	1,895,919	48	7,352	791,514	108
6	46,773	2,341,322	50	26	2,369	91
10	41,645	2,203,083	53	1,381	292,940	212
12	39,562	1,768,097	45	2,086	537,781	258
16	36,036	3,380,368	94	2,906	839,845	289
8	32,469	1,970,330	61	3,761	936,164	249
22	33,032	1,568,525	47	20	2,118	106
19	17,503	1,129,192	64	3,930	894,000	227
20	16,317	698,687	43	1,479	669,958	453
18	12,056	665,173	55	5,549	1,643,706	296
17	11,724	448,658	38	4,297	941,730	219
11	13,568	484,488	36	0	0	--
1	6,656	258	39	0	0	--
TOTAL	1,230,984	67,725,144	55	102,389	17,812,498	174

product of the routed tons and the route miles covered in each region, as calculated by the HTFS model. The totals cannot agree with those in Section 3 because of the different levels of detail and methods of calculation. However, the regional average hauls which were the objective of this table appear generally consistent with those shown in Section 3. The average hauls of the regionally generated traffic were very short, ranging between 36 and 94 miles. The weighted national average was 55 miles. The average hauls of the pass-through traffic within a region's boundaries were considerably longer, ranging between 91 and 658 miles. The weighted national average was 174 miles.

Examination of Tables 5-5 and 5-6 together reveals that even the pass-through traffic was relatively short haul, probably moving between two regions immediately adjacent or very close to the region being examined. The longest hauls were generated by very small portions of the traffic. For example, the longest average haul for pass-through traffic was 659 miles in region 15 (Texas), which shows less than 1 percent of its regional total tons was pass-through. The second longest average haul for pass-through traffic was 453 miles in region 20 (Arizona and New Mexico), which shows 8 percent of its regional total tons was pass-through.

5.4 MAPPING HIGHWAY CORRIDORS

The third approach produced maps of highway corridor traffic volumes for selected disaggregations of the chemical and petroleum products. The o/d commodity flow data supported two categories of disaggregation. The first category involved estimation of the route tonnage for chemical products and petroleum products transported in combination trucks (semi-trailer or doubles). Three groups were isolated: a) bulk shipments of chemical products transported in tank combinations, b) bulk shipments of petroleum products in tank combinations, and c) packaged, mixed, small shipments transported in other than tank body combinations. Table 5-7 lists these groups and shows the percent of the national total tonnage represented by the maps. Since the emphasis of the maps is on displaying inter-BEA traffic, the table indicates that 64 percent of the chemical products shipped in bulk, 90 percent the petroleum products shipped in bulk and 93 percent the packaged, mixed, small shipments were represented

TABLE 5-7. HIGHWAY CORRIDOR MAP REPRESENTATION OF NATIONAL TOTAL FLOWS

	NATIONAL SHIPMENT TONS[3] (1000)	BEA-TO-BEA O/D FLOW TONS[4] (1000)	PERCENT[5] IN COMB. TRUCK	BEA-TO-BEA O/D FLOW TONS[6] IN COMB. TRUCK (1000)
Bulk Shipments[1] Chemical Prod.				
Intra-BEA	---	35,234	11.6	4,087[7]
Inter-BEA	---	70,372	63.8	44,897[7]
Total	108,536	105,606	46.4	48,984[7]
Bulk Shipments[1] Petroleum Prod.				
Intra-BEA	---	74,036	36.8	27,245[7]
Inter-BEA	---	40,826	89.5	36,53[7]
Total	163,777	114,862	55.5	63,784[7]
Mixed Small Shipments[2]				
Intra-BEA	---	62,645	65.6	41,095[8]
Inter-BEA	---	35,038	93.3	32,690[8]
Total	129,915	97,683	75.5	73,785[8]

Notes:

1 Equal to or greater than 10,000 pounds.
2 Less than 10,000 pounds and shipments of unknown size of chemical or petroleum products.
3 1977 CTS, National Summary, Table 7.
4 1977 CTS/TSC BEA-to-BEA 2 Digit Commodity O/D Data File.
5 1977 TIUS Survey truck use pattern by truck type and area of operation.
6 BEA-to-BEA flow tons x percent in combination trucks.
7 Tank combination trucks.
8 Non-tank combination trucks.

on the maps. Table 5-7 also indicates that 92 percent of the bulk shipments of chemical products tons transported in the dominant truck type (i.e., tank combinations) were shipped between BEAs, whereas 57 percent of the bulk petroleum tons transported in tank combinations were inter-BEA shipment. Only 44 percent of the packaged, mixed, small shipments were inter-BEA. The actual percentage may have been even lower, because the shipments of unknown weight were also included in this category. The remainder in each group was intra-BEA traffic. Table 5-7 shows that high volumes of intra-BEA flows, in which combinations play a significantly lesser role than do single units, lowered the combination's share of the total for all three groups.

The CTS tonnage was allocated to the vehicle types in accordance with the percent distribution of fleet capacity as revealed by the TIUS. Three variables of the TIUS data file were used to develop the percent distributions: area of operation, vehicle class and body type. Specifically, three areas of operation (local or under 50 miles, over-the-road less than 200 miles, and over-the-road greater than 200 miles), two vehicle classes (single units and combinations) and two body types (tank and all other) were used.

The second category of disaggregation involved mapping commodity groups, without any truck type distinction, at the finest level of product detail that the data would support. Ten 3, 4, and 5-digit commodity groups had sufficient o/d flow data to justify plotting. Table 5-8 lists the commodity groups and shows the percent of the national total tonnage that could be represented by the maps, as well as the number of o/d pairs represented.

The state-to-state o/d flow data has been shown to be the most complete, but the origin and destination points within states were unknown. For small states this would not matter for the purpose of discerning broad regional distribution patterns, but traffic assignment onto highway corridors into and out of a few large states could be grossly misrepresented if a single point within the state were selected as the network origin/destination node point. The distribution patterns of the BEA-to-BEA 2-digit commodity o/d data file were used to distribute the state-to-state flows among BEAs within states. The centroid city of each BEA was matched with the nearest network node for subsequent assignment of the o/d flows to network paths. Therefore, all highway

TABLE 5-8. HIGHWAY CORRIDOR MAP REPRESENTATION OF NATIONAL TOTAL FLOWS OF SPECIFIC COMMODITY GROUPS

TCC CODE	COMMODITY	NATIONAL SHIPMENT TONS[3] (1000)	STATE-TO-STATE O/D FLOW TONS[4] (1000)	PERCENT[5] NATIONAL SHIPMENT TONS	NUMBER OF COMBINED TWO-WAY BEA PAIRS
281	Industrial Inorganic and Organic Chemicals	109,370	75,547	88.5	4,216
2812	Potasium, Sodium or Basic Inorganic Compounds	8,939	7,055	78.9	2,212
28128	Chlorine	736	428	52.8	250
28151	Cyclic Intermediates of Benzene	4,136	2,853	70.0	951
28192	Nitric Acid	794	580	73.0	473
28198	Anhydrous Ammonia	2,799	1,193	42.6	300
289	Miscelaneous Chemical Products	16,570	10,194	61.5	3,385
291	Products of Petroleum Refining	109,370	75,547	69.1	803
29111	Gasoline and Jet Fuel	40,594	22,278	54.9	299
29121	Liquified Petroleum and Coal Gases	4,913	3,495	71.1	324

corridors in this section represent an allocation of state level data to network nodes and subsequent assignment to one of many alternative highway routes connecting each pair of o/d nodes. The network link flows represent the sum of the flows in both directions on each route. The volume scales are equal on each of the first category of maps, but the volume scales of the second category of maps vary by commodity group because of the large volume variation among the groups. The intra-BEA flows are represented by open circles centered on the appropriate nodes, at a scale equal to that used for the link flows. In some cases the intra-BEA flow is substantial and can be readily observed on the maps, but in others it is too small to be seen.

Since these maps show only the flows from plants, as defined by the CTS data, and do not show the large volumes of traffic from regional storage facilities, the plotted circles under-represent the short-haul intra-BEA truck activity. The link flows shown represent varying percentages of the actual total flows. Figures 5-5 and 5-6, for example, are estimated to include 64 percent of the bulk shipments of chemicals and 90 percent of the bulk shipments of petroleum products in over-the-road operations of combination trucks. Figure 5-7 on the other hand is estimated to show 93 percent of the actual over-the-road packaged, mixed, small shipments (plus the shipments of unknown size) of chemical and petroleum products.

Within each category of disaggregation, complementary pairs of maps were prepared for each commodity group. The first map of each pair shows the total link loading of each specified commodity group assigned to that network's links. The second map of each pair isolates only that portion of the total link loads attributable to flows between points within the BEA region and points in immediately adjacent BEA areas. Traffic to and from points beyond the adjacent BEAs were deleted from this plot. Table 5-9 shows that the distribution of ton-miles of bulk and packaged chemical and petroleum products in combination trucks was heavily oriented toward shipments between BEAs that are not immediately adjacent to each other. Only the bulk petroleum shipments showed a substantial portion of the total moving between immediately adjacent BEAs, and even this traffic was only 23 percent of the total of the group.

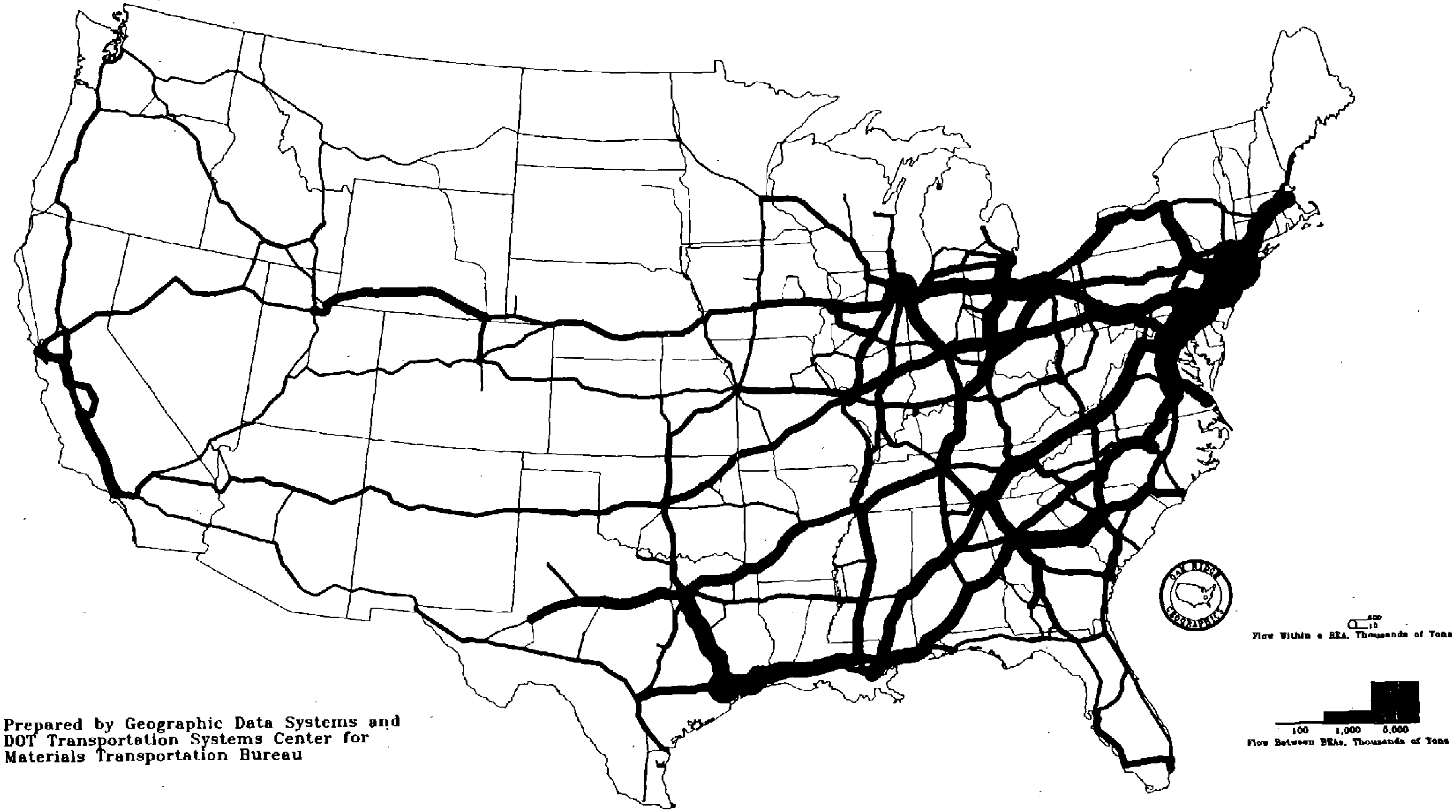


FIGURE 5-5. HAZARDOUS MATERIALS TRUCK TRAFFIC - ALL TRAFFIC FROM PLANTS - BULK SHIPMENTS OF CHEMICAL PRODUCTS IN COMBINATION TANK TRUCKS (TCC 28)

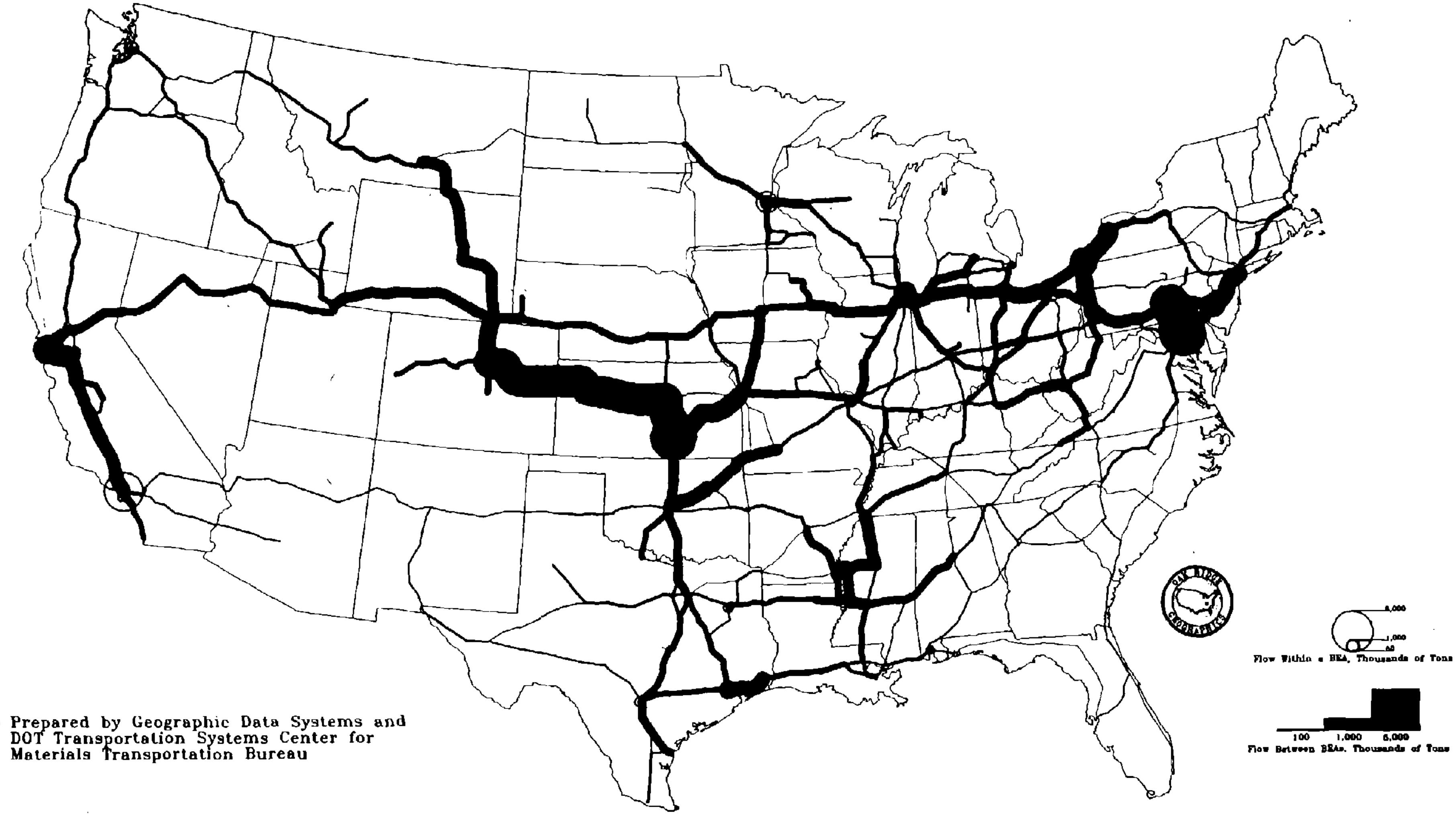


FIGURE 5-6. HAZARDOUS MATERIALS TRUCK TRAFFIC - ALL TRAFFIC FROM PLANTS - BULK SHIPMENTS OF PETROLEUM PRODUCTS IN COMBINATION TANK TRUCKS (TCC 29)

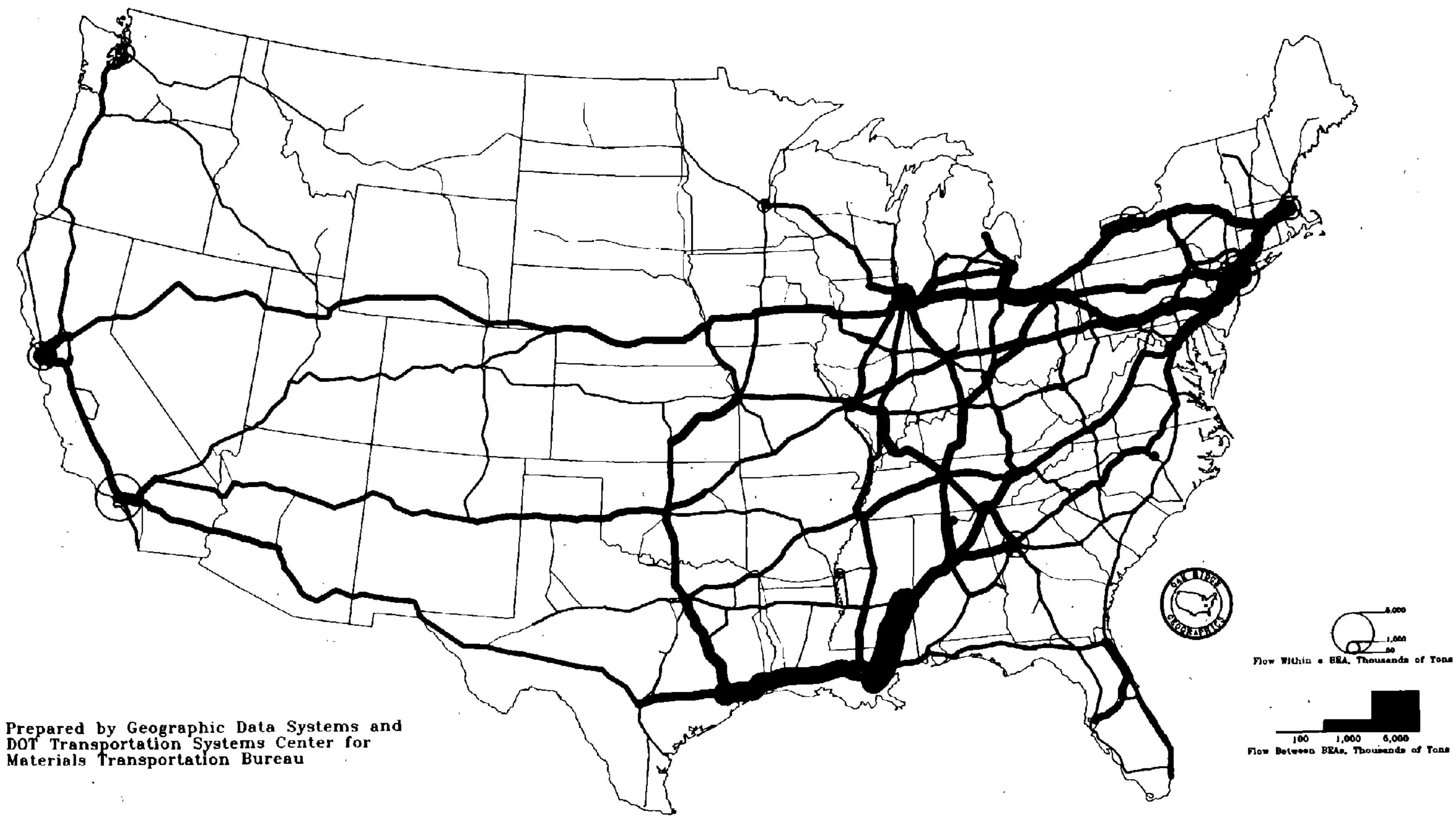


FIGURE 5-7. HAZARDOUS MATERIALS TRUCK TRAFFIC - ALL TRAFFIC FROM PLANTS - MIXED PACKAGED SHIPMENTS OF CHEMICAL AND PETROLEUM PRODUCTS IN NON-TANK COMBINATION TRUCKS (TCC 28 AND 29)

TABLE 5-9. HIGHWAY CORRIDOR MAP REPRESENTATION OF FLOWS BETWEEN ADJACENT BEAs AND NONADJACENT BEAs

	BEA-TO-BEA O/D FLOW[3] TON-MILES (1000)	PERCENT[4] BY AREA OF OPERATION	BEA-TO-BEA O/D FLOW TON-MILES[5] IN COMB. TRUCKS (1000)	PERCENT[6] BY AREA OF OPERATION
<u>Bulk Shipments[1] Chemical Prod.</u>				
Intra-BEA	1,131,965	4	131,308	1
Inter-Adjacent BEA	---	9	---	9
Inter-Non-Adjacent BEA	---	87	---	90
Total	28,756,110	100	17,755,513	100
<u>Bulk Shipments[1] Petroleum Prod.</u>				
Intra-BEA	1,885,252	13	693,773	6
Inter-Adjacent BEA	---	22	---	23
Inter-Non-Adjacent BEA	---	65	---	71
Total	15,043,853	100	12,470,720	100
<u>Mixed Small Shipments[2]</u>				
Intra-BEA	1,131,374	8	742,181	6
Inter-Adjacent BEA	---	5	---	5
Inter-Non-Adjacent BEA	---	87	---	89
Total	13,761,428	100	12,526,021	100

Notes:

1 Equal to or greater than 10,000 pounds.
2 Less than 10,000 pounds and shipments of unknown size of chemical or petroleum products.
3 Intra-BEA ton-miles calculated by the FHWA/HTFS network route assignment algorithm.
4 Inter-Adjacent BEA and Inter-Non-Adjacent BEA traffic shares were directly measured from Figure 2-4.
5 Allocation per percent distribution from 1977 TIUS.
6 Same as notes 4 and 5.

Inspection of the maps for each group reveals the patterns of regional concentration of some commodities and the rather dispersed patterns of others. Directing our attention first to the transport of products in combination tank trucks, Figures 5-5 and 5-6 display patterns of chemicals and petroleum products moving in bulk shipments from plants. Figure 5-7 displays the pattern of packaged, mixed, small shipments (less than 10,000 pounds) sharing space on van or flat bed combination trucks. The first two maps display the bulk shipments in tank vehicles which are operated for the most part by specialized operators who are more experienced with the hazardous nature of these materials. The third map displays packaged, mixed, small shipments (and those shipments of unknown size) of both chemical and petroleum products loaded in vans and on flat bed combination trucks. Hazardous materials shipments and other small shipments of nonhazardous freight may be mixed during terminal handling and hauling by general commodity operator personnel less experienced with the hazardous nature of some of these shipments. Table 4-3 indicated that vans and other body types were placarded less frequently than were the tank trucks. It is not clear, from these data, whether the level of placarding of non-tank combinations is commensurate with the volumes of traffic and the broad geographical distribution of these packaged, mixed, small shipments of chemical and petroleum products. The broader and more uniform distribution of the chemical products (Figure 5-5) as compared with the petroleum products (Figure 5-6) is consistent with the comparisons of shipment average haul distances presented in Sections 3.1 and 5.2. The eastern highways in general were more heavily burdened with traffic of chemical products than were the western highways. The relative burden of chemical versus petroleum products varied substantially among the regions and states.

The flows shown on Figure 5-5 total 17.8 billion ton-miles of chemical products in combination tank trucks, while the flows on Figure 5-6 totaled 12.5 billion ton-miles of petroleum products in combination tank trucks. The chemical flows of Figure 5-5 resulted from plotting 2,804 BEA o/d pairs, while the petroleum flows of Figure 5-6 resulted from plotting 791 o/d pairs. The flows of petroleum products were very concentrated and appear to dominate the total in a few highway corridors. The importance of these concentrations will, of course, vary with the region. Extremely large highway corridor flows in the prairie states will be less of a concern than the same or lesser flow volume in a highway corridor in the more populous eastern states.

The packaged, mixed, small shipments (and shipments of unknown size) of chemical and petroleum products flows shown on Figure 5-7 totaled 12.5 billion ton-miles in non-tank trucks, which was 29 percent of the total of the combined chemical and petroleum products in combination trucks plotted in these three maps. Figure 5-7 suggests that the volume of traffic and the broad national distribution pattern of the packaged, mixed, small shipments in non-tank combination trucks perhaps deserves as much attention as the more observable bulk shipments in combination tank trucks.

In order to better expose the over-the-road, inter-BEA traffic that is essentially short haul distribution to adjacent regions rather than long haul (as might appear from the maps of Figures 5-5, 5-6 and 5-7), Figures 5-8, 5-9 and 5-10 were created. Using exactly the same o/d flow trip tables and network path assigments, a separate subtotal of network link flows was aggregated. These subtotals include network link flows of o/d pairs having one end of the trip in the BEA and one end in an immediately adjacent BEA. These maps, therefore, display the open circle centered on the originating network node representing the intra-BEA flows (as in Figures 5-5, 5-6 and 5-7) and the black flow band representing the flows between neighboring economic entities. These maps display the mid-range operations which were as short as 100-200 miles in most of the small eastern regions and as long as 200-400 miles between the large western regions.

Comparing Figures 5-8 and 5-9 with Figures 5-5 and 5-6 respectively, it appears that the flows between adjacent BEAs represent on the whole 20 to 30 percent of the total inter-BEA, over-the-road petroleum products traffic and approximately 10 percent of the the total for chemical products. This also is consistant with the average haul distance findings of Sections 3.1 and 5.2, namely that most chemical shipments from plants by truck were longer distance hauls than the petroleum shipments by truck. Comparing Figure 5-10 with 5-7, it appears that a smaller percentage of the inter-BEA packaged, mixed, small shipments of chemicals and petroleum products in combination non-tank trucks were between adjacent economic regions. Most of this type of traffic appears to have been relatively long haul.

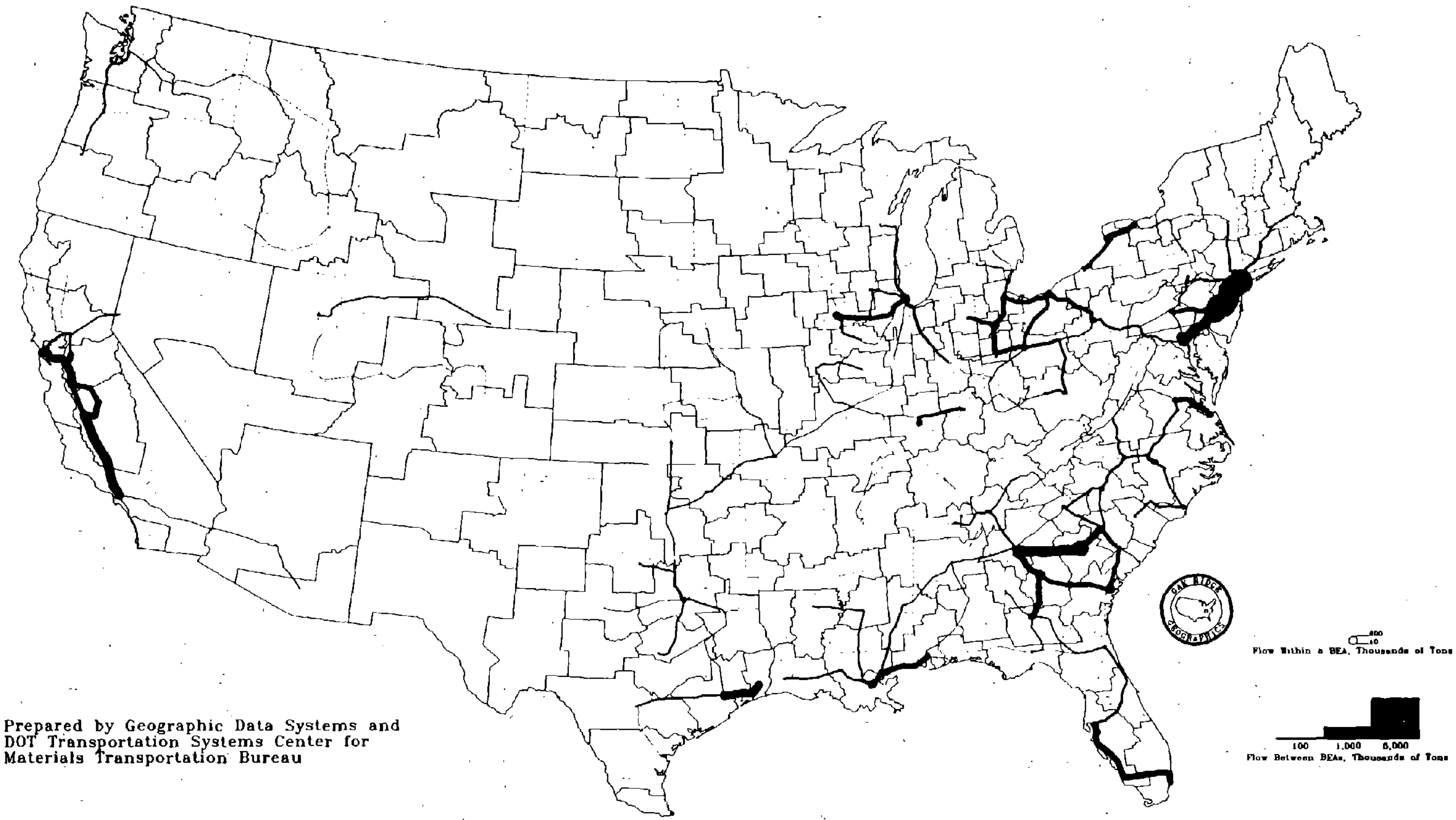


FIGURE 5-8. HAZARDOUS MATERIALS TRUCK TRAFFIC - TRAFFIC BETWEEN ADJACENT BEAs - BULK SHIPMENTS OF CHEMICAL PRODUCTS IN COMBINATION TANK TRUCKS (TCC 28).

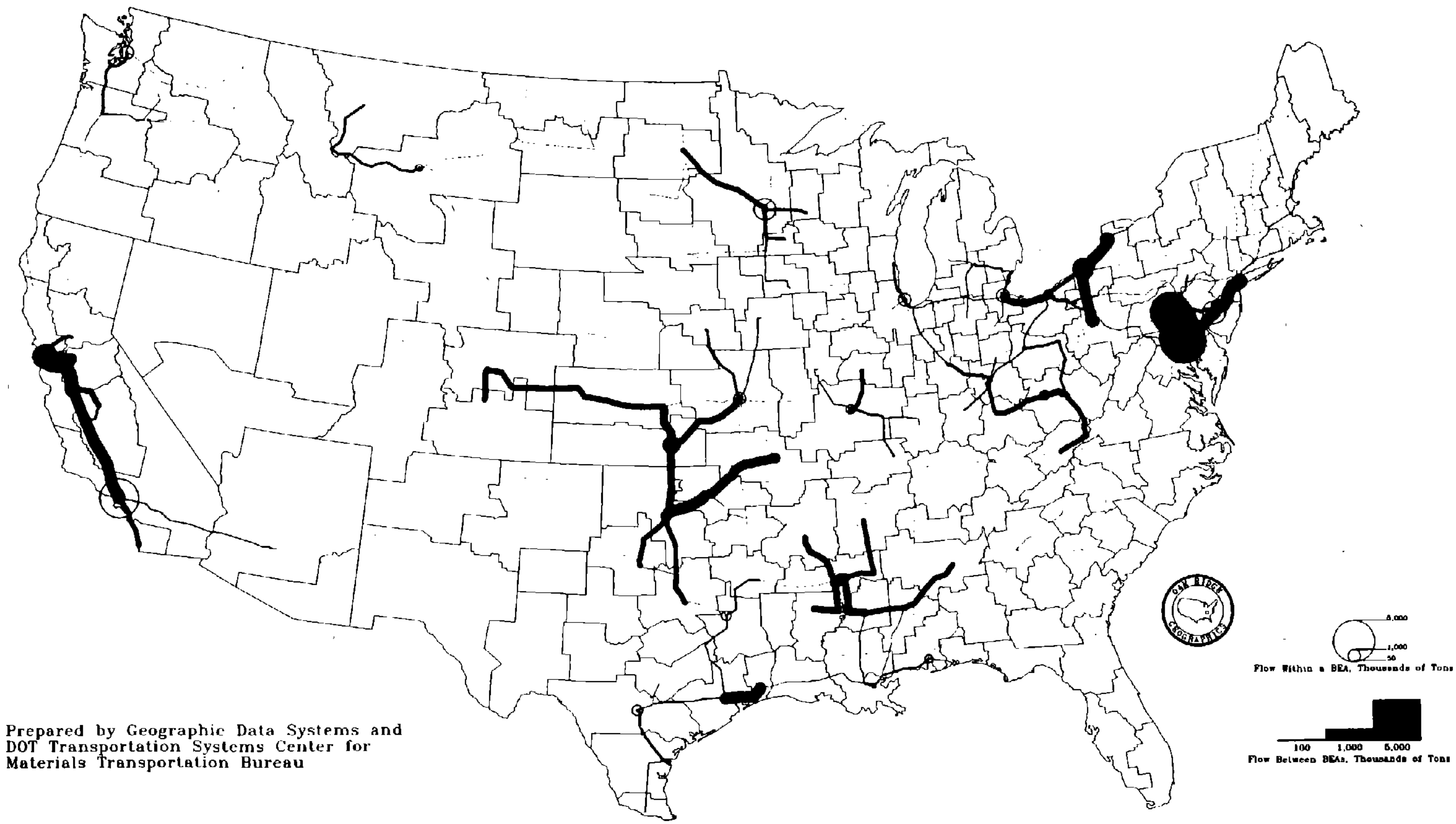


FIGURE 5-9. HAZARDOUS MATERIALS TRUCK TRAFFIC - TRAFFIC BETWEEN ADJACENT BEAs - BULK SHIPMENTS OF PETROLEUM PRODUCTS IN COMBINATION TANK TRUCKS (TCC 29)

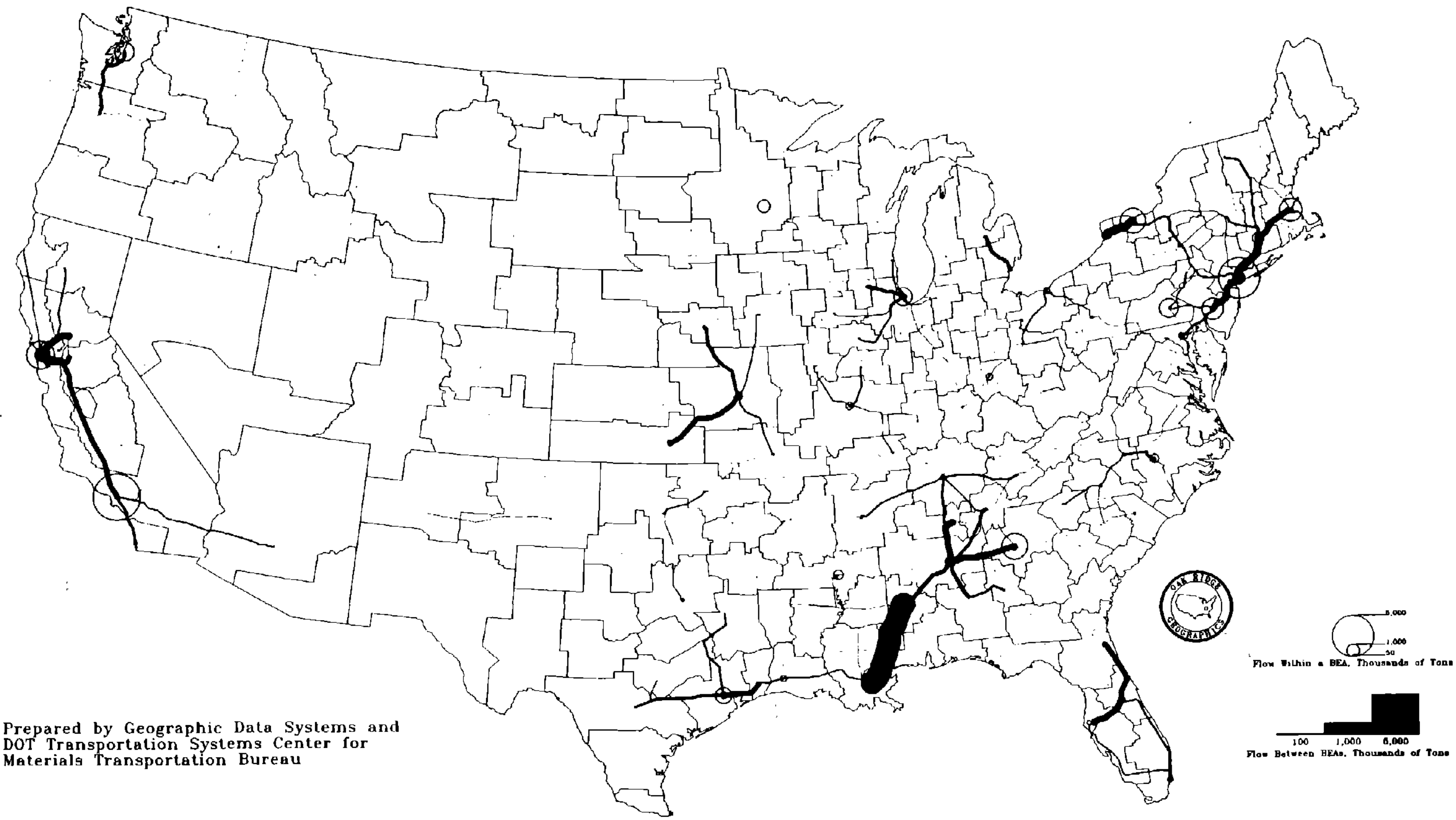


FIGURE 5-10. HAZARDOUS MATERIALS TRUCK TRAFFIC - TRAFFIC BETWEEN ADJACENT BEAs - MIXED PACKAGED SHIPMENTS OF CHEMICAL AND PETROLEUM PRODUCTS IN NON-TANK COMBINATION TRUCKS (TCC 28 AND 29)

Moving on to more detailed commodity level analysis using the second category of commodity disaggregation (Figures 5-11 through 5-20), hazardous materials flows may be examined in successive levels of detail where the data permit. Figures 5-11, 5-12, and 5-13 display the distribution patterns at three successive levels (3-digit, 4-digit and 5-digit) of one group of chemical products. Figure 5-13 displays chlorine (TCC 28128) as a subset of TCC 2812 displayed on Figure 5-12 that, in turn, is a subset of TCC 281 displayed on Figure 5-11. Note that the volume scale of Figure 5-13 is 20 times that of Figure 5-12 which, in turn, is 5 times that of Figure 5-11. Examining Figures 5-11, 5-12 and 5-13 in sequence, it can be seen that the flows became more concentrated as the total volume of the commodity group decreased. Chlorine tended to show heavy flows in fewer traffic lanes than did its parent group. Figure 5-14 for cyclic intermediates of benzene (TCC 28151), Figure 5-15 for nitric acid (TCC 28192) and Figure 5-16 for anhydrous ammonia (TCC 28198) support the observation that greater specificity of the product group reduces the number of regions and highway routes involved. Figure 5-17 displays a catch-all commodity group for products not classified elsewhere, "Miscellaneous Chemical Products" (TCC 289). The volume scale for Figure 5-17 is 5 times that of Figure 5-11. As on Figure 5-11, there appears to have been broad geographical involvement of this 3 digit group, although the volumes were considerably lower.

Figures 5-18, 5-19 and 5-20 show similar patterns. "Products of Petroleum Refining" (TCC 291) in Figure 5-18 is the parent group, and the other two are subsets. Since Figures 5-18 and 5-19 have equal scales, it is apparent that this hazardous material was rather concentrated in a few corridors. "Gasoline and Jet Fuels" (TCC 29111) was the major portion of the large highway segment flows in the central region of the country. The extremely low values of "Liquified Petroleum and Coal Gases" (TCC 29121) necessitated the enlargement of the volume scale approximately 15 times. However, here also the pattern was one that suggests more limited geographical involvement as the commodity detail increases.

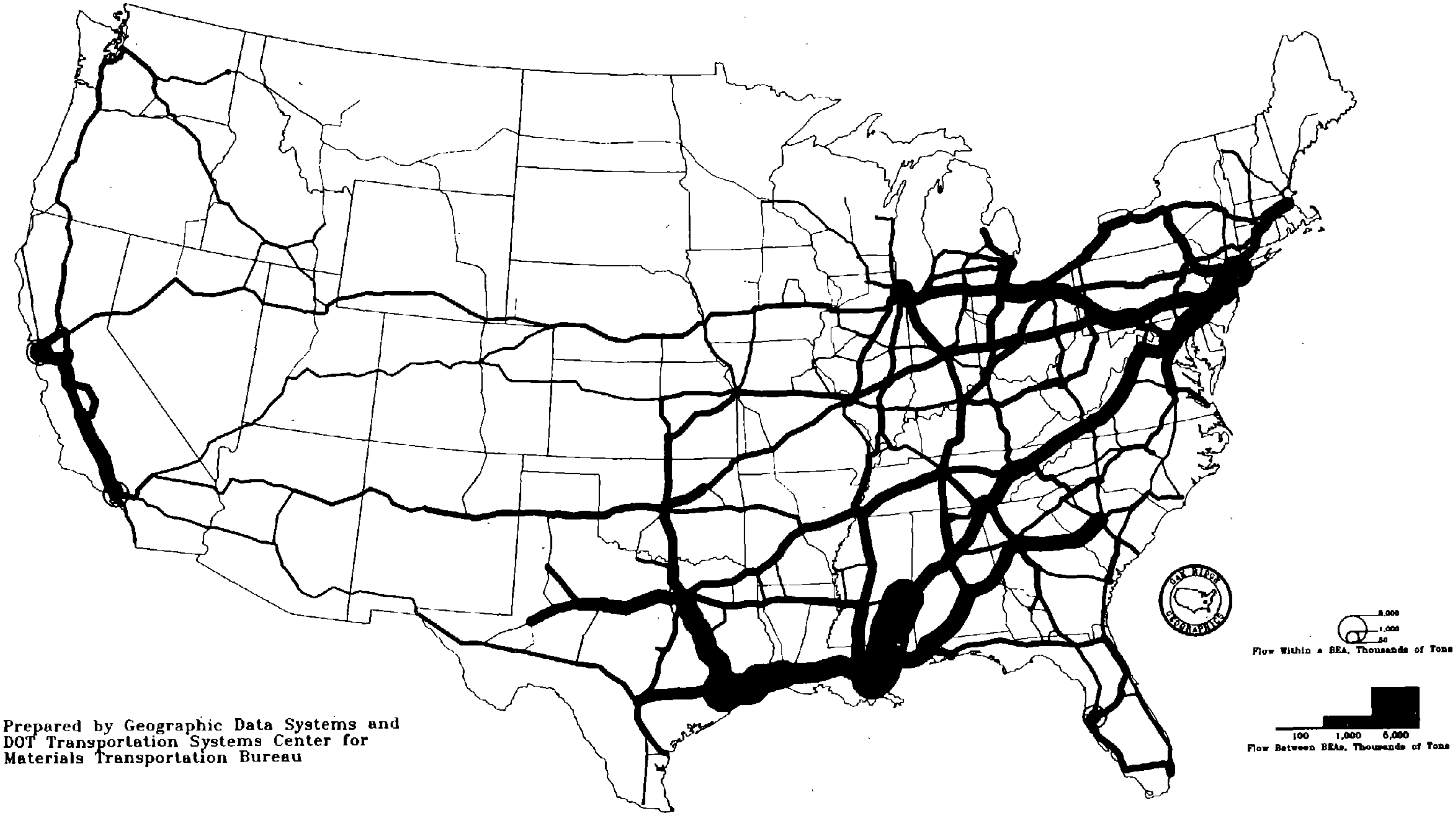


FIGURE 5-11. HAZARDOUS MATERIALS TRUCK TRAFFIC - ALL TRAFFIC FROM PLANTS - INDUSTRIAL INORGANIC AND ORGANIC CHEMICALS (TCC 281)

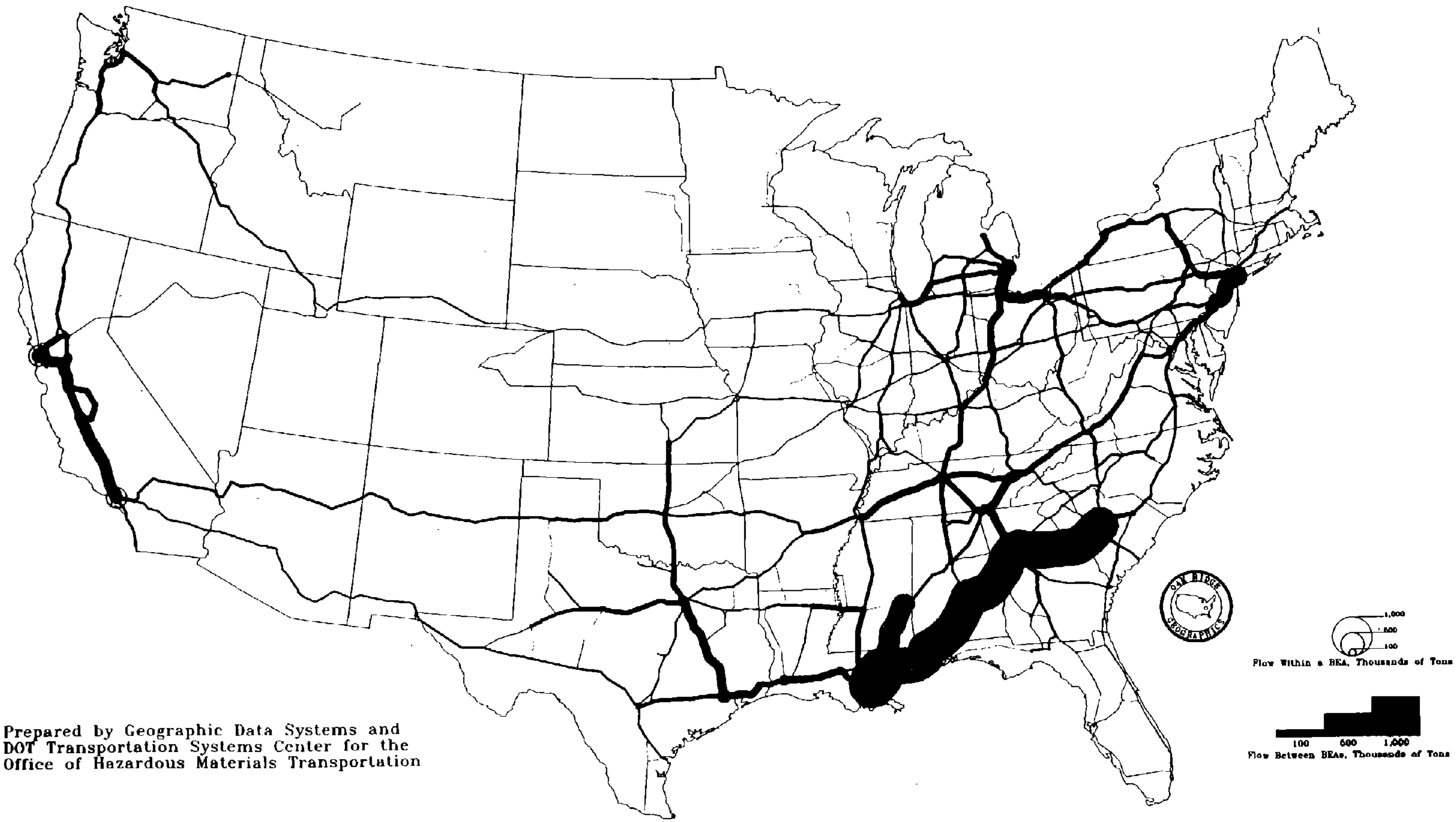


FIGURE 5-12. HAZARDOUS MATERIALS TRUCK TRAFFIC - ALL TRAFFIC FROM PLANTS - POTASIUM, SODIUM OR OTHER BASIC INORGANIC COMPOUNDS (TCC 2812)

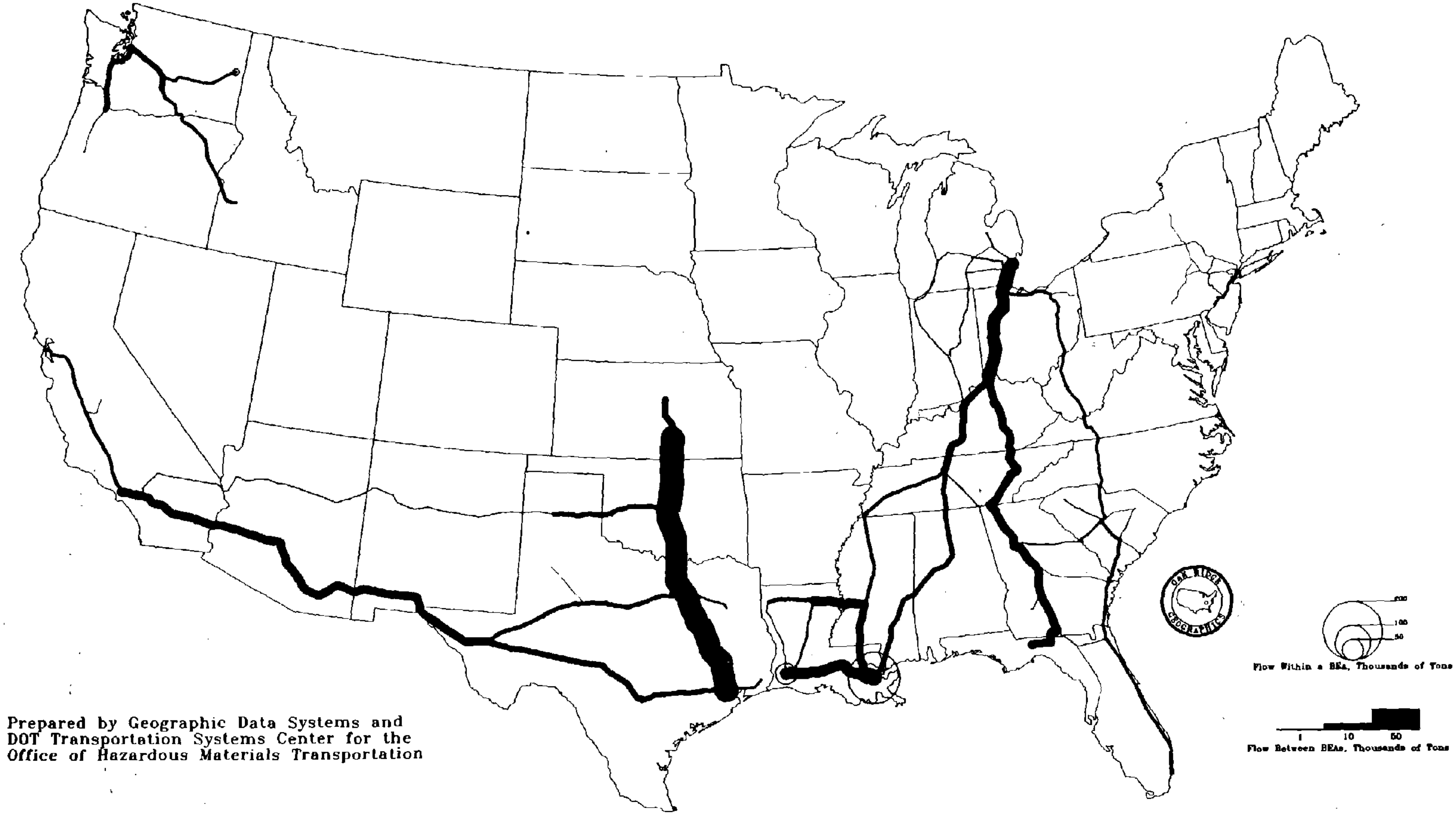


FIGURE 5-13. HAZARDOUS MATERIALS TRUCK TRAFFIC - ALL TRAFFIC FROM PLANTS - CHLORINE (TCC 28128)

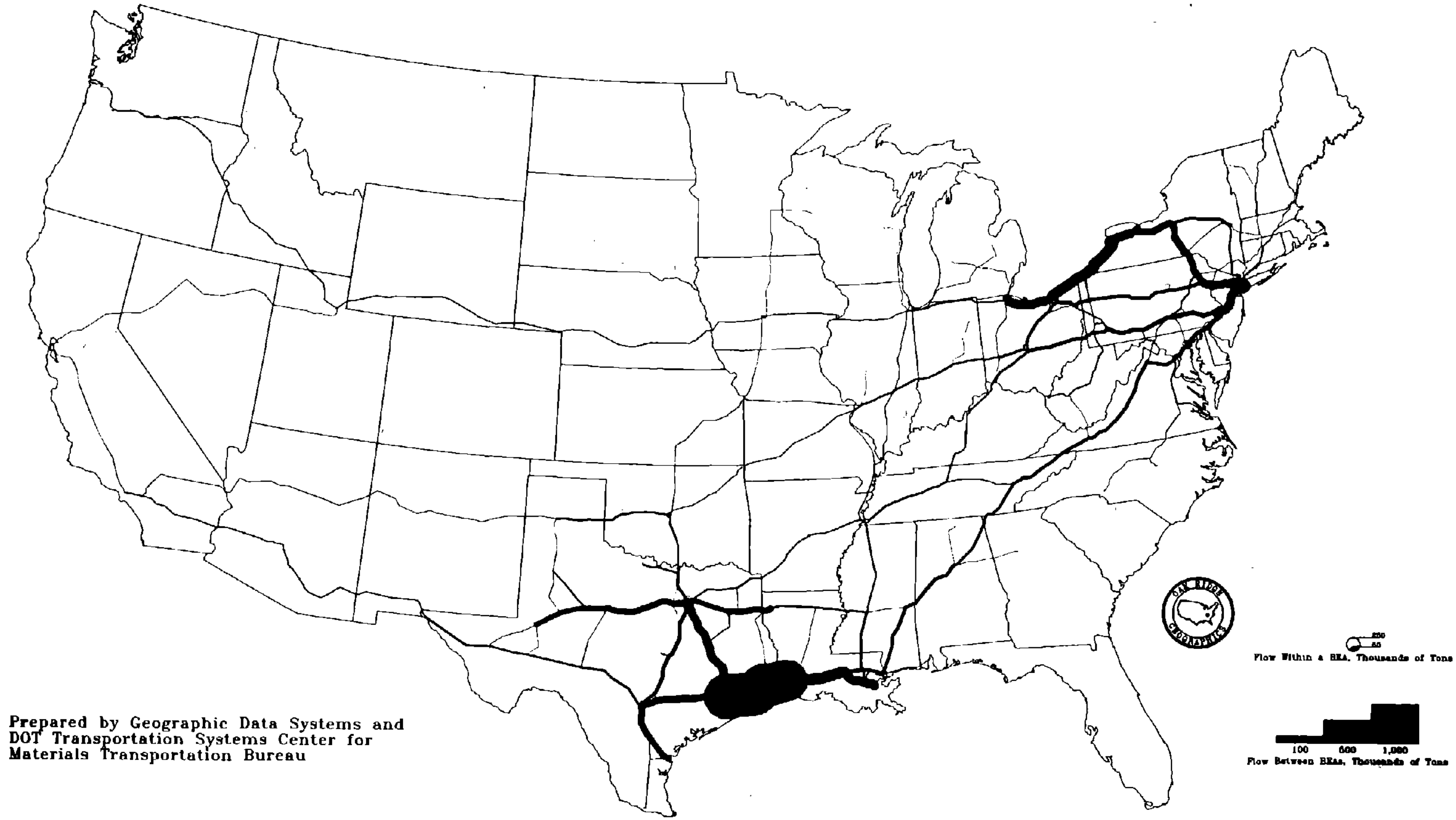


FIGURE 5-14. HAZARDOUS MATERIALS TRUCK TRAFFIC - ALL TRAFFIC FROM PLANTS - CYCLIC INTERMEDIATES OF BENZENE (TCC 28151)

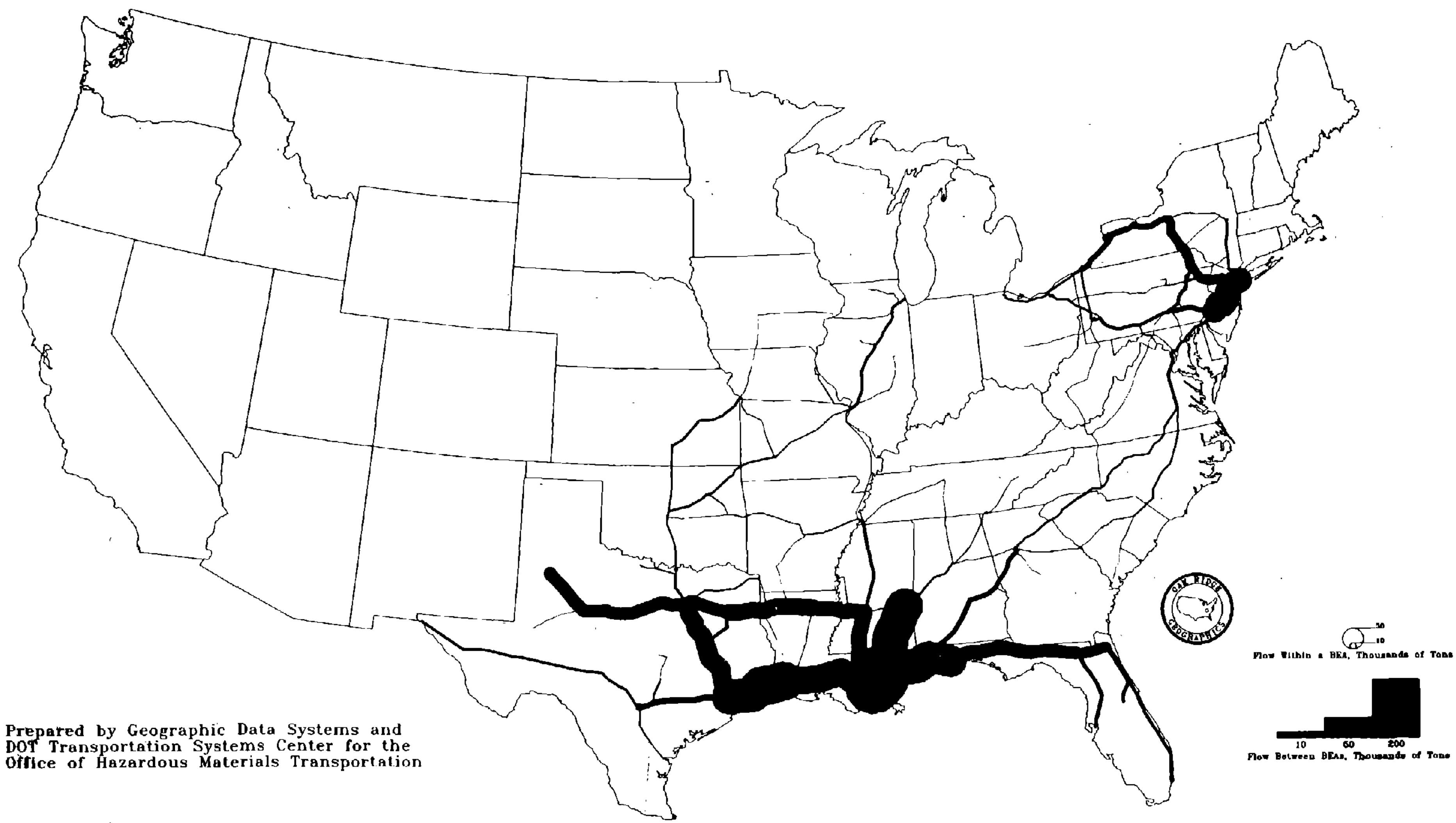


FIGURE 5-15. HAZARDOUS MATERIALS TRUCK TRAFFIC - ALL TRAFFIC FROM PLANTS - NITRIC ACID (TCC 28192)

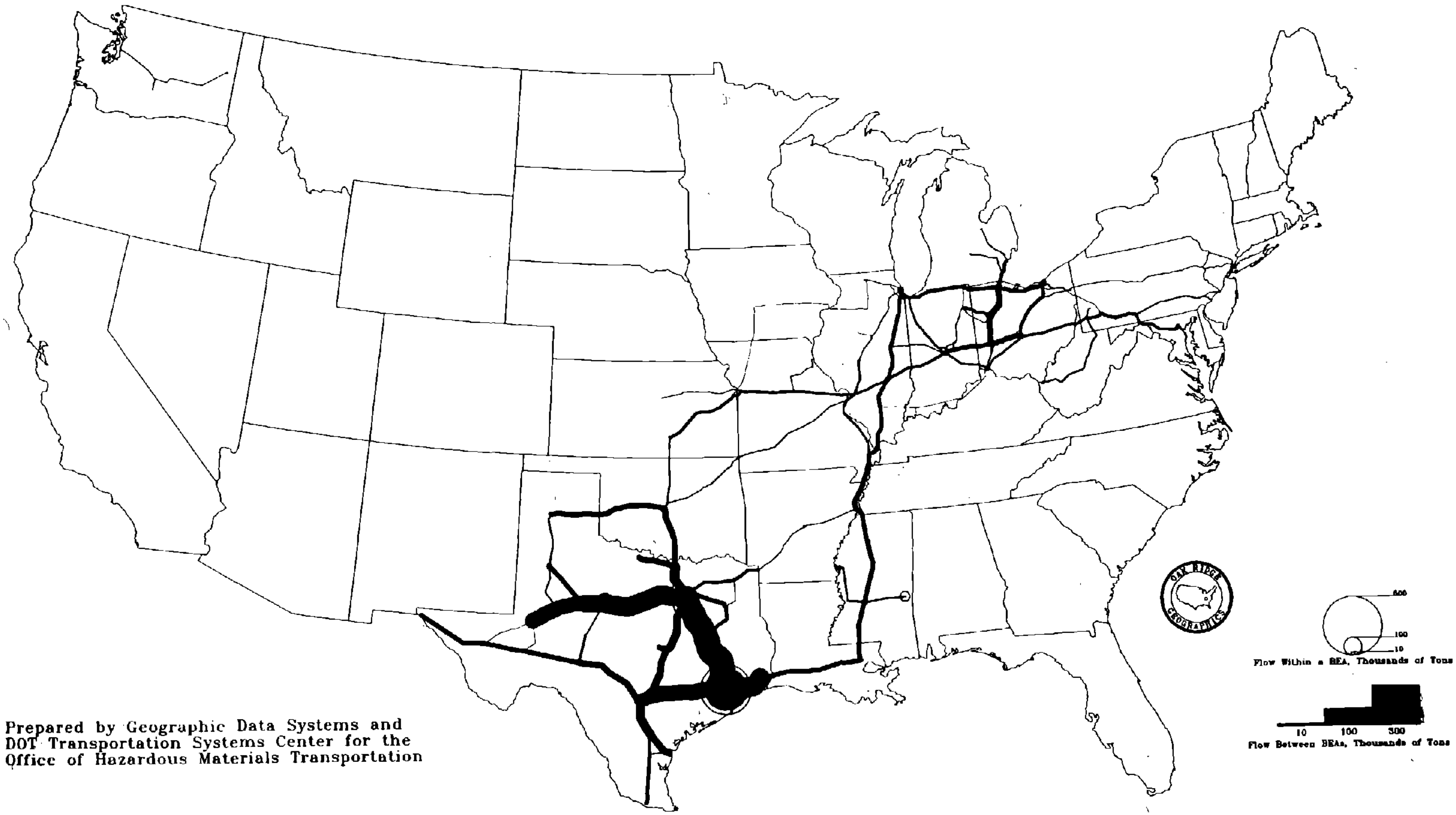


FIGURE 5-16. HAZARDOUS MATERIALS TRUCK TRAFFIC - ALL TRAFFIC FROM PLANTS - ANHYDROUS AMMONIA (TCC 28198)

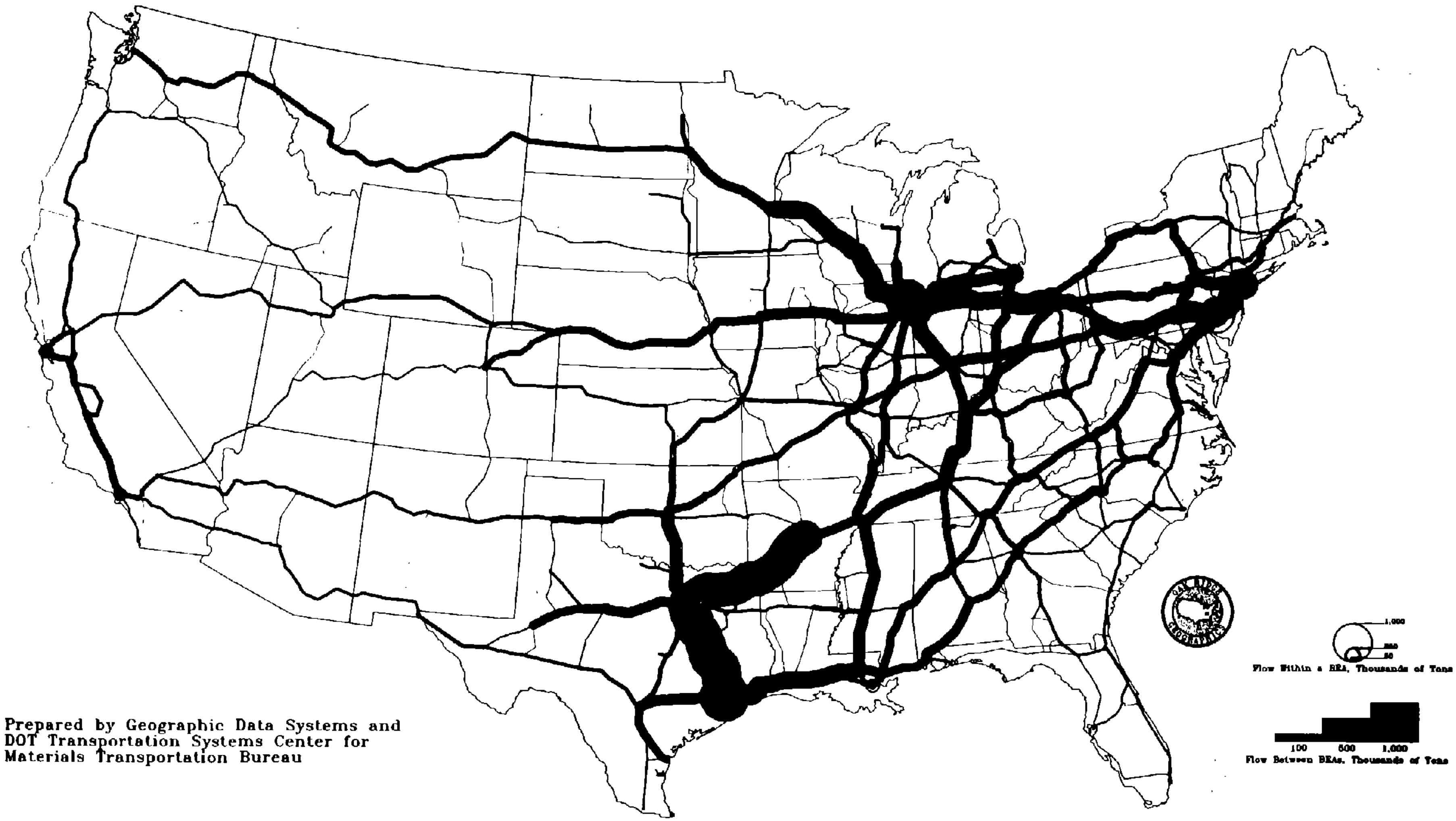


FIGURE 5-17. HAZARDOUS MATERIALS TRUCK TRAFFIC - ALL TRAFFIC FROM PLANTS - MISCELLANEOUS CHEMICAL PRODUCTS (TCC 289)

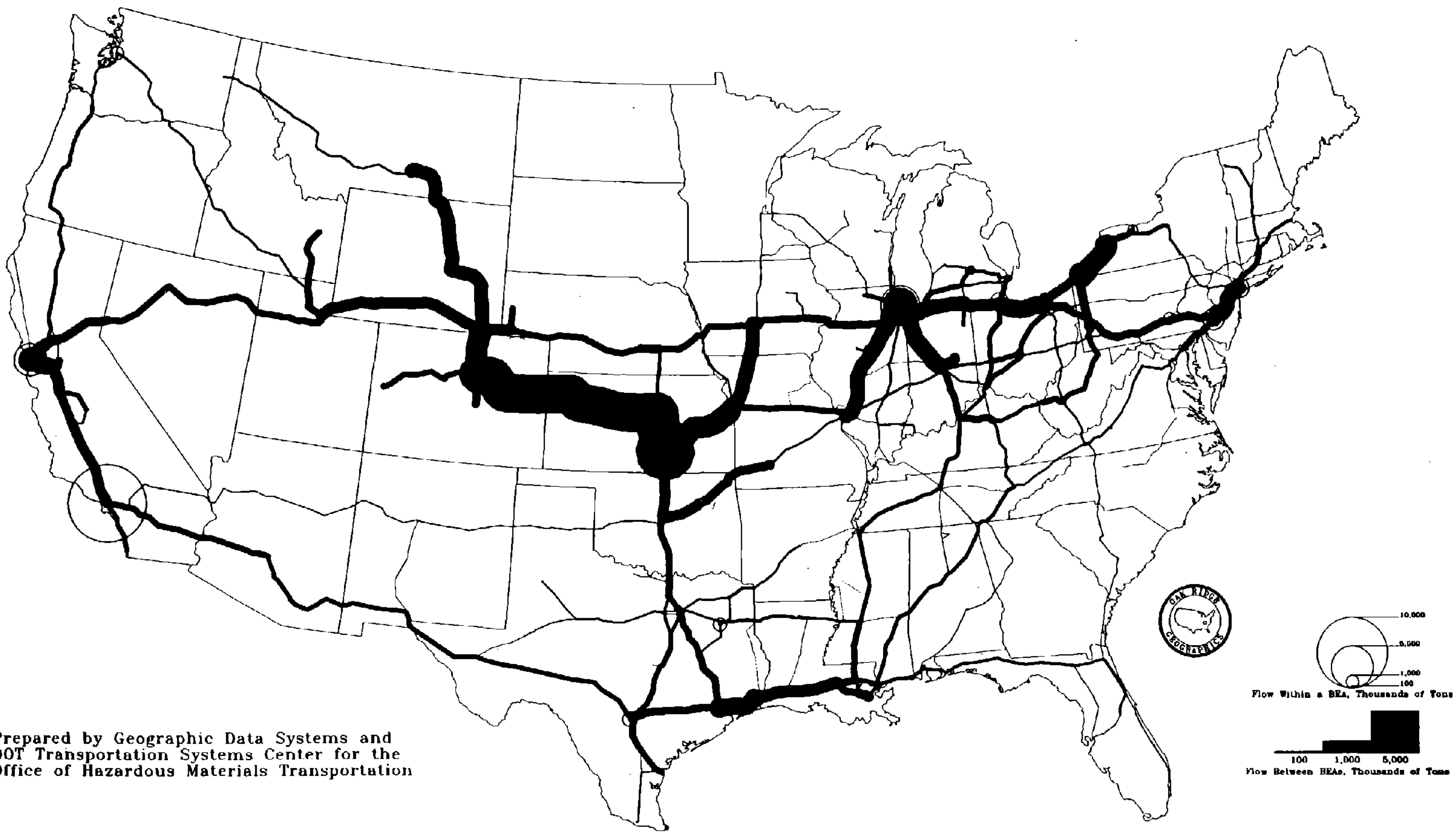


FIGURE 5-18. HAZARDOUS MATERIALS TRUCK TRAFFIC - ALL TRAFFIC FROM PLANTS - PRODUCTS OF PETROLEUM REFINING (TCC 291)

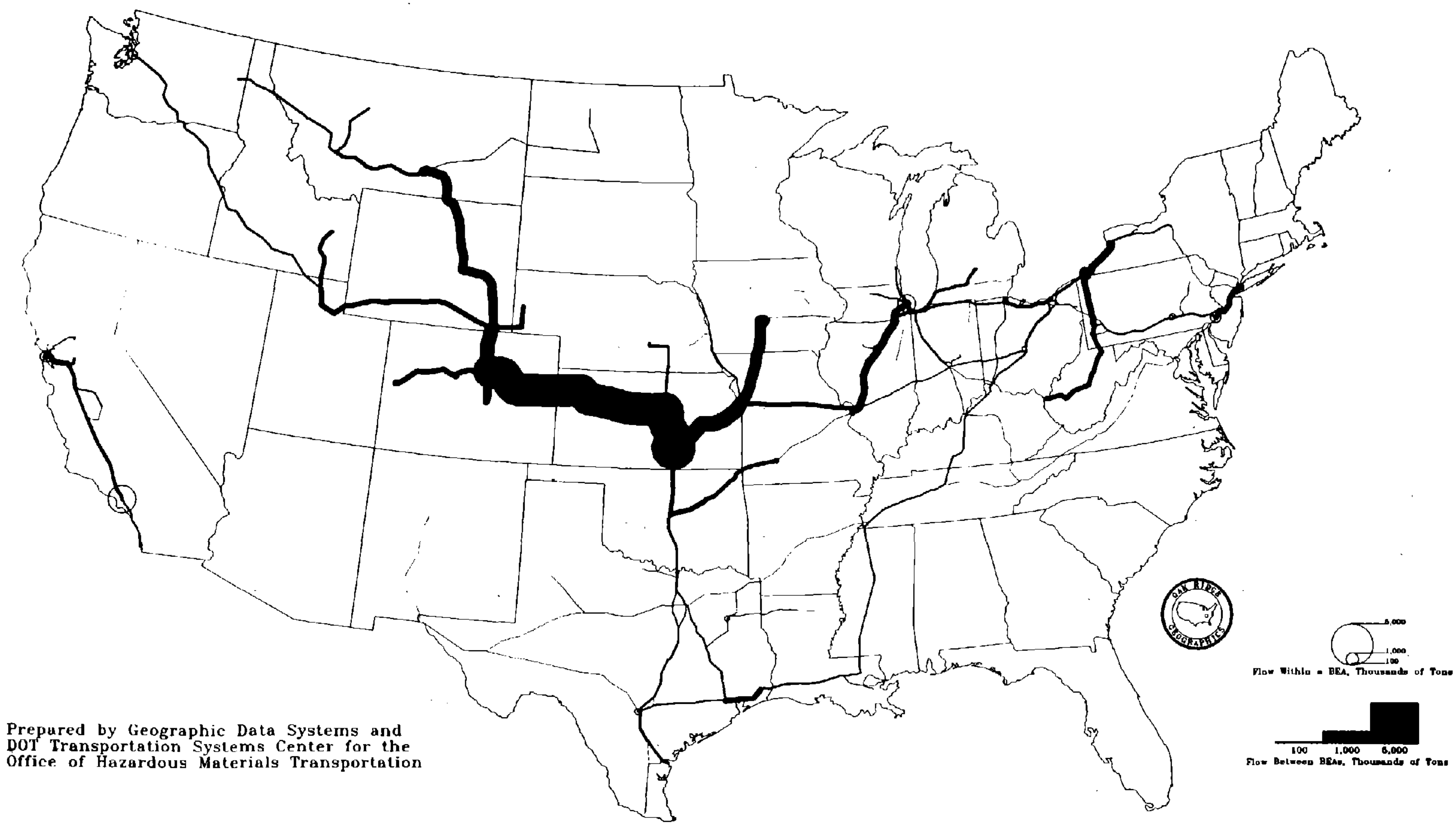


FIGURE 5-19. HAZARDOUS MATERIALS TRUCK TRAFFIC - ALL TRAFFIC FROM PLANTS - GASOLINE AND JET FUEL (TCC 29111)

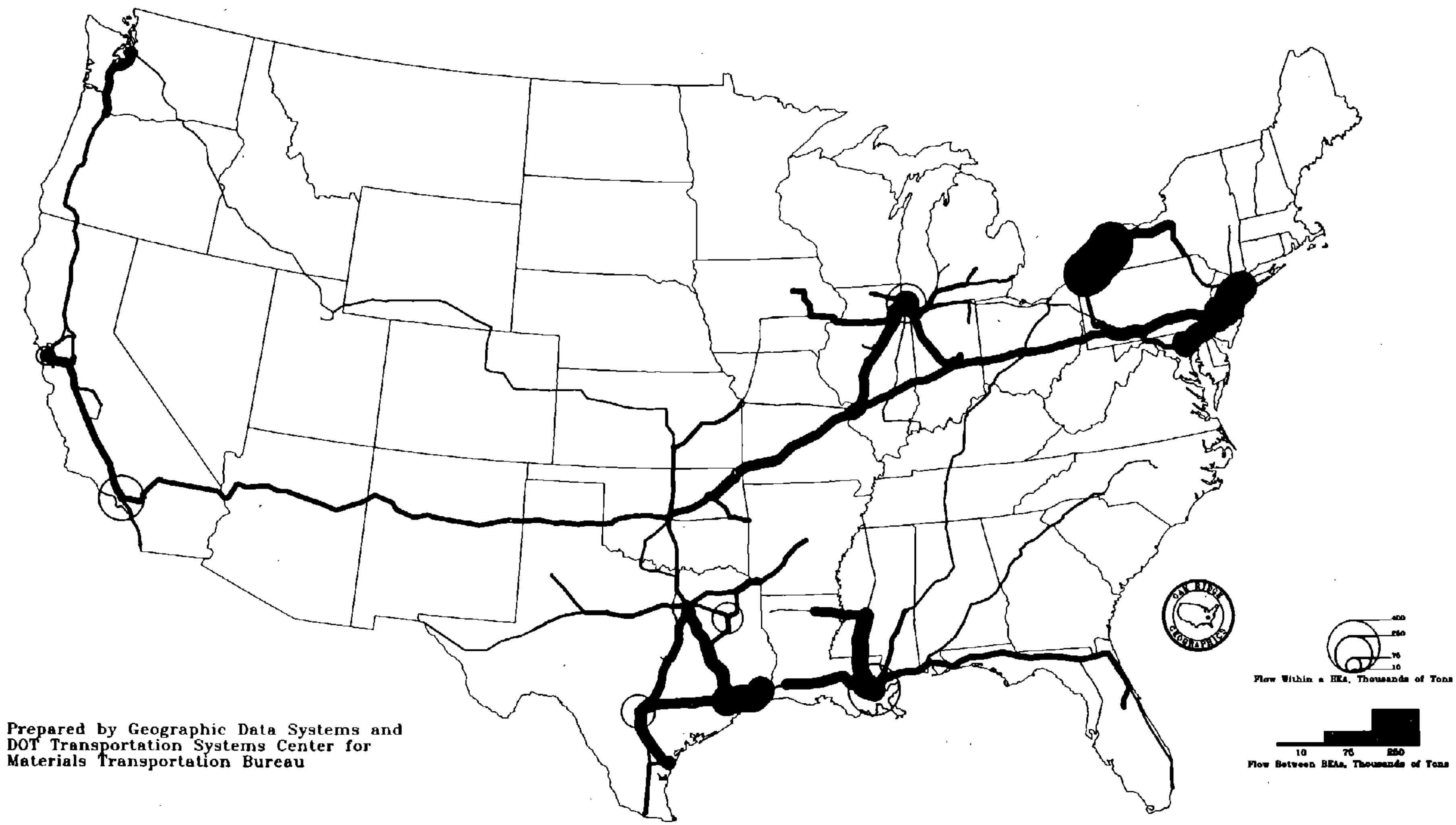


FIGURE 5-20. HAZARDOUS MATERIALS TRUCK TRAFFIC - ALL TRAFFIC FROM PLANTS - LIQUIFIED PETROLEUM AND COAL GASES (TCC 29121)

To complete the map pairing for inter-regional flow analysis, Figures 5-21 through 5-30 were created. As in the first category of disaggregation, these maps, when compared with Figures 5-11 through 5-20 respectively, expose the over-the-road, inter-BEA traffic that was essentially short haul distribution between adjacent regions. For each commodity group, the matched pairs have identical volume scales to facilitate observation of those regions and highway corridors where most or all of the link flows were between adjacent regions and, conversely, where most of the flow was longer range traffic. At the 5-digit level it appears that, with a few exceptions, a very small percentage of the total traffic was between adjacent BEAs. However, Table 3-2 indicated that these same 5-digit groups had average haul distances of 197 to 265 miles for the chemical products and 118 to 168 miles for the petroleum products. Therefore, it is very likely that the flows were limited to BEAs just beyond the immediately adjacent BEAs.

It appears, from these data, that transportation safety concerns that are product group specific should be addressed in concert by neighboring regions that participate in the specific product flows but may or may not share common borders. To the extent that safety hazards vary among product groups, safety oversight, regulation and enforcement provisions should correspondingly vary among regions. Of the six 5-digit commodity groups plotted on these maps, by far the largest was gasoline and jet fuel (TCC 29111), with 6.8 billion ton-miles transported by truck from plants. The map displays an estimated 55 percent of this national total among 299 BEA o/d pairs. The smallest quantity was chlorine (TCC 28128) at 154 million ton-miles. The map displays an estimated 53 percent of this national total among 250 BEA o/d pairs. The highest representation (percent of national total) by a map was for liquified petroleum and coal gases (TCC 29121) at 581 ton-miles. This was estimated to be 71 percent of the national total, followed closely by cyclic intermediates of benzene (TCC 28151) at 70 percent of a 1.1 billion ton-mile national total.

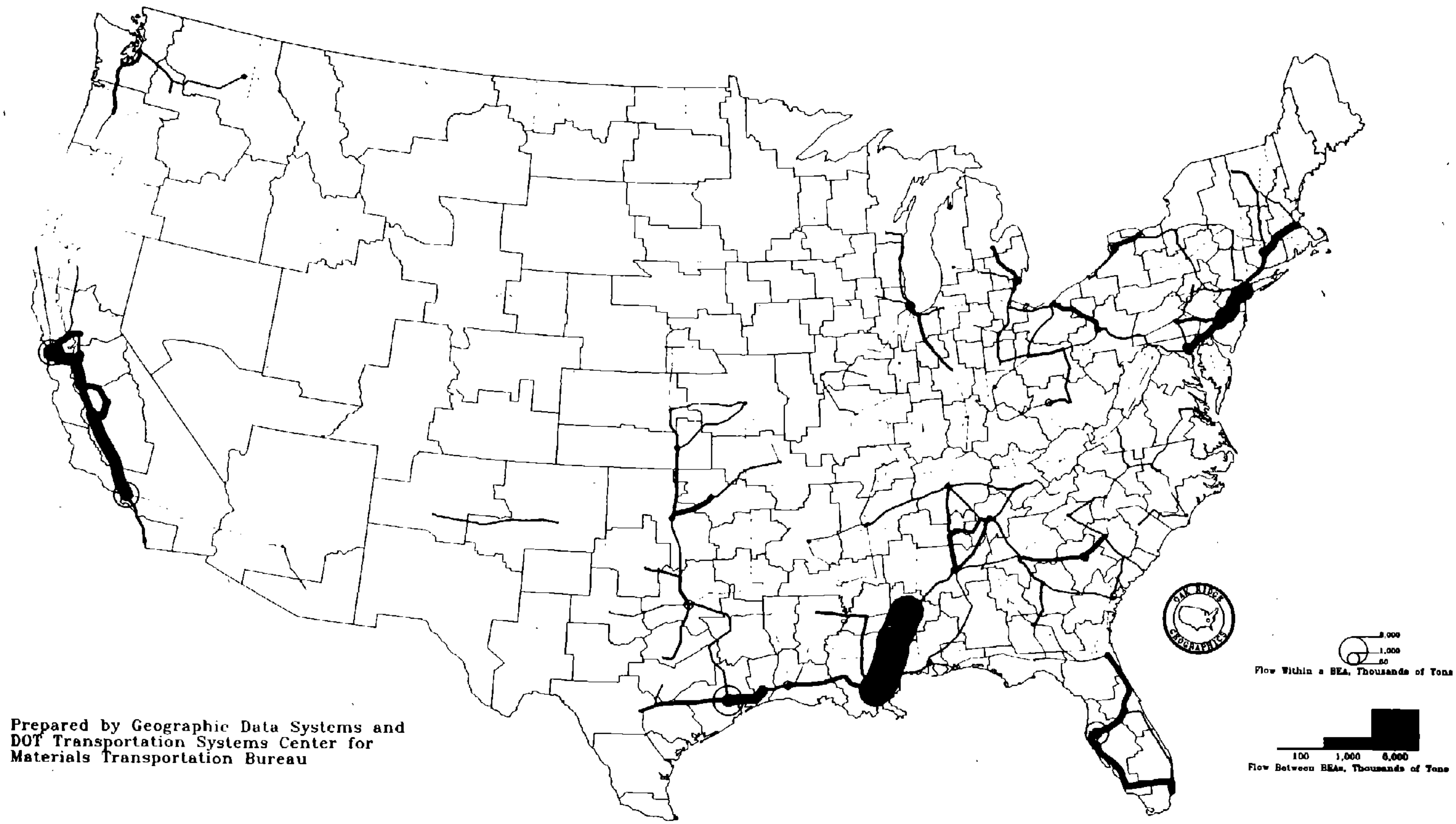


FIGURE 5-21. HAZARDOUS MATERIALS TRUCK TRAFFIC - TRAFFIC BETWEEN ADJACENT BEAs - INDUSTRIAL INORGANIC AND ORGANIC CHEMICALS (TCC 281)

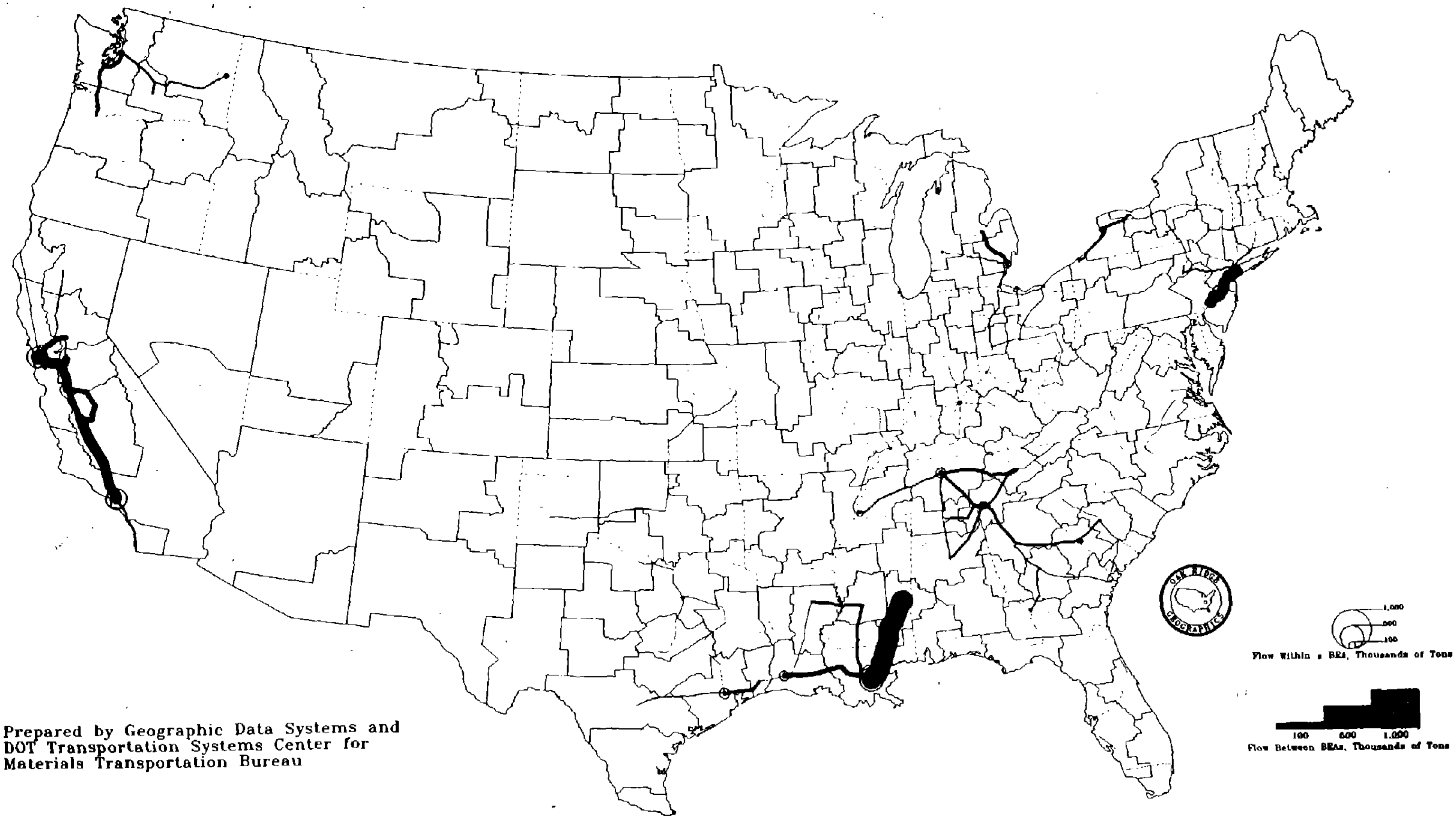


FIGURE 5-22. HAZARDOUS MATERIALS TRUCK TRAFFIC - TRAFFIC BETWEEN ADJACENT BEAs - POTASIUM, SODIUM OR OTHER BASIC INORGANIC COMPOUNDS (TCC 28120)

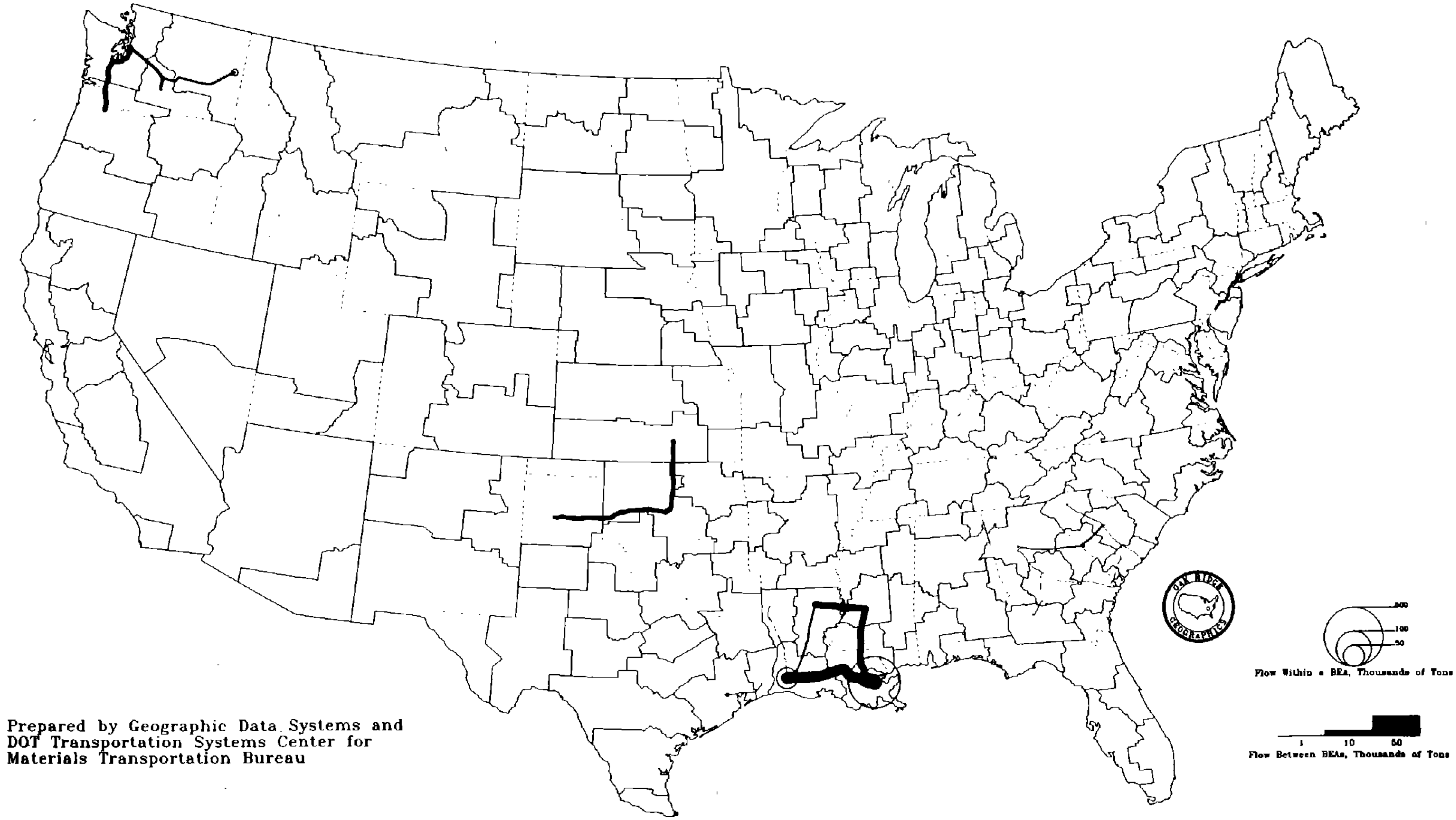


FIGURE 5-23. HAZARDOUS MATERIALS TRUCK TRAFFIC - TRAFFIC BETWEEN ADJACENT BEAs - CHLORINE (TCC 28128)

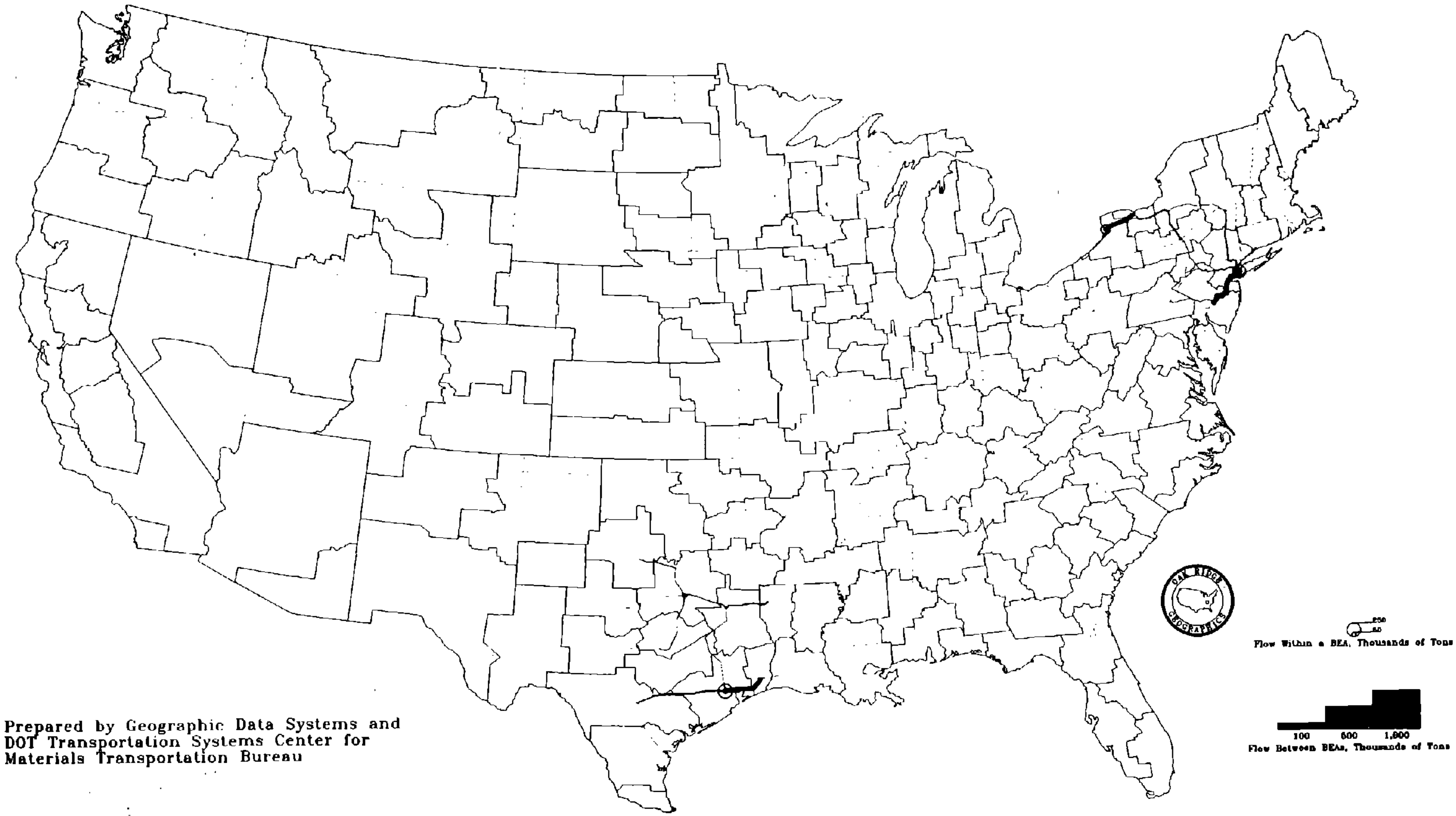
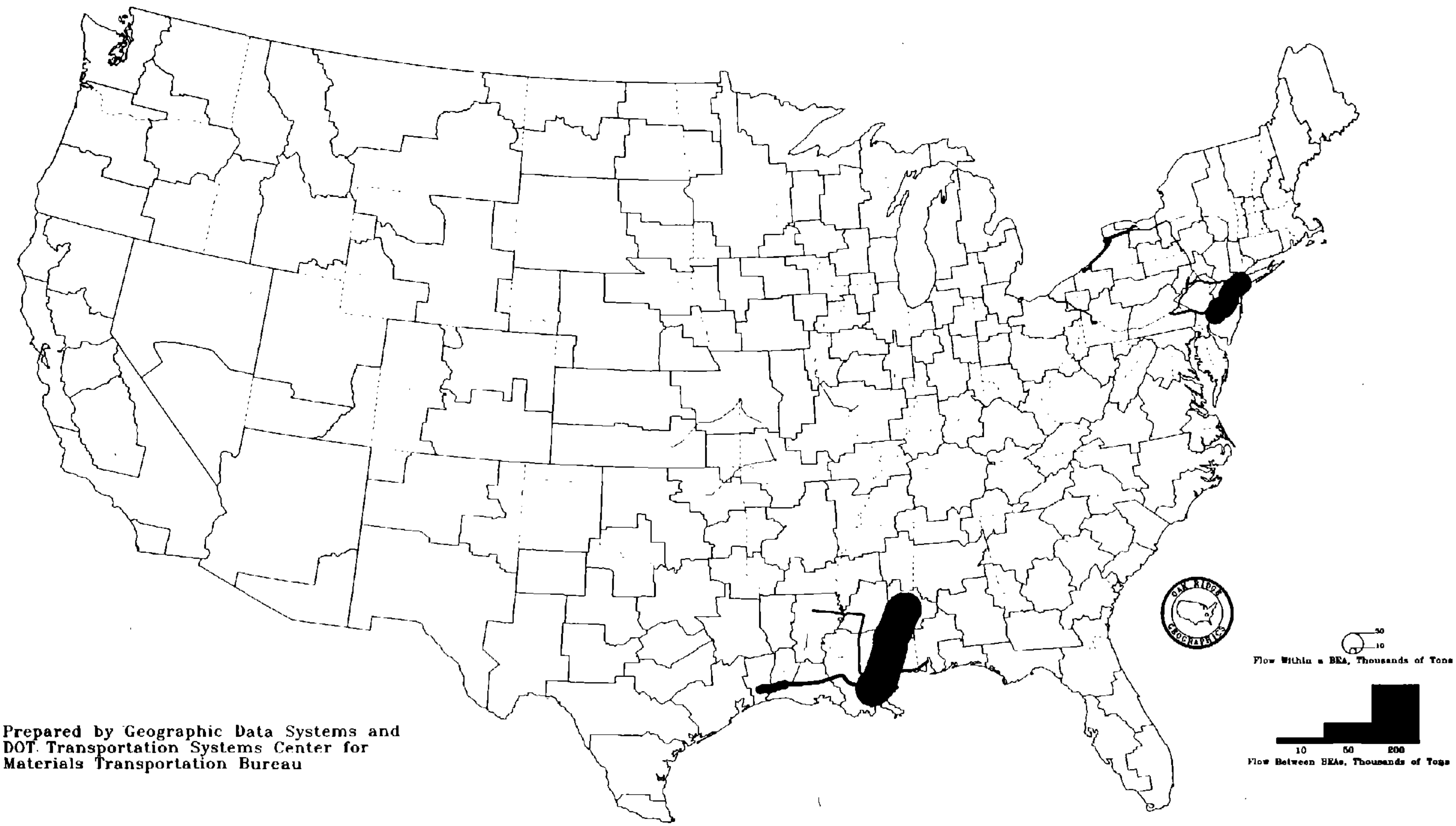


FIGURE 5-24. HAZARDOUS MATERIALS TRUCK TRAFFIC - TRAFFIC BETWEEN ADJACENT BEAs - CYCLIC INTERMEDIATES OF BENZENE (TCC 28151)



Prepared by Geographic Data Systems and
DOT Transportation Systems Center for
Materials Transportation Bureau

FIGURE 5-25. HAZARDOUS MATERIALS TRUCK TRAFFIC - TRAFFIC BETWEEN ADJACENT BEAs - NITRIC ACID (TCC 28192)

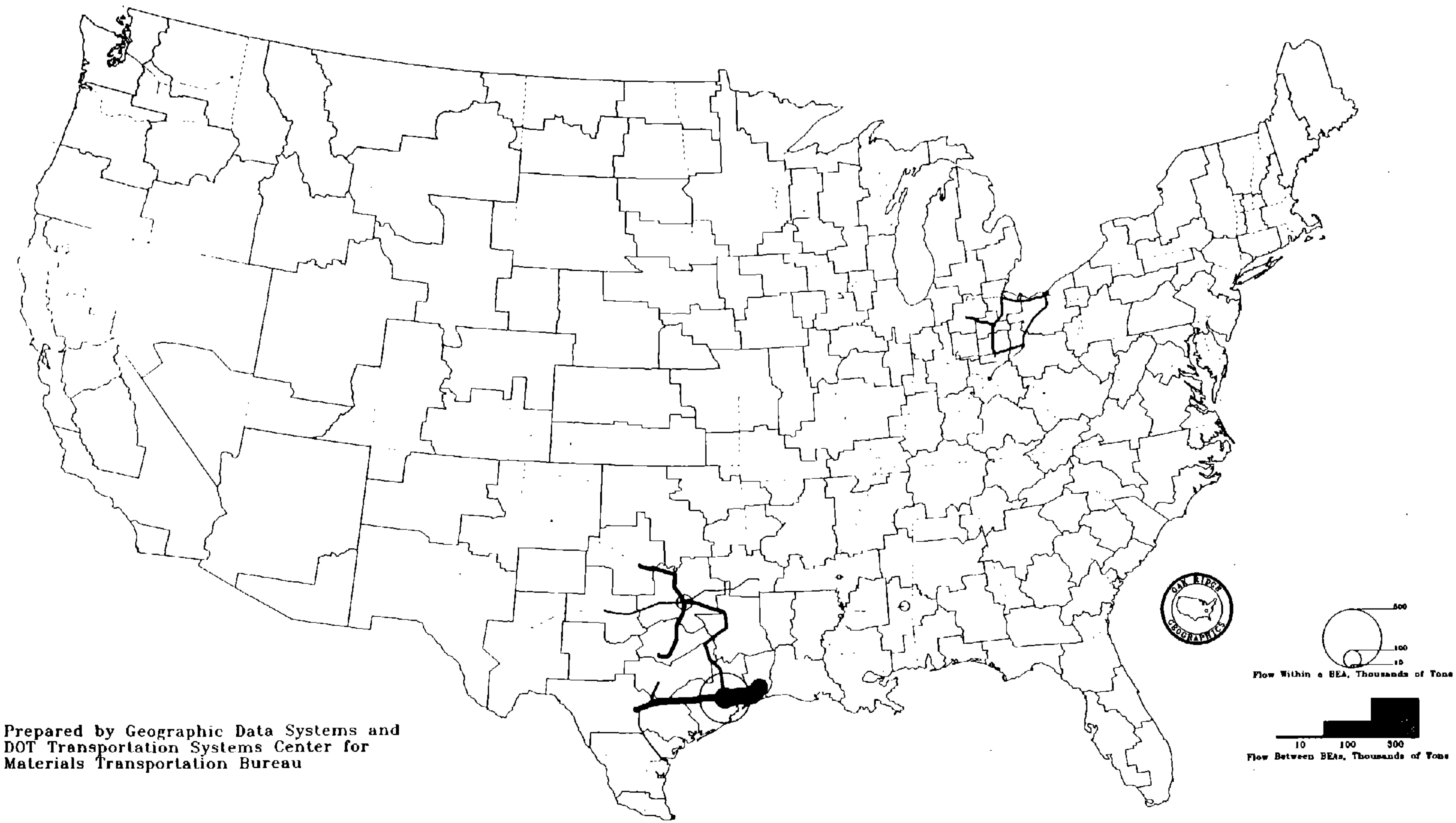


FIGURE 5-26. HAZARDOUS MATERIALS TRUCK TRAFFIC - TRAFFIC BETWEEN ADJACENT BEAs - ANHYDROUS AMMONIA (TCC 28198)

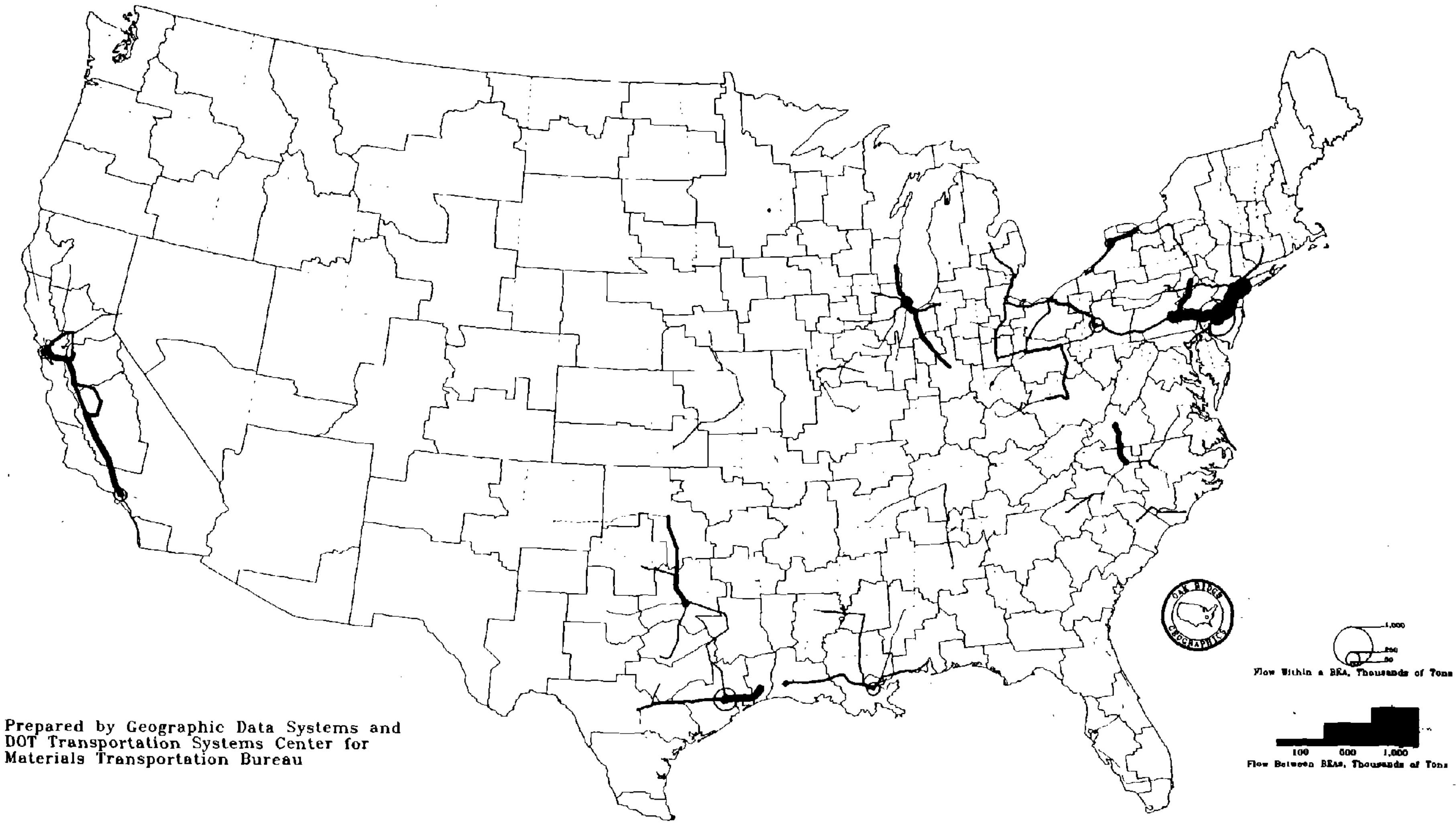


FIGURE 5-27. HAZARDOUS MATERIALS TRUCK TRAFFIC - TRAFFIC BETWEEN ADJACENT BEAs - MISCELLANEOUS CHEMICAL PRODUCTS (TCC 289)

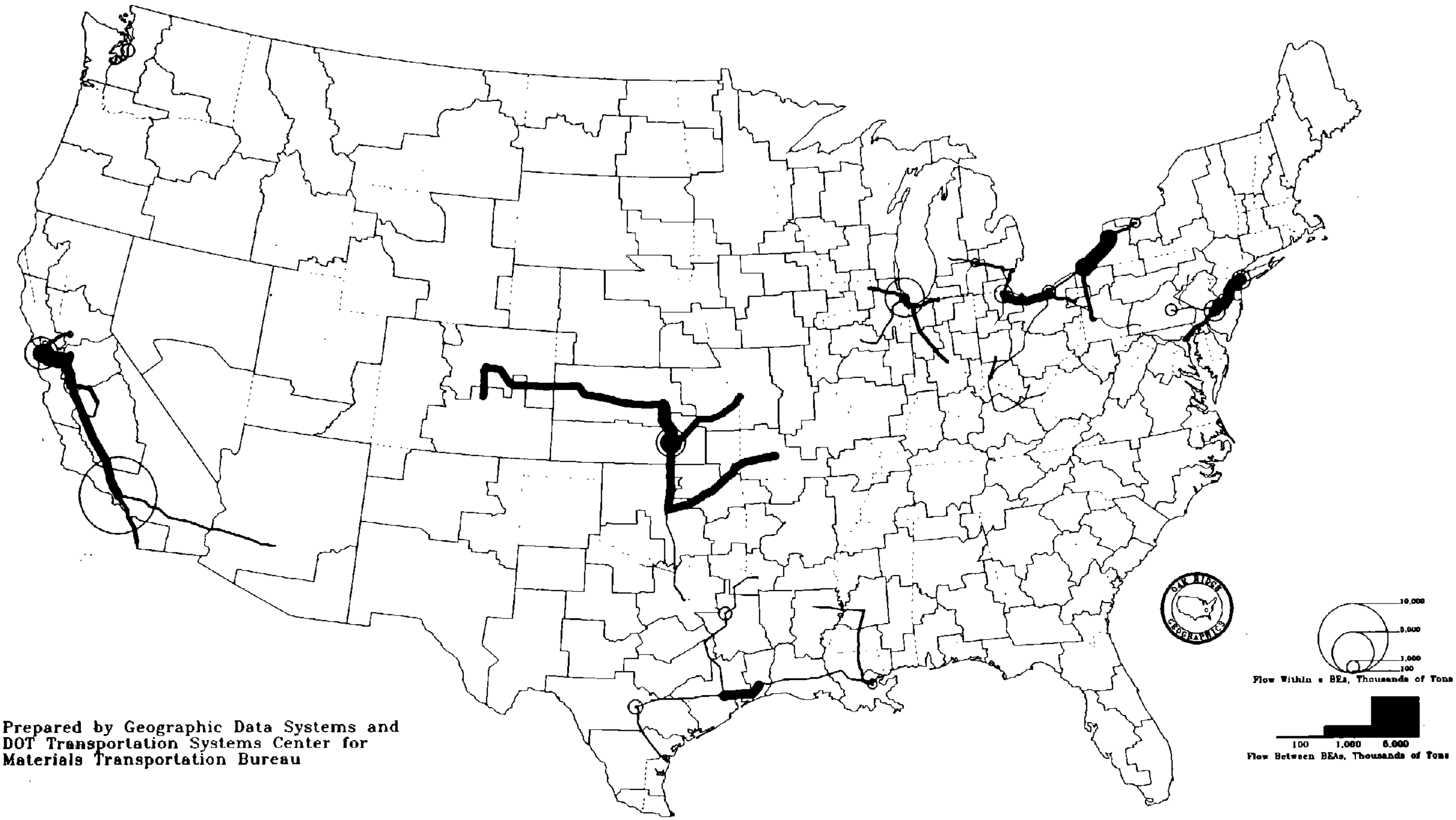


FIGURE 5-28. HAZARDOUS MATERIALS TRUCK TRAFFIC - TRAFFIC BETWEEN ADJACENT BEAs - PRODUCTS OF PETROLEUM REFINING (TCC 291)

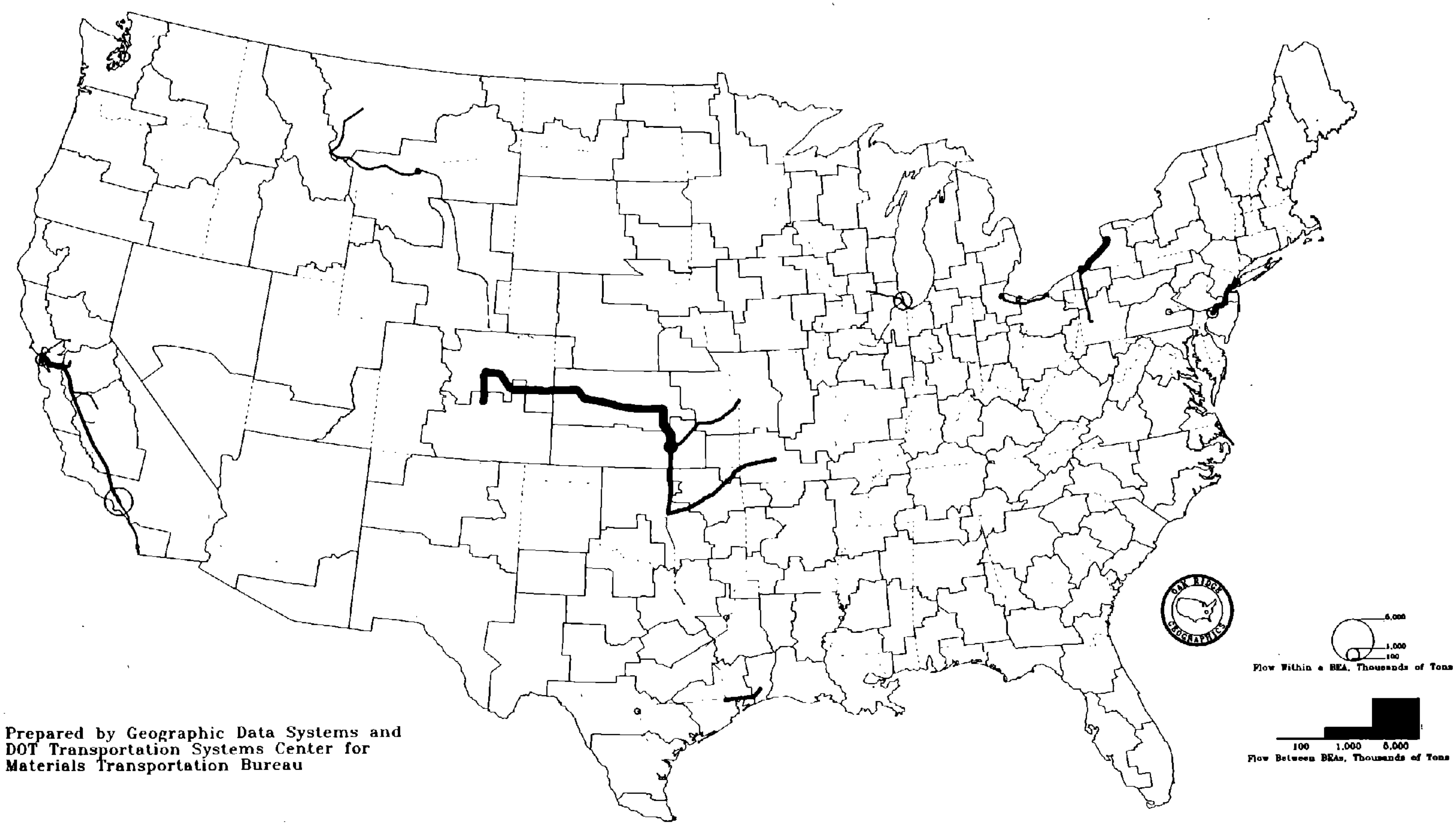


FIGURE 5-29. HAZARDOUS MATERIALS TRUCK TRAFFIC - TRAFFIC BETWEEN ADJACENT BEAs - GASOLINE AND JET FUEL (TCC 29111)

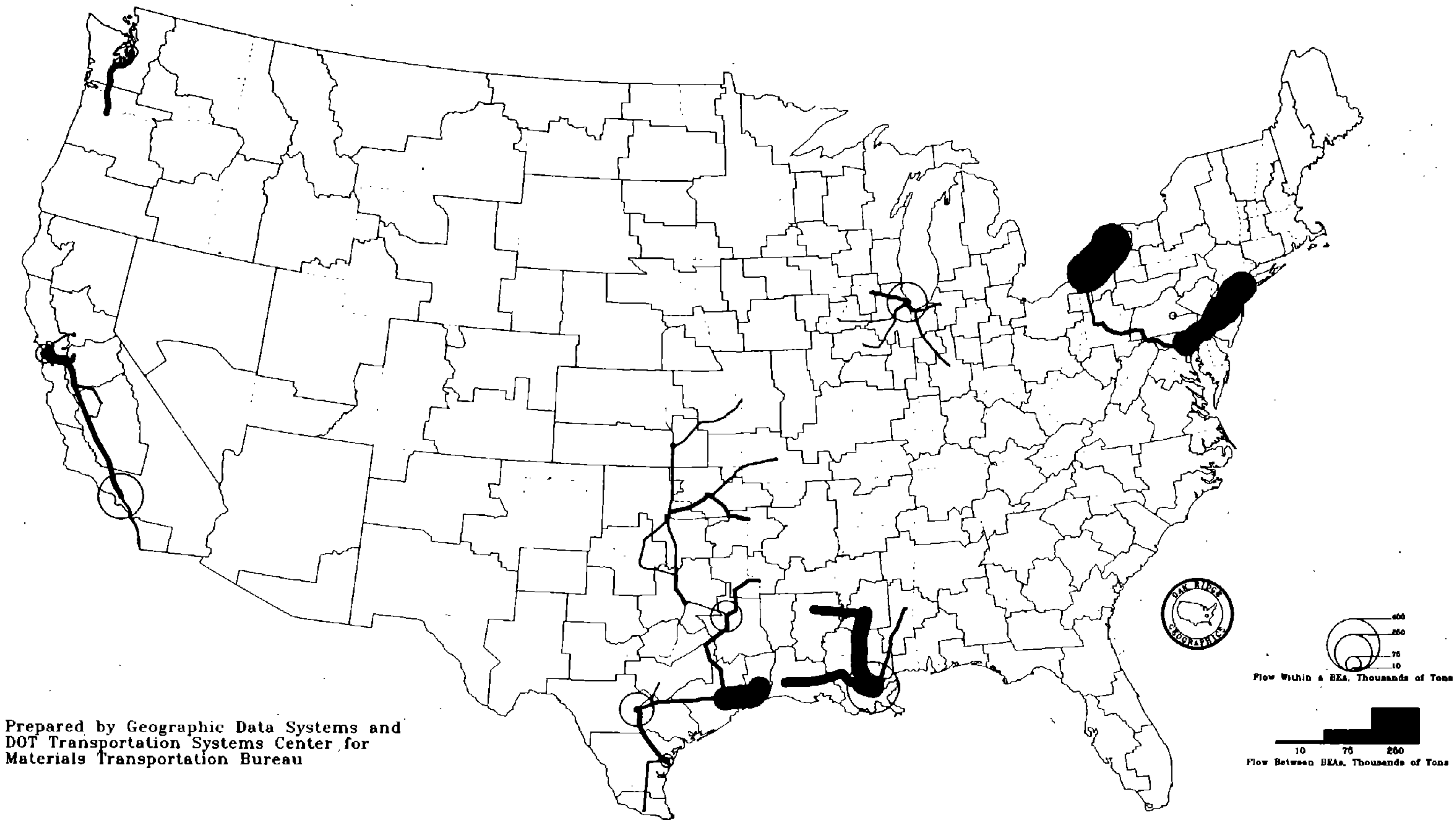


FIGURE 5-30. HAZARDOUS MATERIALS TRUCK TRAFFIC - TRAFFIC BETWEEN ADJACENT BEAs - LIQUIFIED PETROLEUM AND COAL GASES (TCC 29121)

6. TRENDS IN TRUCK ACTIVITY REVEALED BY MORE RECENT DATA

The patterns of truck activity in chemical and petroleum products transportion are determined by domestic consumption, the shares of the market satisfied by domestic production and by foreign imports, the competitive price structure of the competing modal services, and the operating environment of the trucking industry. The 1977 CTS provided a one-year picture of the volume of truck transport from manufacturing plants and the inter-regional flow patterns. Since that period, some changes in the U.S. economy as a whole as well as in the economic regulation of the truck and rail industries have taken place.

The U.S. Bureau of the Census has produced no comparable commodity transportation survey that would provide an indication of trends in commodity o/d flows by truck since 1977. The Bureau's 1982 Truck Inventory and Use Survey does, however, provide a comprehensive update on the national truck fleet population, the fleet's physical characteristics and its VMT activity. It is the most recent comprehensive data file on truck activity available. A comparison of the 1982 with the 1977 TIUS data is a way of detecting any changes in the characteristics that have been described in the previous sections of this report. Combined with a few aggregate statistics on domestic production and foreign imports covering the same time period, some indication can be obtained of the stability of the truck activity patterns presented in the earlier sections of this report. Section 6.1 analyzes the changes in the truck fleet and its activity between 1977 and 1982. Section 6.2 analyzes the trends in domestic production, foreign imports and relevant rail traffic. Section 6.3 assesses the implications of these data and draws inferences about trends in the truck traffic patterns vis-a-vis transport of chemical and petroleum products.

6.1 COMPARISON OF 1977 AND 1982 TIUS DATA

The 1977 and 1982 TIUS surveys cover similar physical and operational characteristics of the nation's truck population. As indicated in Section 4.3, there are numerous data items included in the surveys to describe the size of vehicle, classification of operator, product carried, fleet size, area of operation, body type, annual miles, etc. A comparison of the changes between

1977 and 1982 TIUS with respect to specific variables can indicate the change of truck use patterns over the five-year span. However, due to the difference in sample stratification and the specification changes for some data items, there remains some uncertainty associated with the results of the following analysis.

Before proceeding with a comparison of the 1977 and 1982 TIUS, one should observe the effect on the fleet population and VMT totals of the light trucks and those trucks reporting "no load carried" or "personal use only." The light trucks (two axle, four tired, pickups, panels, and vans of less than 10,000 pounds gross weight) were very large in number (over 60 percent of the total vehicles used for all freight shipments and over 80 percent of the total truck fleet population in the TIUS data base). Although this class of truck was not important in terms of freight volume carried, it did represent a large portion of the total vehicle fleet and VMT reported to be involved in the transport of chemical and petroleum products. It should also be noted that 60 percent of the total light trucks were reported as carrying "no loads" or were used for "personal use" in 1977; this percentage increased to 75 percent in 1982. In terms of the absolute number of "personal use" and "no load" vehicles, this represented an increase of 65 percent between 1977 and 1982.

Although there were indications that the 1977 TIUS under-reported the light trucks because it classified many of them as automobiles, there were other indications that the economic downturn in 1982 had left a lot of trucks idle. Disregarding the light trucks, the comparison of 1977 and 1982 TIUS data indicated that the total single unit trucks reporting "no load" increased from 4.6 percent of all single units in 1977 to 8.8 percent in 1982, while the idle combination trucks increased from less than 1 percent to 5.4 percent in 1982.

Figures 6-1 and 6-2 display the distributions of vehicles and VMT by commodity group and vehicle class. Appendix H contains tabulations of values used for these displays. The vehicles reporting "no load" or "personal use" are excluded. Of the two measures (fleet population and VMT), VMT is considered to be a more significant indicator of exposure to potential highway accident/incidents. For truck transport of all commodities shipped, the same trend appeared in the fleet population as in the VMT. The number of combination trucks increased 19 percent, while the light trucks decreased 17 percent and the single unit trucks decreased 14 percent. The VMT for combination trucks

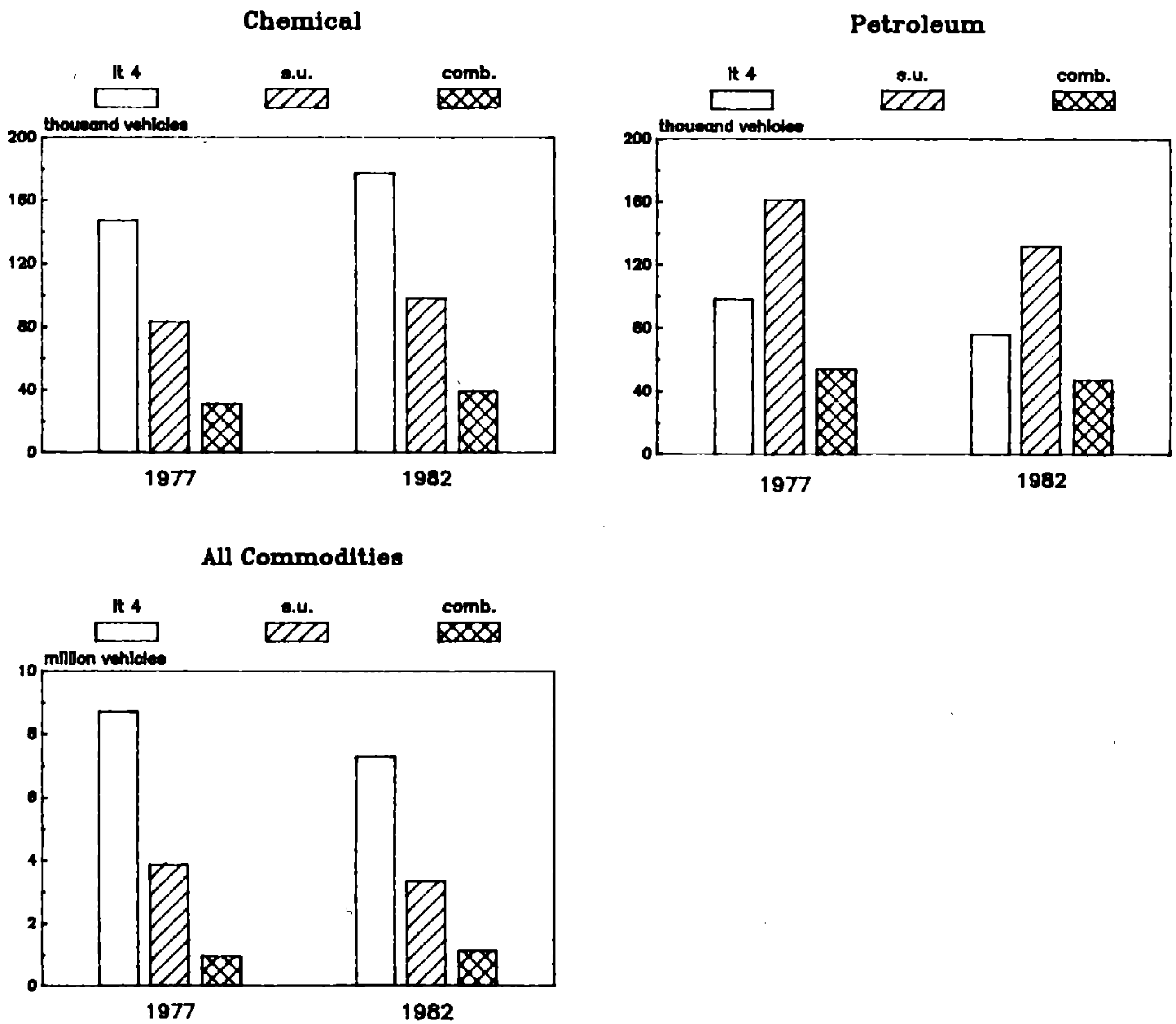


FIGURE 6-1. COMPARISON OF 1977 AND 1982 TOTAL TRUCK FLEETS

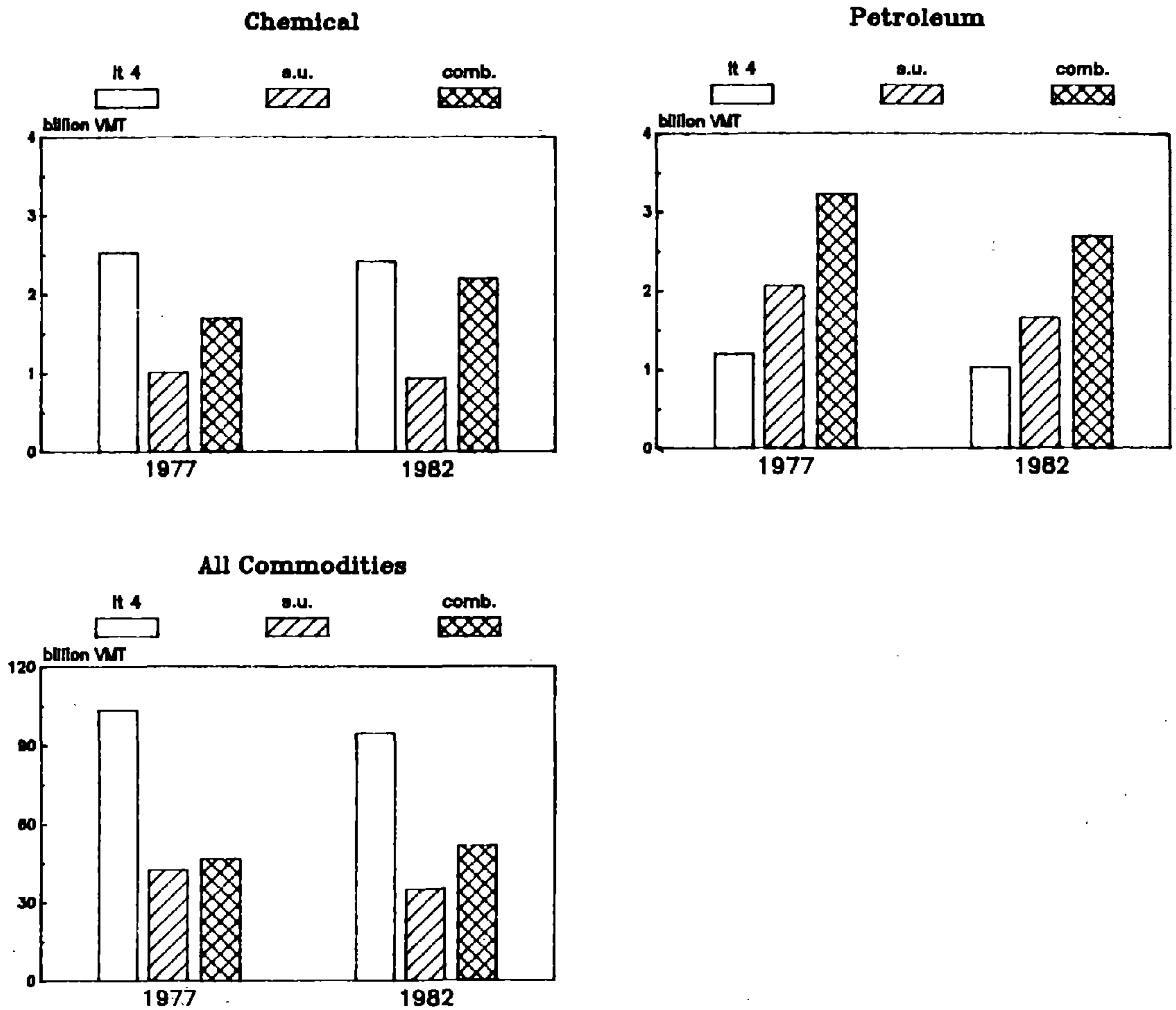


FIGURE 6-2. COMPARISON OF 1977 AND 1982 TOTAL VMT

increased 11 percent, while the light trucks and single units decreased 9 percent and 17 percent respectively. Both of these measures imply a general shift to the larger combination trucks for all commodities between 1977 and 1982.

Focusing primarily on the transport of chemical and petroleum products, several attributes of the associated truck fleets and their respective VMTs were examined. Figure 6.1 displays the 1977 and 1982 fleet populations involved in chemical products transport and petroleum products transport. The total of all trucks reporting transport of all commodities is also shown for comparison. Combination trucks represented 18 percent of the petroleum fleet and 12 percent of the chemical products fleet. The single unit trucks represented 52 percent of the petroleum fleet and 31 percent of the chemical fleet. The light trucks represented 30 percent of the petroleum fleet and 56 percent of the chemical fleet. The change between 1977 and 1982 was insignificant. Figure 6-2 displays the 1977 and 1982 VMT generated by the fleets involved in transport of chemical and petroleum products. Diverse distribution patterns appeared between VMT and fleet populations. Combination trucks generated 50 percent of the petroleum traffic and 33 percent of the chemical traffic in 1977. Single units generated 32 percent of the petroleum and 19 percent of the chemical traffic. The light trucks generated 18 percent of the petroleum and 48 percent of the chemical traffic. The change between 1977 and 1982 for each was slight.

The decrease in total VMT for chemical and petroleum products between 1977 and 1982 did not necessarily translate into a decrease in product ton-miles. The general shift from smaller truck classes to larger truck classes can translate into increased shipment ton-miles. For example, by applying the vehicle average loads presented in Appendix F to the VMT, the total shipment ton-miles for all freight shipments increased 5 percent, even though the VMT decreased 6 percent. The overall size of the truck fleet involved in chemical products transport had increased 20 percent, while the size of the truck fleet involved in petroleum products transport decreased 19 percent. During the same period, the total truck fleet associated with all commodities decreased 13 percent.

The total VMT generated by trucks whose principal product carried was chemicals increased 6 percent, and the VMT for trucks whose principal product carried was petroleum products decreased 17 percent, while the VMT for all freight dropped 6 percent.

In chemicals transportation, the 29 percent increase in combination truck VMT was countered by a 7 percent decrease in single unit VMT, and a 4 percent decrease in light truck VMT. In petroleum products transportation, the reduction in VMT occurred in all three vehicle classes with a decrease of 14, 35, and 17 percent in the light trucks, single unit trucks and combination trucks respectively.

Figure 6-3 displays the trend in distribution of activity by vehicle class among the areas of operation. The TIUS divides the area of operations into local (less than 50 miles haul) and over-the-road (greater than 50 miles haul). A comparison of the 1977 and 1982 VMT distributions for chemical and petroleum products, as displayed in Figure 6-3, suggested that the relative local and over-the-road (abbreviated as o.t.road) shares of the total VMT had changed. The local shares had in general increased due to the fact that over-the-road VMT had been decreased by the vehicle class shift from single units to combinations. In chemicals transportation, the VMT in light trucks used for over-the-road decreased 62 percent and the VMT in single unit trucks in over-the-road operations decreased 30 percent, while the VMT in combination trucks in over-the-road operations increased 21 percent. In petroleum products transportation, the VMT in each of the vehicle classes had decreased due to the overall reduction in total demand for petroleum products. Among the three vehicle classes for over-the-road operations, light trucks decreased 62 percent, single units decreased 58 percent and combinations decreased the least, with 34 percent.

The apparent vehicle class shift from single units to combinations for both chemical and petroleum products in the over-the-road operations was reflected in local operations by the increased use of combination trucks. The combination VMT in local operations increased 98 percent for chemical products and 52 percent for petroleum products, while the combined light truck and single unit truck VMT increased 12 percent for chemicals and decreased 6 percent for petroleum products. Since the total VMT of all vehicle classes transporting chemical and petroleum products as their principal product had increased moderately despite the reduction in total demand for petroleum products, the continued growth of local truck activity appears to have been associated with increased use of combination trucks.

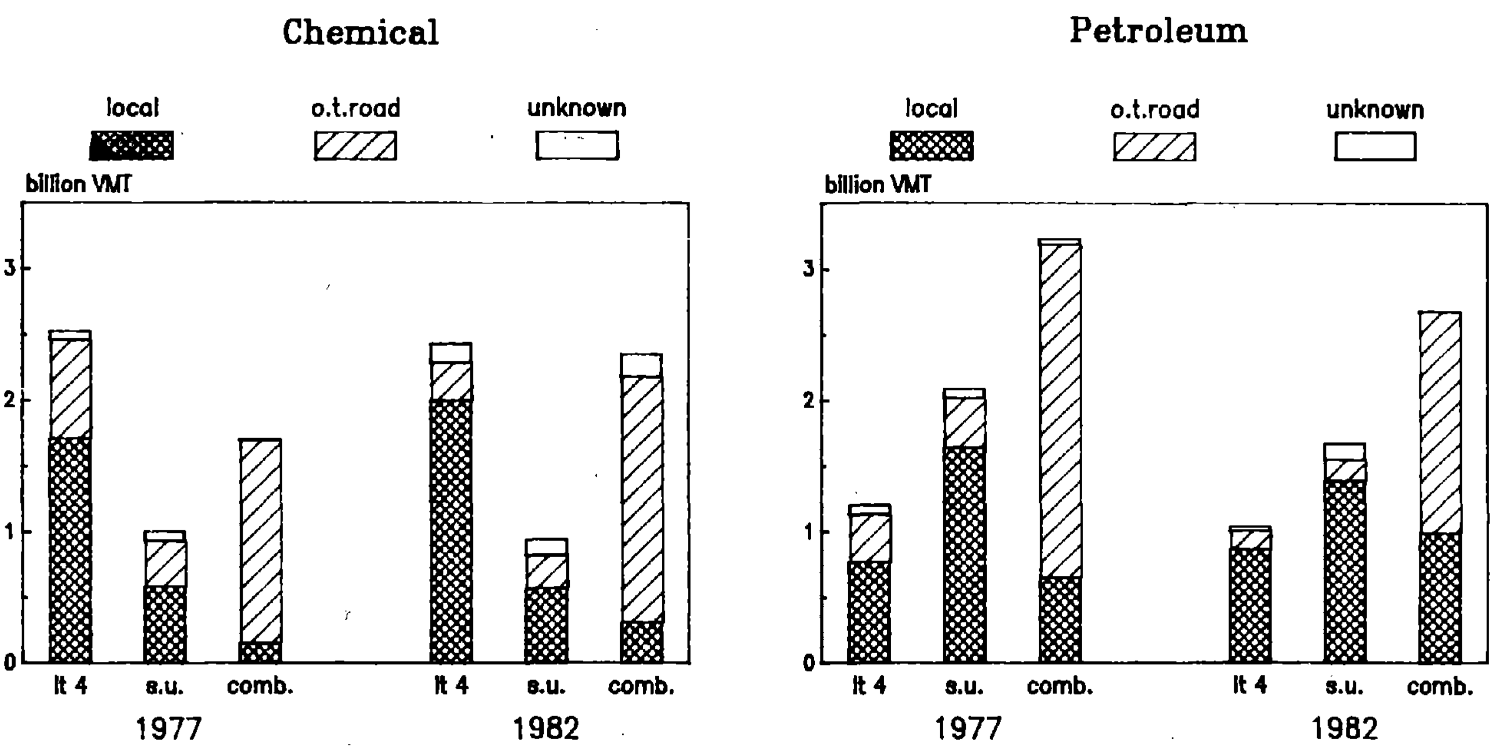


FIGURE 6-3. COMPARISON OF 1977 AND 1982 VMT BY AREA OF OPERATION

Figure 6-4 displays a comparison of the distribution by vehicle body type. No significant change was evident between 1977 and 1982 in the use of tank bodies (bulk shipments) versus other body types (packaged shipments). The fleet involved in chemical products transport showed only a 4 percent (51 to 55 percent) difference in the tank body share of trucks between 1977 and 1982. No measurable change was apparent in single unit truck use (24 percent) of tank bodies. The fleet involved in petroleum products transport showed only 4 percent (92 to 88 percent) difference in tank body combinations and a 5 percent (80 to 75 percent) difference in single unit tank bodies.

Figure 6-5 displays the same relationships but with VMT in lieu of vehicle population as the dependent variable. In chemicals transport, the VMT generated by tank body combinations did not change, remaining at 58 percent of the total combination VMT, but the VMT of the single unit tank bodies increased from 21 to 24 percent of the total single unit VMT. In petroleum products transportation, the VMT generated by tank body combinations decreased from 93 to 90 percent of the combination total VMT, and the VMT of single unit tanks decreased from 82 to 74 percent of the single unit total VMT.

It appears from Figures 6-4 and 6-5 that tank body trucks carrying bulk shipments remained the primary highway risk exposure concern in petroleum products transport. However, in chemicals transport, packaged shipments in non-tank vehicles should be of equal concern as tank vehicles.

Table 6-1, which is identical in format to Table 4-2, displays a profile of the truck fleet in placarded operations derived from the 1982 TIUS. The reported placarded portion of the chemical and petroleum fleets was small in 1982, as it was in 1977. The percentage of chemical trucks placarded was 13 percent in 1977 and 19 percent in 1982, while the percentage of petroleum trucks placarded was 33 percent in 1977 and 54 percent in 1982. These percentages were lower than would be indicated by the estimates of hazardous chemical and petroleum products shipments presented in Section 3. In 1977, 96 percent of the chemical tons shipped and 42 percent of the petroleum products tons shipped were hazardous. The placarded trucks in the TIUS may under-represent a greater number of trucks actually involved in the transport of hazardous materials. There is room to question whether all van body trucks transporting small shipments of packaged hazardous materials were represented. However, a

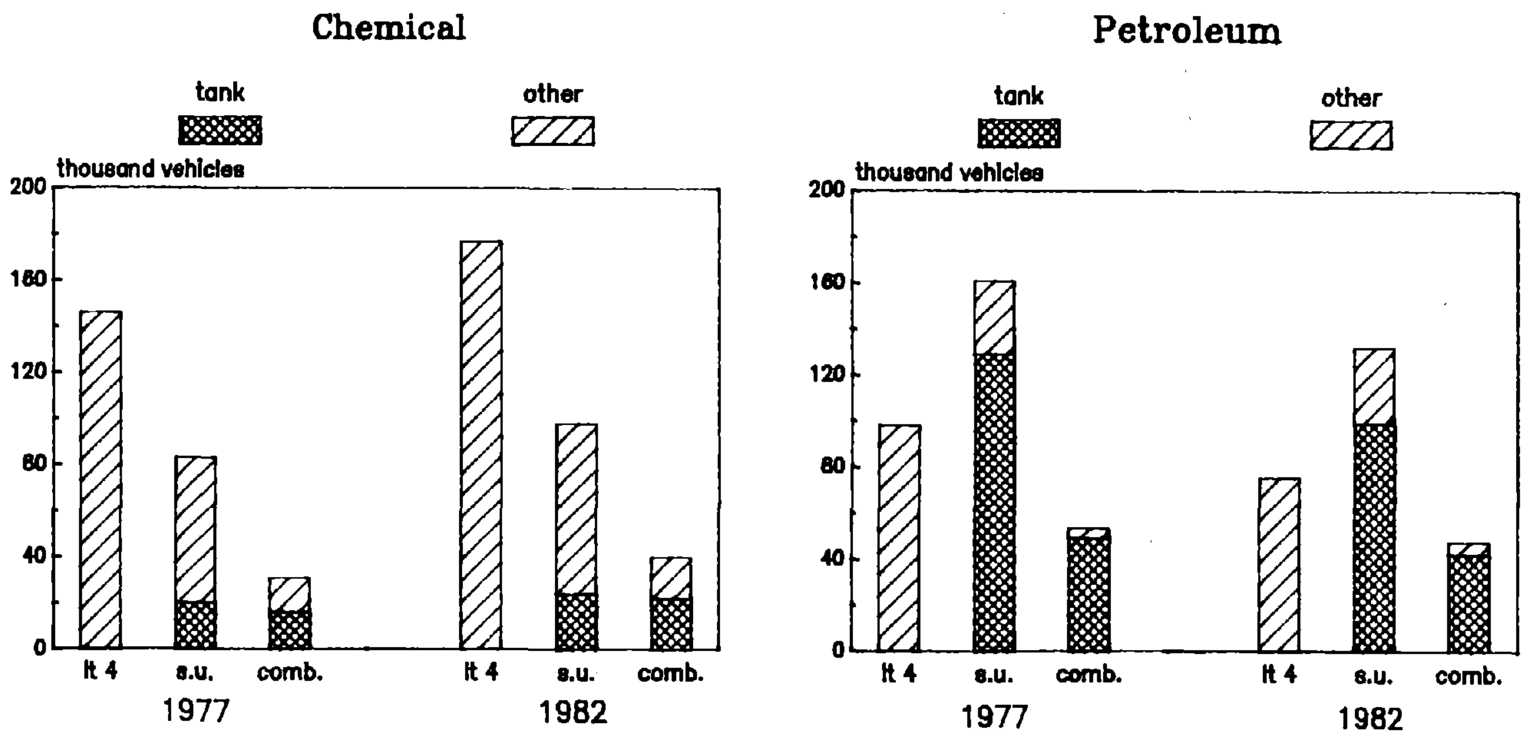


FIGURE 6-4. COMPARISON OF 1977 AND 1982 TRUCK FLEETS BY SIZE AND BODY TYPE

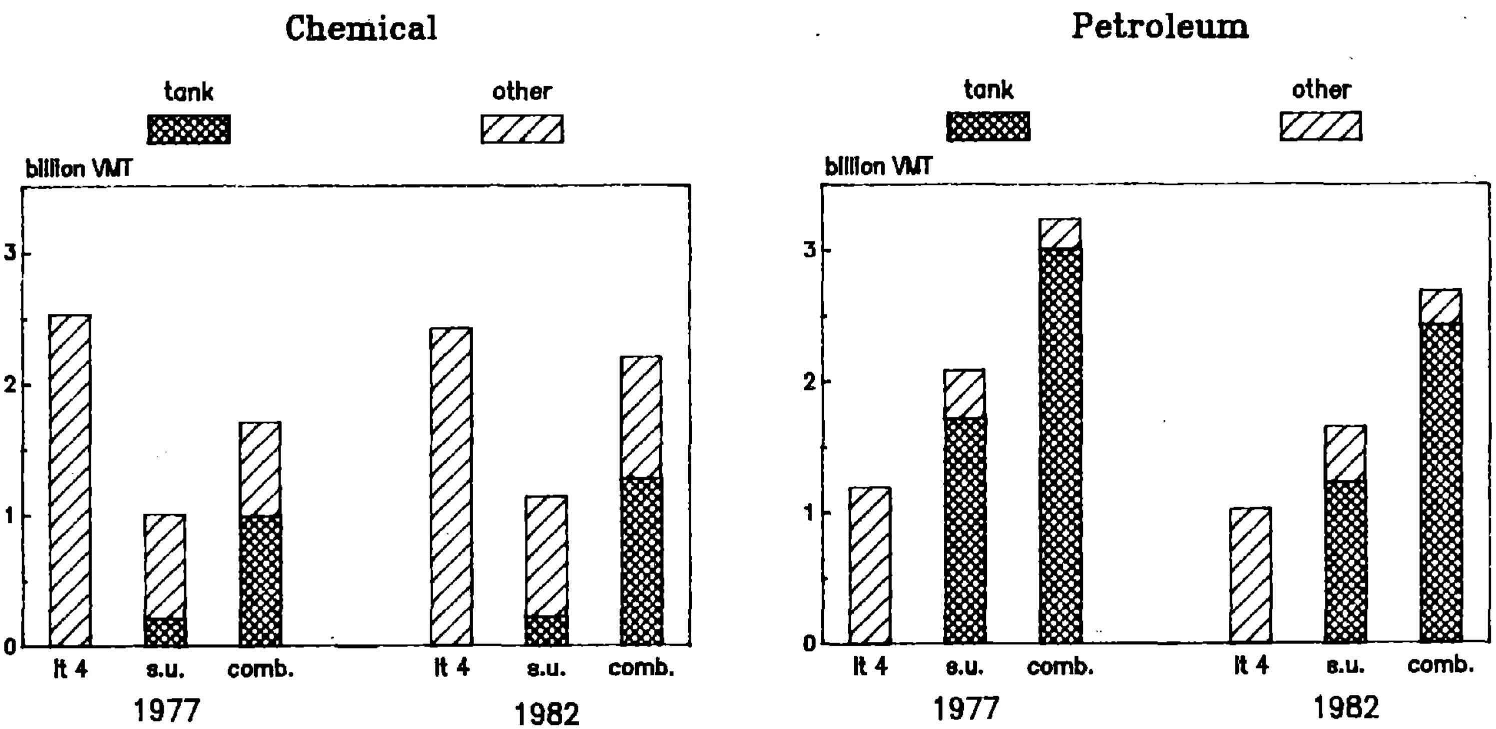


FIGURE 6-5. COMPARISON OF 1977 AND 1982 VMT AND BODY TYPE

TABLE 6-1. PROFILE OF TRUCK FLEET PLACARDED FOR TRANSPORT OF HAZARDOUS MATERIALS - 1982

	PLACARDED	<75% OF VMT		75-100% OF VMT	
	NUMBER	NUMBER[1]	%	NUMBER[1]	%
Fleet Total	465,591	380,398	100.0	80,163	100.0
Vehicle Class					
Single- Units	261,427	198,996	52.3	57,503	71.7
Combinations	204,164	181,402	47.7	22,660	28.3
Unknown	0	0	0	0	0
Body Type					
Vans	141,810	139,139	36.6	2,458	3.1
Tanks	132,705	65,367	17.2	67,296	83.9
Pickup, Panel, Walk-in	105,660	98,773	26.0	2,364	2.9
Other	85,416	77,118	20.2	8,045	10.1
Unknown	0	0	0	0	0
Area of Operation					
Local	269,299	204,773	53.9	59,748	74.5
Over-The-Road <200 Miles	90,865	77,518	20.4	13,245	16.5
Over-The-Road >200 Miles	73,060	70,569	18.6	2,492	3.1
Off-Road	32,278	27,537	7.1	4,678	5.9
Unknown	89	1	0	0	0
Principal Product Carried					
Chemical Prod.	60,328	49,649	13.1	10,617	13.2
Petroleum Prod.	136,488	68,110	17.9	68,337	85.3
Mixed Shipments	113,463	113,464	29.8	0	0
Other	155,312	149,175	39.2	1,209	1.5
Unknown	88	44	0	0	0
Major Use/Industry					
Wholesale/Retail Trade	119,650	68,927	18.1	50,468	63.0
For-Hire Transport	173,680	164,459	43.2	9,222	11.5
Other	172,261	147,011	38.7	20,473	25.5
Unknown	0	1	0	0	0

Note: [1] Excludes respondents who gave no percent of miles placarded.

comparison of Tables 4-2 and 6-1 should provide some insight into any changes of the reported placarded operations between 1977 and 1982. A major difference in the two tables is that in 1977 the survey respondent was asked for the "percent of time" that the sampled truck was placarded, whereas in 1982 the respondent was asked for the percent of the sampled truck's VMT associated with that activity. Whether the respondents answered in terms of time or miles, these variables served as indicators of any changes in the characteristics of the trucks involved in hazardous materials transportation. Comparing Tables 4-2 and 6-1 indicates that, on the whole, the total number of trucks reporting placarded operations increased 33 percent, largely attributed to a 41 percent increase in single unit trucks.

Disregarding the 12 percent of respondents who did not report the rate of placard use, the number of trucks reporting essentially dedicated placarded operations decreased 26 percent. Most of this decrease was in petroleum trucks. This could indicate an increase in the relative importance of trucking operations in which the transport of hazardous materials is a part-time affair. The distributions within each descriptive variable for the dedicated operations was virtually unchanged between 1977 and 1982, while the distributions for the occasionally placarded services had changed substantially, with the exception of area of operations. In 1977 the single unit trucks were about equally divided between the essentially dedicated to placarded service and the occasionally placarded, but in 1982 those reporting essentially dedicated service dropped from one half to one quarter of the placarded fleet. Placarded combination trucks dropped from 23 to 11 percent in dedicated placarded service. Placarded tank trucks reduced their essentially dedicated services from 78 percent of the placarded fleet in 1977 to 51 percent in 1982. There was a 77 percent increase in placarded trucks reporting their primary products carried were products other than chemical, petroleum products or mixed shipments. Table 6-1 suggests that these other products were the largest category of principle product carried reported for placarded operations, which was not the case in 1977. However, the table also shows that 96 percent of these were placarded less than 75 percent of their VMT. In fact, 60 percent of these were placarded less than 25 percent of their VMT. This is consistent with the increase in placarded single unit trucks, many of which may be transporting radioactive materials not classified as chemical products.

6.2 ANALYSIS OF TRENDS IN DOMESTIC PRODUCTION AND IMPORTS - 1977-1983

Comparing trends in truck activity with trends in aggregate economic statistics of domestic production and foreign imports, and with trends in rail transport of chemical and petroleum products, all over the same time period, should yield some insight into the stability of the distribution patterns described in Sections 3, 4, and 5. Unfortunately the latest data available for these aggregate sources are from 1983. However, if a relationship between these aggregate annual economic and transportation statistics and truck activity patterns can be established, then recent trends in truck patterns may be inferred as new statistics become available. Limited by the absence of periodic data on commodity flows by truck and more frequent updates of data on freight demand and truck activities, this approach appears to be the only analytical alternative available.

Table 6-2 shows trends in domestic production and foreign imports of chemical products in value of sales (1977 constant dollars). It also displays trends in domestic production and foreign imports of petroleum products in physical units of volume. For each item, a growth index is shown with the 1977 value as its base. The indexes are comparable because the dollar values have been adjusted for inflation. Table 6-2 indicates that chemical products sales between 1977 and 1982 did not change significantly in total volume, while total VMT for trucks whose principal product carried was chemicals increased by 6 percent (Section 6-1). Table 6-3 indicates that, in the same time period, rail carloads of chemicals decreased by 14 percent and tons of chemicals shipments by rail decreased by 3 percent. These two pieces of information could indicate a shift of chemical products market shares from rail to truck. Since the rail ton-miles had increased by 11 percent, this would suggest that the rail market share losses were most likely in the shorter haul markets rather than in the longer haul markets. Generally this type of modal shift is reflected by an increase in activity of combination trucks in over-the-road services rather than in the single unit trucks in local transport. Section 6-1 indicated that the combination trucks transporting chemicals over-the-road did in fact experience a 21 percent increase in VMT between 1977 and 1982. This increase could be a composite vehicle class shift and modal diversion effect.

TABLE 6-2. TRENDS IN CHEMICAL AND PETROLEUM PRODUCTS IN U.S. DOMESTIC DISTRIBUTION - 1977-1983

	1977	1978	1979	1980	1981	1982	1983
A. Chemical Products ($ Millions[1])							
U.S. Production	113,841 (100.0)	125,946 (110.6)	130,396 (114.5)	124,444 (109.3)	120,869 (106.1)	113,986 (100.1)	124,472 (109.3)
Imports	5,458 (100.0)	7,103 (130.1)	7,504 (137.5)	7,317 (134.1)	6,327 (115.4)	5,029 (92.1)	6,162 (112.9)
Total	119,349 (100.0)	133,049 (111.5)	137,900 (115.5)	131,761 (110.4)	127,196 (106.6)	119,015 (99.7)	130,634 (109.5)

Sources: United Nations, "Market Trends for Chemical Products 1975-1980 and Projections to 1990", Volume II Statistical Annex, and "Annual Review of the Chemical Industries" 1978-1983.

	1977	1978	1979	1980	1981	1982	1983
B. Petroleum Products (Millions Barrels Per Day)							
U.S. Production	9.86 (100.0)	10.27 (104.2)	10.14 (102.8)	10.17 (103.1)	10.18 (103.2)	10.20 (103.4)	10.25 (104.0)
Imports	8.81 (100.0)	8.36 (94.9)	8.46 (96.0)	6.91 (78.4)	6.00 (68.1)	5.11 (58.0)	5.05 (57.3)
Total	18.67 (100.0)	18.63 (99.8)	18.60 (99.6)	17.08 (91.5)	16.18 (86.7)	15.31 (82.0)	15.30 (81.9)

Source: Energy Information Administration, "Annual Energy Review 1984"

Notes:

[1] 1977 U.S. Constant Dollars adjusted by the price index for all chemicals
Values ( ) represent index of growth based on 1977 = 100.0

TABLE 6-3. TRENDS IN RAIL TRANSPORT OF CHEMICAL AND PETROLEUM PRODUCTS - 1977-1982

	1977	1978	1979	1980	1981	1982
A. Chemical Products						
Carloads (Thousands)	1,262 (100.0)	1,301 (103.1)	1,401 (111.0)	1,267 (100.4)	1,199 (95.0)	1,088 (86.2)
Tons (Thousands)	92,223 (100.0)	96,941 (105.1)	106,368 (115.3)	99,526 (107.9)	96,278 (104.4)	89,231 (96.7)
Ton-Miles (Millions)	63,498 (100.0)	66,501 (104.7)	73,105 (115.1)	67,139 (105.7)	65,934 (103.8)	70,462 (111.0)
B. Petroleum Products						
Carloads (Thousands)	698 (100.0)	694 (99.4)	677 (97.0)	542 (77.7)	527 (75.5)	452 (64.7)
Tons (Thousands)	42,074 (100.0)	41,786 (99.3)	41,387 (98.4)	34,313 (81.6)	33,506 (79.6)	30,502 (72.5)
Ton-miles (Millions)	20,131 (100.0)	20,148 (100.1)	20,294 (100.8)	16,949 (84.2)	16,981 (84.4)	17,494 (86.9)

Source: I.C.C. Carload Waybill Statistics

Table 6-2 also indicates that total petroleum products distribution decreased 18 percent between 1977 and 1982, while total VMT for trucks whose principal product carried was petroleum products decreased by 17 percent. Table 6-3 indicates that, in the same time period, rail carloads and tons of petroleum products shipments decreased 35 percent and 28 percent respectively. The rail ton-miles also decreased, but only by 13 percent. This would indicate the rail losses of petroleum products were also in the short haul markets. It appears that rail transport experienced substantially more than a proportionate share of the total national reduction in transport demand. Here again a modal shift is implied, but in this case in a shrinking market, and the shift may not be from rail to truck. Section 6.1 indicated that combination trucks transporting petroleum products over-the-road experienced a 33 percent decrease in VMT, some of which may be attributed to truck operations shifts to larger trucks. It is not clear whether or not over-the-road truck operations were the beneficiary of the rail market share loss.

6.3 IMPLICATIONS FOR PATTERNS OF TRUCK ACTIVITY

The trend in total domestic production and foreign imports of chemical and petroleum products observed from 1977 to 1983 showed that the total chemical supply had a relatively slow average annual growth rate which generated an overall growth of only 9.5 percent over the six year period. The chemical market has been dominated (over 95 percent) by domestic production and substantive changes in location of domestic sources could significantly alter the truck distribution patterns presented in this report. The petroleum market, on the other hand, experienced a total demand reduction of 18 percent and a shift of supply sources from imports to domestic production (that is, imports fell from 47 to 33 percent of total consumption), which probably did not effect the patterns of truck activity presented in here. Truck activity for petroleum products distribution was heavily concentrated in local and short haul markets oriented toward final consumers' locations. Without major relocations of gasoline and heating oil consuming populations and industries, the patterns presented in this report would show little change.

Truck activities associated with transport of chemical and petroleum products, as for most other commodities, were shifting from smaller trucks to larger trucks. These changes could have effected the overall patterns of truck activity if one were more concerned about the vehicle fleet mix and its activity than about the tonnage of products shipped. The increase in the average vehicle load associated with the shift to larger trucks implies a lower total number of vehicle trips for a given volume of freight transport demand. This shift to larger vehicles, if continued, could permit somewhat greater concentration of regulatory attention toward the operations of larger vehicles.

The shift in freight market shares between rail and truck may be more significant in some regions than in others because of variations in modal competition factors. There was an indication in Table 6-3 that only a slight shift of the national total shipment tons of chemical products from rail to truck had occurred between 1977 and 1983. That level of the market shift may be more significant to specific regions than appeared at the national total level.

The 1982 ton-miles of hazardous chemical and petroleum products transported by truck were estimated based on the 1977 base values and the growth factors of production and imports of chemical and petroleum products. The shift between vehicle classes and the diversions from rail were also considered in the estimation. Table 6-4, which is identical in format to Table 4-1, shows the estimated 1982 hazardous chemical and petroleum products truck traffic volumes in ton-miles, shipment tons, vehicle miles and truck trips. The average loads and the average hauls for single unit and combination trucks were assumed unchanged between 1977 and 1982. The procedure for estimating 1982 ton-miles is explained in Appendix I. This procedure can be used to project future hazardous materials truck traffic, provided growth factors reflecting economic changes and regulatory policies can be developed.

Comparing the total vehicle miles and vehicle trips in Table 4-1 and Table 6-4, a 12 percent reduction appeared in the total vehicle miles hauling hazardous chemical and petroleum products and a commensurate decrease of 18 percent in the associated truck trips. The only increase shown was for combination trucks hauling hazardous chemical products. This 21-22 percent increase in activity was, however, outweighed by a 30 percent decrease in the

TABLE 6-4. PROJECTION OF 1982 TRUCK FLEET MIX AND ACTIVITY TRANSPORTING HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS FROM PLANTS, PORTS AND REGIONAL STORAGE FACILITIES

	SINGLE UNIT TRUCKS	COMBINATION TRUCKS	ALL TRUCKS
Chemical Products			
Shipment Tons[4] (Millions)	58.5	220.1	278.6
Shipment Ton-Miles[1] (Millions)	4,735	47,230	51,965
Average Haul[2] (Miles)	81.0	214.6	---
Adjusted Average Load[3] (Tons)	1.52	13.76	---
Vehicle Miles Traveled[5] (Millions)	3,115	3,432	6,547
Annual Truck Trips[6] (Millions)	38.5	16.0	54.5
Petroleum Products			
Shipment Tons[4] (Millions)	203.2	487.4	690.6
Shipment Ton-Miles[1] (Millions)	3,474	32,362	35,836
Average Haul[2] (Miles)	17.1	66.4	---
Adjusted Average Load[3] (Tons)	2.64	14.84	---
Vehicle Miles Traveled[5] (Millions)	1,316	2,181	3,497
Annual Truck Trips[6] (Millions)	77.0	32.8	109.8

Notes:

1 Appendix
2 Appendix E, assuming 1977 average hauls unchanged
3 Appendix F, assuming 1977 average loads unchanged
4 Shipment ton-miles/average haul
5 Shipment ton-miles/adjusted average load
6 Shipment tons/adjusted average load

single unit truck activity resulting in an overall decrease of 10 percent in total truck VMT while carrying chemicals. This 10 percent decrease suggested a conflict with the 6 percent increase of total VMT revealed in the TIUS data in Section 6.1. It should be noted, however, that the control volumes presented in Tables 4-1 and 6-4 represent shipments of hazardous chemical and petroleum products only. Whereas the VMT presented in Section 6.1 represented all operations of the reporting vehicles, including the VMT associated with products other than hazardous chemical and petroleum products. As mentioned in Section 6.1, part of the apparent discrepancy may be attributed to the change in classification of light trucks in 1982, which substantially increased the total number of single units reported to be involved in chemical transport.

The truck trips and truck-miles for hazardous materials transport in both Tables 4-1 and 6-4 may have been underestimated because of the use of average vehicle loads. In mixed shipments of packaged chemicals the use of average vehicle loads by commodity group could underestimate the number of trucks actually carrying the hazardous tonnage. The calculation process implicitly assumes that all the hazardous tonnage is assigned to trucks carrying only hazardous materials, and that no nonhazardous shipments share the truck load. In reality the hazardous shipments may be loaded more sparsely into more trucks (that is, more truck trips and more VMT), sharing the average load with non-hazardous shipments.

Section 6 has been limited to analysis of changes in the national total truck traffic volume and the mix of commodities and vehicle classes; no attempt has been made to analyze any shifts in regional distribution patterns. Section 5 of this report indicated that a significant portion of truck activity was directly linked to local or regional economic activities. Analysis of changes in regional patterns will require recent data at the state or regional level. Therefore, in addition to projection of future hazardous materials truck traffic, perhaps state and regional level sources of data may be fruitfully explored. To be more precise, analysis of shifts in regional hazardous materials truck activity and shifts of transport markets between modes should be pursued using data obtained from state, regional and industry sources.

7. CONCLUDING OBSERVATIONS

This report offers a broad general perspective on the nation's volume of hazardous truck traffic, and the characteristics of truck transport of hazardous chemical and hazardous petroleum products in particular. Although this research effort has exhausted the publicly available data and has incorporated numerous analytical assumptions and economic factors to estimate traffic volumes and to illustrate the traffic patterns, the results will probably fail to entirely satisfy any one interest group. The data deficiencies identified in this report restrict the field of view and the sharpness of focus of the overall picture presented here. However, this report has identified the three major sources of truck trips - domestic production plants, ports of entry of foreign imports and regional storage facilities - and has indicated the relative magnitudes of truck activity from these three sources. The truck traffic from the primary storage facilities associated with production plants has been segregated from traffic originating at secondary storage facilities associated with regional distributors. This segregation is an essential element in understanding the past and probable future distribution patterns.

Although the underlying assumptions and data quality might be refined in the future, the analysis process used here yielded insights into the nature of hazardous materials truck traffic and the associated regional distribution patterns. The resulting maps and regional traffic distributions should help to focus the attention of federal and state level regulators and policy makers. Although the base year data are a decade old, comparison with 1982 data from the TIUS and some more recent aggregate production statistics provided a five to six year update on the patterns of truck fleet mix and activities associated with the transport of chemical and petroleum products relative to other truck freight.

A great deal of effort in this study has been directed toward exploitation of data from several sources, and creative synthesis using discrete assumptions to produce a more sophisticated result than would have been otherwise possible. This report has generalized the national truck activities associated with the transport of hazardous chemical and petroleum products. Future studies of more limited scope focusing on specific industrial subgroups, or on certain geographical regions, could benefit from the analysis framework presented here.

In comparing the 1977 base year data with more recent data, the most significant change was found to be the increased use of combination trucks in over-the-road service in lieu of single unit trucks. Combination trucks were also found to have increased their involvement in secondary distribution activities and local services, even while the single unit trucks maintained their high level of activity in local operations.

Increased activities of large combination (i.e., articulated multi-unit) vehicles loaded with hazardous chemical and petroleum products in the local and short haul distribution markets, could pose an increased risk to other highway traffic in the more congested urbanized areas. However, a substantial vehicle class shift, resulting in greater average vehicle loads, would certainly reduce the total number of truck trips and truck-miles generated in local and short haul regional distribution for a given annual shipment tonnage, thus reducing the overall risk of accident. To accurately assess the net change in risk, new data from selected state and regional sources would be required.

Locally oriented shipment volumes of petroleum products from regional storage facilities have been shown to be substantially larger than those from the other two sources. The flows from the second largest source, domestic production plants, have been shown to be mostly short haul and intra-regional in nature, with relatively small percentages inter-regional. There may have been some subtle changes within the petroleum industry which might have resulted in minor shifts of regional traffic patterns since the data base year (1977). Although the imports and consumption of petroleum products had substantially reduced in volume during the early 1980s, the major U.S. domestic production and refining centers have not geographically shifted. In addition, truck transport of petroleum products tend to be short hauls and heavily concentrated in the consumption region rather than the production region of the distribution system. Most of the truck transport of petroleum products has been from regional storage facilities for local and regional distribution, and major shifts in regional consumption would have been required to substantially change the petroleum truck patterns presented in this report. Therefore, it is unlikely that any substantive shifts have taken place in the truck distribution patterns of petroleum products during the past nine years.

Chemical products transport, however, differs in that half of the tonnage loaded on trucks originating at U.S. domestic production plants was transported longer distances to other regions. Substantial shifts in location of supply sources, such as imports of selected chemical products in lieu of domestic production, and shifts in the location of intermediate consumers of chemical products could have substantively changed the inter-regional flow patterns. However, it is not likely that substantially different distribution patterns of chemical products (representing 30 percent of the total 1977 hazardous shipment tons identified by this report) would have substantially changed the aggregate (that is, the sum of both chemical and petroleum products) hazardous truck activity patterns presented in this report.

Structural changes in the chemical or the petroleum industries, resultant shifts of regional production and consumption, and their effect on the associated truck traffic have not been explored in this research effort. Such changes therefore remain undetermined.

There are still areas of weakness in the information presented here, though it can serve as a picture on the national level of the truck distribution patterns of hazardous chemical and petrolueum products. One such weakness is the under-representation, in the CTS data, of petroleum products in the South, which is a major production area. There is obviously a need for continued data collection to resolve this problem. Industry and state sources of data on production, consumption and transportation in the heavy industrial states are likely sources to fill the gaps in the CTS data. Another weakness may be the possible overestimate of the tonnage of hazardous chemicals transported by trucks. In this report, the entire flow of a 5-digit commodity group reported in the CTS was included if any subgroup was identified as hazardous. It is not known how great this overestimate might be.

One last observation to be made is that, in the TIUS, trucks reporting placarded operations are only a small fraction of the total number of vehicles reporting chemical and petroleum products as their principal product carried.

The percentage of chemical trucks placarded was 13 percent in 1977 and 19 percent in 1982, while the percentage of petroleum trucks placarded was 33 percent in 1977 and 54 percent in 1982. In 1977, 96 percent of the CTS total chemical shipment tons and 42 percent of the petroleum shipment tons by truck were hazardous, according to estimates in this report. This discrepancy may be explained in part by the overestimated hazardous portion of the chemical products and petroleum products total mentioned above. In addition, there may have been a substantial quantity of small shipments of packaged hazardous chemical products moving in unplacarded van trucks along with other shipments of nonhazardous freight. Of these two possible causes, the latter should be of greatest concern and should receive research attention to determine whether regulations are in need of revision or additional enforcement or both.

APPENDIX A

ESTIMATING IMPORTS OF HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS FROM CANADA AND MEXICO

The Bureau of the Census microfiche reports (FAS 236) for Canada and Mexico provide annual quantities of shipments into the U.S. at the 7-digit commodity code level. The vessel and air quantities are listed separately and have been subtracted from the import totals to provide the total quantity transported by the truck and rail modes (industry sources indicated that pipelines were not involved in transport of chemical or petroleum products). The quantities are given in non-weight units such as gallons and barrels as well as in pounds, short tons, long tons and hundred weight; they required conversion before they could be used in this analysis.

Hazardous chemical and petroleum products were selected manually. The quantity units of the selected individual commodities were converted to one thousand pound units. The vessel and air quantities were subtracted from the import totals to estimate the truck and rail subtotals. The truck shares of these subtotals were estimated at 80 percent of the imported tons of chemical products and 60 percent of the imported tons of petroleum products. These truck shares reflect the U.S. domestic truck shares as shown in the CTS data.

All of the truck tonnage thus calculated was assumed to be transported in combination trucks and assumed to have average hauls approximately equal to their domestic counterparts (i.e., 257 mile for chemicals and 149 miles for petroleum products). The ton-miles generated for truck transported imports are the product of the tons imported and the average haul distance.

	Hazardous Chemical Prod.	Hazardous Petroleum Prod.
1977 Imports From:		
Mexico (Thousand Tons)	184	30
Canada (Thousand Tons)	13,422	2,998
Total Rail and Truck Modes	13,606	3,028
Truck Share (Thousand Tons)	10,885	1,816
Truck Ton-Miles (Millions)	2,797	270

APPENDIX B

NATIONAL TRUCK TRANSPORT OF PETROLEUM PRODUCTS FROM REGIONAL STORAGE FACILITIES

The tables in this section demonstrate how the Annual Energy Review, April 1983[8] and information from the Oil Jobbers Council were used to derive estimates of truck transport tons, ton-miles and average hauls from regional storage facilities. Estimates of ton-miles for each product were obtained by multiplying the annual tons shipped by an estimated average haul for each.

TABLE B-1. NATIONAL TRUCK TRANSPORT OF PETROLEUM PRODUCTS FROM REGIONAL STORAGE FACILITIES

	TONS (Millions)	TON-MILES (Millions)	AVERAGE HAUL (Miles)
Gasoline[1]			
Combination Trucks	(71.3%) 204.5	(81.1%) 9,284	45
Single Unit Trucks	(53.9%) 154.6	(18.9%) 2,163	14
Heating Oil[1]			
Combination Trucks	(100.0%) 91.7	(86.5%) 4,584	50
Single Unit Trucks	(91.7%) 84.3	(13.5%) 716	8
Other Petroleum Products[1]			
Combination trucks	(100.0%) 166.2	(100.0%) 8,310	50
All Hazardous Petroleum Products			
Combination Trucks	(84.9%) 462.4	(88.5%) 22,178	48
Single Unit Trucks	(43.8%) 238.9	(11.5%) 2,879	12
All Trucks	(128.7%) 701.3	(100.0%) 25,057	36

Notes:

[1] Total Product Tons and Ton-Miles From Table B-2

(%) Indicates percent tons or ton-miles in vehicle class within product group, sum of percents for combinations and single units greater than 100% indicated double handling of product

TABLE B-2. PETROLEUM PRODUCTS FROM REGIONAL STORAGE FACILITIES CALCULATION OF AVERAGE HAULS AND TON-MILES

TRUCK CLASS	% TONS[1]	AVERAGE HAUL[1]	TON-MILE FACTOR	%DIST.
Gasoline				
Combinations	.54x.50[2] =.270	x 50 =	13.50	.463
Combinations	.46x.40	x 50 =	9.20	.316
	=.184			
S.U. Trucks	.46x.40	x 14 =	2.58	.089
Combinations	.46x.145=.067	x 14 =	0.938	.032
S.U. Trucks	.46x.145=.067	x 14 =	0.938	.032
S.U. Trucks	.46x.20 =.092	x 14 =	1.288	.044
S.U. Trucks	.46x.11 =.051	x 14 =	0.714	.024
	.731		29.158	1.000

Average Haul = 29.158 / 0.731 = 39.9 Miles

Ton-Miles = 286.9 x 10^6 Tons[3] x 39.9 = 11,447 x 10^6

TRUCK CLASS	% TONS	AVERAGE HAUL	TON-MILE FACTOR	%DIST.
Heating Oil				
Combinations	.15x.50 =.075	x 50 =	3.75	.070
Combinations	.85x1.00	x 50 =	42.50	.795
	=.850			
S.U. Trucks	.85x1.00	x 8.5 =	7.22	.135
	0.925		53.47	1.000

Average Haul = 53.47 / 0.925 = 57.8 Miles

Ton-Miles = 91.7 x 10^6 Tons[3] x 57.8 = 5,300 x10^6

Other Petroleum Products

Average Haul = 50.0 Miles

Ton-Miles = 166.2 x 10^6 Tons[3] x 50.0 = 8,310 x10^6

Notes:

1 Percent distribution of tons and average haul from Table B-3

2 Assumes 50% distributed from primary storage at production plants covered by CTS data and 50% from regional storage facilities not covered by CTS data

3 Total tons of Products from Table B-4

TABLE B-3. DISTRIBUTION PATTERNS OF PETROLEUM PRODUCTS FROM REGIONAL STORAGE FACILITIES

Gasoline (National Pattern)[1]

Major oil company trucks transport 54% of total in 9,000 gal. tank trailers to major oil company gas stations (average haul = 50 miles)

Oil jobbers' trucks transport 46% of total:

40.0% in 9,000 gal. tank trailers to jobbers' bulk storage facilities (average haul = 50 miles) for subsequent distribution within the county service area in 1500-2000 gal. tank single unit trucks (maximum service radius = 20 miles, average haul = 14 miles[2])

14.5% in 9,000 gal. tank trailers to local dealers (maximum service radius = 20 miles, average haul = 14 miles[2])

14.5% in 1500-2000 gal. single unit tank trucks to local dealers (maximum service radius = 20 miles, average haul = 14 miles[2])

20.0% in 1500- 2000 gal. single unit tank trucks to large customer end users (Maximum service radius = 20 miles, average haul = 14 miles[2])

11.0% unknown

100.0%

No. 2 Residential Heating Oil (Northeast, north central, pacific northwest regional patterns)

Major oil company trucks transport 15% of total in 9,000 gal. tank trailers to major customers (average haul = 50 miles)

Oil Jobbers trucks transport 85% of total

100.0% in 9,000 gal. tank trailer trucks to jobbers regional storage facilities (average haul = 50 miles) for subsequent distribution in 1500-2000 gal. single unit trucks to final customers (maximum service radius = 12 miles, average haul = 8.5 miles[2])

Notes:

1 National Oil Jobbers Council
2 Assumes uniform distribution over service area

TABLE B-4. PETROLEUM PRODUCTS - CALCULATION OF TOTAL ANNUAL DOMESTIC DISTRIBUTION FROM REGIONAL STORAGE FACILITIES - INCLUDING IMPORTS

Gasoline (National Domestic Consumption):

Million Barrels/Day = 7.18[1]

Million Tons/Year = 7.18 x 365 days x 0.15 tons/barrel[2] = 393.1

Distribution From Regional Storage Facilities:

Distribution by Major Oil Companies = 393.1 x .27[3] = 106.1

Distribution by Oil Jobbers = 393.1 x .46[4] = 180.8

Total Distribution from Regional Storage Facilities = 286.9

Heating Oil :

Million Barrels/Day of Distillate Fuel Oil = 3.35[1]

Million Tons/Year = 3.35 x 365 days x 0.15 tons/barrel[2] =183.4

Heating Oil = 183.4 x .50[5] = 91.7 Million Tons/Year

Other Petroleum Products (National Domestic Consumption):

Diesel Fuel for Transportation = 183.4 x .50[5] = 91.7

Residual Fuel Oil except for Electric Utilities:

Million Barrels/Day = 3.07 - 1.71 = 1.36[1]

Million Tons/Year = 1.36 x 365 days x 0.15 = 74.5

Total Other Petroleum Products = 166.2 Million Tons/Year

Notes:

1 1982 Annual Energy Review, Energy Information Administration, DOE/EIA-EIA-0384(82), Tables 29 and 30, pp. 65 and 67. These quantities are assumed to move from primary storage facilities at plants via modes as defined by Bureau of Census sources. Distribution to oil jobbers facilities and to final points of consumption assumed to follow the patterns defined in Table B-3

2 Conversion factors, average specific gravity, 1982 Annual Energy Review, p.233

3 54% transported by major oil company, 50% of which is assumed to be shipped from regional storage facilities, Table B-3

4 46% transported by oil jobbers, see Table B-3

5 50% heating oil and 50% diesel fuel for transportation, 1982 Annual Energy Review, Fig. 33, p.68

APPENDIX C

NATIONAL TRUCK TRANSPORT OF CHEMICAL PRODUCTS FROM REGIONAL STORAGE FACILITIES

	TONS (Millions)	**TON-MILES (Millions)**	**AVERAGE Haul (Miles)**
<u>All Chemical Products</u>:			
Single Unit Trucks	68.1[3]	2,410[1]	35.4[2]
Combination Trucks	35.6[3]	1,262[1]	35.4[2]
All Trucks	103.7[3]	3,672[1]	35.4[2]
<u>Hazardous Chemical Products</u>:			
Single Unit Trucks	65.2[7]	2,310[6]	35.4[2]
Combination Trucks	34.2[7]	1,210[6]	35.4[2]
All Trucks	99.4[4]	3,520[5]	35.4[2]

Notes:

1 Federal Highway Administration (FHWA), Highway Traffic Forecasting System (HTFS), 1977 Master Traffic File (MTF), Local Service Trucks Carrying Chemicals
2 Assumes uniform distribution of activity over a 50 mile radius service area
3 Ton-Miles/Average Haul
4 95.9% of all chemical tons per Table 3-1
5 Tons multiplied by Average Haul
6 Assume combination and single unit percent distribution of All Chemicals holds for Hazardous Chemicals
7 Ton-Miles/Average Haul

APPENDIX D

NATIONAL TRUCK TRANSPORT OF HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS FROM REGIONAL STORAGE FACILITIES

	TONS (Millions)	TON-MILES (Millions)	AVERAGE Haul (Miles)
Hazardous Petroleum Products:[1]			
Single Unit Trucks	238.9	2,879	12
Combination Trucks	462.4	22,178	48
All Trucks	701.3	25,057	36
Hazardous Chemical Products:[2]			
Single Unit Trucks	65.2	2,310	35
Combination Trucks	34.2	1,210	35
All Trucks	99.4	3,520	35
Hazardous Chemical and Petroleum Products:			
Single Unit Trucks	304.1	5,189	17
Combination Trucks	496.6	23,388	47
All Trucks	800.7	28,577	36

Notes:

[1] Appendix B
[2] Appendix C

APPENDIX E

ESTIMATING AVERAGE HAUL FOR TRUCK TRANSPORT OF HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS BY VEHICLE CLASS

	SINGLE UNIT TRUCKS	COMBINATION TRUCKS	ALL TRUCKS
Chemical Products			
From Regional Storage			
Shipment Ton-miles[2] (Millions)	2,310	1,210	3,520
Average Haul[4] (Miles)	35	35	---
Shipment Tons[6] (Millions)	66	34.6	100.6
From Plants and Ports			
Shipment Ton-miles[3] (Millions)	4,436	37,624	42,060
Average Haul[5] (Miles)	257	257	---
Shipment Tons[7] (Millions)	1703	146.4	163.7
Total From Plants, Ports and Regional Storage			
Shipment Ton-miles[1] (Millions)	6,746	38,834	45,580
Average Haul[9] (Miles)	81.0	214.6	---
Shipment Tons[8] (Millions)	83.3	181	264.3
Petroleum Products			
From Regional Storage			
Shipment Ton-miles[2] (Millions)	2,879	22,178	25,057
Average Haul[4] (Miles)	12	48	---
Shipment Tons[6] (Millions)	239.9	462.0	701.9
From Plants and Ports			
Shipment Ton-miles[3] (Millions)	1,378	15,301	16,679
Average Haul[5] (Miles)	149	149	---
Shipment Tons[7] (Millions)	9.3	102.7	112
Total From Plants, Ports and Regional Storage			
Shipment Ton-miles[1] (Millions)	4,257	37,479	41,736
Average Haul[9] (Miles)	17.1	66.4	---
Shipment Tons[8] (Millions)	249.2	564.7	813.9

Notes:

[1]See Table 3-6 for total ton-miles, the split between single unit trucks and combination trucks is derived from 1977 MTF, trucks carrying chemical and petroleum products
[2]See Appendix D
[3]Total ton-miles minus ton-miles from regional storage
[4]See Table 3-6
[5]See Table 3-6
[6]Ton-miles / average haul
[7]Ton-miles / average haul
[8]Tons from plants and ports plus tons from regional storage
[9]Total Ton-miles / total tons, assuming average load is the same within each vehicle class

APPENDIX F

ESTIMATING AVERAGE VEHICLE LOADS FOR TRUCK TRANSPORT OF HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS

	SINGLE UNITS			COMBINATIONS		
	Tank	Other	All	Tank	Other	All
Chemical Products						
VMT (Millions)[1]	208	3,205	3,414	986	717	1,703
Ton-Miles (Millions)[1]	355	2,743	3,098	11,041	6,734	17,775
Average Load (Tons)[2]	1.70	0.86	0.91	11.20	9.39	10.43
Petroleum Products						
VMT (Millions)[1]	1,720	1,497	3,217	3,006	225	3,231
Ton-Miles (Millions)[1]	3,880	1,209	5,089	34,225	2,130	36,355
Average Load (Tons)[2]	2.26	0.81	1.58	11.38	9.47	11.25
All Freight						
VMT (Millions)[1]	2,893	134,170	137,063	5,662	42,781	48,444
Ton-Miles (Millions)[1]	6,848	128,438	135,286	63,700	400,163	463,863
Average Load (Tons)[2]	2.37	0.96	0.99	11.25	9.35	9.58

Notes:

[1] 1977 MTF
[2] Ton-miles/VMT

APPENDIX G

DATA SOURCES AND COMPUTING METHODS FOR THREE APPROACHES TO THE ANALYSIS OF REGIONAL DISTRIBUTION PATTERNS

The U.S. Bureau of the Census "Commodity Transportation Survey" public use tape of state-to-state o/d flows, and a BEA-to-BEA o/d flow tape prepared by the Bureau specifically for TSC in a previous project, provided the basic data for the three analytical approaches used. The first appproach relied upon the state-to-state file only. The second and third approaches each used the state-to-state and BEA-to-BEA files in conjunction with one of two different highway network models (the FHWA HTFS or the ORNL HIGHWAY model). The specific data and methods used for each approach are detailed in the following sections.

G.1. INTRA-REGION VERSUS INTER-REGION TRAFFIC

The intra-region and inter-region traffic flows from plants was derived from the CTS state-to-state o/d data file using records specified at the 2-digit TCC commodity code level. A two-dimensional cross-tabulation was constructed with the file record variables "origin" and "destination" containing the value of "shipment tons". Each state code in the data file was equated with a corresponding region code, so that a 22 by 22 region o/d table could be produced. The intra-region traffic was thus identified by the diagonal of the o/d matrix. The intra-region percentage shares of each region's total originated tons were calculated and displayed in Tables 5-2 and 5-3.

G.2. REGIONALLY-GENERATED VERSUS REGIONAL PASS-THROUGH TRAFFIC

The traffic assignment procedure in the FHWA HTFS computer-based analysis system was utilized to allocate the o/d chemical and petroleum shipment tons to the highway network and to segregate the aggregate network link loadings into four traffic categories for each region. The four traffic categories in each region are: a) shipments originated and terminated within the region,
b) shipments originated in the region but terminated outside the region,
c) shipments originated outside the region but terminated in the region, and
d) shipments that neither originated nor terminated within the region, but were assigned to highway routes that passed through the region.

The input data was the CTS/TSC BEA-to-BEA o/d commodity flows at the 2-digit TCC code level. The assignment procedure included the following four steps of computation and processing of data:

a) A minimum path algorithm which builds a minimum time/distance path between each o/d pair. The minimum path consists of a sequence of joined highway links having attributes of distance and speed.

b) A loading procedure which allocated the o/d traffic onto the paths and aggregated loads on each highway link along the minimum path.

c) A pointer procedure which identified whether an origin or destination was beyond regional boundaries, and thus classified the link loads in each region by the four traffic categories.

d) An aggregation procedure which accumulated traffic by region and by traffic category.

The traffic volume was calculated in both tons and ton-miles. The total aggregate volume of all regions when measured in tons is greater than the actual total shipment tons among all the o/d pairs because multiple counting occurs when shipments traverse several regions between the origin and destination. This multiple counting problem does not exist in the ton-mile estimates because the sum of the miles traveled in each region traversed equals the route miles between the o/d pairs.

The region shares of the national total traffic from regional storage facilities for chemical products and for petroleum products (national totals are presented in Section 3) were calculated from percent distributions of national totals derived from different sources and by different methods. The region shares of petroleum products from regional storage facilities were derived from state level consumption volumes of petroleum products. The region shares of chemical products from regional storage facilities were derived from truck activity associated with chemical transportation in each state. State-level percent distributions were subsequently aggregated into regional distributions for each commodity group.

The petroleum products consumption by state was derived from the "Basic Petroleum Data Book," Vol. III, Number 3, September 1983. Tables 9a, 10b and

12b provided the volumes for gasoline, distillate fuels and residual fuels respectively. The chemical products percent distribution was derived from the distribution of ton-miles of activity for trucks in local service carrying chemicals. The ton-miles were estimated from the 1977 TIUS data on reported truck VMT, the gross weight of the vehicle, and the percent of miles in local area of operation. The regional percent distributions of national total transport of chemical and petroleum products from regional storage facilities are displayed in Table G-1.

The tons and ton-miles thus derived for chemical and petroleum products from regional storage facilities were then added to the intra-region portion of the transport from manufacturing plants. The percent pass-through of the combined chemical and petroleum products flows in trucks in each region was then calculated and presented in Table 5-5 and Figure 5-3.

G.3. MAPPING HIGHWAY CORRIDOR FLOWS

The o/d flow files used as input to the Oak Ridge National Laboratories (ORNL) Highway Model for plotting the highway corridor maps were created from the CTS state-to-state and the CTS/TSC BEA-to-BEA commodity o/d flow files with TCC commodity codes at several different levels. An allocation procedure written in SAS programs was developed on the DOT AMDAHL computer to transform the state-to-state o/d records at 2-digit, 3-digit, 4-digit and 5-digit levels into BEA-to-BEA o/d flows which could be loaded onto the ORNL highway network. Traffic originating anywhere in a BEA region or terminating anywhere in a BEA region was allocated to the BEA's centroid city, which coincided with a network node. The ORNL network included virtually all the centroid cities of the 1977 system of BEA regions.

The allocation procedure followed a distribution pattern determined by the TSC/CTS BEA-to-BEA commodity flow data file. The formula for the allocation rule was as follows:

$$X^{ij}_{a,mn} = V^{ij}_{a} * \frac{F^{ij}_{A,mn}}{\sum_{m}^{G^i} \sum_{n}^{G^j} F^{ij}_{A,mn}}, \text{ if } \sum_{m}^{G^i} \sum_{n}^{G^j} F^{ij}_{A,mn} > 0$$

where

V^{ij}_{a} = State i to State j flow volume of commodity a.

$F^{ij}_{A,mn}$ = BEA m in State i to BEA n in State j flow volume of Commodity Group A.

A = 2-digit TCC commodity code group, here all chemical or all petroleum products.

G^i = total number of BEA regions in origin state i.

G^j = total number of BEA regions in destination state j.

$X^{ij}_{a,mn}$ = flow volume of commodity a assigned to BEA m in State i to BEA n in State j from V^{ij}_{a}.

There are four states (New Jersey, Delaware, New Hampshire and Rhode Island) that do not have BEA centroid cities within their own borders. This meant that any traffic associated with one of those states could not be assigned automatically by the formula. Therefore, an adjustment procedure was introduced to allocate this traffic to one or a few of the adjacent BEA regions. Among the four states, traffic associated with New Hampshire and Rhode Island were insignificant compared to the traffic to/from New Jersey and Delaware that had to be assigned. The adjustment procedure was in essence designed to deal only with the traffic flows to/from New Jersey and Delaware. These flows were allocated primarily to the New York City and Philadelphia BEA region centroids.

TABLE G-1. REGIONAL PERCENT DISTRIBUTION OF NATIONAL TOTAL TONS OF TRUCK TRANSPORT FROM REGIONAL STORAGE FACILITIES

REGION	STATES	% OF NATIONAL CHEMICAL TONS [1]	% OF NATIONAL PETROLEUM TONS [2]
1	Maine	0.1	0.8
2	Ver., N.Ham., Mass., Conn., R.I.	1.9	7.3
3	N.York, Penn., N.Jersey, Del.	9.8	19.2
4	Maryland, Vir., W.Vir., N.Car.	5.2	8.3
5	South Carolina, Georgia	3.1	3.6
6	Florida	4.2	4.7
7	Alabama, Mississippi	3.2	1.5
8	Kentucky, Tennessee	2.1	3.2
9	Illinois, Indiana, Ohio	17.4	7.5
10	Michigan	3.0	3.9
11	Wisconsin	0.9	1.8
12	Minnesota, Iowa	5.6	3.2
13	Missouri, Arkansas	3.6	3.2
14	Louisiana	3.8	2.8
15	Texas	7.5	6.9
16	Kansas, Oklahoma	3.3	2.3
17	Nebraska, N. Dakota, S. Dakota	1.4	1.4
18	Montana, Idaho, Wyoming	1.5	1.4
19	Utah, Colorado	0.8	1.7
20	Arizona, New Mexico	3.4	1.7
21	California, Nevada	13.7	10.9
22	Oregon, Washington	4.5	2.7
	Total	100.00	100.00

Notes:

[1]Derived from 1977 TIUS data of VMT, gross weight of vehicle and area of operation

[2]"Basic Petroleum Data Book", Vol. III, Number 3, September 1983, Tables 9a, 10b and 12b

APPENDIX H

COMPARISON OF 1977 AND 1982 TIUS

This appendix contains tabulations of values used in Figures 6-1 and 6-2, displaying the distributions of vehicles and VMT by commodity group and vehicle class. Vehicles reporting "no load" or "personal use" are excluded.

TABLE H-1. 1977 AND 1982 TIUS - PRINCIPAL PRODUCT CARRIED AND VEHICLE CLASS

PRODUCT CARRIED	1977 LT.	1977 SINGLE UNIT	1977 COMB.	1977 ALL	1982 LT.	1982 SINGLE UNIT	1982 COMB.	1982 ALL
(1,000 Vehicles)								
Chemical	147	83	31	261	177	98	39	314
Petroleum	98	161	54	313	76	132	47	255
All Products	8,713	3,874	940	13,527	7,278	3,348	1,121	11,747
No Load	12,967	188	0.6	13,156	21,346	324	64	21,734
Total	21,680	4,062	941	26,683	28,623	3,673	1,186	33,482
(1,000,000 VMT)								
Chemical	2,528	1,007	1,703	5,238	2,423	940	2,195	5,558
Petroleum	1,204	2,058	3,231	6,521	1,034	1,661	2,692	5,388
All Products	103,546	42,339	46,703	192,597	94,464	34,978	51,757	181,199
No Load	130,498	1,621	4	132,123	193,159	1,684	1,060	195,903
Total	234,044	43,960	46,707	324,710	287,623	36,662	52,817	377,102

TABLE H-2. 1977 AND 1982 TIUS - AREA OF OPERATION AND VEHICLE CLASS

	1977				1982			
	LT.	SINGLE UNIT	COMB.	ALL	LT.	SINGLE UNIT	COMB.	ALL
	(1,000,000 VMT)							
CHEMICAL PRODUCTS								
Unknown & Off-Road	65	74	4	142	135	124	17	275
Over-The-Road	754	353	1,545	2,652	287	248	1,872	2,407
Local	1,709	580	154	2,443	2,002	568	305	2,876
Total	2,528	1,007	1,701	5,237	2,423	940	2,195	5,558
PETROLEUM PRODUCTS								
Unknown & Off-Road	74	72	40	186	28	118	14	160
Over-The-Road	361	378	2,540	3,279	138	157	1,686	1,981
Local	770	1,636	651	3,056	868	1,387	992	3,247
Total	1,204	2,078	3,221	6,504	1,034	1,661	2,692	5,388

TABLE H-3. 1977 AND 1982 TIUS - TRUCK BODY TYPE AND VEHICLE CLASS

	1977				1982			
	LT.	SINGLE UNIT	COMB.	ALL	LT.	SINGLE UNIT	COMB.	ALL
				(1,000 Vehicles)				
CHEMICAL PRODUCTS								
Tank	0	20	16	36	0	24	22	46
Other	146	63	15	224	177	74	17	269
Total	146	83	31	260	177	98	39	315
PETROLEUM PRODUCTS								
Tank	0	129	49	178	0	99	42	141
Other	98	32	5	134	76	33	5	114
Total	98	161	54	312	76	132	47	255
				(1,000,000 VMT)				
CHEMICAL PRODUCTS								
Tank	0	208	986	1,194	0	224	1,268	1,492
Other	2,528	799	717	4,044	2,423	716	927	4,066
Total	2,528	1,007	1,703	5,238	2,423	940	2,195	5,558
Petroleum Products								
Tank	0	1,720	3,006	4,726	0	1,232	2,431	3,663
Other	1,204	365	225	1,794	1,034	429	261	1,725
Total	1,204	2,085	3,231	6,520	1,034	1,661	2,692	5,388

APPENDIX I

ESTIMATING 1982 TOTAL TON-MILES FOR TRUCK TRANSPORT OF HAZARDOUS CHEMICAL AND PETROLEUM PRODUCTS, INCLUDING EFFECTS OF VEHICLE CLASS SHIFT AND MODAL DIVERSIONS

TABLE I-1. 1982 TOTAL TON-MILES FOR CHEMICAL PRODUCTS

		FROM PLANTS	FROM PORTS	FROM REGIONAL STORAGE	TOTAL
1977 Ton-Miles (Millions)[1]					
	Single Units	3,975	461	2,310	6,746
	Combinations	33,714	3,910	1,210	38,834
1977 - 1982 Growth Index[2]		1.001	0.921	0.997	
1982 Projected Ton-Miles (Millions)[3] (without Vehicle Class Shift)					
	Single Units	3,979	425	2,303	6,607
	Combinations	33,748	3,601	1,206	38,555
Vehicle Class Shift Factor[4]					
	Single Units	- 50%		+ 10%	
	Combinations	+ 15%		+ 100%	
1982 Projected Ton-Miles (Millions)[5] (with Vehicle Class Shift)					
	Single Units	2,202		2,533	4,735
	Combinations	42,951		2,412	45,363
Diversion Factor[6] (Rail to Highway)					
	Single Units	0.0		0.0	
	Combinations	0.05		0.0	
1977 - 1982 Ton-Mile Diversions from Rail (Millions)[7]					
	Single Units	0		0	0
	Combinations	1,867		0	1,867
1982 Projected Ton-Miles (Millions)[8] (with Vehicle Class shift plus Modal Diversion)					
	Single Units	2,192		2,533	4,735
	Combinations	44,843		2,412	47,230

TABLE I-2. 1982 TOTAL TON-MILES FOR PETROLEUM PRODUCTS

		FROM PLANTS	FROM PORTS	FROM REGIONAL STORAGE	TOTAL
1977 Ton-Miles (Millions)[1]					
	Single Units	1,306	72	2,879	4,257
	Combinations	14,507	794	22,178	37,479
1977 - 1982 Growth Index[2]		0.82	0.58	0.82	
1982 Projected Ton-Miles (Millions)[3] (without Vehicle Class Shift)					
	Single Units	1,071	42	2,361	3,474
	Combinations	11,896	461	18,186	30,543
Vehicle Class Shift Factor[4]					
	Single Units	0		0	
	Combinations	0		+ 10%	
1982 Projected Ton-Miles (Millions)[5] (with Vehicle Class Shift)					
	Single Units	1,113		2,361	3,474
	Combinations	12,357		20,005	32,362
Diversion Factor[6] (Rail to Highway)					
	Single Units	0		0	
	Combinations	0		0	
1977 - 1982 Ton-Mile Diversions from Rail (Millions)[7]					
	Single Units	0		0	
	Combinations	0		0	
1982 Projected Ton-Miles (Millions)[8] (with Vehicle Class shift plus Modal Diversion)					
	Single Units	1,113		2,361	3,474
	Combinations	12,357		20,005	32,362

Notes:

[1]Derived from Table 3-6 and Appendix E
[2]Table 6-1
[3]Ton-miles According to the Growth Index
[4]Derived from Tables H-1 and H-2 (light trucks combined with single units) with modal diversion adjustments as indicated by Table 6-3
[5]1982 base case ton-miles and the change of ton-miles attributed to vehicle class shift
[6]Derived from Table 6-3 and Table H-1
[7]1982 base case ton-miles multiplied by modal diversion factor
[8]1982 Projected ton-miles w/vehicle class shift plus ton-mile diversion from rail

APPENDIX J
BEA ECONOMIC AREAS

The delineation of the economic areas to be used in the projections was critical. Central place theory, with its emphasis on cities as the hubs around and within which integrated economic activity concentrates, provided the conceptual basis for the delineation of the desired areas. The application of this theory to the economic data relating to the counties of the nation resulted in 173 city-oriented areas, each with its hinterland in which there is a definite interaction of the various parts with the center and in which the establishments, both businesses and households, are functionally related. These nodal-functional economic areas have been designated BEA Economic Areas and are presented in the map on page J-5. A list of the counties and independent cities in each state by economic areas begins on page J-6.

One of the functional characteristics of these regions is that each combines its labor market and labor supply (i.e., the place of work and the place of residence of the labor force). There is, therefore, a minimum of commuting across economic area boundaries.

Each economic area has essentially two types of industries. One group constitutes the basic, or export, industries which produce goods and services, most of which are exported to other areas, thus earning the means with which to purchase the specialized goods and services of other areas.

The production location of export types of goods and services is determined mainly by the costs associated with special resources. Different commodities are associated with production processes requiring different input relationships, and the comparative advantage of an area for the production of a commodity is determined by the area's relative endowment with the factors of production. Of course, regional specialization has implications for regional economies of size in the production of commodities, thus further reinforcing regional comparative advantage and specialization.

In addition to basic, or export, industries, each area has another group of industries, termed "residentiary," which are functionally related to the households and businesses of the area in that they produce most of the services and some of the goods required by the household sector and by other local businesses as intermediate products. Each of the areas approaches self-sufficiency in regard to these residentiary industries, which include general and convenience retail and wholesale trade activities and those other goods which are difficult or impossible to transport and which are most efficiently consumed in the vicinity of their production. Thus the economic areas correspond to the closed trade areas of central place theory in which the number and type of residentiary establishments and their size and trade areas are bounded by the relative transportation costs from hinterland to competing centers.

Among economic areas, the relationship of basic and residentiary industries and the composition of the latter vary according to factors such as type of basic industry, economic size of area, level of per capita income, economic maturity, and nature of surrounding areas. Despite these differentiating factors, interindustry relationships within each area exhibit a general similarity and substantial stability, although they do change as a result of secular trends and developmental threshholds (points at which local markets for intermediate or consumer products become large enough for local production to supplant all or a portion of imports). These characteristics of similarity and stability are what make the economic areas superior for projection purposes to other geographic areas delineated in accordance with noneconomic criteria.

The first step in the economic area delineation was the identification of the economic centers. Standard metropolitan statistical areas (SMSAs) that are general trade and labor market centers were chosen as the nodal centers. However, not all SMSAs are centers of economic areas because some are integral parts of larger metropolitan complexes. For example, the Jersey City, Newark, Paterson-Clifton-Passaic, Stamford, Norwalk, and Bridgeport SMSAs are all part of the New York City complex. In rural parts of the country where there are no SMSAs, cities of 25,000 to 50,000 population are the economic centers.

After identifying the economic centers, the next task was to determine on which center each of the remaining counties was focused economically. The primary data used in this determination were the journey-to-work data from the 1960 Census of Population. Those data were summarized and posted on maps so as to show the gross commuting for each individual county to each adjacent county, and to as many as 13 countries altogether if such commuting occurred. Counties were then associated with the economic centers in accordance with the commuting pattern.

In places where the commuting pattern of adjacent economic centers overlapped, counties were included in the economic area containing the center with which there was the greatest commuting connection. In the case of cities where the commuting pattern overlapped to a great degree, no attempt was made to separate them. Instead, both cities were included in the same economic area. Many counties were associated with an economic area not because of their commuting ties to the city itself, but because of their association with other counties which were tied to the economic center. Thus, for the first ring of counties around the central county, the criterion was a commuting link to the latter, while for the next ring the criterion was a commuting link to the central county or to the first ring.

In the more rural parts of the country, the journey-to-work information was insufficient to establish the boundaries of the economic areas. For these areas the road network and certain geographic features which would affect the possibility and time of travel to the economic center, and the linkage of counties by other socioeconomic ties such as communications and cultural, recreational and trade activities were the major determinants.

Because of the necessity of using counties as the building blocks, a number of compromises had to be made in assigning counties when it was obvious that residents of one portion of a county commuted in one direction while those of another portion commuted in a different direction. Such compromises did not damage the delineation significantly, however, as separate areas were not delineated when the overlapping of commuting patterns was considered too great.

A map showing a preliminary delineation of these economic areas was circulated among state planning agencies, bureaus of business research and Federal agency fields offices for critical review. Careful consideration was given to the review suggestions in the preparation of the revised map shown here.

FIGURE J-1. BEA ECONOMIC AREAS

ECONOMIC AREA COUNTY COMPOSITION

COUNTIES AND INDEPENDENT CITIES IN BEA ECONOMIC AREAS BY STATE WITH WATER RESOURCES SUB AREA AND FIPS SMSA CODES

State, economic area and county names	Water resources sub area code	FIPS SMSA code
ALABAMA		
039 Pensacola, Fla. (Part, see Fla.)		
Escambia	0314	
040 Montgomery, Ala.		
Autauga	0315	
Barbour	0313	
Bullock	0314	
Butler	0314	
Coffee	0314	
Coosa	0315	
Covington	0314	
Crenshaw	0314	
Dale	0314	
Dallas	0315	
Elmore	0315	5240
Geneva	0314	
Henry	0313	
Houston	0313	
Lowndes	0315	
Macon	0315	
Montgomery	0315	5240
Perry	0315	
Pike	0314	
Tallapoosa	0315	
043 Columbus, Ga.–Ala. (Part, see Ga.)		
Chambers	0313	
Lee	0313	
Randolph	0315	
Russell	0313	1800
044 Atlanta, Ga. (Part, see Ga.)		
Cleburne	0315	
045 Birmingham, Ala. (Part, see Miss.)		
Bibb	0315	
Blount	0316	
Calhoun	0315	
Cherokee	0315	
Chilton	0315	
Clay	0315	
Cullman	0316	
Etowah	0315	2880
Fayette	0316	
Greene	0316	
Hale	0316	
Jefferson	0316	1000
Lamar	0316	
Marion	0316	
Pickens	0316	
St. Clair	0315	
Shelby	0316	1000
Talladega	0315	
Tuscaloosa	0316	8600
Walker	0316	1000
Winston	0316	
047 Huntsville, Ala. (Part, see Miss. and Tenn.)		
Colbert	0603	2650
Franklin	0603	
Lauderdale	0603	2650
Lawrence	0603	
Limestone	0603	3440
Madison	0603	3440
Marshall	0603	
Morgan	0603	
048 Chattanooga, Tenn.–Ga. (Part, see Ga., N.C. and Tenn.)		
De Kalb	0603	
Jackson	0603	
136 Meridian, Miss. (Part, see Miss.)		
Choctaw	0316	
Marengo	0316	
Sumter	0316	
137 Mobile, Ala. (Part, see Miss.)		
Baldwin	0316	5160
Clarke	0316	
Conecuh	0314	
Mobile	0316	5160
Monroe	0315	
Washington	0316	
Wilcox	0315	
ARIZONA		
162 Phoenix, Ariz.		
Apache	1501	
Coconino	1502	
Gila	1505	
Maricopa	1505	6200
Mohave	1502	
Navajo	1501	
Pinal	1504	
Yavapai	1505	
Yuma	1506	
163 Tucson, Ariz.		
Cochise	1504	
Graham	1503	
Greenlee	1503	
Pima	1504	8520
Santa Cruz	1504	
ALASKA		
172 Anchorage, Alaska		
First Judicial District	1906	
Second Judicial District	1901	
Third Judicial District	1904	0389
Fourth Judicial District	1903	
ARKANSAS		
046 Memphis, Tenn.–Ark. (Part, see Miss. and Tenn.)		
Clay	0802	
Craighead	0802	
Crittenden	0801	4920
Cross	0802	
Greene	0802	
Lawrence	1101	
Lee	0802	
Mississippi	0802	
Phillips	0802	
Poinsett	0802	
Randolph	1101	
St. Francis	0802	
116 Springfield, Mo. (Part, see Kans., Mo. and Okla.)		
Baxter	1101	
Boone	1101	
Carroll	1101	
Marion	1101	
Newton	1101	
Searcy	1101	
117 Little Rock–North Little Rock, Ark.		
Arkansas	0802	
Clark	0804	
Cleburne	1101	
Cleveland	0804	
Conway	1111	
Faulkner	1111	
Fulton	1101	
Garland	0804	
Grant	0804	
Hot Spring	0804	
Independence	1101	
Izard	1101	
Jackson	0802	
Jefferson	0804	6240
Johnson	1111	
Lincoln	0804	
Lonoke	0802	
Monroe	0802	
Montgomery	0804	
Perry	1111	
Pike	0804	
Pope	1111	
Prairie	0802	
Pulaski	1111	4400
Saline	1111	4400
Sharp	1101	
Stone	1101	
Van Buren	1101	
White	0802	
Woodruff	0802	

State, economic area and county names	Water resources sub area code	FIPS SMSA code
118 Fort Smith, Ark.–Okla. (Part, see Okla.)		
Crawford	1111	2720
Franklin	1111	
Logan	1111	
Polk	1114	
Scott	1111	
Sebastian	1111	2720
Yell	1111	
119 Tulsa, Okla. (Part, see Okla.)		
Benton	1107	
Madison	1101	
Washington	1111	
131 Texarkana, Tex.–Ark. (Part, see Okla. and Texas)		
Hempstead	0804	
Howard	1114	
Lafayette	1114	
Little River	1114	
Miller	1114	8360
Nevada	0804	
Sevier	1114	
134 Greenville, Miss. (Part, see Miss.)		
Ashley	0804	
Bradley	0804	
Calhoun	0804	
Chicot	0805	
Columbia	1114	
Dallas	0804	
Desha	0805	
Drew	0804	
Ouachita	0804	
Union	0804	
CALIFORNIA		
164 San Diego, Calif.		
San Diego	1808	7320
165 Los Angeles–Long Beach, Calif.		
Imperial	1810	
Inyo	1809	
Los Angeles	1808	4480
Mono	1809	
Orange	1808	0360
Riverside	1808	6780
San Bernardino	1808	6780
San Luis Obispo	1807	
Santa Barbara	1807	7480
Ventura	1808	6000
166 Fresno, Calif.		
Fresno	1803	2840
Kern	1803	0680
Kings	1803	
Madera	1804	
Tulare	1803	
167 Stockton, Calif.		
Alpine	1809	
Amador	1805	
Calaveras	1805	
Mariposa	1804	
Merced	1804	
San Joaquin	1805	8120
Stanislaus	1804	5170
Tuolumne	1804	
168 Sacramento, Calif.		
Butte	1802	
Colusa	1802	
El Dorado	1802	
Glenn	1802	
Nevada	1802	
Placer	1802	6920
Sacramento	1802	6920
Sutter	1802	
Yolo	1802	6920
Yuba	1802	
169 Redding, Calif.		
Lassen	1802	
Modoc	1802	
Plumas	1802	
Shasta	1802	
Sierra	1802	
Siskiyou	1801	
Tehama	1802	
170 Eureka, Calif.		
Del Norte	1801	
Humboldt	1801	
Trinity	1801	
171 San Francisco–Oakland, Calif.		
Alameda	1806	7360
Contra Costa	1806	7360
Lake	1802	
Marin	1806	7360
Mendocino	1801	
Monterey	1807	7120
Napa	1806	8720
San Benito	1807	
San Francisco	1806	7360
San Mateo	1806	7360
Santa Clara	1806	7400
Santa Cruz	1807	7485
Solano	1806	8720
Sonoma	1806	7500
COLORADO		
147 Pueblo, Colo.		
Alamosa	1301	
Baca	1104	
Bent	1102	
Chaffee	1102	
Conejos	1301	
Costilla	1301	
Crowley	1102	
Custer	1102	
El Paso	1102	1720
Fremont	1102	
Huerfano	1102	
Kiowa	1102	
Las Animas	1102	
Lincoln	1102	
Mineral	1301	
Otero	1102	
Prowers	1102	
Pueblo	1102	6560
Rio Grande	1301	
Saguache	1301	
Teller	1102	
148 Denver, Colo. (Part, see Nebr.)		
Adams	1019	2080
Arapahoe	1019	2080
Boulder	1019	2080
Cheyenne	1026	
Clear Creek	1019	
Denver	1019	2080
Douglas	1019	
Elbert	1019	
Gilpin	1019	
Grand	1405	
Jefferson	1019	2080
Kit Carson	1025	
Lake	1102	
Larimer	1019	
Logan	1019	
Morgan	1019	
Park	1019	
Phillips	1025	
Sedgwick	1019	
Summit	1405	
Washington	1019	
Weld	1019	
Yuma	1025	
149 Grand Junction, Colo. (Part, see N.M. and Utah)		
Archuleta	1407	
Delta	1404	
Dolores	1406	
Eagle	1405	
Garfield	1405	
Gunnison	1404	
Hinsdale	1404	
La Plata	1407	
Mesa	1405	
Moffat	1402	
Montezuma	1407	
Montrose	1406	
Ouray	1404	
Pitkin	1405	
Rio Blanco	1402	
Routt	1402	
San Juan	1407	
San Miguel	1406	
150 Cheyenne, Wyo. (Part, see Wyo.)		
Jackson	1018	
CONNECTICUT		
005 Hartford, Conn. (Part, see Mass., N.H. and Vt.)		
Hartford	0108	3283
Litchfield	0107	
Middlesex	0108	
New Haven	0107	5483
New London	0107	5523
Tolland	0107	
Windham	0107	
014 New York, N.Y. (Part, see N.J. and N.Y.)		
Fairfield	0107	1163
DELAWARE		
015 Philadelphia, Pa.–N.J. (Part, see Md., N.J. and Pa.)		
New Castle	0204	9160
017 Baltimore, Md. (Part, see Md. and Va.)		
Kent	0204	
Sussex	0206	
DISTRICT OF COLUMBIA		
018 Washington, D.C.–Md.–Va. (Part, see Md. and Va.)		
District of Columbia	0207	8840
FLORIDA		
034 Jacksonville, Fla. (Part, see Ga.)		
Alachua	0311	2900
Baker	0307	
Bradford	0311	
Clay	0308	
Columbia	0311	
Dixie	0311	
Duval	0308	3600
Gilchrist	0311	
Hamilton	0311	
Lafayette	0311	
Levy	0310	
Marion	0308	
Nassau	0307	
Putnam	0308	
St. Johns	0308	
Suwannee	0311	

State, economic area and county names	Water resources sub area code	FIPS SMSA code
Union	0311	
035 Orlando, Fla.		
Brevard	0308	4900
Flagler	0308	
Lake	0308	
Orange	0308	5960
Osceola	0309	
Seminole	0308	5960
Sumter	0310	
Volusia	0308	2020
036 Miami, Fla.		
Broward	0309	2680
Dade	0309	5000
Glades	0309	
Hendry	0309	
Indian River	0309	
Martin	0309	
Monroe	0309	
Okeechobee	0309	
Palm Beach	0309	8960
St. Lucie	0309	
037 Tampa–St. Petersburg, Fla.		
Charlotte	0310	
Citrus	0310	
Collier	0309	
Desoto	0310	
Hardee	0310	
Hernando	0310	
Highlands	0309	
Hillsborough	0310	8280
Lee	0309	2700
Manatee	0310	
Pasco	0310	
Pinellas	0310	8280
Polk	0309	3980
Sarasota	0310	7510
038 Tallahassee, Fla.		
Bay	0314	
Calhoun	0313	
Franklin	0312	
Gadsden	0312	
Gulf	0313	
Holmes	0314	
Jackson	0313	
Jefferson	0312	
Leon	0312	8240
Liberty	0312	
Madison	0311	
Taylor	0312	
Wakulla	0312	
Washington	0314	
039 Pensacola, Fla. (Part, see Ala.)		
Escambia	0314	6080
Okaloosa	0314	
Santa Rosa	0314	6080
Walton	0314	
GEORGIA		
032 Augusta, Ga. (Part, see S.C.)		
Burke	0306	
Columbia	0306	
Emanuel	0306	
Glascock	0306	
Jefferson	0306	
Jenkins	0306	
Lincoln	0306	
McDuffie	0306	
Richmond	0306	0600
Taliaferro	0306	
Warren	0306	
Wilkes	0306	
033 Savannah, Ga. (Part, see S.C.)		
Appling	0307	
Atkinson	0307	
Bacon	0307	
Bryan	0306	
Bullock	0306	
Candler	0306	
Chatham	0306	7520
Coffee	0307	
Effingham	0306	
Evans	0306	
Jeff Davis	0307	
Liberty	0306	
Long	0307	
Montgomery	0307	
Screven	0307	
Tattnall	0307	
Toombs	0307	
Wayne	0307	
034 Jacksonville, Fla. (Part, see Fla.)		
Brantley	0307	
Camden	0307	
Charlton	0307	
Glynn	0307	
McIntosh	0307	
Pierce	0307	
Ware	0307	
041 Albany, Ga.		
Baker	0313	
Ben Hill	0307	
Berrien	0311	
Brooks	0311	
Calhoun	0313	
Clay	0313	
Clinch	0311	
Colquitt	0311	
Cook	0311	
Decatur	0313	
Dougherty	0313	0120
Early	0311	
Echols	0311	
Grady	0312	
Irwin	0311	
Lanier	0311	
Lee	0313	
Lowndes	0311	
Miller	0313	
Mitchell	0313	
Randolph	0313	
Seminole	0313	
Terrell	0313	
Thomas	0312	
Tift	0311	
Turner	0311	
Worth	0313	
042 Macon, Ga.		
Baldwin	0307	
Bibb	0307	4680
Bleckley	0307	
Crawford	0313	
Crisp	0313	
Dodge	0307	
Dooly	0313	
Hancock	0307	
Houston	0307	4680
Jasper	0307	
Johnson	0307	
Jones	0307	
Laurens	0307	
Macon	0313	
Monroe	0307	
Peach	0307	
Pulaski	0307	
Putnam	0307	
Taylor	0313	
Telfair	0307	
Treutlen	0307	
Twiggs	0307	
Washington	0307	
Wheeler	0307	
Wilcox	0307	
Wilkinson	0307	
043 Columbus, Ga.–Ala. (Part, see Ala.)		
Chattahoochee	0313	1800
Harris	0313	
Heard	0313	
Marion	0313	
Meriwether	0313	
Muscogee	0313	1800
Quitman	0313	
Schley	0313	
Stewart	0313	
Sumter	0313	
Talbot	0313	
Troup	0313	
Webster	0313	
044 Atlanta, Ga. (Part, see Ala.)		
Banks	0306	
Barrow	0307	
Bartow	0315	
Butts	0307	
Carroll	0313	
Cherokee	0315	
Clarke	0307	
Clayton	0313	0520
Cobb	0313	0520
Coweta	0313	
Dawson	0315	
Douglas	0313	
Elbert	0306	
Fannin	0602	
Fayette	0313	
Floyd	0315	
Forsyth	0313	
Franklin	0306	
Gilmer	0315	
Greene	0307	
Gwinett	0313	0520
Habersham	0313	
Hall	0313	
Haralson	0315	
Hart	0306	
Henry	0307	
Jackson	0307	
Lamar	0307	
Lumpkin	0313	
Madison	0306	
Morgan	0307	
Newton	0307	
Oconee	0307	
Oglethorpe	0306	
Paulding	0315	
Pickens	0315	
Pike	0313	
Polk	0315	
Rabun	0306	

State, economic area and county names	Water resources sub area code	FIPS SMSA code
Rockdale	0307	......
Spalding	0313	......
Stephens	0306	......
Towns	0602	......
Union	0602	......
Upson	0313	......
Walton	0307	......
White	0313	......
Dekalb + Fulton	0313	0520
048 Chattanooga, Tenn.–Ga. (Part, see Ala., N.C. and Tenn.)		
Catoosa	0602	......
Chattooga	0315	......
Dade	0602	......
Gordon	0315	......
Murray	0315	......
Walker	0602	1560
Whitfield	0315	......
HAWAII		
173 Honolulu, Hawaii		
Hawaii	2001	......
Honolulu	2006	3320
Kauai	2007	......
Maui + Kalawao	2002	......
IDAHO		
151 Salt Lake City, Utah (Part, see Ida. and Wyo.)		
Bear Lake	1601	......
Franklin	1601	......
Oneida	1601	......
152 Idaho Falls, Idaho (Part, see Wyo.)		
Bannock	1705	......
Blaine	1705	......
Bonneville	1705	......
Butte	1705	......
Camas	1705	......
Caribou	1705	......
Cassia	1705	......
Clark	1705	......
Custer	1707	......
Gooding	1705	......
Jefferson	1705	......
Jerome	1705	......
Lemhi	1707	......
Lincoln	1705	......
Madison	1705	......
Minidoka	1705	......
Power	1705	......
Teton	1705	......
Twin Falls	1705	......
Fremont Co. + Yellowstone Natl. Park	1705	......
154 Spokane, Wash. (Part, see Wash.)		
Benewah	1703	......
Bonner	1702	......
Boundary	1701	......
Clearwater	1708	......
Idaho	1707	......
Kootenai	1703	......
Latah	1708	......
Lewis	1708	......
Nez Perce	1708	......
Shoshone	1703	......
159 Boise City, Idaho (Part, see Oreg.)		
Ada	1706	1080
Adams	1706	......
Boise	1706	......
Canyon	1706	......
Elmore	1706	......
Gem	1706	......
Owyhee	1706	......
Payette	1706	......
Valley	1706	......
Washington	1706	......
ILLINOIS		
055 Evansville, Ind. (Part, see Ind. and Ky.)		
Edwards	0513	......
Gallatin	0515	......
Hamilton	0513	......
Lawrence	0513	......
Saline	0515	......
Wabash	0513	......
White	0513	......
056 Terre Haute, Ind. (Part, see Ind.)		
Clark	0513	......
Crawford	0513	......
057 Springfield, Ill.		
Cass	0713	......
Christian	0713	......
De Witt	0713	......
Logan	0713	......
Macon	0713	2040
Mason	0713	......
Menard	0713	......
Morgan	0713	......
Moultrie	0714	......
Sangamon	0713	7880
Scott	0713	......
Shelby	0714	......
058 Champaign–Urbana, Ill.		
Champaign	0513	1400
Coles	0513	......
Cumberland	0513	......
Douglas	0513	......
Edgar	0513	......
Ford	0712	......
Piatt	0713	......
Vermilion	0513	......
077 Chicago, Ill. (Part, see Ind.)		
Cook	0404	1600
De Kalb	0708	......
Du Page	0404	1600
Grundy	0712	......
Iroquois	0712	......
Kane	0404	1600
Kankakee	0712	......
Kendall	0712	......
Lake	0404	1600
La Salle	0713	......
Livingston	0713	......
McHenry	0404	1600
Putnam	0713	......
Will	0404	1600
078 Peoria, Ill.		
Fulton	0713	......
Knox	0713	......
McDonough	0713	......
McLean	0713	1040
Marshall	0713	......
Peoria	0713	6120
Stark	0713	......
Tazewell	0713	6120
Warren	0710	......
Woodford	0713	6120
079 Davenport–Rock Island–Moline, Iowa–Ill. (Part, see Iowa)		
Bureau	0713	......
Carroll	0707	......
Henry	0710	1960
Mercer	0710	......
Rock Island	0710	1960
Whiteside	0708	......
081 Dubuque, Iowa (Part, see Iowa and Wis.)		
Jo Daviess	0707	......
082 Rockford, Ill. (Part, see Wis.)		
Boone	0708	6880
Lee	0708	......
Ogle	0708	......
Stephenson	0708	......
Winnebago	0708	6880
113 Quincy, Ill. (Part, see Iowa and Mo.)		
Adams	0711	......
Brown	0713	......
Hancock	0711	......
Henderson	0710	......
Pike	0711	......
Schuyler	0713	......
114 St. Louis, Mo.–Ill. (Part, see Mo.)		
Bond	0714	......
Calhoun	0711	......
Clay	0513	......
Clinton	0714	......
Effingham	0513	......
Fayette	0714	......
Franklin	0714	......
Greene	0713	......
Jackson	0714	......
Jasper	0513	......
Jefferson	0714	......
Jersey	0713	......
Macoupin	0713	......
Madison	0714	7040
Marion	0714	......
Monroe	0714	......
Montgomery	0714	......
Perry	0714	......
Randolph	0714	......
Richland	0513	......
St. Clair	0714	7040
Washington	0714	......
Wayne	0513	......
Williamson	0714	......
115 Paducah, Ky. (Part, see Ky., Mo. and Tenn.)		
Alexander	0714	......
Hardin	0515	......
Johnson	0515	......
Massac	0515	......
Pope	0515	......
Pulaski	0515	......
Union	0714	......
INDIANA		
054 Louisville, Ky.–Ind. (Part, see Ky.)		
Clark	0511	4520
Crawford	0511	......
Floyd	0511	4520
Harrison	0511	......
Jefferson	0511	......
Orange	0512	......
Scott	0512	......
Washington	0512	......
055 Evansville, Ind. (Part, see Ill. and Ky.)		
Daviess	0512	......
Dubois	0512	......
Gibson	0513	......
Knox	0513	......
Martin	0512	......
Perry	0515	......
Pike	0512	......

State, economic area and county names	Water resources sub area code	FIPS SMSA code
Posey	0513	
Spencer	0515	
Vanderburgh	0515	2440
Warrick	0515	2440
056 Terre Haute, Ind. (Part, see Ill.)		
Clay	0513	8320
Greene	0512	
Parke	0513	
Sullivan	0513	8320
Vermillion	0513	8320
Vigo	0513	8320
059 Lafayette–West Lafayette, Ind.		
Benton	0513	
Carroll	0513	
Clinton	0513	
Fountain	0513	
Montgomery	0513	
Tippecanoe	0513	3920
Warren	0513	
White	0513	
060 Indianapolis, Ind.		
Bartholomew	0512	
Boone	0512	3480
Brown	0512	
Cass	0513	
Decatur	0512	
Hamilton	0512	3480
Hancock	0512	3480
Hendricks	0512	3480
Howard	0513	
Jackson	0512	
Jennings	0512	
Johnson	0512	3480
Lawrence	0512	
Marion	0512	3480
Miami	0513	
Monroe	0512	
Morgan	0512	3480
Owen	0512	
Putnam	0512	
Rush	0512	
Shelby	0512	3480
Tipton	0513	
061 Muncie, Ind.		
Blackford	0513	
Delaware	0512	5280
Grant	0513	
Henry	0512	
Jay	0513	
Madison	0512	0400
Randolph	0512	
Wayne	0508	
062 Cincinnati, Ohio–Ky.–Ind. (Part, see Ky. and Ohio)		
Dearborn	0509	1640
Fayette	0508	
Franklin	0508	
Ohio	0509	
Ripley	0512	
Switzerland	0509	
Union	0508	
075 Fort Wayne, Ind. (Part, see Ohio)		
Adams	0410	
Allen	0410	2760
Dekalb	0410	
Huntington	0513	
Noble	0405	
Steuben	0405	
Wabash	0513	
Wells	0513	
Whitley	0513	
076 South Bend, Ind. (Part, see Mich.)		
Elkhart	0405	
Fulton	0513	
Kosciusko	0513	
LaGrange	0405	
Marshall	0405	7800
St. Joseph	0405	7800
077 Chicago, Ill. (Part, see Ill.)		
Jasper	0712	
Lake	0404	2960
Laporte	0404	
Newton	0712	
Porter	0404	2960
Pulaski	0513	
Starke	0404	
IOWA		
079 Davenport–Rock Island–Moline, Iowa–Ill. (Part, see Ill.)		
Clinton	0710	
Louisa	0710	
Muscatine	0710	
Scott	0710	1960
080 Cedar Rapids, Iowa		
Benton	0710	
Cedar	0710	
Iowa	0710	
Johnson	0710	
Jones	0710	
Linn	0710	1360
Washington	0710	
081 Dubuque, Iowa (Part, see Ill. and Wis.)		
Allamakee	0707	
Clayton	0707	
Delaware	0707	
Dubuque	0707	2200
Howard	0707	
Jackson	0707	
Winneshiek	0707	
099 Sioux Falls, S.D. (Part, see Minn. and S.D.)		
Lyon	1017	
Osceola	1023	
103 Sioux City, Iowa–Nebr. (Part, see Nebr. and S.D.)		
Cherokee	1023	
Crawford	1023	
Ida	1023	
Monona	1023	
O'Brien	1023	
Plymouth	1023	
Sioux	1017	
Woodbury	1023	7720
104 Fort Dodge, Iowa		
Buena Vista	0709	
Calhoun	0709	
Carroll	0709	
Clay	1023	
Dickinson	1023	
Emmet	0709	
Greene	0709	
Guthrie	0709	
Hamilton	0709	
Humboldt	0709	
Palo Alto	0709	
Pocahontas	0709	
Sac	0709	
Webster	0709	
Wright	0709	
105 Waterloo, Iowa		
Black Hawk	0710	8920
Bremer	0710	
Buchanan	0710	
Butler	0710	
Cerro Gordo	0710	
Chickasaw	0710	
Fayette	0707	
Floyd	0710	
Franklin	0710	
Grundy	0710	
Hancock	0710	
Hardin	0710	
Kossuth	0709	
Mitchell	0710	
Winnebago	0710	
Worth	0710	
106 Des Moines, Iowa		
Adair	1024	
Appanoose	1028	
Boone	0709	
Clarke	0709	
Dallas	0709	
Davis	0709	
Decatur	1028	
Jasper	0710	
Jefferson	0710	
Keokuk	0710	
Lucas	0709	
Madison	0709	
Mahaska	0710	
Marion	0709	
Marshall	0710	
Monroe	0709	
Polk	0709	2120
Poweshiek	0710	
Ringgold	1028	
Story	0710	
Tama	0710	
Union	1028	
Van Buren	0709	
Wapello	0709	
Warren	0709	
Wayne	1028	
107 Omaha, Nebr.–Iowa (Part, see Nebr.)		
Adams	1024	
Audobon	1024	
Cass	1024	
Fremont	1024	
Harrison	1023	
Mills	1023	
Montgomery	1024	
Page	1024	
Pottawattamie	1023	5920
Shelby	1024	
Taylor	1024	
113 Quincy, Ill. (Part, see Ill. and Mo.)		
Des Moines	0710	
Henry	0710	
Lee	0709	
KANSAS		
109 Salina, Kans.		
Barton	1103	
Cheyenne	1025	
Clay	1025	
Cloud	1025	
Decatur	1025	
Dickinson	1026	
Ellis	1026	
Ellsworth	1026	

State, economic area and county names	Water resources sub area code	FIPS SMSA code
Gove	1026	
Graham	1026	
Greeley	1103	
Jewell	1025	
Lane	1103	
Lincoln	1026	
Logan	1026	
McPherson	1103	
Mitchell	1026	
Morris	1107	
Ness	1103	
Norton	1025	
Osborne	1026	
Ottawa	1026	
Phillips	1026	
Rawlins	1025	
Republic	1025	
Rice	1103	
Rooks	1026	
Rush	1103	
Russell	1026	
Saline	1026	
Scott	1103	
Sheridan	1026	
Sherman	1025	
Smith	1026	
Thomas	1025	
Trego	1026	
Wallace	1026	
Wichita	1103	
110 Wichita, Kans.		
Barber	1106	
Butler	1103	9040
Chase	1107	
Chautauqua	1107	
Clark	1104	
Comanche	1106	
Cowley	1103	
Edwards	1103	
Elk	1107	
Finney	1103	
Ford	1103	
Grant	1104	
Gray	1103	
Greenwood	1107	
Hamilton	1103	
Harper	1106	
Harvey	1103	
Haskell	1104	
Hodgeman	1103	
Kearny	1103	
Kingman	1103	
Kiowa	1103	
Marion	1107	
Meade	1104	
Morton	1104	
Pawnee	1103	
Pratt	1103	
Reno	1103	
Sedgwick	1103	9040
Seward	1104	
Stafford	1103	
Stanton	1104	
Stevens	1104	
Sumner	1103	
111 Kansas City, Mo.–Kans. (Part, see Mo.)		
Anderson	1029	
Atchison	1024	
Brown	1024	
Coffey	1107	
Doniphan	1024	
Douglas	1027	
Franklin	1029	
Geary	1027	
Jackson	1027	
Jefferson	1027	
Johnson	1030	3760
Leavenworth	1027	
Linn	1029	
Lyon	1107	
Marshall	1027	
Miami	1029	
Nemaha	1024	
Osage	1029	
Pottawatomie	1027	
Riley	1027	
Shawnee	1027	8440
Wabaunsee	1027	
Washington	1027	
Wyandotte	1030	3760
116 Springfield, Mo. (Part, see Ark., Mo. and Okla.)		
Allen	1107	
Bourbon	1029	
Cherokee	1107	
Crawford	1107	
Labette	1107	
Montgomery	1107	
Neosho	1107	
Wilson	1107	
Woodson	1107	
KENTUCKY		
049 Nashville, Tenn. (Part, see Tenn.)		
Allen	0515	
Barren	0515	
Butler	0515	
Christian	0514	
Clinton	0514	
Cumberland	0514	
Edmonson	0515	
Logan	0515	
Metcalfe	0515	
Monroe	0515	
Simpson	0515	
Todd	0514	
Trigg	0514	
Warren	0515	
050 Knoxville, Tenn. (Part, see Tenn.)		
Bell	0514	
Harlan	0514	
Knox	0514	
Laurel	0514	
McCreary	0514	
Wayne	0514	
Whitley	0514	
052 Huntington–Ashland, W. Va.–Ky. (Part, see Ohio and W. Va.)		
Boyd	0507	3400
Carter	0507	
Elliott	0507	
Floyd	0507	
Greenup	0507	
Johnson	0507	
Lawrence	0507	
Martin	0507	
Pike	0507	
Rowan	0510	
053 Lexington, Ky.		
Adair	0515	
Anderson	0511	
Bath	0510	
Bourbon	0510	
Boyle	0511	
Breathitt	0510	
Casey	0515	
Clark	0510	
Clay	0510	
Estill	0510	
Fayette	0510	4280
Franklin	0510	
Garrard	0510	
Green	0515	
Harrison	0510	
Jackson	0514	
Jessamine	0510	
Knott	0510	
Lee	0510	
Leslie	0510	
Letcher	0510	
Lincoln	0510	
Madison	0510	
Magoffin	0510	
Menifee	0510	
Mercer	0511	
Montgomery	0510	
Morgan	0510	
Nicholas	0510	
Owsley	0510	
Perry	0510	
Powell	0510	
Pulaski	0514	
Rockcastle	0514	
Russell	0514	
Scott	0510	
Taylor	0515	
Wolfe	0510	
Woodford	0510	
054 Louisville, Ky.–Ind. (Part, see Ind.)		
Breckinridge	0515	
Bullitt	0511	
Grayson	0515	
Hardin	0515	
Hart	0515	
Henry	0510	
Jefferson	0511	4520
Larue	0515	
Marion	0511	
Meade	0511	
Nelson	0511	
Oldham	0511	
Shelby	0511	
Spencer	0511	
Trimble	0511	
Washington	0511	
055 Evansville, Ind. (Part, see Ill. and Ind.)		
Caldwell	0515	
Crittenden	0515	
Daviess	0515	5990
Hancock	0515	
Henderson	0515	2440
Hopkins	0515	
McLean	0515	
Muhlenberg	0515	
Ohio	0515	

COUNTIES AND INDEPENDENT CITIES IN BEA ECONOMIC AREAS BY STATE WITH WATER RESOURCES SUB AREA AND FIPS SMSA CODES—Continued

State, economic area and county names	Water resources sub area code	FIPS SMSA code
Union	0515	
Webster	0515	
062 Cincinnati, Ohio–Ky.–Ind. (Part, see Ind. and Ohio)		
Boone	0509	1640
Bracken	0510	
Campbell	0509	1640
Carroll	0510	
Fleming	0510	
Gallatin	0510	
Grant	0510	
Kenton	0509	1640
Lewis	0509	
Mason	0510	
Owen	0510	
Pendleton	0510	
Robertson	0510	
115 Paducah, Ky. (Part, see Ill., Mo. and Tenn.)		
Ballard	0515	
Calloway	0604	
Carlisle	0801	
Fulton	0801	
Graves	0801	
Hickman	0801	
Livingston	0514	
Lyon	0514	
McCracken	0515	
Marshall	0604	
LOUISIANA		
132 Shreveport, La.		
Bienville	1114	
Bossier	1114	7680
Caddo	1114	7680
Claiborne	0804	
De Soto	1201	
Natchitoches	1114	
Red River	1114	
Sabine	1201	
Webster	1114	
133 Monroe, La.		
Avoyelles	0804	
Caldwell	0804	
Catahoula	0804	
East Carroll	0805	
Franklin	0805	
Grant	0804	
Jackson	0804	
La Salle	0804	
Lincoln	0804	
Madison	0805	
Morehouse	0805	
Ouachita	0804	5200
Rapides	0804	0220
Richland	0805	
Tensas	0805	
Union	0804	
West Carroll	0805	
Winn	0804	
138 New Orleans, La. (Part, see Miss.)		
Ascension	0807	
Assumption	0809	
Concordia	0805	
East Baton Rouge	0807	0760
E. Feliciana	0807	
Iberville	0807	
Jefferson	0809	5560
LaFourche	0809	
Livingston	0807	
Orleans	0809	5560
Plaquemines	0809	
Pointe Coupee	0807	
St. Bernard	0809	5560
St. Charles	0809	
St. Helena	0807	
St. James	0809	
St. John The Baptist	0809	
St. Tammany	0809	5560
Tangipahoa	0807	
Terrebonne	0809	
Washington	0318	
West Baton Rouge	0807	
West Feliciana	0807	
139 Lake Charles, La.		
Acadia	0808	
Allen	0808	
Beauregard	0808	
Calcasieu	0808	3960
Cameron	0808	
Evangeline	0808	
Iberia	0808	
Jefferson Davis	0808	
Lafayette	0808	3880
St. Landry	0808	
St. Martin	0808	
St. Mary	0808	
Vermilion	0808	
Vernon	0808	
MAINE		
001 Bangor, Maine		
Aroostook	0101	
Hancock	0102	
Penobscot	0102	
Piscataquis	0102	
Waldo	0103	
Washington	0101	
002 Portland, Maine (Part, see N.H.)		
Androscoggin	0103	4243
Cumberland	0104	6403
Franklin	0103	
Kennebec	0103	
Knox	0103	
Lincoln	0103	
Oxford	0103	
Sagadahoc	0103	
Somerset	0103	
York	0104	
MARYLAND		
015 Philadelphia, Pa.–N.J. (Part, see Del., N.J. and Pa.)		
Cecil	0204	9160
017 Baltimore, Md. (Part, see Del. and Va.)		
Anne Arundel	0206	0720
Baltimore	0206	0720
Baltimore—Independent City	0206	0720
Caroline	0206	
Carroll	0206	0720
Dorchester	0206	
Frederick	0207	
Harford	0206	0720
Howard	0206	0720
Kent	0206	
Queen Annes	0206	
Somerset	0206	
Talbot	0206	
Washington	0207	
Wicomico	0206	
Worcester	0206	
018 Washington, D.C.–Md.–Va. (Part, see D.C. and Va.)		
Calvert	0206	
Charles	0207	
Montgomery	0207	8840
Prince Georges	0207	8840
St. Marys	0207	
066 Pittsburgh, Pa. (Part, see Ohio, Pa. and W. Va.)		
Allegany	0207	
Garrett	0207	
MASSACHUSETTS		
004 Boston, Mass. (Part, see N.H. and R.I.)		
Barnstable	0106	
Bristol	0106	5403
Dukes	0106	
Essex	0106	1123
Middlesex	0106	1123
Nantucket	0106	
Norfolk	0106	1123
Plymouth	0106	1123
Suffolk	0106	1123
Worcester	0106	9243
005 Hartford, Conn. (Part, see Conn., N.H. and Vt.)		
Franklin	0108	
Hampden	0108	8003
Hampshire	0108	8003
006 Albany–Schenectady–Troy, N.Y. (Part, see N.Y. and Vt.)		
Berkshire	0107	6323
MICHIGAN		
070 Toledo, Ohio (Part, see Ohio)		
Lenawee	0410	
Monroe	0410	8400
071 Detroit, Mich.		
Genesee	0408	2640
Lapeer	0408	2640
Livingston	0409	
Macomb	0409	2160
Oakland	0409	2160
St. Clair	0409	
Sanilac	0409	
Shiawassee	0405	
Washtenaw	0409	0440
Wayne	0409	2160
072 Saginaw, Mich.		
Alcona	0407	
Alpena	0407	
Arenac	0408	
Bay	0408	0800
Cheboygan	0407	
Chippewa	0402	
Clare	0408	
Crawford	0407	
Gladwin	0408	
Gratiot	0408	
Huron	0408	
Iosco	0408	
Isabella	0408	
Luce	0402	
Mackinac	0406	
Midland	0408	
Montmorency	0407	
Ogemaw	0408	
Oscoda	0407	
Otsego	0407	
Presque Isle	0407	
Roscommon	0406	
Saginaw	0408	6960
Tuscola	0408	
073 Grand Rapids, Mich.		
Allegan	0405	
Antrim	0406	
Benzie	0406	

State, economic area and county names	Water resources sub area code	FIPS SMSA code
Charlevoix	0406	....
Emmet	0406	....
Grand Traverse	0406	....
Ionia	0405	....
Kalkaska	0406	....
Kent	0405	3000
Lake	0406	....
Leelanau	0406	....
Manistee	0406	....
Mason	0406	....
Mecosta	0406	....
Missaukee	0406	....
Montcalm	0405	....
Muskegon	0406	5320
Newaygo	0406	....
Oceana	0406	....
Osceola	0406	....
Ottawa	0405	3000
Wexford	0406	....
074 Lansing, Mich.		
Barry	0405	....
Branch	0405	....
Calhoun	0405	0780
Clinton	0405	4040
Eaton	0405	4040
Hillsdale	0405	....
Ingham	0405	4040
Jackson	0405	3520
Kalamazoo	0405	3720
Van Buren	0405	....
076 South Bend, Ind. (Part, see Ind.)		
Berrien	0405	....
Cass	0405	....
St. Joseph	0405	....
085 Green Bay, Wis. (Part, see Wis.)		
Alger	0402	....
Baraga	0402	....
Delta	0403	....
Dickinson	0403	....
Houghton	0402	....
Iron	0403	....
Keweenaw	0402	....
Marquette	0402	....
Menominee	0403	....
Schoolcraft	0406	....
087 Duluth–Superior, Minn.–Wis. (Part, see Minn. and Wis.)		
Gogebic	0402	....
Ontonagon	0402	....
MINNESOTA		
087 Duluth–Superior, Minn.–Wis. (Part, see Mich. and Wis.)		
Carlton	0401	....
Cook	0401	....
Itasca	0702	....
Koochiching	0903	....
Lake	0401	....
St. Louis	0401	2240
089 La Crosse, Wis. (Part, see Wis.)		
Houston	0705	....
Winona	0705	....
090 Rochester, Minn.		
Dodge	0705	....
Fillmore	0705	....
Freeborn	0710	....
Mower	0710	....
Olmsted	0705	6820
Steele	0705	....
Wabasha	0705	....
091 Minneapolis–St. Paul, Minn. (Part, see Wis.)		
Aitkin	0702	....
Anoka	0702	5120
Beltrami	0902	....
Benton	0702	....
Big Stone	0701	....
Blue Earth	0701	....
Brown	0701	....
Carver	0702	....
Cass	0702	....
Chippewa	0701	....
Chisago	0703	....
Cottonwood	0701	....
Crow Wing	0702	....
Dakota	0702	5120
Douglas	0701	....
Faribault	0701	....
Goodhue	0705	....
Grant	0902	....
Hennepin	0702	5120
Hubbard	0702	....
Isanti	0702	....
Kanabec	0703	....
Kandiyohi	0702	....
Lac Qui Parle	0701	....
Lake of the Woods	0903	....
Le Sueur	0701	....
McLeod	0702	....
Martin	0701	....
Meeker	0702	....
Mille Lacs	0702	....
Morrison	0702	....
Nicollet	0701	....
Pine	0703	....
Pope	0701	....
Ramsey	0702	5120
Redwood	0701	....
Renville	0701	....
Rice	0705	....
Scott	0701	....
Sherburne	0702	....
Sibley	0701	....
Stearns	0702	....
Stevens	0701	....
Swift	0701	....
Todd	0702	....
Traverse	0902	....
Wadena	0702	....
Waseca	0701	....
Washington	0702	5120
Watonwan	0701	....
Wright	0702	....
Yellow Medicine	0701	....
092 Grand Forks, N.D. (Part, see N.D.)		
Clearwater	0902	....
Kittson	0902	....
Marshall	0902	....
Pennington	0902	....
Polk	0902	....
Red Lake	0902	....
Roseau	0902	....
097 Fargo–Moorhead, N.D.–Minn. (Part, see N.D.)		
Becker	0902	....
Clay	0902	2520
Mahnomen	0902	....
Norman	0902	....
Otter Tail	0902	....
Wilkin	0902	....
099 Sioux Falls, S.D. (Part, see Iowa and S.D.)		
Jackson	0701	....
Lincoln	0701	....
Lyon	0701	....
Murray	0701	....
Nobles	1017	....
Pipestone	1017	....
Rock	1017	....
MISSISSIPPI		
045 Birmingham, Ala. (Part, see Ala.)		
Calhoun	0803	....
Chickasaw	0316	....
Choctaw	0806	....
Clay	0316	....
Itawamba	0316	....
Lee	0316	....
Lowndes	0316	....
Monroe	0316	....
Noxubee	0316	....
Oktibbeha	0316	....
Pontotoc	0803	....
Prentiss	0316	....
Union	0803	....
Webster	0806	....
046 Memphis, Tenn.–Ark. (Part, see Ark. and Tenn.)		
Benton	0803	....
Coahoma	0803	....
De Soto	0803	....
Lafayette	0803	....
Marshall	0803	....
Panola	0803	....
Quitman	0803	....
Tate	0803	....
Tippah	0801	....
Tunica	0803	....
047 Huntsville, Ala. (Part, see Ala. and Tenn.)		
Alcorn	0801	....
Tishomingo	0603	....
134 Greenville, Miss. (Part, see Ark.)		
Bolivar	0803	....
Carroll	0803	....
Grenada	0803	....
Humphreys	0803	....
Issaquena	0803	....
Leflore	0803	....
Montgomery	0806	....
Sharkey	0803	....
Sunflower	0803	....
Tallahatchie	0803	....
Washington	0803	....
Yalobusha	0803	....
135 Jackson, Miss.		
Attala	0806	....
Claiborne	0806	....
Copiah	0318	....
Hinds	0318	3560
Holmes	0803	....
Leake	0318	....
Madison	0806	....
Rankin	0318	3560
Scott	0318	....
Simpson	0318	....
Smith	0317	....
Warren	0803	....
Yazoo	0803	....
136 Meridian, Miss. (Part, see Ala.)		
Clarke	0317	....
Covington	0317	....
Forrest	0317	....
Jasper	0317	....

State, economic area and county names	Water resources sub area code	FIPS SMSA code
Jones	0317	
Kemper	0316	
Lamar	0317	
Lauderdale	0317	
Neshoba	0318	
Newton	0317	
Perry	0317	
Wayne	0317	
Winston	0318	
137 Mobile, Ala. (Part, see Ala.)		
George	0317	
Greene	0317	
Harrison	0317	0920
Jackson	0317	
Stone	0317	
138 New Orleans, La. (Part, see La.)		
Adams	0806	
Amite	0807	
Franklin	0806	
Hancock	0318	
Jefferson	0806	
Jefferson Davis	0318	
Lawrence	0318	
Lincoln	0318	
Marion	0318	
Pearl River	0318	
Pike	0318	
Walthall	0318	
Wilkinson	0806	
MISSOURI		
111 Kansas City, Mo.–Kans. (Part, see Kans.)		
Andrew	1024	
Atchison	1024	
Bates	1029	
Benton	1029	
Buchanan	1024	7000
Caldwell	1028	
Carroll	1028	
Cass	1030	3760
Clay	1030	3760
Clinton	1028	
Daviess	1028	
Dekalb	1028	
Gentry	1028	
Grundy	1028	
Harrison	1028	
Henry	1029	1029
Holt	1024	
Jackson	1030	3760
Johnson	1030	
Lafayette	1030	
Livingston	1028	
Mercer	1028	
Nodaway	1024	
Pettis	1030	
Platte	1030	3760
Ray	1030	
Saline	1030	
Worth	1028	
112 Columbia, Mo.		
Adair	1028	
Audain	0711	
Boone	1030	1740
Callaway	1030	
Camden	1029	
Chariton	1028	
Cole	1030	
Cooper	1030	
Howard	1030	
Knox	0711	
Linn	1028	
Macon	1028	
Miller	1029	
Moniteau	1030	
Monroe	0711	
Morgan	1029	
Osage	1029	
Putnam	1028	
Randolph	1028	
Schuyler	0711	
Scotland	0711	
Shelby	0711	
Sullivan	1028	
113 Quincy, Ill. (Part, see Ill. and Iowa)		
Clark	0711	
Lewis	0711	
Marion	0711	
Ralls	0711	
114 St. Louis, Mo.–Ill. (Part, see Ill.)		
Crawford	0714	
Dent	0714	
Franklin	0714	7040
Gasconade	1029	
Iron	0802	
Jefferson	0714	7040
Laclede	1029	
Lincoln	0711	
Madison	0802	
Maries	1029	
Montgomery	0714	
Perry	0714	
Phelps	1029	
Pike	0711	
Pulaski	1029	
Reynolds	1101	
St. Charles	0714	7040
St. Francois	0714	
St. Louis	0714	7040
St. Louis Ind. City	0714	7040
Ste. Genevieve	0714	
Texas	1029	
Warren	0714	
Washington	0714	
115 Paducah, Ky. (Part, see Ill., Ky. and Tenn.)		
Bollinger	0714	
Butler	1101	
Cape Girardeau	0714	
Carter	1101	
Dunklin	0802	
Mississippi	0802	
New Madrid	0802	
Pemiscot	0802	
Ripley	1101	
Scott	0802	
Stoddard	0802	
Wayne	0802	
116 Springfield, Mo. (Part, see Ark., Kans. and Okla.)		
Barry	1101	
Barton	1107	
Cedar	1029	
Christian	1101	
Dade	1029	
Dallas	1029	
Douglas	1101	
Greene	1029	7920
Hickory	1029	
Howell	1101	
Jasper	1107	
Lawrence	1107	
McDonald	1107	
Newton	1107	
Oregon	1101	
Ozark	1101	
Polk	1029	
St. Clair	1029	
Shannon	1101	
Stone	1101	
Taney	1101	
Vernon	1029	
Webster	1029	
Wright	1029	
MONTANA		
093 Minot, N.D. (Part, see N.D.)		
Daniels	1006	
Richland	1010	
Roosevelt	1006	
Sheridan	1006	
094 Great Falls, Mont.		
Blaine	1005	
Broadwater	1003	
Cascade	1003	3040
Chouteau	1003	
Fergus	1004	
Glacier	1003	
Hill	1005	
Jefferson	1002	
Judith Basin	1004	
Lewis and Clark	1003	
Liberty	1003	
Meagher	1003	
Petroleum	1004	
Phillips	1005	
Pondera	1003	
Teton	1003	
Toole	1003	
Valley	1005	
Wheatland	1004	
095 Billings, Mont. (Part, see Wyo.)		
Big Horn	1008	
Carbon	1007	
Carter	1011	
Custer	1010	
Dawson	1010	
Fallon	1010	
Gallatin	1002	
Garfield	1004	
Golden Valley	1004	
McCone	1006	
Musselshell	1004	
Park (Incl. Ylwstn. Natl. Pk.)	1007	
Powder River	1009	
Prairie	1010	
Rosebud	1010	
Stillwater	1007	
Sweet Grass	1007	
Treasure	1010	
Yellowstone	1010	0880
096 Bismarck, N.D. (Part, see N.D.)		
Wibaux	1010	
153 Butte, Mont.		
Beaverhead	1002	
Deer Lodge	1702	
Flathead	1702	
Granite	1702	
Lake	1702	
Lincoln	1701	

State, economic area and county names	Water resources sub area code	FIPS SMSA code
Madison	1002	
Mineral	1702	
Missoula	1702	
Powell	1702	
Ravalli	1702	
Sanders	1702	
Silver Bow	1702	
NEBRASKA		
101 Scotts Bluff, Nebr. (Part, see Wyo.)		
Banner	1018	
Box Butte	1015	
Cheyenne	1019	
Dawes	1015	
Deuel	1019	
Garden	1018	
Kimball	1019	
Morrill	1018	
Scotts Bluff	1018	
Sheridan	1015	
Sioux	1015	
102 Grand Island, Nebr.		
Adams	1027	
Arthur	1020	
Blaine	1020	
Boone	1020	
Buffalo	1021	
Cherry	1015	
Clay	1027	
Custer	1020	
Dawson	1021	
Franklin	1025	
Frontier	1025	
Furnas	1025	
Garfield	1020	
Gosper	1025	
Grant	1020	
Greeley	1020	
Hall	1021	
Hamilton	1027	
Harlan	1025	
Hayes	1025	
Hitchcock	1025	
Hooker	1020	
Howard	1020	
Kearney	1021	
Keith	1021	
Lincoln	1021	
Logan	1020	
Loup	1020	
McPherson	1020	
Merrick	1021	
Nance	1020	
Nuckolls	1027	
Phelps	1021	
Red Willow	1025	
Sherman	1020	
Thomas	1020	
Valley	1020	
Webster	1025	
Wheeler	1020	
103 Sioux City, Iowa–Nebr. (Part, see Iowa and S.D.)		
Antelope	1022	
Boyd	1015	
Brown	1015	
Cedar	1017	
Cuming	1022	
Dakota	1023	7720
Dixon	1017	
Holt	1015	
Keya Paha	1015	
Knox	1017	
Madison	1022	
Pierce	1022	
Rock	1015	
Stanton	1022	
Thurston	1023	
Wayne	1022	
107 Omaha, Nebr.–Iowa (Part, see Iowa)		
Burt	1022	
Cass	1023	
Colfax	1022	
Dodge	1022	
Douglas	1023	5920
Platte	1020	
Sarpy	1023	5920
Saunders	1022	
Washington	1023	
108 Lincoln, Nebr.		
Butler	1027	
Fillmore	1027	
Gage	1027	
Jefferson	1027	
Johnson	1024	
Lancaster	1022	4360
Nemaha	1024	
Otoe	1024	
Pawnee	1024	
Polk	1027	
Richardson	1024	
Saline	1027	
Seward	1027	
Thayer	1027	
York	1027	
148 Denver, Colo. (Part, see Colo.)		
Chase	1025	
Dundy	1025	
Perkins	1025	
NEVADA		
160 Reno, Nev.		
Churchill	1605	
Douglas	1605	
Elko	1604	
Eureka	1604	
Humboldt	1604	
Lander	1604	
Lyon	1605	
Mineral	1605	
Ormsby	1605	
Pershing	1604	
Storey	1605	
Washoe	1605	6720
White Pine	1606	
161 Las Vegas, Nev. (Part, see Utah)		
Clark	1502	4120
Esmeralda	1606	
Lincoln	1502	
Nye	1606	
NEW HAMPSHIRE		
002 Portland, Maine (Part, see Maine)		
Strafford	0104	
003 Burlington, Vt. (Part, see Vt.)		
Coos	0108	
Grafton	0108	
Sullivan	0108	
004 Boston, Mass. (Part, see Mass. and R.I.)		
Belknap	0105	
Carroll	0104	
Hillsborough	0105	4763
Merrimack	0105	
Rockingham	0104	
005 Hartford, Conn. (Part, see Conn., Mass. and Vt.)		
Cheshire	0108	
NEW JERSEY		
014 New York, N.Y. (Part, see Conn. and N.Y.)		
Bergen	0203	6040
Essex	0203	5640
Hudson	0203	3640
Hunterdon	0204	
Middlesex	0203	5460
Monmouth	0203	4410
Morris	0203	5640
Passaic	0203	6040
Somerset	0203	
Sussex	0204	
Union	0203	5640
015 Philadelphia, Pa.–N.J. (Part, see Del., Md. and Pa.)		
Atlantic	0204	0560
Burlington	0204	6160
Camden	0204	6160
Cape May	0204	
Cumberland	0204	8760
Gloucester	0204	6160
Mercer	0204	8480
Ocean	0204	
Salem	0204	9160
Warren	0204	0240
NEW MEXICO		
122 Amarillo, Tex. (Part, see Okla. and Tex.)		
Curry	1205	
De Baca	1306	
Guadalupe	1306	
Harding	1108	
Quay	1108	
Roosevelt	1205	
Union	1109	
145 El Paso, Tex. (Part, see Tex.)		
Catron	1503	
Chaves	1306	
Dona Ana	1303	
Eddy	1306	
Grant	1503	
Hidalgo	1503	
Lea	1208	
Lincoln	1305	
Luna	1303	
Otero	1305	
Sierra	1303	
Socorro	1302	
146 Albuquerque, N.M.		
Bernalillo	1302	0200
Colfax	1108	
Los Alamos	1302	
McKinley	1501	
Mora	1108	
Rio Arriba	1302	
Sandoval	1302	
San Miguel	1306	
Santa Fe	1302	
Taos	1302	
Torrance	1305	
Valencia	1302	
149 Grand Junction, Colo. (Part, see Colo. and Utah)		
San Juan	1407	

State, economic area and county names	Water resources sub area code	FIPS SMSA code
NEW YORK		
006 Albany–Schenectady–Troy, N.Y. (Part, see Mass. and Vt.)		
Albany	0202	0160
Clinton	0201	
Columbia	0202	
Essex	0201	
Fulton	0202	
Greene	0202	
Hamilton	0202	
Montgomery	0202	
Rensselaer	0202	0160
Saratoga	0202	0160
Schenectady	0202	0160
Schoharie	0202	
Warren	0202	
Washington	0202	
007 Syracuse, N.Y.		
Cayuga	0414	
Cortland	0205	
Franklin	0415	
Herkimer	0202	8680
Jefferson	0415	
Lewis	0415	
Madison	0414	8160
Oneida	0202	8680
Onondaga	0414	8160
Oswego	0414	8160
St. Lawrence	0415	
Tompkins	0414	
008 Rochester, N.Y.		
Livingston	0413	6840
Monroe	0413	6840
Ontario	0414	
Orleans	0413	6840
Seneca	0414	
Wayne	0413	6840
Yates	0414	
009 Buffalo, N.Y.		
Allegany	0413	
Cattaraugus	0412	
Chautauqua	0412	
Erie	0412	1280
Genesee	0413	
Niagara	0412	1280
Wyoming	0413	
012 Binghampton, N.Y.–Pa. (Part, see Pa.)		
Broome	0205	0960
Chemung	0205	2335
Chenango	0205	
Delaware	0204	
Otsego	0205	
Schuyler	0414	
Steuben	0205	
Tioga	0205	0960
014 New York, N.Y. (Part, see Conn. and N.J.)		
Dutchess	0202	6460
Nassau	0203	5600
Orange	0202	
Putnam	0202	
Rockland	0203	5600
Suffolk	0203	5600
Sullivan	0204	
Ulster	0202	
Westchester	0203	5600
New York City (5 Boroughs)	0203	5600
NORTH CAROLINA		
020 Roanoke, Va. (Part, see Va.)		
Caswell	0301	
022 Norfolk–Portsmouth, Va. (Part, see Va.)		
Bertie	0301	
Camden	0301	
Chowan	0301	
Currituck	0301	
Gates	0301	
Hertford	0301	
Pasquotank	0301	
Perquimans	0301	
023 Raleigh, N.C.		
Beaufort	0302	
Bladen	0303	
Chatham	0303	
Cumberland	0303	2560
Dare	0301	
Durham	0302	2280
Edgecombe	0302	
Franklin	0302	
Granville	0302	
Greene	0302	
Halifax	0302	
Harnett	0303	
Hoke	0303	
Hyde	0302	
Johnston	0302	
Lee	0303	
Martin	0301	
Nash	0302	
Northampton	0301	
Orange	0302	2280
Person	0302	
Pitt	0302	
Robeson	0304	
Sampson	0303	
Tyrrell	0301	
Vance	0302	
Wake	0302	6640
Warren	0302	
Washington	0301	
Wayne	0302	
Wilson	0302	
024 Wilmington, N.C.		
Brunswick	0303	9200
Carteret	0302	
Columbus	0304	
Craven	0302	
Duplin	0303	
Jones	0302	
Lenoir	0302	
New Hanover	0303	9200
Onslow	0303	
Pamlico	0302	
Pender	0303	
025 Greensboro–Winston Salem–High Point, N.C. (Part, see Va.)		
Alamance	0303	
Alleghany	0505	
Ashe	0505	
Davidson	0304	
Davie	0304	
Forsyth	0304	3120
Guilford	0304	3120
Montgomery	0304	
Moore	0303	
Randolph	0304	3120
Rockingham	0301	
Stokes	0301	
Surry	0304	
Wilkes	0304	
Yadkin	0304	3120
026 Charlotte, N.C. (Part, see S.C.)		
Alexander	0305	
Anson	0304	
Burke	0305	
Cabarrus	0304	
Caldwell	0305	
Catawba	0305	
Cleveland	0305	
Gaston	0305	2970
Iredell	0304	
Lincoln	0305	
Mecklenburg	0305	1520
Richmond	0304	
Rowan	0304	
Rutherford	0305	
Scotland	0304	
Stanley	0304	
Union	0305	1520
Watauga	0505	
027 Asheville, N.C.		
Avery	0601	
Buncombe	0601	0480
Clay	0602	
Graham	0601	
Haywood	0601	
Henderson	0601	
Jackson	0601	
McDowell	0305	
Macon	0601	
Madison	0601	
Mitchell	0601	
Swain	0601	
Transylvania	0601	
Yancey	0601	
028 Greenville, S.C.		
Polk	0305	
048 Chattanooga, Tenn.–Ga. (Part, see Ala., Ga. and Tenn.)		
Cherokee	0602	
NORTH DAKOTA		
092 Grand Folks, N.D. (Part, see Minn.)		
Benson	0902	
Cavalier	0902	
Grand Forks	0902	
Nelson	0902	
Pembina	0902	
Ramsey	0902	
Towner	0902	
Walsh	0902	
093 Minot, N.D. (Part, see Mont.)		
Bottineau	0901	
Burke	0901	
Divide	0901	
McHenry	0901	
McKenzie	1011	
McLean	1011	
Mountrail	0901	
Pierce	0901	
Renville	0901	
Rolette	0901	
Ward	0901	
Williams	1011	
096 Bismarck, N.D. (Part, see Mont.)		
Adams	1013	
Billings	1011	
Bowman	1013	
Burleigh	1013	
Dunn	1011	
Emmons	1013	
Golden Valley	1011	

COUNTIES AND INDEPENDENT CITIES IN BEA ECONOMIC AREAS BY STATE WITH WATER RESOURCES SUB AREA AND FIPS SMSA CODES—Continued

State, economic area and county names	Water resources sub area code	FIPS SMSA code
Grant	1013	
Hettinger	1013	
Kidder	1013	
Mercer	1011	
Morton	1013	
Oliver	1013	
Sheridan	1013	
Sioux	1013	
Slope	1011	
Stark	1013	
Wells	1016	
097 Fargo–Moorhead, N.D.–Minn. (Part, see Minn.)		
Barnes	0902	
Cass	0902	2520
Dickey	1016	
Eddy	1016	
Foster	1016	
Griggs	0902	
LaMoure	1016	
Logan	1013	
McIntosh	1013	
Ransom	0902	
Richland	0902	
Sargent	0902	
Steele	0902	
Stutsman	1016	
Traill	0902	
OHIO		
052 Huntington–Ashland, W. Va.–Ky. (Part, see Ky. and W. Va.)		
Gallia	0507	
Lawrence	0507	3400
Meigs	0507	
Scioto	0506	
062 Cincinnati, Ohio–Ky.–Ind. (Part, see Ind. and Ky.)		
Adams	0509	
Brown	0509	
Butler	0508	3200
Clermont	0509	1640
Clinton	0509	
Hamilton	0509	1640
Highland	0506	
Warren	0509	1640
063 Dayton, Ohio		
Campaign	0508	
Clark	0508	7960
Darke	0508	
Greene	0508	2000
Logan	0508	
Miami	0508	2000
Montgomery	0508	2000
Preble	0508	2000
Shelby	0508	
064 Columbus, Ohio (Part, see W. Va.)		
Athens	0507	
Delaware	0506	1840
Fairfield	0507	
Fayette	0506	
Franklin	0506	1840
Guernsey	0504	
Hocking	0507	
Jackson	0507	
Licking	0504	
Madison	0506	
Marion	0506	
Morgan	0504	
Muskingum	0504	
Noble	0507	
Perry	0504	
Pickaway	0506	1840
Pike	0506	
Ross	0506	
Union	0506	
Vinton	0507	
Washington	0504	6020
066 Pittsburgh, Pa. (Part, see Md., Pa. and W. Va.)		
Belmont	0503	9000
Harrison	0504	
Jefferson	0503	8080
Monroe	0507	
067 Youngstown–Warren, Ohio (Part, see Pa.)		
Mahoning	0503	9320
Trumbull	0503	9320
068 Cleveland, Ohio		
Ashland	0504	
Ashtabula	0411	
Carroll	0504	
Columbiana	0503	
Coshocton	0504	
Crawford	0410	
Cuyahoga	0411	1680
Erie	0410	
Geauga	0411	1680
Holmes	0504	
Huron	0410	
Knox	0504	
Lake	0411	1680
Lorain	0411	4440
Medina	0411	1680
Morrow	0506	
Portage	0411	0080
Richland	0504	4800
Stark	0504	1320
Summit	0411	0080
Tuscarawas	0504	
Wayne	0504	
Wyandot	0410	
069 Lima, Ohio		
Allen	0410	4320
Auglaize	0410	
Hardin	0506	
Mercer	0410	
Putnam	0410	4320
Van Wert	0410	4320
070 Toledo, Ohio (Part, see Mich.)		
Fulton	0410	
Hancock	0410	
Henry	0410	
Lucas	0410	8400
Ottawa	0410	
Sandusky	0410	
Seneca	0410	
Wood	0410	8400
075 Fort Wayne, Ind. (Part, see Ind.)		
Defiance	0410	
Paulding	0410	
Williams	0410	
OKLAHOMA		
116 Springfield, Mo. (Part, see Ark., Kans., Mo.)		
Craig	1107	
Ottawa	1107	
118 Fort Smith, Ark.–Okla. (Part, see Ark.)		
Haskell	1111	
Latimer	1111	
LeFlore	1111	2720
Pittsburg	1110	
Pushmataha	1114	
Sequoyah	1111	2720
119 Tulsa, Okla. (Part, see Ark.)		
Adair	1111	
Cherokee	1111	
Creek	1111	8560
Delaware	1107	
Kay	1106	
McIntosh	1110	
Mayes	1107	
Muskogee	1111	
Nowata	1107	
Okmulgee	1110	
Osage	1111	8560
Pawnee	1106	
Payne	1105	
Rogers	1107	
Tulsa	1111	8560
Wagoner	1107	
Washington	1107	
120 Oklahoma City, Okla.		
Alfalfa	1106	
Atoka	1114	
Beckham	1113	
Blaine	1110	
Canadian	1110	5880
Carter	1113	
Cleveland	1110	5880
Coal	1114	
Custer	1113	
Dewey	1110	
Ellis	1110	
Garfield	1105	
Garvin	1113	
Grady	1113	
Grant	1106	
Harper	1104	
Hughes	1110	
Johnston	1113	
Kingfisher	1105	
Lincoln	1110	
Logan	1105	
Love	1113	
McClain	1110	
Major	1105	
Murray	1113	
Noble	1106	
Okfuskee	1110	
Oklahoma	1110	5880
Pontotoc	1114	
Pottawatomie	1110	
Roger Mills	1113	
Seminole	1110	
Washita	1113	
Woods	1105	
Woodward	1110	
121 Wichita Falls, Tex. (Part, see Tex.)		
Caddo	1113	
Comanche	1113	4200
Cotton	1113	
Greer	1113	
Harmon	1113	
Jackson	1113	
Jefferson	1113	
Kiowa	1113	
Stephens	1113	
Tillman	1113	
122 Amarillo, Tex. (Part, see N.M. and Tex.)		
Beaver	1109	
Cimarron	1109	
Texas	1109	

State, economic area and county names	Water resources sub area code	FIPS SMSA code
127 Dallas, Tex. (Part, see Tex.)		
Bryan	1114	
Marshall	1113	
131 Texarkana, Tex.–Ark. (Part, see Ark. and Tex.)		
Choctaw	1114	
McCurtain	1114	
OREGON		
156 Yakima, Wash. (Part, see Wash.)		
Baker	1706	
Gilliam	1711	
Grant	1711	
Morrow	1711	
Umatilla	1711	
Union	1708	
Wallowa	1708	
Wheeler	1711	
157 Portland, Ore.–Wash. (Part, see Wash.)		
Benton	1712	
Clackamas	1713	6440
Clatsop	1716	
Columbia	1713	
Crook	1710	
Deschutes	1710	
Hood River	1711	
Jefferson	1710	
Lincoln	1716	
Linn	1712	
Marion	1712	7080
Multnomah	1713	6440
Polk	1712	7080
Sherman	1711	
Tillamook	1716	
Wasco	1710	
Washington	1713	6440
Yamhill	1712	
158 Eugene, Ore.		
Coos	1716	
Curry	1716	
Douglas	1716	
Jackson	1716	
Josephine	1716	
Klamath	1801	
Lake	1717	
Lane	1712	2400
159 Boise City, Idaho (Part, see Ida.)		
Harney	1717	
Malheur	1706	
PENNSYLVANIA		
009 Buffalo, N.Y. (Part, see N.Y.)		
McKean	0501	
Potter	0205	
010 Erie, Pa.		
Crawford	0501	
Erie	0412	2360
Forest	0501	
Venango	0501	
Warren	0501	
011 Williamsport, Pa.		
Cameron	0205	
Centre	0205	
Clearfield	0205	
Clinton	0205	
Elk	0501	
Jefferson	0501	
Lycoming	0205	9140
Sullivan	0205	
012 Binghamton, N.Y.–Pa. (Part, see N.Y.)		
Bradford	0205	
Susquehanna	0205	0960
Tioga	0205	
013 Wilkes–Barre–Hazelton, Pa.		
Columbia	0205	
Lackawanna	0205	7560
Luzerne	0205	9120
Pike	0204	
Wayne	0204	
Wyoming	0205	
015 Philadelphia, Pa.–N.J. (Part, see Del., Md. and N.J.)		
Berks	0204	6680
Bucks	0204	6160
Carbon	0204	
Chester	0204	6160
Delaware	0204	6160
Lehigh	0204	0240
Monroe	0204	
Montgomery	0204	6160
Northampton	0204	0240
Philadelphia	0204	6160
Schuylkill	0205	
016 Harrisburg, Pa.		
Adams	0205	9280
Bedford	0205	
Blair	0205	0280
Cumberland	0205	3240
Dauphin	0205	3240
Franklin	0207	
Fulton	0207	
Huntingdon	0205	
Juniata	0205	
Lancaster	0205	4000
Lebanon	0205	
Mifflin	0205	
Montour	0205	
Northumberland	0205	
Perry	0205	3240
Snyder	0205	
Union	0205	
York	0205	9280
066 Pittsburgh, Pa. (Part, see Md., Ohio and W. Va.)		
Allegheny	0503	6280
Armstrong	0501	
Beaver	0503	6280
Butler	0503	
Cambria	0501	3680
Clarion	0501	
Fayette	0502	
Greene	0502	
Indiana	0501	
Somerset	0501	3680
Washington	0503	6280
Westmoreland	0503	6280
067 Youngstown–Warren, Ohio (Part, see Ohio)		
Lawrence	0503	
Mercer	0503	
RHODE ISLAND		
004 Boston, Mass. (Part, see Mass. and N.H.)		
Bristol	0106	6483
Kent	0106	6483
Newport	0106	
Providence	0106	6483
Washington	0106	
SOUTH CAROLINA		
026 Charlotte, N.C. (Part, see N.C.)		
Chester	0305	
Lancaster	0305	
York	0305	
028 Greenville, S.C. (Part, see N.C.)		
Abbeville	0306	
Anderson	0306	
Cherokee	0305	
Greenville	0305	3160
Greenwood	0305	
Laurens	0305	
Oconee	0306	
Pickens	0305	3160
Spartanburg	0305	7820
Union	0305	
029 Columbia, S.C.		
Calhoun	0305	
Clarendon	0305	
Fairfield	0305	
Kershaw	0305	
Lee	0304	
Lexington	0305	1760
Newberry	0305	
Orangeburg	0305	
Richland	0305	1760
Sumter	0304	
030 Florence, S.C.		
Chesterfield	0304	
Darlington	0304	
Dillon	0304	
Florence	0304	
Georgetown	0304	
Horry	0304	
Marion	0304	
Marlboro	0304	
Williamsburg	0304	
031 Charleston, S.C.		
Beaufort	0305	
Berkeley	0305	1440
Charleston	0305	1440
Colleton	0305	
Dorchester	0305	
Hampton	0305	
032 Augusta, Ga. (Part, see Ga.)		
Aiken	0306	0600
Allendale	0305	
Bamberg	0305	
Barnwell	0305	
Edgefield	0306	
McCormick	0306	
Saluda	0305	
033 Savannah, Ga. (Part, see Ga.)		
Jasper	0305	
SOUTH DAKOTA		
098 Aberdeen, S.D.		
Brown	1016	
Clark	1016	
Codington	1017	
Day	1017	
Deuel	1017	
Edmunds	1016	
Faulk	1016	
Grant	0701	
Hamlin	1017	
McPherson	1013	
Marshall	1016	
Roberts	0701	
Spink	1016	
099 Sioux Falls, S.D. (Part, see Iowa and Minn.)		
Aurora	1016	
Beadle	1016	
Brookings	1017	
Davison	1016	
Hand	1016	

State, economic area and county names	Water resources sub area code	FIPS SMSA code
Hanson	1016	....
Jerauld	1016	....
Kingsbury	1017	....
Lake	1017	....
Lincoln	1017	....
McCook	1017	....
Miner	1017	....
Minnehaha	1017	7760
Moody	1017	....
Sanborn	1016	....
Turner	1017	....
100 Rapid City, S.D. (Part, see Wyo.)		
Bennett	1014	....
Brule	1014	....
Buffalo	1014	....
Butte	1012	....
Campbell	1013	....
Corson	1013	....
Custer	1012	....
Dewey (Armstrong)	1013	....
Fall River	1012	....
Gregory	1014	....
Haakon	1013	....
Harding	1013	....
Hughes	1013	....
Hyde	1014	....
Jackson	1014	....
Jones	1014	....
Lawrence	1012	....
Lyman	1014	....
Meade	1012	....
Mellette	1014	....
Pennington	1012	....
Perkins	1013	....
Potter	1013	....
Shannon (Washington)	1014	....
Stanley	1013	....
Sully	1013	....
Todd	1014	....
Tripp	1014	....
Walworth	1013	....
Washabaugh	1014	....
Ziebach	1013	....
103 Sioux City, Iowa–Nebr. (Part, see Iowa and Nebr.)		
Bon Homme	1017	....
Charles Mix	1014	....
Clay	1017	....
Douglas	1016	....
Hutchinson	1016	....
Union	1017	....
Yankton	1016	....
TENNESSEE		
046 Memphis, Tenn.–Ark. (Part, see Ark and Miss.)		
Carroll	0801	....
Chester	0801	....
Crockett	0801	....
Decatur	0604	....
Dyer	0801	....
Fayette	0801	....
Gibson	0801	....
Hardeman	0801	....
Haywood	0801	....
Henderson	0604	....
Henry	0604	....
Lauderdale	0801	....
Madison	0801	....
Shelby	0801	4920
Tipton	0801	....
Weakley	0801	....
047 Huntsville, Ala. (Part, see Ala. and Miss.)		
Franklin	0603	....
Hardin	0604	....
Lincoln	0603	....
McNairy	0801	....
Wayne	0604	....
048 Chattanooga, Tenn.–Ga. (Part, see Ala., Ga. and N.C.)		
Bledsoe	0602	....
Bradley	0602	....
Grundy	0602	....
Hamilton	0602	1560
McMinn	0602	....
Marion	0602	....
Meigs	0602	....
Polk	0602	....
Rhea	0602	....
Sequatchie	0602	....
049 Nashville, Tenn. (Part, see Ky.)		
Bedford	0604	....
Benton	0604	....
Cannon	0514	....
Cheatham	0514	....
Clay	0514	....
Coffee	0604	....
Davidson	0514	5360
DeKalb	0514	....
Dickson	0514	....
Giles	0603	....
Hickman	0604	....
Houston	0514	....
Humphreys	0604	....
Jackson	0514	....
Lawrence	0603	....
Lewis	0604	....
Macon	0514	....
Marshall	0604	....
Maury	0604	....
Montgomery	0514	....
Moore	0603	....
Overton	0514	....
Perry	0604	....
Pickett	0514	....
Putnam	0514	....
Robertson	0514	....
Rutherford	0514	....
Smith	0514	....
Stewart	0514	....
Sumner	0514	5360
Trousdale	0514	....
Van Buren	0514	....
Warren	0514	....
White	0514	....
Williamson	0514	....
Wilson	0514	5360
050 Knoxville, Tenn. (Part, see Ky.)		
Anderson	0601	3840
Blount	0601	3840
Campbell	0601	....
Claiborne	0601	....
Cocke	0601	....
Cumberland	0601	....
Fentress	0514	....
Grainger	0601	....
Hamblen	0601	....
Jefferson	0601	....
Knox	0601	3840
Loudon	0601	....
Monroe	0601	....
Morgan	0601	....
Roane	0601	....
Scott	0514	....
Sevier	0601	....
Union	0601	....
051 Bristol, Va.–Tenn. (Part, see Va. and W. Va.)		
Carter	0601	....
Greene	0601	....
Hancock	0601	....
Hawkins	0601	....
Johnson	0601	....
Sullivan	0601	....
Unicoi	0601	....
Washington	0601	....
115 Paducah, Ky. (Part, see Ill., Ky. and Mo.)		
Lake	0801	....
Obion	0801	....
TEXAS		
121 Wichita Falls, Tex. (Part, see Okla.)		
Archer	1113	9080
Baylor	1113	....
Childress	1113	....
Clay	1113	....
Cottle	1113	....
Foard	1113	....
Hardeman	1113	....
Jack	1203	....
Throckmorton	1206	....
Wichita	1113	9080
Wilbarger	1113	....
Young	1206	....
122 Amarillo, Tex. (Part, see Okla. and N. Mex.)		
Armstrong	1113	....
Briscoe	1113	....
Carson	1109	....
Castro	1205	....
Collingsworth	1113	....
Dallam	1109	....
Deaf Smith	1112	....
Donley	1113	....
Gray	1113	....
Hall	1113	....
Hansford	1109	....
Hartley	1109	....
Hemphill	1110	....
Hutchinson	1109	....
Lipscomb	1110	....
Moore	1109	....
Ochiltree	1109	....
Oldham	1109	....
Parmer	1205	....
Potter	1112	0320
Randall	1112	0320
Roberts	1110	....
Sherman	1109	....
Swisher	1112	....
Wheeler	1113	....
123 Lubbock, Tex.		
Bailey	1205	....
Cochran	1208	....
Crosby	1205	....
Dickens	1206	....
Floyd	1205	....
Garza	1206	....
Hale	1205	....
Hockley	1205	....
Kent	1206	....
Lamb	1205	....

State, economic area and county names	Water resources sub area code	FIPS SMSA code
Lubbock	1205	4600
Lynn	1205	
Motley	1113	
Terry	1208	
Yoakum	1208	
124 Odessa, Tex.		
Andrews	1208	
Borden	1209	
Brewster	1304	
Crane	1307	
Crockett	1307	
Dawson	1208	
Ector	1208	5800
Gaines	1208	
Glasscock	1209	
Howard	1208	
Loving	1307	
Martin	1208	
Midland	1208	5040
Pecos	1307	
Reagan	1209	
Reeves	1307	
Terrell	1304	
Upton	1307	
Ward	1307	
Winkler	1307	
125 Abilene, Tex.		
Brown	1209	
Callahan	1209	
Coleman	1209	
Comanche	1207	
Eastland	1207	
Fisher	1206	
Haskell	1206	
Jones	1206	0040
King	1113	
Knox	1113	
Mitchell	1209	
Nolan	1209	
Scurry	1209	
Shackelford	1206	
Stephens	1206	
Stonewall	1206	
Taylor	1206	0040
126 San Angelo, Tex.		
Cooke	1209	
Concho	1209	
Irion	1209	
Kimble	1209	
McCulloch	1209	
Mason	1209	
Menard	1209	
Mills	1209	
Runnels	1209	
San Saba	1209	
Schleicher	1209	
Sterling	1209	
Sutton	1308	
Tom Green	1209	7200
127 Dallas, Tex. (Part, see Okla.)		
Collin	1203	1920
Cooke	1203	
Dallas	1203	1920
Delta	1114	
Denton	1203	1920
Ellis	1203	1920
Erath	1206	
Fannin	1114	
Grayson	1113	7640
Hood	1206	
Hopkins	1114	
Hunt	1201	
Johnson	1203	2800
Kaufman	1203	1920
Montague	1113	
Navarro	1203	
Palo Pinto	1206	
Parker	1206	
Rains	1201	
Rockwall	1203	1920
Somervell	1206	
Tarrant	1203	2800
Van Zandt	1201	
Wise	1203	
128 Waco, Tex.		
Bell	1207	3810
Bosque	1206	
Coryell	1207	3810
Falls	1207	
Freestone	1204	
Hamilton	1207	
Hill	1206	
Lampasas	1207	
Limestone	1207	
McLennan	1206	8800
129 Austin, Tex.		
Bastrop	1209	
Blanco	1209	
Brazos	1207	1260
Burleson	1207	
Burnet	1207	
Caldwell	1210	
Grimes	1207	
Hays	1209	
Lee	1207	
Leon	1204	
Llano	1209	
Madison	1204	
Milam	1207	
Robertson	1207	
Travis	1209	0640
Williamson	1207	
130 Tyler, Tex.		
Anderson	1204	
Angelina	1202	
Cherokee	1202	
Franklin	1114	
Gregg	1201	
Harrison	1114	
Henderson	1203	
Houston	1204	
Marion	1114	
Nacogdoches	1202	
Panola	1201	
Rusk	1201	
Sabine	1201	
San Augustine	1202	
Shelby	1201	
Smith	1201	8640
Trinity	1204	
Upshur	1114	
Wood	1201	
131 Texarkana, Tex.-Ark. (Part, see Ark. and Okla.)		
Bowie	1114	8360
Camp	1114	
Cass	1114	
Lamar	1114	
Morris	1114	
Red River	1114	
Titus	1114	
140 Beaumont-Port Arthur-Orange, Tex.		
Hardin	1202	
Jasper	1202	
Jefferson	1202	0840
Newton	1201	
Orange	1202	0840
Tyler	1202	
141 Houston, Tex.		
Austin	1207	
Brazoria	1204	3360
Chambers	1204	
Colorado	1209	
Fayette	1209	
Fort Bend	1204	3360
Galveston	1204	2920
Harris	1204	3360
Liberty	1204	3360
Matagorda	1209	
Montgomery	1204	3360
Polk	1204	
San Jacinto	1204	
Walker	1204	
Waller	1207	
Washington	1207	
Wharton	1209	
142 San Antonio, Tex.		
Atascosa	1211	
Bandera	1210	
Bexar	1210	7240
Calhoun	1210	
Comal	1210	
DeWitt	1210	
Edwards	1211	
Frio	1211	
Gillespie	1209	
Goliad	1210	
Gonzales	1210	
Guadalupe	1210	7240
Jackson	1210	
Karnes	1210	
Kendall	1210	
Kerr	1210	
Kinney	1308	
Lavaca	1210	
Maverick	1308	
Medina	1211	
Real	1211	
Uvalde	1211	
Val Verde	1308	
Victoria	1210	
Wilson	1210	
Zavala	1211	
143 Corpus Christi, Tex.		
Aransas	1210	
Bee	1210	
Brooks	1211	
Dimmit	1211	
Duval	1211	
Jim Hogg	1211	
Jim Wells	1211	
Kenedy	1211	
Kleberg	1211	
La Salle	1211	
Live Oak	1211	
McMullen	1211	
Nueces	1211	1880

COUNTIES AND INDEPENDENT CITIES IN BEA ECONOMIC AREAS BY STATE WITH WATER RESOURCES SUB AREA AND FIPS SMSA CODES—Continued

State, economic area and county names	Water resources sub area code	FIPS SMSA code
Refugio	1210	
San Patricio	1211	1880
Webb	1308	4080
Zapata	1309	
144 Brownsville–Harlingen–San Benito		
Cameron	1309	1240
Hidalgo	1309	4880
Starr	1309	
Willacy	1309	
145 El Paso, Tex. (Part, see N. Mex.)		
Culberson	1307	
El Paso	1303	2320
Hudspeth	1305	
Jeff Davis	1307	
Presidio	1304	
UTAH		
149 Grand Junction, Colo. (Part, see Colo. and N. Mex.)		
Grand	1406	
San Juan	1408	
151 Salt Lake City, Utah (Part, see Ida. and Wyo.)		
Box Elder	1601	
Cache	1601	
Carbon	1403	
Daggett	1401	
Davis	1602	7160
Duchesne	1403	
Emery	1403	
Juab	1603	
Millard	1603	
Morgan	1602	
Piute	1603	
Rich	1601	
Salt Lake	1602	7160
Sanpete	1603	
Sevier	1603	
Summit	1602	
Tooele	1602	
Uintah	1403	
Utah	1602	6520
Wasatch	1602	
Wayne	1408	
Weber	1602	5840
161 Las Vegas, Nev. (Part, see Nev.)		
Beaver	1603	
Garfield	1408	
Iron	1603	
Kane	1408	
Washington	1502	
VERMONT		
003 Burlington, Vt. (Part, see N.H.)		
Addison	0201	
Caledonia	0108	
Chittenden	0201	1299
Essex	0108	
Franklin	0201	
Grand Isle	0201	
Lamoille	0201	
Orange	0108	
Orleans	0109	
Rutland	0201	
Washington	0108	
Windsor	0108	
005 Hartford, Conn. (Part, see Conn., Mass. and N.H.)		
Windham	0108	
006 Albany–Schenectady–Troy, N.Y. (Part, see Mass. and Vt.)		
Bennington	0202	
VIRGINIA		
017 Baltimore, Md. (Part, see Del. and Md.)		
Accomack	0208	
Northampton	0208	
018 Washington, D.C.–Md.–Va. (Part, see D.C. and Md.)		
Arlington + Alexandria	0207	8840
Culpeper	0208	
Fairfax (F'fx + Falls Church)	0207	8840
Fauquier	0207	
King George	0207	
Loudoun	0207	8840
Prince William	0207	8840
Rappahannock	0208	
Spotsylvania + Fredricksburg	0208	
Stafford	0207	
019 Staunton, Va. (Part, see W. Va.)		
Augusta Sta'tn + Waynesboro	0207	
Bath	0208	
Clarke	0207	
Frederick + Winchester	0207	
Highland	0208	
Page	0207	
Rockbridge + Buena Vista	0208	
Rockingham + Harrisonburg	0207	
Shenandoah	0207	
Warren	0207	
020 Roanoke, Va. (Part, see N.C.)		
Alleghany Cliftn.Frg. + Cov't'n.	0208	
Amherst	0208	4640
Appomattox	0208	
Bedford	0301	
Boutetourt	0208	
Campbell + Lynchburg	0208	4640
Charlotte	0301	
Craig	0208	
Floyd	0505	
Franklin	0301	
Giles	0505	
Halifax + South Boston	0301	
Henry + Martinsville	0301	
Montgomery + Radford	0505	
Nelson	0208	
Patrick	0301	
Pittsylvania + Danville	0301	
Pulaski	0505	
Roanoke + Roanoke + Salem	0301	6800
Wythe	0505	
021 Richmond, Va.		
Albemarle + Charlottesville	0208	
Amelia	0208	
Brunswick	0301	
Buckingham	0208	
Caroline	0208	
Charles City	0208	
Chesterf'ld + Colonial Heights	0208	6769
Cumberland	0208	
Dinwiddie + Petersburg	0301	6149
Essex	0208	
Fluvanna	0208	
Goochland	0208	
Greene	0208	
Greensville	0301	
Hanover	0208	6769
Henrico + Richmond	0208	6769
King and Queen	0208	
King William	0208	
Lancaster	0208	
Louisa	0208	
Lunenberg	0301	
Madison	0208	
Mecklenburg	0301	
New Kent	0208	
Northumberland	0208	
Nottoway	0208	
Orange	0208	
Powhatan	0208	
Prince Edward	0208	
Prince George + Hopewell	6140	6149
Richmond	0208	
Sussex	0301	
Westmoreland	0207	
022 Norfolk–Portsmouth, Va. (Part, see N.C.)		
Gloucester	0208	
Isle of Wight	0208	
James City + Williamsburg	0208	
Mathews	0208	
Middlesex	0208	
Nansemond + Suffolk	0208	
Chesapeake + Norfolk + Portsmouth	0208	5720
Virginia Beach	0208	5720
Southampton + Franklin	0301	
Surry	0208	
York, Hampton + Newport News	0208	5680
025 Greensboro–Winston Salem–High Point, N.C. (Part, see N.C.)		
Carroll + Galax	0505	
Grayson	0505	
051 Bristol, Va.–Tenn. (Part, see Tenn. and W. Va.)		
Bland	0505	
Buchanan	0507	
Dickenson	0507	
Lee	0601	
Russell	0601	
Scott	0601	
Smyth	0601	
Tazewell	0601	
Washington + Bristol	0601	
Wise + Norton	0601	
WASHINGTON		
154 Spokane, Wash. (Part, see Idaho)		
Adams	1709	
Asotin	1708	
Chelan	1709	
Columbia	1711	
Douglas	1709	
Ferry	1709	
Garfield	1708	
Grant	1709	
Lincoln	1709	
Okanogan	1709	
Pend Oreille	1702	
Spokane	1703	7840
Stevens	1709	
Whitman	1708	
155 Seattle–Everett, Wash.		
Clallam	1714	
Grays Harbor	1715	
Island	1714	
Jefferson	1714	
King	1714	7600
Kitsap	1714	
Lewis	1713	
Mason	1714	
Pacific	1715	
Pierce	1714	8200
San Juan	1714	
Skagit	1714	
Snohomish	1714	7600
Thurston	1714	
Whatcom	1714	

COUNTIES AND INDEPENDENT CITIES IN BEA ECONOMIC AREAS BY STATE WITH WATER RESOURCES SUB AREA AND FIPS SMSA CODES—Continued

State, economic area and county names	Water resources sub area code	FIPS SMSA code
156 Yakima, Wash. (Part, see Ore.)		
Benton	1704	6740
Franklin	1709	6740
Kittitas	1704	....
Walla Walla	1711	....
Yakima	1704	9260
157 Portland, Ore.-Wash. (Part, see Ore.)		
Clark	1713	6440
Cowlitz	1713	....
Klickitat	1711	....
Skamania	1713	....
Wahkiakum	1713	....
WEST VIRGINIA		
019 Staunton, Va.		
Berkeley	0207	....
Grant	0207	....
Hampshire	0207	....
Hardy	0207	....
Jefferson	0207	....
Morgan	0207	....
Pendleton	0207	....
051 Bristol, Va.-Tenn. (Part, see Tenn. and Va.)		
McDowell	0507	....
Mercer	0505	....
052 Huntington-Ashland, W. Va.-Ky. (Part, see Ky. and Ohio)		
Boone	0505	....
Braxton	0505	....
Cabell	0507	3400
Calhoun	0507	....
Clay	0505	....
Fayette	0505	....
Gilmer	0507	....
Greenbrier	0505	....
Jackson	0507	....
Kanawha	0505	1480
Lincoln	0507	....
Logan	0507	....
Mason	0505	....
Mingo	0507	....
Monroe	0505	....
Nicholas	0505	....
Pocahontas	0505	....
Putnam	0505	....
Raleigh	0505	....
Roane	0507	....
Summers	0505	....
Wayne	0507	3400
Webster	0505	....
Wyoming	0507	....
064 Columbus, Ohio (Part, see Ohio)		
Pleasants	0507	....
Ritchie	0507	....
Wirt	0507	....
Wood	0507	6020
065 Clarksburg, W. Va.		
Barbour	0502	....
Doddridge	0507	....
Harrison	0502	....
Lewis	0502	....
Marion	0502	....
Monongalia	0502	....
Preston	0502	....
Randolph	0502	....
Taylor	0502	....
Tucker	0502	....
Upshur	0502	....
066 Pittsburgh, Pa. (Part, see Md., Ohio and Pa.)		
Brooke	0503	8080
Hancock	0503	8080
Marshall	0503	9000
Mineral	0207	....
Ohio	0503	9000
Tyler	0507	....
Wetzel	0507	....
WICONSIN		
081 Dubuque, Iowa (Part, see Ill. and Iowa)		
Crawford	0706	....
Grant	0707	....
Lafayette	0708	....
082 Rockford, Ill. (Part, see Ill.)		
Green	0708	....
Rock	0708	....
083 Madison, Wis.		
Adams	0706	....
Columbia	0706	....
Dane	0708	4720
Green Lake	0403	....
Iowa	0708	....
Marquette	0403	....
Richland	0706	....
Sauk	0706	....
Waushara	0403	....
084 Milwaukee, Wis.		
Dodge	0708	....

State, economic area and county names	Water resources sub area code	FIPS SMSA code
Fond Du Lac	0403	....
Jefferson	0708	....
Kenosha	0404	3800
Milwaukee	0404	5080
Ozaukee	0404	5080
Racine	0404	6600
Sheboygan	0403	....
Walworth	0404	....
Washington	0404	5080
Waukesha	0404	5080
085 Green Bay, Wis. (Part, see Mich.)		
Brown	0403	3080
Calumet	0403	0460
Door	0403	....
Florence	0403	....
Forest	0403	....
Kewaunee	0403	....
Manitowoc	0403	....
Marinette	0403	....
Oconto	0403	....
Outagamie	0403	0460
Shawano (Incl. Menominee)	0403	....
Waupaca	0403	....
Winnebago	0403	0460
086 Wausau, Wis.		
Clark	0705	....
Langlade	0403	....
Lincoln	0706	....
Marathon	0706	....
Oneida	0706	....
Portage	0706	....
Price	0704	....
Taylor	0704	....
Vilas	0706	....
Wood	0706	....
087 Duluth-Superior, Minn.-Wis. (Part, see Mich. and Minn.)		
Ashland	0401	....
Bayfield	0401	....
Douglas	0401	2240
Iron	0401	....
088 Eau Claire, Wis.		
Barron	0704	....
Chippewa	0704	....
Dunn	0704	....
Eau Claire	0704	....
Pepin	0704	....
Rusk	0704	....
Sawyer	0704	....
Washburn	0703	....
089 La Crosse, Wis. (Part, see Minn.)		
Buffalo	0705	....
Jackson	0705	....
Juneau	0706	....
La Crosse	0705	3870
Monroe	0706	....
Trempealeau	0705	....
Vernon	0706	....
091 Minneapolis-St. Paul, Minn. (Part, see Minn.)		
Burnett	0703	....
Pierce	0705	....
Polk	0703	....
St. Croix	0703	....
WYOMING		
095 Billings, Mont. (Part, see Mont.)		
Big Horn	1008	....
Hot Springs	1008	....
Park (Incl. Yel. Natl. Park 65 Fwd.)	1008	....
Washakie	1008	....
Yellowstone Natl. Park (1929-62)	1007	....
100 Rapid City, S.D. (Part, see S.D.)		
Crook	1012	....
Weston	1012	....
101 Scotts Bluff, Nebr. (Part, see Nebr.)		
Goshen	1018	....
150 Cheyenne, Wyo. (Part, see Colo.)		
Albany	1018	....
Campbell	1009	....
Carbon	1018	....
Converse	1018	....
Fremont	1008	....
Johnson	1009	....
Laramie	1019	1579
Natrona	1018	....
Niobrara	1012	....
Platte	1018	....
Sheridan	1009	....
151 Salt Lake City, Utah (Part, see Idaho and Utah)		
Lincoln	1401	....
Sublette	1401	....
Sweetwater	1401	....
Uinta	1401	....
152 Idaho Falls, Idaho (Part, see Idaho)		
Teton	1705	....

Codes ending in 3 relate to New England County Metropolitan Areas which are the equivalent of SMSA's outside New England.

Codes ending in 9 relate to areas which differ from OMB definition. Anchorage, Alaska is officially defined as the Anchorage Census County Division whereas the area used in this report is the Third Judicial District, therefore, the code has been changed from 0380 to 0389.

The Petersburg-Colonial Heights-Va., and the Richmond, Va. areas as included in this report differ from the OMB definition in that Colonial Heights is included with Richmond rather than with Petersburg and Hopewell. The Richmond, Va. code has been changed from 6760 to 6769 and the Petersburg, Colonial Heights-Hopewell, Va. code has been changed from 6140 to 6149.

Burlington, Vt. (1299) and Cheyenne, Wyo. (1579) are not designated SMSA's.

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