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TRANSPORTATION OF HAZARDOUS MATERIALS IN ARIZONA

Volume I: Comprehensive Study Approach, Analyses and Findings

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Prepared for:
Arizona Department of Transportation
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16. Abstract

The objective of the study was to assess the magnitude of hazardous materials shipments, load characteristics in terms of chemical type, volume and hazard class. These data were allocated to routes in Arizona. The analyses is a first step in understanding the hazardous materials transportation situation and will serve as a basis for risk assessment studies. A data base management system was developed for data manipulation and retrieval by state agencies for program planning, risk evaluations and as a basis for risk evaluations. Several surveys were conducted to obtain the data. These included: 1) hazardous waste shipments for 1983 and 1984 compiled from RCRA manifests; 2) two one-week surveys of placarded trucks at Arizona's major ports of entry; 3) an intra-state survey at 9 state locations; 4) interviews with distributors of gasoline, acids and propane.

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CHAPTER 1

INTRODUCTION TO THE STUDY

Hazardous materials, their manufacture, use, transportation, and disposal, and the consequent risks to public safety, present many challenges for planning and management at local, state and national levels. Hazardous materials (HM) concerns include HM definition and designation, regulatory action in material use, manufacture, transportation safety and disposal, emergency response to accidents, and involvement in clean-up of spills. The transportation of HM has now emerged as a national and state concern because of increasing incidents and the potential for major catastrophe.

There are thousands of materials classified as "hazardous materials," "hazardous substances," and "hazardous wastes" depending on their destination and material nature. "Hazardous materials" are defined to be those the Secretary of Transportation has found to be "in a quantity and form that may pose an unreasonable risk to health and safety or property when transported in commerce."(1) Explosives, flammables, oxidizing materials, organic peroxides, corrosives, gases, poisons, radioactive substances, and etiologic (human disease-causing) agents are included in this definition. "Hazardous substances" are defined differently by the Environmental Protection Agency (EPA) under two distinct statutes: the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund). Designation as "hazardous" is based upon threat to waterways and the environment in the event of spillage. To date, over 300 specific chemicals have been identified by the EPA.[2] Obviously, there is considerable overlap between the two hazardous classes. Most EPA designated chemicals are already regulated in transit due to potential threat unrelated to pollution. Additionally, "hazardous wastes" are regulated by the EPA under the Resource Conservation and Recovery Act from origin to disposal and treatment. The U.S. Department of Transportation has identified 1500 specific chemicals as hazardous materials subject to regulation (Hazardous Materials Transportation Act).

NATIONAL TRENDS

The HM situation in the U.S. is serious, as indicated by the following statistics: at least 250,000 shipments of HM are made each day, totalling at least 4 billion tons per year and this volume is expected to double every ten years.[3] The Department of Transportation (DOT) estimates that between 5 and 15 percent of all trucks on the road at any time carry HMs.[4] Of the 621 most severe commercial carrier accidents investigated by the Federal Highway Administration between 1973 and 1976, those involving HMs accounted for 24.9 percent of the accidents and 57.3 percent of the property damages.[5]

The conclusion to be drawn from these statistics is that toxic and hazardous substances are in wide use, and consequently, are widely transported. Clearly, these materials pose particular risks in transit in the event of accidents and spillage. Hazardous materials and substances pose risk to public health and safety at any or all of their handling stages: production, transport, use, disposal and cleanup.

Figure 1 shows time series data (1976-1982) of the total number of commercial vehicular accidents. The overall national commercial accident trend shows that the overall number of commercial accidents has been decreasing slowly since 1978. The incidence of transit accidents in which HMs were carried is fairly constant. However, as a percentage of total accidents, these are increasing. More specifically, Figure 2 shows that the percent of HM rail accidents to the total number of rail accidents has continued to increase. HM highway accidents has fluctuated between 5 and 6 percent during the 1976-1982 period despite an overall decline in commercial vehicle accidents.

Figure 3 shows the property damages per accident for both hazardous and nonhazardous material carriers. Clearly, damage/accident for HM carriers, indicate the comparative severity of HM involved accidents.

Figure 4 shows the number of HM incidents reported to the Motor Vehicle Transportation Board. An "incident" is defined by DOT as any unintentional release of HM during transit. Reporting reached its peak in 1978 and has been declining since. However, it is not indicative of either the level of HM transport or the number of HM releases. Between 1980 and 1982 when the number of incidents reported decreased by almost 60%, dollar damage rose by 45%. Even accounting for inflation, increased incident severity and mandated costlier clean-up procedures, this is a disturbing contradiction. It is perhaps indicative of problems in reporting and compliance procedures. It might be viewed as representative of a critical problem central to Federal HM regulation -- the failure of "voluntary compliance." Figures 1-4 were compiled from data of the U.S. Government Transportation Safety Board reports.

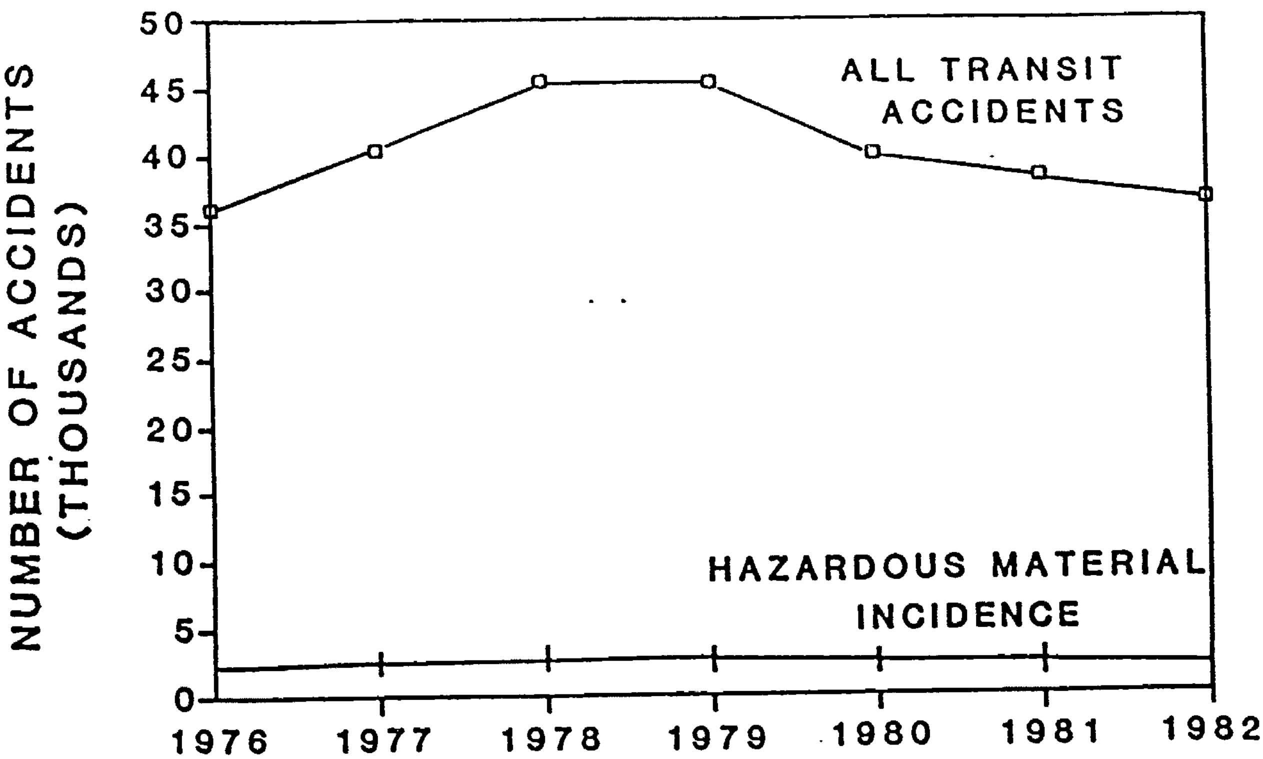


FIGURE 1. Number of accidents (commercial vehicles) and number of accidents involving hazardous materials, 1976-1982.

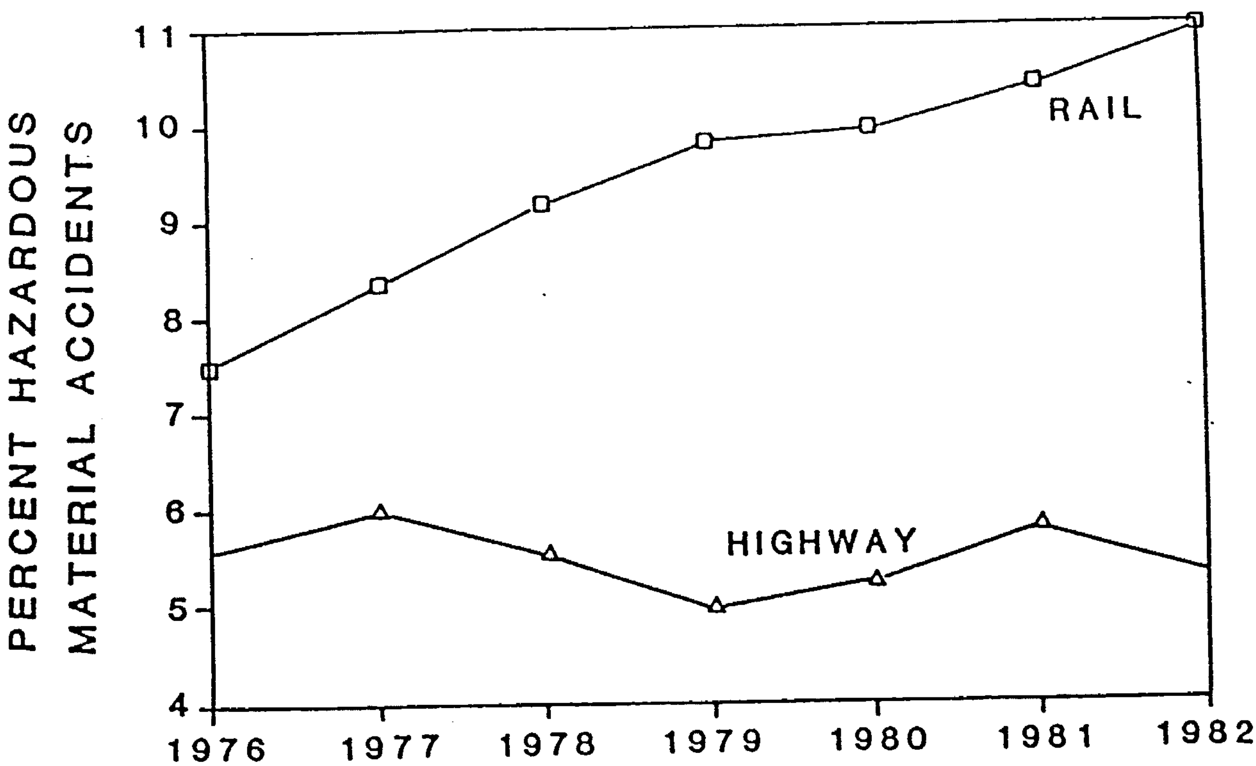


FIGURE 2. Percent hazardous materials accidents for rail and highway, 1976-1982.

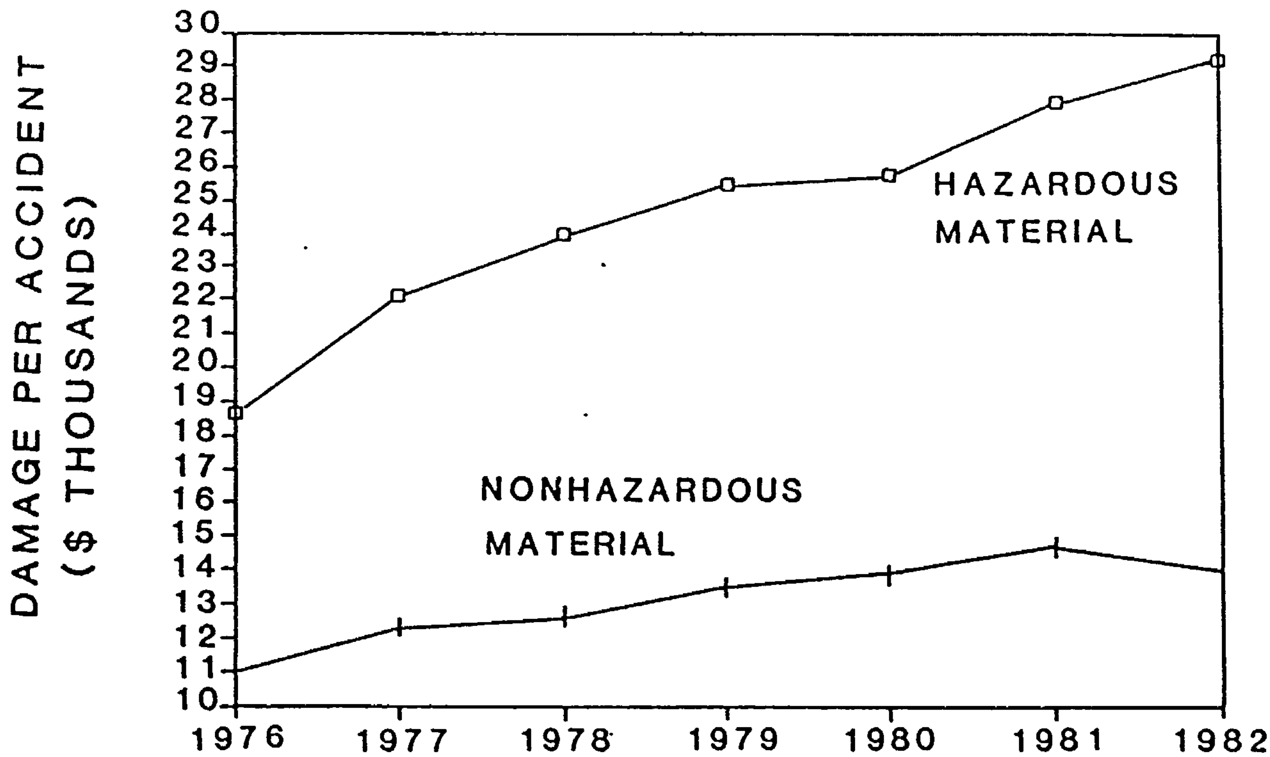


FIGURE 3. Damage per accident for hazardous materials and nonhazardous materials accidents, 1976-1982.

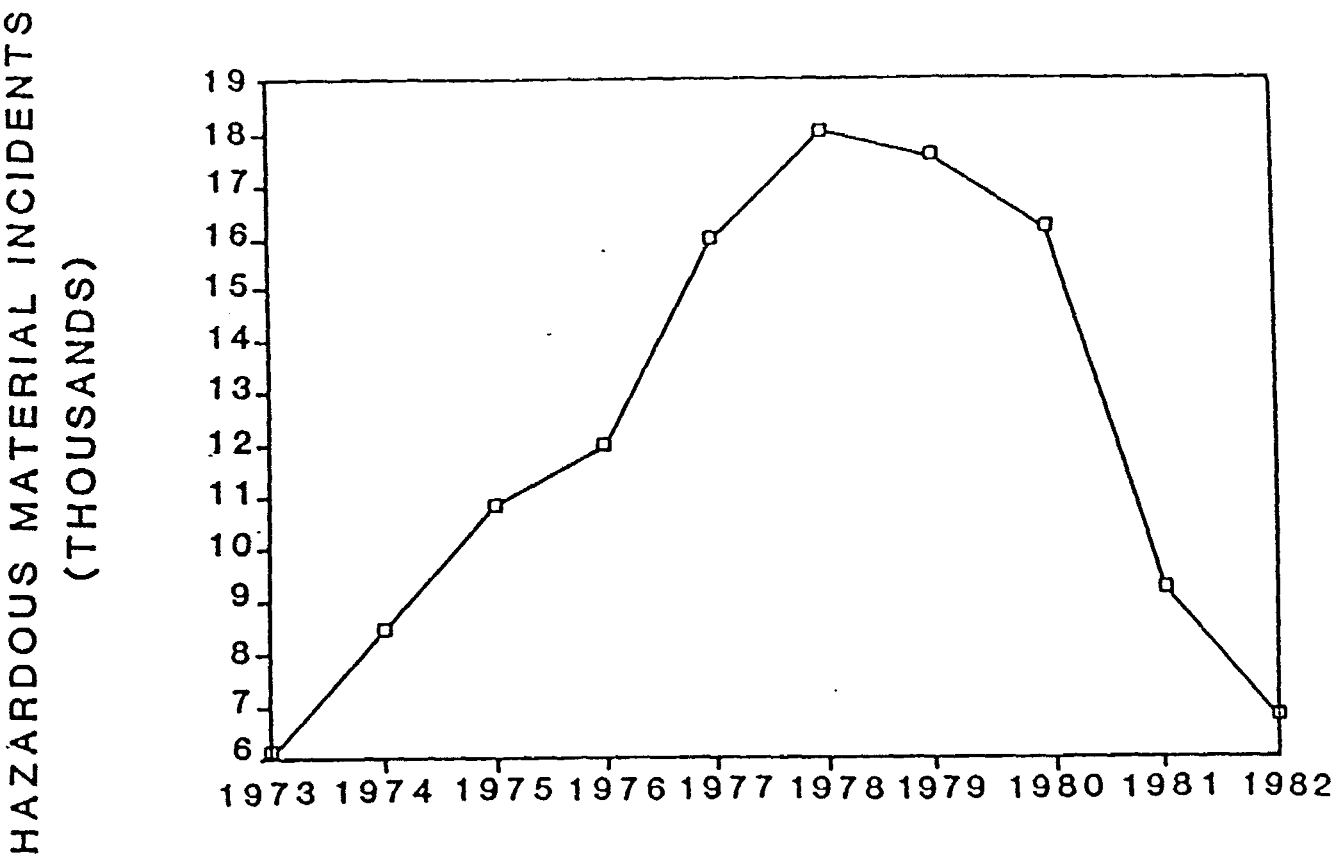


FIGURE 4. Hazardous materials incidents, 1973-1982.

Arizona's Growth and Hazardous Materials

The state of Arizona has continued to experience substantial growth in industrial development and population. The high technology industries have invested heavily in building industrial parks in Phoenix and Tucson. With the development of these activities, more chemical substances are imported, many of which are considered hazardous materials. The continued growth of advanced technology industry and other manufacturing activity will necessitate greater amounts of materials for manufacturing processing. Because Arizona's economy is not based on chemical manufacturing and processing, these materials will largely be imported into Arizona for industrial consumption along a few major routes.

In addition, the manufacturing activities in Arizona are concentrated in the two metropolitan areas, Phoenix and Tucson, so we can expect substantial intra-urban movements of hazardous materials within the two metropolitan areas. Cognizant of the risks posed to the Phoenix area because of HM shipments, the city has established a commission on HM transportation and emergency response in order to identify problem areas and to make recommendations. Moreover, the fact that a major interstate highway (I-10) runs through both Phoenix and Tucson, and I-17 through Phoenix, may pose additional risk to nearby populations.

As industrial development continues to expand in Arizona, hazardous wastes will also be generated in greater amounts. With the advent of more stringent regulations for storage and disposal, greater demands will be placed on transporting hazardous waste to treatment, reclamation and disposal facilities. The incorporation of additional regulations for the "small generator" of waste will add to the already large transportation load in the near future. As this study will show, almost 50 percent of hazardous waste shipments occur as intra-urban movements - traffic from generating source to storage facilities and treatment plants. The remainder are principally carried to California for disposal.

In Arizona, a hazardous waste management facility for storage and disposal has been proposed and will likely be built and operating in 1987. The siting of the facility (Mobile, AZ) will alter existing patterns of waste transportation by focusing HW traffic along the few routes from Phoenix to the facility. Moreover, the facility will also attract additional hazardous waste from outside the state (a substantial amount if existing disposal sites are terminated in California). The result will be a significant expansion in total truck loads carrying hazardous waste and an increase in risk of accidents and releases of hazardous substances.

The state of Arizona is considered to be a "drive-through" state; that is, a substantial number of trucks travelling on interstate routes, pass through Arizona to other destinations. Almost 50 percent of hazardous materials shipments "drive through" the state without unloading. Special inspection programs may have to be considered for this category of HM transportation.

While national statistics show an increasing percentage of vehicular accidents with hazardous materials, increasing damages per HM accident, and problems in safety enforcement, HM incidents and accidents are increasing in Arizona according to HM incidents statistics. Arizona is one of the few states where rail accidents are continuing to increase (1979-1984) despite trends over the last few years showing a slow decline for the nation as a whole.

Table 1 which follows illustrates types and locations of HM incidents in Arizona. A HM incident is defined as an accident, leak, or spill in transit. The list should not be construed as a complete or exhaustive inventory of HM incidents. Rather it is illustrative of incidents during the 1977-1983 period. Incidents for 1984, alone, numbered over 200. Incidents 1 through 75 are those which were responded to by the Department of Public Safety, Commercial Vehicle Safety Specialists. The remainder were collected from the EPA, newspaper stories, government documents and other sources.

BACKGROUND STUDIES

Three studies, of which we are aware, attempted to develop a data base information system for hazardous materials. The first study was conducted in Virginia with the goal of estimating the volume of hazardous materials transported over all modes of transportation (highway, rail and air). On-the-road surveys were conducted at strategic locations, and statistical techniques were used to predict the number of annual shipments moved on selected routes.(6)

The second study was conducted in the St. Louis region of the states of Illinois and Missouri to develop hazardous material information that covers all modes of transportation -- highway, rail, barge and air. An employment survey was conducted to show the number of

TABLE 1

Identification of Selected Hazardous Materials Incidents in Arizona

DATE	LOCATION	HAZARD FACTOR[1]	MATERIAL TYPE	AREA AT RISK
5-07-82	Williams	1	Corrosive	1/2 mile in all directions
5-14-82	Stateroad 60, milepost 236-244	0	Corrosive	Area of spill
5-14-82	I-10, milepost 370	1	Explosives C	1/2 mile in all directions
5-21-82	Goodyear (R.R.)	2	Nonflamable gas	100 feet in all directions
6-04-82	U.S. 89, milepost 460	2	Flammable gases	1/2 mile in all directions
6-11-82	Stateroad 87, milepost 212	1	Combustible liquid	1/2 mile in all directions
6-27-82	U.S. 60, milepost 198	2		1/2 mile in all directions
6-30-82	I-10, milepost 205	2	Flammable liquid	1/2 mile in all directions
7-05-82	Phoenix-4th St. & Buckeye	1		
7-10-82	U.S. 60, milepost 240	0	Corrosives	Area of spill
6-06-80	Stateroad 87 milepost 222	2	Flammable liquid	1/2 mile in all directions
8-06-80	I-40, milepost 187	0	Corrosive	Area of spill
8-11-80	Stateroad 85 milepost 170	1	Combustible liquid	1/2 mile in all directions
8-14-80	Buckeye	2	Flammable gas	1/2 mile in all directions
10-23-80	I-17, milepost 249	2	Flammagle liquid	1/2 mile in all directions
3-26-81	Williams	1	Flammable liquid	1/2 mile in all directions
		5		110 feet in all directions
3-26-81	I-17, milepost 226	2	Flammable gas	1/2 mile in all directions
3-30-81	Flagstaff	2		1/2 mile in all directions
4-01-81	I-10, milepost 260	2	Non-flammable gas	100 feet in all directions
4-03-81	I-10, milepost 201	0	Corrosive	Area of spill
4-08-81	Williams		Combustible	1/2 mile in all directions
9-17-81	Camp Verde			
9-19-81	Prescott	10	Radioactive	
10-04-81	I-10, milepost 245	0	Oxidizers	
10-31-81	I-10, milepost 18		Nonflammable gases	
11-30-81	Goodyear	2	Flammable liquid	1/2 mile in all directions
11-30-81	Phoenix			
12-04-81	U.S. 60, milepost	0	Corrosives	
12-13-81	I-10, milepost 111	2	Flammable liquid	1/2 mile in all directions
1-04-82	I-40, milepost 348	0	Corrosive	Area of spill
1-16-82	I-40, milepost 318	10	Radioactive	

TABLE 1 (Continued)

DATE	LOCATION	HAZARD FACTOR[1]	MATERIAL TYPE	AREA AT RISK
1-18-82	Holbrook	5		110 feet in all directions
1-18-82	Snowflake	5		110 feet in all directions
1-27-82	I-10, milepost 352	0	Corrosives	Area of spill
2-01-82	Douglas	1		1/2 mile in all directions
2-11-82	I-17, milepost 300	2	Flammable liquid	1/2 mile in all directions
2-19-82	I-17, milepost 223	0		Immediate area
2-26-82	Phoenix-27th Ave./McDowell	2		1/2 mile in all directions
3-04-82	U.S. 60, milepost 321	2	Flammable gases	1/2 mile in all directions
3-24-82	I-10, milepost 205	2	Flammable liquid	1/2 mile in all directions
3-25-82	I-40, milepost 166	0	Corrosive	Area of spill
3-29-82	Stateroad 87, milepost 217	1	Combustible liquid	1/2 mile in all directions
4-05-82	Douglas	2	Flammable liquid	1/2 mile in all directions
4-05-82	Stateroad 360	1	Poisions B	
4-28-82	U.S. 60, milepost 243	0	Corrosives	Area of spill
4-29-82	Stateroad 87, milepost 106	0	Corrosives	Area of spill
7-13-82	Stateroad 77, milepost 159	1	Combustible liquid	1/2 mile in all directions
8-17-82	I-10, milepost 248	2	Flammable liquid	1/2 mile in all directions
8-27-82	Rainbow Valley			
9-03-82	So. Pacific R.R. milepost 981	0	Corrosives	Area of spill
10-01-82	Phoenix	0	Corrosives	Area of spill
10-02-82	Payson	0		Area of spill
10-14-82	Stateroad 360, milepost 54			
10-22-82	Phoenix 24th Ave. & McDowell	0	Corrosives	Area of spill
10-26-82	Phoenix	5	Explosives	1/2 mile in all directions
4-14-83	Casa Grande (R.R.)	5		
5-22-78	Phoenix	2	Poison B	Evacuate downwind beyond visible smoke cloud
6-26-78	Navajo Co.	3	Poison B	Evacuate downwind beyond visible smoke cloud
6-27-78	Tucson	1	Combustible liquid	1/2 mile in all directions
8-23-78	Tucson	1	Flammable liquids	1/2 mile in all directions
9-22-78	Tucson	0	Corrosives	Area of spill
9-24-78	Tunis	2	Non-flammable gas	100 feet in all directions

TABLE 1 (Concluded)

DATE	LOCATION	HAZARD FACTOR[1]	MATERIAL TYPE	AREA AT RISK
7-05-73	Kingman	5	Flammable gas	1/2 mile in all directions
11-23-73	Kingman	1	Combustible liquid	1/2 mile in all directions
3-26-84	Phoenix	2	Poison B	Evacuate beyond visible smoke cloud
10-03-78	Tucson	2	Flammable liquid	1/2 mile in all directions
10-27-78	Phoenix	0	Corrosives	280 feet in all directions
4-23-79	Globe	0	Corrosives	280 feet in all directions
5-08-79	Kingman	1	Poison B	Area of spill
9-04-79	Tucson	2	Non-flammable gas	100 feet in all directions
9-05-79	Phoenix	0	Corrosives	280 feet in all directions
11-10-77	Gila Bend	2	Flammable liquid	1/2 mile in all directions
11-30-77	Douglas (R.R.)	0	Corrosives	280 feet in all directions
12-31-77	Tucson (R.R.)	0	Corrosives	280 feet in all directions
1-31-78	Florence	5	Poison B	1/2 mile in all directions
2-24-78	Pinetop	0	Corrosives	280 feet in all directions
4-12-78	Guadalupe	0	Oxidizers	1 mile in all directions

1 Population hazard index for airborne substances, A, Highly Hazardous Material Spills and Emergency Planning by J.E. Zajic and W.A. Himmelman, p. 152-157. Factor 5 is the most serious hazard rating; 0 is the least hazardous.

firms, type and employment total in the region. The firms were coded by Standard Industrial Classfication (SIC) code number and by census district. Surveys were mailed to selected firms, and the return rate was low. The significant conclusion drawn from this research was that reliable data do not exist, and that to assemble good statistical data requires the cooperation of industry -- information taken from their own records. Truck and railway associations do not assemble such information; federal agencies can not generally provide such data.[7]

The third study was conducted for the Puget Sound Region in the state of Washington. The four tasks undertaken were:

a) to identify the types and amounts of hazardous cargo transported through the region by ship, rail, motor carrier, air and pipe line;

b) to evaluate the roles, responsibilities and capabilities of agencies with prevention and response mandates;

c) to survey federal and state programs elsewhere; and

d) to develop options for a regional prevention and response plan, and incorporating public responsibilities, industry perspectives, legal considerations, and resource requirements.

The study partially succeeded in identifying the types of hazardous materials being transported by the five modes. Although dominant transportation corridors that carry the most hazardous materials were outlined, the amounts of these shipments were documented in a crude manner, with no breakdown of amounts by routes and by chemical class, nor were nonbulk chemicals addressed [8].

It was concluded from this review of the three major studies that there is a critical need to develop a comprehensive data collection procedure that includes hazardous wastes, bulk and non-bulk shipments of hazardous materials, and radioactive substances. More importantly, at the state level a computerized data base management system needs to be developed and updated periodically. Such a system would provide researchers, agency planners, and policy makers with data related to transportation routes and hazardous classes, and assist them to develop response plans as well as address the issues of risk posed by HM transport.

The literature is replete with studies related to specific HM shipment problems such as:

. Rerouting railroad shipments of hazardous materials to avoid population areas (9);

. Risk Assessment and safety in the transportation of hazardous materials (10, 11, 12);

. Estimating the release rates and costs of transporting hazardous waste (13); and

. Federal and State Regulatory Programs (14, 15, 16)

All, however, have recommended the need for a comprehensive data base at the state level which few states have accomplished to date. The salient purpose of this study is to rectify this lack of knowledge of HM transportation in the State of Arizona.

STUDY OBJECTIVES

The research project was originally conceptualized around two phases. The first phase is aimed at the development of characteristics of hazardous materials and waste transportation in Arizona. Such characteristics include the shipment origin, the shipment destination, chemical class, the chemical description, and the most commonly used transportation routes. Prior to this study, little detailed information was available to adequately describe the characteristics of hazardous material transportation, and more importantly, no regulations and response plans can be effectively established for Arizona without this knowledge. The data base developed in this study can provide a basis for comprehensive risk assessments for Arizona routes and communities and serve as a basis for studies on preparedness, response, and enforcement.

The tasks of phase I were:

1. To survey hazardous material shipments on Arizona highways:
   a. Survey of bulk tank truck shipment (propane, gasoline, acids)
   b. Sample surveys of non-bulk and bulk hazardous material shipments at the ports of entry;
2. To collect hazardous waste shipment data from the Resource Conservation and Recovery Act manifests.
3. To develop a data base management system using microcomputers.

The data base in its current form is comprehensive and detailed with information on thousands of chemicals. For example, complete coverage for 1983 and 1984 hazardous waste shipments data is available. The data are stored on microcomputer discs and are available to state agencies by chemical, route or generator. Not all the data dealing with specific chemicals can be reported in the study. The attempt herein is to highlight the significant trends in HM transportation by the major hazard classes and significant chemical substances. Detailed information of specific chemicals or routes and other statistics related to shipment patterns can be obtained from the data base as needs arise.

Report Organization

The second chapter of this report describes in detail the data collection approach used in this study. It includes the design of the surveys, the locations of the field studies, the approach used in analyzing the results, and a description of the information management system. The third chapter provides statistics on hazardous waste transportation in Arizona. The fourth chapter describes the results of the hazardous material shipment surveys, both at the ports and the intrastate survey. Results cover the port of entry surveys, the intra-state survey, and specifically, shipments of gasoline, acids, propane and radioactive substances. The fifth chapter is a summary for the study. Chapter six deals with further research needs and a study update methodology.

List of References

1. Bierlein, L.W. Hazardous materials - A Guide for State and Local Officials. Washington, D.C. U.S. Department of Transportation. 1982.

2. Bierlein, L.W. Red Book on Transportation of Hazardous Materials. Boston, Massachusetts. Cahners Books International, Inc. 1977.

3. Colle, J. (ed). Federal Activities in Toxic Substances. U.S. EPA. May 1980.

4. Doniger, D. The Law and Policy of Toxic Substances Control. Johns Hopkins University Press. 1978.

5. Federal Highway Administration. Summary of Accident Investigations, 1973-1976. U.S. Department of Transportation, Bureau of Motor Carrier Safety. 1977.

6. Price, D.L. et. al. Multi Modal Hazardous Materials Transportation In Virginia. Final Report, Virginia Polytechnic Institute and State University, September, 1981.

7. Swoboda, D.P. Hazardous Material Transportation In the St. Louis Region. East-West Gateway Coordinating Council, June 1983.

8. Hazardous Materials Demonstration Project Report - Puget Sound Region. Material Transportation Bureau. U.S. Department of Transportation.

9. Glickman, T.S. Rerouting Railroad Shipments of Hazardous Materials to avoid populated areas. Journal of Hazardous Materials, 1983.

10. Scanlon, R.D., and E. J. Cantilli. "Assessing Risk and Safety in the Transportation of Hazardous Materials." Paper presented at the 64th Annual Meeting of the Transportation Research Board, National Research Council, Washington, D.C., January 1985.

11. Russell, E.R., J.T. Smaltz, J.P. Lambert, V.P. Deines, R.L. Jaspen, P.G. Joski, and T.R. Mansfield, "Risk Assessment Users Manual for Small Communities and Rural Areas," Department of Civil Engineering, Kansas State University, Manhattan, Kansas 66506 (1980) DOT/RSPA DPB/50/81/30.

12. Garbor, T. and T.K. Griffith, "The Assessment of Community Vulnerability to Acute Hazardous Materials Incidents." Journal of Hazardous Materials, Vol. 8 (1980) pp. 323-333.

13. Abkowitz, M. et. al. Estimating the Release Rates and Costs of Transporting Hazardous Waste. Transportation Research Board, Record Number 977, 1984.

14. A Guide to the Federal Hazardous Materials Transportation Regulatory Program. Material Transportation Bureau, Research and Special Program Administration, U.S. D.O.T., January 1983.

15. Toward a Federal/State/Local Partnership in Hazardous Materials Transportation Safety. Materials Transportation Bureau, Research and Special Program Administration, U.S. D.O.T., September 1982.

16. Transportation of Hazardous Materials: Toward a National Strategy. Volumes 1 and 2. Transportation Research Board, Special Report Number 197, 1983.

CHAPTER 2

DATA COLLECTION AND ANALYSES

INTRODUCTION

Several attempts have been made to ascertain the magnitude and nature of hazardous material transportation at the state level (see Chapter 1 references). The studies have revealed serious drawbacks in both the availability of statistical information and the ability to develop reliable data bases. These problems include the following: 1) poor response rates using questionnaires dissemenated to the private sector that are based on Standard Industrial Classification code sampling procedures; 2) seriously incomplete data sets retrieved from state agencies, except for a few bulk chemicals for which data is specifically needed (e.g. gasoline imports for taxing purposes); 3) lack of linking hazardous materials shipments specifically to routes travelled; 4) spot-check surveys on routes that have not covered all relevant state routes and/or insufficient sampling time per route 5) concentration on only a selected few materials in transit; and 6) lack of an integrated approach which combines shipments of hazardous waste and hazardous materials with respect to intra-state and internal- external state shipments.

Cognizant of the shortcomings in earlier studies, the approach utilized in this study was based on securing maximum data on hazardous materials shipments by attacking the problem from several directions. A preliminary assessment to test the feasibility of conducting a sample survey of generators, transporters and receivers of hazardous substances showed serious problems in obtaining statistically sufficient and appropriate data. The following outlines the major efforts in the study to obtain and conduct the analyses. The first part describes the surveys undertaken to retrieve the data. The second, describes the computer information management system developed to store, manipulate and analyze the information.

SURVEY OF HAZARDOUS WASTE TRANSPORTATION

Information on hazardous waste shipments in Arizona is provided by a manifest system which tracks the movement of hazardous waste from generator to disposal site. The manifests covering the years 1983 and 1984 served as the base from which information was retrieved and, represented 100 percent of the legally constituted hazardous waste movements in the state. "Hazardous Waste" is clearly defined under the Resources Conservation and Recovery Act (RCRA) and the information recorded in the manifests reflect shipments of wastes that are defined by the statute. As Chapter 3 discusses, even a 100 percent survey underestimates the total movement of hazardous waste. First, it does not "capture": a) shipments made by small generators (less than 1000 Kg/month) which were exempt from the regulations, b) hazardous waste that is transported "illegally" without manifests, and c) shipments that are not covered by RCRA and can be classified as "potentially hazardous waste." The manifest data provide comprehensive coverage of hazardous waste shipments that pass through the state (interstate transport), into the state, and out of the state from places originating in Arizona, but represent only the minimal legal shipment records. The use of manifest data for hazardous waste transportation is an acceptable procedure and has been utilized in several EPA studies.

The 1984 data provided information on 2,521 individual manifests which represent an equal number of truckloads of hazardous waste. Each truckload may carry more than one type of waste. The individual waste types being carried are referred to as "shipments." Statistics were derived for hazardous waste movement over time (month and day of the week), number of shipments by hazard class (U.S. Department of Transportation definitions), shipment distribution of the most frequently carried wastes by chemical identification and the origin-destination pattern for the state.

The next step in the analysis was to allocate the number of truckloads and hazardous waste shipments to specific routes. The statistical data was derived by means of a telephone survey of transporters who were identified in the manifests as carriers of hazardous waste. The results of the route designation between places of origin and destination was considered highly reliable due to the large response rate (135 transporters) representing 71 percent of those who were surveyed. Additionally, principal routes were discerned for all origin-destination points. Lastly, the number of truckloads and shipments by hazard class were allocated to the route designations.

SURVEY OF HAZARDOUS MATERIALS

To ascertain the magnitude of hazardous materials movement in Arizona in total, and its transportation pattern, it was important to identify the volume of hazardous materials entering the state by chemical type, hazard class and the routes over which the hazardous materials were shipped. To meet these objectives, two surveys were undertaken at the five major ports of entry -- Topock, Ehrenberg, Yuma, Sanders and San Simon. The first survey occurred in March, 1985, and covered one full week (7 days, 24 hours /day) while the second effort was held in July and again spanned one complete week. Two surveys were undertaken in order to gauge seasonal shifts in hazardous materials shipments and as a check for consistency.

Trucks that carry hazardous materials above a weight threshold (chemicals are identified by U.S. Department of Transportation) require placards specifying the material carried and its hazard class (flammable, corrosive, oxidizer, explosive etc.). In addition, the driver of each vehicle carrying a hazardous material is required to carry a bill of lading or manifest that identifies and characterizes the hazardous materials load in terms of volume, weight, chemical identification, hazard class, and consignee. The data for the analysis was retrieved from these manifests.

The objective of the March survey was to have 100 percent coverage of placarded trucks during the one-week survey period. However, unanticipated queing problems occurred at the Ehrenberg port that resulted in a 50 percent sample of placarded trucks taken there. Thus, the statistics of the March, 1985 shipments are based on a 50 percent sample of placarded trucks at Ehrenberg, and 100 percent at the other four ports of entry. The July survey was based on a 50 percent sample at each port.

The sample size represents one of the largest data sets obtained at the state level for hazardous materials transportation. Moreover, the five ports of entry were selected because they represent a large frequency of vehicular traffic entering the east and west borders of Arizona. As Table 2 shows, total truck traffic entering the five ports in 1984 totaled 1,811,084 trucks. The total traffic for Arizona's 16 ports of entry was estimated to be 2,483,969 trucks. Thus, the five ports of entry on which the survey was based, accounted for 72.9 percent of total commercial truck traffic entering the state. Statistical inferences and generalizations from the survey would show strong reliability.

TABLE 2
Arizona Ports of Entry
and Total Truck Traffic Entering Arizona
1984

Port of Entry	Total Number of Trucks Entering Arizona
Ehrenberg	411,049
Nogales	69,129
Parker	24,653
Yuma	159,304
Duncan	11,374
San Simon	424,009
Douglas	5,439
Springerville	17,209
Sanders	476,831
Window Rock	18,108
Teec Nos Pos	20,523
Fredonia	16,799
Page	24,679
Topock	339,891
Kingman	84,347
Black Rock	380,625
	2,483,969

Source: Motor Vehicle Division, Arizona Department of Transportation.

Figure 5 shows the response form utilized in the second survey. The survey form provides data on shipments by day of the week, entry place, and destination. The hazardous materials listed represent chemicals identified in the first survey (March 1985) that were transported into

FIGURE 5

HAZARDOUS MATERIALS ENTERING ARIZONA

DAY OF WEEK: ___ SUN ___ MON ___ TUE ___ WED ___ THURS ___ FRI ___ SAT

TIME OF DAY: ______ 8 AM - 5 PM ______ 5 PM - 12 PM ______ 12 PM - 8 AM

PORT ______________ CONSIGNEE ______________ CITY/STATE ______________

✓	PROPER SHIPPING NAME	HAZARD CLASS	LBS.	GALS.	✓	PROPER SHIPPING NAME	HAZARD CLASS	LBS.	GALS.
	GASOLINE, DIESEL FUEL (1203)					BENZINE (1115)			
	PAINT AND PAINT RELATED (1263)					BENZOYL PEROXIDE (2085-2090)			
	EXPLOSIVES CLASS A					BERRYLIUM COMPOUNDS (1566)			
	CLASS B					BIPYRIDILIUM PESTICIDE (2781,2782)			
	CLASS C					BORON TRIFLUORIDE (1008)			
	PROPANE, LPG (1978)					BROMINE (1744)			
	BATTERIES (SPECIFY)								
	RESIN SOLUTION (1866)					CALCIUM CARBIDE (1402)			
	SULFURIC ACID (1830)					CALCIUM HYPOCHLORITE (SPECIFY)			
	CLEANING COMPOUND, LIQUID (1760)					CARBON MONOXIDE (1016)			
	ADHESIVE (1133)					CAUSTIC SCDA, DRY (1823)			
	LIQUID CEMENT (1133)					SOLUTION (1834)			
	[redacted]					CEMENT COMPOUND (1133)			
	ACETIC ACID (2789)					CHLORPYRIFOS (2783)			
	ACETONE (1090)					CHROMIC ACID (1755)			
	ACID, LIQUID (SPECIFY)					CIGARETTE LIGHTER, GAS (1057)			
	ADHESIVE, FLAMMABLE (1133)					CLEANING FLUID (1760)			
	ALCOHOL (SPECIFY) (1987)					CARBON DIOXIDE, LIQUIFIED (2187)			
	ALKALINE CORROSIVE (1719)					COMBUSTIBLE LIQUID (1993)			
	ALUMINUM ALKYL (2003)					COMPRESSED GAS (1956)			
	AMINOETHYLPIPERAZINE (2815)					COPPER CYANIDE (1587)			
	AMMONIUM CHLORIDE (9085)					CORROSIVE LIQUID (1760)			
	AMMONIUM FLOURIDE (2505)					CORROSIVE SOLID (1759)			
	AMMONIUM HYDROXIDE (2672)					CYCLOHEXANE (1145)			
	AMMONIUM NITRATE FERTILIZER (2067)								
	AMMONIUM SULFITE (9090)					DENATURED ALCOHOL (1987)			
	ANHYDROUS AMMONIA (1005)					DICHLORODIFLUOROMETHANE (1028)			
	ARGON REFRIGERATION (1951)					DICHLOROPROPENE (2047)			
	ASPHALT, LIQUID (1999)					DIMETHYL DISULFIDE (2381)			

✓	PROPER SHIPPING NAME	HAZARD CLASS	LBS.	GALS.
	DISINFECTANT, CORROSIVE (1903)			
	POISONOUS (1601)			
	DODECYLBENZENE-SULFONIC ACID (2584)			
	DRIERS, LIQUID (PAINT) (1168)			
	EMPTY DRUMS (SPECIFY)			
	ENGINE STARTING FLUID (1960)			
	ETHYL ACETATE (1173)			
	ETHYL ALCOHOL (1170)			
	ETHYL ETHER (1155)			
	ETHYL METHACRYLATE (2277)			
	ETHYL NITRATE (1993)			
	EXTRACT, FLAVORING (1197)			
	FIRE EXTINGUISHERS (1044)			
	FLAMMABLE LIQUID (1993)			
	FLUOBORIC ACID (1775)			
	FORMIC ACID (1779)			
	FUEL OIL (1993)			
	HELIUM (SPECIFY)			
	HEXANE (1208)			
	HYDROCHLORIC ACID (1789)			
	HYDROFLUORIC ACID (1790)			
	HYDROGEN CHLORIDE			
	HYDROGEN (SPECIFY)			
	HYDROGEN PEROXIDE (SPECIFY)			

✓	PROPER SHIPPING NAME	HAZARD CLASS	LBS.	GALS.
	INK (1210)			
	INSECTICIDES, DRY (2588)			
	LIQUID (1993)			
	LIQUID POISONOUS (2902)			
	ISOBUTANOL (1212)			
	ISOOCTANE (1262)			
	ISOPROPANOL (1219)			
	ISOPROPYL ALCOHOL (1219)			
	LACQUER (1263)			
	LIQUID NITROGEN (1977)			
	MAGNESIUM (SPECIFY)			
	MAGNESIUM NITRATE (1474)			
	MATCHES (SPECIFY)			
	METHANOL (1230)			
	METHYL ACETYLENE (1060)			
	METHYL ALCOHOL (1230)			
	METHYL ETHYL KETONE (1193)			
	METHYL ETHYL KETONE PEROXIDE(2550)			
	MORPHCLINE (2054)			
	NITRATE (1477)			
	NITRIC ACID (SPECIFY)			
	NITROGEN (SPECIFY)			
	NITROGEN FERTILIZER (1043)			
	NITROGEN TETROXIDE (1067)			
	NITROMETHANE (1261)			

✓	PROPER SHIPPING NAME	HAZARD CLASS	LBS.	GALS.	✓	PROPER SHIPPING NAME	HAZARD CLASS	LBS.	GALS.
	OIL, WASTE (1270)					SODIUM NITRATE (1498)			
	ORGANIC PEROXIDE (SPECIFY)					SODIUM PEROXIDE (1504)			
	OXIDIZER (SPECIFY)					SOLVENT (1993)			
	OXYGEN (SPECIFY)					STYRENE WASTE (2055)			
						SULFUR HEXAFLUORIDE (1080)			
	PAINT REMOVING (1263)								
	PENTANE (1265)					TERT-BUTYL PEROXY-2			
	PEROXIDE (1483)					ETHYLHEXANOATE (2143)			
	PETROLEUM DISTILATE (1268)					TERT-BUTYL PEROXY			
	PETROLEUM ETHER (1271)					NEODECANOATE (2177)			
	PETROLEUM OIL (1270)					TETRAHYDROFURAN (2056)			
	PETROLEUM NAPHA (2553)					THINNER (1263)			
	PHOSPHORIC ACID (1805)					TOULENE (1294)			
	PHOSPHOROUS OXYCHLORIDE (1810)					TRICHLOROSILANE (1295)			
	PHOSPHOROUS TRICHLORIDE (1809)					TRICHLOROTRIAZINETRIONE (2468)			
	PINE OIL (1272)					TRIETHYLAMINE (1296)			
	PLASTICS (2006)					TURPENTINE (1299)			
	POLYCHLORINATED BIPHENYL [PCB] (2315)								
	POTASSIUM CYANIDE (1680)					VARNISH (1263)			
	POTASSIUM HYDROXIDE (1814)								
	PROPHY ALCOHOL (1274)					XYLENE (1307)			
	PYRIDINE (1282)								
	RADIOACTIVE MATERIAL (SPECIFY)					OTHER			
						OTHER			
	SILVER NITRATE (1493)					OTHER			
	SODIUM CYANIDE (1689)					OTHER			
	SODIUM DICHLORO-S-TRIAZINETRICONE (2465)					OTHER			
	SODIUM HYDROSULFIDE SOLUTION (2922)					OTHER			
	SODIUM HYDROXIDE, SOLID (1823)								
	SOLUTION (1824)								

Arizona and were found to be carried in at least two truckloads during the week. To facilitate completion response time, the ten most frequently shipped items were identified in the first section of the survey form. For each hazardous material carried, the survey instrument requested information on hazard class and volume transported.

Several intrastate surveys were conducted to measure the number of and type of shipments originating within the state that would not be obtained from the ports of entry surveys. Spot checks were established by the Arizona Department of Public Safety at key intrastate points of travel over a one week survey period. Detailed information on the survey is found in Chapter 3. In addition, a count of hazardous materials-carrying trucks was taken on westbound Interstate 10 (west of Route 85). The purpose of this count was to reinforce the data from the DPS survey of intrastate shipments and to gauge levels of internal-external movement. Lastly, interviews were held with approximately 150 firms to help establish patterns and characteristics for specific bulk chemical shipments such as propane and acids.

DATA BASE MANAGEMENT SYSTEM

This section of the chapter describes the steps undertaken to develop the Data Base Management System (DBMS) for hazardous materials and hazardous wastes transportation in Arizona. First steps involved the selection of hardware and software, the design of the data base input and output form, and the development of the necessary command procedures to produce statistical relationships.

Computer System

The first decision was to choose between main-frame computers and microcomputers. Main-frame computers are known for their superiority over microcomputers in terms of speed and memory capabilities. Most state agencies have access to main-frame computers of one type or another. Although main-frame computers have speed superiority, they have some disadvantages including high initial cost, relatively high maintenance cost, user's training needs, and data system incompatability.

Microcomputers are inexpensive reliable, easy to master and need less office space. The advancement in the microcomputer technology is diminishing the gap between them and main-frame computers as far as memory and speed is concerned. Numerous state agencies are purchasing microcomputers and they are actively training their employees to use them efficiently.

Considering these factors, it was decided that the study utilize microcomputers in developing the information management system. They have been proven to perform well, and are suitable for business and engineering applications. Furthermore, IBM is being used by the Information System Group at ADOT. For these reasons it was decided that IBM microcomputers be adopted for this project.

Software Selection

Data storage and retrieval is one organizational activity that benefits from microcomputer use. Electronic recordkeeping systems managed with microcomputers are superior to manual systems because of the speed with which individual records can be stored or located in files. A record is the basic component of a file. It contains all the pertinent information about a specific case within a file. For example, in a hazardous waste file, each record would contain information extracted from the manifest such as the generator's name, the transporter name, the chemical name, the shipment quantity, along with any other information of interest about that manifest.

Data base managers are good for managing large amounts of information (up to 100,000 records on fast microcomputers) that might be stored in several related files. Some examples of data base management software include dBASE II, dBASE III, R:base 4000, and DATAEASE.

Graphic presentation of data is a most effective mode of presentation. Microcomputers can produce good quality business graphics such as pie charts, bar charts, x-y plots, and other types of displays. Given the appropriate software and hardware, the computer can generate graphics on the screen, on dot matrix printers, and on pen plotters. Data base managers do not have graphics capability, however integrated software may contain graphic modules. A typical integrated software generally offers word processing, data management, spread sheet, and graphics capabilities in one integrated program. Lotus symphony, Lotus 123, Framework, and Enable are examples of integrated packages. The data management module in all the integrated software is limited in its capability and speed in manipulating large size data. The use of such software in this research project is clearly an inefficient way of creating a data base management system for hazardous material transportation.

The next logical step was to select a data base manager. The four popular commercial software, namely dBASE II, dBASE III, R:base 4000 and

DATAEASE, were evaluated in terms of: 1) capability 2) speed 3) friendliness and 4) memory usage. dBASE II and R:base 4000 were eliminated at the initial stage because they did not meet the four criteria listed above.

The comparative assessment of software was discussed with officials from the Information System Group at ADOT, and it was strongly recommended to the research team to use dBASE III since it is supported by ADOT personnel. It was therefore decided to adopt dBASE III for this project.

HAZARDOUS WASTE DATA BASE

The Arizona Department of Health Services (ADHS) made available the original hazardous waste manifests. Data was collected for the years 1983 and 1984, and a total of 5078 manifests were recorded.

To manipulate the waste data by time period, chemical identification, hazard class, and transportation routes, it was found necessary to create three files. The first file is the manifest file (abbreviated "mani") that contained information related to shipment date, generator E.P.A. I.D., Transporter E.P.A.I.D., Transporter/storage/disposal (T/S/D) E.P.A I.D., chemical U.N. number, hazard class, transportation route and quantity of wastes. Figure 6 shows the structure for mani, and the width of individual fields. Up to four chemicals were listed per record and up to two routes were permitted. Field T1 and T2 are used for data maintenance (sorting and other activities). Figure 6 displays a selected record of the mani file.

The second file (called "cpid") contained information related to the generators, T/S/D, and transporters. Detailed information, such as

E.P.A. I.D., address, phone number and type (attribute) are documented in individual records.

FIGURE 6
Structure of "mani" Records

Field	Field Name	Type	Width
1	Mani No	Character	8
2	Mani Tag	Character	1
3	Ship Date	Date	8
4	Gen ID	Character	12
5	Tran1 ID	Character	12
6	Tran2 ID	Character	12
7	TSD ID	Character	12
8	CHName1	Character	4
9	Class1	Character	5
10	Quant1 lb	Numeric	8
11	Vol1 Gal	Numeric	8
12	CHName2	Character	4
13	Class2	Character	5
14	Quant2 lb	Numeric	8
15	Vol2 Gal	Numeric	8
16	CHName3	Character	4
17	Class3	Character	5
18	Quant3 lb	Numeric	8
19	Vol3 gal	Numeric	8
20	CHName4	Character	4
21	Class4	Character	5
22	Quant4 lb	Numeric	8
23	Vol4 Gal	Numeric	8
24	Route1	Character	5
25	Route2	Character	5
26	T1	Character	1
27	T2	Character	1
TOTAL			178

The structure of the "cpid" file is shown in Figure 7 and a sample of selected T/S/D facility data is displayed in Figure 8.

The third file contained the transportation routes that connect generators and T/S/D facilities as reported in the manifests. As Figure

9 shows, each record contained the origin city, the destination city (CITY 2), route code, and up to 15 links per route. Figure 10 displays a sample of a record extracted from the "tra" file.

Counts of records contained in the second and the third files revealed that for the transportation of hazardous wastes, there exist a total of 228 companies (generators, T/S/D, etc.), eighty-two (82) transportation routes, and fifty-two (52) links.

FIGURE 7
Structure of "Cpid" Records

Field	Field Name	Type	Width
1	ID	Character	12
2	Name	Character	30
3	City	Character	15
4	Address	Character	50
5	Phone	Character	11
6	Attribute	Character	3
7	Tag	Character	1
8	Tag 2	Character	1
TOTAL			124

FIGURE 8
A Sample of "cpid" records

Record No.	6
ID	ARD069748192
Name	Ensco
City	El Dorado
Address	47th Smith Road El Dorado AR 71730
Phone	501-8637173
Attribute	TSD
Tag	
Tag2	

FIGURE 9
Structure of "tra" Records

Field	Field Name	Type	Width
1	CITY	Character	15
2	CITY2	Character	15
3	ROUTE	Character	4
4	SEC1	Character	3
5	SEC2	Character	3
6	SEC3	Character	3
7	SEC4	Character	3
8	SEC5	Character	3
9	SEC6	Character	3
10	SEC7	Character	3
11	SEC8	Character	3
12	SEC9	Character	3
13	SEC10	Character	3
14	SEC11	Character	3
15	SEC12	Character	3
16	SEC13	Character	3
17	SEC14	Character	3
18	SEC15	Character	3
19	T1	Character	1
20	T2	Character	1
TOTAL			82

FIGURE 10
A Sample of "tra" Records

Record No.	38
CITY	PHOENIX
CITY2	SAN SIMON
ROUTE	FS1
SEC1	1
SEC2	2
SEC3	3
SEC4	4
SEC5	5
SEC6	6
SEC7	17
SEC8	18
SEC9	19
SEC10	20
SEC11	
SEC12	
SEC13	
SEC14	
SEC15	
T1	
T2	

HAZARDOUS MATERIAL DATA BASE

Data collected from the port of entry surveys were coded and stored in two files. The first file, called "haz," contained information related to:

1) Survey Date and time of day
2) Port name
3) Consignee name and address
4) Chemical number and hazard class and subclass
5) Chemical amount
6) Transportation route

The structure of the "haz" file is displayed in Figure 11. In regard to the transportation routes, a file similar to "tra" was created and contained all possible routes from the five ports of entry to all possible consignees. The first survey data amounted to 3045 records, 316 transportation routes, and 80 links. It is important to point out that each record contains only one chemical.

FIGURE 11
Structure of "haz" Records

Field	Field Name	Type	Width
1	NOO	Character	6
2	NO	Character	5
3	TAG	Character	1
4	DATE	Date	8
5	TIME	Character	3
6	PORT	Character	15
7	CONSIGNEE	Character	20
8	CITY	Character	15
9	STATE	Character	5
10	CHEM NUM	Character	4
11	CLASS	Character	5
12	STATUS	Character	1
13	SUBCLASS	Character	1
14	LBS	Numeric	8
15	GALS	Numeric	8
16	ROUTE1	Character	4
17	T1	Character	1
18	T2	Character	1
TOTAL			112

COMMAND PROCEDURES

A command procedure called "MAIN" was developed to diagnose the data, develop statistical reports, and permit the user to select between hazardous material data and hazardous waste data. A group of sub-command procedures were developed in coordination with MAIN to perform the three functions mentioned earlier. MAIN is menu driven and it permits the user to access information interactively. The flow diagram of the command procedure and the sub-command procedures is shown in Figure 12. The command procedure and the sub-command procedures are written in the dBASE III special language which is very similar to the PASCAL language.

The program permits the user to perform three functions. The first function is used to develop a statistical report by time period, chemical number, and hazard class. The second function provides the capability of screen editing of individual records and enables the user to correct faulty records. The third function is used to select the appropriate data base (waste versus hazardous materials).

The statistical report produced from the first function follows the following criterion:

1. By time period:
    a) By year (1984, 1983)
    b) By month (January, February, etc.)
    c) By day (4/13/1984)
    d) By weekday (Sunday, Monday, etc.)
2. By chemical origin city
3. By destination city
4. By chemical number (9289, 1760, etc.)
5. By company (E.P.A. I.D number)
6. By chemical class (explosive, corrosive, etc.)
7. By transportation route (IF 1, FE 3, etc.)

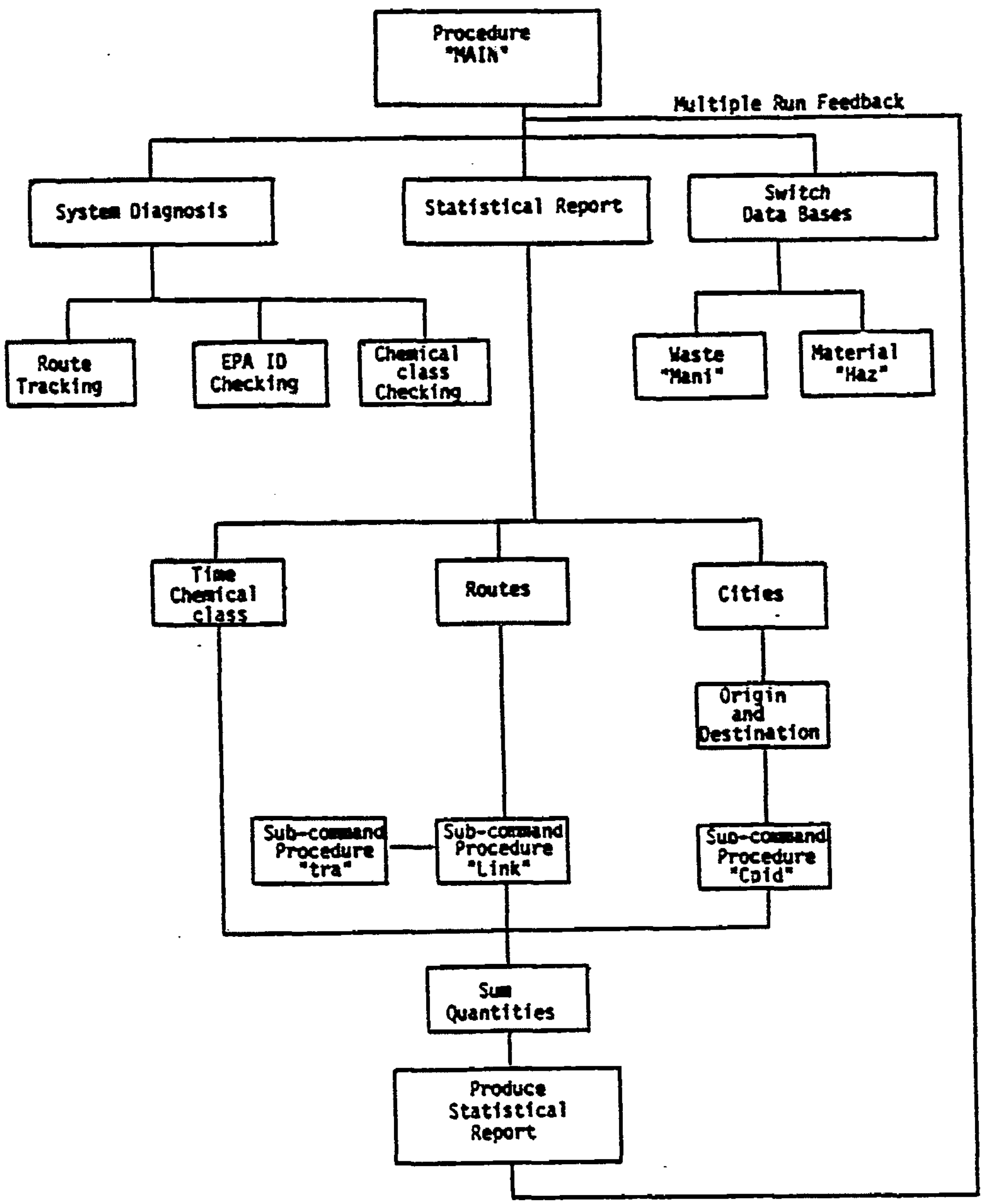


FIGURE 12. Flow Diagram of Procedure "MAIN"

The user may use the AND and OR options with the above listed criteria. The AND provides a cross tabulation of two or more criteria. For example, a statistical report can be created for the month of May and by chemical number 1760. The OR option sums up the data of two or more criteria. For example, a report can be created for Saturday OR Sunday. Such a report contains the total weekend shipments.

The statistical report contains the number of shipments, the total weight (in lbs), and the total volume (in gallons), summed for the desired criteria.

CHAPTER 3

TRANSPORTATION OF HAZARDOUS WASTE IN ARIZONA

INTRODUCTION

The purpose of Chapter 3 is to describe the pattern of shipments of hazardous waste in the State of Arizona and to ascertain the magnitude of these shipments by type and by route. The first section describes the source of the data base and the methods utilized in the analysis. Of particular importance in the approach was the allocation of origin-destination data and traffic volume to specific routes.

The next section serves as a backdrop to the analysis by defining hazardous waste and the regulations that govern its transportation. The findings of a previous Department of Health Services survey was used to reinforce and confirm the statistical information on waste volumes transported to disposal sites in this study. In addition, factors influencing future trends in the transport of hazardous wastes are looked at.

The third section of the chapter provides summary statistical data on hazardous waste shipments. The data is discussed in the following way: 1) breakdown of shipments by time factors; 2) shipment distribution by hazard class; 3) distribution by chemical number; 4) allocation of shipments to routes by total truckloads, hazard class and major chemicals. Finally, we briefly address the transportation implications of the proposed Arizona hazardous waste management facility.

APPROACH FOR MEASURING SHIPMENTS OF HAZARDOUS WASTE

According to the Resource Conservation and Recovery Act (RCRA), the generator and transporter of hazardous waste are required to identify and list in a manifest the hazardous wastes shipped, volume and/or weight, hazard class and disposal site. Because the U.S. Department of Transportation has adopted RCRA transportation regulations, the provision of a completed hazardous waste manifest is one of the requirements in the shipment of hazardous waste. Thus, information collected from the manifests provides the best source of data on amounts of hazardous waste transported in Arizona by chemical, hazardous class and shipment pattern.

The manifests for a specific year represent 100 percent coverage of hazardous waste shipments. The hazardous waste manifest file did not include wastes that have been exempted because of their "small quantity generation" status. Moreover, the data do not include waste shipments of "potential hazardous waste." Based on a 1981 survey of industries in Arizona there were an estimated 123,000 tons HW generated, exempt hazardous waste and "potential hazardous waste." The Arizona Department of Health Services indicated that approximately 92,000 tons were either exempt or "potentially hazardous" waste that require special treatment, handling and disposal but "fall outside the present scope of hazardous waste regulatory controls" (Arizona Department of Health Services, 1982). It is significant that an estimated 94 percent of "potentially hazardous waste" is disposed at off-site requiring transport to landfills, land farms and reclamation facilities. The analysis of hazardous waste shipments represent an underestimation of total shipments of substances that include "small quantity" exempt hazardous waste and "potential hazardous waste." Rather, the analysis is based on what constitutes legally-defined hazardous waste according to RCRA.

Data on hazardous waste shipments were based on complete manifest files for 1983 and 1984. Every manifest provided the following information: hazardous waste chemicals; assigned chemical number (known as the U.N. clasification number) hazard class; identification of generator, carrier and consignee; volume or weight of wastes; and date of shipment. To facilitate data collection efforts, the information obtained in individual manifests was re-recorded onto forms specifically designed to key and enter the data into the study's computer based transportation information system.

The total number of manifests recorded in 1984 was 2539. Each manifest represents one truckload; each truckload may consist of several chemical waste types (regarded as shipments). The manifest provides data on individual chemical wastes unless the waste is deliberately classified as a "mixed" chemical type. The identification of generator, carrier and consignee permitted the study to trace the origin and destination of each hazardous waste shipment. There were four patterns of transport:

1. Hazardous waste shipments originating out-of-state, transported through Arizona to an out-of-state destination;
2. hazardous waste shipments originating out-of-state with an in-state destination for reclamation or storage;
3. hazardous waste shipments that originate in Arizona and are transported out-of-state for disposal; and

4. intra-state shipments of hazardous waste that originate at a generating source and are transported to a TSD facility in-state for collection, recycling, reclamation or storage prior to ultimate disposal.

The next step in the analysis was to allocate hazardous waste shipments to specific routes. In order to accomplish this task, generators and shippers of hazardous waste were identified through the manifests and 135 firms were subsequently interviewed. The interviews solicited information on route selection between places of origin and destination. Responses were obtained for all origin-destination shipments and the principal routes identified were selected between each origin-destination point.

The number of transporters that responded represented a large proportion of shippers of hazardous waste in the state and all origin-destination places were identified for respective routes. In addition, there was a significantly high level of consistency and agreement among the transporters over the principal routes taken for transporting waste. Because the Tucson and Phoenix metropolitan areas dominate as generators of hazardous waste and that the disposal sites are located in the State of California, the general pattern of hazardous waste traffic flow in Arizona is concentrated along major highway routes. As the methodology chapter showed, each major route between origin and destination was broken down into several identifiable links to facilitate risk assessment studies and to permit the data base to be utilized at smaller geographic scales when needed. For each link- segment in the transportation system, data can be allocated to total truckloads over time, total number of shipments by chemical, volume or weight, and hazard class.

HAZARDOUS WASTE IN ARIZONA: IMPLICATIONS FOR TRANSPORTATION

Definition of Hazardous Waste

In the State of Arizona, the management and enforcement of EPA hazardous waste regulations is the responsibility of the Arizona Department of Health Services (ADHS) Bureau of Waste. Since 1983, ADHS has administered most regulatory requirements that apply to, among other needs, the transportation of the hazardous wastes as defined under the Resource Conservation and Recovery Act (RCRA) authorized in 1976, 1980 and 1984. ADHS has responsibility for investigating and assistance in regard to spills and other transportation related incidents and has established a state "spill incident report system." Haulers who transport hazardous waste are certified by the Arizona Corporation Commission.

As one component of the various types of hazardous materials being transported, these RCRA hazardous wastes make up only a small percentage of toxic substances being transported within and through Arizona. As a class of hazard, however, these wastes represent risk in commerce through transportation. The transportation of waste (slurries, sludges, liquids, solids, contained gases) has become a concern because of the potential of accidents and attendant release of toxic material. In Arizona, almost all of the shipments of hazardous waste takes place over highways. Occasional loads of specialized material are transported by rail. In the United States as a whole, approximately 90 percent of all hazardous waste transport is by truck.

It is important to distinguish hazardous waste from hazardous material because the record keeping requirements differ. A hazardous waste is only classified as such under RCRA if it meets criteria established in regulations from 40 CFR 260 through 40 CFR 271. Specifically, within 40 CFR 261, lists of hazardous wastes are specified as are criteria for defining hazardous wastes based on toxicity, reactivity, ignitability, and corrosivity characteristics. The State of Arizona has essentially adopted the U.S. RCRA regulations which define the four categories of hazardous waste (ignitability, corrosivity, reactivity and toxicity) supplemented by lists of chemicals considered to be hazardous.

Assuming the waste being shipped meets one or more criteria listed in the regulations, that waste must be transported with an accompanying manifest in addition to proper packaging and labeling under Department of Transportation's regulations. Copies of those manifests are sent to ADHS for review and filing. The manifest information file exists for 1983 and 1984 to allow complete analysis of what wastes were being shipped, their quantities, destinations, and points of origin. It was those records which were reviewed to obtain the information for the hazardous waste segment of this study.

Generation of Hazardous Waste and Disposal/Transportation

To fully appreciate the need and capacity for transporting hazardous waste, it is useful to record the amount of hazardous waste generated in Arizona and the proportion of generated waste that is shipped off site for reclamation and/or treatment and disposal. Table 3 shows the amounts of non-sewerable hazardous waste generated in Arizona in 1981 and the off-site transport related component of that waste.

In 1981, an estimated 38,034 tons of hazardous waste was generated in the state. Of this, 4,737 tons went off site for reclamation purposes and another 16,582 tons were shipped off site for treatment and disposal.

TABLE 3
Non-Sewerable Hazardous Waste In Arizona
Generation and Off-Site Transport (Tons)
1981

Hazard Class	Amount Generated	Off-site Reclamation	Off-site Treatment & Disposal	Total Off-site	Inter-State Shipment	Intra-State Shipment
Ignitability	3,165.3	2,264.6	822.6	3,087.2	1,572.1	1,515.1
Corrosivity	26,003.4	701.6	8,701.5	9,403.1	9,127.1	276.0
Reactivity	15.4	3.3	2.4	5.7	5.7	0
Toxicity	353.8	25.7	330.9	356.6	31.7	324.9
Organic Solvent	963.0	659.8	289.6	949.4	357.6	591.8
Electroplating Wastewater	3,076.3	484.0	2,612.9	3,096.9	566.0	2,530.9
Other non specific sources	44.8	4.1	38.8	42.9	4.1	38.8
Waste specific sources	1,467.8	36.0	1,441.3	1,477.3	40.9	1,436.4
Acutely Toxic Products	65.4	--	31.7	31.7	.8	30.9
Chemical Products	1,721.8	372.3	1,302.7	1,675.0	517.1	1157.9
Other	1,217.5	186.2	1,008.1	1,194.3	1,125.3	69.0
TOTAL	38,034.5	4,737.6	16,582.5	21,320.1	13,348.4	7,971.7

SOURCE: Arizona Department of Health Service, Arizona Hazardous Waste Statistics, 1981, June 1982.

A total of 21,319 tons of hazardous waste would require some form of off-site transportation, equivalent to 56 percent of generated non-sewerable hazardous waste in the state. On-site disposal, storage and recycling would constitute the remaining tonnage.

When off-site hazardous waste was categorized, approximately 63 percent of the waste was transported outside the state for disposal. The remainder of waste stream would be shipped to reclamation and storage facilities within the state. A substantial waste volume would subsequently be transported out of state for disposal. ADHS found that 78 percent of total off-site wastes would ultimately be transported for disposal. In addition, ADHS expects that the quantity of hazardous waste generated in Arizona will expand 5 to 10 percent annually over the next decade.

OTHER TRANSPORT FACTORS

Much of the hazardous wastes produced in Arizona must be transported out of state for either disposal or reclamation. There are no approved hazardous waste disposal facilities available in the state. However, perhaps not as obvious are the existing regulatory requirements, both federal and state, that force hazardous waste generators to dispose of waste in out-of-state disposal facilities. This situation arises because opportunities for recyclers or reclaimers to take wastes have been discouraged by the very hazardous waste regulations created under RCRA (40CFR Part 260-271).

For instance, the language of Part 261, 262 and Parts 264, 265, and 266 spell out which wastes can be recycled without RCRA permits and which wastes cannot. The qualifying requirements for approval to handle these wastes, however, are so complex that most regulatory bodies have interpreted these requirements to mean a recycler must be a permitted treatment, storage and disposal (TSD) facility which presents formidable financial requirements to the small recycling company. Thus, generators are left with the alternative of placing their otherwise recyclable wastes on the highways, shipping them long distances out of state for disposal or recycle at a company that is sufficiently large to meet TSD regulatory requirements.

For wastes in transportation, this situation will promote shipments to disposal facilities in California that otherwise could travel much shorter distances to local recyclers.

In 1984, RCRA was ammended and reauthorized to enhance requirements for hazardous waste generators. Two significant areas were regulated under these new ammendments that formerly were not addressed, both of which will cause more hazardous wastes to be manifested and transported to either proper disposal sites or recyclers.

The first area of concern is the classification called Small Quantity Generators (SQG). In regulations proposed since 1984 under these ammendments, this class has been changed to generators who produce between 100 and 1000 kilograms of waste per month. EPA estimates there are more than 130,000 such generators nationally who will be shipping wastes and an internal document in ADHS suggests there are 3000-5000 SQG in Arizona. More wastes will now be required to be properly packaged, labeled, stored, and shipped. In the near future, the amount of hazardous waste to be transported to disposal sites will be larger than the volumes found in this study.

The second set of regulations under RCRA are promulgated for companies that store hazardous materials in underground tanks. This program, "leaking underground storage tanks," will require over 100,000 gasoline station owners, solvent and petrochemical storage tank owners and many other industries in the country to test their underground tanks to evaluate if they are leaking. EPA estimates that 70-80% of tanks may have to be remediated which will create large volumes of hazardous wastes to be transported for disposal. In Arizona, no estimate has officially been made of the impact on total volumes that may have to be disposed. However, if a conservative 30%-40% are leaking, there may be as many as 3000-4000 underground tanks leaking wastes in Arizona. If implementation of the amended RCRA requirements are added to existing TSD and generators, the picture for Arizona wastes being shipped within the state will show a clear trend of increasing traffic over the next few years.

SUMMARY OF STATISTICS: TRANSPORTING HAZARDOUS WASTE 1984

Shipment Breakdown by Time Factors

The total number of truckloads of hazardous waste in 1984 was estimated to be 2539 of which 18 loads consisted of empty waste drums. The total number of loaded shipments was 2521 shipments carrying a volume of 9357 tons and 2,382,577 gallons. When hazardous waste volume in gallons are converted to tonnage using a waste unit conversion factor of 8.377 lbs/gallon, a total transport waste load for the state in 1984 was determined at 19,336 tons.

Figure 13 displays the distribution of the total number of truckloads of hazardous waste by month for 1984. It was observed that July, August and October represented the largest number of shipments, 9.9 percent, 11.3 percent and 10.4 percent of total annual shipments respectively. Outside these months, however, the range in number of shipments was found to be small. Shipments during January numbered slightly less than 180 compared to about 220 shipments during May. Based on waste generation during 1984, we can expect a range of 180 to 280 trucks per month, with July, August and October representing periods of high traffic flow.

The distribution of number of shipments by the day of the week was also derived and the distribution (Figure 14) showed that shipments on Tuesdays represented the highest number (over 600 shipments) followed by shipments on Wednesdays, Thursdays and Fridays with about 450 shipments each, respectively. There was a drop in the number of shipments on Mondays (400 shipments) and significantly low volumes of hazardous waste traffic during Saturdays and Sundays (less than 100 trucks on Saturdays). Statistics of this kind may be of assistance to the Arizona Department of Public Safety in order to schedule enforcement programs on the state highway system.

SHIPMENT BREAKDOWN BY HAZARD CLASS

Hazardous wastes were allocated into 10 hazard classes. Table 4 identifies these classes and their characteristics. Table 5 shows the distribution of shipments by hazard class and the volume/weight assigned to each class.

The "number of shipments" in Table 5 was estimated to be 2933. This figure is larger than the 2521 estimated for the number of truckloads of hazardous waste. This discrepancy is explained by the fact that an individual truckload may carry several different chemical wastes - known as "shipments" in the analysis.

FIGURE 13. Hazardous Waste Shipments by Month.

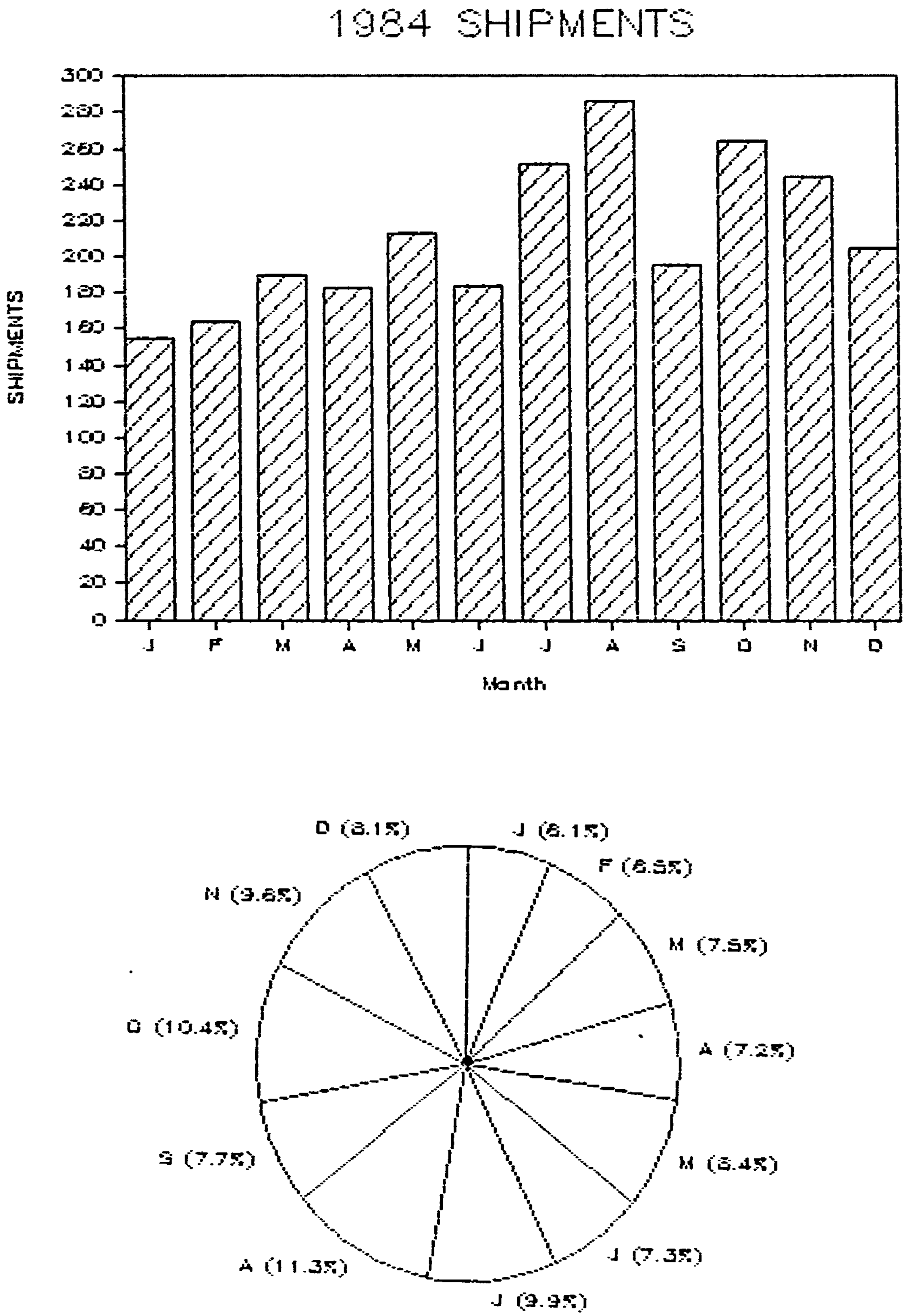


FIGURE 14. Hazardous Waste Shipments by Day of the Week.

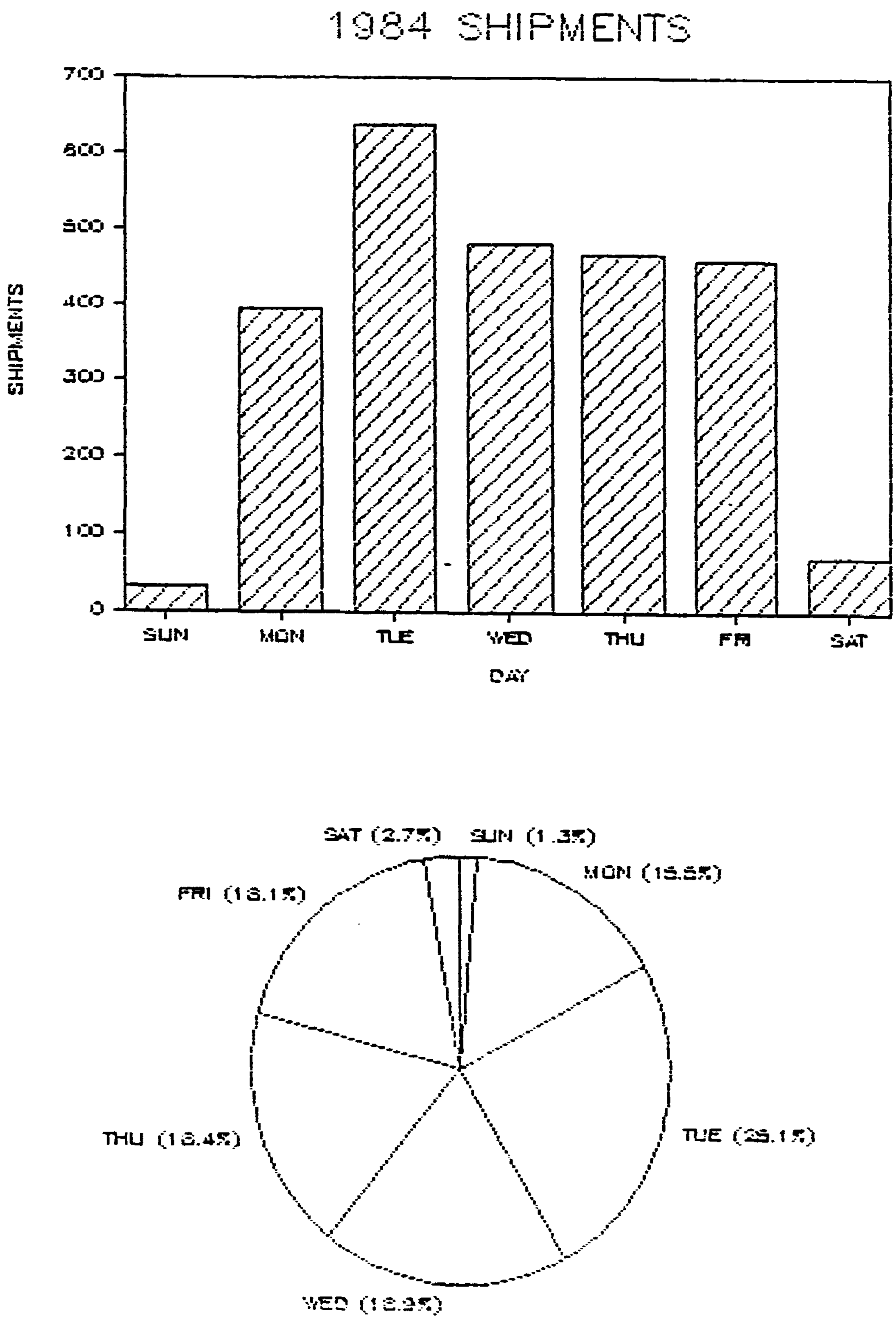


TABLE 4

Hazard Classes for Wastes and Definitions

HazaClass	Definition
Corrosive	Any liquid or solid that causes destruction of human skin tissue or a liquid that has a severe corrosion rate on steel.
Flammable Liquid	Any liquid with a flash point less than 100°F as measured by the test specified in Sec. 173.115, with the following exceptions: (i) A flammable liquid with a vapor pressure greater than 40 psia at 100°F; (ii) Any mixture having one component or more with a flash point of 100°F or higher that makes up at least 99 percent of the total volume of the mixture; and (iii) A water-alcohol solution containing 24 percent or less alcohol by volume if the remainder of the solution does not meet the definition of a hazardous material contained in this subchapter.
Solid	Any solid material, other than an explosive, which is liable to cause fires through friction, absorption of moisture, spontaneous chemical changes, retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious transportation hazard. (Sec. 173.150).
Poison A	Extremely Dangerous Poisons - Poisonous gasses or liquids of such nature that a very small amount of the gas, or vapor of the liquid, mixed with air is dangerous to life. (Sec. 173.326).
Poison B	Less Dangerous Poisons - Substances, liquids, or solids (including pastes and semi-solid), other than Class A or Irritating materials, which are known to be so toxic to man as to afford a hazard to health during transportation; or which in the absence of adequate data on human toxicity, are presumed to be toxic to man. (Sec. 173.343).
Combustible	Any liquid with a flash point from 100°F as measured by the tests specified in Sec. 173.115, except any mixture having one component or more with a flash point at 200°F or higher, that makes up at least 99 percent of the total volume of the mixture. (Sec. 173. 115(b)).

Oxidizer	A substance such as chlorate, permanganate, inorganic peroxide, nitrocarbo nitrate, or a nitrate, that yields oxygen readily to stimulate the compustion of organic matter. (Sec. 173.151).
Organic	Any organic compound containing the bivalent -0-0 structure and which may be considered a derivative of hydrogen peroxide where one or more of the hydrogen atoms have been replaced by organic radicals must be classed as an organic peroxide unless--(See Sec. 173.151 (a) for details).
<u>ORM-A</u>	A material which has an anesthetic, irritating, noxious, toxic, or other similar property and which can cause extreme annoyance or discomfort to passengers and crew in the event of leakage during transportation (Sec. 173.500(a)(1)).
<u>ORM-B</u>	A material (including a solid when wet with water) capable of causing significant damage to a transport vehicle or vessel from leakage during transportation. Materials meeting one or both of the following criteria are ORM-B materials: (i) A liquid substance that has a corrosion rate exceeding 0.250 inch per year (IPY) on aluminum (nonclad 7075-T6) at a test temperature of 130^{o}F. An acceptable test is described in NACE Standard TM-01-69, and (ii) Specifically designated by name in Sec. 172.101.
<u>ORM-C</u>	A material which has other inherent characteristics not described as an ORM-A or ORM-B but which make it unsuitable for shipment, unless properly identified and prepared for transportation.
<u>ORM-D/E</u>	A material such as a consumer commodity which, though otherwise subject to the regulations presents a limited hazard during transportation due to its form, quantity and packaging. They must be materials for which exceptions are provided in Sec. 172.101.

Source: U.S. Department of Transportation, Hazardous Materials Transportation, <u>Hazardous Materials Definitions</u>.

Sections refer to the Code of Federal Regulations.

The largest number of shipments were found in the flammable hazard class and accounted for 34.4 percent of total shipments of hazardous waste and 26.7 percent of total tonnage. Equally large were shipments within the ORM-E class, accounting for 34.2 percent of total shipments but 48.3 percent of total tonnage. Corrosives were the next largest category of hazardous waste with 14.8 percent of all shipments and representing 18.8 percent of tonnage transported.

TABLE 5

Distribution of Shipments of Hazardous Waste by

Hazardous Class and Volume

1984

Hazard Class	Number of Shipments	Percent of total	Lbs.	Gallons	Total Weight in tons[1]	Percent of Total
Flammable	1009	34.4	3,749,834	784,014	5,158	26.7
Corrosive	434	14.8	1,364,334	706,458	3,641	18.8
Poison	67	2.3	174,498	16,398	156	0.8
Combustible	40	1.4	83,180	15,458	106	0.5
Oxidizer	35	1.2	20,024	11,132	57	0.2
Organic	1	--	0	1	--	--
ORM-A	325	11.1	427.268	128,532	752	4.0
ORM-B	4	0.1	0	12,532	52	.3
ORM-C	15	0.5	130,990	996	70	.4
ORM-E	1,003	34.2	12,764,983	707,088	9,344	48.3
TOTAL	2,933	100	18,715,111	2,382,577	19,336	100.0

[1] A unit conversion factor of 8.377 lbs/gal. was used.

DISTRIBUTION BY CHEMICAL

The distribution of shipments by "chemical" for the largest six chemicals was determined. In regard to the rank order of shipments these are shown in Table 6. In total, these six chemicals collectively, as defined by chemical number (Emergency Response Guidebook 1984) constitute two-thirds of total hazardous waste shipments in the state. Chemical number 9189 is defined as hazardous waste in general, while chemical number 1993 included 11 different substances such as: combustible liquid, weed killing substances, ethylnitrate, insecticide, solvent and others.

TABLE 6
Distribution of Shipments by Chemical Number

Rank Order	Chemical Number	Name	Number of Shipments
1	9189	Hazardous Waste	929
2	1993	Combustible Liquid	612
3	1760	Mixed (corrosives)	224
4	2831	Trichloroethane	215
5	1090	Acetone	143
6	1593	Dichloromethane	124

ALLOCATION OF HAZARDOUS WASTE SHIPMENTS TO ROUTES

Origin-destination Analysis

The manifests provided origin-destination information which was supplemented by specific routing data through interviews with transporters of hazardous waste. An origin-destination analysis was conducted to reconstruct shipment flows within and out of the state. Shipments originating and terminating within the metropolitan areas of Phoenix and Tucson amounted to 1082 and 116 shipments in 1984, respectively, which, in sum, represented approximately 48 percent of all truckloads of hazardous materials. These intra-urban movements represent shipments generated from a company and transported to processing or storage facilities prior to disposal.

The origin-destination analysis showed that 848 truckloads originated from Arizona and were sent outside the state (internal-external), 40 trucks represented external-internal movements, 10 shipments were external-external movements (shipments through Arizona) and 1623 shipments represented internal-internal movements. As mentioned earlier, intraurban shipments (Phoenix and Tucson) were responsible for 1198 out of the 1623 shipments in the internal-internal categories representing 74 percent of the internal-internal flow.

Closer examination of shipments originating or terminating in Phoenix resulted in the following:

1) 539 truckloads left Phoenix for out-of-state disposal destinations.
2) 385 truckloads left Phoenix for in-state destinations.

A total of 924 truckloads left Phoenix in 1984. On the other hand, 54 shipments destined for Phoenix from other localities plus the 1082 intra-urban shipments totaled 1136 shipments. The difference between the 924 figure and the 1136 figures represents the reduction in number of shipments due to intermediate waste processing or assembly that took place in some of the Phoenix facilities. Furthermore, the 539 shipments that left Phoenix to out-of-state destinations were heading to disposal sites. The 10 shipments that crossed Arizona (external-external) originated from New Mexico and were destined for disposal sites in southern California. Figure 15 shows the annual distribution of truckloads by route.

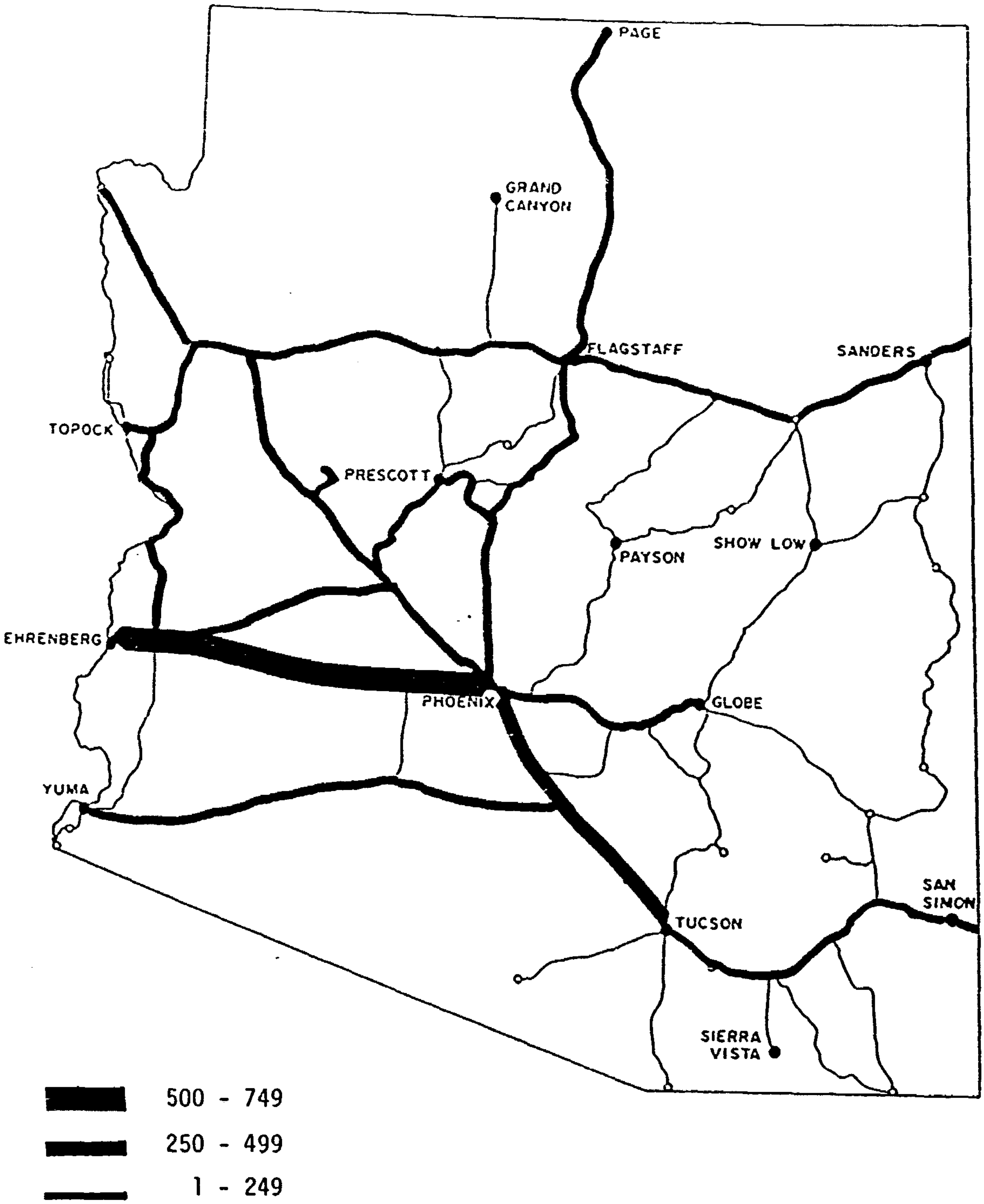


FIGURE 15. Annual Total Truckloads of Hazardous Wastes for 1984.

Route Distribution by Hazard Class

Table 7 shows the distribution of the number of hazardous waste shipments by route and hazard class in 1984. The largest movement of hazardous waste shipments occurred within the Phoenix metropolitan area as intra-urban transportation from generating source to storage/ reclamation facilites. When shipments of all hazardous classes are totaled by route, Route Interstate 10 from Phoenix to Ehrenberg heads the routes with the largest traffic of hazardous waste shipments. Figures 16 - 20 show the distribution of hazardous waste shipments by class and routes.

CHEMICAL IDENTIFICATION BY ROUTE

The six most frequently transported hazardous wastes by chemical was identified and allocated to routes. Table 8 shows these data. When the number of shipments are summed for all six chemicals, the most frequent movements were found to occur within the Phoenix metropolitan area. There were an estimated 959 such intra-urban shipments.

Route I-10 between Phoenix and Tucson represented the second largest traffic flow for these six chemicals. Table 9 shows that the volume of such shipments vary considerably along the route. Chemicals 1090 and 1993 move along the entire length of I-10 from Tucson to Phoenix on route to disposal sites in California. However, substantial truck traffic was found between Phoenix and the Eloy/Casa Grande area along Interstate 10. In fact, this segment of the route was shown to have 294 shipments consisting of chemicals 1593, 2831, 1760, and 9189. The same chemicals also were carried between Tucson and the Eloy/Casa Grande area but at a slightly less frequency than the former route segment. The

TABLE 7
Distribution of Shipments of Hazardous Waste
and by Hazard Class, 1984

Hazard Class	Routes	Number of Shipments
Combustible	Phoenix Intra-urban	24
	Tucson Intra-urban	1
	I-10 Phoenix to Ehrenberg	12
	I-10 Phoenix to Picacho	8
	I-10 Tucson to Picacho	6
	I-17 Phoenix to Flagstaff	1
	I-40 Sanders to Flagstaff	1
	I-40 Flagstaff to Topock	1
Flammable	Phoenix Intra-urban	585
	Tucson Intra-urban	39
	I-10 Phoenix to Ehrenberg	180
	I-10 Casa Grande to Phoenix	182
	I-10 Tucson to Casa Grande	168
	I-8 Casa Grande to Yuma	4
	I-10 Tucson to San Simon	1
	Bagdad to Phoenix	6
	I-17 Flagstaff - Phoenix	6
	I-40 Sanders - Flagstaff	6
	I-40 Flagstaff - Topock	2
Corrosive	Phoenix Intra-urban	75
	Tucson Intra-urban	42
	I-10 Phoenix - Ehrenberg	140
	I-10 Tucson - San Simon	7
	I-10 Tucson - Casa Grande	108 - 147
	I-10 Casa Grande - Phoenix	163
	I-8 Casa Grande - Yuma	4
	I-17 Flagstaff - Phoenix	17
	I-40 Sanders - Flagstaff	10
	I-40 Flagstaff - Topock	2
Poison	Phoenix Intra-urban	31
	Tucson Intra-urban	1
	I-10 Phoenix - Ehrenberg	20
	I-10 Tucson - Casa Grande	1
	I-10 Casa Grande - Phoenix	2
	I-8 Casa Grande - Yuma	1
	I-17 Phoenix - Flagstaff	2
	I-40 Sanders - Topock	2
Organic	I-17 Phoenix - Page	1

TABLE 7
Distribution of Shipments of Hazardous Waste
and by Hazard Class, 1984
(Continued)

Hazard Class	Routes	Number of Shipments
Oxidizer	Phoenix Intra-urban	5
	Tucson Intra-urban	1
	I-10 Phoenix - Ehrenberg	9
	I-10 Tucson - Casa Grande	7
	I-10 Casa Grande - Phoenix	10
	I-17 Phoenix - Flagstaff	6
	I-40 Sanders - Flagstaff	7
	I-40 Flagstaff - Topock	2
ORM-A	Phoenix Intra-urban	201
	Tucson Intra-urban	7
	I-10 Tucson - San Simon	2
	I-10 Tucson - Picacho	48
	I-10 Casa Grande - Phoenix	60
	I-10 Phoenix - Ehrenberg	55
	I-17 Phoenix - Flagstaff	2
	I-40 Sanders - Flagstaff	2
	I-40 Flagstaff - Topock	1
ORM-B	Phoenix Intra-urban	1
	I-10 Phoenix - Tucson	1
	I-10 Phoenix - Ehrenberg	2
ORM-C	Phoenix Intra-urban	4
	I-10 Phoenix - Tucson	3
	I-10 Phoenix - Ehrenberg	2
	I-17 Phoenix - Flagstaff	1
ORM-E	Phoenix Intra-urban	323
	Tucson Intra-urban	41
	I-8 Casa Grande - Yuma	53
	I-10 Tucson - San Simon	28
	I-10 Tucson - Casa Grande	231
	I-10 Casa Grande - Phoenix	193
	I-10 Phoenix - Quartzsite	338
	I-10 Quartzsite - Ehrenberg	348
	Rt. 60 Phoenix - Globe	8
	I-17 Flagstaff - Phoenix	53
	I-40 Sanders - Flagstaff	20
	Rt. 89 Flagstaff - Page	28

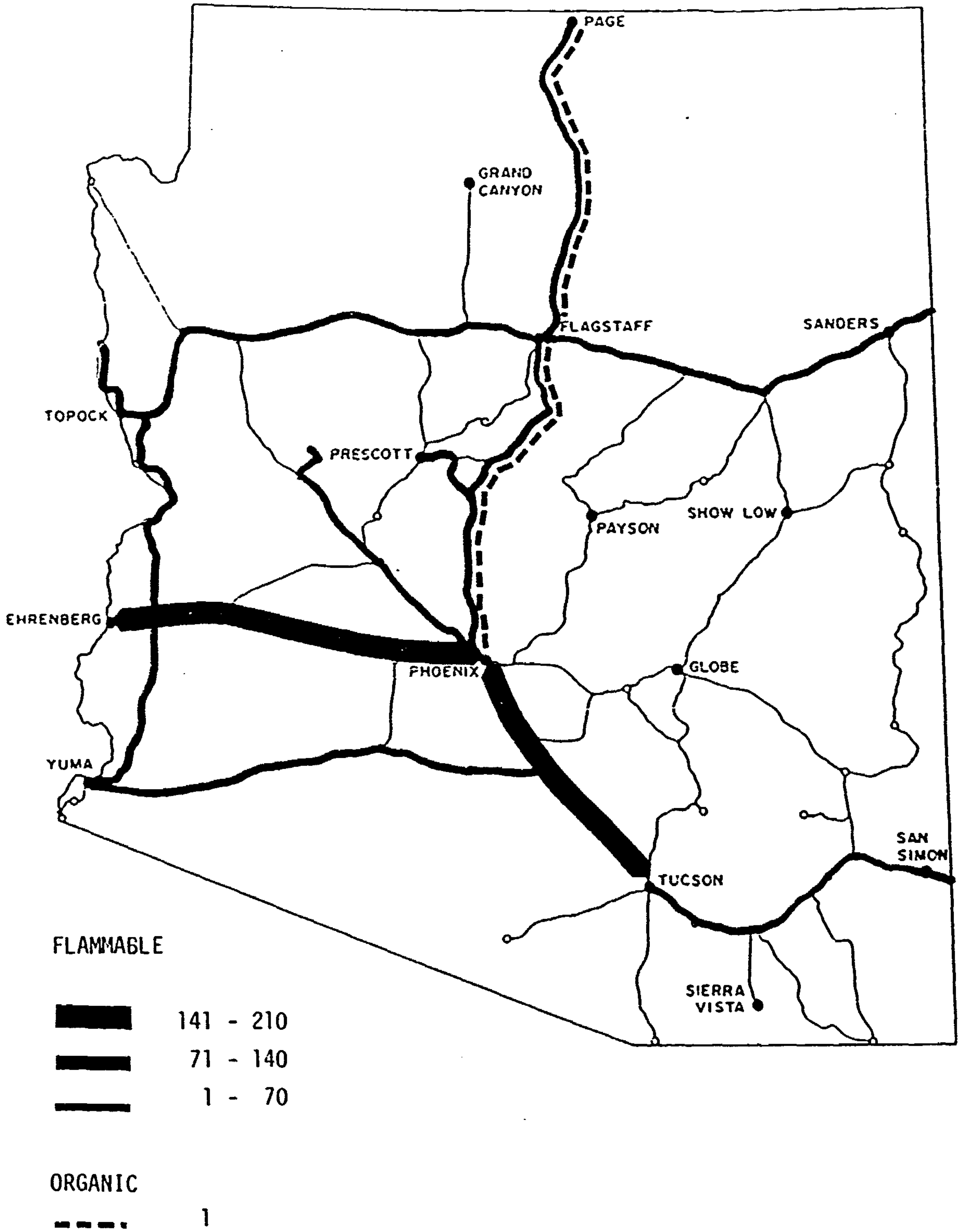


FIGURE 16: Annual Shipments of Flammable and Organic Wastes for 1984.

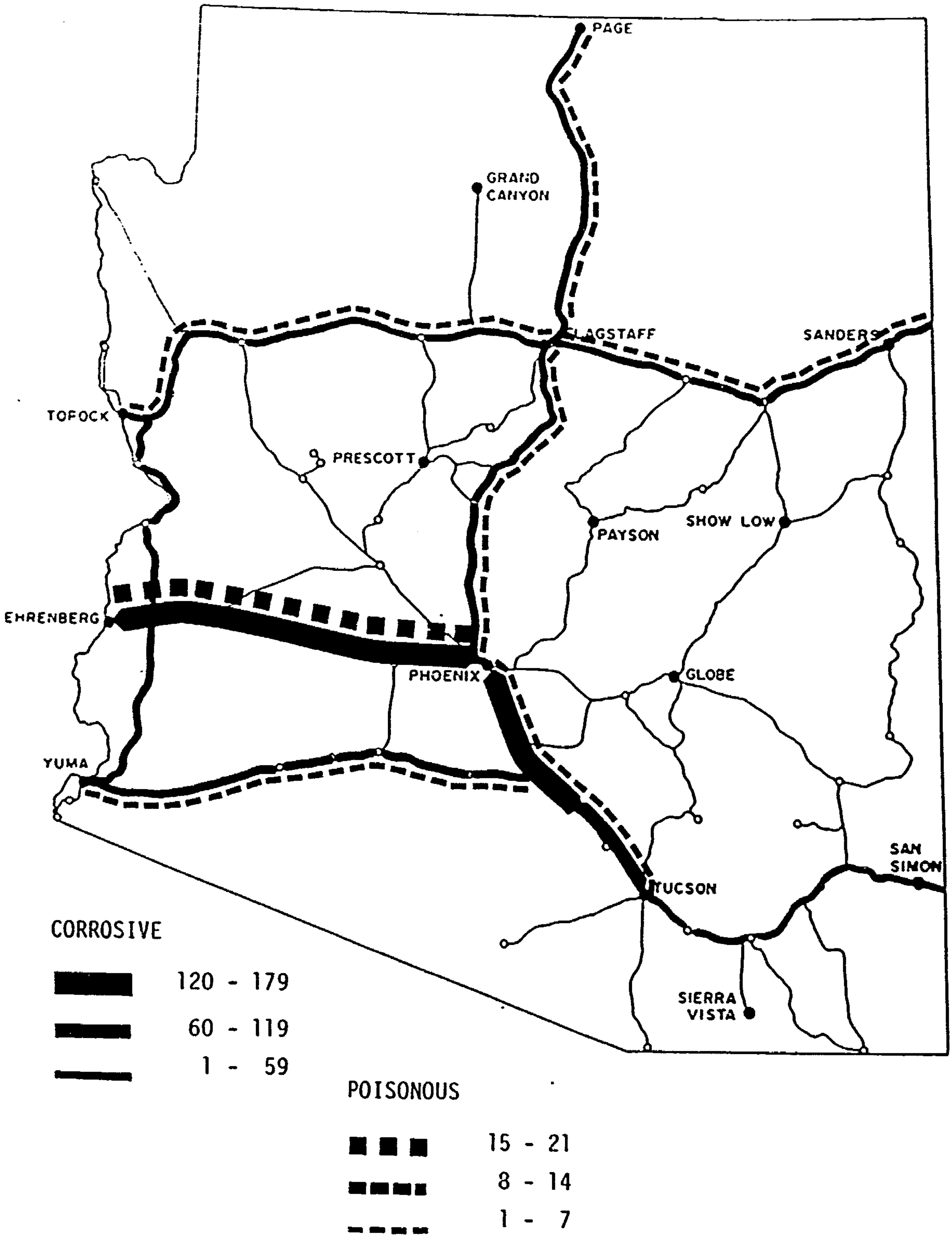


FIGURE 17. Annual Shipments of Corrosive and Posionous Wastes for 1984.

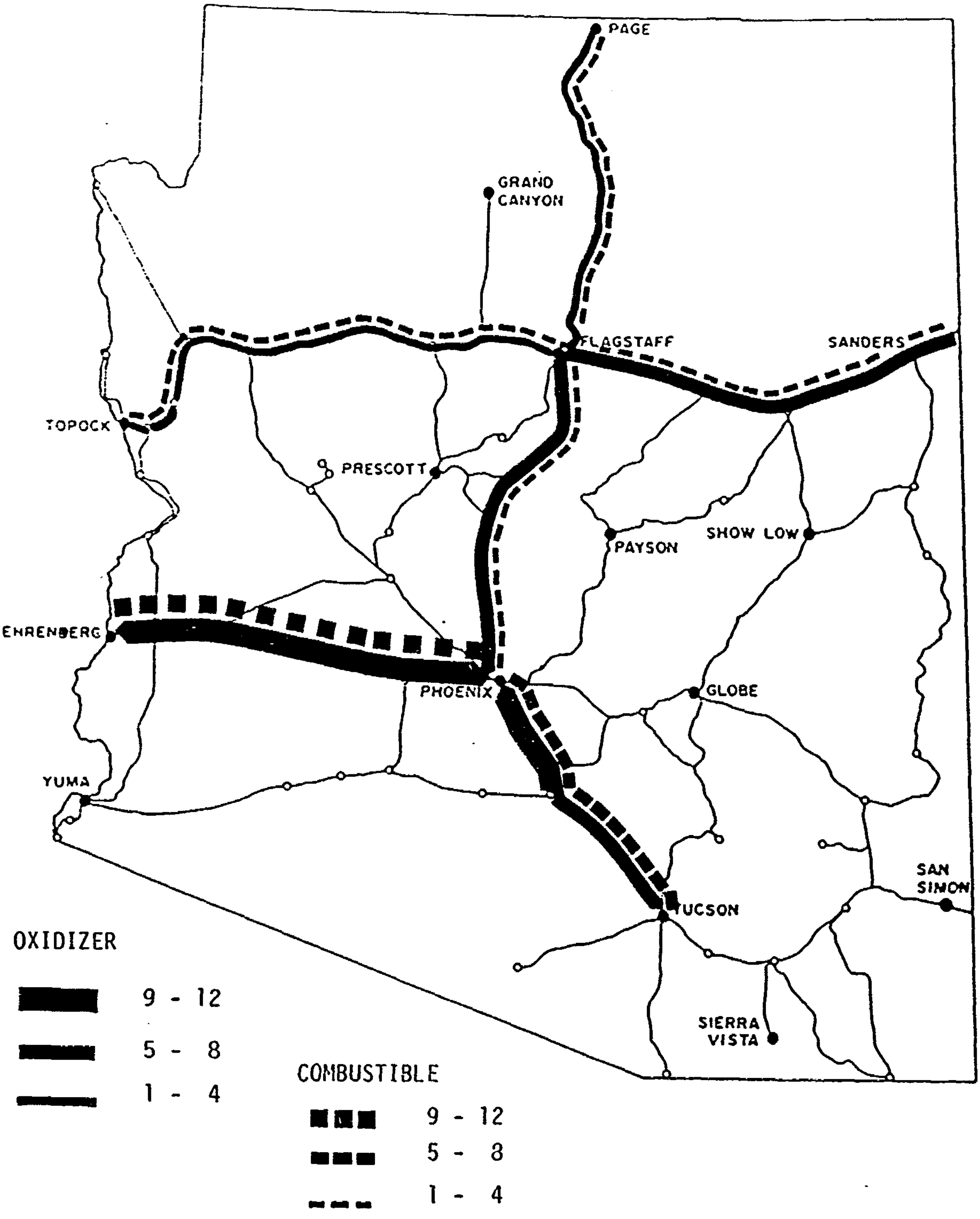


FIGURE 18. Annual Shipments of Oxidizer and Combustible Wastes for 1984.

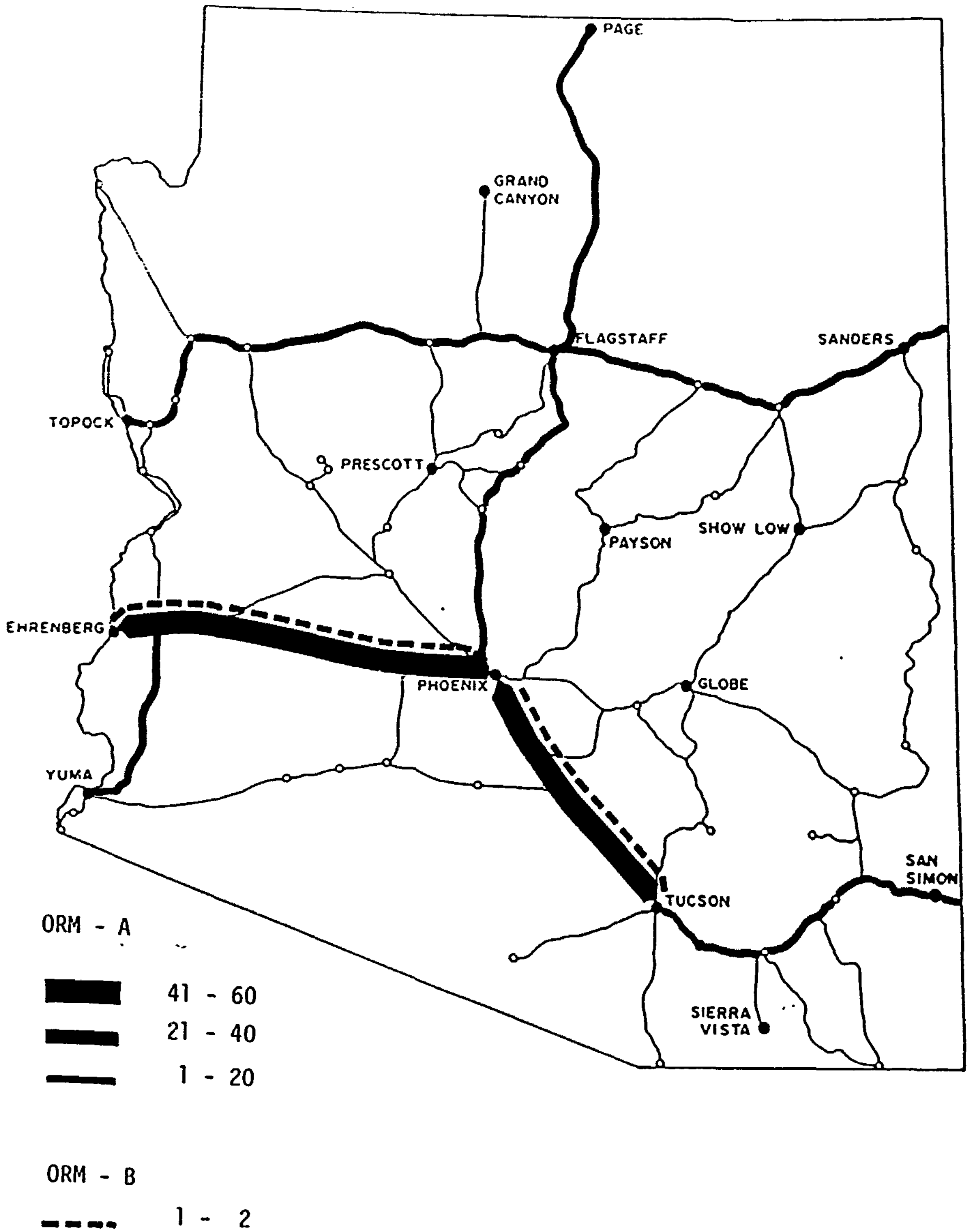


FIGURE 19. Annual Shipments of ORM-A and ORM-B Wastes for 1984.

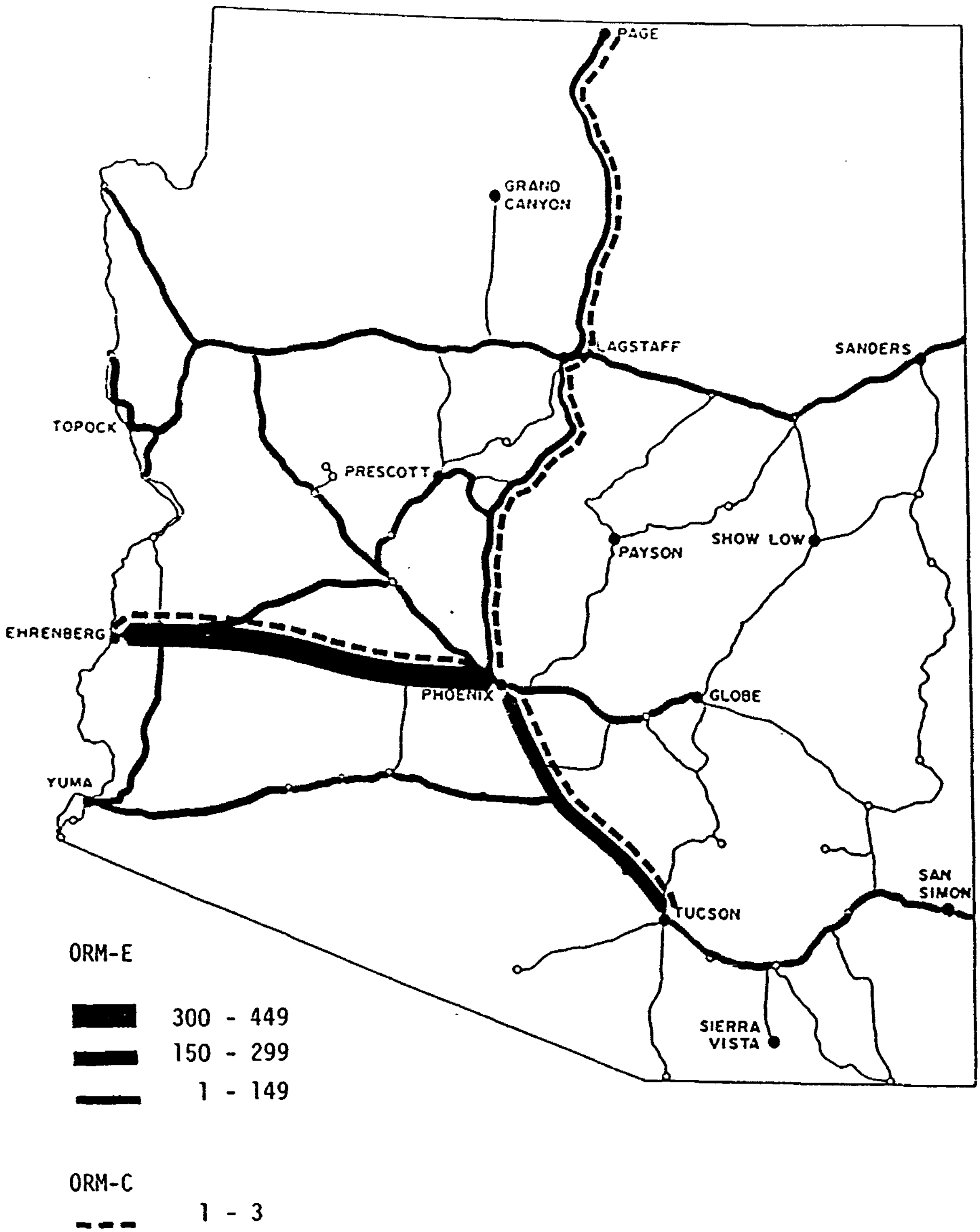


FIGURE 20. Annual Shipments of ORM-C and ORM-E Wastes for 1984.

TABLE 8
Hazardous Waste Shipments by Hazard Class on Selected Major Arizona Routes
1984

Routes	Combustible	Flammable	Corrosive	Poison	Oxidizer	ORM-A	ORM-B	ORM-C	ORM-E	Total
I-10 Phoenix-Ehrenberg	12	180	140	20	9	55	2	2	348	768
I-10 Tucson - Phoenix	8	182	163	2	10	60	1	3	231	660
I-10 Tucson - San Simon	-	1	7	-	-	2	-	-	28	38
I-17 Phoenix - Flagstaff	1	6	17	2	6	2	-	1	53	88
I-40 Sanders - Flagstaff	1	6	10	2	7	2	-	1	20	49
I-40 Flagstaff - Topock	1	2	2	2	2	1	-	-	-	10
I-8 Yuma - Casa Grande	-	4	4	1	-	-	-	-	53	62

next largest shipment location was Route I-10 from Phoenix to Ehrenberg with 338 shipments along that route.

The intra-urban movement of these chemicals within Tucson was about 10 percent of the level found for the Phoenix area. Few shipments occurred (8 shipments) between Tucson and the port-of-entry at San Simon. Hazardous waste shipments along I-40 were also not large during 1984. Between Flagstaff and Sanders 31 shipments were identified and another 13 shipments between Flagstaff and Topock. An equal number (44)

TABLE 9
Shipments of Six Major Chemical Wastes by Route[1]

Routes	1090	1593	2831	1760	1993	9189	Total
Phoenix Intra-urban	69	-	134	32	433	291	959
Tucson Intra-urban	7	-	-	38	6	38	89
I-10 Phoenix - Ehrenberg	1	19	38	80	100	90	338
I-10 Phoenix - Tucson	63	-	-	-	27	-	90
I-10 Tucson - SanSimon	1	-	-	4	-	3	8
I-17 Phoenix - Flagstaff	2	-	1	5	5	48	62
I-10 Phoenix - Eloy	-	20	39	61	-	174	294
I-10 Eloy - Tucson	-	11	35	32	-	210	288
I-40 Flagstaff - Sanders	-	-	2	6	3	20	31
I-40 Flagstaff - Topock	-	-	1	2	1	4-9	13
89-93 Phoenix - Bagdad	-	-	-	-	1	2	3
89 Flagstaff - Page	-	-	-	-	-	28	28
I-8 Yuma - Casa Grande	-	-	-	-	-	44	44
60 Phoenix - Globe	-	-	-	-	-	7	7
324 Bagdad - I-40	-	-	-	-	-	2	2
69 Prescott - Cordes Jct.	-	-	-	-	-	4	4

1 The hazardous wastes are identified as follows: 9189 (Hazardous Waste N.O.S.); 1993 (Creosote, wax, tar, insecticide, etc.); 1760 (acid, cleaning solvents, paint); 1593 (Dichloro methane/methylene chloride); 1090 (Acetone).

of shipments were found along I-8, between the Casa Grande area and Yuma.

The intra-urban movement of hazardous waste in the Phoenix area showed two distinctive features. First, the most frequent shipments consisted of three chemical types - 2831, 1993 and 9189. Chemical 1993 consists of creosote, tar, and insecticide wastes. Second, the average volume carried per truck is apparently substantially less than the average amount carried per truck over the interstate system for the same waste type. To illustrate, the average amount carried per truck within the Phoenix metropolitan area was estimated to be 7,854 lbs/shipment and 16,076 lbs/shipment on I-10 between Phoenix and Ehrenberg. A similar analysis for chemical 9189 showed that the average truckload weight within Phoenix was 13,306 lbs/shipment compared to 40,357 lbs/shipment along I-10. Table 10 displays these data.

Hazardous Waste Distribution - Truck-loads by Route

The distribution of total number of truck-loads of hazardous waste by route is shown in Table 11. The largest number of shipments occurred as intra-urban movements within the Phoenix metropolitan area. Phoenix intra-urban truck-loads for 1984 numbered 1,306 which represented 40.9 percent of all truck-loads. The second highest frequency of hazardous waste traffic was on I-10 between Phoenix and Ehrenberg, accounting for 25.4 percent of total truck-loads. The Tucson-Phoenix link along I-10 also experienced substantial waste flow with a peak of 491 truck-loads along one of its route segments. This represented 19.4 percent of total waste traffic in the state. The remaining routes were characterized by low numbers of annual truck traffic carrying hazardous waste, with a range of 0.1 percent to 4.5 percent of total waste transport.

TABLE 10
Average Weight Per Load Comparison
Phoenix Area and I-10

	9189		1993		ORM-E	
	Phoenix	I-10	Phoenix	I-10	Phoenix	I-10
No. Shipments	291	80	433	99	323	339
Total Weight (lbs.)	3,872,151	3,228,592	3,400,858	1,591,522	4,130,551	8,815,907
Average Load/ Vehicle (lbs/truck)	13,306	40,357	7,854	16,076	12,788	26,006
Ratio	1	3	1	2	1	2

Table 11
Distribution of Hazardous Waste to Truckloads by Route
1984

Route	Maximum Truck-loads in Route Segment[1]	Percent of Total
Phoenix Intra-urban	1,036	40.9
Tucson Intra-urban	115	4.5
I-10 Phoenix-Ehrenberg	643	25.4
I-10 Tucson-Phoenix	491	19.4
I-8 Casa Grande-Yuma	49	1.9
I-17 Phoenix-Flagstaff	67	2.6
89 Flagstaff-Page	30	1.2
I-40 Flagstaff-Sanders	33	1.3
I-40 Flagstaff-Kingman	7	0.3
I-40 Kingman-Topock	9	0.4
93 Phoenix-Bagdad	8	0.3
324 Bagdad-I-40	2	0.1
I-10 Tucson-San Simon	28	1.1
69 Prescott-Cordes Junction	9	0.3
89-314 Prescott-Quartzsite	1	0.1
60 Phoenix-Globe	7	0.2

IMPLICATIONS OF ARIZONA HAZARDOUS WASTE DISPOSAL FACILITY

The future predictions for where hazardous wastes will be transported may show a startling reversal, however, for out-of-state disposal shipments when (and if) the planned hazardous waste disposal site is constructed near Mobile, Arizona. Projecting that the waste shipments currently manifested to California disposal sites will be transported to the new Arizona disposal facility changes the intra-state picture significantly in two ways.

First, a worst-case analysis can be made that shows all Tucson generated wastes that currently is disposed of in California disposal sites either comes to Phoenix to a transfer station for temporary storage before being shipped by truck over Interstate 10 to California or, if it travels directly from Tucson to California, use is made of both Interstate 10 and 8. These wastes will now go directly from Tucson to the disposal site half way between Tucson and Phoenix, using Interstate 10 (and perhaps a portion of Interstate 8), thereby reducing the total miles these wastes travel and the potential exposed population.

Wastes generated in the Phoenix metropolitan area will travel from Phoenix to the disposal site by Interestate 10 and Maricopa Road. Although routing changes in the inner-city area will put a different population at risk, as well as the Interstate 10 population between Phoenix and the disposal road turnoff, the total miles traveled will be sharply reduced from the current shipments going to California.

The second significant feature noted by looking at the future transportation trends after the Arizona disposal site becomes available is that the in-flow of hazardous wastes from out-of-state, notably California, will increase the risks associated with hazardous wastes on the highways. This prediction is based also on the trends occurring in California that are beginning to close down available disposal sites there, notably the BKK site in West Covina, which will leave California generators with few options except shipping to the new Arizona site.

Therefore, rather than seeing a reduction of waste volumes in the near future, we will most likely see potential increases in volumes in an eastward direction offsetting the formerly westward movement of Arizona-generated volumes of wastes. In addition, the Arizona Facility may attract PCB wastes from a number of states.

CHAPTER 4

HAZARDOUS MATERIALS TRANSPORTATION

INTRODUCTION

Chapter 1 discussed the various definitions regarding hazardous substances and a clear distinction can be made between 'hazardous waste' (subject of Chapter 3) and 'hazardous materials,' the focus of this chapter. From a regulatory perspective, the U.S. Department of Transportation, under the regulations of the Hazardous Materials Transportation Act (Public Law 93-633) has incorporated the regulations governing the transportation of hazardous waste under the authority of the Resource Conservation and Recovery Act.

Hazardous materials in transportation are regulated by the Department of Transportation in Title 49CFR 170 to 179. Part 171.8 defines "hazardous material" as "...a substance or material in a quantity or form which may pose an unreasonable risk to health or safety or property when transported in commerce." In Arizona, these regulations have been directly adopted and enforced by the Arizona DOT. As mentioned in the section dealing with hazardous waste, the ADHS enforces RCRA regulations under Title 40 which incorporated Title 49 DOT regulations by reference. The Arizona Department of Public Safety together with the Department of Motor Vehicles enforces DOT regulations on the highways.

Subchapter C of the DOT regulations is that portion that governs hazardous materials. These sections include hazardous materials tables and communication regulations in Part 172, shipping and packaging requirements in Part 173 and all the other carrier methods such as rail, aircraft and water vessels in Parts 174 through 177. Special shipping containers are regulated in Part 178 and a section dealing with tank cars is found in Part 179. Thus, when determining how hazardous materials are shipped in Arizona, it is necessary to first understand the regulation requirements in Subchapter C that apply to transporters.

The distribution of hazardous materials in the transportation system may be different for Arizona than other more heavily industrialized states. This means that a great number of hazardous materials must come into the state from refineries and chemical manufacturing facilities elsewhere because there are few such manufacturing facilities in Arizona. Therefore, unlike the pattern of hazardous wastes which are primarily generated in Arizona and shipped out of the state, bulk tanker trucks and other hazardous materials shipments move either through or into the state carrying hazardous materials. This phenomenon is a result of the growing demand created by an expanding industrial base that relies on chemicals for high technology manufacturing.

What this situation means for emergency planning purposes is that every small and large community is faced with potential highway accidents involving large volumes of hazardous materials with perhaps only limited resources for mitigating and responding. Large volumes of hazardous materials will be partially concentrated in the two or three largest metropolitan areas of the state (as intra-urban movements) but it is the highways that present risks of serious accidents, especially at inter-state routes located within metropolitan areas. The number of HM incidents requiring a hazardous material response team in Arizona is increasing but the precise data is not now available. Hazardous materials transportation on highways and other ground transportation routes may pose increasingly larger risks for the general public. Distribution of hazardous materials throughout the transportation system must be examined, both at the intraurban level that shows high concentrations of shipments (particularly gasoline) and the state and interstate level.

PORTS OF ENTRY SURVEYS

Two ports of entry surveys were conducted. The first port of entry survey, conducted in March 1985 collected data related to hazardous material shipments entering the State of Arizona. One week of data (24 hours per day for 7 days) was collected for the five major ports, namely: Ehrenberg, Sanders, San Simon, Topock and Yuma. A total of 1888 truckloads were recorded carrying 3045 shipments. These figures reflect an attempt at 100 percent sampling for all ports, except Ehrenberg, which had a 50 percent sampling rate of placarded trucks. (Follow-up interviews with the Arizona Motor Vehicle Division personnel who conducted the surveys indicated some underreporting from the expected sampling rate).

A one week survey was also conducted in July that sampled the same five ports. The sampling design was based on a 50 percent sample of placarded trucks at each port. Since the percentage (7.39 percent) of hazardous materials truckloads in the July survey did not differ significantly from that in the March survey (7.3 percent) there was insufficient data on seasonal variation on hazardous materials entry into Arizona to be used to develop a seasonal-dependent annualization of the surveys. Annual estimates of survey results were determined on the hazardous material sampling data in the March survey allocated on a yearly basis.

Appropriate command procedures were developed, which operate within the dBASE III environment, and they were used to develop cross tabulation statistics by port of entry, chemical classes, and selected chemicals. Table 12 displays the annual number of shipments and truckloads cross tabulated by the five ports of entry. Table 12 also contains total tons, gallons, and equivalent tonnage of HM entering vehicles. The equivalent tonnage was determined by multiplying the total gallons by a conversion factor of 8.377 lb/gallon and adding the outcome to the weight using the appropriate units.

The general statistics broken down by shipments and truckloads are displayed in Figure 21. As Figure 21 shows, the number of truckloads approximate the number of shipments for all ports except Sanders.

TABLE 12
Total Number of Annual Shipments and Truckloads
By Port of Entry

Port of Entry	Shipments	Truckloads	Tons	Gallons	Total Equivalent Tons
Ehrenberg	46,800	43,368	176,532	149,000,000	799,571
Sanders	99,580	47,840	239,255	117,000,000	730,524
Topock	6,136	5,772	40,437	17,900,000	115,407
Yuma	11,856	11,024	20,740	76,200,000	340,080
San Simon	17,368	11,856	124,225	71,800,000	425,148

FIRST SURVEY STATISTICS

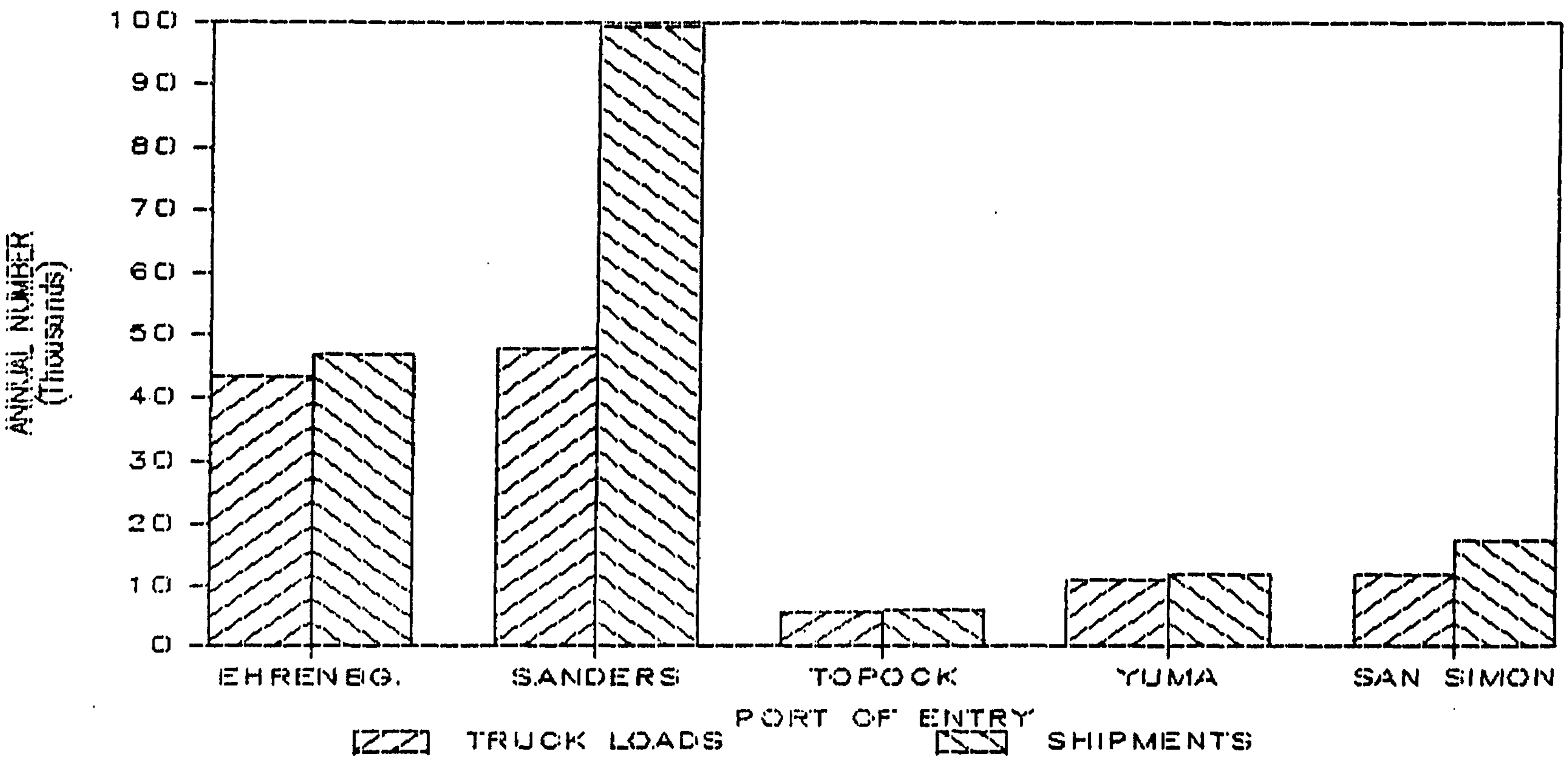


FIGURE 21

FIRST SURVEY STATISTICS BY TRUCK LOAD

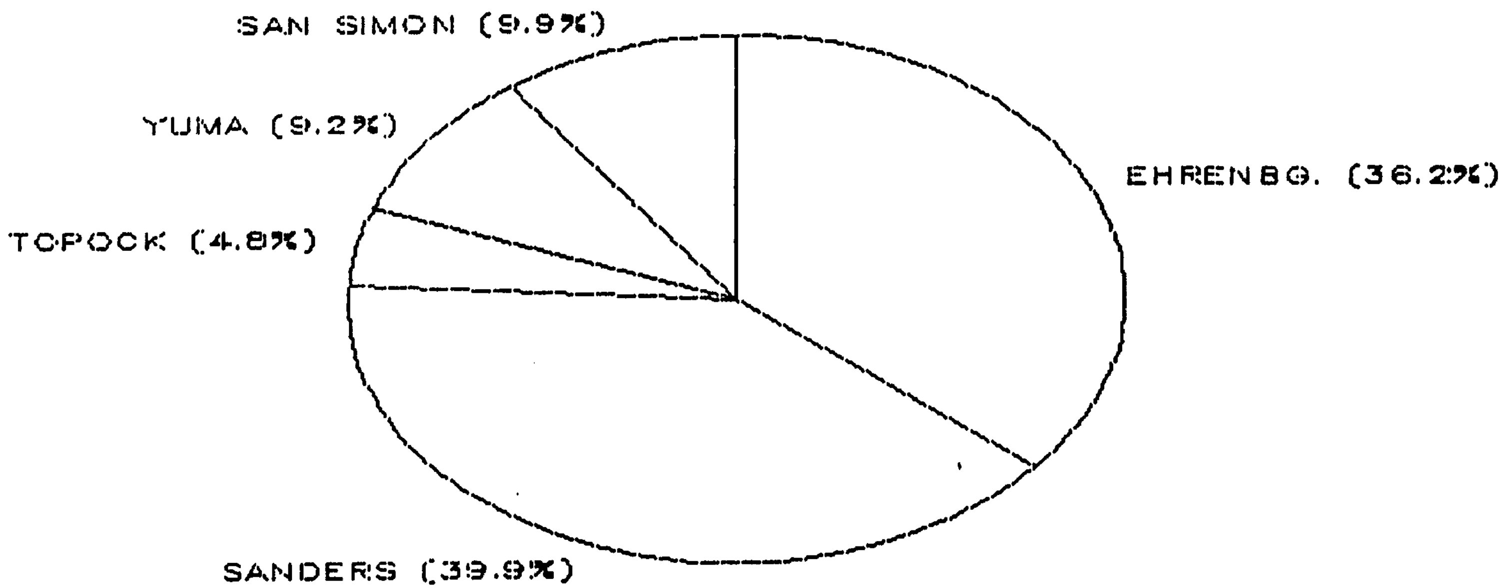
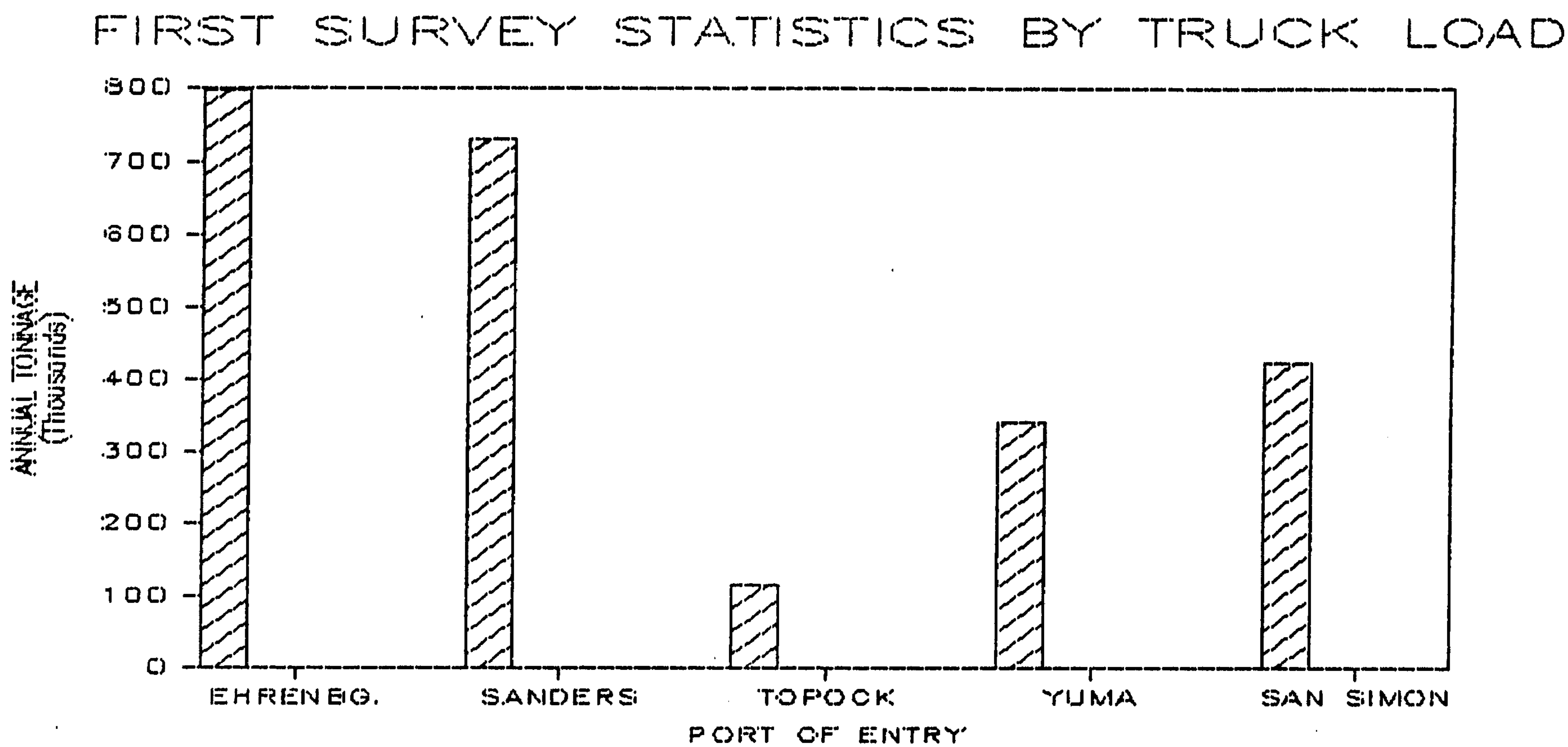
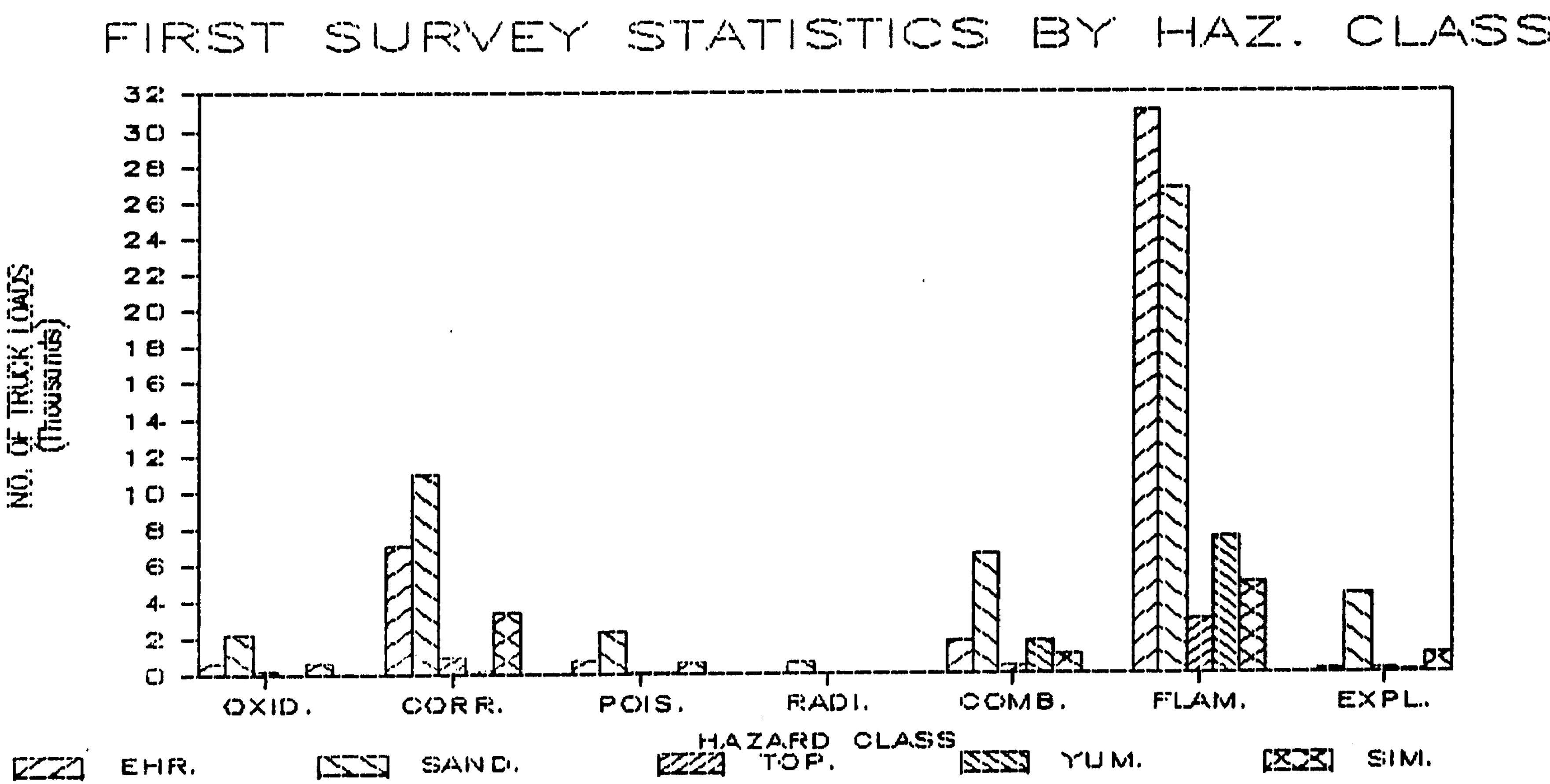


FIGURE 22



FIRST SURVEY STATISTICS BY TRUCK LOAD
ANNUAL TONNAGE (Thousands)
800
700
600
500
400
300
200
100
0
EHRENBG.
SANDERS
TOPOCK
YUMA
SAN SIMON
PORT OF ENTRY

FIGURE 23



FIRST SURVEY STATISTICS BY HAZ. CLASS
NO. OF TRUCK LOADS (Thousands)
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
OXID.
CORR.
POIS.
RADI.
COMB.
FLAM.
EXPL.
HAZARD CLASS
EHR.
SAND.
TOP.
YUM.
SIM.

FIGURE 24

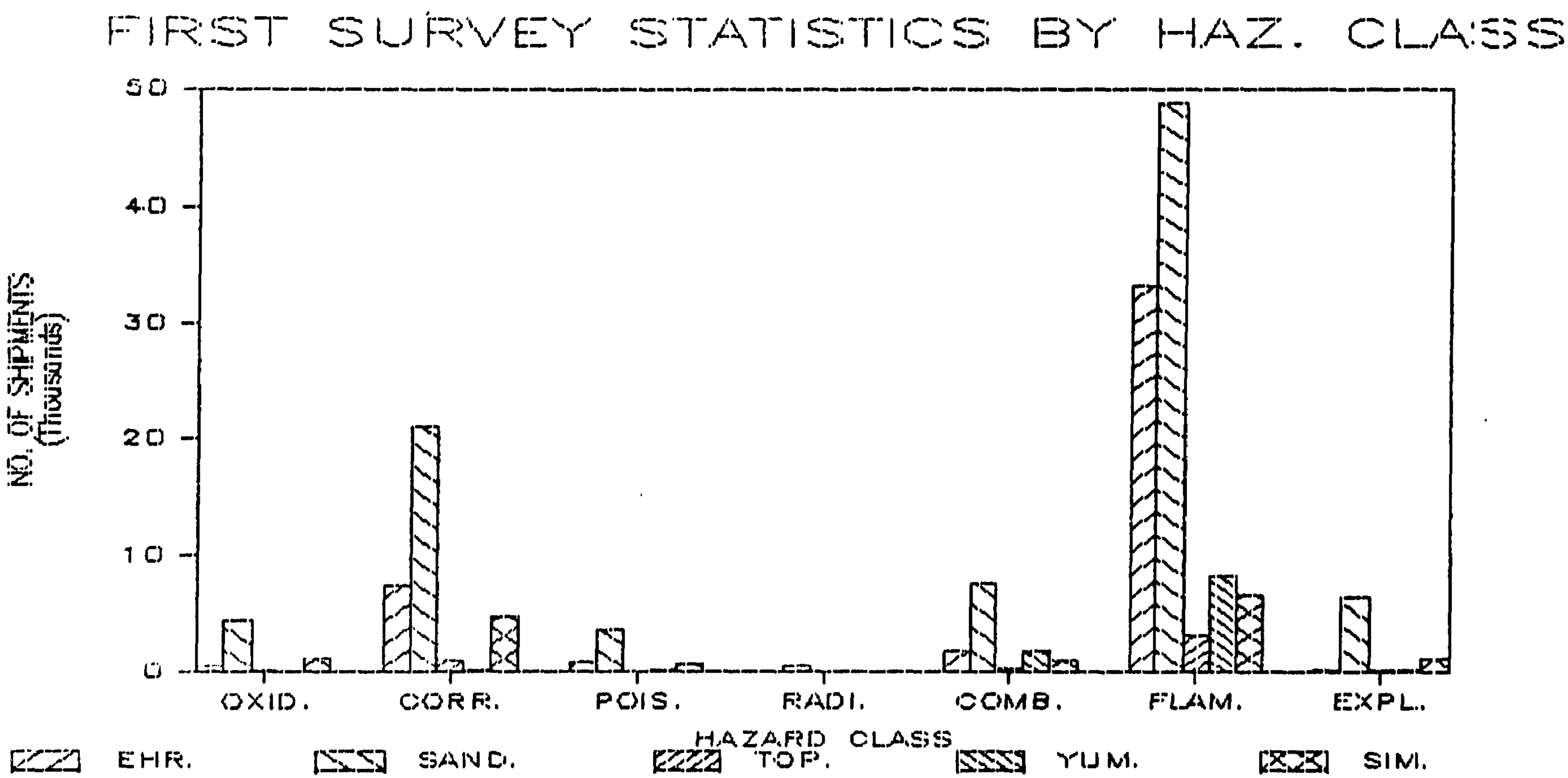

FIRST SURVEY STATISTICS BY HAZ. CLASS
NO. OF SHIPMENTS (Thousands)
50
40
30
20
10
0
OXID.
CORR.
POIS.
RADI.
COMB.
FLAM.
EXPL.
HAZARD CLASS
EHR.
SAND.
TOP.
YUM.
SIM.

FIGURE 25

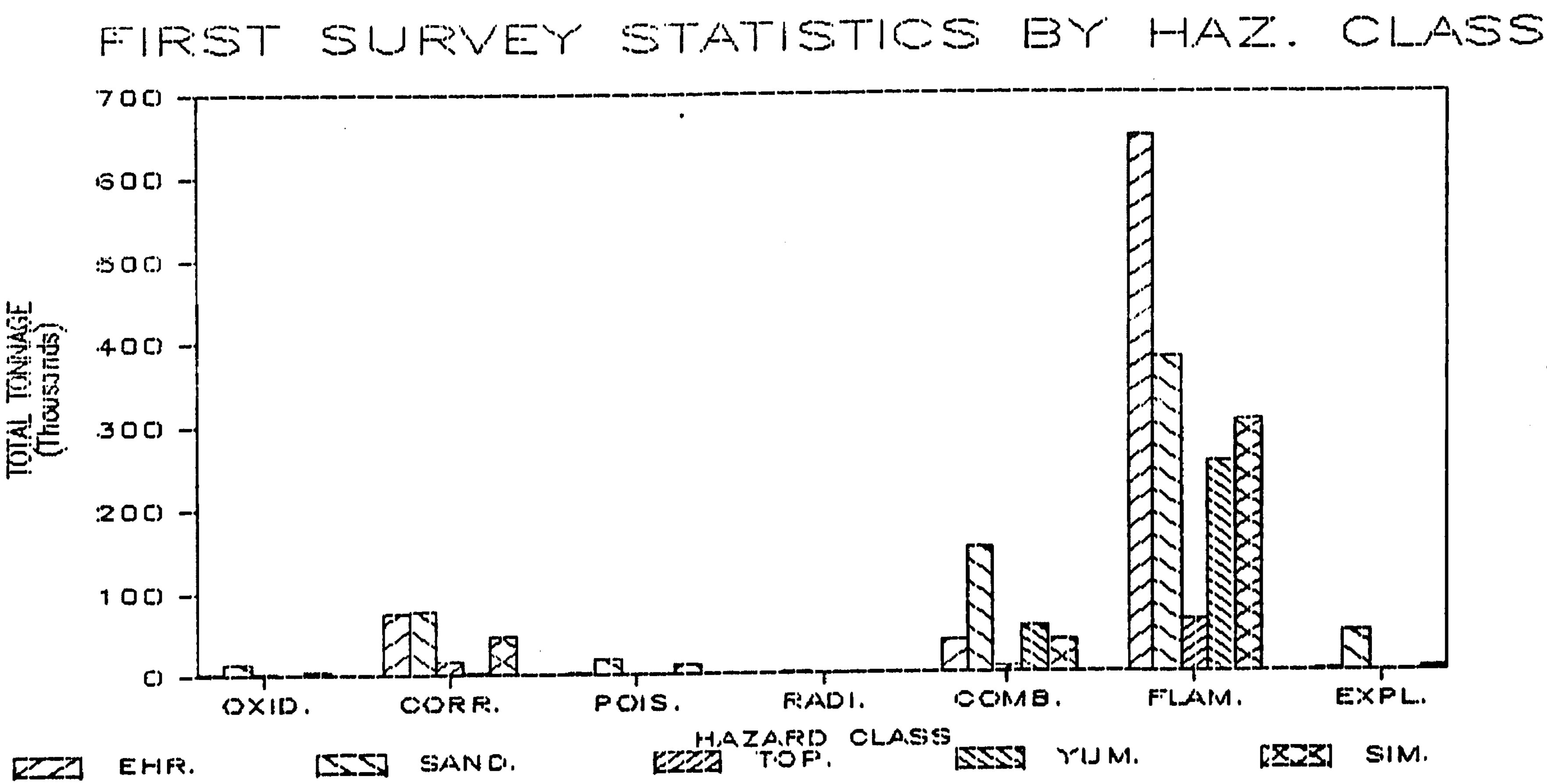

FIRST SURVEY STATISTICS BY HAZ. CLASS
TOTAL TONNAGE (Thousands)
700
600
500
400
300
200
100
0
OXID.
CORR.
POIS.
RADI.
COMB.
FLAM.
EXPL.
HAZARD CLASS
EHR.
SAND.
TOP.
YUM.
SIM.

FIGURE 26

TABLE 13
Percentage of Truckloads by Port of Entry and Hazard Class

Hazard Class	Sander	%	Topock	%	Ehrenberg	%	Yuma	%	San Simon	%	Total	%
Ozidizer	2,236	4.2	260	5.2	624	1.5	52	.5	728	6.0	3,900	3.2
Corrosive	10,920	20.4	988	19.7	7,072	16.9	208	2.0	3,380	28.2	22,568	18.5
Poison	2,340	4.4	104	2.0	832	2.0	156	1.6	676	5.7	4,108	3.3
Radioactive	624	1.0	---	---	---	---	---	---	52	.4	676	.5
Explosive	4,316	8.0	208	4.1	312	.8	156	1.6	1,092	9.1	6,084	4.9
Combustible	6,552	12.0	426	8.5	1,872	4.4	1,872	18.8	1,040	8.6	11,762	10.0
Flammable	26,728	50.0	3,016	60.5	30,992	74.4	7,488	75.5	4,992	42.0	73,216	59.6
TOTAL	53,716		5,002		41,704		9,932		11,960		122,314	

It means that haulers entering Arizona from New Mexico are carrying much more than one shipment per truck. Such findings suggest that the planning needed to cope with the consequences resulting from a hazardous material truck accident around Sanders may be different than those for other ports of entry. Furthermore, it was observed that Sanders and Ehrenberg have the highest number of truckloads representing 39.9%, and 36.2%, respectively (Figure 22).

The annual equivalent tonnage entering the state from the five ports are displayed in Figure 23. As can be seen, Sanders and Ehrenberg represent the highest equivalent tonnage. Even though Sanders had a larger number of shipments than Ehrenberg, the equivalent tons entering Ehrenberg were observed to be higher than those of Sanders. This reflects differences in types of HM entering each port (see Table 13).

The total number of truckloads, the total number of shipments, and the equivalent tonnages were calculated for the five ports of entry and cross tabulated by the most common hazard classes, namely: Oxidizer, Corrosive, Poison, Radioactive, Combustible, Flammable, and Explosive. Tables 14, 15, and 16 display the truckloads, the truckload percentage, the number of shipments, and the equivalent tonnages, respectively by hazard class. The statistics were plotted, and Figures 24, 25, and 26 display the results.

Closer examination of Figures 24, 25, and 26 reveals that flammable materials represent the highest share of hazardous material classes, followed by corrosives and combustibles. As was observed from the general statistics, for flammable materials, Ehrenberg had a higher number of truckloads than Sanders and the opposite was noticed for number of shipments. Furthermore, Table 14 shows that flammable materials, in general, represent the highest share of total truckloads entering the five ports. In addition, Yuma showed a relatively high percentage of combustible materials, and San Simon, Sanders, and Topock showed a relatively high percentage of corrosive materials.

TABLE 14
Total Number of Truckloads by Port of Entry and Hazard Class

Hazard Class	Ehrenberg	Sanders	Topock	Yuma	San Simon
Oxidizer	624	2,236	260	52	728
Corrosive	7,072	10,920	988	208	3,380
Poison	832	2,340	104	156	676
Radioactive	0	624	0	0	52
Combustible	1,872	6,552	426	1,872	1,040
Flammable	30,992	26,728	3,016	7,488	4,992
Explosive	312	4,316	208	156	1,092

TABLE 15
Total Number of Shipments by Port of Entry and Hazard Class

Hazard Class	Ehrenberg	Sanders	Topock	Yuma	San Simon
Oxidizer	624	4,428	260	52	1,144
Corrosive	7,384	21,060	1,040	208	4,836
Poison	832	3,640	104	260	780
Radioactive	0	624	0	0	52
Combustible	1,872	7,540	426	1,872	1,092
Flammable	33,176	48,984	3,120	8,216	6,656
Explosive	312	6,396	208	156	1,300

TABLE 16
Total Equivalent Tonnage by Port of Entry and Hazard Class

Hazard Class	Ehrenberg	Sanders	Topock	Yuma	San Simon
Oxidizer	4,485	13,854	3,924	1,396	4,866
Corrosive	74,364	76,953	17,069	3,542	46,835
Poison	3,536	19,254	548	1,676	11,326
Radioactive	0	4,191	0	0	5
Combustible	39,526	152,960	7,668	55,387	38,998
Flammable	649,285	380,323	63,183	255,433	305,815
Explosive	2,734	49,076	705	854	5,311

A manual check was conducted to find the most frequent chemical numbers shipped through the ports of entry, and the following seven chemicals were found: 1203 (Gasoline), 1263 (paint related substances), 1866 (resin), 1830 (Sulphuric acid), 1760 (cleaning compound), and 1133 (adhesives). The total truckloads, total shipments, and total equivalent tonnages were developed for the seven chemicals cross tabulated by the five ports of entry as seen in Tables 17, 18, and 19. It is important to point out that the remaining chemicals were grouped under the 'Others' category. This category represented as high as 74 percent of the total number of truckloads at San Simon and as low as 17 percent of the total number of truckloads at Yuma.

The gasoline shipments as observed in this survey (Chemical number 1203) represented a higher percentage when compared to the rest of the chemicals at four out of the five ports. Yuma and Ehrenberg's share of incoming gasoline shipments amounted to 34 percent, and 80 percent of the total shipments, respectively; yet, San Simon's share was observed to be only 2 percent.

The reason for having an unusual high number of gasoline shipments going through Ehrenberg, Sanders and Yuma is that the gasoline pipelines going to Phoenix and Tucson were shut down temporarily during the survey. The low share of San Simon's gasoline shipment can be explained by the fact that San Simon is within the region that the Tucson pipeline serves. Since chemical 1203 is a flammable chemical, the results shown pertaining to the flammable hazardous class were observed to be exceptionally higher than the other classes and which biased the results to some degree.

In order to develop useable data, gasoline shipments within the state were based on an allocation formula which is discussed later in the Chapter.

TABLE 17
Total Truckloads by Port of Entry and Selected Chemical Numbers

Chemical No.	Ehrenberg	Sanders	Topock	Yuma	San Simon
1203	14,872	9,256	1,040	8,840	208
1263	4,680	6,864	728	104	780
1978	0	4,420	52	156	156
1866	1,560	1,872	312	0	312
1830	832	728	104	0	416
1760	1,352	4,628	104	0	832
1133	936	1,560	0	0	364
Others	19,136	18,512	3,432	1,924	8,788
TOTAL	43,368	47,840	5,772	11,024	11,856

The total truckloads cross tabulated by port of entry and chemical number are plotted in Figures 27 and 28. As Figure 28 shows, the number of truckloads for the 'Others' category are relatively high for

TABLE 18
Total Shipments by Port of Entry
and Selected Chemical Numbers

Chemical No.	Ehrenberg	Sanders	Topock	Yuma	San Simon
1203	15,288	10,660	1,092	9,464	208
1263	5,616	12,376	728	208	1,040
1978	0	4,628	52	156	312
1866	1,560	2,184	312	0	312
1830	832	832	104	0	468
1760	1,352	5,980	104	0	1,040
1133	1,144	3,016	0	0	520
Others	21,008	59,904	3,744	2,028	13,468
TOTAL	46,800	99,580	6,136	11,856	17,368

TABLE 19
Total Equivalent Tonnage by Port of Entry
and Selected Chemical Numbers

Chemical No.	Ehrenberg	Sanders	Topock	Yuma	San Simon
1203	494,772	251,581	42,149	298,570	5,131
1263	24,439	51,946	7,692	1,082	4,448
1978	0	146,432	0	6,329	110,649
1866	27,701	8,362	5,509	0	11,881
1830	8,801	5,316	1,171	0	7,726
1760	12,718	20,622	90	0	7,127
1133	5,549	2,443	0	0	5,064
Others	225,591	209,809	58,796	34,099	273,121
TOTAL	799,571	696,611	115,407	340,080	425,147

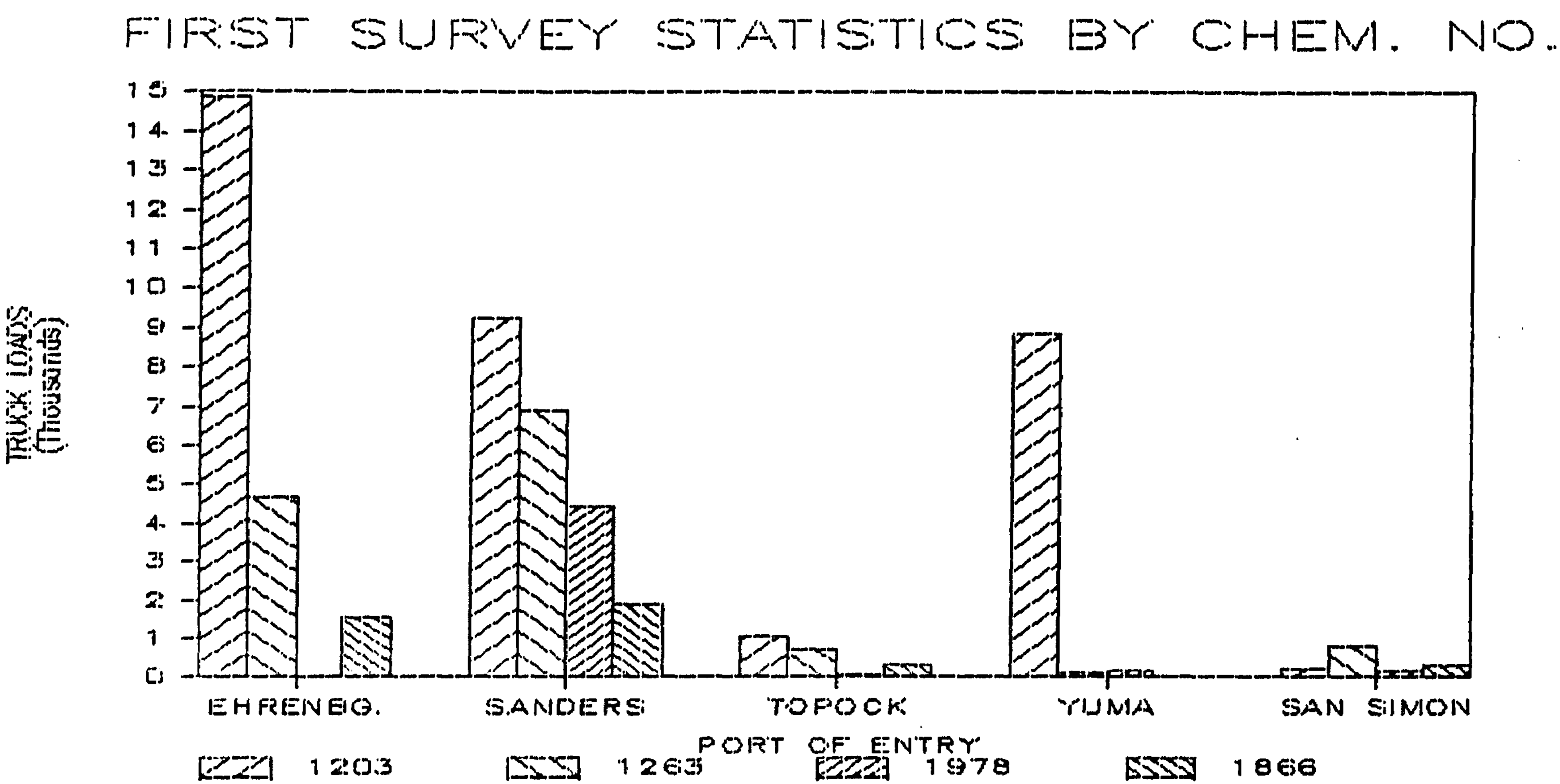

FIRST SURVEY STATISTICS BY CHEM. NO.
TRUCK LOADS (Thousands)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
EHRENBG.
SANDERS
TOPOCK
YUMA
SAN SIMON
PORT OF ENTRY
1203
1263
1978
1866

FIGURE 27

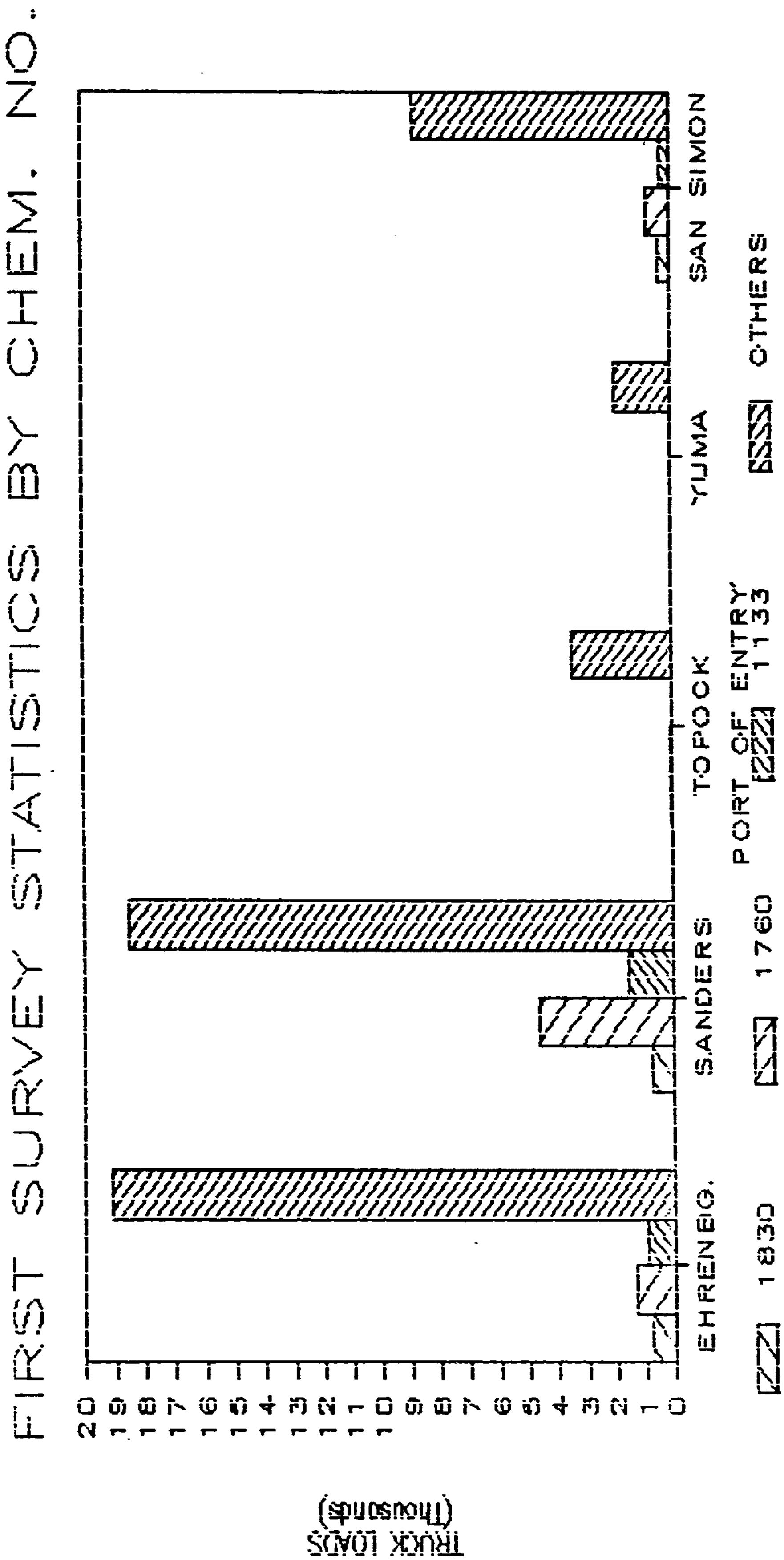

FIRST SURVEY STATISTICS BY CHEM. NO.
TRUCK LOADS (Thousands)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
EHRENBG.
SANDERS
TOPOCK
YUMA
SAN SIMON
PORT OF ENTRY
1830
1760
1133
OTHERS

FIGURE 28

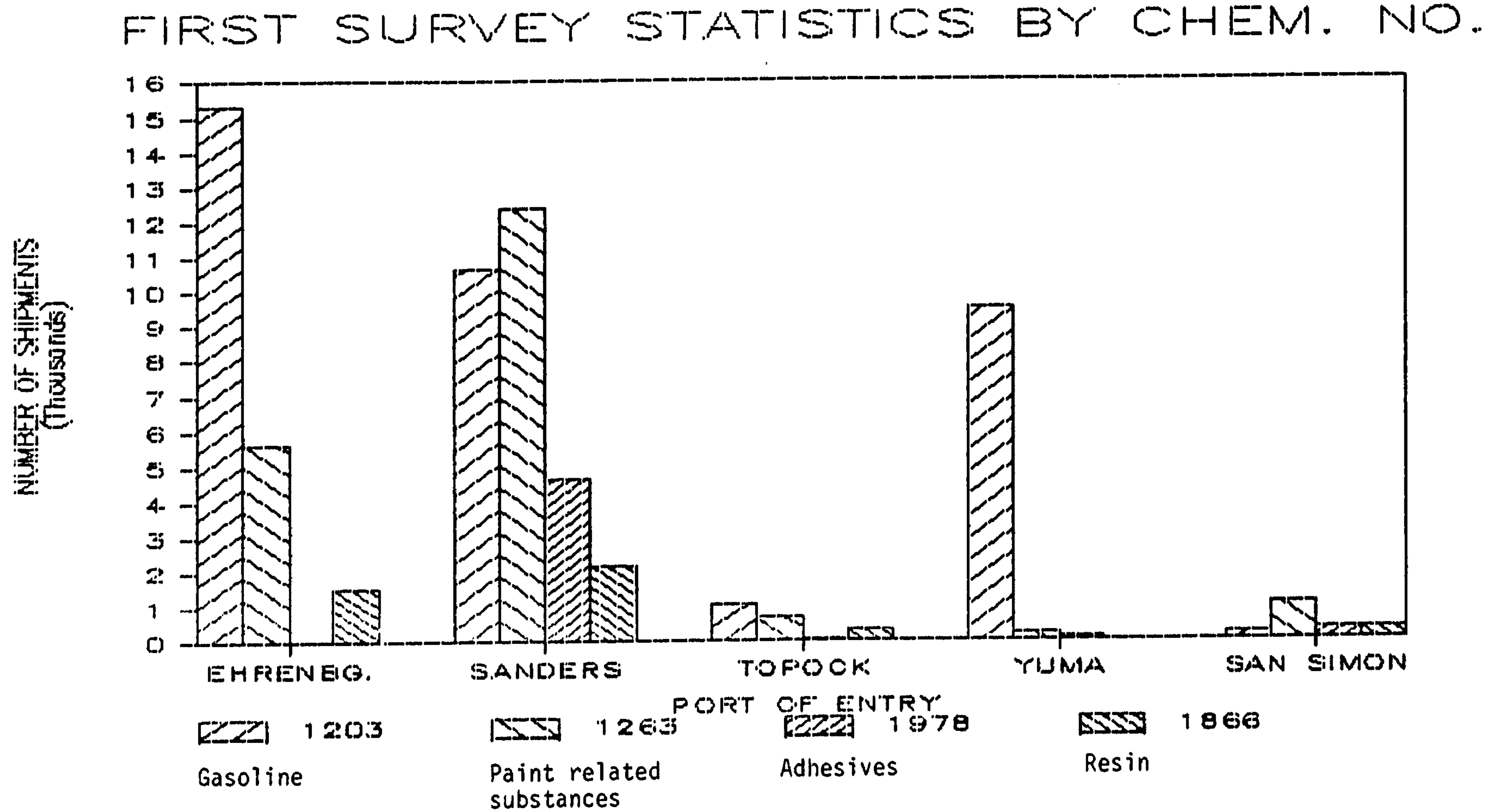
Ehrenberg and Sanders, and their shares of the total number of truckloads entering Arizona through these ports were found to be 44 percent and 38 percent, respectively.

The total shipments cross tabulated by port of entry and chemical number are plotted in Figures 29 and 30, and the total equivalent tonnage results are plotted in Figures 31 and 32.

Chemicals Entering and Remaining in State

The data in Table 20 show that a large proportion of the "bulk" tank materials - gasoline, propane and sulfuric acid, that enter Arizona do so specifically for deliveries in the state. Of the total propane and sulfuric acid shipments entering the sample ports 85.1 percent and 62.5 percent remain in the state; the other shipments represented are "drive-through" traffic to surrounding states.

The "non-bulk" carriers (1263, 1866, 1700, 1133) show a strong tendency for external-external movement through the state. For example, of the total shipments of 1263 (paint related substances) entering Arizona, only 39.2 percent remain in the state. The percentage that enters the state and directly exists Arizona for chemicals, 1263, 1866, 1760, 1133, was found to be 66.8 perdent. The analysis found that a very high proportion of "bulk" tank trucks that enter Arizona do so for consumption and distribution purposes within the state. Of the nontank carriers, a large percentage pass through the state for other destinations. However, it is important to note that the total number of entering shipments of nonbulk materials exceed the number of tank carriers. Despite the large percent of non-bulk transport passing through the state, the percent remaining for distribution within the



FIRST SURVEY STATISTICS BY CHEM. NO.
NUMBER OF SHIPMENTS (Thousands)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
EHRENBG.
SANDERS
TOPOCK
YUMA
SAN SIMON
PORT OF ENTRY
1203
Gasoline
1263
Paint related substances
1978
Adhesives
1866
Resin

FIGURE 29

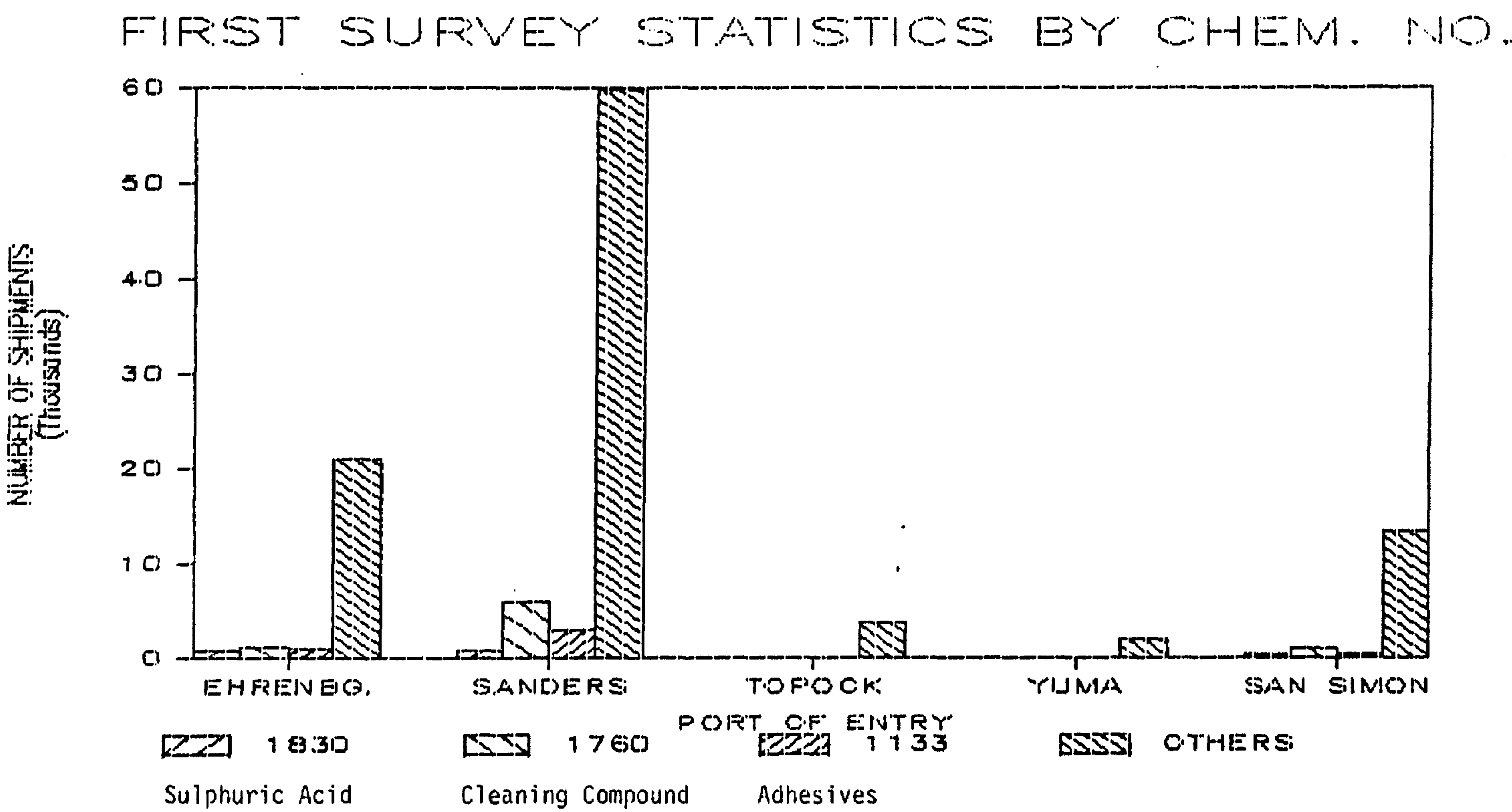

FIRST SURVEY STATISTICS BY CHEM. NO.
NUMBER OF SHIPMENTS (Thousands)
60
50
40
30
20
10
0
EHRENBG.
SANDERS
TOPOCK
YUMA
SAN SIMON
PORT OF ENTRY
1830
1760
1133
OTHERS
Sulphuric Acid
Cleaning Compound
Adhesives

FIGURE 30

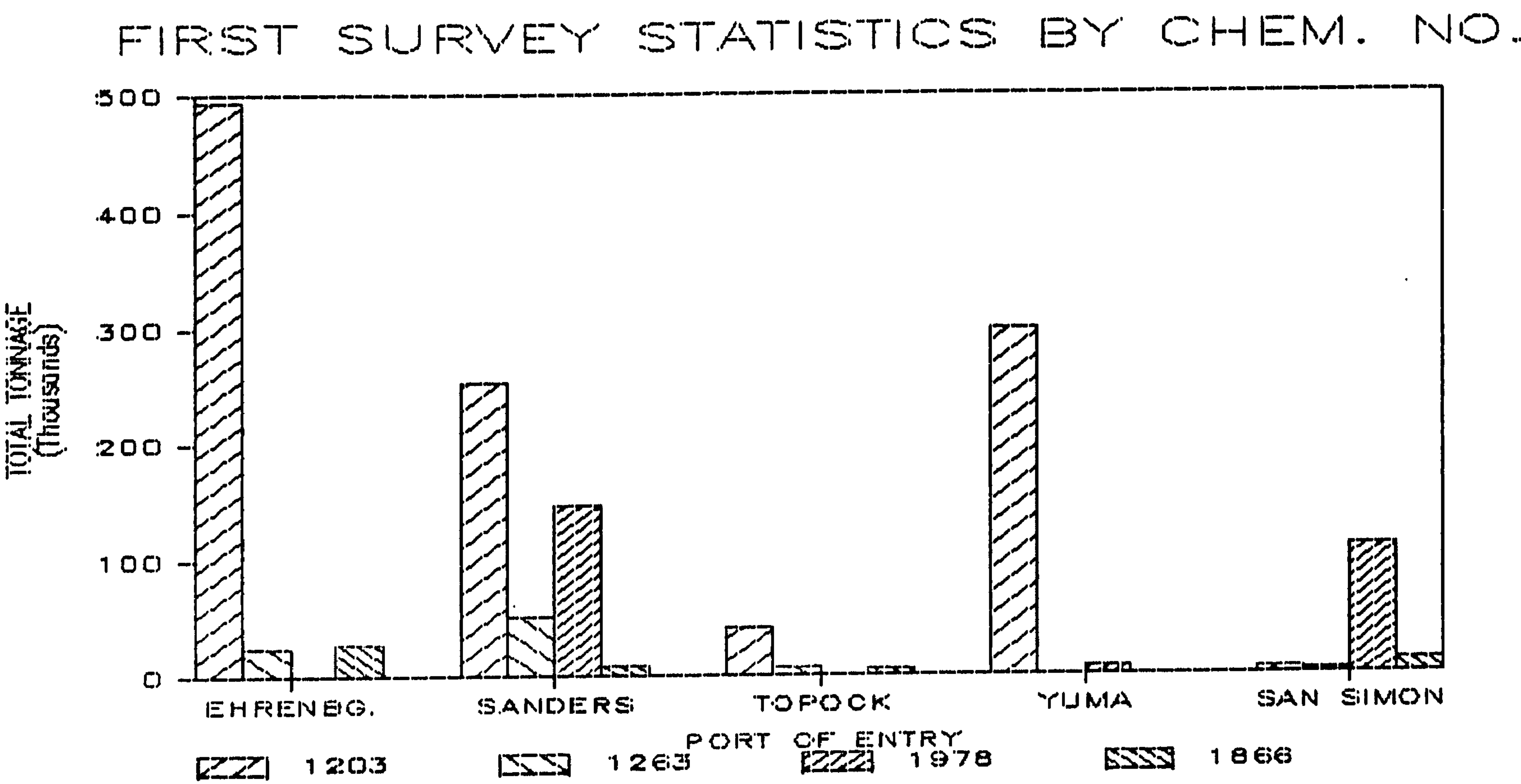

FIRST SURVEY STATISTICS BY CHEM. NO.
TOTAL TONNAGE (Thousands)
500
400
300
200
100
0
EHRENBG.
SANDERS
TOPOCK
YUMA
SAN SIMON
PORT OF ENTRY
1203
1263
1978
1866

FIGURE 31

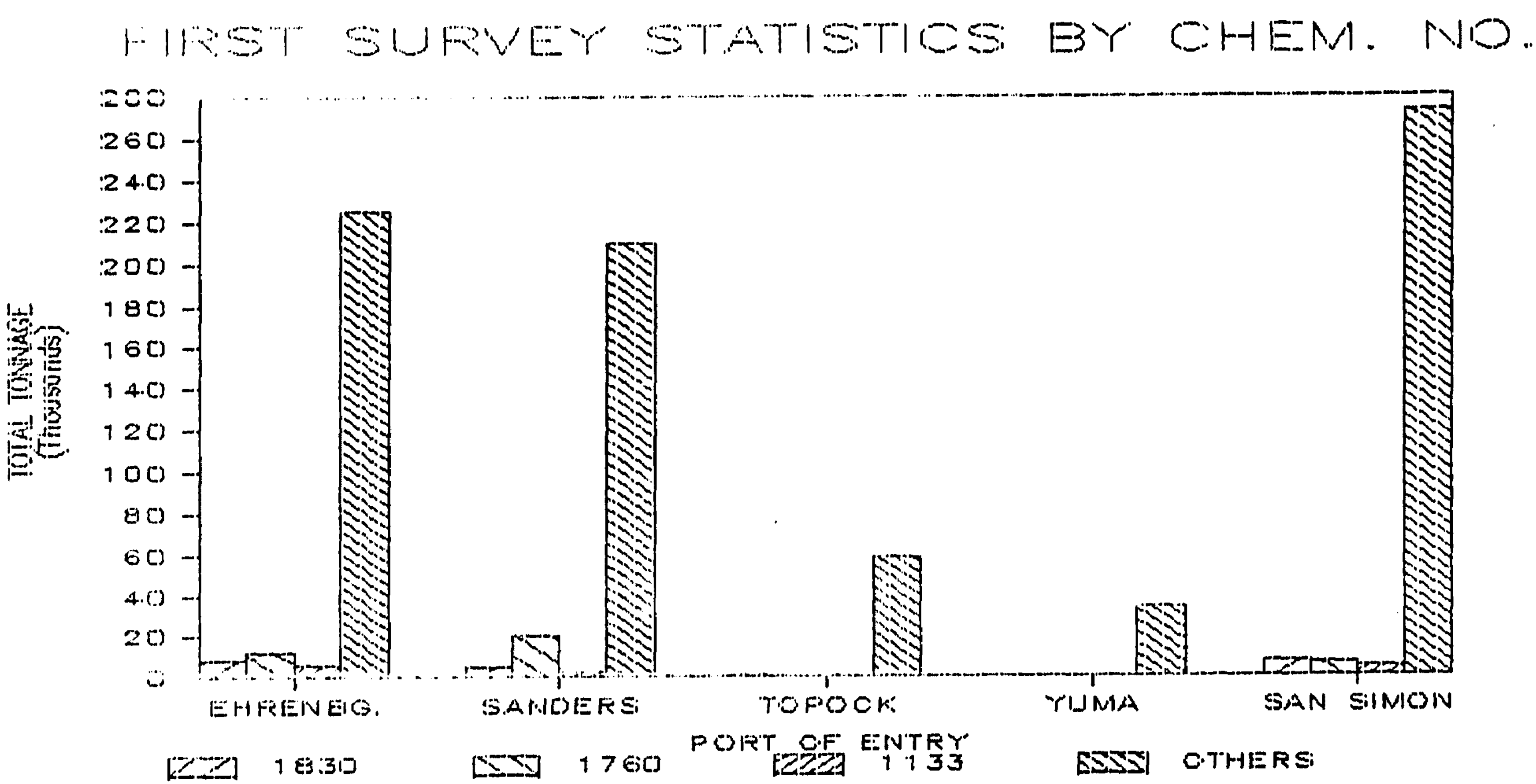

FIRST SURVEY STATISTICS BY CHEM. NO.
TOTAL TONNAGE (Thousands)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
EHRENBG.
SANDERS
TOPOCK
YUMA
SAN SIMON
PORT OF ENTRY
1830
1760
1133
OTHERS

FIGURE 32

TABLE 20
Distribution of Selected Chemicals Entering Arizona
and Percent Remaining in State

Chemical	Port	Incoming	Outgoing	In-State	Percent Remaining
1263	Topock	676	624	52	7.7
	Ehrenberg	4,680	936	3,744	80.0
	Sanders	7,384	6,188	1,196	16.2
	San Simon	832	572	260	31.3
	Yuma	104	--	104	100.0
		13,676	8,320	5,356	39.2
1866	Topock	260	260	0	0.0
	Ehrenberg	1,352	624	728	53.8
	Sanders	1,768	1,612	156	8.8
	San Simon	312	312	0	0.0
	Yuma	--	--	--	--
		3,692	2,808	884	23.9
1760	Topock	104	104	0	0.0
	Ehrenberg	1,352	312	1,040	76.9
	Sanders	4,628	3,848	780	16.9
	San Simon	832	780	52	6.3
	Yuma	--	--	--	--
		6,916	5,044	1,872	27.1
1133	Topock	--	--	--	0
	Ehrenberg	832	312	520	62.5
	Sanders	1,560	1,300	260	16.7
	San Simon	312	260	52	16.7
	Yuma	--	--	--	--
		2,704	1,872	832	30.8
1203	Topock	410	0	410	100.0
	Ehrenberg	14,560	0	14,560	100.0
	Sanders	9,204	0	9,204	100.0
	San Simon	208	0	208	100.0
	Yuma	8,788	0	8,788	100.0
		33,170	0	33,170	100.00
1978	Topock	--	--	--	--
	Ehrenberg	--	--	--	--
	Sanders	4,212	624	3,588	85.2
	San Simon	156	52	104	66.7
	Yuma	156	0	156	100.0
		4,524	676	3,848	85.1

TABLE 20. (Concluded)

Chemical	Port	Incoming	Outgoing	In-State	Percent Remaining
1830	Topock	104	0	104	100.0
	Ehrenberg	832	0	832	100.0
	Sanders	778	624	104	14.3
	San Simon	416	156	260	62.5
	Yuma	--	--	--	--
		2,080	780	1,300	62.5

state amounts to as many, if not more, shipments than the tank carriers entering the state. For tank carriers, enforcement programs should be cognizant of the strong intra-state pattern of shipments to Arizona communities. For non-tank transportation of hazardous materials, enforcement programs should be sensitive to the two dimensions of transport: strong external-external movements along the two major east-west interstates; and, a smaller but significant external-internal pattern.

"Drive-Through" Measurements by Hazard Class and Port of Entry

The extent to which Arizona serves as a 'drive-through' state for hazardous materials transportation was a subject of analysis. If the drive-through level is large, then such shipments may present risks that are not matched by benefits that accrue from incoming vehicles to Arizona's economy. Because of lax inspection programs in other states, resource limitations in transportation enforcement/compliance programs in Arizona may result in 'drive-through' commercial traffic of hazardous materials that is less safe than what Arizonans desire. In addition, a relatively large 'drive-through' component of total shipments may suggest a regional approach to truck safety.

Table 21 shows total shipments of incoming hazardous materials by hazard class, the 'drive-through' shipments, and the proportion of entering vehicles that remain in the state to unload. Based on our sample, around 119 thousand shipments of hazardous materials would enter the state at the five ports in 1985. Of these, around 52 thousand or 43.4 percent was 'drive-through' transport. However, on closer examination, the large number of shipments of gasoline and related products (60 percent of total shipments) would skew and bias the distribution towards a greater percentage unloading in Arizona. (During the survey the gasoline pipelines to the Arizona tank farms were temporarily closed resulting in tank truck deliveries from outside the state to meet demand). If gasoline shipments are factored because of the anomoly of increased external demand for gasoline during the survey period, then, approximately 57 percent of all hazardous material shipments entering the five ports would be 'drive-through' shipments.

Table 21 also reveals a strong bimodal distribution of 'drive-through' shipments along hazard class. Very high percentages of combustible (fuel oil) and flammable (gasoline) substances enter and unload in Arizona, 75.9 percent and 65.6 percent, respectively. Substances belonging to other hazard classes, namely oxidizers, corrosives, poisons, radiation and explosives, show a much stronger trend of passing through the state. Of the total hazardous materials shipments representing these hazard classes, 67.5 percent were 'drive-through' shipments.

TABLE 21
Assessment of "Drive-Through" Level by Hazard Class
(Numbers of Trucks)

Hazard Class	Entering	Drive-Through	Unloading	Percent Remaining
Ozidizer	3,796	2,964	832	21.9
Corrosive	22,048	13,260	8,788	39.8
Poison	3,900	2,652	1,248	32.0
Radioactive	572	572	--	0.0
Explosive	5,876	4,992	884	15.0
Combustible	11,908	2,860	9,048	75.9
Flammable	71,032	24,388	46,644	65.6
TOTAL	119,132	51,688	67,444	56.6

Port	Entering	Drive-Through	Unloading	Percent Remaining
Sanders	53,456	34,424	19,032	35.6
Topock	3,640	3,172	468	12.8
Ehrenberg	40,560	5,720	34,840	85.8
Yuma	9,724	--	9,724	100.0
San Simon	11,752	8,372	3,380	28.7
TOTAL	119,132	51,688	67,444	56.6

HM Allocation by Route

The computer management system was used to generate statistics for the total incoming truckloads from the hazardous material port of entry survey data. The first step in this process was to generate the most common routes used by haulers that link the ports of entry and the destination points. An exhaustive list of routes and their corresponding links were attained and they are plotted in Figures 33 and 34. The annual total incoming truckloads are shown in Figure 35. As the map shows, Interstate 40 (between Sanders and Topock), and Interstate 10 (between Phoenix and Ehrenberg) represent the most traveled routes by incoming truckers. It is estimated that these two sections carry

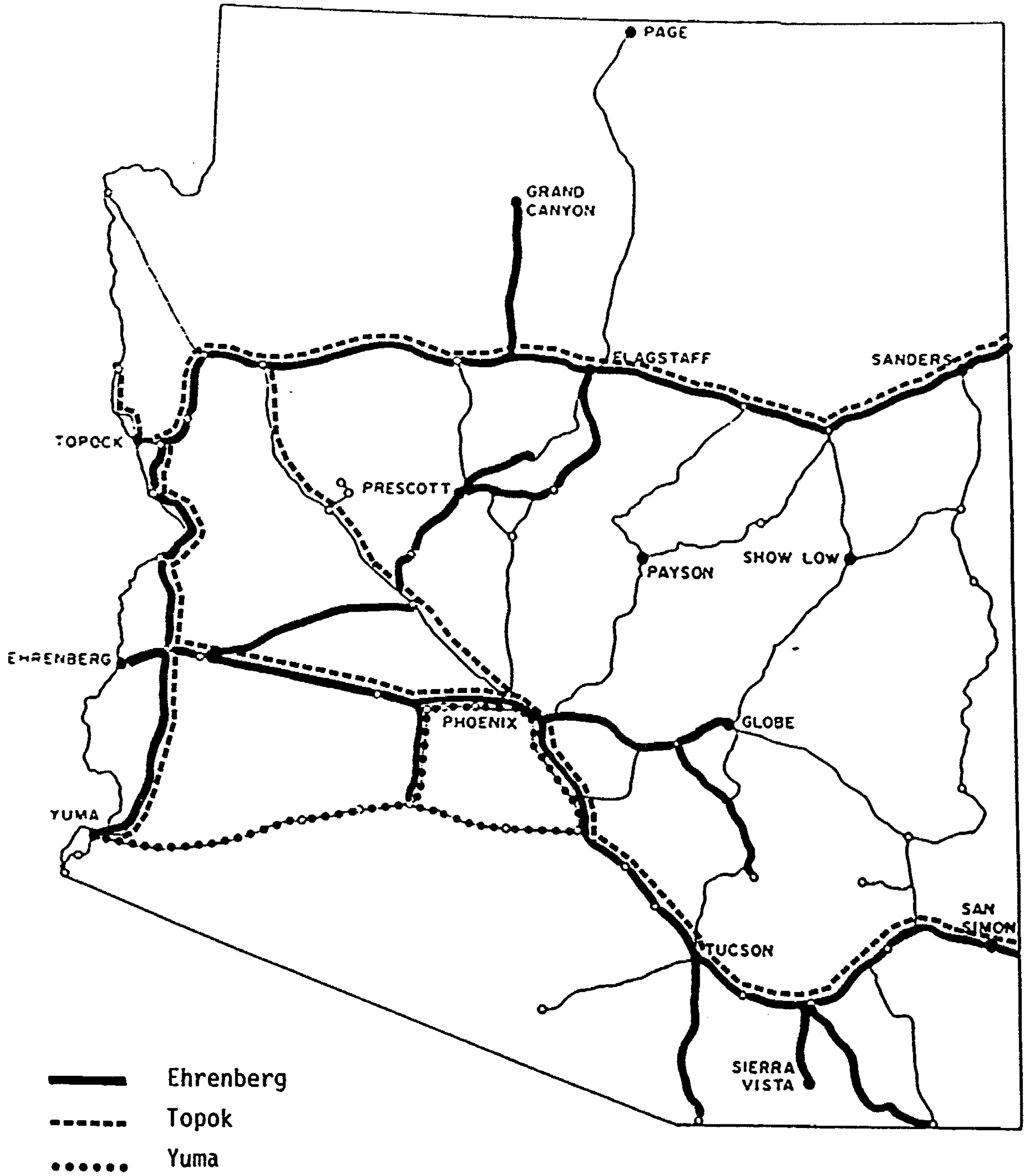


FIGURE 33. The Common Routes and Destination Points for Ehrenberg, Topock, and Yuma as Derived from the Hazardous Materials Port of Entry Survey.

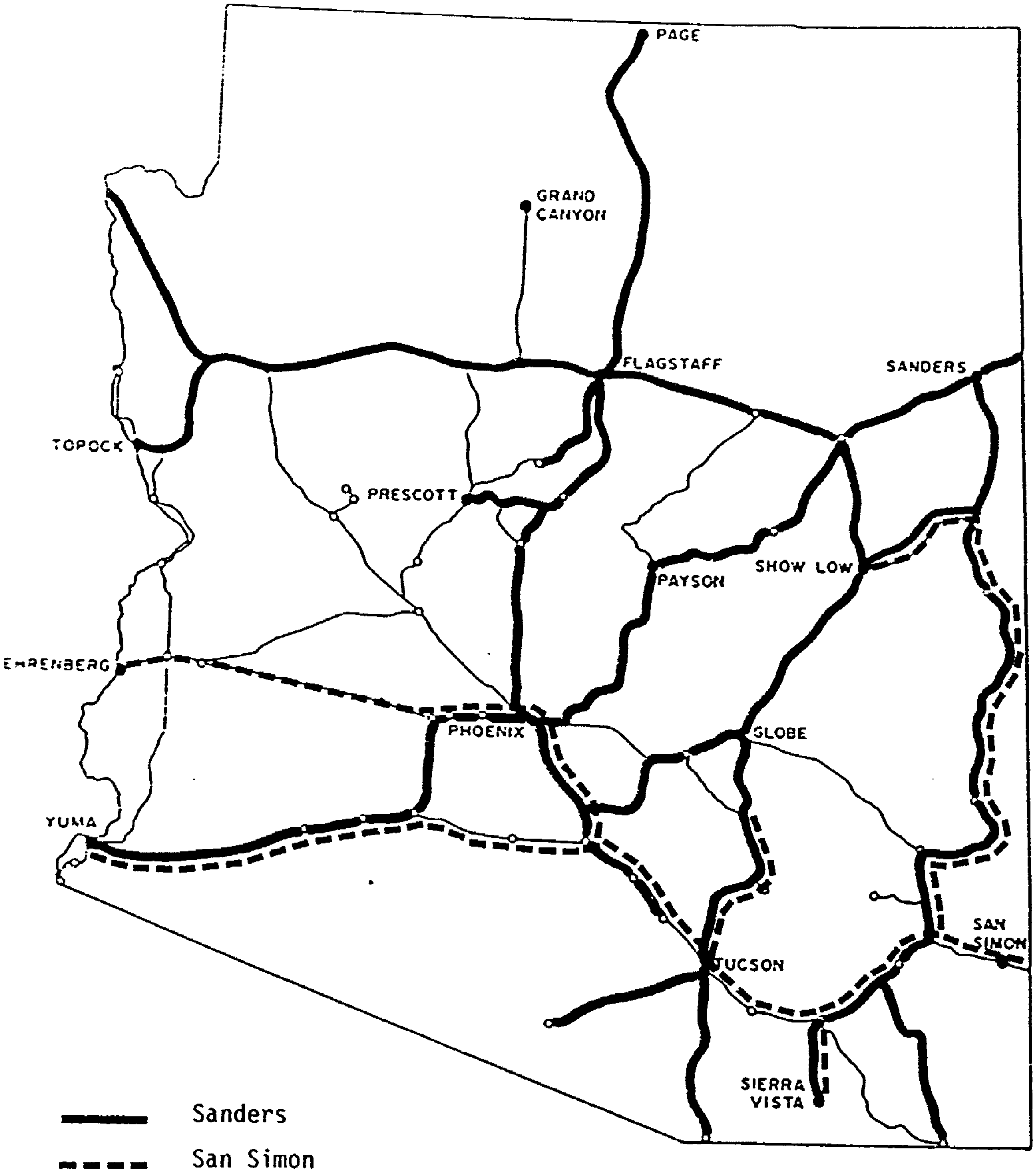


FIGURE 34. The Common Routes and Destination Points for Sanders and San Simon as Derived from the Hazardous Material Port of Entry Survey.

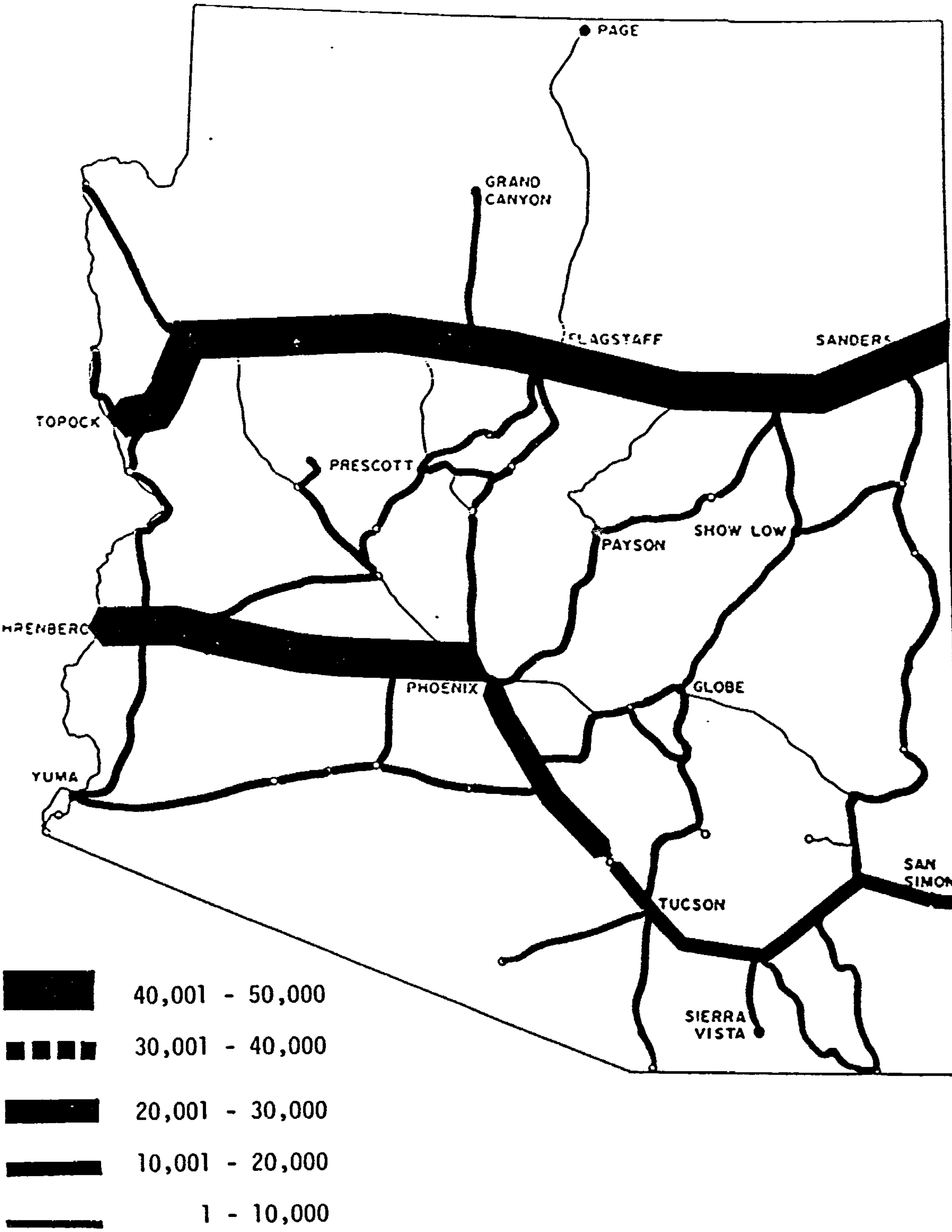


FIGURE 35. Annual Total Incoming Truckloads as Estimated from the Hazardous Material Port of Entry Survey.

between 40,000 and 50,000 annual truckloads. The route that connects Phoenix and Marana, on Interstate 10, was observed to follow in order with an estimated annual truckload range of 30,000-40,000, and that the route between Marana and San Simon is the third in order with an estimated annual truckload of 20,000 to 30,000. The remaining routes were found to carry less than 10,000 truckloads annually.

To identify the critical routes cross tabulated by different hazardous classes, the computer management system was utilized to produce the annual shipments by hazardous class for all routes. The annual oxidizer and corrosive shipments were plotted as shown in Figure 36. It can be seen from this plot that Interstate 40 is the route most used by oxidizer and corrosive materials followed by Interstate 10. The annual poisonous and radioactive shipments, as shown in Figure 37, reveals that Interstate 40 is the route most traveled for poisonous materials followed by Interstate 10 between Ehrenberg and Phoenix. As for radioactive materials, it was found that Interstate 40 carried about 500 annual shipments. A much smaller number of radioactive shipments were found on Interstate 10 between Ehrenberg and San Simon.

The annual explosive and combustible shipments were plotted in Figure 38. Interstate 40 was observed to carry the highest number of explosive shipments, and that the other routes are traveled by a relatively smaller number of shipments as compared to Interstate 40. Furthermore, it can be observed from Figure 38 that part of Interstate 40, between Sanders and Flagstaff, captures a major portion of the annual combustible shipments entering Arizona.

The annual flammable shipments, as obtained from the computer, were plotted in Figure 39. As the figure displays, Interstate 40, between

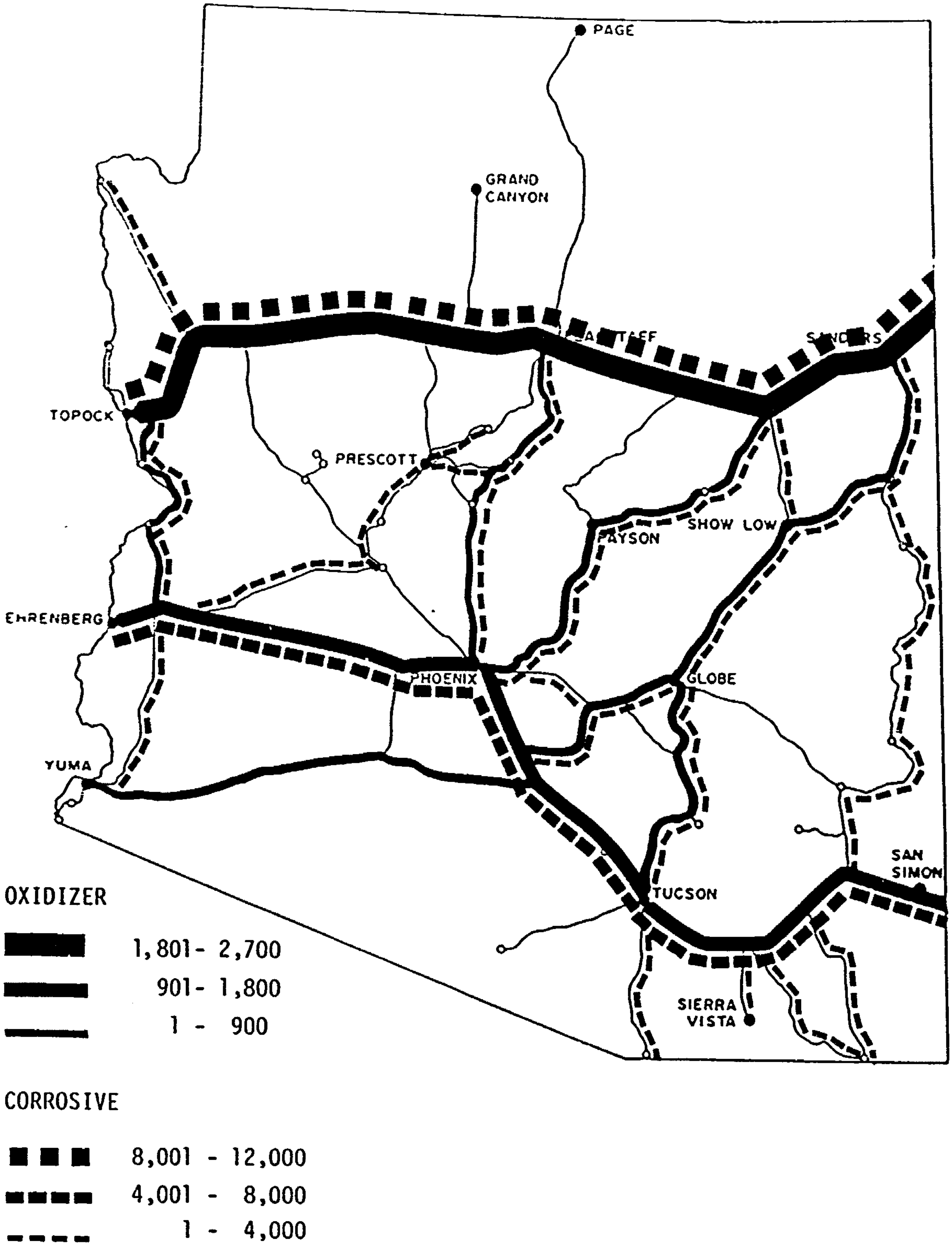


FIGURE 36. Annual Oxidizer and Corrosive Shipments as Estimated from the Port of Entry Survey.

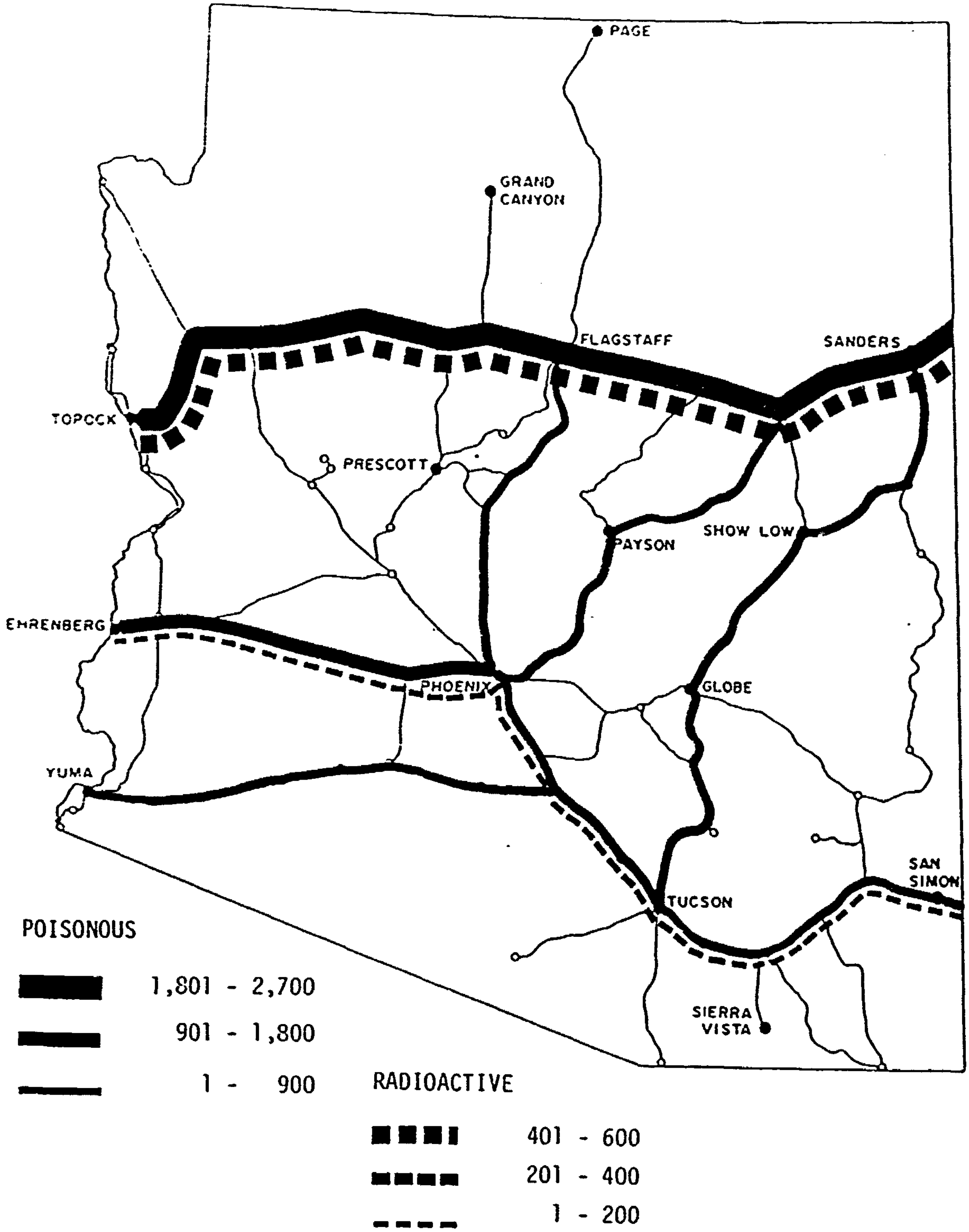


FIGURE 37. Annual Poisonous and Radioactive Shipments as Estimated from the Hazardous Material Port of Entry Survey.

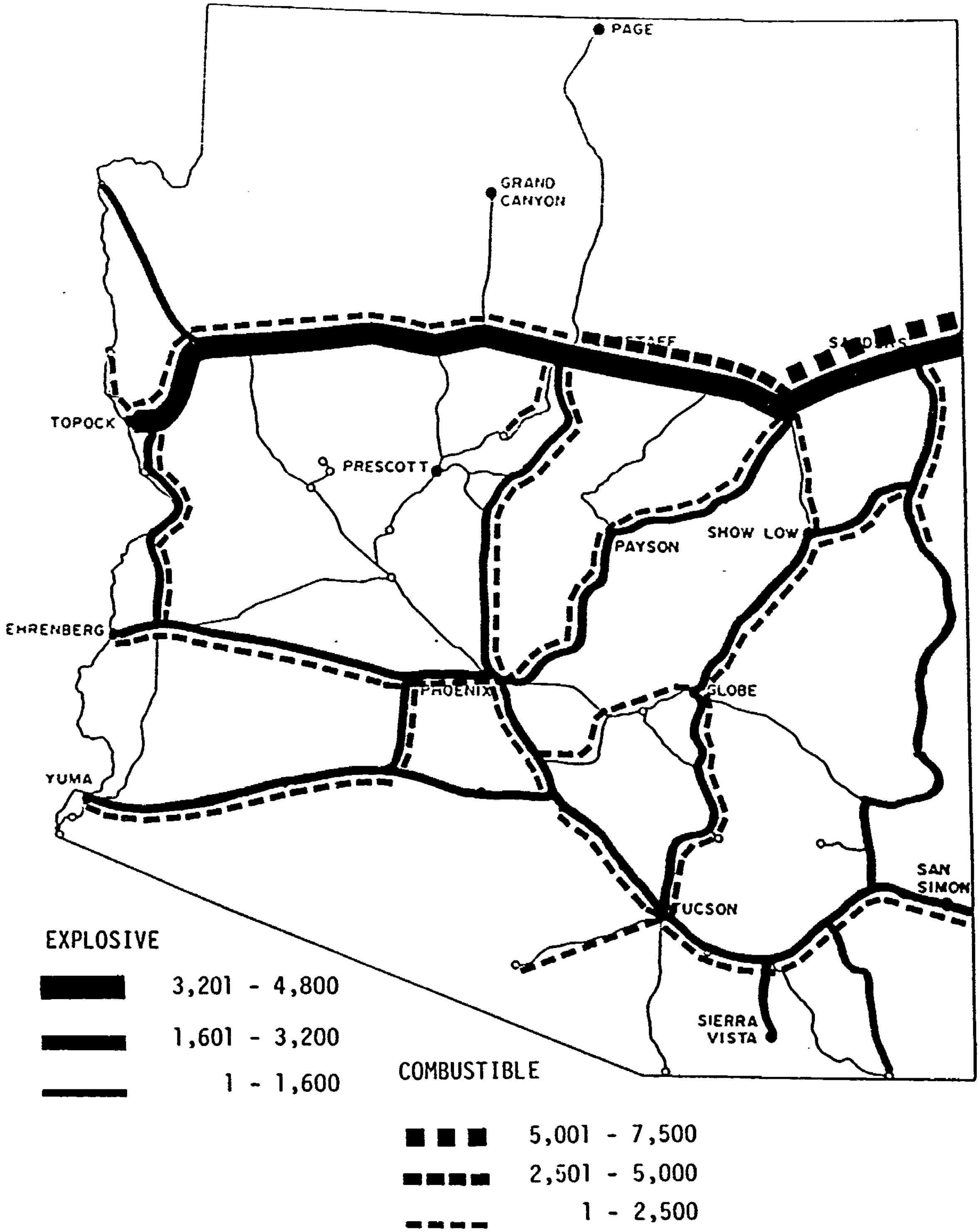


FIGURE 38. Annual Explosive and Combustible Shipments as Estimated from the Hazardous Material Port of Entry Survey.

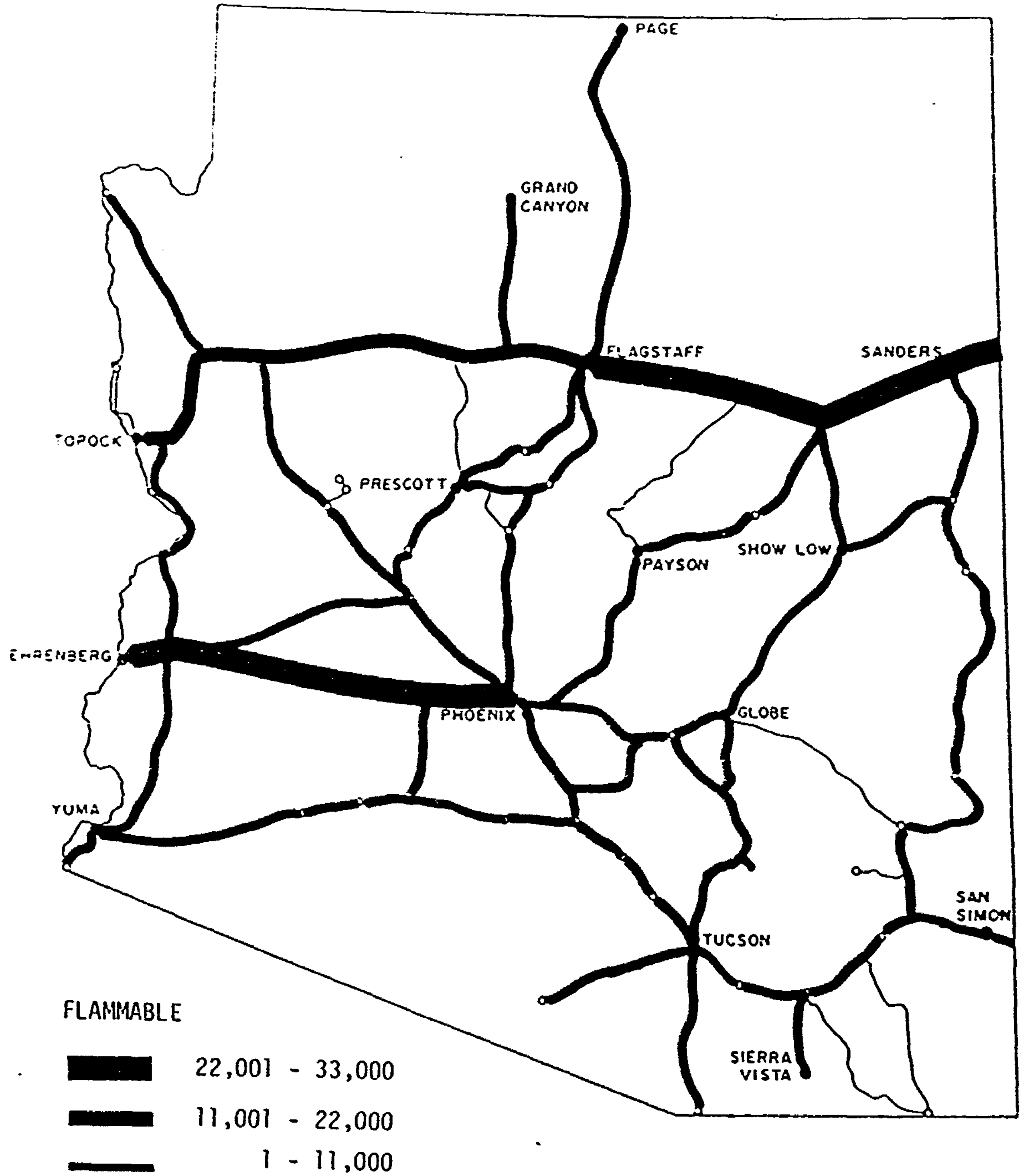


FIGURE 39. Annual Flammable Shipments as Estimated from the Hazardous Material Port of Entry Survey.

Sanders and Flagstaff, and Interstate 10 between Phoenix and Ehrenberg, represent the highest traveled routes by flammable shipments.

Shipments of Selected Non-Tank Carriers by Route

The route pattern of "bulk" tank shipments within the state - acids, gasoline, and propane, is reported later in the Chapter because they were a product of separate surveys and analyses. Table 22 however, shows the distribution by route of four frequently shipped non-tank materials - 1263, 1866, 1760, and 1133.

Route I-40 is the principal route for shipments of these substances. Between Sanders and Flagstaff, the cumulative shipment total for the four chemicals was 17,420 shipments for the year. There were also 15,314 shipments between Flagstaff and Topock on I-40. Together, the 32,734 shipments along I-40 represent 67.5 percent of total shipments of the largest carried non-tank materials. I-10 from Phoenix to Ehrenberg had 8,814 shipments of these four mateials resulting in the next highest ranking. The Yuma - Casa Grande route (I-8) represented the lowest ranked interstate with only 52 shipments of the frequently transported hazardous substances.

Shipment of Radioactive Materials: A Special Consideration

Background

Radioactive materials are generally defined as those materials which spontaneously emit ionizing radiation and have a specific activity in excess of 0.002 microcuries ($_{u}Ci$) per gram of materials. The delimitation of 0.002 $_{u}Ci$/gram allows a distinction between materials

TABLE 22
Selected Hazardous Materials by Route, 1984

Route/Chemical	Paint Related	Resin	Cleaning Compound	Adhesives	Total	Rank
I-40 Sanders-Flagstaff	8,216	2,652	4,810	1,742	17,420	1
I-40 Flagstaff-Topock	6,786	2,678	4,238	1,612	15,314	2
I-17 Flagstaff-Phoenix	156	0	0	0	156	6
I-10 Ehrenberg-Phoenix	4,602	1,300	1,976	936	8,814	3
I-10 Phoenix-Tucson	2,106	416	1,248	416	4,186	4
I-10 Tucson-San Simon	1,066	312	858	312	2,548	5
I-8 Yuma-Casa Grande	52	0	0	0	52	7

not normally considered radioactive and those which are regulated as radioactive in transportation. Materials with a specific activity lower than 0.002 $_u$Ci/gram are not regulated by U.S. Department of Transportation (DOT) or the International Atomic Energy Agency (IAEA). However, they may be subject to use or transfer regulations issued by the U.S. Nuclear Regulatory Commission (NRC) or U.S. Environmental Agency (EPA).

There has been an excellent record of safety regarding radioactive materials transportation. In the United States, between 75,000 and 100,000 cubic meters of commercial low-level waste (LLW) are generated each year. Nearly half comes from nuclear power plants with almost one quarter from industry and the remainder from medical and research institutions. Approximately 2,500,000 packages of radioactive materials are shipped each year in the United States. In Arizona there were 1,162 cubic feet of LLW generated and shipped for burial in 1980. By 1983 the amount increased to 4,000 cubic feet.

Based on the Sandia National Laboratory study concerning accidents in transportation, there have been no known deaths or serious injuries to the public or to transportation personnel as a result of the radioactive nature of materials involved in accidents.

The vast majority of shipments of radioactive materials involves small or intermediate quantities of materials in relatively small packages. Many of these packages involve radioisotopes which are intended for medical diagnostic or therapeutic application. Such materials are characterized by a short "half-life." Therefore, they are often shipped by air freight or air express.

Shipments of High-Level Radioactive Materials

Data on shipments of high-level irradiated reactor (spent) fuel was made available by the U.S. Nuclear Regulatory Commission (see Public Information Circular for Shipments of Irradiated Reactor Fuel, June, 1985, NUREG-0725 Rev.4). The Federal Government has regulated the routes over which spent reactor fuel is shipped and specific interstate and state routes have been approved for these shipments. These routes, however, are approved prior to first use but subsequent approval is required on a shipment or series basis. These regulations have been in place since 1979. The approved routes for radioactive shipments are the larger primary highways and were selected because of the lower accident rates. Highway routes for low-level and other categories of nuclear material have not been approved by the Nuclear Regulatory Commission.

Two routes in Arizona have been designated for carrying spent fuel. These routes are I-40 from Topock (California) to New Mexico and State Route 413 (I-15) between Nevada and Utah. The number of shipments during July 1979 and June 1985 totaled 16 shipments (6800 kilograms of spent fuel) on I-40, averaging about 3 shipments per year. These shipments were carried from the San Clemente area in California through Arizona on their way to Morris, Illinois.

Shipments of Low-Level Radioactive Substances

The port of entry survey provided information on shipments of low-level radioactive materials into Arizona. The data show that radioactive materials entered via Sanders and San Simon. During the week survey, 10 trucks carrying radioactive substances entered by the Sanders port and followed I-40 to Kingman. At that juncture, two trucks followed State Highway 93 to Nevada and eight truckloads continued on I-40 to Topock where they exited Arizona. The one shipment that entered via San Simon followed I-10 directly to Ehrenberg and entered the State of California. The survey data suggest a strong external-external pattern of movement for radioactive materials. In regard to radioactive materials, Arizona can be characterized as a "drive-through" state. To reiterate, during the last 5 years, 16 truckloads of irridiated material left California through Arizona to Illinois. The survey data indicate that a possible 570 shipments/year of low-level nuclear material may pass through Arizona as well.

Low-level radioactive waste material is also generated in Arizona and intra-state movements occur, but are relatively small in number between cities. There are several reasons for this. First, low-level radioactive wastes generated at medical clinics, hospitals, and research institutions are usually stored at site until the levels of radiation emitted are reduced to acceptable levels for disposal at local landfills. Second, radioactive materials used in medical research or therapy are often imported by air transportation to specialized pharmacies located in Phoenix and Tucson which process the material, and in turn, distribute them to medical clinics around the state. Intraurban shipments in the Phoenix and Tucson metropolitan areas dominate these shipments. Shipments outside the Phoenix and Tucson metropolitan areas are periodic and small in volume. They were not found in the sample intra-state surveys.

The third class of shipments include small and periodic movements of radioactive materials in specially constructed drums. These are stored until a sufficient number can be transported to disposal sites located outside Arizona. One or two of these shipments can be expected annually.

INTRASTATE SURVEY OF HAZARDOUS MATERIALS SHIPMENTS: GASOLINE, ACIDS, PROPANE

Shipments of hazardous materials within the State of Arizona were obtained in two ways. First, interviews were conducted with distributors and shippers of bulk hazardous materials which included liquid petroleum gas, acids and gasoline products. Second, a survey was conducted at nine inspection points of trucks carrying hazardous materials originating within the state. The survey information was similar to that of the port of entry survey consisting of origin-destination, time of travel, material carried and hazard class designation. The intrastate survey was intended to gauge or provide an indication as to the magnitude of hazardous material traffic originating in Arizona and was carried out by Arizona Department of Public Safety personnel.

Survey Locations and Time

The locations of the survey are shown in Table 23. Trucks that were placarded for hazardous materials were stopped during a two week survey in July, 1985. Of these, those whose trip originated in Arizona were asked to complete the survey form. The inspection sites included I-17 in Phoenix, I-10 near Ahwatukee, SR-77 at Oracle Junction, DR-177 at Kearney, Central Tucson I-10, I-10 east of Tucson, I-19 at Suarito, and U.S. 89 near Catalina. The total sample included 40 responses over a 14 day period. Table 24 shows the breakdown of the survey by location, days per site and number of responses by site.

TABLE 23
Intra-State Survey of Hazardous Materials

Site	Location	Days	Response Frequency
1	I-17 Central Phoenix	2	17
2	I-10 Ahwatukee	1	6
3	US 86 Ajo Way, Tucson	1	3
4	SR-77 Oracle Junction	1	1
5	SR-177 Kearney	1	1
6	I-10 Central Tucson	2	2
7	I-10 East tucson	1	1
8	I-19 Sahuarito	2	2
9	US 89 Catalina	3	7
			40

TABLE 24
Distribution of Responses in Intra State Survey

Site	Sample Size	Origin City	Origin Sample	Destination City	Destination Sample	Hazardous Materials
1	17	Phoenix	17	Phoenix	14	Gasoline (13); Acetylene (1)
				Superior	1	Sulfuric Acid (2)
				Hayden	1	Sulfuric Acid (1)
2	6	Phoenix	6	Phoenix	3	Gasoline (1); Butyl Acetate (1); Keytone (1)
				Tucson	2	gasoline (2)
				Picacho	1	Acid (1)
3	3	Tucson	3	Tucson	2	Aviation fuel (1); gasoline (1)
				Phoenix	1	Gasoline (1)
4	1	San Manuel	1	Noranda	1	Sulfuric Acid (1)
5	1	Phoenix	1	Superior	1	Oxygen (1)
6	2	Tucson	1	Nogales	1	Mixed-acetone, ketone etc. (1)
		Phoenix	1	Tucson	1	Mixed-acetone, coal tar, sulphuric acid (1)
7	1	San Manuel	1	Sahuarita	1	Sulfuric acid (1)
8	2	Tucson	1	Nogales	1	Propane (1)
		San Manuel	1	Sahuarita	1	Sulfuric Acid (1)
9	7	Tucson	3	Catalina	1	Heat oil (1)
				Tucson	1	Propane (1)
				Ray	1	Gasoline (1)
		San Manuel	3	Sahuarita	2	Sulfuric Acid (2)
				Green Valley	1	Sulfuric Acid (1)
		Suhuarita	1	San Manuel	1	Dimethyl phosphoro chlorido thiate (1)

The intra-state survey was also broken down by origin-destination and hazardous material carried. The survey asked the point of origin of the hazardous material load and destination. The results show a pattern of movement characterized by a strong local concentration. Of the sample, none could be found originating in Arizona with destinations outside of the state. This reflects the structure of the state's economic base. Arizona's economy does not support a strong chemical manufacturing or processing industry that "exports" material. The manufacturing and agricultural sectors rely on the importation of acids, and other hazardous material for processing. We did not expect to find shipments of hazardous materials in substantial amounts originating in the state for transportation to places outside Arizona.

The type of material transported was dominated by gasoline shipments originating at the "tank farms" in either Phoenix or Tucson. The second largest frequency was the transportion of sulfuric acid. Out of a sample population of 40 carriers, 22 shipments (55 percent) were gasoline and 11 shipments were sulfuric acid (27.5 percent). Shipments of gasoline and acids, therefore, represented 82.5 percent of intrastate movement of hazardous material in the sample.

The sample size was too small for statistical significance and the data are suggestive rather than conclusory. The data suggest that intrastate movement of hazardous materials may be dominated by gasoline, acids, and propane. These shipments may also show strong local concentrations of movements from the two metropolitan areas and smaller rural/mining communities. In addition, the number of shipments originating in Arizona for extra-state locations would be relatively small.

To further assess the magnitude of internal-external shipments, another survey was carried out on Interstate I-10 west of Route 85. The objective was to identify the level and types of hazardous materials transported westbound from the Phoenix area and to gauge the potential for extra-state destinations. The total number of trucks passing the inspection point was estimated at 300 trucks over a 3 hour daytime period. Of this number, 13 trucks were placarded as carrying hazardous materials, which represented 4.3 percent of truck traffic. When the placarded vehicles were distributed on the basis of material type, 69 percent of all hazardous shipments was gasoline. Other materials transported included oxygen (chemical identification 1073) and other flammable substances. Gasoline shipments from the Phoenix area do not represent internal to external state transportation but rather, shipments from Phoenix to other Arizona communities. This survey supports the results of the intra-state survey; that, internal-external state movements are relatively small in number.

Shipments of Gasoline

The transportation of gasoline (U.N. Chemical Identification Number 1203) is of particular concern because of the relatively large number of such shipments by vehicular mode along routes in proximity to dense populations. It very often represents the largest category of hazardous materials in transportation. Because of its importance, the objective of this section is to discuss the characteristics of its transportation pattern in Arizona. It also deserves particular attention because, unlike the statistics on other chemicals which were derived from direct survey data, the data on gasoline shipments were not directly available from surveys nor from industry. The approach used in estimating the results requires explication.

Analytical Approach

Gasoline is imported into Arizona in one of two ways. The bulk is carried by pipeline which terminates at two gasoline "tank farms" located in Phoenix and Tucson. The 'tank farms' serve both as a place for gasoline and diesel fuel storage and as a distribution center for the two metropolitan centers and surrounding areas. Gasoline also enters Arizona via the interstates and Arizona ports of entry. These are mainly the ports at Sanders, Topock, Ehrenberg and Yuma. However, the survey origin-destination data show that distribution from these ports of entry support a limited market area. Shipments to Yuma from California serve the cities of Yuma, Wellton, Somerton and San Luis. The market area for Sanders is somewhat larger including Holbrook, Winslow, Show Low, and a few shipments to Flagstaff. Gasoline shipments via the ports of entry have fluctuated enormously, depending on the capacity of the pipeline and demand. There have been times when the capacity could not satisfy demand, and truck shipments of gasoline have occurred to both Phoenix and Tucson.

The week-long survey of hazardous materials undertaken at 5 ports of entry found an unusually large frequency of gasoline tank trucks entering Arizona in March, 1985. This resulted from a temporary closure of the pipeline. The data thus obtained on gasoline shipments into Arizona would be strongly skewed and would not be statistically representative of annual trends. The July survey provided data on origin-destination movements for areas not receiving shipments from Phoenix or Tucson.

Based on the port of entry data, an average truckload of 8,500 gallons was used for the analysis.

Because of the small sample population, the intra-state survey would also not be a reliable indicator of state trends in gasoline tank truck movement (except for a highly concentrated area). Attempts to obtain information on origin-destination trips by gasoline truck from industry was not successful. Therefore, an indirect approach was required for the estimations; a method that would provide, it was felt, an acceptable indication of the general pattern of vehicular shipment.

Data on imported motor vehicle fuel was collected by Arizona counties as shown in Table 25. The fuel represents the amounts delivered to gasoline stations and is collected for sales tax purposes. The information is aggregated at the county level and does, therefore, not permit disaggregation by geographic area within the county and by usage. Some communities may be consuming a greater amount of gasoline than their share of population or number of gasoline stations; shipments to these areas would exceed their proportional position. However, for the analysis, the number of shipments were allocated on the basis of the distribution of gasoline stations within individual counties and an assumed equal consumption rates.

Results

Motor vehicle fuel importation by county is shown in Table 25. In addition, the number of gasoline stations for each county is also shown. The number of stations in all Arizona communities were determined and fuel imports allocated to them. Table 26 shows the total number of truckloads of gasoline delivered within 18 Arizona municipalities in

TABLE 25
Motor Vehicle Fuel Imported by Month and County[1]
(Gallons)

County	January	February	March	April	May	June	July
Apache	1,646,065	1,769,578	1,841,436	1,980,652	2,184,505	2,189,808	2,355,716
Cochise	2,626,760	2,514,748	2,585,159	2,776,401	2,899,002	2,315,989	3,258,105
Coconino	4,094,758	3,232,526	4,690,916	3,356,257	6,430,030	7,114,333	7,753,302
Gila	2,417,991	3,017,073	2,457,118	2,138,902	2,281,746	1,775,941	2,093,106
Graham	607,488	1,022,537	648,463	671,686	757,205	546,476	742,825
Greenlee	270,644	241,985	283,551	260,086	257,178	261,665	245,137
LaPaz	1,015,837	1,376,261	1,077,637	947,663	1,017,277	1,097,042	907,584
Maricopa	63,881,422	55,434,615	69,454,078	70,056,083	65,419,074	64,593,331	63,241,566
Mohave	3,560,003	3,582,907	4,088,014	3,973,902	4,928,631	4,204,650	4,453,021
Navajo	2,949,554	3,311,524	3,400,980	3,550,483	4,345,776	4,549,449	4,422,581
Pima	20,468,390	19,612,016	19,953,881	20,724,118	22,579,411	21,597,090	19,269,452
Pinal	4,229,805	5,617,166	4,243,062	4,197,675	2,056,972	3,035,652	3,553,570
Santa Cruz	732,621	1,406,437	146,198	770,826	700,452	624,481	603,452
Yavapai	2,773,372	4,004,890	7,038,177	3,735,452	4,812,832	3,509,262	4,209,572
Yuma	4,773,314	6,397,086	4,923,990	4,100,451	3,715,942	3,466,765	3,416,309
TOTAL	116,048,024	118,541,349	126,632,660	123,240,637	124,386,033	120,881,914	120,525,298

County	August	September	October	November	December	Total	No. Gas Stations[2]
Apache	2,261,666	1,876,588	2,337,105	1,855,832	1,778,121	24,077,072	11
Cochise	2,729,565	2,332,284	3,627,323	3,097,185	3,754,133	34,316,654	49
Coconino	7,627,982	6,963,949	6,222,316	4,791,360	4,549,750	72,827,479	90
Gila	2,161,723	1,909,139	3,414,276	2,372,891	2,073,144	28,113,050	26
Graham	703,060	403,599	935,870	651,930	643,859	8,334,998	15
Greenlee	246,880	188,782	296,383	232,900	229,696	3,014,887	9
LaPaz	817,427	855,417	828,084	858,533	844,635	11,643,397	23
Maricopa	65,783,050	64,694,829	74,062,502	65,730,424	76,597,308	798,948,282	338
Mohave	4,391,158	3,400,360	4,298,739	3,387,083	7,196,947	51,465,415	64
Navajo	4,528,537	3,897,625	4,077,333	3,454,735	3,644,648	46,133,225	59
Pima	19,167,540	22,475,302	23,316,303	19,703,147	28,143,382	257,010,032	92
Pinal	2,478,289	3,201,495	5,324,931	3,941,938	4,069,625	45,950,160	48
Santa Cruz	637,790	693,078	706,840	744,229	798,504	8,564,908	13
Yavapai	3,558,214	4,385,352	3,859,957	3,297,251	3,415,306	48,599,642	60
Yuma	3,651,868	2,685,363	3,319,661	4,251,023	4,440,624	49,142,396	42
TOTAL	120,744,749	119,963,167	136,627,623	118,370,461	142,179,682	1,488,141,597	939

Sources:

[1] Arizona Department of Transportation Motor Vehicle Division, Motor Vehicle Fuel, Importation by County 1984.

[2] 1. Contacts Influential 1984/1985
2. Mountain Bell Phone Book 1984, 1985
3. Continental Telephone Book 1981, 1983, 1985

1984. Total truck shipments within the Phoenix metropolitan area, for example, was estimated to be 85,902 truckloads, representing over 730 million gallons of gasoline. These shipments are principally intraurban, originating from the "tank farm" located in Phoenix. Intraurban shipments in Tucson ranks second in terms of total number of shipments with 26,840 yearly shipments. Flagstaff received gasoline shipments primarily from Phoenix and some via Sanders' port of entry. The number of shipments into Flagstaff was estimated to be 4004.

The two metropolitan areas accounted for shipments estimated at 958 million gallons representing over 112 thousand truckloads. Shipments of gasoline in the Phoenix and Tucson areas, together, account for almost 65 percent of all transportation of gasoline tank trucks in the state.

TABLE 26
Intra-Urban Gasoline Shipments
Arizona, 1984

Urban Area	Truckloads	Total Gallons
Phoenix Metropolitan area	85,902	730,167,000
Tucson Metropolitan area	26,840	228,140,000
Flagstaff	4,004	34,034,000
Prescott	2,764	23,494,000
Yuma	4,582	39,797,000
Kingman	3,027	25,729,500
Wickenburg	2,502	21,267,000
Holbrook	1,472	12,512,000
Showlow	920	7,820,000
Payson	1,272	10,803,500
Miami	1,399	11,891,500
Safford	609	5,176,500
Willcox	577	4,904,500
Douglas	824	7,004,000
Sierra Vista	824	7,004,000
Nogales	775	6,587,500
Casa Grande	1,914	16,269,000
Gila Bend	2,224	18,904,000

Figure 40 shows the distribution of gasoline shipments by routes. Routes in northeastern Arizona (north of I-40) were not demarcated due to the paucity of reliable origin-destination data for that area.

Routes with heavy gasoline traffic include I-17 between Phoenix and Flagstaff, I-10 west of Phoenix to 85, I-10 between Tucson and Benson, I-10 between Phoenix and the Eloy area and I-40 between Sanders and Holbrook. On an annual basis, these route segments represent shipments ranging from 5,000 to 12,000 shipments.

Table 27 details the number of truckloads by route, tonnage and ton-miles. The number of truckloads are generated for links between communities on the interstate highways. In addition, the average weighted truckloads are estimated for the major intersections. For example, the number of gasoline tank trucks between Phoenix and Cordes Junction was estimated to be 11,391, and the number of shipments between Mundspark and Flagstaff was estimated to be 4,348. The average weighted truckloads along the entire length of I-17 between Phoenix and Flagstaff was 8,231. The data on average weighted truckloads is displayed in Figure 41.

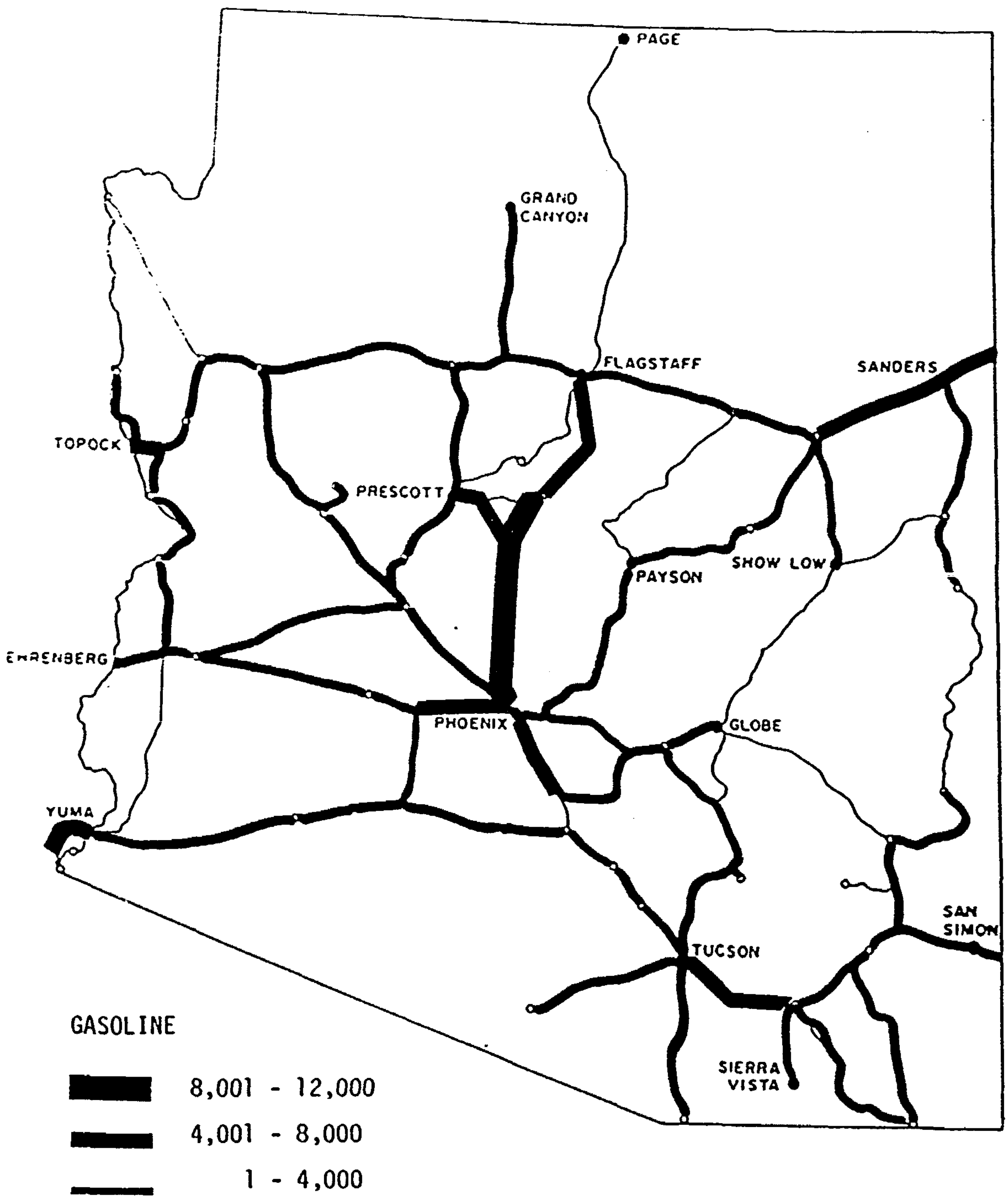


FIGURE 40. Annual Total Gasoline Shipments as Estimated from the Gasoline Sales Tax Data.

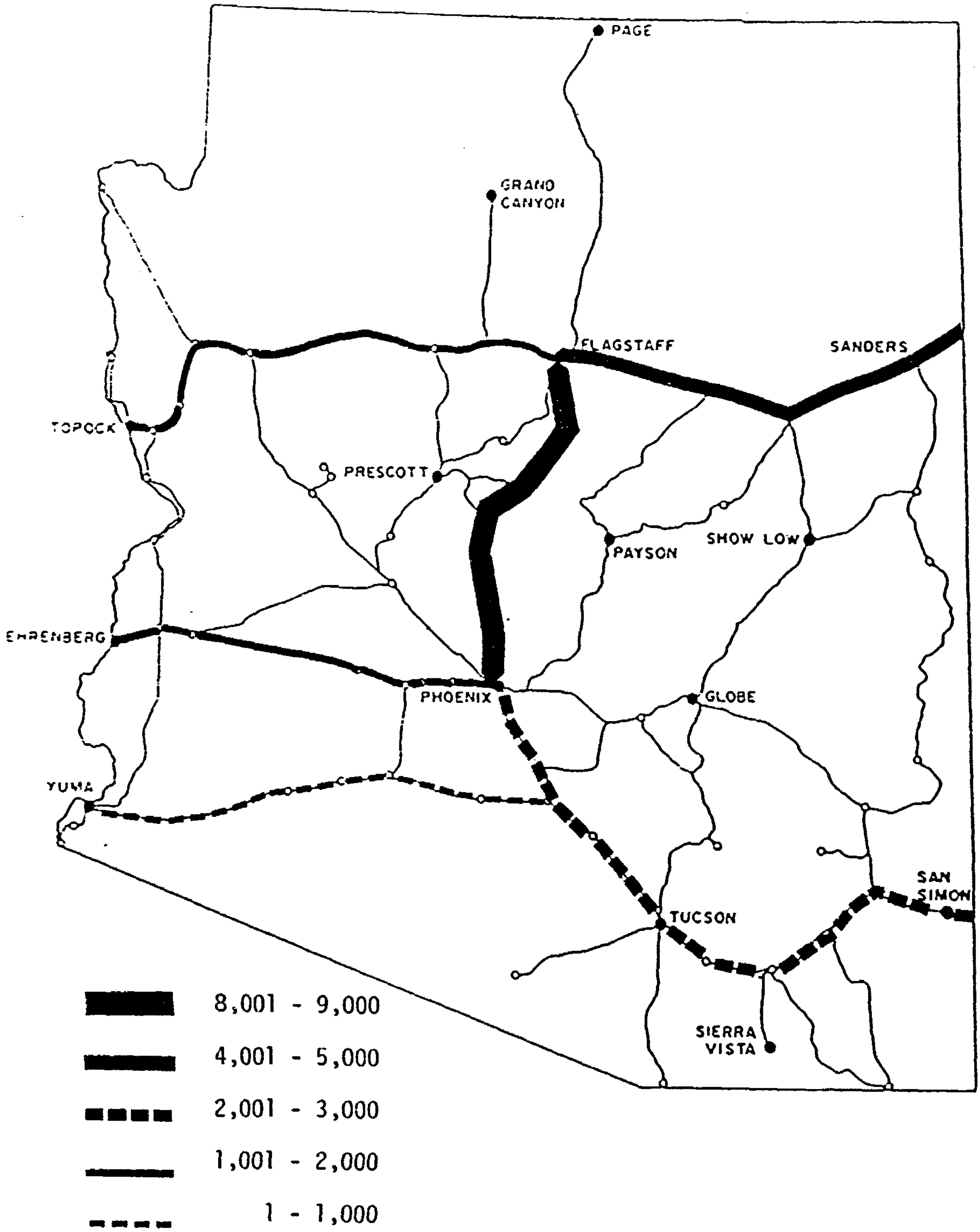


FIGURE 41. Weighted Average Truckload-Miles of Gasoline on Selected Major Routes.

TABLE 27
Gasoline Shipments by Interstate Routes
Arizona, 1984

Route	Miles	Truckloads	Tonnage	Ton-Mile
I-17 Phoenix - Flagstaff	144.97	8,231	216,878	31,440,777
Phoenix - Cordes Junction	67.60	11,391	300,153	20,290,332
Cordes Jct. - Camp Verde	24.64	7,007	184,635	4,549,393
Camp Verde - McGuireville	5.97	6,056	159,576	952,666
McGuireville - Mundspark	29.46	4,723	124,451	3,666,328
Mundspark - Flagstaff	17.30	4,348	114,570	1,982,058
I-40 Topock - Flagstaff	15.73	41,454	7,945	7,945,482
State Line - Topock	0.54	6,055	159,549	86,157
Topock - Junction S-95	9.25	5,014	132,119	1,222,100
Junction S-95 - Kingman	39.21	3,879	102,212	4,007,719
Kingman - Junction U-93	22.96	378	9,960	228,688
Junction U-93 - Seligman	49.12	378	9,960	489,250
Seligman - Ashfork	25.17	572	15,072	379,367
Ashfork - Williams	21.27	572	15,072	320,586
Williams - Flagstaff	24.15	1,904	50,170	1,211,615
I-40 Flagstaff - Sanders	41.88		110,359	18,535,933
Flagstaff - Winslow	61.95	1,560	41,106	2,546,517
Winslow - Joseph City	19.68	2,756	72,621	1,429,173
Joseph City - Holbrook	11.87	2,948	77,580	922,059
Holbrook - Sanders	54.35	6,812	179,496	9,755,618
Sanders - State Line	20.11	7,327	193,067	3,882,566
I-8 Yuma - Casa Grande	178.33	325	8,555	1,525,604
State Line - Yuma	0.57	5,783	152,382	86,858
Yuma - Tacna	41.49	413	10,883	451,517
Tacna - Dateland	25.35	275	7,246	183,692
Dateland - Gilabend	47.73	275	7,246	345,646
Gilabend - Casa Grande	63.19	275	7,246	457,891
I-10 Ehrenberg - Phoenix	154.90	1,189	31,328	4,852,649
State Line - Ehrenberg	0.70	1,371	36,126	25,288
Ehrenberg - Quartsite	13.77	1,371	36,126	497,453
Quartsite - Harquahala	27.89	60	1,581	44,094
Harquahala - Tonopah	48.79	60	1,581	77,137
Tonopah - Buckeye	35.55	278	7,325	260,414
Buckeye - Phoenix	25.20	5,946	156,677	3,948,263
I-10 Phoenix - Tucson	105.46	2,349	54,846	5,784,093
Phoenix - Junction S-87	30.36	4,506	118,733	3,604,737
Junction S-87 - Casa Grande	12.79	3,154	83,108	1,062,950
Casa Grande - Arizona City	2.07	1,127	29,696	61,472
Arizona city - Eloy	8.67	1,014	26,719	231,653
Eloy - Picacho	3.42	338	8,906	30,460
Picacho - Marana	24.21	338	8,906	215,622
Marana - Tucson	23.94	915	24,110	577,199

TABLE 27. (Concluded)

Route	Miles	Truckloads	Tonnage	Ton-Mile
I-10 Tucson - San Simon	130.87	2,636	69,460	9,090,264
Tucson - Junction 583	21.32	5,471	144,161	3,073,509
Junction 583 - Benson	22.19	5,393	142,106	3,153,322
Benson - Junction 666S	27.75	2,344	61,764	1,713,962
Junction 666S - Willcox	5.28	2,180	57,443	303,299
Willcox - Junction 666N	15.50	1,603	42,239	654,705
Junction 666N - Bowie	10.48	247	6,508	68,209
Bowie - San Simon	16.07	165	4,348	69,868
San Simon - State Line	12.28	165	4,348	53,390

Shipments of Acids

Data on the shipments of acids were derived from three sources: the ports of entry survey, the intra-state survey, and interviews with producers, distributers (suppliers) and transporters of acids in the state. The principal importers of acid to Arizona are four suppliers - Hill Brothers, McKesson Chemical, Van Waters and Rogers and Ashland Chemical. These suppliers either receive bulk tank tracks of acid from places out of the state to warehouses in Phoenix and Tucson or act as brokers for large orders for other firms. Large high technology companies tend to order special high quality acids from California. One supplier indicated that the company imports 25,000 gallons/week of combined acids (8 truckloads/week) which include hydrochloric, nitric and sulfuric acids. Information from other suppliers and most transporters of corrosives was not made available due to proprietory concerns. Large suppliers, repackage the acids according to consumers needs, and are, subsequently distributed to smaller supply companies, farms, and manufacturers.

Information on such second-order shipments of acids was not obtainable from the suppliers. Much of these shipments were intraurban within the Phoenix or Tucson areas, or shipped in various volumes on an irregular basis. The concern of this study was not to "capture" the complexities of the many smaller repackaged shipments that characterize the intraurban and some intrastate movements; rather, to ascertain the general pattern and magnitude of tank truck shipments over the state highway system. The port of entry survey provides the data of incoming bulk shipments used for the major suppliers, the agricultural areas, the mines, and the smaller distributors. Additional information was provided by smelters that produce sulfuric acid as a by-product and subsequently is sold and transported to users, such as the mines for their leaching activities, or to utilities. For example, SRP utilities require approximately 990,000 gallons/year of acid for their Page plant and 450,000 gallons/year for the St. Johns generating facility.

Interviews were held with the three major smelters that produce acid, Magma Copper (San Manuel), Asarco (Hayden) and Inspiration Copper (Miami, Arizona). Inspiration produces 1000 tons/day but uses 100 percent of its acid. The Hayden smelter produces about 1400 tons/day but 90 percent is transported by rail. Approximately 10 truckloads/day carry acid from Hayden. The largest percentage are shipped to mines: for example, 3000 tons/month are transported to Bagdad, Arizona. Some are sent to a paper mill in Snow Flake, to Phoenix, to utilities all over the state and to Casa Grande for use in agriculture.

The San Manuel smelter provided detailed information on the distribution of acid shipments as shown in Table 28. It is important to note that the Anamax mine will be closing and that the Magma mine will begin to utilize its own acids for leaching and water treatment. This will result in a substantial shift in the shipment pattern of acids. Discussions with the Arizona Mining Association also indicated that at least 90 percent of the shipments are by rail. In addition, it was suggested that tank truck shipments of acids are highly localized. This is reinforced from the information obtained in the intrastate surveys. Approxiamtely 5-10 trucks of acid daily are transported from San Manuel.

TABLE 28
Distribution of Sulfuric Acid
Magma Copper Smelter, San Manuel, Arizona
1984

Distribution	Tons
Anamax Mine	182,000
Hayden	4,000
Phoenix Area	32,000
Bagdad	7,000
Bisbee/Willcox	4,000
(In-house)	(7,000)
Casa Grande Area	131,000
Miami	8,500
Total Shipments	375,000 Tons

The measurement for intrastate shipments of acid is based on the distribution of acid from the smelters, the small percentage of truck transport as compared to rail, and the highly local nature of these shipments. Data from the interviews were seen in the context of the intrastate survey. Because of difficulties in obtaining information on allocating tank truck shipments from truck transporters and lacking the information on amounts/trucks shipped to particular places (e.g. acid shipments from San Manuel to Snowflake) the overall reporting on intrastate acid shipments may be underestimated and focuses on the area south-east of Phoenix.

Table 29 shows the number of truckloads of acid in the state for 1984. Intrastate shipments are underestimated because of data shortcomings and some shipments from Hayden were not allocated to routes.

TABLE 29
Shipments of Acids in Arizona
by Route Segments and Truckloads
1984

Rt. 40	Topock-Kingman	884	I-10	Willcox - Benson	3,120
40	Flagstaff-Sanders	9,360	Rt. 90	Benson-Sierra Vista	572
81	Sanders-St. Johns	260	I-10	Benson-Tucson	2,288
81	St. Johns-Douglas	52	Rt. 77	San Manuel-Hayden	184
61-60	St. Johns-Globe	208	77-89	San Manuel-Phoenix	1,304
77	Globe-San Manuel	104	77-89-I-10	San Manuel-Willcox	160
377	Holbrook-Heber	1,300	77	San Manuel-Miami	340
87	Heber-Phoenix	575	77-19	San Manuel-Suarita	240
60	Globe-Superior	52	177-60	Hayden-Phoenix	450
I-10	Ehrenberg-Phoenix	8,112	77	Hayden-Tucson	50
60	Phoenix-Miami	104	77-I-10	Hayden-Casa Grande	15
85	I-10-Gila Bend area	104	77-I-10-I-8	Hayden-Wellton	10
60-89	Hope-Prescott	208	89	Prescott-Cottonwood	104
69-17	Prescott-Flagstaff	104	I-10	Casa Grande-Tucson	2,912
I-10	Phoenix-Casa Grande	5,408	89	TucsonI-10-Nogales	208

Shipments of Propane

Propane is imported into Arizona principally from Gallup, New Mexico and some from Aneth, Utah. Most of the propane is shipped by rail to underground storage facilities at Holbrook and Peoria and to propane distribution places where they are further transported by 10,000 gallon trucks. In addition, a substantial number of tank trucks enter Arizona for direct distribution to suppliers in Glendale, Phoenix, Flagstaff or to farming area retailers. Generally, shipments of propane increase during the winter months, by as much as 3-4 times the summer useage. Petrolane, for example, distributes 3 million gallons/month during the summer months and 9 million gallons during the winter season. Based on the March survey data, annual shipments entering Arizona via Sanders was estimated at 4,212 tank trucks. Tank trucks that enter the state to ship propane to major distribution centers and from there to retail places usually hold 9,000-10,000 gallons. "Bobtail" trucks with 2,000-3,000 gallon capacity haul propane from the retail centers to individual customers.

An examination of the distribution pattern of the largest propane supplier, Petrolane, will clarify the origin-destination routing. The company brings into Arizona approximately 900,000 gallons/month of propane for retail use and another 650,000 gallons/month for wholesaling to large cattle ranches, defense facilities and to Wickenburg. The main distribution center is located in Peoria. Propane is brought in from Gallup, New Mexico, and is shipped in two ways: approximately 800 tank trucks/year carry propane from Sanders, along I-40 to Flagstaff, down I-17 to Peoria. From the distribution center, tank trucks (10,000 gallon capacity) carry propane to the company's retail plants located in the following communities: Yuma, Tucson, Casa Grande, Chandler, Glendale, Sedona and Buckeye. The distribution for December, 1984 is shown in Table 30.

TABLE 30
Estimated Distribution of Petrolane's Retail Propane Deliveries
December, 1984
by Bulk Tank Truck[1]

Retail Plants	Volume(Gallons)	Approximate Annual Truckloads
Yuma	300,000	300
El Central	200,000	200
Buckeye	200,000	200
Chandler	250,000	250
Casa Grande	100,000	100
Sedona	100,000	100
Other Shipments		
Prescott	N/A	12
Bagdad	N/A	72
Superior	N/A	24
Springerville	N/A	48
Globe	N/A	24
Safford	N/A	24
Quartzite	N/A	24
Young	N/A	48
Payson	N/A	24

1 Does not include wholesale distributions

Figure 42 shows the primary routes over which propane is transported in Arizona and represents shipments of 10,000 gallon bulk tank trucks. Secondary routes taken periodically by tank trucks or "bobtail" shipments of 2,000-3,000 gallon trucks are not included. Still, the amounts of propane transported and the number of truckloads are underestimated due to the lack of data specificity in some cases regarding intrastate origin-destination movements. The volumes transported and shown on the map represent only reported shipments. An additional 20 percent increase in total truckloads of propane along some the the major routes identified would not be an unreasonable estimation.

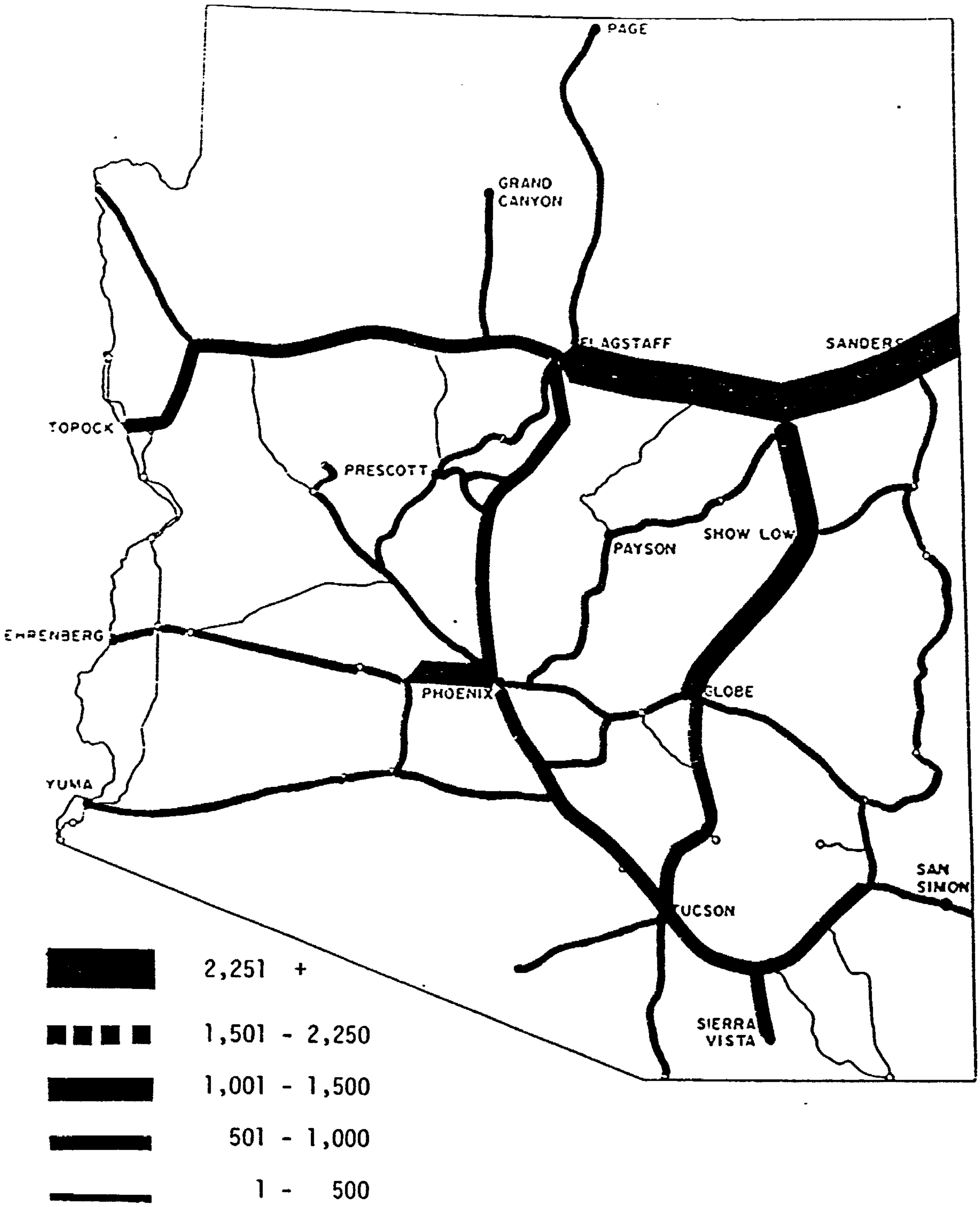


FIGURE 42. Estimated Annual Truckloads of Propane.

As Figure 42 shows, the major route for propane is I-40 between Flagstaff and Sanders. Over 4,000 truckloads enter Arizona via Sanders annually and are subsequently distributed. The second major route for propane shipments is from Holbrook to Globe with 1,000-1,500 shipments carried yearly. Of equal importance as a route is I-10 between Phoenix and the Buckeye area.

TOTAL TRUCKLOADS: COMBINING HAZARDOUS WASTES, MATERIALS AND INTRASTATE BULK CHEMICAL MOVEMENT

The study looked at three major components of transporting hazardous chemicals in Arizona. These included: 1) the characteristics of shipping hazardous waste; 2) the pattern and magnitude of commercial trucks carrying hazardous materials entering Arizona; and 3) the intrastate movement of bulk tank trucks for gasoline, acids, and propane. The total truckloads measured are underestimated because of the lack of specificity of volumes transported by some companies and routes between points of origin and destination, particularly for intrastate movements. Underestimation of the number of truckloads for acids and propane by a factor of 15 percent would not be unreasonable. In addition, intrastate vehicular movements of various gases were not 'captured' either by the interstate survey or through interviews with the respective industries. Further underestimation of hazardous material shipments results from the following three factors: 1) The surveys and interviews with distributors emphasized HM placarded trucks and the larger bulk carriers, while smaller shipments, such as the "bobcat" 2000 gallon propane carrier, were not surveyed. 2) There is some evidence from the Arizona Department of Public Safety indicating that some carriers of HM are not legally placarded. Although the number of such violations are not known, expert opinion suggests that such trucks may increase the number of HM carriers from 10 to 25 percent. 3) In Arizona, a large number (10-15 percent) attempt to circumvent the ports of entry and enter Arizona illegally. The proportions of such illegal traffic which are HM carriers are not known.

Despite these underestimations, the data utilized in the statistical analyses are one of the largest available for hazardous materials in any state. The port-of-entry surveys, alone, represent about 74 percent of all incoming commercial vehicles in the state. In addition, the data provide relative weights of total hazardous materials carried on a route basis. Figure 43 and 44 show the total yearly truckloads on Arizona routes. These figures represent hazardous waste carriers, the number of truckloads of HM entering the state via the five major ports, and the number of intrastate shipments of bulk HM - gasoline, acids, and propane. Figure 43 categorizes HM truckloads into five levels for route designation. I-10, I-40, and I-17 between Phoenix and Flagstaff, represent the routes with the largest annual volumes of HM traffic, between 10,000 and 60,000 truckloads annually. This compares to the second largest route volume 4,500-6,000 truckloads found on route 60 between Phoenix and Superior. I-8 between Yuma and Gila Bend and north along route 85 to Buckeye, represents route segments belonging to the third largest volume of trucks carrying HM, those from 3,000 to 4,500 trucks yearly.

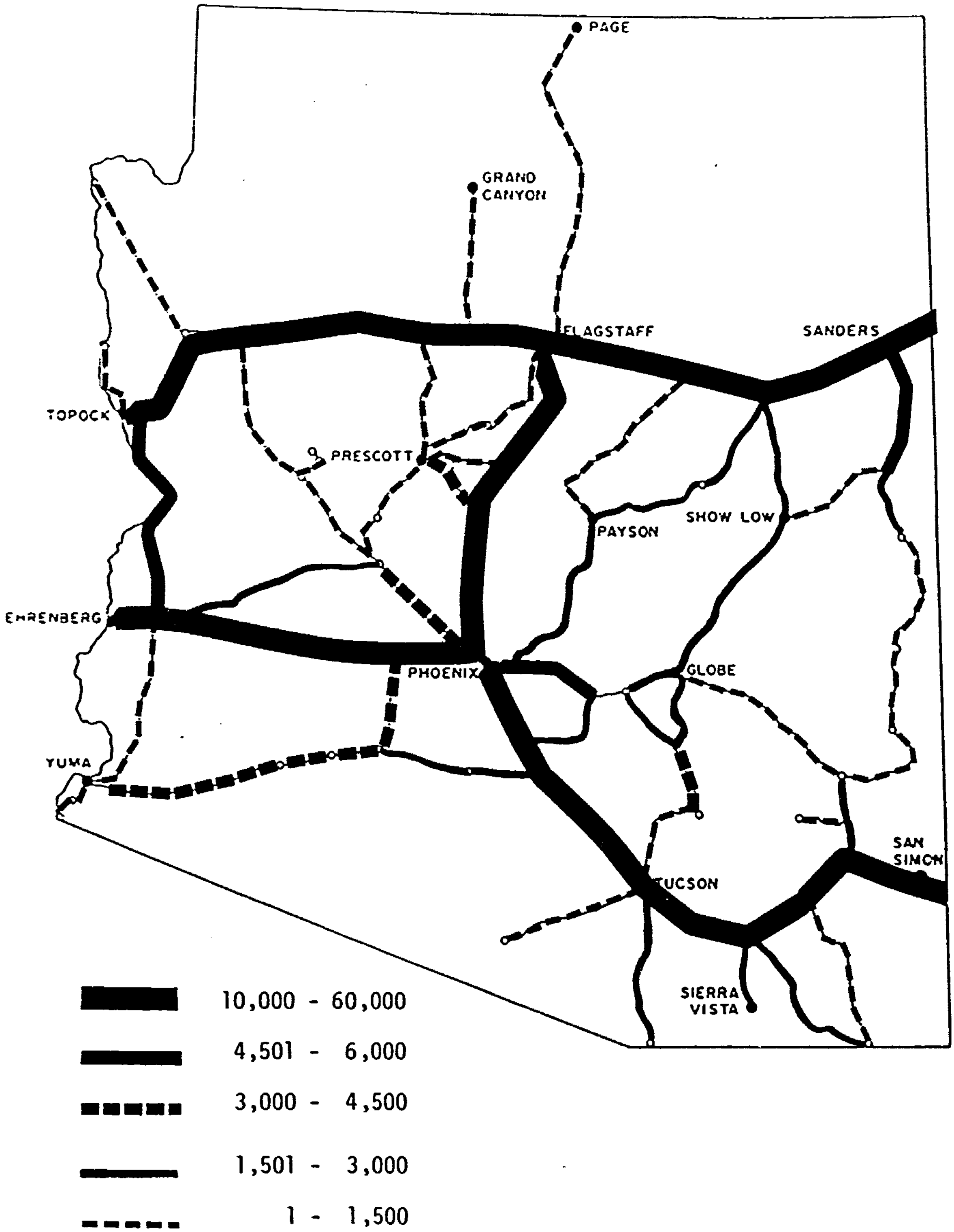


FIGURE 43. Estimated Cumulative Annual Truckloads of Hazardous Materials and Hazardous Wastes.

Figure 44 further breaks down the first category of HM truckloads, those routes experiencing 10,000 to 60,000 trucks yearly. I-10 between Tucson and San Simon and I-17 have had an average of 10,000-20,000 trucks placarded for HM. Route I-10 between Phoenix and Tucson showed a yearly count of 20,000-40,000 HM trucks and I-40 was the prime route in Arizona with the highest frequency of HM transport, with an average route link volume of about 45,000 trucks.

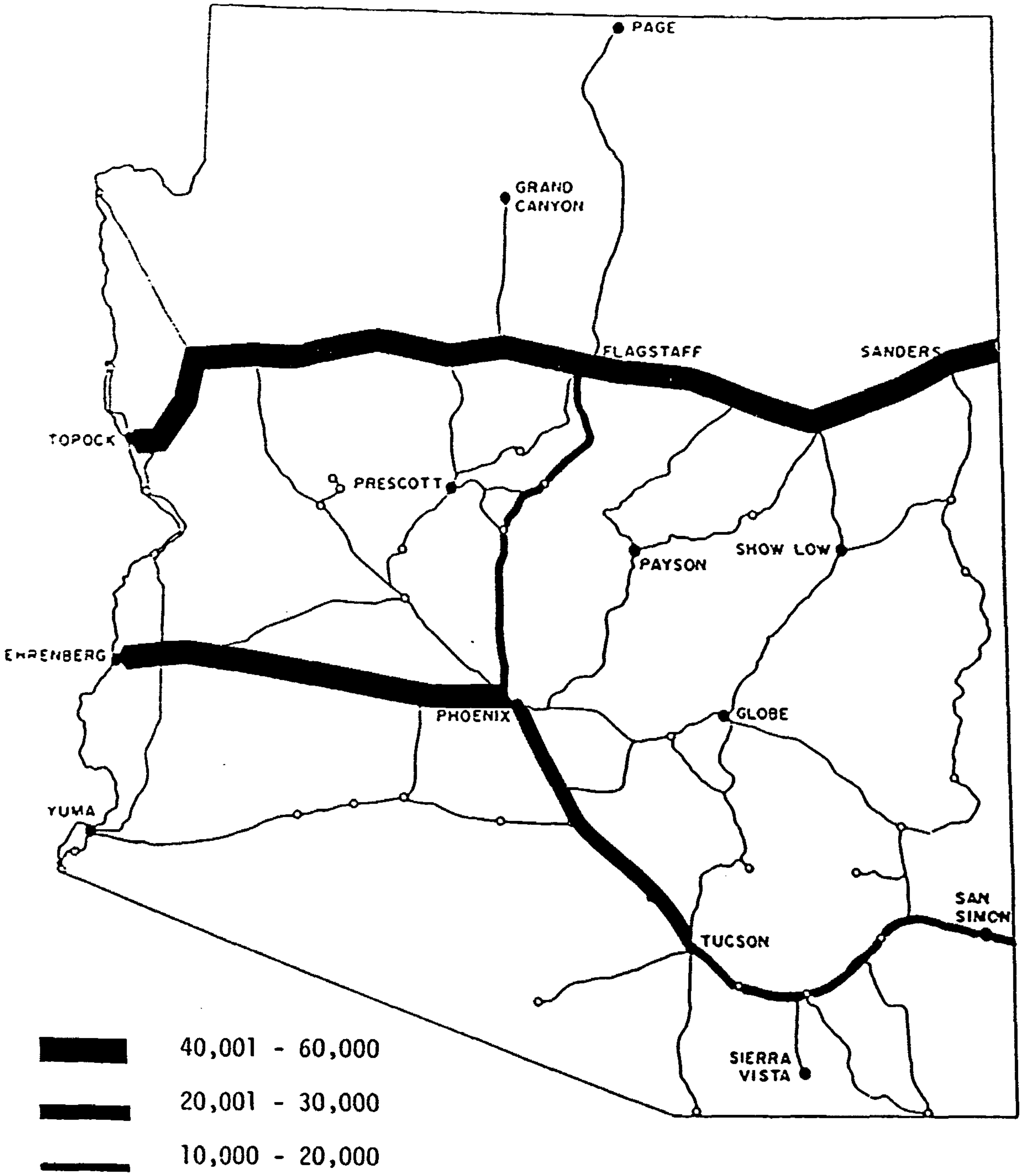


FIGURE 44. Estimated Cumulative Annual Truckloads of Hazardous Wastes for Selected Major Routes.

CHAPTER 5

SUMMARY AND FINDINGS

1. VEHICLES CARRYING HAZARDOUS MATERIALS ENTERING ARIZONA

The ports of entry surveys conducted in March and July, 1985 for Ehrenberg, Sanders, San Simon, Topock, and Yuma represented about 74 percent of all incoming commercial vehicles. There were 1.8 million commercial vehicles estimated to have entered Arizona through these major ports in 1984. The number of commercial vehicles entering these ports have fluctuated over the last 5 years with figures both larger and smaller than those in 1984. The 1984 estimate was used as the base from which to determine the percentage of HM vehicles.

The survey showed there were an estimated 122,314 truckloads of hazardous materials entering Arizona. Based on perfect sample reporting (where no trucks are let through during the survey) trucks carrying hazardous materials account for about 7.3 percent of incoming commercial vehicles. Follow-up interviews with survey personnel indicated that less than 100 percent coverage was attainable and a 20 percent under-counting was not an unreasonable estimate. The percentage of HM entering trucks was based on this information. Of all incoming trucks 1 out of 13 trucks transport hazardous material. The July survey reinforced the findings from the first survey. Of the total number of incoming trucks, 7.39 percent were carrying hazardous materials.

These estimations were based on the number of total trucks entering Arizona at the five major ports. However, the percent of hazardous materials carried at each port varies by port. For example, hazardous material trucks entering Sanders would account for 11.2 percent of all incoming trucks. At Ehrenberg, about 10 percent are HM carriers. Another way of assigning a magnitude measure to the relative amount of incoming HM traffic is by the number of HM shipments. In regards to risk (probability of transit-related release of material), each shipment of HM can be considered as having the potential for causing undesired consequences and should be considered individually. A "shipment" represents a hazardous material item or type carried of which there can be more than one per truck. The 176,000 thousand annual shipments of HM account for 9.7 percent of total incoming commercial vehicles.

2. DATA BASE MANAGEMENT SYSTEM

A data base management system has been established for use by state agencies. While the report could not display the thousands of chemicals for which information is now available -- volumes entering Arizona, truckloads, routes taken, the information can be retrieved for use in program planning and for conducting risk assessments. In addition, the management system is flexible and can quickly and easily be adapted for particular uses or additions. Now, that the first step has been taken to assemble such a large data base for use by the State of Arizona, serious discussion should take place over annual updates and where and how the data should be housed. The attempt to gather a comprehensive data set has alleviated the problems identified in other state studies and permits management studies based on solid and robust data.

3. SEASONAL VARIATION OF INCOMING COMMERCIAL VEHICLES

It is important to notice that some seasonal shifts occur in the volume of incoming commercial vehicles. Figures 45 and 46 show yearly fluctuations in traffic volume by port. For Sanders, there are small but noticeable declines during December and January and a larger decline in August. An even larger decline in incoming vehicles occurs during August at Ehrenberg, a drop in over 10,000 vehicles from the previous month. The pattern for trucks entering Topock shows increasing numbers during the summer months and decline during winter. While Yuma ranks lowest of the five ports in the number of shipments, it is relatively stable during the year except for an increase in December through February. Sanders is clearly influenced by the winter season with significant declines. The data on the percent of HM vehicles entering the state did not show any significant difference when March and July data were compared. However, the information is lacking to assume that the number of truckloads carrying HM will correspond to the general pattern of seasonal fluctuations.

4. NATIONAL AND STATE TRENDS

National studies in the transportation of HM project a continuing increase in HM shipments, doubling every 10 years, increases in the percentage of HM vehicular accidents, and larger damage costs per HM release (see Chapter 1). The robust growth in Arizona's economy will result in larger amounts of hazardous materials entering the state, particularly for the high technology sector. Because Arizona's economy is not based on chemical fabrication and manufacturing, such substances will largely be shipped into the state along a few major highways. In

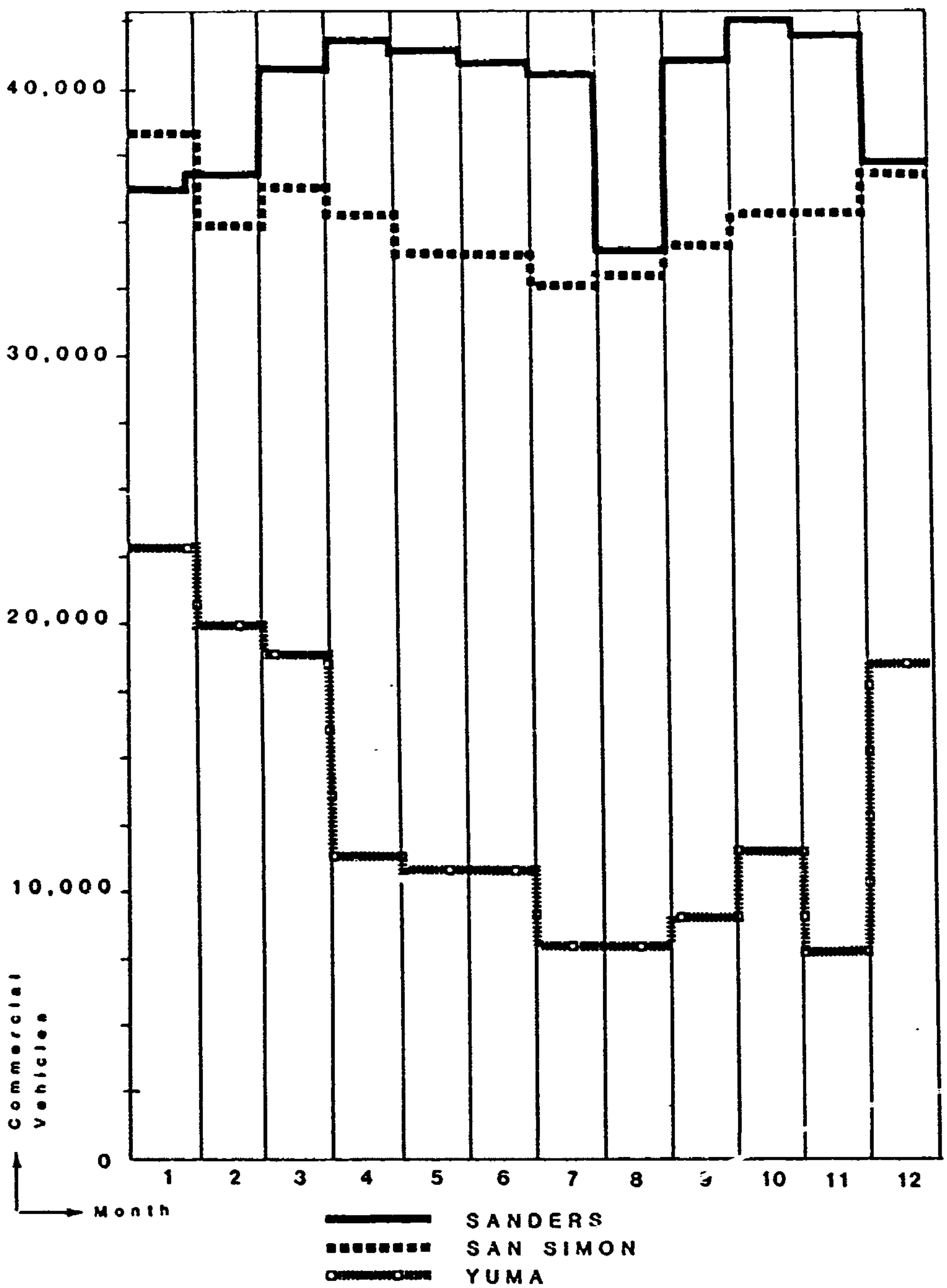


FIGURE 45. Seasonal Fluctuations of Commercial Vehicles Entering Arizona by Sanders, San Simon and Yuma.

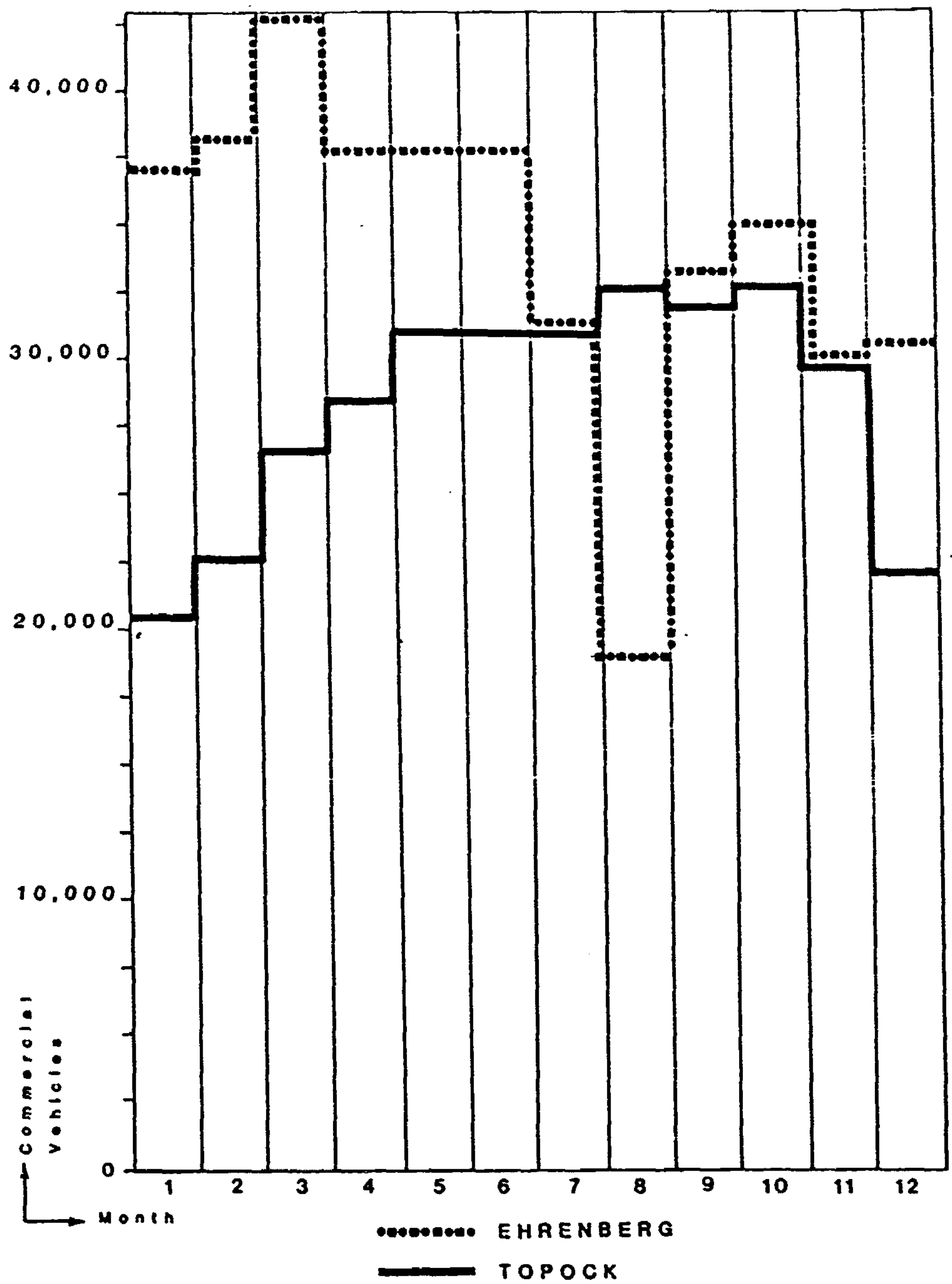


FIGURE 46. Seasonal Fluctuations of Commercial Vehicles Entering Ehrenberg and Topock.

addition, because industrial activity in Arizona is concentrated in the Phoenix and Tucson metropolitan areas. The fact that a major interstate passes through the cities, presents an unusual risk situation because of the population that is exposed to potential HM releases.

We can also expect the number of carriers of hazardous waste to increase substantially over the next few years, partly as a function of an expanding economic base, and partly because of additional and more stringent regulations in this area such as RCRA's Small Quantity Generator regulations which will require the transportation and disposal of hazardous waste which were exempt. Moreover, the development of a proposed hazardous waste facilty in the state will result in additional shipments of hazardous waste entering the state.

5. HAZARDOUS WASTE SHIPMENTS

The shipments of Hazardous waste were analyzed for 1984 and the data were based on 100 percent coverage of Arizonas hazardous waste manifests. In 1984, 2,521 manifests or truck trips were recorded for a total transport waste load of 19,336 tons. On a seasonal basis, July, August, and October represent the largest number of shipments. Based on waste shipment data during 1984, a range of 180 to 280 trucks per month can be expected currently.

Shipments of hazardous waste were distributed among 10 hazard classes. The largest number of shipments were in the flammable hazard class that accounted for 34.4 percent of total shipments and 26.7 percent of total tonnage. Equally large were shipments within the ORM-E class, accounting for 34.2 percent of total shipments. Corrosives were the next largest class, with 14.8 percent of all shipments.

Of the 2,521 truckloads of hazardous waste, 848 truckloads originated in Arizona and were shipped outside the state for disposal. About 40 trucks entered the state from other states. Intraurban shipments within Phoenix and Tucson represented about 48 percent of all HW shipments. Total intrastate movements accounted for 64 percent of all manifests. When shipments of all hazardous classes are totalled by route, Interstate 10 from Phoenix to Ehrenberg heads the routes with the largest traffic volume of HW shipments. This route supports 25.4 percent of all HW-generated truckloads, while the Interstate 10 between Tucson and Phoenix accounts for 19.4 percent. Ninety percent of all HW shipments are accounted for by 1) intraurban shipments in Phoenix and Tucson, 2) Interstate 10 from Phoenix to Ehrenberg and 3) Interstate 10 from Tucson to Phoenix.

6. PORTS OF ENTRY SURVEY STATISTICS

The port of entry survey for March 1985 reported a total of 1,000 truckloads of hazardous material entering the State of Arizona from the five major ports of entry. A total of 3,045 shipments were transported in those 1,888 truckloads. These figures reflect a 100 percent sampling for all the ports, except for Ehrenberg, which had a 50 percent sampling rate. All ports of entry had the number of truckloads approximate the number of 'shipments' except for Sanders. This suggests consideration of a special enforcement program because of the substantially large "mixed" loads of chemicals at Sanders.

It was concluded that Sanders and Ehrenberg have the highest number of entering truckloads and the highest equivalent tonnage. Even though Sanders had a larger number of shipments than Ehrenberg, the equivalent tonnage entering Ehrenberg was larger than that of Sanders. The analysis of hazardous materials shipments by class revealed that flammable materials represented the highest share of hazardous material classes followed by corrosive and combustibles. For flammable materials, Ehrenberg had a higher number of truckloads than Sanders, and the opposite was found for the number of shipments.

The analysis of hazardous material shipments by chemical number concluded that the most frequent chemicals shipped through the ports of entry were: 1203 (gasoline), 1263 (paint related substances), 1866 (resin), 1830 (sulfuric acid), 1760 (cleaning compound), 1133 (adhesive), and 1978 (propane).

The number of shipments are important for risk assessment purposes in addition to the hazard type and amount of the chemical carried. Most of the "bulk" tank materials enter Arizona for specific deliveries inside the state, and these consist mostly of flammable and combustible materials.

The analysis of total incoming truckloads by routes concluded that Interstate 40 (between Sanders and Topock), and Interstate 10 (between Ehrenberg and Phoenix) represented the most frequently traveled routes. These two routes were estimated to carry between 40,000 to 50,000 truckloads of hazardous materials yearly.

7. RADIOACTIVE, ACID AND PROPANE MATERIALS SHIPMENTS

In Arizona, there were 1,162 cubic feet of low level waste generated and shipped for disposal in 1980. By the year 1983, the amount increased to 4,000 cubic feet.

For high level radioactive waste, there are two routes designated for carrying spent fuel:

1. Interstate 40 from Topock to New Mexico; and
2. Interstate 15 between Nevada and Utah.

Between July, 1979 and June, 1985, a total of 16 high-level radioactive waste shipments were observed on Interstate 40, with an average of 3 shipments per year. Data on military/defense shipments of radioactive materials were not available.

For low-level radioactive substances, the port of entry survey revealed that during one week of observation (March, 1985), 10 trucks carrying radioactive substances entered the state from Sanders, followed interstate 40 to Kingman, and then exited the state. Furthermore, it was concluded that Arizona is a "drive-through" state as far as radioactive shipments is concerned. Shipments of radioactive materials for medical research and treatment usual enter Arizona by air mode and are distributed in small volumes to medical facilities. The transportation of shipments of such packages were not determined.

With respect to the shipment of acids, San Manuel and Hayden Smelters produce substantial amounts of acid for shipment within Arizona. In 1984, the San Manuel Smelter produced 375,000 tons of sulfuric acid. Interstate shipments follow a pattern of movement from smelters to mines and to Phoenix for processing. The following routes represented the highest incoming and interstate shipments of acids in 1984:

1. Interstate 40 from Sanders to Flagstaff;
2. Interstate 10 from Ehrenberg to Phoenix; and
3. Interstate 10 from Phoenix to Casa Grande.

Nearly all of the propane used in Arizona is imported from Gallup, New Mexico, and smaller quantities are imported from Aneth, Utah. Propane is brought in by tank truck and rail to major distribution centers. Distribution by truck has been mapped. From the distribution center propane is shipped to retail outlets in 10,000 gallon tank trucks. Interstate 40 between Sanders and Flagstaff represented the route with the largest frequency of propane shipments.

8. INTRASTATE SURVEY

The sample size of the intrastate survey was found to be too small for statistical significance. The results of the survey suggested that the internal-external shipments are minimal. The survey, conducted by the research team on Interstate 10 west of Route 85, revealed that the internal-external truckloads amounted to 4.3 percent of the total truck traffic, which support the findings of the intrastate survey. Intrastate shipments of acids and gasoline were also highly localized.

9. GASOLINE SHIPMENTS STATISTICS:

Data related to gasoline shipments were collected from importation records provided by the counties. It was found that the total number of truck gasoline shipments within the Phoenix metropolitan area amounted to 85,902 truckloads. Furthermore, the combined annual demand estimated for phoenix and Tucson totaled over 112,000 truckloads, which represented 65 percent of all transportation gasoline shipments in the state.

It was observed that the following routes carry the highest gasoline shipments in Arizona:

1. Interstate 17 from Phoenix to Flagstaff
2. Interstate 10 west of Phoenix to Highway 85
3. Interstate 10 from Tucson to Benson
4. Interstate 10 from Phoenix to Eloy
5. Interstate 40 from Sanders to Holbrook.

These route segments were found to have an average annual frequency of 5,000 - 12,000 shipments.

CHAPTER 6

RECOMMENDATIONS FOR FURTHER RESEARCH

Presentations to State Agencies

Formal presentations of the approach, findings, and implications of the Phase I Study were made to the following agencies: Arizona Department of Transportation; Motor Vehicle Division of ADOT; Arizona Department of Public Safety; Governor's Office of Highway Safety; Arizona Department of Health Services; and the Arizona Corporation Commission. Informal discussion was held with the Arizona Division of Emergency Services. The objectives of the presentations were to:

1. Obtain detailed information on the draft study report which was under review by members of the Advisory Committee;
2. Overview the study's findings as to relevance and implications for individual state agencies;
3. Discuss the proposed research effort on risk assessment, hazard management, and regulatory issues pertaining to the transportation of hazardous materials.

Agency responses were solicited at the meetings and by means of a questionnaire. There was a high level of consistency in response to the questions. A summary of the responses follows.

1. In what ways can the agency use the data in the Phase I Study?

Overall, the response to this question was highly positive in that the data were considered useful for agency decision making, manpower planning, and in enforcement programs. The Arizona Department of Health Services, for example, will be adopting the Data Base Management System developed in the study and may utilize the hazardous waste data as part of its compliance program.

The Governor's Office for Highway Safety indicated that the data base can be used for "enforcement and training proposals." MVD stated that the information could be used in "the considerations dealing with routing, regulations, licensing and personnel needs." DPS suggested that the data "will be utilized for purposes of planning and operational commitment and deployment of manpower" for problem areas.

2. Will the agency be interested in the Data Base Management System for its own data retrieval?

The response to this question varied by agency. ADHS and ADOT, for example, are apparently very interested in utilizing the DBMS for their own data retrieval. On the other hand, MVD, suggested that the DBMS be housed elsewhere, (for example, (Arizona State University) but that the agency continue to have access to the DBMS for specific information requirements. For those agencies who will directly use and manipulate the data, a user manual has been written. the manual is Volume II of the study.

3. Annual Updates

There is a concensus on the need for data updates. Both MVD and GOHS stated that the agencies were interested in annual information for consideration in making management decisions. The DPS also strongly supported the need for annual updates.

There are several factors that argue for annual updates of the data base. The computer management information system has been developed and accompanied by a user manual. Annual updates will be cost effecient from this perspective. In addition, ADHS has indicated that the agency will enter the hazardous waste manifest data on a continual basis. Additionally, the Transportation Planning Division of ADOT would consider taking on the responsibility of entering survey data.

For annual updates, the following work elements will have to be satisfied:

1. Port of entry surveys as described in the next section. The MVD is the logical choice to conduct the surveys because of their port of entry inspection function and previous experience with the HM survey. The survey form is available for use.
2. Hazardous waste manifest data collection and computer entry. This can be undertaken by ADHS and strong interest has been expressed.
3. A survey of the distributors of acids, propane, gasoline, and other intrastate HM shipments will have to be undertaken. The survey instrument is available and the distributors have been identified. No agency has been identified to carry out this work element. A logical choice would be Arizona State University given its previous experience with the survey.
4. A commitment for entering the HM data from the Ports of Entry surveys and the Intra-state survey will be required by one agency or by the ASU team now in place. Volume II of the study provides a manual for data entry and manipulation.
5. There will be a critical need to coordinate these various efforts. One agency has to develop a working knowledge with the

data sets and their integration. the logical choice is for this task to be undertaken by ASU as an annual commitment. Because there is such a strong desire for study updates by all the state agencies, we recommend that ASU and ADOT serve as coordinators for annual updates of the study. The data set can be housed both at ASU and ADOT for agency use and annual reports can be disseminated. No decision has yet been made with respect to identifying the coordinating agency or where the data is to be housed. This requires immediate resolution.

Recommended Update Adjustment Factors for Port-of-Entry Survey

Because seasonal fluctuations exist in the number of commercial vehicles entering Arizona, and because some shifts may occur in the types of hazardous materials entering by season, it is important to capture the magnitude and characteristics of HM by season. Thus surveys are recommended to be undertaken four times per year in March, June, August, and December. The port of entry should include Yuma, Ehrenberg, San Simon, Sanders and Topock.

Based on the total number of truckloads entering per week, two days -- Tuesday and Wednesday, represented the most frequently traveled days, 20.4 percent and 15.7 percent of weekly HM traffic, respectively. The ports of entry survey would be based on 24-hour counts at all five ports of entry, for Tuesday and Wednesday, four times annually. Because of potential queing problems, a 50 percent sample of placarded trucks would be expected.

$$\text{Annual truckloads} = \left[\frac{\dfrac{\text{Tuesday Count}}{0.204} + \dfrac{\text{Wednesday Count}}{0.157}}{2} \times 13 \right] \times 4 \text{ (seasonal survey)}$$

The ports of entry survey will be supplemented with ADHS manifest data for hazardous waste and by intrastate data from interviews with distributors of HM.

MVD Accident Data for Vehicles Carrying HM

The MVD will develop a new reporting form on accidents involving HM and it is recommended that these data be computer entered and analyzed periodically. The data should include the following items:

* Date of Accident/Time of Day
* Type of Vehicle
* Release vs. Nonrelease of HM
* Quantity Released and Chemical Identification
* Nature of Accident (Vehicle vs. vehicle, etc.)
* Cause of Accident
* Timing of Emergency Response
* Location of Accident
* Evacuation Activity
* Impact on Person and Place (Injuries, Fatalities)
* Time of Recovery

These data will be critical for future risk assessment and hazard management activities. Supplemental information relating to accidents and HM containment incidents can be obtained from the Highway Patrol Bureau. These data will be used for future risk assessments. Again, the data compilation entry and analysis will require the commitment of one agency or Arizona State University.

4. Proposed Research: Transportation Risk Assessment and Hazard Management

The following items have been proposed for research as a follow-up to the Phase I Study. These proposed items have met with general approval of the representative agencies and the study's Advisory Committee.

I. Prioritization and Projections of Critical Hazardous Materials.

a. Prioritization.

Phase I resulted in a comprehensive inventory if all hazardous material transported through the State of Arizona. For planning and management purposes, it is important to identify, from the set of hazardous materials, these substances that

1) are most frequently transported,
2) are transported in the largest quantities, and
3) pose the greatest threat to surrounding communities.

A prioritized index will be developed to incoporate the three classes mentioned above. This will result in a smaller set of the most important or relevant substances for which planning, response, and investigation activities can be developed.

b. Projections.

The Phase I data base was established for 1983-1985 hazardous movements in Arizona. To establish a sound basis for planning, it is important to forecase hazardous movements for the next decade. This is especially critical because of the growing industrial (hi-tech) base in Arizona and the fact that Arizona will expand its importation of hazardous substances. Furthermore, the impending shift in the pattern of transporting hazardous waste, due to the new hazardous waste management facility is mobile, Arizona will have a significant impact on the existing hazardous materials traffic and risk pattern.

We propose to conduct projections of hazardous materials transport for the priority set of materials identified in part A.

II. RISK ASSESSMENT OF HAZARDOUS MATERIALS TRANSPORTATION

Risk refers to both the probability of occurrence of a hazardous event (an accident with potential for HM release through a breach in containment or the release of HM necessitating emergency response) and the probability of certain consequences resulting from the event (injury and chronic health effects and property damage). The level of risk associated with HM in transit considers three possibilities: the probability of an accident to occur; the probability of containment breach and release of hazardous material into the environment; and the consequences of the release in terms of the population-at-risk. The latter estimation -- consequences to the population-at-risk, is the most difficult to quantify. Assessment of the consequence domain requires estimates of the extent and nature of the population and necessarily incorporates 1) the type of HM in transit (hazard class) and hazard properties (toxicity, nature of effects to human safety and health and impacts on environmental quality), 2) population at risk (evacuation distance by chemical type, population density), and 3) prevailing local geographical factors.

The development of an effective HM transportation management system is contingent on an understanding of the nature and degree of risk. Risk assessment consists of three vital activities: identification of the hazards, estimation of risk, and evaluation of possible consequences. When considering threats posed by HM, identification includes type and volume of the HM transported in the area under study and the routes over which the HM are carried (Phase I). Estimation asks the question of how often (frequency) one can expect HM transit-related accidents along the routes identified and the nature of those accidents (type of material). Evaluation of consequences refers to the population-at-risk from a potential HM release and the nature of the threat.

When knowledge of the probability of hazardous events are combined with knowledge of their potential to impact upon the environment and/or populations the result is a measurement of risk to the environment and/or populations concerned. Determinations of probability, severity and location can be made on the basis of historical evidence and empirical research.

To illustrate the various components of risk, a probabilistic model, that uses the conditional probability of an accident and the magnitude of its consequence, is presented below.

Each route is divided to i number of segments, and for every i^{th} segment for trip j, the risk R_{ij} is determined by:

$$R_{ij} = P_{1ij} \times P_{2ijk} \times P_{3ijmn} \times P_{4ijp} \times P_{5ijp} \times P_{6ij} \times P_{7ijq} \times N_{ij}$$

where:

- P_{1ij}: Probability of an incident in mode segment 1.
- P_{2ijk}: Probability of an incident resulting in an accident of severity class K.
- P_{3ijmn}: Probability of release of cargo type m, in an amount of spill of a size class n.
- P_{4ijp}: Probability of release spreading by pathway p.
- P_{5ijp}: Probability of ignition for a flammable or explosive material via the pathway p.
- P_{6ij}: Probability of wind direction for an air release.
- P_{7ijq}: Probability of damage to an area q, receiving the spill and the probabilities that an exposed person will die or be injured.
- N_{ij}: Number of people exposed.

The overall risk is obtained by summing all route segments and all trips.

$$R = {}_{i}\Sigma_{j}\, R_{ij}$$

In less quantitative terms a risk assessment will tell us 1) how often we can expect a hazardous material accident on each route, 2) the threat to population for particular accidents, 3) identify high risk areas for enforcement programs and response planning, 4) identify routes as to level of risk, and 5) provide a basis for transportation planning to reduce levels of risk for individual routes.

A risk assessment will involve the following components:

1. Accident Analysis. Existing accident data will be examined and applied to shipments of hazardous material.

2. Determination of Risk by Route. Locations of major generators and destinations will identify the transportation routes in Arizona. Accident rates will be determine on a route-by-route basis.

3. Population-at-Risk. Once routes are identified, the population vulnerable to hazardous material accidents will be ascertained in relation to particular hazards and evacuation requirements.

4. Probability Analysis. The above factors and others will be used to calculate the probability of hazardous material accidents and their consequences. A ranking mechanism will be applied to identify relative risks by route and for planning purposes (risk reduction). In addition, this analysis will incorporate the movements of hazardous materials through and into metropolitan areas done an an aggregate risk level.

5. Operational Scenarios. A by-product of the risk assessment will be to evaluate the pattern of future traffic flow and risks of hazardous material on the Arizona transportation network due to the hazardous materials disposal facility to be built in Arizona.

III. Development of Computer Mapping/Planning Tools

To maximize the visual display of the risk assessment results, a set of computer mapping/planning programs will be developed. Such programs will permit the user to view transportation routes showing all the necessary data (amounts, number of shipments, risk level, population at risk, preparedness and vulnerability levels, accident distribution, etc.) related to HM transportation planning. The system will be flexible to assure that specific data will be retrieved by route and plotted on a hard copy if necessary. Further, the system will be a multi-purpose tool for which additional data components can be incorporated. For example, future land-use development can be added to a population factor to determine a change in risk or preparedness level on a route-by-route basis.

IV. Vulnerability Assessment and Hazardous Materials Response Planning

Vulnerability assessment is emerging as a critical area of study. This concern for community vulnerability to the transportation of hazardous material reflects the significantly growing number of transportation-related accidents, the potential for catastrophic events, and problems related to preparedness, response and regulations. The information obtained in risk assessment section will provide determinations of levels of risk of shipping hazardous material, probabilities of accidents, the characteristics of such accidents, and consequences to populations that are threatened by potential accidents. Additionally, areas of high risk along routes will be identified and the risks to the vehicular traffic because of hazardous materials accidents will be assessed. But these assessments deal only with one side of the hazardous material coin. Vulnerability refers to the relationship between risk and preparedness/response capabilities.

This component of the proposed study will investigate the preparedness, response, and enforcement implications of the risk assessment findings. In addition, the current levels of preparedness, training and enforcement efforts will be assessed in relation to the quantity, types and pattern of movements of hazardous material. Further, this component will incorporate an examination of legal/regulatory tools and policy that may be utilized to expand mitigation and transportation planning to reduce the occurrence of transportation accidents involving hazardous material and to minimize their consequences when they do occur.

The following two major study components are suggested in this section:

a. Review of literature and government reports on regulatory issues, emergency response planning, and risk mitigation activities related to transportation of hazardous material.

b. An assessment of Arizona's state and local preparedness efforts (strengths and shortcomings) and recommendations on policy and transportation planning.

V. Other Modal Assessments

The Phase I Study obtained excellent and statistically reliable data for hazardous materials transported through and into Arizona by means of truck carrier. There is a critical need to understand the total movement of hazardous material in Arizona by rail by volume, chemical type, places of exchange, and routings. This could be explained by the fact that the total volume or amount of hazardous material in bulk carried by rail in Arizona may exceed that carried by truck. National statistics show that the percent of HM rail accidents is increasing and that many are occurring within populated urban areas. Rail accidents involving hazardous materials have occurred in Arizona resulting in a number of evacuations and injuries.