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NATIONAL CRASH SEVERITY STUDY

Final Report

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16. Abstract

This is a final report of a study conducted over 4 years involving the investigation of accidents within a prescribed geographic area with known demographic characteristics as part of the National Crash Severity Study. The project was conducted in the counties of Lenawee and Washtenaw, Michigan, with selected accidents investigated in accordance with a well-defined protocol and sampling plan. Investigations were conducted by the University of Michigan Highway Safety Research Institute, they involved specific protocols for vehicles, environment, and occupants. The sampling plan involved three strata of accidents, based on their severity and injuries sustained by vehicle occupants.

A major accomplishment, in addition to the development of an accident data base, was the trial use and development of a crash severity index based on vehicle damage and vehicle movement prior to crash, during crash, and after crash, as described by crash scene observations and measurements. This involved the instantaneous change of vehicle velocity in a crash, called "Delta V". A second major accomplishment was the conducting of a centrally planned and administered accident investigation program which served as a pilot test of the National Accident Sampling System. While various problems were encountered in conducting the project, they were not of a nature to compromise the goals of the project.

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1.0 EXECUTIVE SUMMARY

This is the final report of the National Crash Severity Study (NCSS) team operated by the Highway Safety Research Institute (HSRI). This project was sponsored by the National Highway Traffic Safety Administration (NHTSA) to investigate various proposed accident severity measures such as Delta "V", relative velocities and absorbed energy. NCSS was also to determine the national cumulative distribution function of accident severity in fatal and injury accidents.

There were two major accomplishments of NCSS. The first was the trial use and development of a crash severity index. The Delta "V" index involves the instantaneous change of velocity of the crash-involved vehicle during impact. The second was the institution and operation of a centrally planned and operated investigation program. The lessons learned from NCSS were valuable in the institution of the National Accident Sampling System (NASS).

The geographic area in which the HSRI team operated was a two-county area of southeastern Michigan. Washtenaw and Lenawee Counties are contiguous counties approximately 45 miles west of Detroit. Washtenaw County is a combination of rural and urban environment with a population of 243,000 (1970 Census). Lenawee County is predominantly rural with one urban center: Adrian. The population of Lenawee County is 81,000 (1970 Census). In the two-county area there were 21 police agencies and 9 hospitals to be contacted and coordinated.

HSRI used a two-office approach to ensure full coverage of the study area. The main office was located in Ann Arbor, Michigan. The satellite office was in Adrian, Michigan. The team consisted of a Project Director, field manager, three field investigators and an editor.

Accidents were selected for study from police accident reports. During the first three years of the project, three sample criteria

were used. The first criterion was fatal and hospitalized occupants for every accident (100%); the second was occupants treated and released for injuries (25%); the third was occupants with no injury (10%). In April of 1978 light trucks and vans were added to the sampled population of vehicles. On May 1, 1979, the sample was revised to a 100%, 75%, 20%, and 5% system.

Cooperative arrangements had to be initiated and continued with towyards, police agencies, and hospitals. These agreements presented no problem to HSRI due to its long participation in the transportation research field. In addition, a transportation research "shield law" was passed by the Michigan Legislature early in 1980.

The case review process began when the police accident reports were selected as eligible cases. The project manager would double-check to ensure consistency of the sample. The case then went to the investigator for completion. Other investigators would routinely review the case, and finally the editor would make a complete check before the case was submitted. In mid-1979 the Remote Data Entry (RDE) system was instituted. It enhanced the editor's ability to correct errors and assure consistency.

Three problems arose during the course of the NCSS project. The most serious problem was the unpredictability of the sampling system. This unpredictability caused some problems in the planning of personnel and facility usage. Training of new investigators became a problem in the later stages of the project but was remedied somewhat by in-house training. The third problem was the occasional ambiguity of direction given by the Quality Control Monitor.

In conclusion, the NCSS project was a very important learning experience for the highway safety research community. It was found that many teams could be centrally directed in a nationwide project. Also, strict adherence to a sampling plan was an important accomplishment.

Two deficiencies showed up during the course of the project. The first was the lack of an unambiguous sampling design. The second relates

to the first, in that the lack of a specific plan created an unpredictability of case load that made planning difficult.

The Highway Safety Research Institute recommends that in future accident studies of this scope, three conditions be met. The first is that an unambiguous sampling system be instituted. The second is that more and better training be afforded the individual investigators. The third is that there be closer coordination between investigation teams and quality control monitors.

2.0 INTRODUCTION

The National Crash Severity Study (NCSS) was a major accident research program of the National Center for Statistics and Analysis (NCSA) of the National Highway Traffic Safety Administration (NHTSA). The study involved obtaining detailed information on passenger cars (and their occupants) in crashes which were severe enough to disable the car. NCSS constituted a significant step forward into use of centrally controlled, sampled investigations of accidents for research purposes.

Prior to the initiation of NCSS, efforts to obtain accident data representative of our national accident experience through use of professional accident investigators, based on a well-defined sampling plan, had never been attempted. While not a true random sample of accidents, NCSS was implemented as a purposive sample through use of existing high-quality accident investigation teams located in seven different geographic areas in the U.S.* This is the final report describing the conduct and accomplishments of but one of these seven teams, the HSRI accident investigation team responsible for Lenawee and Washtenaw Counties in Michigan.

There were two major accomplishments in NCSS in addition to the accident data base developed from the various data elements included in each investigation. One was the trial use and development of a crash severity index based on vehicle and scene crash observations and measurements. This index involves the instantaneous change of velocity of the crash-involved vehicle during impact, called "Delta V". The other was operation of a centrally planned and operated accident investigation program which served as a pilot test for the National Accident Sampling System (NASS) program. The National

*Erie County, New York; Sixteen counties in SW Indiana; Miami, Florida, Lexington, Kentucky and surrounding counties; Bexar, Guadalupe, and thirteen other counties in South Texas; Los Angeles, California; and Lenawee and Washtenaw Counties, Michigan

Accident Sampling System, which is intended to follow NCSS, is a random sample of accidents, designed to be truly national in scope and similar in many respects to the accident investigation protocols developed and utilized in NCSS.

HSRI had recommended a sampled data approach to accident investigation studies for many years. Such an approach was presented by the recommendations presented in the final report of the NHTSA-sponsored Statistical Inference from MDAI Data study in 1973, which was followed by the NHTSA-sponsored study to develop the protol type for NASS, completed in mid-1975. This later effort presented not only the detailed sampling and data acquisition design for NASS, but also recommended an organizational structure designed to accomplish the objectives of a national system in the most cost-effective manner. Thus, NCSS was an effort in which HSRI was vitally concerned and whose success was felt to be essential for an effective NASS.

This final report of HSRI's participation in NCSS summarizes the complete involvement of HSRI in the accident investigation phase of NCSS.* A detailed description of the project study area incorporating Lenawee and Washtenaw Counties, Michigan, is presented with explanations of team structure, sampling procedures, cooperative arrangements with community and county organizations, accident case preparation and review, as well as the difficulties encountered and overcome to complete the project. Results of the total effort are included along with recommendations for improvements to future sampled accident investigation study programs.

*HSRI is also under contract to NHTSA (Contract DOT-HS-8-01944) for analysis of accident data obtained in the NCSS program consisting of seven accident investigation teams.

3.0 TECHNICAL DISCUSSION

The following sections describe the area and the manner in which the Highway Safety Research Institute carried out the National Crash Severity Study. Section 3.1 describes the geographical area of south-eastern Michigan in which the team operated. Section 3.2 explains the structuring of the NCSS team. Section 3.3 describes the sampling procedures used in selection of cases. Section 3.4 describes the arrangements that had to be made in order to operate in the two-county area. Section 3.5 describes the methods used to ensure high quality investigative data. Section 3.6 describes the problems encountered.

3.1 STUDY AREA DOCUMENTATION

Washtenaw County is a combination of rural and urban areas. Its major urban areas, Ann Arbor and Ypsilanti, contain slightly over one-half of the county's population. The University of Michigan at Ann Arbor and Eastern Michigan University at Ypsilanti contain over 50,000 students. Also another 21% of the population live in the urbanized areas surrounding Ann Arbor and Ypsilanti. In addition to the two universities, Ann Arbor contains several large research and development firms. The Ypsilanti area contains five major automotive production plants and many small industrial firms which attract many workers from neighboring Wayne County. Further, Ann Arbor's work force is almost three-fourths white collar, while less than half of Ypsilanti's workers are employed in white collar positions.

The western half of Washtenaw County, as well as its southeast and northeast sections, has a wealth of agricultural and recreational land. Three percent of the county's population lived on farms in 1970 and 19% were classified as living on rural nonfarm residences.

Lenawee County is principally a rural area. Adrian is the largest city (20,000 persons as of 1970 census) and is the county seat. Rich in agriculture, Lenawee County is also a thriving recreational area. The Irish Hills and surrounding environs provide residents, as well as tourists, with rolling hills, forests, and lakes. The county has very little heavy industry of its own. There are various numbers of light industry plants in and around the Adrian area. The county's permanent residents, if they are not full or part time farmers, tend to commute to either Ann Arbor or Ypsilanti to work. Adrian College and Siena Heights College are the county's two institutions of higher learning. Both colleges are oriented towards the liberal arts and have rather small student populations.

The southern extreme portion of the county is flat productive farm land and shares a common border with northern Ohio. The northern and eastern portions of the county are hilly, wooded, and contain less farmland and share a common boundary with Washtenaw County. The western portion of the county, primarily agricultural borders Hillsdale and Jackson counties. Overall, Lenawee County is stable both economically and demographically.

The following tables list some of the salient features of the two county area in which the NCSS team operated. Included are the population figures for Washtenaw and Lenawee County. The vehicle population and a breakdown of the accident experience during the NCSS project is also included. In addition, the police agencies, hospitals,and towyards that the team had to cooperate with are listed.

URBAN AND RURAL POPULATION

Census 1960 & 1970 and Percentage Change 1960 - 1970

1960 Population

Area	Total	Urban	Rural
State of Michigan	7,823,194	5,739,132	2,084,062
Lenawee	77,789	32,591	45,198
Washtenaw	172,440	121,484	50,956

1970 Population

Area	Total	Urban	Rural
State of Michigan	8,875,083	6,553,773	2,321,310
Lenawee	81,951	32,873	48,736
Washtenaw	243,103	182,994	51,109

Percentage Change 1960 - 1970

Area	Total	Urban	Rural
State of Michigan	13.4	14.2	11.4
Lenawee	4.9	0.9	7.8
Washtenaw	35.8	50.6	0.3

Source: U.S. Bureau of the Census, U.S. Census of Population 1970.

POPULATION STATISTICS

Location	1970	1960	Percent Change
Washtenaw County	234,103	172,440	35.8
Ann Arbor City	99,797	67,340	48.2
Ann Arbor Township	3,589	3,521	1.9
Augusta Township	4,378	3,754	16.6
Bridgewater Township	1,204	1,002	20.2
Dexter Township	2,238	1,698	31.8
Freedom Township	1,267	1,065	19.0
Lima Township	1,695	1,400	21.1
Chelsea Village (part)	414	405	2.2
Lodi Township	1,934	1,411	37.1
Lyndon Township	1,373	1,037	32.4
Manchester Township	2,856	2,590	10.3
Manchester Village	1,650	1,560	5.2
Milan City (part)	3,775	2,847	32.6
Northfield Township	3,975	3,279	21.2
Whitmore Lake (part)	1,494	...	...
Pittsfield Township	8,185	6,043	35.4
Salem Township	3,001	2,097	43.1
Saline City	4,811	2,334	106.1
Saline Township	922	906	1.8
Scio Township	7,230	6,156	17.4
Dexter Village	1,729	1,702	1.6
Sharon Township	831	760	9.3
Superior Township	5,562	3,600	54.5
Sylvan Township	5,086	4,401	15.6
Chelsea Village (part)	3,444	2,950	16.7
Webster Township	1,981	1,286	54.0
York Township	5,681	9,853	-42.3
Ypsilanti City	29,538	20,957	40.9
Ypsilanti Township	33,194	25,950	27.9

Source: U.S. Department of Commerce, Bureau of the Census, United States Census of Population: 1970, Number of Inhabitants, Michigan.

POPULATION STATISTICS

Location	1970	1960	Percent Change
Lenawee County	81,609	77,789	4.9
Adrian City	20,302	20,347	0.2
Adrian Township	3,725	3,341	11.5
Blissfield Township	3,475	3,458	0.5
Blissfield Village	2,753	2,653	3.8
Cambridge Township	2,647	2,143	23.5
Onstead Village	555	526	5.5
Clinton Township	2,540	2,298	10.5
Clinton Village	1,677	1,481	13.2
Deerfield Township	1,589	1,656	-4.0
Deerfield Village	834	866	-3.7
Dover Township	1,637	1,533	6.8
Clayton Village (part)	312	274	13.9
Fairfield Township	2,047	2,117	-3.3
Franklin Township	1,768	1,813	-2.5
Hudson City	2,618	2,546	2.8
Hudson Township	1,373	1,341	2.4
Clayton Village	193	196	-1.5
Macon Township	1,316	1,262	4.3
Madison Township	5,494	5,226	5.1
Medina Township	1,227	1,301	-5.7
Morenci City	2,132	2,053	3.8
Ogden Township	1,211	1,305	-7.2
Palmyra Township	2,424	2,418	0.2
Raisin Township	4,322	3,061	41.2
Ridgeway Township	1,756	1,605	9.4
Britton Village	697	622	12.1
Riga Township	1,675	1,863	-10.1
Rollin Township	2,983	2,692	10.8

Location	1970	1960	Percent Change
Addison Village (part)	363	331	9.7
Manitou Beach-Devils Lake (V) (part)	1,560	1,291	20.8
Rome Township	1,330	1,219	9.1
Seneca Township	1,337	1,297	3.1
Tecumseh City	7,120	7,045	1.1
Tecumseh Township	1,048	775	35.2
Woodstock Township	2,433	2,074	17.3
Addison Village (part)	232	244	-4.9
Cement City Village (part)	489	429	14.0
Manitou Beach-Devils Lake (part)	332	253	31.2

	Lenawee	Washtenaw
1970 Land Area Square Miles	753	711

Source: U.S. Department of Commerce, Bureau of the Census, United States Census of Population: 1970, Number of Inhabitants, Michigan

NUMBER OF VEHICLE REGISTRATIONS

Year	Area	Total Plates
1975	State of Michigan	6,534,630
	Lenawee County	67,804
	Washtenaw County	166,199
1976	State of Michigan	6,691,859
	Lenawee County	69,605
	Washtenaw County	170,232
1977	State of Michigan	6,959,527
	Lenawee County	71,913
	Washtenaw County	177,332
1978	State of Michigan	7,269,835
	Lenawee County	75,909
	Washtenaw County	188,865

Source: Vehicle Registrations, Michigan Traffic Accident Facts, 1975 - 1978, Michigan Department of State Police.

NUMBER OF FATAL ACCIDENTS

Year	Area	Fatal Accidents
1975	State of Michigan	1,611
	Lenawee County	24
	Washtenaw County	38
1976	State of Michigan	1,730
	Lenawee County	18
	Washtenaw County	44
1977	State of Michigan	1,741
	Lenawee County	20
	Washtenaw County	60
1978	State of Michigan	1,833
	Lenawee County	23
	Washtenaw County	58

Source: County Fatalities, Michigan Traffic Accident Facts, 1975 - 1978, Michigan Department of State Police.

PROPERTY DAMAGE ACCIDENTS

Year	Area	Property Damage Accidents
1975	State of Michigan	233,712
	Lenawee County	2,364
	Washtenaw County	5,922
1976	State of Michigan	256,807
	Lenawee County	2,569
	Washtenaw County	2,846
1977	State of Michigan	263,401
	Lenawee County	2,934
	Washtenaw County	6,852
1978	State of Michigan	275,101
	Lenawee County	3,205
	Washtenaw County	7,028

Source: County Property Damage, Michigan Traffic Accident Facts, 1975 - 1978, Michigan Department of State Police.

NUMBER OF INJURY ACCIDENTS

Year	Area	Injury Accidents
1975	State of Michigan	98,237
	Lenawee County	800
	Washtenaw County	2,490
1976	State of Michigan	107,063
	Lenawee County	948
	Washtenaw County	2,846
1977	State of Michigan	109,609
	Lenawee County	952
	Washtenaw County	2,915
1978	State of Michigan	112,259
	Lenawee County	1,070
	Washtenaw County	3,034

Source: County Injury Accidents, Michigan Traffic Facts, 1975 - 1978, Michigan Department of State Police.

POLICE AGENCIES

Washtenaw County

Michigan State Police

- Brighton, Michigan
- Clinton, Michigan
- Plymouth, Michigan
- Ypsilanti, Michigan

County Sheriff

- Washtenaw, Michigan

City Police

- Ann Arbor, Michigan
- Chelsea, Michigan
- Manchester, Michigan
- Milan, Michigan
- Saline, Michigan
- Ypsilanti

Lenawee County

Michigan State Police

- Blissfield, Michigan

County Sheriff

- Lenawee, Michigan

City Police

- Adrian, Michigan
- Addison, Michigan
- Britton, Michigan
- Clinton, Michigan
- Hudson, Michigan
- Morenci, Michigan
- Tecumseh, Michigan

HOSPITALS

Washtenaw County

University of Michigan Medical Hospital	Ann Arbor, Michigan
St. Joseph Medical Hospital	Ann Arbor, Michigan
Beyer Medical Hospital	Ypsilanti, Michigan
Chelsea Medical Hospital	Chelsea, Michigan
Saline Medical Hospital	Saline, Michigan

Lenawee County

Bixby Medical Hospital	Adrian, Michigan
Herrick Medical Hospital	Tecumseh, Michigan
Morenci Area Hospital	Morenci, Michigan
Thorn Medical Hospital	Hudson, Michigan

TOW YARDS

Washtenaw County

Ann Arbor

Brewer's	1763 Plymouth
Double A	3055 Washtenaw
Sakstrup's	3055 Packard
Westgate	2342 Dexter

Chelsea

Red's	889 S. Main
Smith's	11451 Jackson

Clinton

Blaisdell's	109 E. Michigan

Dexter

Dexter Body	8030 Fifth

Lodi

Town and Country	3127 S. Wagner

Manchester

Fillyaw's	327 W. Main

Saline

Ted's	820 W. Michigan

South Lyon

Country Collision	57440 Ten Mile

Whitmore Lake

Territorial Standard	60 E. North Territorial

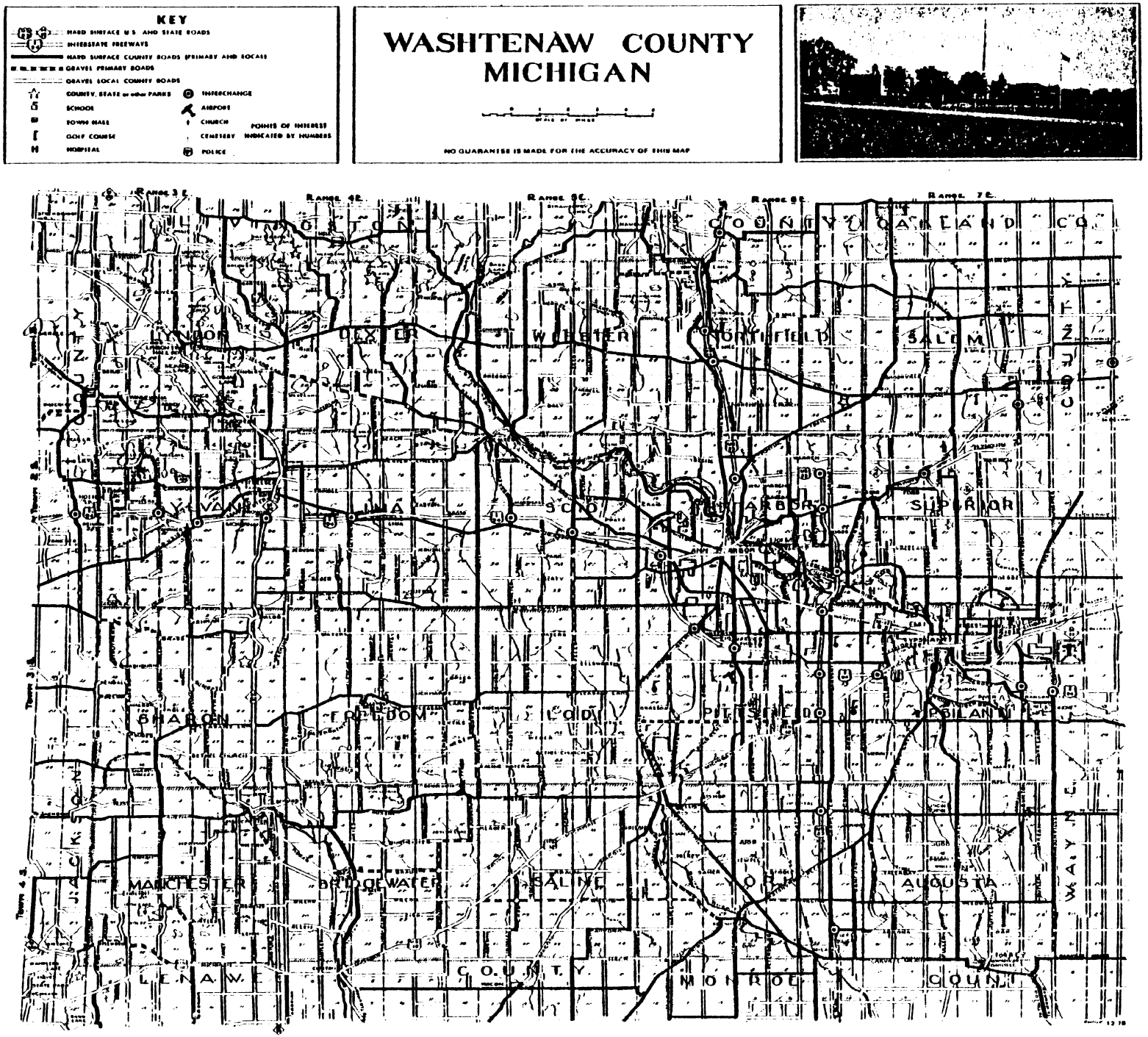
TOW YARDS

Ypsilanti

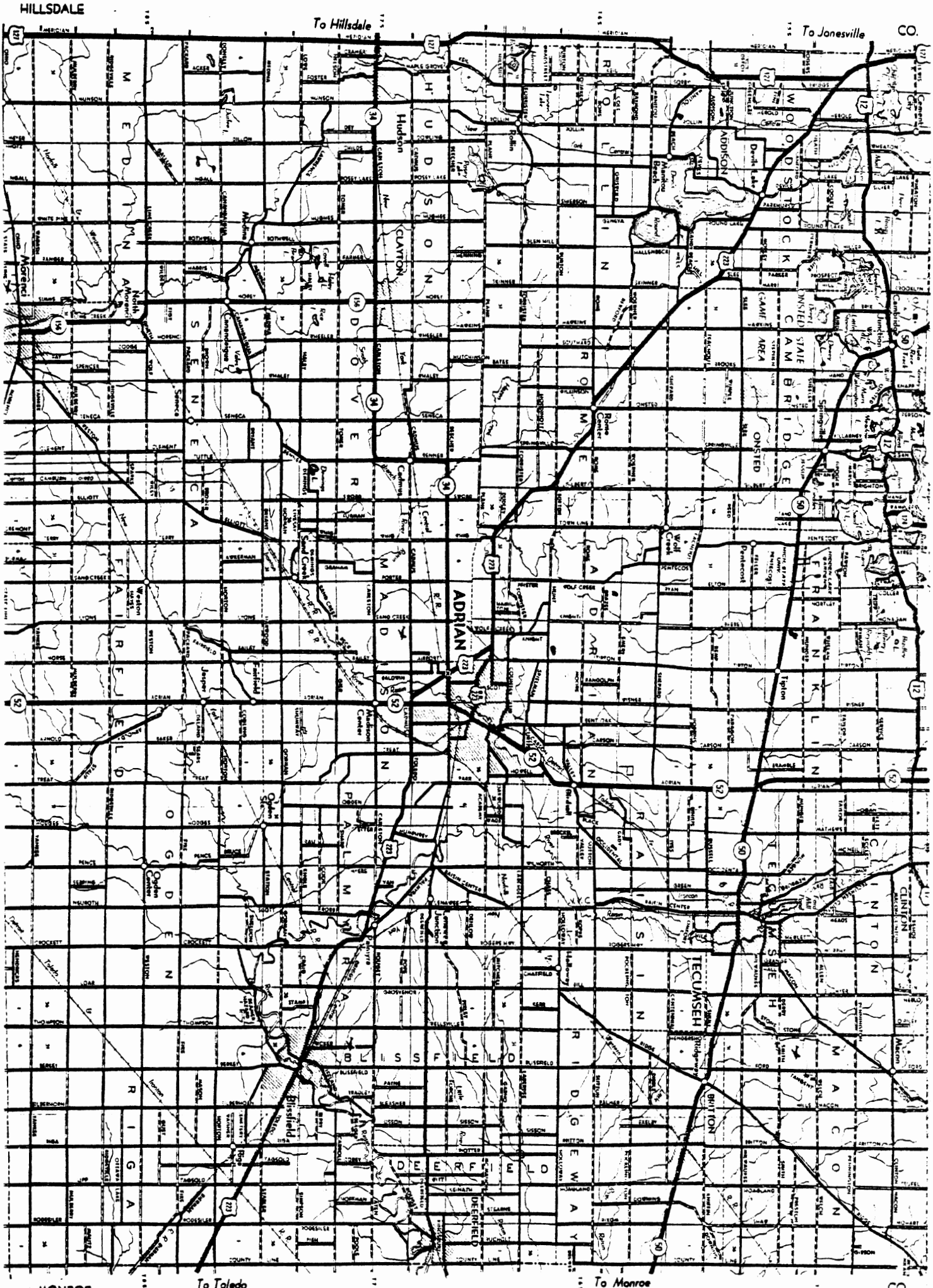
Able	221 N. Lincoln
H & H	896 N. Harris
Martin's	65 Emerick
Sobbry's	8960 Stony Creek
Ypsi Towing	707 W. Michigan

Lenawee County

Blissfield Gulf	505 W. Adrian	Blissfield, MI
Cal's Standard	403 W. Maumee	Adrian, MI
Hancock's Garage	4709 W. Michigan	Tipton, MI
Hane's	7993 US-12	Irish Hills, MI
Hill's Wrecker	2558 Treat	Adrian, MI
Jim's Marathon	666 S. Center	Adrian, MI
Kyle's Standard	150 Main	Hudson, MI
Poe's Mobil	1099 E. U.S.-223	Adrian, MI
Schneider's	10003 E. U.S.-223	Blissfield, MI
Tecumseh Sunoco	402 E. Chicago	Tecumseh, MI
Tecumseh Towing	102 W. Logan	Tecumseh, MI


KEY
HARD SURFACE U.S. AND STATE ROADS
INTERSTATE FREEWAYS
HARD SURFACE COUNTY ROADS (PRIMARY AND LOCAL)
GRAVEL PRIMARY ROADS
GRAVEL LOCAL COUNTY ROADS
COUNTY, STATE or other PARKS
INTERCHANGE
SCHOOL
AIRPORT
TOWN HALL
CHURCH
GOLF COURSE
CEMETERY
POINTS OF INTEREST INDICATED BY NUMBERS
HOSPITAL
POLICE
WASHTENAW COUNTY
MICHIGAN
NO GUARANTEE IS MADE FOR THE ACCURACY OF THIS MAP
Range 3 E
Range 4 E
Range 5 E
Range 6 E
Range 7 E
Town 2 S
Town 3 S
Town 4 S
LYNDON
DEXTER
WEBSTER
NORTHFIELD
SALEM
YPSILANTI
ANN ARBOR
SUPERIOR
SHARON
FREEDOM
LODI
PITTSFIELD
PITTSFORD
MANCHESTER
BRIDGEWATER
SALINE
AUGUSTA
WAYNE
WASHTENAW COUNTY
MONROE COUNTY

LENAWEE COUNTY



3.2 Team Structure

The Highway Safety Research Institute NCSS team operated in two counties of southeastern Michigan, (Washtenaw and Lenawee). Both counties are predominantly rural with medium-size cities as the major population centers. Due to the distances involved, two offices were set up in the two counties.

The main office for the NCSS project was located in Washtenaw County at the HSRI building in Ann Arbor. Another office was set up in Adrian, Michigan, to serve as the Lenawee County office. Both offices were centrally located in the county to provide easy access to police agencies, hospitals, and tow-yards.

The Lenawee County office originally supported two people. The first was a senior accident investigator and the second was a human subjects specialist. After two years the staff was reduced to one person, with support services rendered from the Washtenaw County Office at HSRI.

The Washtenaw County office consisted of the Project Director, Field Manager, two accident investigators, and one case editor. This office submitted cases for both counties. All editing and case review functions were centered in this office.

The Project Director's duties and responsibilities included technical editing, formal relations with NHTSA, and the overall direction of the project. It was the Director's responsibility to set the general policies in the NCSS project. It was his primary duty to assure the validity of the sampling procedure and to recieve the directives from the Quality Control Contractor and NHTSA and see that they were put into operation.

The project field manager's chief concern was to see that day-to-day operations of the NCSS project functioned properly. It was his job to coordinate work assignments among the investigators and editors to assure the efficient utilization of facilities and personnel. It was also his responsibility to see that directives from NHTSA and the Quality Control Monitor were followed by the investigators and the editors on the NCSS project.

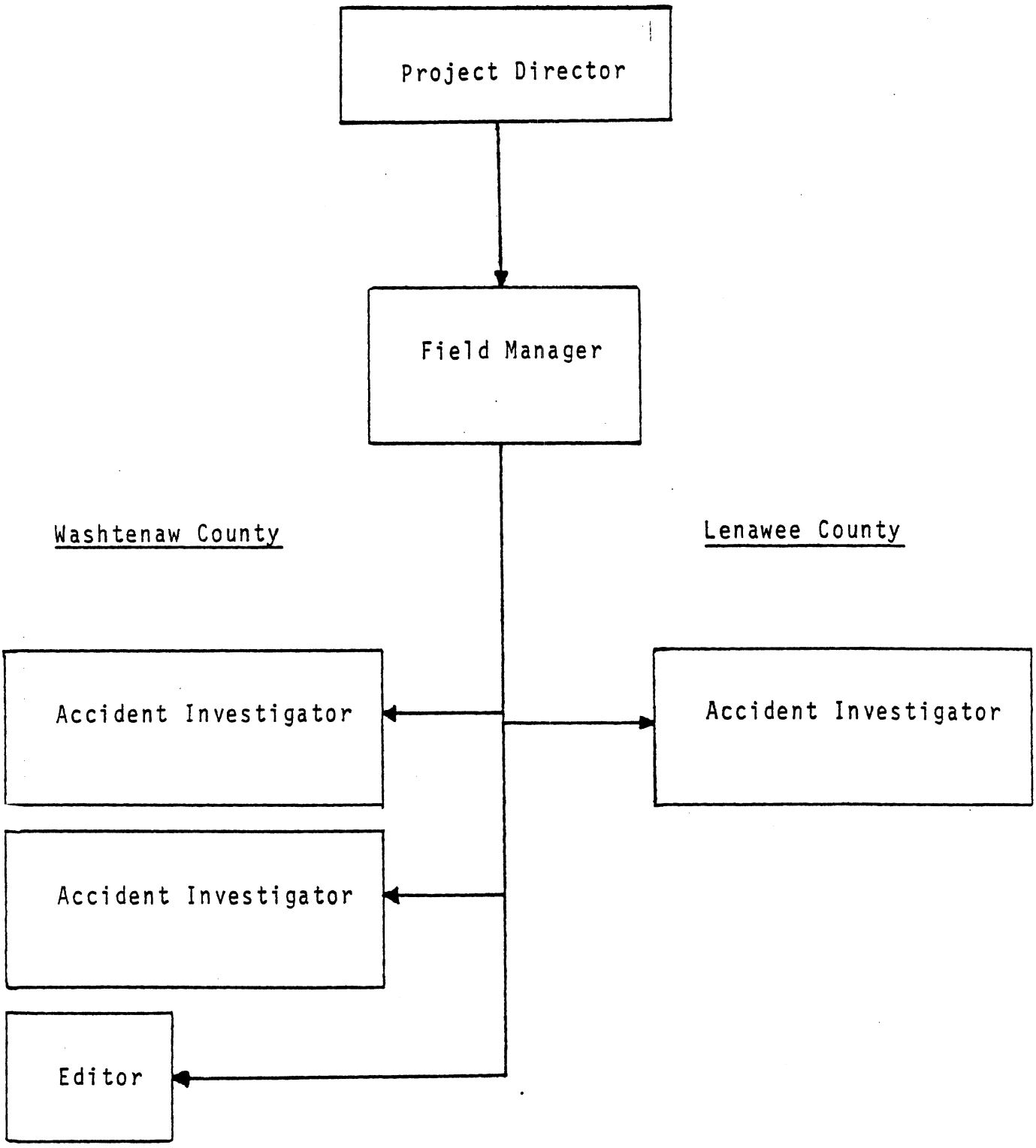
The investigator's duties consisted of field work on the vehicles and scenes, interviews of the occupants, and the initial review of the case for accuracy and consistency. The investigator's prime responsibility was to ensure the prompt and accurate investigation of cases, using methods consistent with directives from NHTSA and the Quality Control Monitor.

The editors worked as internal quality control monitors. Their job was to inspect every case for errors, check for proper coding conventions, and to include the medical records information. The editor's major responsibility was to ensure that every case was as complete and consistent as possible before the case left HSRI for inclusion into the NCSS file.

In conclusion, the NCSS project at HSRI was instituted as a self-checking operation that caught its own errors before submission of the case. Because of the statistical nature of the project, the validity of the data was of paramount importance. For that reason every effort was made to structure the team so that mistakes were discovered and corrected before the cases left HSRI. A diagram showing project organization and team structure is shown in Figure 1.

HSRI TEAM STRUCTURE

Figure 1



3.3 Sampling Procedures

Prior to the commencement of data collection for the National Crash Severity Study (NCSS) a well-defined sampling plan was devised by the HIghway Safety Research Institute (HSRI) in response to the basic contract work statement and initial direction from the National Highway Traffic Safety Administration (NHTSA). This plan, designed to satisfy the stratified probability sampling requirements of NCSS, was outlined in detail and confirmed in a letter of October 4, 1976, from Mr. Peter Cooley of HSRI to Mr. John Garrett of the Calspan Corporation.*

The HSRI sampling plan was followed, with minor variations, until the conclusion of data collection on March 31, 1980. Changes and modifications in the sampling system are discussed in greater detail in following sections of this report.

The sampling plan employed by HSRI followed criteria set forth by the Calspan Corporation for the National Highway Traffic Safety Administration.** Automobile accidents to be investigated would be selected from police accident reports. In order for an accident to be eligible for selection it would have to involve at least one occupied passenger car whose damage was such that it had to be towed from the accident scene. Once the police reports' eligibility was established, it would be screened to determine if it met one of the three sampling strata criteria, 100%, 25%, or 10%. A 100% sample case would be an accident in which at least one occupant of a towed-for-crash-damage passenger car was transported to a medical facility and admitted for treatment, or succumbed to fatal injuries in the crash. Accidents meeting this criterion would be investigated. A 25% sample case would be an accident not meeting the 100% criterion but where at least one occupant of a towed for crash damage passenger car was transported to a medical facility for treatment, but not hospitalized overnight or admitted. One quarter of these accidents would be investigated.

*A copy was also sent to the Contract Technical Manager, Mr. James Kistle

**Coding Manual for NCSS, January 1977, Calspan Corporation

A 10% sample case would be an accident which did not qualify for either the 100% or 25% categories. In this sample strata (10%) occupants of towed-for-crash damage vehicles would be either not injured or their injuries would not require their transport to a treatment facility. One tenth of these accidents would be investigated.

The selection of the 25% and 10% sample strata cases was accomplished through a systematic random sampling procedure. The specific selection procedure differed from team to team but was in accordance with the sample design approved by NHTSA with the consultation of the individual NCSS teams. At HSRI, this sampling procedure was based on license plate numbers as they appeared on police accident reports.

At HSRI, police reports were picked up every weekday from two county sheriffs departments, the police departments of the three largest cities in our study area, as well as two state police posts. Reports were picked up twice a week from a township police force and weekly from all other police agencies in the two counties covered by the HSRI NCSS team. Those police agencies that were visited once or twice a week were phoned on a daily basis to check for recent traffic accidents.

Each weekday morning, when the police reports arrived, one person would go through them to select those that were eligible for NCSS investigation. This person also maintained log sheets and was responsible for case assignments and for following progress of individual cases.

Police reports were first screened to eliminate accidents where no passenger car was towed because of crash damage or reports with no passenger cars. Most often this could be done by looking at the box on the official Michigan traffic accident reporting form (UD 10) marked "drivable/not driveable." At times this section would have to be confirmed by a phone call to a towing facility or by inspection of the vehicle. Police accident reports were then scanned for occupants of towed-for-crash damage passenger cars who were fatally injured as a result of the accident. Reports that met this criterion would

automatically qualify as 100% sample cases. Screening proceeded for occupants of towed-for-crash damage passenger cars who were transported to a hospital or treatment facility. When these reports were accumulated they would be sorted out by specific hospitals or clinics. Each treatment facility would then be called to determine which occupants were admitted (hospitalized overnight) and which were treated and released or not seen. Those accidents involving occupants who were admitted to a treatment facility (and had been in a passenger car towed because of crash damage) would qualify for NCSS as 100% sample cases. Those accidents involving occupants not fatally injured and not hospitalized overnight would become eligible for the 25% sample catagory if they passed another test. This test involved examining the first vehicle appearing on the police report which had been towed for damage and had at least one occupant transported to a treatment facility by a police, fire, or emergency vehicle (or by a friend if so stated on the police report) and examining its license number.

This method of sampling by the first vehicle meeting sampling selection category requirements, rather than second vehicle or any vehicle, was used for two reasons. If one were looking at more than one vehicle for determination of case eligibility, one would not be sampling accidents, but rather vehicles. If one based case selection on more than the first vehicle, it would result in more than one quarter (25%) of the accidents being investigated.

Once the first vehicle appearing on the the police report (meeting the 25% sample case criteria) was determined, the license plate number* of that vehicle was examined. If the last digit, or digits, were a 1, a 2, an 03, a 13, a 23, a 33, or a 43, the case would be investigated, as these numbers comprise 25% of the total possible last-number combinations. Should the last number, as it appeared on the police report, be obscured, or should there be no numbers as in the case of a vanity plate, a ten sided die would be thrown. If a

*The use of license plate numbers for case selection was previously used in an HSRI accident sample program. The randomness of Michigan license numbers was verified in a study which preceded this program.

1 or a 2 was rolled the case would be investigated. If a 3, 4, 5, 6, 7, or an 8 was rolled, the cases would be discarded. If a 9 or a 10 were rolled the die would be thrown again until either a 1 or a 2 (eligible) or a 3, 4, 5, 6, 7, or an 8 (ineligible) was rolled.

Those accident reports not meeting the 100% or 25% criteria would be examined next. To be eligible for selection as a 10% sample selection case, an accident had to have at least one towed-for-damage passenger car where no occupants were transported to a treatment facility. The license number of the first occupied, towed-for-crash damage vehicle meeting the 10% sample criterion would be an investigatable accident if the license number ended in a 6. Again, if the license numbers were obscured on the police report, or if the vehicle had vanity plates, a die would be rolled. Like the license number, if a 6 resulted from the throw of the die, the case would be investigated.

Accidents were sampled by HSRI for Washtenaw and Lenawee counties in this manner until receipt of a letter, dated October 10, 1978, from Mr. John W. Garrett, Manager of the Accident Research Division of the Calspan Corporation, Buffalo, New York. In his letter, Mr. Garrett informed HSRI that four of our cases had been deleted from the NCSS case file because the most severe injury in the accident (severity of injury as defined by treatment, i.e hospitalized more severe than transported) did not occur to an occupant of an applicable vehicle (a non-applicable vehicle being either a non-towed for damage passenger car or a non-passenger car). This statement seemed to be a modification of our original sampling plan as delineated in a letter from Peter Cooley to John Garrett, dated October 4, 1976. Mr. Cooley wrote: "Please note that our interpretation of NCSS sampling requirements is that the injury strata is based only on occupants of passenger cars towed for crash damage. We believe this to be the correct interpretation. Another possible interpretation is that the injury strata are defined by the most severe injury in the crash. I'm sure you are aware of the subtle but important differences and the need for all NCSS contractors to follow the same interpretation."

After receiving Mr. Garrett's letter of October 10, 1978, HSRI modified its sampling procedures to comply with Calspan Corporation instructions. These identical instructions also appeared in late revisions of NCSS Coding Manuals.

In April of 1978, light trucks and vans were added to the sampling system design as applicable vehicles. The sampling procedure remained the same. All, or 100%, of the accidents involving fatally injured or overnight hospitalized occupants of towed-for-damage passenger cars (and now light trucks and vans), one quarter (25%) of the accidents involving occupants of applicable vehicles who were transported to a treatment facility, and one tenth (10%) of the accidents involving uninjured or non-transported occupants of applicable vehicles would be investigated. The inclusion of light trucks and vans tended to increase the number of accidents investigated as it broadened the number of accidents potentially eligible for investigation.

In May of 1979, along with the adoption of National Accident Sampling System (NASS) forms, the NCSS sampling system was revised. In place of the previous 100%, 25%, and 10% stratification procedure, the sampling design was redesigned into a 100%, 75%, 20%, and 5% format. The 100% sample cases now would be accidents involving applicable vehicles with at least one occupant who was fatally injured. A 75% sample case would be an accident involving an applicable vehicle containing one or more occupants who were hospitalized overnight. A 20% sample case was an accident in which any occupant of an applicable vehicle was transported to a medical facility for treatment but not hospitalized overnight. A 5% sample case was an accident involving an applicable vehicle whose occupant or occupants were uninjured or received injuries such that they were not transported to a treatment facility or hospitalized. Like the previous sample design, these accidents were sampled at a rate as described by their names, i.e all of the 100% cases, three quarters of the 75% cases, one fifth of the 20% cases, and one twentieth of the 5% cases. The system used to select

eligible accidents was based, again, on license numbers as they appeared on the police report. Those cases meeting the 75% catagory criteria, whose first eligible vehicle's license number ended in a 1, 2, 3, 4, 5, 6, 7, 18, 28, 38, 48, or 58 would be investigated. Those cases meeting the 20% category criterion, whose first eligible vehicle's license number ended in a 1 or a 2 would be investigated. Those cases meeting the 5% category criterion whose first eligible vehicle's license number ended in an 11, a 21, a 31, a 41, or a 51 would be investigated. As done previously, if the vehicle being examined in the police report had vanity plates or obscured numbers, a ten-sided die would be thrown to determine case eligibility. This system continued unaltered until the end of data collection on March 31st, 1980.

3.4 Cooperative Arrangements

The cooperative arrangements necessary to implement the NCSS project in Washtenaw and Lenawee Counties presented no problems for HSRI. Because of our long-standing relationship with the local police agencies, towyards and hospitals, the arrangements were set up quickly and efficiently. HSRI has been doing various accident investigations in Southeast Michigan since the late 1960's, and the University of Michigan since the early 1960's. Because of that long experience in the field, most HSRI staff members involved in accident research are on a "first name" basis with local officials and towyard operators.

The cooperative arrangements were set up at the initial briefings given by HSRI. Police agencies, hospital administrators, and towyard operators were contacted during the setup phase of the project in 1976. The NCSS project was explained to them and their support was elicited. All parties agreed to cooperate, the arrangements were not put into writing. All cooperative agreements were verbal and on an informal basis.

Some problems associated with this arrangement did develop. One problem was that as personnel changed in some of the support organizations,

the NCSS project had to be re-explained and arrangements re-established. The only major problem occurred late in 1979, when local hospitals became sensitive to possible liability resulting from release of medical records. This led one hospital to terminate its support of NCSS.

This problem of liability for the release of confidential material led HSRI, in conjunction with the Michigan Department of State Police, Office of Highway Safety Planning, to press for a "shield law" applicable to areas of transportation and safety research. Early in 1980 this effort was successful with the passage of House Bill No. 4377. The shield law (Section 257.624 MCLA) prevents subpoena of confidential material and eliminates civil liability for individuals divulging such information. This law eliminates the last impediment to full cooperation of hospitals, towyards, and police agencies in the area of highway safety research in Michigan.

3.5 NCSS Case Review Process

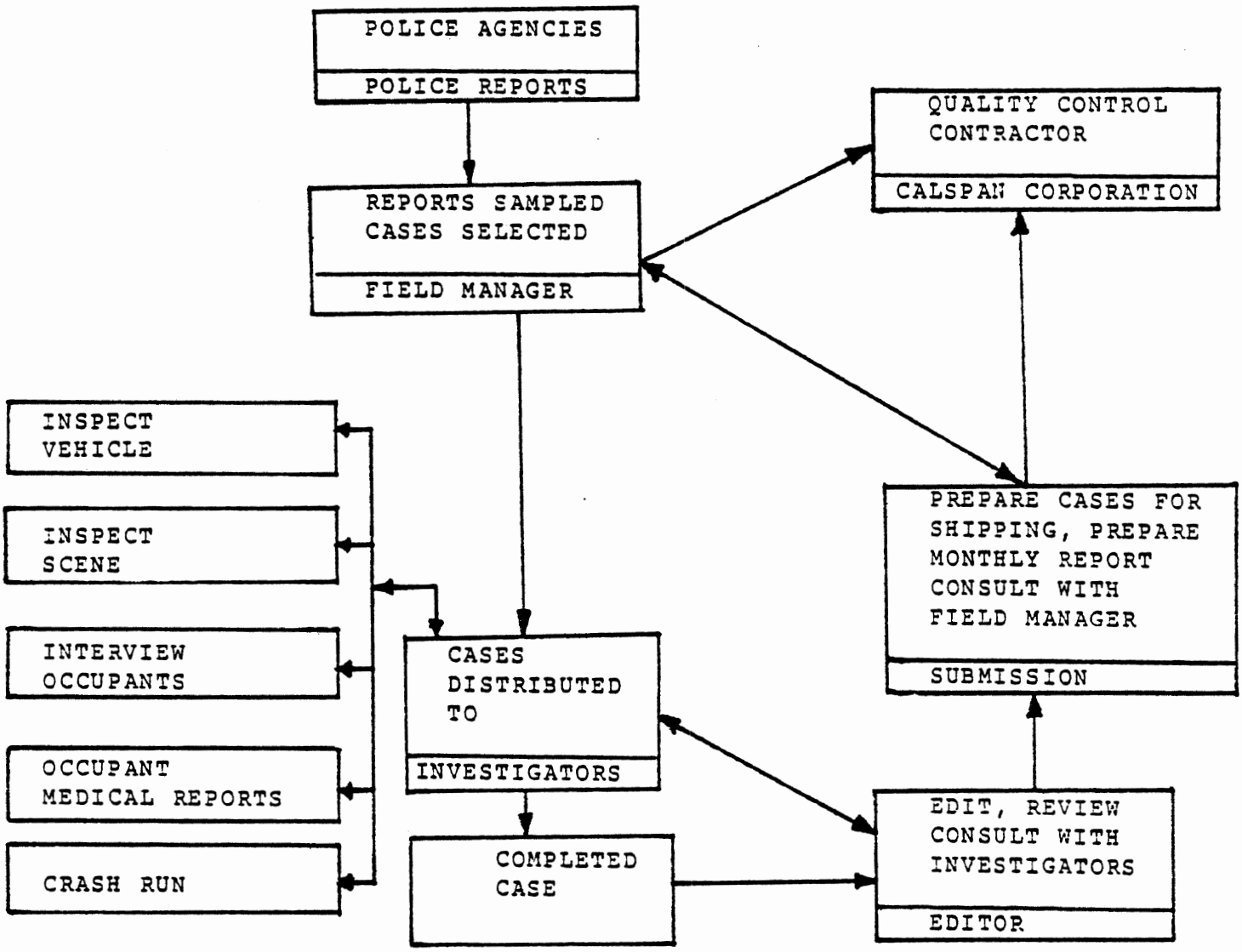
Procedures used to review cases at HSRI internally for correctness and consistency were not limited to the editing of completed cases, but rather were applied to a case from the time it was sampled until forwarded to the quality control contractor.

The basic process is outlined in the NCSS Case Flow chart and will be described herein in more detail. Various checks were made as a case progressed from the time it was initially selected until it was completed. Some of these checks were part of a system of continuous training while others were more related to quality control within a case.

Internal case review began with the process of selection of eligible traffic accidents as cases to be investigated for the NCSS. Police accident reports arrived at HSRI every morning, being brought in by one of our accident investigators, who would screen them for potentially elibible accidents. These same accident reports would then be screened a second time by the field manager during the process of accident sampling and case selection. When the eligible accident reports were handed out to individual investigators as work assignments they would be scrutinized once more. Many times police accident

NCSS CASE FLOW CHART

Figure 2



reports appearing to be eligible NCSS cases would be dropped due to information furnished by an investigator. The more common reasons for dropping a case, once initiated, were a vehicle reported to have been towed for damage which actually was driven from the accident scene; an occupant reported to have been hospitalized, actually turning out not to have been admitted to a treatment facility; or an occupant reported to have been transported to a medical facility who had not sought medical treatment or was transported. By making use of these checks, HSRI staff were able to provide an extra measure of assurance that the integrity of the sampling structure and the sample itself were maintained.

When possible, accident investigators worked in pairs. By working together, many tasks performed in the field could be more quickly accomplished. But more importantly, by working together the investigators would exchange opinions and ideas and be less likely to develop individual styles which might differ from established procedure or instructions as established for NCSS to achieve uniformity and consistency. These pairings would rotate at non-regular intervals, giving each investigator ample opportunity to work with every other investigator. In addition to working in the field with one another, accident investigators would also work with the field manager and the editor. At various times during the course of the NCSS project, the entire team would go to a towyard and select accident scenes to compare techniques, interpretation, and measurements of vehicles and scenes. Investigators would be critiqued by one another, by the field manager, and editor while at the scenes and tow yard and again when back at the office. Any differences among team members, in style, technique, or results, would be discussed in an attempt to standardize procedures used for NCSS accident investigation and data collection and maintain consistency within the HSRI NCSS team.

Besides improving and maintaining consistency of data, the system of pairing investigators and team practice investigation was used to train new investigators.

Once an eligible case was handed out to an investigator, that case would remain with that investigator until its completion. An

individual would be responsible for all aspects of a case except for the medical reports, which were picked up from treatment facilities by a member of the HSRI Bio mathematics department. This person would make copies of pertinent documents, extract needed information, and code injuries. Part of the investigator's job would be to review the medical report and double check the injury coding for any errors. The injury information and coding would be checked again once the completed case reached the editor. Investigators were encouraged to make notes and comments regarding any portion of a case where a question of interpretation might occur. These additional case notes proved helpful to the HSRI case editors and hopefully to editors at the quality control contractor, the Calspan Corporation.

At times during the course of the NCSS project it became necessary for the accident investigators to devote a majority of their time to investigation and inspection of vehicles and scenes. When this situation arose, other employees would be called upon to help out with interviewing occupants. At one point in the project, additional staff had to be assigned to NCSS solely for the purpose of conducting interviews. Two of these additional staff eventually became accident investigators. During this period, an investigator initiating the case would give instructions to an interviewer regarding questions to ask, in addition to questions on the standard interview form. These additional questions would frequently relate to vehicle position, driver actions, or other areas of inquiry that would give the investigator a better understanding of the accident as a whole. When interviews were completed, the investigator would get the case back for completion and be debriefed by the interviewer.

Though individual investigators were responsible for completing CRASH* computations for his or her cases, three people at HSRI were

*The CRASH II computer program, used to determine vehicle crash severity, was developed under a National Highway Traffic Safety Administration (NHTSA) contract with the Calspan Corporation of Buffalo, New York. The program was developed in an attempt to improve accuracy and uniformity in interpreting physical evidence from automobile accidents. The program is presently being used by the NCSS (National Crash Severity Study) and the NASS (National Accident Sampling System) projects sponsored by the National Highway Traffic Safety Administration as a method for grouping accident types and vehicle types by severity as defined by change in vehicle velocity in a crash.

most familar and experienced with the CRASH program, so they were often consulted prior to an investigator making use of the program. Investigators were also encouraged to discuss cases with one another and with the editor. In discussions regarding assigning CDCs (Collision Deformation Classification) to a vehicle, the vehicle heading, scene evidence, impact and rest positions would be reviewed, as well as other areas of information descriptive of the crash and pertinent to a CRASH computation. Oftentimes input from co-workers would enable an investigator to arrive at a more clear understanding of an accident.

The function of the editor in the NCSS project was multi-faceted. The editor's primary responsibility was to review cases prior to submission to the quality control contractor to assure that data was complete, consistent, and correct. The philosophy at HSRI was (and is) that the case editor should have a strong background in accident investigation as well as data handling. In order for an editor to be able to properly review a case, he or she should have a good understanding of the accident sequence, the paths traveled by the vehicles to impact and to rest, occupant kinematics, the NCSS accident investigation and data collection format, and NCSS forms. NCSS editors had previous experience as accident investigators prior to assuming editorial duties. In addition to the broader outlook an accident investigator would bring to the editing position, the experience of having investigated accidents enabled the editor to have a better appreciation of the problems, concerns, and daily routines of the other accident investigators. This investigative background, coupled with the time spent in the field with investigators working on individual cases, made for a better working relationship than would have been possible had the editor not had a background in data handling and processing.

Actual editing of a case was a process involving a number of elements. All forms within a case summary, vehicle, scene, interview,

medical, and special studies, had to be completed. Besides each data element being completed on each form, each element had to be correct and had to be reasonable when viewed in the case as a whole. Here again, editors with previous training as investigators had that ability to discuss a problem with an investigator regarding various factors of the case. The investigative background of the editor was particularly helpful in identifying data elements which, although correctly coded, might be questionable. For example, with a single vehicle that had been driven into a tree, it might be possible to have an occupant sustain a minor puncture wound in the area of the scapula. Because of his investigative background, the editor would question such an injury and resolve its accuracy with the the investigator. Since it would be unusual for an occupant in a frontal type collision to suffer a wound resulting from a sharp object to the rear of the torso, such an injury would be challenged. Though this injury could be valid in terms of coding based on interview and medical forms, it would be somewhat unexpected in terms of usual vehicle and occupant dynamics. There may have been a plausible explanation in this example, such as a protruding seat spring contacting the occupant, and it also may have easily been an error. Plausibility of data elements was as important in the review and edit process as the validity and consistency of data.

Once cases were edited and accumulated, coded information would be transferred to IBM-type key punch cards. Keypunch operators at HSRI are familiar with accident investigation data and it was not uncommon for the keypunchers to identify and correct mistakes within a case, while keypunching. This served as another check on potential errors.

The advent of Remote Data Entry (RDE) into NCSS was of significant assistance to NCSS editors. RDE was set up in such a manner as to not allow the entry of contradictory answers in a number of key areas. We believe the inclusion of RDE into NCSS significantly improved the overall quality of NCSS cases. In addition to improved data, the elimination of keypunching freed the editor to devote more time to individual cases and accident investigation.

Another editorial function was to act in a supervisory role within the team. Because of the nature of the position and familiarity with the NCSS coding manual, the editor would often be answering questions relative to interpretation, and in general providing information, clarification, and direction for accident investigators. In the event of the absence of the field manager, the editor would sample accidents and make case assignments, thus acting in a supervisory capacity. The editor was also responsible, along with the field manager and senior investigators, for the training of new staff investigators.

Preparation of quarterly reports and submission of reports, as well as maintaining the case log record from which case progress and work load was determined, was also an area where the editor provided major contributions.

3.6 Problems Experienced

Due to the experimental nature of the NCSS project, problems were anticipated and did occur. NCSS was the first attempt to organize and operate an accident sampling system on a nationwide basis; therefore some difficulties were expected. However, none of the difficulties experienced were of sufficient seriousness to threaten the functional operation of the project to satisfy overall NCSS goals.

The most basic problem was that of the sampling system itself. Due to the unpredictability of the sample on a daily basis, work could not be programmed ahead in time with any degree of certainty. This situation occasionally led to higher than normal missing vehicle rates because of our inability to investigate in one day all the cases that came in on a particularly "heavy" day.

Although casework would usually average out over the course of a quarter, it was not unusual for a week or longer to pass without the arrival of any new candidate cases. Nor was it unusual to investigate 15 cases in one week. This kind of unpredictibility led to unnecessary backlogging of the cases at certain times, and difficulty in utilizing personnel effectively through planning.

This problem was addressed in the NASS system by using the case stratification and sampling algorithm. This process leads to a predictable constant number of cases to be investigated every week. It allows for more effective management of personel and inhibits the "feast or famine" mentality among those directly involved in the investigation.

Training field investigators was also a problem area at times, particularly during later stages of the project. Preparatory training offered in 1976 was adequate to start the program. As personnel turnover changed the composition of the staff, no provisions were made for the training of new investigators except by in-house instruction and on-the-job training. Our solution was an in-house training program in which the more experienced investigators instructed new people.

This method did, in fact, train the new investigator in the basic techniques of accident investigations. But there were problems associated with it. The first difficulty is that it tends to perpetuate the biases and incorrect techniques of the older investigators. It also leads to the same mistakes in succeeding "generations" of investigators. The second problem is a slowdown in the productivity of the trainer/investigator. The trainer cannot work as quickly and efficiently as he could alone. This could lead to a backup of cases in his possession.

There were some problems associated with the NCSS team/Quality Control Monitor relationship. The standards and direction were sometimes ambiguous. This was to be expected in an experimental project like NCSS. Differences of opinion of fine points of procedure and interpretations were to be expected. When they arose they were handled with civility and tolerance on both sides. One area that caused some problem was the lack of timely feedback on problems. Since site visits were relatively infrequent, problems could develop for some time without our knowledge. Also the time period from case submission to positive feedback sometimes approached 8 months.

The last problem occurred during the last year of the project. Due to an increased awareness on the part of the hospitals in the area of their liability for release of medical records, some hospitals in Washtenaw and Lenawee Counties withdrew their participation in the NCSS project. The problem has been resolved by a new Michigan statute which releases hospitals from civil liability for their participation in highway safety research projects.

In conclusion, it must be reiterated that at no time did these problems ever compromise the daily operational efforts needed to meet project goals. They were more on the order of inconveniences and annoyances. Due to the strong support services of HSRI and the support of NHTSA and Calspan Corporation, the NCSS project was at no time in danger of failing in its basic purpose.

4.0 COMPILATION OF RESULTS

The following graphs present a visual representation of the work-product generated by the HSRI NCSS team. Figure 3 shows the number of cases sampled, dropped, and submitted in each quarter of operation. Figures 4 and 5 show the breakdown of submitted cases by sample category (eg. 100% 75% etc.). Figure 6 is a representation of the total number of special studies done during the course of their use in the NCSS project (1 May 79-31 March 80). Figure 7 shows the number of fatal accidents investigated during each quarter of the project. Figure 8 shows the usage of the CRASH II computer program during each quarter of the project.

Figure 3

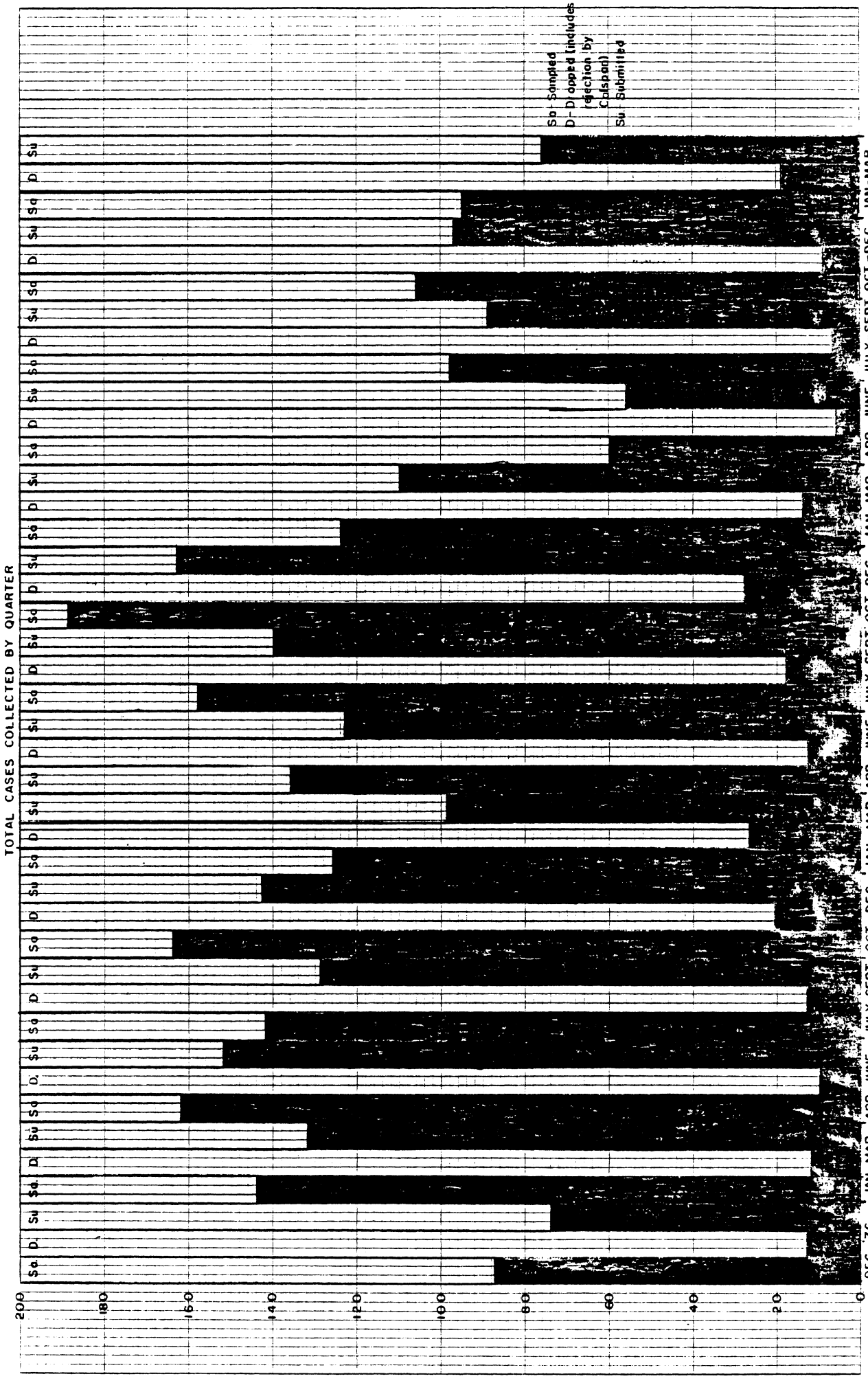

TOTAL CASES COLLECTED BY QUARTER
200
180
160
140
120
100
80
60
40
20
0
Sa- Sampled
D- Dropped (includes rejection by Calspan)
Su- Submitted
DEC. '76
JAN.-MAR. '77
APR.-JUNE '77
JULY-SEPT. '77
OCT.-DEC. '77
JAN.-MAR. '78
APR.-JUNE '78
JULY-SEPT. '78
OCT.-DEC. '78
JAN.-MAR. '79
APR.-JUNE '79
JULY-SEPT. '79
OCT.-DEC. '79
JAN.-MAR. '80

Figure 4

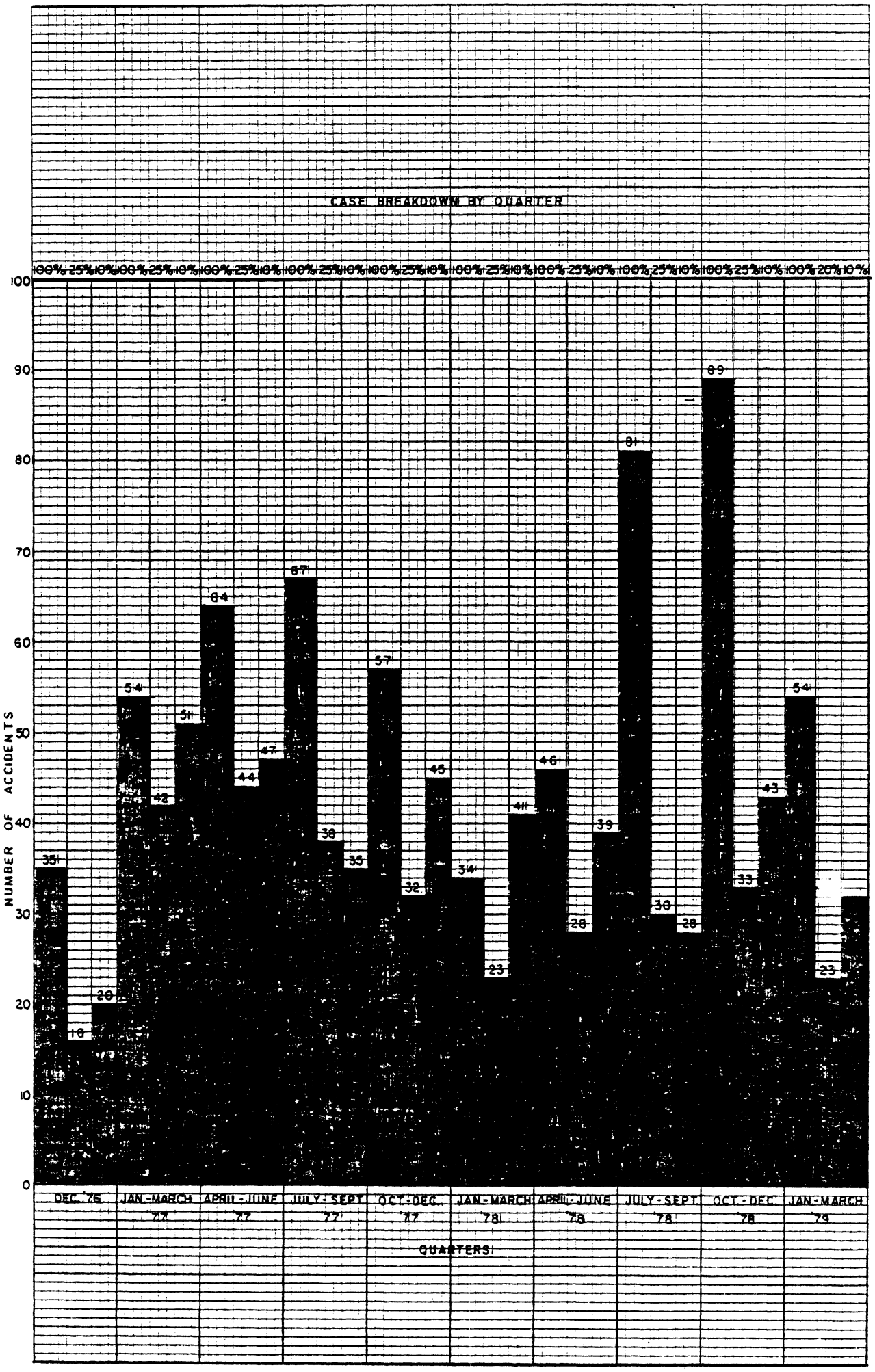

CASE BREAKDOWN BY QUARTER
100% 25% 10%
NUMBER OF ACCIDENTS
0
10
20
30
40
50
60
70
80
90
100
35
18
20
54
42
51
64
44
47
67
38
35
57
32
45
34
23
41
46
28
39
81
30
28
89
33
43
54
23
32
DEC. '76
JAN-MARCH '77
APRIL-JUNE '77
JULY-SEPT '77
OCT-DEC '77
JAN-MARCH '78
APRIL-JUNE '78
JULY-SEPT '78
OCT-DEC '78
JAN-MARCH '79
QUARTERS

Figure 5

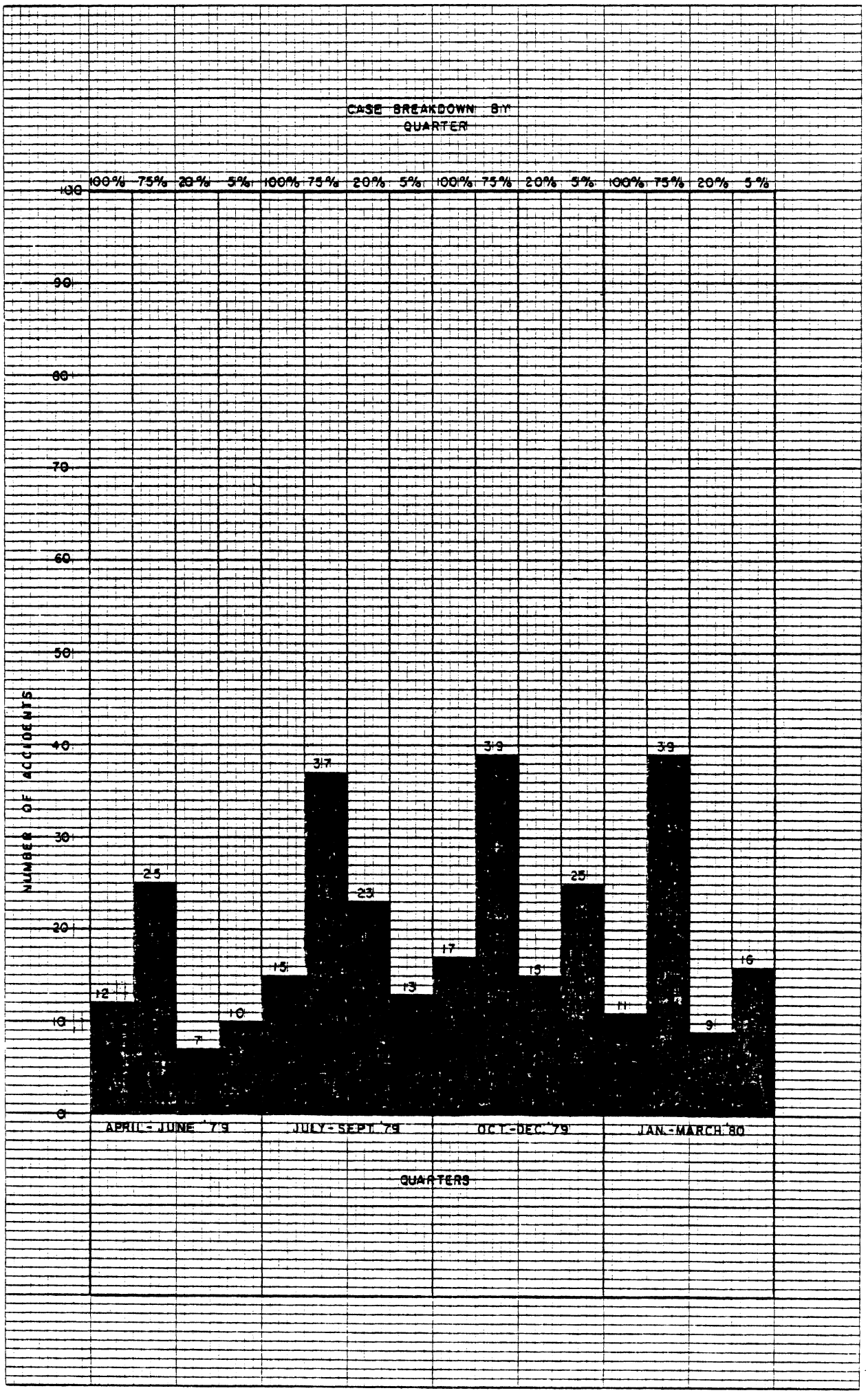

CASE BREAKDOWN BY QUARTER
100% 75% 20% 5% 100% 75% 20% 5% 100% 75% 20% 5% 100% 75% 20% 5%
NUMBER OF ACCIDENTS
0
10
20
30
40
50
60
70
80
90
100
12
25
7
10
15
37
23
13
17
39
15
25
11
39
9
16
APRIL - JUNE '79
JULY - SEPT '79
OCT - DEC '79
JAN. - MARCH '80
QUARTERS

Figure 6

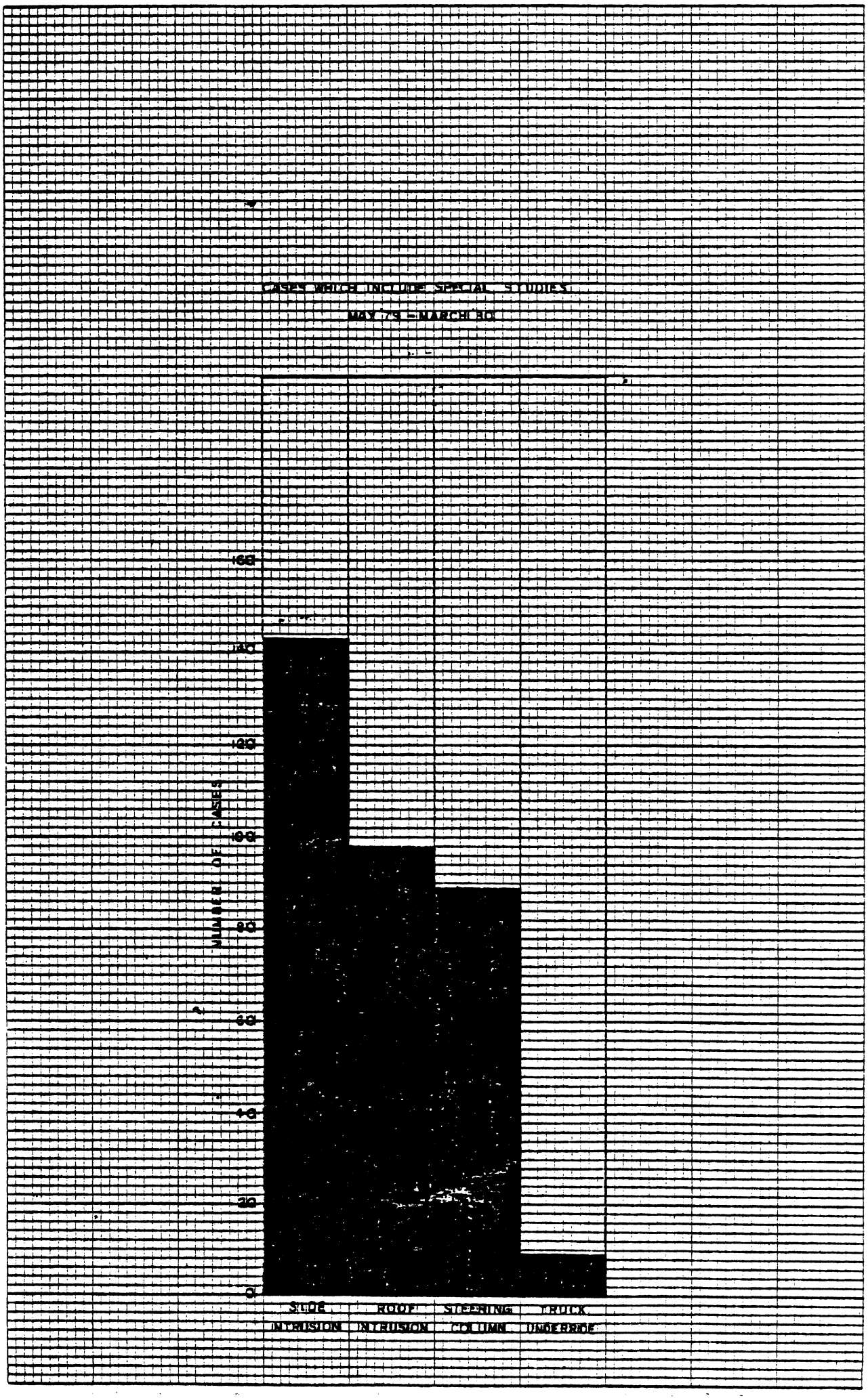
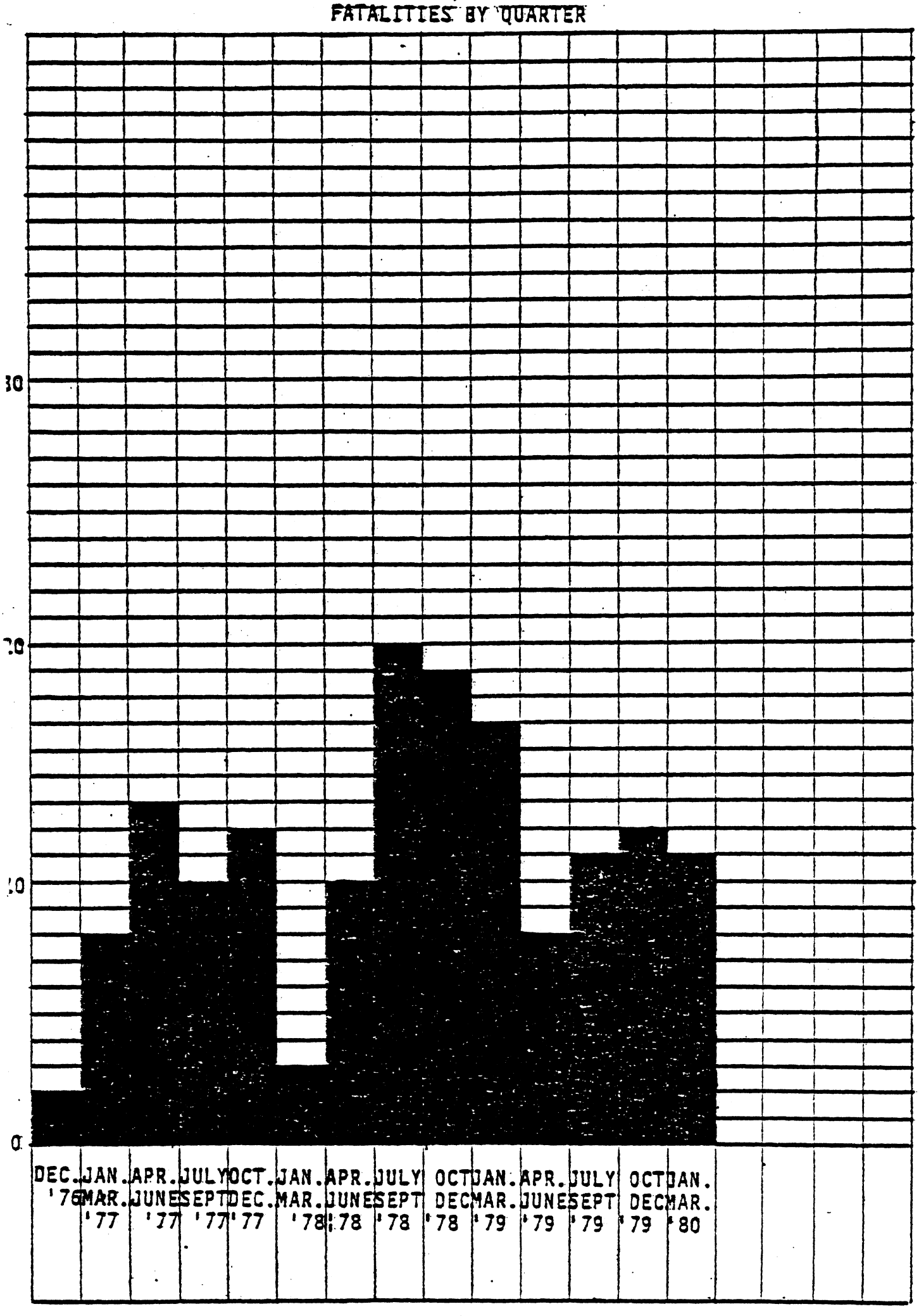
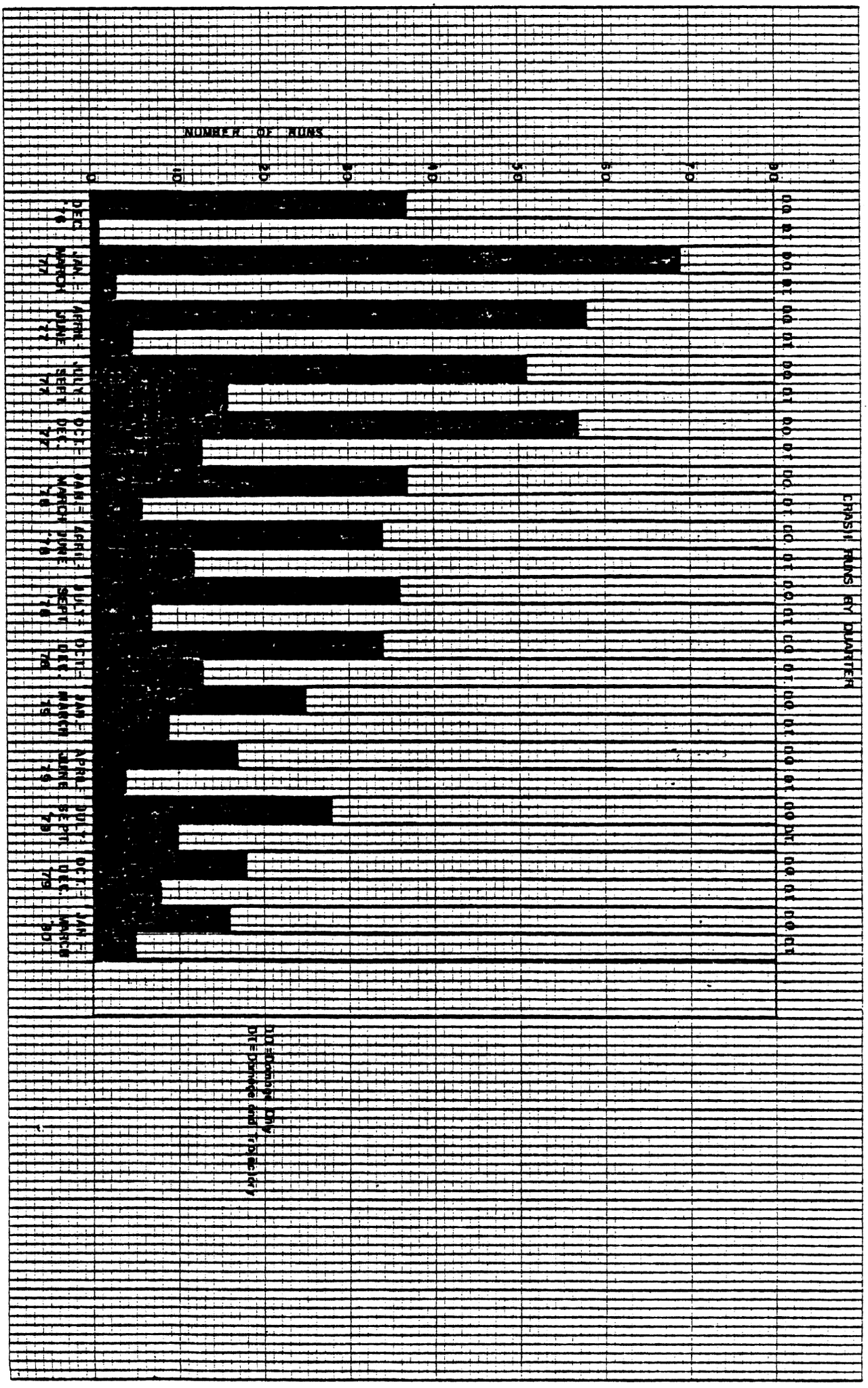

CASES WHICH INCLUDE SPECIAL STUDIES
MAY '79 - MARCH '80
NUMBER OF CASES
160
140
120
100
80
60
40
20
0
SIDE INTRUSION
ROOF INTRUSION
STEERING COLUMN
TRUCK UNDERRIDE

Figure 7


FATALITIES BY QUARTER
30
20
10
0
DEC. '76
JAN.-MAR. '77
APR.-JUNE '77
JULY-SEPT '77
OCT.-DEC. '77
JAN.-MAR. '78
APR.-JUNE '78
JULY-SEPT '78
OCT.-DEC. '78
JAN.-MAR. '79
APR.-JUNE '79
JULY-SEPT '79
OCT.-DEC. '79
JAN.-MAR. '80

47 0700



5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The development of NCSS into an effective, centrally controlled, sampled accident data program was accomplished while satisfying most expectations of the original NCSS design. In many respects NCSS was a learning process for both HSRI and NHTSA, as well as the other research contractors experienced in conducting accident investigations for research purposes. It served as a proving ground for new accident investigation protocols, many of these were improved and carried over into the National Accident Sampling System (NASS) program. In addition, NCSS demonstrated that numerous, dispersed professional accident investigation teams could be effectively managed so as to produce accident data of satisfactory completeness, accuracy, consistency, and detail to meet most of the program goals.

Conveying the importance of strict adherence to a system sampling plan, and following that plan without deviation, was in itself a significant achievement. This assured, to a large extent, the validity of the data acquired in terms of its geographical representativenes. We are confident that accident data obtained through NCSS will make an important contribution towards better understanding problems associated with drivers, vehicles, and roadways as they affect highway safety.

The two most serious deficiencies in the NCSS program, as reflected in the data obtained, are both related to sampling procedures. One was the lack of a specific, well-planned sampling design for each of the seven accident teams that had sufficient commonality so as permit an accurate projection of the data acquired to geographic regions represented by the seven teams. The three basic sampling strata, 100%, 25%, and 10%, were not interpreted precisely the same by all of the NCSS accident investigation teams. This could only be detrimental to the efficacy of the data.

The second deficient area was one of unpredictability of the accident case load. While the three strata candidate accidents and their sampling ratios did reflect an average number of crashes to be investigated, the actual daily and weekly number of eligible accidents could vary widely. This often created an erratic work load and inhibited planning to make the most effective use of team investigators.

5.2 Recommendations

To better improve future programs such as NCSS, the following recommendations are offered. To a large extent these have already been followed in the design and implementation of NASS.

1) It is recommended that a more structured sampling procedure be developed. Sampling should be unambiguous in the criteria used to establish case eligibility. It should be capable of being uniformly followed by different accident teams in various parts of the country.

2) More and better training of program accident investigators is recommended. While training was offered in NCSS, it left many areas where investigators were deficient, or where a lack of uniformity in certain portions of the accident investigations protocols existed. Individuals were left to proceed as they perceived the correct way, rather than in comformance with well-defined procudures and guidelines.

3) It is further recommended that the edit and evaluation process of accident data provide greater guidance back to individual accident teams, as well as individuals in those accident teams. This would help to remedy errors which are repeated because of a lack of guidelines or well-explained procedures.