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TEXAS
TRANSPORTATION
INSTITUTE

STATE DEPARTMENT
OF HIGHWAYS AND
PUBLIC TRANSPORTATION

COOPERATIVE
RESEARCH

EVALUATION OF THE TEXAS TRUCK WEIGHING PROGRAM

in cooperation with the
Department of Transportation
Federal Highway Administration

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STUDY 2-20-424-1F
TRUCK WEIGHING EVALUATION

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16. Abstract

This report documents the findings of an evaluation study of the Texas Truck Weighing Program. The evaluation included an analysis of the data from the six existing sites; the current and future data needs; the existing highway system and related truck traffic stream; statistical sampling techniques; and procedures for economic design sample distribution . The emphasis of the evaluation was on the data capture, data reduction and archiving procedures to satisfy the internal and external reporting requirements and planning, design and maintenance needs of the Department.

The evaluation resulted in a Truck Weighing Program that would increase the number of weigh-in-motion sites from six to twenty-six. These sites would be distributed across the State so as to capture the variability in the truck traffic stream from interstate to farm-to-market road classes, from high to low percentage of heavy trucks, and from region to region. The system design proposes several ways and formats to get the results into the hands of the user in a timely and efficient manner.

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EVALUATION OF THE TEXAS TRUCK WEIGHING PROGRAM

Final Report

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Research Report 424 -1F

Evaluation of The Texas Truck Weighing Program
Research Study Number 2-10-84-424

Sponsored by

State Department of Highways and Public Transportation
In Cooperation with the
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Federal Highway Administration

Texas Transportation Institute
The Texas A&M University System
College Station, Texas 77843

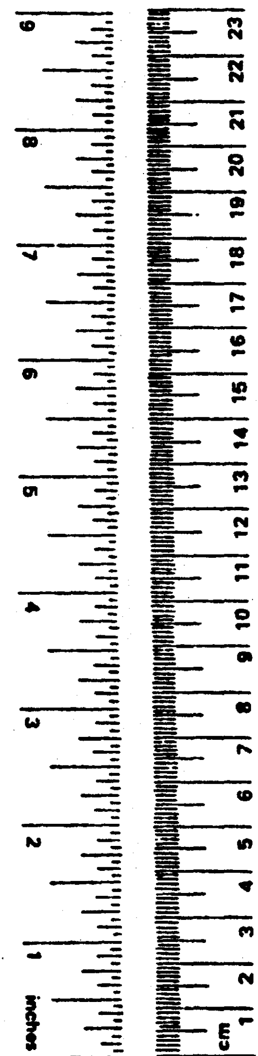
June 1985

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

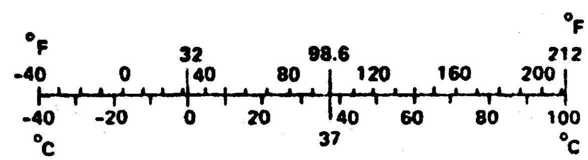
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2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

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



Approximate Conversions from Metric Measures

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



ABSTRACT

This report documents the findings of an evaluation study of the Texas Truck Weighing Program. The evaluation included an analysis of: the data from the six existing sites, the current and future data needs, the existing highway system and related truck traffic stream, statistical sampling techniques, and procedures for stratified sample distribution. The emphasis of the evaluation was on the data capture, data reduction and archiving procedures to satisfy the internal and external reporting requirements and planning, design and maintenance needs of the Department.

The evaluation resulted in a Truck Weighing Program that would increase the number of weigh-in-motion sites from six to twenty-six. These sites would be distributed across the state so as to capture the variability in the truck traffic stream from interstate to farm-to-market road classes, from high to low percentage of heavy trucks, and from region to region. The system design proposes several ways and formats to get the results into the hands of the user in a timely and efficient manner.

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Wyley Cunagin -- TTI, Associate Research Engineer
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DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the interpretation and accuracy of the data presented to support their conclusions. The contents do not necessarily reflect the official views or policies of the Texas Transportation Institute, The State Department of Highways and Public Transportation, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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INTRODUCTION

Goals, Objectives and Scope

The volume/classification/weight characteristics of the truck traffic using the Texas highway system are estimated by sampling the traffic stream using those highways. Volume counts are collected daily at 128 sites located along various highways within the State. Likewise there are also 206 volume/classification count stations where data are gathered and reported annually. The weigh component of this data collection effort is confined to six (as of August 1984) sites located along major highways with annual reporting of summary results. It is generally understood that the truck weighing program is inadequate and needs to be improved; however, additional sites and the manpower required to collect the data carry a high cost. The question then is: How should the Department employ its limited resources in gathering an improved truck weight sample.?

Thus from the very beginning, the goal of this research project was to evaluate the Texas Truck Weighing Program being conducted by D-10 Research with the expressed purpose of designing an enhanced Program that would more nearly serve the purposes of the Department. Since D-10 Research had been collecting weight data at the six sites and had some experience in the operation of Radian WIM equipment, it was decided to build upon this base in formulating the following research objectives:

1. Determine how many additional WIM sites would be needed to attain the accuracy required for the Department's internal planning, design and maintenance operations and the external reporting procedures.

2. Determine where these sites should be located and how often they should be visited. If possible, the six existing sites would be kept within the selected sites.

3. Design a system that would cover all operations from the time the data were generated by the WIM equipment (including the microcomputer used to collect the data and transmit them to D-19) to the time that the results would be furnished to the various users. The system should also satisfy the needs of the Department for both internal and external reporting.

D-10 continued to gather data and gain experience during the conduct of the project. However, the three objectives, agreed upon from the beginning, remained unchanged throughout the project.

Even though the focus of the research was concentrated on the WIM Program being conducted by D-10, a number of other factors influenced the results of the analysis. Internal and external reporting requirements, possible uses of the results, and the evolving state-of-the-art in weighing equipment and computers all had an effect on the results. In addition, the Department has ongoing programs in vehicle classification and traffic counting that can not be ignored in the design of a weighing program.

Relationship to Other Research

The relationship between truck traffic and roadway damage has recently become an issue of national concern. As the Nation's highways continue to deteriorate at an accelerated rate, more and more research effort is being put into the design of more resistant pavement structures. With the increased emphasis on dealing with this situation, a number of research studies have been initiated to learn more about the problem. There are studies to: correlate heavy truck traffic with pavement damage, to measure the incidence of special-use trucks, to develop and test weigh-in-motion equipment, and so forth.

This study interfaces with the studies underway in Texas in the following way. On one hand there are a number of hardware studies seeking to develop new vehicle counting, classification, and weighing hardware. The RTAP Project (The Seguin Equipment Experiment) helped to demonstrate the viability of the Radian weigh-in-motion (WIM) equipment. On the other hand there are projects which make use of use weight data. These would include the Pavement Damage Assessment type projects which require detailed data not furnished by the existing procedure -- in spite of the fact that these data **are** being collected. At the other extreme, Economic Effects type studies require background and trend data. Finally there are studies which suggest changes in equivalent axle-load estimation procedures. The Oil Field Truck Traffic (2-299) study gave focus to the need to study special-use truck traffic in localized areas. The Special Use Truck (2-420) study demonstrated the need to segregate the truck traffic stream into a "baseline" count plus one or more special uses.

Research Study Activities

The research study was organized into ten specific tasks for administrative and work assignment purposes. The results from each of these tasks had an effect on the final result. The task description and the effect on the final result are summarized below.

Task 1. Review Existing Procedures

The first step was to determine how truck weight/classification data were being collected. Project staff visited several of the permanent collection sites and observed the process from start to finish. This experience influenced all phases of the study, especially the final design.

Task 2. Review Existing State-Of-The Art

This was accomplished in two ways: first, project staff conducted a detailed literature search, and second, project staff examined first hand, portable and permanent type WIM equipment. This is also reflected in the final design.

Task 3. Determine Areas of Vehicle Concentration

The areas of greatest vehicle traffic concentration are known to the Department and displayed upon readily available maps. These maps were used in the design of the site distribution procedure.

Task 4. Determine Areas of Heavy Truck Concentration

Some of the results from the Special-Use Truck study and the existing Departmental classification data from 1982-1983 were used during the design of the site distribution procedure.

Task 5. Stratify Concentration by Functional Classification

The traditional functional classes were divided into four road classes as suggested by a recent FHWA research report. District highway maps were used to determine the road-miles of each class per district and by percent combination vehicles.

Task 6. Determine System Requirements.

External and internal reporting requirements for the system came from the literature search conducted in Task 1 and first-hand knowledge of the Department's procedures; the design of the data flow came from observation of the existing procedures; and equipment specifications from the equipment in use at the time of the study.

Task 7. Develop Candidate Systems
Task 8. Select Implementation Approach

These two tasks were combined for two reasons. First, the final system is essentially an enhancement of the existing system. Second, most of the suggested enhancements were implemented as the project progressed. These enhancements specify that the data be archived and reported in several new formats to serve the needs of a variety of users.

Task 9. Develop Estimation Procedure

The results of this task are based upon the work in Tasks 1-6 and are covered in the two following sections of this report.

Task 10. Design Implementation Plan

Except for a few suggestions developed during the final draft of this resort, all enhancements to the Truck Weighing Program were implemented by D-10 research during the conduct of the project.

Summary of Results

The results of the study are covered in the following three sections of the report. Although work on all three sections proceeded in parallel (in fact a preliminary design of the proposed system was completed before the sampling procedure was completed), they are reported as though they occurred in sequence. The first step is to determine the number of sample sites to achieve the required accuracy. Second, distribute the sites across the state in a rational pattern. And finally, describe a system to collect, store, etc. the data so that it can be used to its best advantage.

NUMBER OF SITES

The primary purpose of the Truck Weighing Program is to capture, as much as possible, the variability in truck weights and types on various functional highway classes and traffic volumes. In this way a relatively small sample will yield representative results for the entire state. The critical "sample size" for truck weight data is the number of sampling sites, not the number of trucks. The equally important companion problem of distributing the sample sites in a random way is covered in the next section.

The first approach for estimating the sample size (called the Standard Method) resulted in a unrealistically large number of sites. This method assumed that neither geography, functional class, nor traffic volume was variable. Secondly, the truck weight distributions on which it was based are bimodal (see Figure 1); this causes the variance to be larger than the scatter in the data would indicate and this in turn caused the large sample size. The second approach (called the Economic-Design Method) resulted in a much more acceptable number of sites. Both of these two methods are described below.

Standard Method

The following equation illustrates a standard statistical technique for estimating sample size required to achieve a desired level of error for the average of a number of samples.

$$\text{Number of Sites} = \frac{(z \times \text{COV})^2}{(\%\text{-Error})^2}$$

Where:

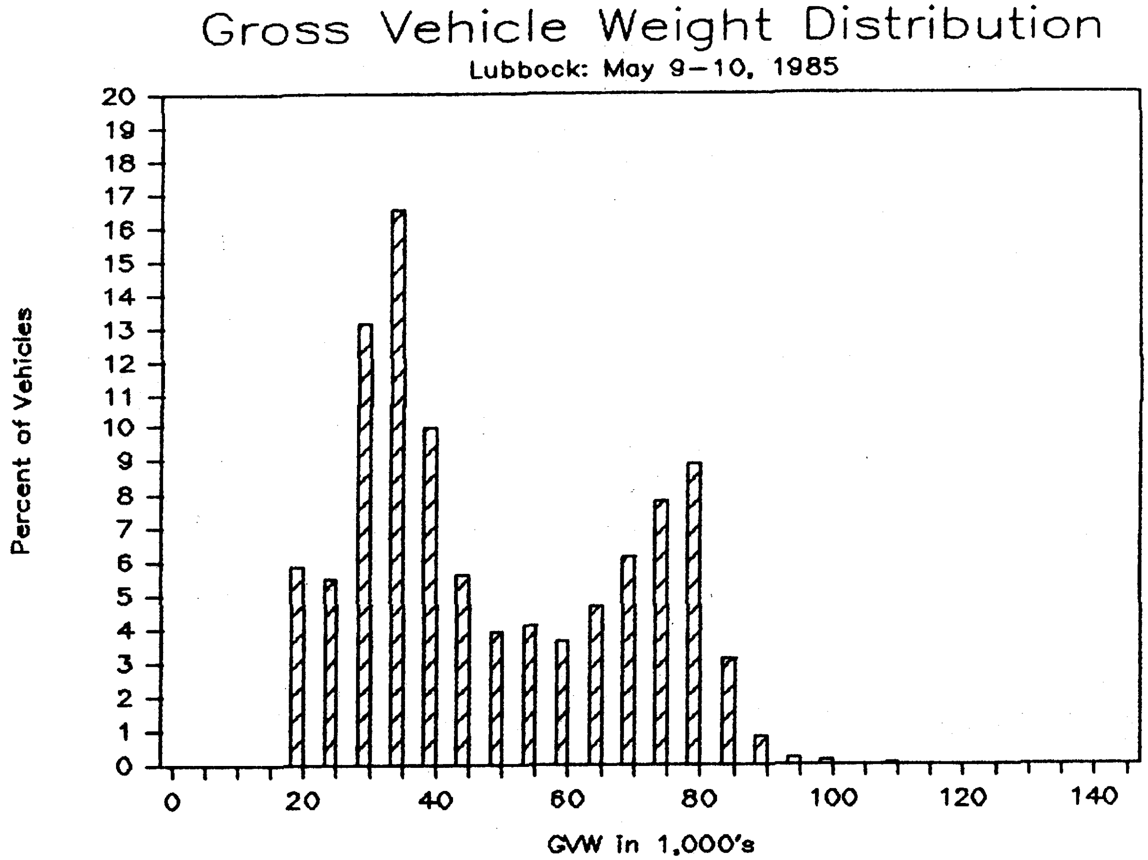
z is a tabular value associated with a 95% level of confidence.

COV is the Coefficient of Variation; the ratio of the Standard Deviation and the Mean of a distribution of values. The Mean is used as the point estimate of a value and the standard deviation is a measure of scatter in the data.

%-Error is the ratio of tolerable error in gross vehicle weight to the mean weight. For example, if the mean weight is 30,000 pounds and an error in the weight is 3,000 pounds, then the percent error is 10%

The procedure for determining the sample size involves estimating the coefficient of variation for the parameter to be estimated. This can either be estimated from a small sample or from data from other sources. Since no data were available from the Texas Program, national averages were obtained from an FHWA report. The next step is to determine the percent error to be tolerated for each road class. This is usually an administrative decision. Once these are in hand, the sample size is determined by substituting into the above equation. The results are shown in the Table 1.

FIGURE 1


Gross Vehicle Weight Distribution
Lubbock: May 9–10, 1985
Percent of Vehicles
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
20
40
60
80
100
120
140
GVW in 1,000's

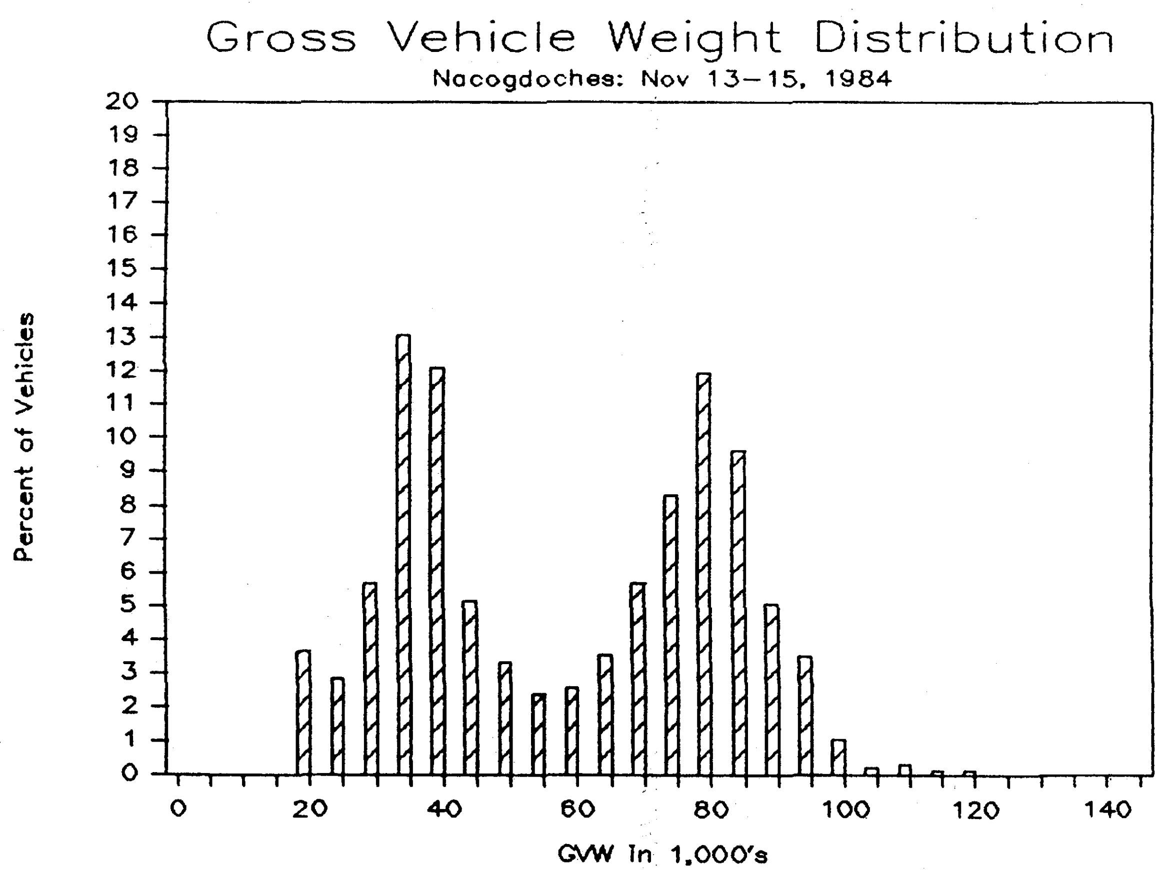

Gross Vehicle Weight Distribution
Nacogdoches: Nov 13–15, 1984
Percent of Vehicles
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
20
40
60
80
100
120
140
GVW in 1,000's

Table 1: Number of Sites by Road Class - Standard Method

Road Class	%Error	Sites
1. Interstate	10	18
2. US Numbered	20	20
3. Texas Numbered	30	17
4. Farm-to-Market	40	19
Total		74

Economic-Design Method

Based on Kish (1965), the following formula can be used (when an estimate of scatter in the means is available from existing data) to determine the minimum number of sites required for the desired level of error:

$$\text{Number of Sites} = \frac{(1 - f) \times S_m^2}{(d/z)^2} \qquad \text{or approximately} = \frac{S_m^2}{(d/z)^2}$$

Where:

f is the fraction of trucks to be sampled. Since this is very small, when compared to the total number of trucks in the traffic stream, the second equation is used.

S^2_m is the known variance in the mean truck weights among the different locations across the state.

d is the desired error margin in estimating the mean truck weight in pounds.

z is the normal variate corresponding to the 95% confidence interval.

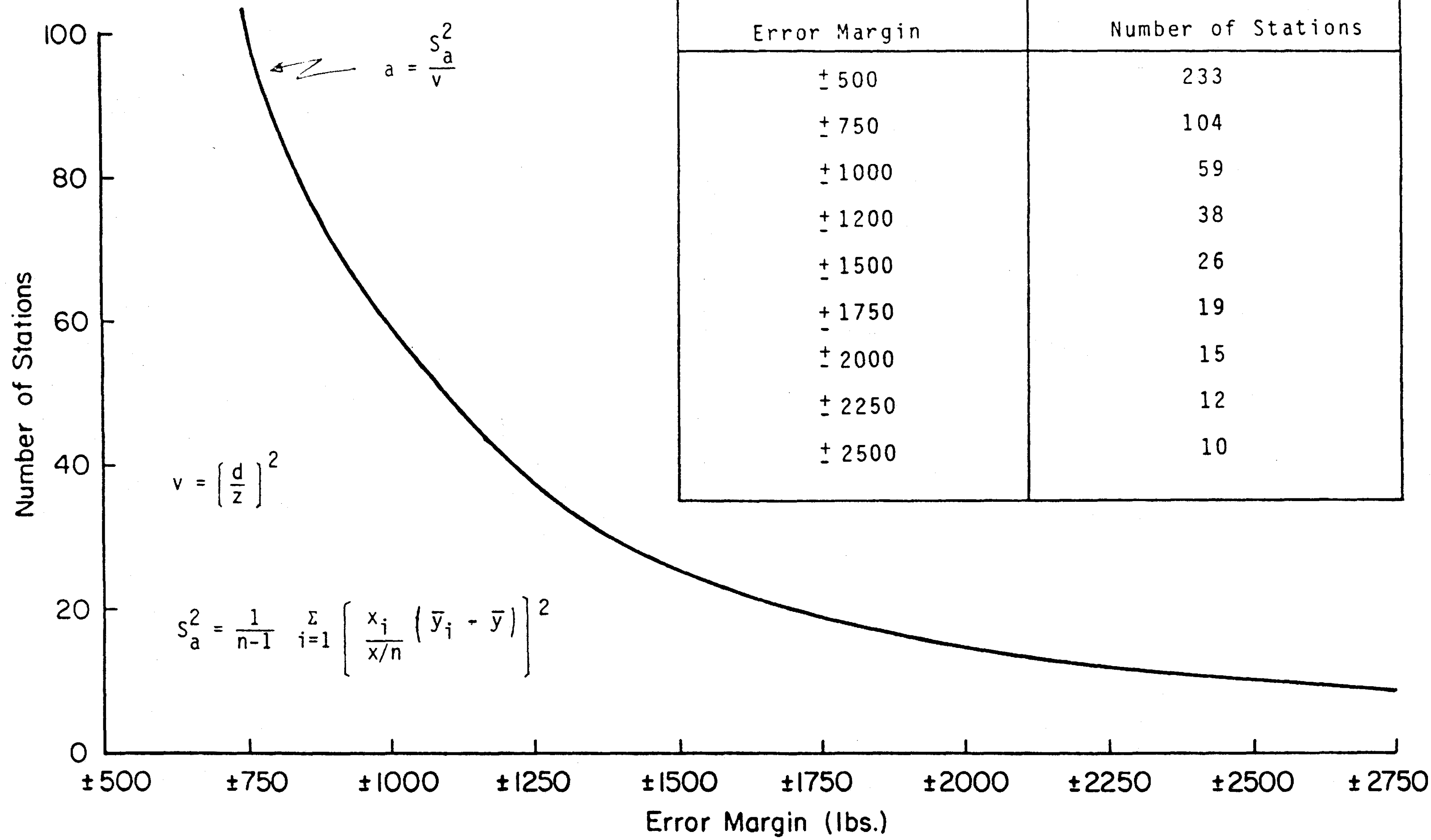
S_m^2 is the assumed known variance in the mean truck weights from different locations across Texas. In this case from stations at Lubbock, Nacogdoches, San Marcos, Seguin and Sweetwater, prior to August 1985. The value used in this analysis was 1.512×10^7. Figure 2 shows the optimal number of WIM sites required for different margins of error based on the above equation.

The recommended number of weight stations, as determined from this curve is, 26 for a estimated margin of error equal to + or - 1,500 pounds in the mean weight. The number for a 1,000 pound marginal error is about sixty. This is well within the accuracy of the existing WIM equipment. The number of WIM sites for each road class should be determined independently according to the procedure described above. Since truck weight data by road class were not available, sites were distributed by relative truck traffic volumes. The results are shown in Table 2.

Optimal Number of Weight Stations

Required by Various Error Margins

Error Margin	Number of Stations
± 500	233
± 750	104
± 1000	59
± 1200	38
± 1500	26
± 1750	19
± 2000	15
± 2250	12
± 2500	10



OPTIMAL NUMBER OF WEIGHT STATIONS BY DESIRED ACCURACY LEVELS

FIGURE 2

Table 2: Number of Sites by Road Class - Economic-Design Method

Road Class	Sites
1. Interstate	10
2. US Numbered	6
3. Texas Numbered	6
4. Farm-to-Market	4
Total	26

This distribution is based upon the idea that more trucks travel on the Interstate System than on any other, that US and Texas numbered routes have 60-percent of the Interstate travel, and that the remainder of the trucks are on Farm-to-Market routes. The number of sites per roadway class can be corrected as soon as data are available to do so.

LOCATION OF SITES

The 26 weight station sites, or for that matter, any number of sites greater than the 26 minimum, need to be distributed around the state so as to prevent a particular region, road class, functional class, or volume class from being over or under represented. The following procedure was used to distribute and locate the 26 sites and can be used to add sites as the situation demands. The procedure is a two step process. First, determine the proper distribution of the sites; then, locate the sites with respect to the existing vehicle classification.

Distribution of Sites

Different regions within Texas are impacted by differences in industrial truck traffic. Agricultural products not only differ regionally but seasonally by region. Oil field traffic varies by region and by economic conditions. The division of Texas into regions will help account for some of these variations. Finally, to aid in the administration of the program, regional boundaries were made to coincide with District boundaries. As a result, Texas is assumed to be made up of five regions: West, Northwest, North, East, and South, as shown on Figure 3.

There is a suspicion that the relative weight of heavy trucks increases with the percent of heavy trucks in the traffic stream; that is, the larger the percentage of trucks, the larger the percentage of heavy trucks. Because combination vehicles constitute the bulk of the heavy truck traffic, the percent of combination vehicles was used to represent the traffic stream of heavy trucks. Three levels of usage were assumed to exist: low, less than 8 percent combination vehicles; medium, between 8 and 16 percent; and high, greater than 16 percent.

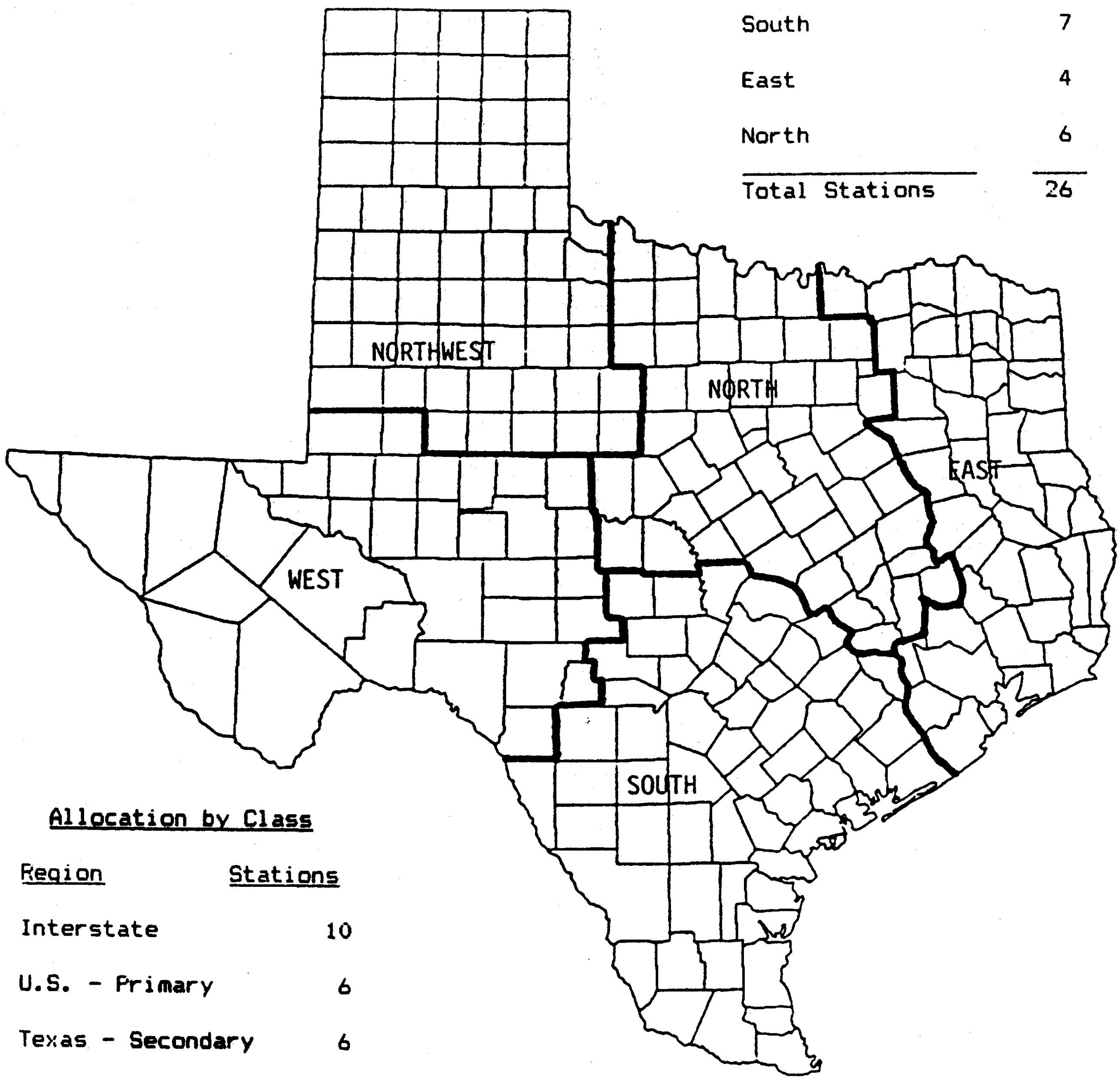
After the regions and percent truck levels were determined, the next step was to estimate the relative distribution of road class (miles) by region and by percent truck. Road class mileages subject to the three levels of truck use were estimated from the 206 vehicle classification stations and road class mileages by region from the District highway maps. Tables 3 and 4 show the results of this analysis.

The fractions in Table 3 were computed by dividing the total number of miles for a particular road class into the number of high, medium, and low percent-truck miles for each region. For example, 21.6 percent of all Interstate road miles occur in the West and 13.5 percent of all Interstate miles occur in the East and have a high percentage of heavy trucks. Table 4 resulted from multiplying each road class fraction by the fraction that roadway class is of the total. That is, of all of the road miles, 2.4 percent are in the Northwest and have a high percentage of combination vehicles.

A final allocation of sites to the various combinations of regions and percent trucks can be made by multiplying the number of sites by the factions in Table 4 and rounding to the nearest whole number. These allocation numbers are shown in Table 4(a). These numbers were then used as bases for a random allocation of the 26 sites to various regions and percent trucks as shown in Table 4(b). Each allocation number in Table 4(a) was used to allocate the rows

Allocation by Region

Region	Stations
Northwest	5
West	4
South	7
East	4
North	6
Total Stations	26



Allocation by Class

Region	Stations
Interstate	10
U.S. - Primary	6
Texas - Secondary	6
FM - Collector	4
Total Stations	26

REGIONS FOR TRUCK-WEIGHT DATA COLLECTION

TABLE 3: DISTRIBUTION OF ROAD CLASS BY TRUCK TRAFFIC AND REGION

Region	Percent Truck	Road Class			
		Interstate	US	Texas	FM
Northwest	High	.062	.090	.036	.046
	Medium	.046	.106	.036	.023
	Low	.015	.016	.072	.139
West	High	.225	.048	.028	.059
	Medium	--	.108	.083	.029
	Low	--	.072	.028	.059
South	High	.101	.061	.044	.010
	Medium	.101	.081	.094	.058
	Low	.017	.092	.143	.164
East	High	.135	.028	.033	--
	Medium	.054	.077	.059	.017
	Low	.027	.065	.145	.205
North	High	.078	.026	.017	--
	Medium	.062	.085	.059	.028
	Low	.047	.042	.122	.163
Total		1.000	1.000	1.000	1.000

TABLE 4: DISTRIBUTION OF SITES ACROSS ALL VARIABLES

Region	Percent Truck	Road Class				$\sum_i P_{ijk}$
		Interstate	US	Texas	FM	
Northwest	High	.024	.021	.008	.007	.060
	Medium	.018	.024	.008	.004	.054
	Low	.006	.004	.017	.021	.048
West	High	.098	.011	.006	.009	.124
	Medium	--	.025	.019	.004	.048
	Low	--	.017	.006	.009	.032
South	High	.039	.014	.010	.002	.065
	Medium	.039	.019	.022	.009	.089
	Low	.007	.021	.033	.025	.086
East	High	.052	.006	.008	--	.066
	Medium	.021	.018	.014	.003	.056
	Low	.010	.015	.033	.032	.090
North	High	.030	.006	.004	--	.040
	Medium	.024	.020	.014	.004	.062
	Low	.018	.010	.028	.025	.081
$\sum_j \sum_k P_{ijk}$		.386	.231	.230	.154	1.000

Table 4 [a]

Allocation Indices and Allocation Numbers by Percent Truck Traffic and Region

Region	Percent Truck	Allocation Index	Allocation Number
Northwest	High	1.560	2
	Medium	1.404	1
	Low	1.248	1
West	High	3.224	3
	Medium	1.248	1
	Low	0.832	1
South	High	1.690	2
	Medium	2.314	2
	Low	2.236	2
East	High	1.716	2
	Medium	1.456	2
	Low	2.340	2
North	High	1.040	1
	Medium	1.612	2
	Low	2.106	2
TOTAL		26	26

Table 4(b)

Random Allocation Matrix and Selection Units

Region	Percent Truck		Road Class																									
			Interstate										US						Texas						FM			
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Northwest	High	1						X								X												
		2										X																X
	Medium	3																			X							
	Low	4																										
West	High	5											X															
		6																		X								
		7			X																				X			
	Medium	8																										
	Low	9																										
South	High	10	X																									
		11									X																	
	Medium	12															X											
		13																										
	Low	14																	X							X		
		15								X														X				
East	High	16																										
		17																										
	Medium	18												X														
		19		X																								
	Low	20							X													X						
		21																										
North	High	22													X													
	Medium	23																					X					
		24				X																						
	Low	25																X									X	
		26					X																					

X denoted selected cells

TABLE 5

Number of Weight Stations Required by

Road Class, Percent Truck Traffic, and Region

Region	Percent Truck	IH	US	Texas	FM
Northwest	High	2	1	-	1
	Medium	-	-	1	-
	Low	-	-	-	-
West	High	1	1	1	1
	Medium	-	-	-	-
	Low	-	-	-	-
South	High	2	-	-	-
	Medium	-	1	1	-
	Low	1	-	1	1
East	High	-	-	-	-
	Medium	1	1	-	-
	Low	1	-	1	-
North	High	-	1	-	-
	Medium	1	-	1	-
	Low	1	1	-	1
TOTAL		10	6	6	4

TABLE 6

Number of Existing Manual Count Stations By Percent Truck Traffic, Road Class, and Region

Region	% Truck Traffic	Road Class				Total
		Inter-state	U.S.	State	FM	
Northwest	High	(4)	(11)	2	(2)	19
	Medium	3	13	(2)	1	19
	Low	1	2	4	6	13
West	High	(6)	(4)	(2)	(2)	14
	Medium	-	9	6	1	16
	Low	-	6	2	2	10
South	High	(6)	12	9	1	28
	Medium	6	(16)	(19)	6	47
	Low	(1)	18	(29)	(17)	65
East	High	5	7	5	-	17
	Medium	(2)	(19)	9	1	31
	Low	(1)	16	(22)	12	51
North	High	5	(10)	4	3	19
	Medium	(4)	32	(14)	4	54
	Low	(3)	(16)	29	(23)	71
	Total	47	191	158	78	474

of Table 4(b) each combination of region and percent truck traffic. For example, the allocation number for **Northwest** and **High Percent Truck** (Table 4(a)) was two, which resulted in two rows of Table 4(b) being assigned to Northwest and High Percent Trucks. Next randomly select one row for each of the 26 columns of Table 4(b) - based upon Yoo and Reiss (1977). A summary of the complete result is shown in Table 5. If additional sites are added to the system at a later date, Table 4 provides a basis for determining a revised Table 5.

Selection of Sites

Preliminary locations for weight station sites from Table 5 should be selected in some systematic manner. Of the several ways to do this, the simplest is to select from the list of classification stations until the conditions in Table 5 are satisfied. The first step of this process is to sort the 474 classification count locations for the 206 classification stations into the same categories as Table 5; that is, by region, by road class and by percent trucks. (The differences are caused by counting trucks at all legs of an intersection, if the site is located at an intersection. Some are; some are not.) The results of this operation are shown in Table 6. The second step is to circle the cells in Table 6 that have non-empty cells in Table 5; that is, the cells where sites are required. Finally, randomly pick sites from the "circled" cells. This does not guarantee a selection that represents maximum variability in truck types, a major weakness

A better way is to rank order the sites within the circles, such that the sites with the more diverse truck types are toward the top. For this purpose four different truck configurations were considered: single-unit, truck and tractor, semi-trailer, and doubles. Sites where then selected at random from the ordered lists within the "circled" cells until the distribution of Table 5 was satisfied. If a site selected by this technique, is determined to be infeasible upon field inspection, then the next site in the list is picked. The final list of sites is shown in Table 7; the complete list of rank ordered sites appears in Appendix C.

TABLE 7

LOCATIONS SELECTED FOR TRUCK WEIGHT STATIONS

Region	Highway Number	Percent Truck	Station Code	District	County	Remarks
Northwest	IH 40	31	M 1083	4	Oldham	IH 40 - West of Adrian
Northwest	IH 40	30	MS 1	1	Wheeler	IH 40 - East of Shamrock
Northwest	US 82	20	L 149	25	King	US 82 - South of Guthrie
Northwest	SH 350	15	M 1105	8	Howard	SH 350 & FM 820 NE of Big Spring
Northwest	FM 1058	23	M 1094	4	Deaf Smith	US 385, FM 1058 & 1062 S of Vega
West	IH 10	35	MS 152	24	Hudspeth	IH 10 West of Van Horn
West	US 277	21	M 1003	7	Edwards	US 277 & SH 55 South of Sonora
West	US 137	21	M 1103	7	Glasscock	SH 158 & 137 West of Garden City
West	FM 181	23	M 1100	6	Ector	SH 302, SH 158, & FM 181 NW of Odessa
South	IH 37	22	L 371	16	Live Oak	IH 37 North of Three Rivers
South	US 83	7	M 1159	15	Zavala	US 83 & FM 1025 - N of Crystal City
South	IH 10	24	MS 164	3	Fayette	IH 10 East of Schulenburg
South	US 57	14	M 1130	15	Frio	US 57 & FM 140 NW of Pearsall
South	SH 123	9	M 1498	15	Wilson	SH 123 & FM 1681 North of Stockdale
South	SH 71	6	M 904	14	Bastrop	SH 21 & 71 West of Bastrop
South	FM 140	8	M 1130	15	Frio	US 57 & FM 140 - NW of Pearsall
East	IH 10	10	M 1200	12	Harris	IH 10 West of SH 6 Houston
East	IH 45	7	MA 16	12	Harris	IH 45 - N or Houston
East	US 59	15	L 72	11	Nacogdoches	US 59 - South of Nacogdoches
East	SH 155	7	M 72	10	Smith	US 271 & SH 155 - NE of Tyler
North	IH 35	15	M 1149	18	Denton	IH 35W N of SH 114 Interchange
North	IH 20	7	M 1181 or 1180	18	Dallas	IH 20 West of Dallas

TABLE 7 - CONTINUED

Region	Highway Number	Percent Truck	Station Code	District	County	Remarks
North	US 82	22	M 278	3	Baylor	US 82 & 183 West of Wichita Falls
North	US 277	6	M 167	3	Wichita	US 287 Wichita River Bridge
North	SH 14	14	M 1144	17	Robertson	SH 6 & 14 South of Bremond
North	FM 407	8	M 1089	2	Wise	US 287 & FM 407 - SE of Decatur

DATA COLLECTION SYSTEM

This section describes an enhanced procedure for collecting, reducing, and analyzing heavy truck data using the Texas Truck Weighing Program. The discussion builds upon the procedure in use prior to this project and suggests certain additions and corrections to it in light of the findings of this effort. This discussion is based upon the use of the existing WIM equipment being used by the Department. Experience gained using this equipment should be a key factor in establishing standards for subsequent equipment purchases.

The following discussion is divided into two sections, each of which is in turn split into several topics. First, a discussion of the types of data analysis that the enhanced system will support. The purpose of this discussion is to show how the data collected by the Texas Truck Weighing Program can be used to satisfy the Department's needs. Second, a discussion of how the existing system for stratifying data could be simplified and still meet weight data reporting and analysis requirements. And finally, a stepwise description of the overall system, including the procedures and equipment necessary for implementation. The purpose of this is show how the Department can improve the collection, analysis, and storage of the data.

INFORMATION REQUIREMENTS

The State Department of Highways and Public Transportation (SDH&PT) expends a great deal of effort collecting traffic data to satisfy a wide variety of internal and external needs. Among other things, the Department routinely collects data on traffic volumes, vehicle classification, and truck weights in response to these needs:

Internal needs include: estimates of annual average daily traffic (AADT), vehicle-miles traveled (VMT), and equivalent axle loads (EAL) for specific roadway segments as well as averages for functional classes and regions. These are used to design new facilities, program maintenance, and so forth.

External needs include data used by other State agencies and the Federal Government, especially the United States Department of Transportation. This information is used to trace national trends, develop reports to Congress, plan for future transportation programs, and assess the effectiveness of existing national programs.

Table 8 contains a summary of traffic data (volume, classification, and weight) requirements usually associated with these needs. This is not intended to be an exhaustive examination of data uses but instead a description of data requirements covering the broadest possible span of individual uses. An analysis of the data requirements in Table 8 shows that three general types of traffic data are required.

Background data are essentially state wide averages for AADT, Vehicle Classification, Vehicle Speed, and Vehicle (and axle group) Weight. These may be also be categorized by functional class, by region, or by urbanized area. This can be thought of as <u>planning type data</u>.

TABLE 8: HEAVY TRUCK TRAFFIC DATA REQUIREMENTS

Departmental Function		Traffic Volume	Classification	Truck Weight
Roadway Management & Maintenance	Maintence	Site Specific AADT	Average by Functional Class	Average EAL by Functional Class
	TSM Projects	Site Specific AADT & Turn Volumes	Average by Functional Class	None
	Safety	Site Specific AADT & Turn Volumes	Average by Functional Class	None
	Environmental Impact Statmnt	Site Specific AADT & VMT	Site Spececific by Functional Class	None
	Enforcement	Site Specific AADT	Site Specific by Special Use	Vehicle Specific Weight & Size Data
System Planning & Design	Trend Analysis	AADT and VMT by Functional Class	Ave Veh Class by Functional Class by year	Ave EAL by Vehicle Class By Functional Class
	Project Programming	Site Specific AADT & VMT	Site Specific Vehicle Class	Ave EAL by Functional Class
	Project Design	Site Specific AADT and Functional Class	Site Specific Vehicle By Veh and Func Class	Site Specific EAL´s
	Environmental Impact Statmnt	Site Specific AADT & VMT	Average Vehicle Class by Functional Class	None
Administrative & Research	Research	AADT and VMT by Functional Class	Vehicle Class by Functional Class	Detailed Volume, Weight Classification, etc,
	System Usage Fund Allocation	VMT by Functional Class	Average by Functional Class	Ave EAL and Gross Wt by Veh and Functnl Class
	System Usage Trend Analysis	VMT by Functional Class	Average by Functional Class	Ave EAL and Gross Wt by Veh and Functnl Class
	Public Policy & Legislation	VMT by Functional Class	Average by Functional Class	Ave EAL and Gross Wt by Veh and Funcntl Class

Site-specific data are related to a given roadway segment. These are the data usually associated with the planning, design, and maintenance of a specific roadway segment. These include: AADT, VMT, Vehicle Classification and EAL's. In addition these may include, vehicle and EAL distribution by lane. This is design type data.

Vehicle-specific data are usually associated with research and/or enforcement of weight/size restrictions. These data are of emerging importance with regards to the Department's expanded activity in assisting the Department of Public Safety and with the Department's own oversize and overweight permit program. This category is enforcement type data.

The enhanced Truck Weighing Program will satisfy all of these data requirements, depending upon how the results are presented. Once the data are in hand and archived (as specified below), it is a matter of retrieving the data and generating the appropriate report.

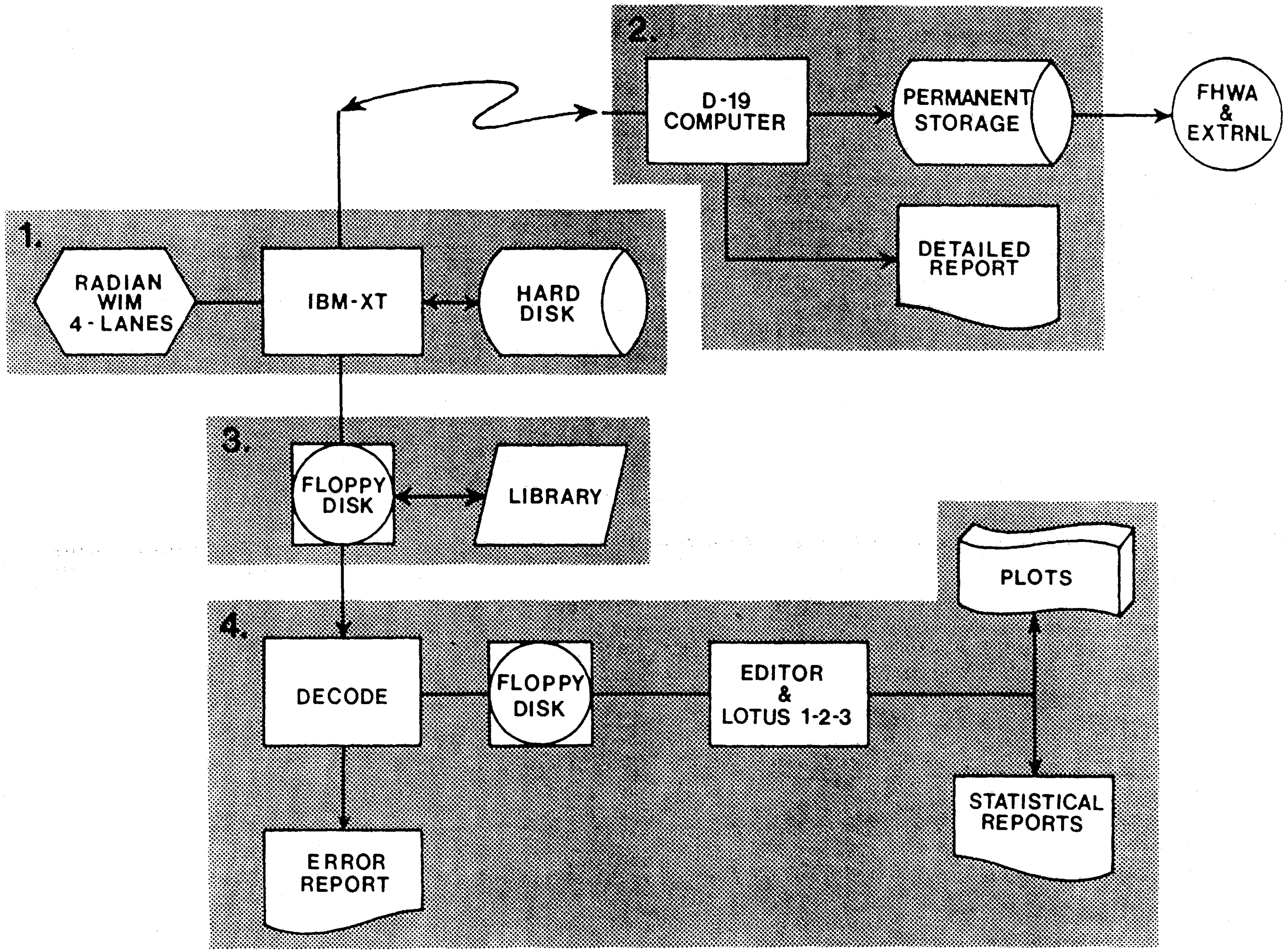
DATA STRATIFICATION

The results of this study suggest that the current Texas data collection stratifications can be consolidated somewhat. This can take place during the collection process or during the data reduction process depending upon the wishes of the Department. Based upon the results of this study the following are suggested:

The suggested Texas stratification by **road class** (Interstate, US Numbered, Texas Numbered, and Farm to Market) is not directly comparable to the preferred stratification of the sites (Interstates, Principal Arterial, Minor Arterial, and Collector). This is because there is not a one-to-one correspondence between the two. That is, an "Interstate" may be a US Numbered highway like US-59 north of Houston, and so forth. The reason for the grouping suggested in this report is that it would have been very difficult to determine the relative road mileage by the preferred grouping -- it was difficult enough by the more obvious highway numbering system. This can be "fixed" by regrouping the sites, after one or two years of data are collected, and filling-in any under represented road-class.

The existing Texas **vehicle classification** system contains more vehicle types than the proposed system. The proposed stratification tends to consolidate the more unusual types into other classes. The Texas percentages were obtained from manual counts at the existing six WIM stations.

If the purpose is to estimate average weights, the classification system can be compacted even further. Because of the predominance of 3S2's in the combination vehicles and light trucks in the single unit class, and the fact that only those vehicles with axle loads in excess of 3,000 pounds are weighed, a more workable classification is single unit vehicle and combination vehicles in excess of 6,000 pounds.



WIM DATA COLLECTION SYSTEM

Figure 4

Table 9: Vehicle Type Classifications

	National	Texas
Passenger Vehicles:		
Standard Car	42.0%	47.8%
Small Car	18.0	--
Motorcycle	.5	.3
Bus	.3	.4
	60.8	48.4
Single Unit Trucks:		
2 axle, 4 tire	18.0	23.8
2 axle, 6 tire	2.5	4.3
3 or more axles	.3	.9
	20.8	28.9
Combination Trucks		
3 axle	.6	.6
2S2 (most common 4 axle)	.9	1.2
Other 4 axle	.7	.5
3S2 (most common 5 axle)	12.6	19.5
Other 5 axle	.9	.6
6 or more axles	.4	.3
	15.1	22.7

DATA COLLECTION SYSTEM

The suggested procedure for collecting, reducing, and storing the WIM data is a four phase process, numbered 1 through 6 on Figure 4. Each of these phases consists of three or more processes or steps. Phases 1 and 2 existed before the study began. Phases 3 and 4 were implemented during the study as a result of the evaluation effort. A description of each, along with suggestions for improvement, follows:

Phase-1: Data Collection

As a vehicle rolls over the WIM weight sensor assembly, which has been previously embedded in the pavement at considerable expense, an electric impulse is generated and communicated to an attached microcomputer (IBM PC-XT) located in a near by trailer. A program (written in FORTH) in the microcomputer interprets the data and stores it on a hard-disk. In general, data collection at a site begins at 00:00:00 (midnight) and proceeds until 24:00:00. Data collected at the site includes:

Administrative:

Sequence Number	- For that day beginning with 1
Location and Operator	- Operator may change during day
Date	- Matches file name
Time record is taken	- To the nearest second

Summary Information:

Lane -	- From 2 to 4 lanes
Speed -	- Recorded to the nearest MPH.
Gross Vehicle Weight -	- Recorded to the nearest 100 lbs. Accurate to the nearest 2,000 lbs.
Vehicle Configuration	- Based upon input table.

Detail Information:

Axle weights -	- Recorded to the nearest 100 lbs. Accurate to the nearest 2,000 lbs.
Axle Spacing -	- Recorded to the nearest 0.1 ft. Accurate to the nearest 1.0 ft.
Weight Violations	- Gross weight, bridge formula, etc. Not recommended

The information from the weight sensing assembly is combined with information resident within the computer (for example, time and date) to form the complete data record. The exact layout for records from the existing RADIAN equipment is shown in Appendix - B.

Losing the contents of the hard-disk has been a source of problems. This could be solved by obtaining a tape back-up unit for the equipment and dumping the hard-disk to tape at the end of the day. (This is well worth the $1,000 in cost.) Otherwise, this operation goes smoothly, when the equipment is working as specified.

Phase-2: Transmittal to D-19

When the field crew returns to Austin, the microcomputer, used to collect the data, is connected to the D-19 mainframe computer (IBM) and the data are transmitted to permanent storage. From time to time these data are combined with other records and sent to the FHWA to produce W-Tables. (The additional sites suggested by this evaluation will increase the quality of the results greatly.) From time to time listings of the daily records stored upon the D-19 computer are transmitted to the Technical Support Group for their review.

This has been a source of problems in the past. Data has been lost, the host computer is difficult to communicate with, etc. Some of these problems would be solved by shifting to the VAX computer system. Additionally, the data would then be more accessible to personnel in the field.

Phase-3: Original Data Archive

A major weakness of the existing system is the fact that it would be difficult to get detailed information in the hands of researchers and others who require it. Storing each day's data on a set of floppy-disks and/or micro-tape and then organizing the disks/tapes into a data library is recommended highly. This should be done by someone other than the field crew responsible for collecting the data and could be accomplished using the back-up tapes instead of the hard-disk.

Phase-4: Statistical Analysis

The statistical analysis phase serves two purposes. First, it gives the D-10 staff the opportunity to examine the data for quality control purposes. Second, it affords the possibility for on-the-spot analysis of data for enforcement, research, and/or design purposes. The analysis is accomplished as follows:

Step-1: The individual floppy disks (or the daily records on the hard disk) are processed with a **DECODE** program. (The program listing is in Appendix - A.) This program looks for errors in the data (illogical data combinations) and extracts: lane number, speed, gross vehicle weight, number of axles, and vehicle type.

Step-2: The summary, detail, and EAL records are passed through an editor for possible corrections, deletions and additions. Any word processing program with the ability to read and manipulate non-document, ASCII files, is used for this purpose. (As the field crew gained experience and RADIAN Corp. corrected some errors in the data capture program, this became unnecessary.)

Step-3: These records are then read into **LOTUS 1-2-3**, a powerful spread sheet program. LOTUS has extensive data manipulation and statistical analysis capability along with the ability to produce plots of the results. Plots of vehicles per lane, distributions of gross vehicle weights, vehicle speeds are produced with LOTUS along with a statistical analysis of the data.

This phase should be improved in the following ways. First, and most important, purchase a copy of LOTUS 1-2-3 Release 2.1. This version will accommodate up to 8,000 trucks per day; the current version can read in only 2024 and this is smaller than some of the available samples. Second, the DECODE program should be given the capability to produce distributions of axle (singles, doubles, etc.) weights. Third, DECODE, could be recoded in the "C" language for portability and speed.

Figure 5 contains an example of a summary record produced by DECODE. Figure 6 shows a statistical summary of GVW and Speed distributions. Figure 7 shows example plots of the same distributions.

FIGURE 5

Typical Output From Decode
Seguin - December 12, 1984

```
3,68,36688,5,"3-S2"
1,50,35424,3,"SU-2"
2,66,34744,5,"3-S2"
1,66,68136,6,"3-S1-T2"
4,56,31016,5,"3-S2"
4,50,30768,3,"SU-2"
1,63,44688,5,"3-S2"
4,53,30232,2,"SU-1"
1,58,30976,3,"2-S1"
1,70,75784,5,"3-S2"
2,60,34680,4,"2-S2"
1,67,49184,5,"3-S2"
1,57,72456,5,"3-S2"
4,53,34608,5,"3-S2"
1,62,62664,5,"3-S2"
1,62,50216,6,"3-S1-T2"
1,66,35336,5,"3-S2"
4,52,21336,2,"SU-1"
3,66,72400,5,"3-S2"
3,62,74328,5,"3-S2"
4,60,73960,5,"3-S2"
4,58,35072,5,"3-S2"
4,54,9568,2,"SU-1"
4,56,43192,5,"3-S2"
1,51,23360,3,"SU-2"
4,58,14520,2,"SU-1"
3,68,36440,5,"3-S2"
3,62,13128,2,"SU-1"
1,56,68536,2,"SU-1"
4,56,33128,5,"3-S2"
1,64,78184,5,"3-S2"
2,61,72480,5,"3-S2"
1,54,15456,2,"SU-1"
1,63,79080,5,"3-S2"
2,58,80064,5,"3-S2"
1,50,26800,4,"2-S2"
4,66,37344,3,"SU-2"
1,53,33400,5,"3-S2"
2,53,33400,5,"3-S2"
4,63,43856,5,"3-S2"
1,59,32456,5,"3-S2"
1,58,46544,5,"2-S1-T2"
1,59,65256,5,"3-S2"
4,60,12968,2,"SU-1"
1,60,15320,2,"SU-1"
1,51,56288,5,"3-S2"
1,52,70648,5,"3-S2"
4,66,73264,5,"3-S2"
1,59,13712,2,"SU-1"
1,61,43320,5,"3-S2"
```

Nacogdoches: Nov 13-15, 1985

FIGURE 6

Gross Vehicle Weight Distribution

GVW	Count	PerCent	X-Label
0	0		0
5,000	0	0.00	
10,000	0	0.00	
15,000	0	0.00	
20,000	59	3.66	20
25,000	46	2.86	
30,000	91	5.65	
35,000	211	13.11	
40,000	195	12.11	40
45,000	82	5.09	
50,000	53	3.29	
55,000	38	2.36	
60,000	41	2.55	60
65,000	57	3.54	
70,000	91	5.65	
75,000	133	8.26	
80,000	193	11.99	80
85,000	154	9.57	
90,000	81	5.03	
95,000	56	3.48	
100,000	17	1.06	100
105,000	3	0.19	
110,000	5	0.31	
115,000	2	0.12	
120,000	2	0.12	120
125,000	0	0.00	
130,000	0	0.00	
135,000	0	0.00	
140,000	0	0.00	140
	0	0.00	
	1,610		

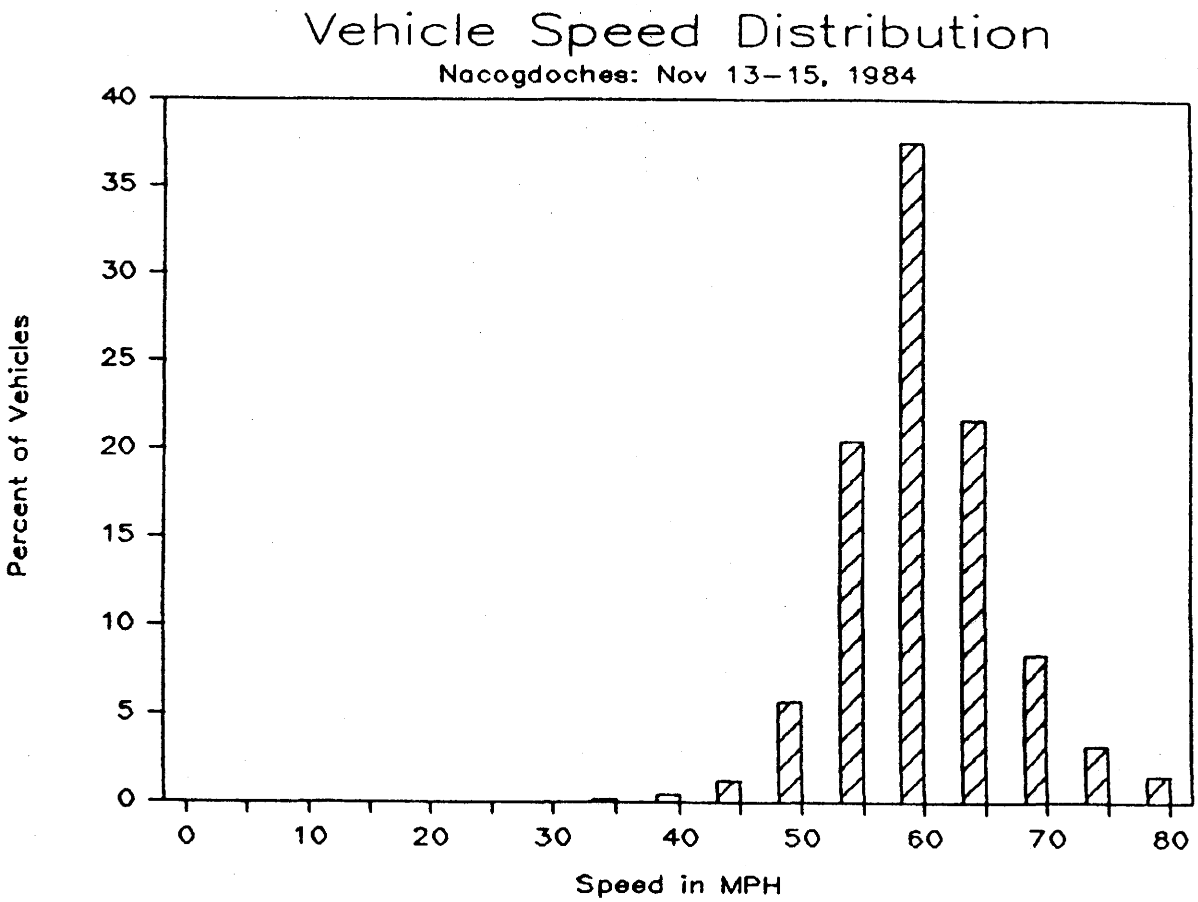
Heavy Distribution

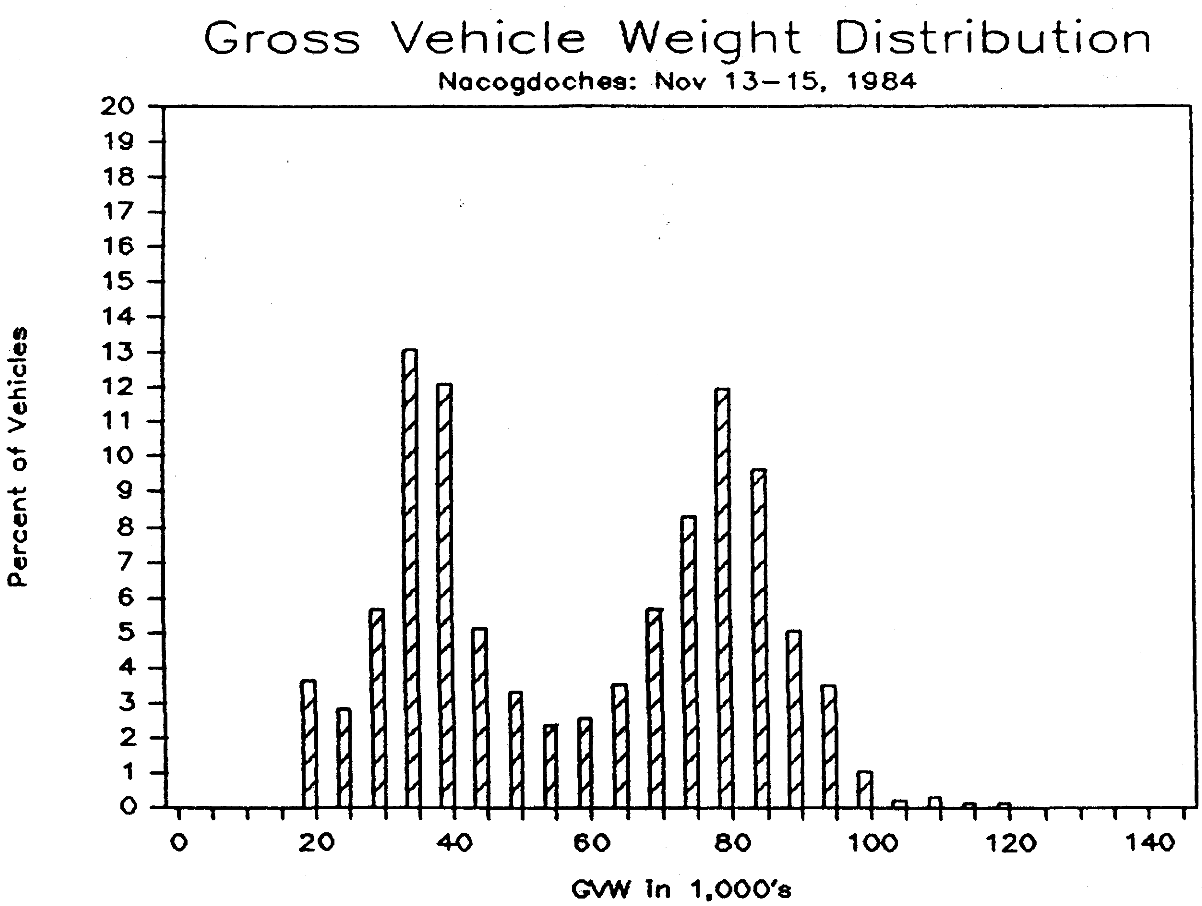
Number =	842
Mean =	77,114
Stn Dev =	10,235

Light Distribution

Number =	768
Mean =	34,253
Stn Dev =	8,266

FIGURE 7


Vehicle Speed Distribution
Nacogdoches: Nov 13–15, 1984
Percent of Vehicles
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60
70
80
Speed in MPH


Gross Vehicle Weight Distribution
Nacogdoches: Nov 13–15, 1984
Percent of Vehicles
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
0
20
40
60
80
100
120
140
GVW in 1,000's

CONCLUSIONS AND RECOMMENDATIONS

The proposed enhancements described in the previous sections should provide a framework for improving the quality of the data resulting from the activities of the Texas Truck Weighing Program. In fact, many of the suggestions implemented during the conduct of the study resulted in immediate improvements. (For example, the results from program DECODE assisted RADIAN in fixing a "bug" in the data collection program.) These improvements were procedural; because improvements in the quality of the overall results will not be apparent until data are available from all of the proposed sites.

So far as further efforts to improve the Texas Truck Weighing Program are concerned, and assuming that the Department will continue to add WIM sites according to the analysis in this report, there are three specific areas deserving of some work.

1. There is no doubt that the WIM equipment will undergo improvements over the coming years. In this regard, the RADIAN equipment should set the standard by which additional equipment is judged. There seems little point in obtaining equipment that does not measure truck weights at least as accurate as the original equipment. Other experiments, such as the RTAP scale comparison near Seguin, should be used to "certify" new equipment before it is purchased.

2. One major problem that remains is the fact that, while D-10 Research is gathering a much larger quantity of substantial more accurate data, the information is not getting into the hands of the users. First, getting the data into usable form is not always easy. And second, "selling" others on the need to use the the latest and best data available is not always easy.

3. Once the twenty-six sites are in place and a year's worth of data gathered, the problem of how many sites are required (remember we estimated the distribution by road class) and their location needs to be reworked using the procedure described in this report. This may show that, more or less sites are needed, or that they need to be redistributed.

4. Finally, the DECODE program needs to be expanded to output distributions of axle weights so that they can be converted the Equivalent Axle Weights (EAL's) for immediate use by designers.

REFERENCES

Peat, Marwick, Mitchell & Co. Development of a Statewide Traffic Counting Program Based Upon the Highway Performance Monitoring System. Prepared for the Federal Highway Administration, Office of Highway Planning. Washington, D.C.: August, 1984

Kish, L. Survey Sampling. John Wiley & Sons. 1965.

Yoo, C. S. and Reiss, M. L. "Sampling Procedure Using Multistate Traffic Records to Sellects Accident and Exposure Data-Collection Sites." TRR 683, 1977, pp 6-9.

Borland International. TURBO PASCAL 3.0. Scotts Valley, California, 1985

APPENDIX - A

Program DECODE -- TURBO Pascal 3.0 Program

```
Program Decode;     { Latest Version: August 10, 1985 }

{--------------------------------------------------------------------
  This Program decodes SDH&PT WIM data from Radian Corp. Scales
  and converts it to LOTUS 1-2-3 compatable data. Developed by:

    Don Maxwell
    Texas Transportation Institute
    Texas A&M University
    College Station, Texas  77843
    409/845-1717
--------------------------------------------------------------------}
{$C-,U-}
const
  Bell        : Char = ^g;
  IOerr       : Boolean = False;
  WriteKey    : Boolean = False;
  ReadKey     : Boolean = False;
  BkSequence : Integer = -1;

var
  Cmd               : Char;
  WIMPath           : String[16];
  WIMFile           : File;
  SUMFile           : Text;
  WIMPathName       : String[13];
  WIMFileName       : String[13];
  SUMFileName       : String[13];
  FirstRecord       : array[0..63] of Integer;
  SecondRecord      : array[0..63] of integer;
  NumberOfRecords  : Integer;
  CurrentRecord     : Integer;
  OutputRecords     : Integer;
  Sequence                    : Integer;
  Hr,min,sec,mo,da,yr         : Integer;
  Lane,MPH,Axles              : Integer;
  SiteOperator                : String[16];
  GVW                         : real;
  Spc                         : Array[0..12] of Real;
  WtLt,WtRt,WtAx              : Array[1..12] of Integer;
  Vtype                       : String[7];
  Buffer                      : String[80];

Type
  Prompt            = string[80];

{------------------------------------------------------------}
Procedure BuildWorkScreen;
{
  Build the working screen layout and default notes
}
var
  Index      :Integer;

begin
```

```
{ ----- Build Command Window}
  ClrScr;
  gotoxy(1,1);write(Chr(201));
  for Index:=2 to 79 do write(chr(205));
  Write(Chr(187));
  gotoxy(20,1);write(' DEBUG Ver 3.0: Enter Command From Menue ');
  for Index:=2 to 4 do
  begin
    gotoxy(1,index);write(chr(186));
    gotoxy(80,index);write(chr(186));
  end;
  gotoxy(1,5);write(chr(200));
  for index:=2 to 79 do write(chr(205));
  write(chr(188));

{ ----- and Put in Text }
  gotoxy(3,3); write('I: Open WIM Input File');
  gotoxy(3,4); write('O: Open PRN Output File');
  gotoxy(54,4);write('Q: Quit & Close Files');
  gotoxy(27,2);write('F: Find 1-st WIM Record');
  gotoxy(27,3);write('S: Find Seq No. 0 or 1');
  gotoxy(27,4);write('N: Decode next WIM Record');
  gotoxy(3,2); write('P: Set Path to WIM File');
  gotoxy(54,3);write('A: Start Auto File Scan');

{----- Build the File Info Window}
  gotoxy(1,10); for index:=1 to 80 do write(chr(196));
  gotoxy(2,11); write('Input File: B:\Vyymmdd.WIM');
  gotoxy(36,11); write('Length =      Records');
  gotoxy(60,11); write('Current Record = ');
  gotoxy(1,12); write('Output File: ');
  gotoxy(1,13); for index:=1 to 80 do write(chr(205));

{----- Build Record Sequence/Date/Time Window}
  gotoxy(1,17); for index:=1 to 80 do write(chr(196));

{----- Build Axle Data Summary Window.}
  gotoxy(3,18); write('Lt Wt: ');
  gotoxy(3,19); write('Rt Wt: ');
  gotoxy(1,20); write('Axle Wt: ');
  gotoxy(1,21); Write('Axle Spacing: ');

end;
{--------------------------------------------------------------}
procedure ClrActMsg;
begin
  gotoxy(1,9);clreol
end;

{--------------------------------------------------------------}
procedure ActMsg(msg:prompt);
{
  Write Action message on line 9 of the screen
}
begin
```

```
  gotoxy(1,9);ClrEol;
  Write(msg)
end;

{-----------------------------------------------------------}
Procedure ErrMsg(msg:prompt);
{
  Write any error message on line 24 of the screen
}
begin
  gotoxy(1,24);ClrEol;
  write(bell,msg)
end;

{------------------------------------------------------------}
Function StopScan :Boolean;
{
  Stop Scan by Pressing the Space-Bar
}
const
  blank :Char = ' ';
var
  Ch : Char;

begin
  stopscan:=false;
  If keypressed then begin
   read(kbd,Ch);
   if ch=' ' then stopscan:=true;
end end;

{------------------------------------------------------------}
Procedure IOcheck;
{
     Check for IOerrors and print messages.
}
var
  IOcode            :Integer;
  Ch                :Char;
Begin
  IOcode:=IOresult;
  IOerr:=(IOcode<>0);
  if IOerr then begin
    case IOcode of
      $01 :errmsg('File does not exist');
      $02 :errmsg('File not open for input');
      $03 :errmsg('flie not open for output');
      $04 :errmsg('File not open');
      $10 :errmsg('Error in numeric format');
      $20 :errmsg('Operation not allowed on logical device');
      $21 :errmsg('Not allowed in direct mode');
      $22 :errmsg('Assign to standard files not allowed');
      $90 :errmsg('Record length mismatch');
      $91 :errmsg('Seek beyond end-of-file');
      $99 :errmsg('Unexpected end-Of-file');
```

```
      $f0 :errmsg('Disk write error');
      $f1 :errmsg('Directory is full');
      $f2 :errmsg('File size overflow');
      $ff :errmsg('File disappeared');
    else {part of case}
      errmsg('Unknown I/O error:  ')
    end; {of case}
  ActMsg('Press any key to continue..... ');
  read(kbd,ch)
  end {end of then begin...}
end;

{-----------------------------------------------------------}
Procedure GracefulHalt;
begin
If writekey then close(SumFile);
if readkey then close(WimFile);
ActMsg('  All Files Closed Upon Programmed Halt....');
gotoxy(1,8); halt
end;

{------------------------------------------------------------}
Procedure ReadCommand(var CmdRd:Char);
{
  Read, check and decode Action Commands
}
const
  CmdSet : set of Char=['I','O','Q','F','S','N','A','P'];

begin
  gotoxy(1,6);ClrEol;
  gotoxy(31,6);write('Command: ');
  write(bell);      {beep to get attention}

  repeat            {read and screen for valid commands}
    gotoxy(40,6);read(Kbd,CmdRd);CmdRd:=UpCase(CmdRd);
    gotoxy(40,6);write(CmdRd);

    if not(cmdrd in Cmdset)
      Then Actmsg('Unrecognized Command, Try Again....')

  until (CmdRd in CmdSet);
  gotoxy(1,24);clreol;ClrActMsg; {Clear Messages}

end;
{------------------------------------------------------------}
Procedure GetWimPath;
{
  Set the Path for the WIM Data File
}
const
  DefaultPath ='B:\';

begin
  ActMsg('Press Return to accept Default Path Name.....  ');
```

```
  gotoxy(23,7);write('Input Path Name: ');
  gotoxy(40,7);write(DefaultPath);gotoxy(40,7);

  ReadLN(TRM,Buffer);
  if ( length(Buffer) = 0 ) then WIMPathName:=DefaultPath
  else WIMPathName:=Buffer;
  gotoxy(14,11);write(WIMPathname);
  gotoxy(1,7);clreol;clractmsg;

  ChDir(WIMPathName)
  end;

{-------------------------------------------------------------}
procedure OpenInputFile;
{
  Open the WIM Input Data File and check for errors
}
const
  Default = 'V840725';
  PtWim   = '.WIM';
  drive   :integer=0;

var
  InputFileName    : String[09];

begin
  ActMsg('Press Return to accept Default File Name.....  ');
  gotoxy(23,7);write('Input File Name: ');

  WIMFileName:=Default;
  gotoxy(40,7);write(WIMFileName);gotoxy(40,7);

  ReadLN(TRM,Buffer);
  If(length(Buffer)<1)
    then WIMFileName:=Default
    else WIMFileName:=Buffer;
  WIMfileName:=concat(wimfilename+ptwim);
  gotoxy(14,11);write(WIMPathName,WIMFileName);
  gotoxy(1,7);clreol;clractmsg;
{$I-}
  Assign(WimFile,WIMFileName);IOcheck;
  Reset(WimFile);IOcheck;
{$I+}
  if not IOerr then begin
    NumberOfRecords:=Filesize(WIMfile);
    CurrentRecord:=Filepos(WIMfile);
    gotoxy(45,11);write(NumberOfRecords);
    gotoxy(77,11);write(CurrentRecord);
    ReadKey:=true;
  end
  else Gracefulhalt
end; {of OpenInputFile Proc}

{-------------------------------------------------------------}
Procedure WriteSummaryRecord;
```

```
{
  Write The Next Summary File Record to Disk.
}
const
  qc : char = ',';
  qq : char = '"';

Begin
{I-}
writeln(Sumfile,lane:1,qc,MPH:2,qc,gvw:6:0,qc,axles:2,qc,qq,vtype,qq);
{I+}
if not IOerr then begin
  OutputRecords:=Outputrecords+1;
  gotoxy(77,12);write(Outputrecords);
  end
else GracefulHalt
end; {of WriteSummaryRecord Proc}

{-----------------------------------------------------------}
Procedure OpenOutputFile;
{
  Open the Summary File and set WriteKey to True.
}
var
  Default          : String[09];
  OutputFileName   : String[09];

Begin
  ActMsg('Press ENTER to Accept Default File Name ..... ');
  Default:='A:S'+copy(wimfilename,2,6);
  gotoxy(22,7);write('Output File Name: ',Default);
  gotoxy(40,7);

  ReadLN(TRM,OutputFileName);
  if (length(OutputFileName)<1)
    then SumFileName:=Default
    else SumFileName:=OutputFileName;
  SumFileName:=SumFileName+'.PRN';
  gotoxy(14,12);write(SumFileName);
  gotoxy(1,7);ClrEol;

{I-}
  Assign(Sumfile,SumFileName);IOcheck;
  Rewrite(SumFile);IOcheck;
{I+}
  if not IOerr then begin
    WriteKey:=true;
    OutPutRecords:=0;
    gotoxy(77,12);write(outputrecords);
    WriteSummaryRecord;
    ClrActMsg;
  end
  else Gracefulhalt
  end; {of open Output File Proc}
```

```
{-----------------------------------------------------------}
function cvi(i:integer):integer;
{
    Function to convert FORTH binary data into "normal"
    format. Note that "i" is a switch associated with
    sequence.
}
var
  cv : integer;

begin
if (i>0) then
  begin
    cv:=hi(firstrecord[i]);
    cvi:=cv*256+lo(firstrecord[i])
  end
else
  begin
    i:=-i; cv:=hi(secondrecord[i]);
    cvi:=cv*256+lo(secondrecord[i])
end end;

{-----------------------------------------------------------}
procedure ReadNextWimRecord;
{
   Get the next valid WIM record in the data-set
}
const
  SiteOprtr                :String[16] = 'looks OK!';

var
  Seq,Zero,One             : Integer;
  LoChr,HiChr              : Char;
  Index,Ia                 : Integer;

{----- Get type "0" Record.}
{$I-}
begin
repeat
  BlockRead(WimFile,firstrecord,1);IOcheck;
  if ioerr then GracefulHalt;
  CurrentRecord:=Filepos(Wimfile);
  gotoxy(77,11);write(currentrecord);
  zero:=lo(firstrecord[0]);yr:=lo(firstrecord[11]);
until (zero=00) and ((yr=84)or(yr=85));
{$I+}

seq:=cvi(1);
mo:=hi(firstrecord[11]);da:=lo(firstrecord[12]);
hr:=hi(firstrecord[12]);min:=lo(firstrecord[13]);
sec:=hi(firstrecord[13]);

{----- Determine site and operator}
delete(siteoprtr,1,16);
for index:=2 to 9 do begin
```

```
  lochr:=Chr(lo(firstrecord[index]));
  hichr:=Chr(hi(firstrecord[index]));
  SiteOprtr:= siteoprtr+lochr+hichr;
  SiteOperator:=SiteOprtr;
end;

gotoxy(1,14);clreol;
write('Seq No.: ',seq:4,
     '     Time:',hr:2,':',min:2,':',sec:2,
     '     Date:',mo:2,'/',da:2,'/',yr:2,'      Site: ',SiteOprtr);
Sequence:=seq;

{----- Read a type "1" card if axles>6 }
axles:=cvi(14);
if (axles>6) then begin

{I-}
  BlockRead(WimFile,SecondRecord,1);IOcheck;
  If IOerr then GracefulHalt;
  CurrentRecord:=FilePos(WimFile);
  gotoxy(77,11);write(CurrentRecord);
{I+}

  one:=lo(secondrecord[0]);
  if (one<>1) then begin
    axles:=0;
    Errmsg('Second Record Expected But Not Found. ')
    end
end; end; {of ReadNextRecord Proc}

{-----------------------------------------------------------}
Procedure SummerizeVehicleData;
{
  Gather Vehicle Summary Data from Current Record
}
const
  TD : real=6;

var
  index,ia : integer;

begin
  lane:=cvi(10)+1;
  mph:=cvi(16);
  gvw:=cvi(19);gvw:=gvw*8;
  axles:=cvi(14);

for index:=1 to axles do Begin
  if index<=6 then begin
    ia:=30+(index-1)*6;
    Spc[index-1]:=cvi(ia)*0.1;ia:=ia+1;
    WtLt[index]:=cvi(ia)*8;ia:=ia+1;
    WtRt[index]:=cvi(ia)*8;ia:=ia+1;
    WtAx[index]:=cvi(ia)*8;ia:=ia+1
    end
```

```
  else begin
    ia:=(3+(index-7)*6);
    spc[index-1]:=cvi(-ia)*0.1;ia:=ia+1;
    WtLt[index]:=cvi(-ia)*8;ia:=ia+1;
    WtRt[index]:=cvi(-ia)*8;ia:=ia+1;
    WtAx[index]:=cvi(-ia)*8;ia:=ia+1
  end;
end;

{-----Determine vehicle type}
vtype:='?-?-?';
if axles=2 then vtype:='SU-1';

if axles=3 then begin
if spc[2]<TD
  then vtype:='SU-2'
  else vtype:='2-S1'
end;

if axles=4 then begin
  if(spc[2]<TD)and(spc[3]<TD)then vtype:='SU-3';
  if(spc[2]<TD)and(spc[3]>TD)then vtype:='3-S1';
  if(spc[2]>TD)and(spc[3]<TD)then vtype:='2-S2';
  if(spc[2]>TD)and(spc[3]>TD)then vtype:='2-T2';
  end;

if axles=5 then begin
  if(spc[2]<TD)and(spc[3]>TD)and(spc[4]<TD)then vtype:='3-S2';
  if(spc[2]>TD)and(spc[3]<TD)and(spc[4]<TD)then vtype:='2-S3';
  if(spc[2]>TD)and(spc[3]>TD)and(spc[4]>TD)then vtype:='2-S1-T2';
  end;

if axles=6 then begin
  if(spc[2]<TD)and(spc[3]<TD)and(spc[4]>TD)and(spc[5]<TD)then vtype:='4-S2';
  if(spc[2]<TD)and(spc[3]>TD)and(spc[4]<TD)and(spc[5]<TD)then vtype:='3-S3';
  if(spc[2]<TD)and(spc[3]>TD)and(spc[4]>TD)and(spc[5]>TD)then vtype:='3-S1-T2';
  end;

if axles=7 then begin
  if(spc[2]<TD)and(spc[3]<TD)and(spc[5]<TD)and(spc[6]<TD)then vtype:='4-S3';
  if(spc[2]<TD)and(spc[4]<TD)and(spc[5]<TD)and(spc[6]<TD)then vtype:='3-S4';

  end;

{----- Write Type ?-?-? and Axles>6 to printer }
  if (Vtype='?-?-?') or (axles>6) then begin
    writeln(lst);
    writeln(lst,'Seq No.: ',sequence:4,
      '     Time:',hr:2,':',min:2,':',sec:2,
      '     Date:',mo:2,'/',da:2,'/',yr:2,'     Site: ',SiteOperator);
    writeln(lst,'Lane: ',lane,'     MPH: ',mph,'      GVW:',gvw:6:0,
      '     Axles:',axles:2,'     Type: ',vtype);
    write(lst,'Lt Wt: ');
    for index:=1 to axles do write(lst,wtlt[index]:6);writeln(lst);
    write(lst,'Rt Wt: ');
```

```
    for index:=1 to axles do write(lst,wtrt[index]:6);writeln(lst);
    write(lst,'Axle Spacing:');
    for index:=1 to axles-1 do write(lst,spc[index]:6:1);writeln(lst);
  end;

{----- Write the results on the screen}
gotoxy(1,16); clreol;
write('Lane: ',lane,'     MPH: ',mph,'      GVW:',gvw:6:0,
      '      Axles:',axles:2,'     Type: ',vtype);

gotoxy(11,18); clreol;
for index:=1 to axles do write(wtlt[index]:6);

gotoxy(11,19); clreol;
for index:=1 to axles do write(wtrt[index]:6);

gotoxy(11,20); clreol;
for index:=1 to axles do write(wtax[index]:6);

gotoxy(14,21); clreol;
for index:=1 to axles-1 do write(spc[index]:6:1);
end; { of Summarize Data Proc}

{------------------------------------------------------------}
Procedure FindZeroSequence;
{
  Look for the next Zero Sequence No. or Break In Sequnece
}
begin
ActMsg('Press Space Bar to Halt Sequence Search ..... ');
repeat
ReadNextWimRecord;
If axles>0 then SummerizeVehicleData;
until (sequence=00) or (sequence<=BkSequence)
      or (stopscan) or eof(WIMfile);
if eof(WIMfile) then GracefulHalt;
clractmsg
end; {of FindZero Proc}

{------------------------------------------------------------}
procedure FindNextWimRecord;
{
  Look for the first valid WIM Record and Decode
}
begin
ReadNextWimRecord;
If axles>0 then SummerizeVehicleData;
if writekey then WriteSummaryRecord;
if eof(wimfile) then GracefulHalt
end; {of next record Proc}
{------------------------------------------------------------}
procedure AutoScanRecords;
{
  Scan through the records until E-O-F or a Key is pressed.
}
```

```
begin
ActMsg('Press Space Bar to Halt AutoScan .....  ');
repeat
FindNextWimRecord;
until stopscan;
ClrActMsg
end; {of AutoScan Proc}

{-----------------------------------------------------------}
begin
  ClrScr;
  BuildWorkScreen;
  readkey:=false;writekey:=false;

{-----Loop through the commands until stopped with a "Q"    }
  repeat
    ReadCommand(Cmd);
    case Cmd of
     'I': if not Readkey
            then OpenInputFile
            else Actmsg('Input File Already Open, TRY AGAIN....');
     'O': if not writekey
            then OpenOutputFile
            else Actmsg('Output File Already Open, TRY AGAIN....');
     'F': FindNextWimRecord;
     'N': FindNextWimRecord;
     'S': FindZeroSequence;
     'A': AutoScanRecords;
     'P': GetWimPath
    end;
  until (Cmd='Q');
  GracefulHalt
end. {Of program Decode}
```

APPENDIX - B

Record Lay-out for RADIAN Corporation WIM Files

This information was furnished by RADIAN Corporation to SDH&PT during previous work with the RADIAN WIM equipment by the SDH&PT and was made available to TTI in support of this research project. It describes the data file sequence and record layout for information generated and transferred to disk by the RADIAN WIM equipment located at the six existing sites.

SPECIFICATIONS

for

VEHICLE CLASSIFICATION & WEIGHT SYSTEM

SOFTWARE (DATA FILE FORMAT)

****

GENERAL:

The data storage on floppy disk shall adhere to and meet the following software format for Weigh-in-Motion data files contained on pages 2 through 8.

WIM DATA FILES ARE NAMED AS FOLLOWS:

PYYMMDD.WIM

ALL FILES ARE PREFIXED WITH "P" (FOR PORTABLE SYSTEM)

AND SUFFIXED WITH THE EXTENSION ".WIM"

YY = TWO DIGITS FOR YEAR

MM = TWO DIGITS FOR MONTH

DD = TWO DIGITS FOR DAY (of month)

EXAMPLE:

P840706.WIM = all vehicle data recorded on July 6, 1984.

THE FILES ARE RECORDED ON DUAL-SIDED, DUAL-DENSITY 5-1/4" DISKETTES (360 KB CAPACITY) UNDER THE FILE STRUCTURE CREATED BY IBM PC-DOS, VERSION 2.1. THEREFORE, THEY SHOULD BE ABLE TO BE READ BY THE SAME DISK OPERATING SYSTEM OR EQUIVALENT.

ALTHOUGH IBM DISKS ARE FORMATTED WITH 512 BYTES PER SECTOR, THE STANDARD IBM LOGICAL RECORD CONSISTS OF 128 BYTES. WITHIN A FILE, A <u>VEHICLE RECORD</u> CONSISTS OF EITHER ONE OR TWO COMPLETE <u>LOGICAL RECORDS</u>, DEPENDING ON THE NUMBER OF VEHICLE AXLES. A VEHICLE RECORD WITH SIX OR FEWER AXLES REQUIRES ONE <u>LOGICAL RECORD</u> (128 BYTES), WHEREAS A VEHICLE RECORD WITH 7 THROUGH 12 AXLES REQUIRES TWO COMPLETE <u>LOGICAL RECORDS</u> (256 BYTES). THE FIRST BYTE IN A <u>LOGICAL RECORD</u> INDICATES WHETHER THE <u>LOGICAL RECORD</u> IS THE FIRST (AND, PERHAPS. ONLY) LOGICAL RECORD IN A VEHICLE RECORD OR WHETHER IT IS THE SECOND LOGICAL RECORD IN A VEHICLE RECORD (FOR A VEHICLE WITH MORE THAN SIX AXLES). IN THE FIRST CASE, THE VALUE OF THE FIRST BYTE IN A <u>LOGICAL RECORD</u> IS ZERO (0); IN THE SECOND CASE, THE VALUE OF THE FIRST BYTE IS ONE (1).

THE FORMAT OF A VEHICLE RECORD, AS RECORDED ON DISK, IS DEPICTED IN FIGURES 1 AND 2. WITH SOME FEW EXCEPTIONS (TO BE INDICATED) VEHICLE DATA IS RECORDED AS 16-BIT BINARY INTEGER DATA. THEREFORE, FOR CLARITY, FIGURES 1 AND 2 ARE IN 16-BIT "WORD" FORMAT, ALTHOUGH BYTE BOUNDARIES ARE INDICATED.

Weight records must be stored on floppy disk in the following binary format:

FORMAT FOR DISK RECORD

	BYTE NO.			BYTE NO.
LOGICAL RECORD NUMBER	01	**0000 0000**	**0000 0000**	00
VEHICLE SEQUENCE NUMBER	03	16-BIT INTEGER		02
SITE (ASCII CHAR.)	05	2ND CHAR	1ST CHAR	04
SITE (ASCII CHAR.)	07	4TH CHAR	3RD CHAR	06
SITE (ASCII CHAR.)	09	6TH CHAR	5TH CHAR	08
SITE (ASCII CHAR.)	11	8TH CHAR	7TH CHAR	10
SITE (ASCII CHAR.)	13	10TH CHAR	9TH CHAR	12
SITE (ASCII CHAR.)	15	12TH CHAR	11TH CHAR	14
OPERATOR	17	2ND CHAR	1ST CHAR	16
OPERATOR	19	4TH CHAR	3RD CHAR	18
VEHICLE LANE (V.LANE) (IE: 0=LN-1;1=LN-2;2=LN-3;3=LN-4)	21	16-BIT INTEGER		20
VEHICLE DATE AND TIME (V.D&T) IE. 0000 1100B FOR DECEMBER	23	MONTH	YEAR	22
VEHICLE DATE AND TIME (V.D&T) IE. 0000 1101B FOR 1PM	25	HOUR	DAY	24
VEHICLE DATE AND TIME (V.D&T)	27	SECONDS	MINUTES	26
NO. OF AXLES DETC. @ SCLE (V.NUM)	29	16-BIT INTEGER		28
*STATUS BITS (V.STAT)	31	VIOLATIONS	SCALES	30
INITIAL SPEED ESTIMATE (V.SPD)	33	16-BIT INTEGER		32
WHLBASE (0.1 FT INC.) (V.WBASE)	35	16-BIT INTEGER		34
*OVRAL LEN. (0.1 FT INC.)(V.OLEN)	37	16-BIT INTEGER		36

* NOT REQUIRED, STORE ZEROS IN THESE LOCATIONS

Fig. 1-1. Disk Record Format, Logical Record.

	BYTE NO.		BYTE NO.
GROSS WEIGHT (8LB INC.) (V.GROSS) IE. 0001000000000000B = 4096D LBS	39	16-BIT INTEGER	38
BODY TYPE (0 IF IN AUTOMATIC) (V.BOD)	41	16-BIT INTEGER	40
FHWA VEH. CATEGORY NUMBER (V.VEH)	43	16-BIT INTEGER	42
*BRDG FORMULA VIOLATIONS (V.BVIDL)	45	16-BIT INTEGER	44
*1ST AXLE NO. VIOLATION (V.FIRST)	47	16-BIT INTEGER	46
*LAST AXLE NO. VIOLATION (V.LAST)	49	16-BIT INTEGER	48
*AXLE GROUP LENGTH (0.1 FT INCR.) (V.GLEN)	51	16-BIT INTEGER	50
*AXLE GROUP WEIGHT (8 LB INCR.) (V.GWGT)	53	16-BIT INTEGER	52
*EXCESS WEIGHT (LBS) (V.XWGT)	55	16-BIT INTEGER	54
AXLE 1: STATUS BITS (A.STAT)	57	SEE NOTES-PAGE 6	56
AXLE 1: AXLE SPEED (MPH) (A.SPD)	59	16-BIT INTEGER	58
AXLE 1: PRIOR AXLE (0.1 FT INCR.) (A.SPACE)	61	0000 0000 0000 0000	60
AXLE 1: LEFT WHEEL (8 LB INCR.) IE. HALF OF TOTAL (A.LWGT)	63	16-BIT INTEGER	62
AXLE 1: RIGHT WHEEL (8 LB INCR.) IE. HALF OF TOTAL (A.RWGT)	65	16-BIT INTEGER	64
AXLE 1: TOTAL WEIGHT (8 LB INCR.) (A.AWGT)	67	16-BIT INTEGER	66
AXLE 2: STATUS BITS (A.STAT)	69	SEE NOTES-PAGE 6	68
AXLE 2: AXLE SPEED (MPH) (A.SPD)	71	16-BIT INTEGER	72
AXLE 2: PRIOR AXLE (0.1 FT INCR.) (A.SPACE)	73	16-BIT INTEGER	74
AXLE 2: LEFT WHEEL (8 LB INCR.) IE. HALF OF TOTAL (A.LWGT)	75	16-BIT INTEGER	76
AXLE 2: RIGHT WHEEL (8 LB INCR.) IE. HALF OF TOTAL (A.RWGT)	77	16-BIT INTEGER	78
AXLE 2: TOTAL WEIGHT (8 LB INCR.) (A.AWGT)	79	16-BIT INTEGER	78

ECT. up to 6 axles.

* NOT REQUIRED, STORE ZEROS IN THESE LOCATIONS

Fig. 1-2. Disk Record Format, Logical Record.

2ND LOGICAL RECORD REQUIRED FOR VEHICLES WITH MORE THAN 6 AXLES

	BYTE NO.		BYTE NO.
LOGICAL RECORD NUMBER	01	**0000 0000 0000 0001**	00
AXLE 7: STATUS BITS (A.STAT)	03	SEE NOTES-PAGE 6	02
AXLE 7: AXLE SPEED (MPH) (A.SPD)	05	16-BIT INTEGER	04
AXLE 7: PRIOR AXLE (0.1 FT INCR.) (A.SPACE)	07	16-BIT INTEGER	06
AXLE 7: LEFT WHEEL (8 LB INCR.) IE. HALF OF TOTAL (A.LWGT)	09	16-BIT INTEGER	08
AXLE 7: RIGHT WHEEL (8 LB INCR.) IE. HALF OF TOTAL (A.RWGT)	11	16-BIT INTEGER	10
AXLE 7: TOTAL WEIGHT (8 LB INCR.) (A.AWGT)	13	16-BIT INTEGER	12
AXLE 8: STATUS BITS (A.STAT)	15	SEE NOTES-PAGE 6	14
AXLE 8: AXLE SPEED (MPH) (A.SPD)	17	16-BIT INTEGER	16
AXLE 8: PRIOR AXLE (0.1 FT INCR.) (A.SPACE)	19	16-BIT INTEGER	18
AXLE 8: LEFT WHEEL (8 LB INCR.) IE. HALF OF TOTAL (A.LWGT)	21	16-BIT INTEGER	22
AXLE 8: RIGHT WHEEL (8 LB INCR.) IE. HALF OF TOTAL (A.RWGT)	23	16-BIT INTEGER	24
AXLE 8: TOTAL WEIGHT (8 LB INCR.) (A.AWGT)	25	16-BIT INTEGER	26

ECT. up to 12 axles

Fig. 2. Disk Record Format, Logical Record 2; Required only for vehicle with more than 6 axles.

A VEHICLE RECORD IS COMPRISED OF TWO PARTS: VEHICLE DATA AND AXLE DATA. BASIC VEHICLE AND SITE/TIME DATA OCCUPY THE FIRST 56 BYTES OF A RECORD. THE REMAINDER OF THE VEHICLE RECORD IS FILLED WITH AXLE DATA, WITH DATA FOR EACH AXLE REQUIRING 12 BYTES. THUS, A VEHICLE RECORD FOR AN N-AXLE VEHICLE REQUIRES

56 + 12N BYTES $(Z \le N \le G)$

IF A 2ND LOGICAL RECORD IS REQUIRED (FOR A VEHICLE WITH MORE THAN 6 AXLES), THE FIRST TWO BYTES OF THE 2ND LOGICAL RECORD ARE REQUIRED FOR "HOUSEKEEPING" INFORMATION; IN THIS CASE, A VEHICLE RECORD REQUIRES

58 + 12N BYTES $(7 \le N \le 12)$

ALL BYTES NOT REQUIRED FOR A VEHICLE RECORD (AT THE END OF A LOGICAL RECORD) ARE FILLED WITH A NUMERIC VALUE OF ZERO.

THE FOLLOWING TABLES DEFINE THE PARAMETERS INDICATED IN FIGURES 1 AND 2.

NAME	# WORDS	PARAMETER DESCRIPTION
V.LANE	1	lane number (0-3)
V.D&T	3	date and time of new vehicle event 6 1-byte integers: yr,mon,day,hr,min,sec
V.NUM	1	status bit mask: weighing (lower) byte: bit: 0 left scale out of service 1 right scale out of service 2 scales calibrated prior to weighing 3 scale calibration verified 4 scale buffer overflow 5 fewer than 2 axles detected at scale violation (upper) byte: bit: 0 excessive speed change 1 too fast for weighing 2 off-scale wheel(s) detected 3 more than 12 axles detected 4 steering axle weight violation 5 single axle weight violation(s) 6 gross weight violation 7 bridge formula weight violation(s)
V.SPD	1	initial speed estimate (mph)
V.WBASE	1	wheel base (0.1 ft increments) (each bit represents 0.1 ft)
*V.OLEN	1	overall length (0.1 ft increments) (each bit represents 0.1 ft)
V.GROSS	1	gross weight (8 lb increments) (each bit represents 8 lbs)
*V.BOD	1	body type (0 when in automatic classification mode)
V.VEH	1	FHWA vehicle category number
V.BVIOL	1	number of bridge formula violations (0 if none) worst bridge formula violation:

NAME	# WORDS	PARAMETER DESCRIPTION
V.FIRST	1	-first axle #
V.LAST	1	-last axle #
V.GLEN	1	-axle group length (0.1 ft increments)
*V.GWGT	1	-axle group weight (8 lb increments)
*V.XWGT	1	-excess weight (lbs)

Axle Data Format

*A.STAT	1	axle status bit mask: bit: 0 off-scale indicator during weighing 1 left wheel weight doubled (right ignored) 2 right wheel weight doubled (left ignored) 3 scale buffer overflow 4 excessive speed change 5 axle overweight
A.SPD	1	axle speed (mph)
A.SPACE	1	spacing (0.1 ft) from prior axle -0 if no speed estimate avali. -0 if first vehicle axle
A.LWGT	1	left wheel weight (8 lb increments)
A.RWGT	1	right wheel weight (8 lb increments)
A.AWGT	1	axle weight (8 lb increments) -includes doubling

* NOT REQUIRED, STORE ZEROS IN THESE LOCATIONS

APPENDIX - C

Rank Ordering of Existing Count Locations by Diversity Index

<u>Notes:</u>

1. Region 1 is Northwest; 2 is West; 3 is South; 4 is East; and 5 is North

2. Based upon 1983 Vehicle Classification Data Furnished by the SDH&PT.

REGION	PERCENT	HIGHWAY	OBS.	LOCATION	D.I.	RANK
1	HIGH	IH	124	M-1083	.373412	1
			429	MS-1	.369537	2
			13	L-201	.352758	3
			461	MS-153	.338878	4
1	HIGH	US	12	L-149	.381903	1
			375	M-1302 8	.367947	2
			371	M-1301 8	.365173	3
			370	M-1301 4	.354412	4
			462	MS-158	.349218	5
			165	M-1106 8	.346097	6
			163	M-1106 4	.342762	7
			373	M-1302 3	.326938	8
			139	M-1904 1	.320188	9
			85	M-954 A	.308060	10
			141	M-1094 5	.285801	11
1	MEDIUM	SH	161	M-1105 6	.281820	1
			159	M-1105 2	.277350	2
			160	M-1105 5	.172100	3
1	HIGH	FM	142	M-1094 7	.262256	1
			140	M-1094 3	.259825	2
2	HIGH	IH	460	MS-152	.375370	1
			435	MS-14	.357588	2
			9	L-101	.349252	3
			23	M-173 A	.341170	4
			353	M-1267	.335836	5
			25	M-178 A	.334042	6
2	HIGH	US	95	M-1003 5	.334044	1
			90	M-1002 1	.326770	2
			93	M-1003 1	.313292	3
			92	M-1002 5	.296770	4
2	HIGH	SH	155	M-1103 1	.336500	1
			157	M-1103 5	.278936	2
	HIGH	FM	151	M-1100 8	.300145	1
			154	M-1101 6	.267149	2
3	HIGH	IH	18	L-371	.369726	1
			258	m-1158	.355251	2
			10	L-102	.354094	3
			465	MS-164	.352679	4
			450	MS-54	.342922	5
			347	M-1249	.336065	6

3	LOW	IH	257	M-1130 4	.196214	1
3	MEDIUM	US	210	M-1130	.297481	1
			391	M-1311 8	.291284	2
			385	M-1310 3	.289172	3
			208	M-1130 2	.280086	4
			387	M-1310 7	.277864	5
			389	M-1311 4	.266365	6
			455	MS-121	.264576	7
			376	M-1305 1	.261769	8
			378	M-1305 5	.254704	9
			46	M-905 8	.248660	10
			44	M-905 3	.247844	11
			53	M-913 5	.247623	12
			57	M-914 7	.246306	13
			51	M-913 1	.240146	14
			40	M-901 8	.237200	15
			218	M-1135 8	.221493	16
3	MEDIUM	SH	422	M-1498 5	.275548	1
			420	M-1498 1	.270219	2
			296	M-1210 1	.253408	3
			54	M-913 8	.251308	4
			201	M-1125 1	.247130	5
			37	M-901 3	.240146	6
			254	M-1158 2	.233627	7
			215	M-1134 7	.232790	8
			203	M-1125 6	.228150	9
			362	M-1287 8	.223051	10
			256	M-1158 7	.222103	11
			202	M-1125 2	.219060	12
			360	M-1287 3	.214267	13
			198	M-1124 2	.207172	14
			445	MS-28	.193894	15
			199	M-1124 4	.185691	16
			114	M-1042A 7	.179715	17

3	LOW	SH	43	M-904 8	.226000	1
			41	M-904 3	.224542	2
			42	M-904 6	.209196	3
			299	M-1210 6	.202978	4
			297	M-1210 2	.199530	5
			86	M-957 1	.196050	6
			219	M-1137 2	.193485	7
			220	M-1137 6	.193464	8
			45	M-905 6	.192301	9
			289	M-1189 4	.183456	10
			200	M-1124 6	.181182	11
			217	M-1135 7	.176035	12
			470	M-1309	.170052	13
			88	M-957	.163226	14
			290	M-1189 8	.153570	15
			204	M-1129 2	.121725	16
			298	M-1210 5	.099332	17
			403	M-1316 3	.093122	18
			405	M-1316 7	.091941	19
			207	M-1129 7	.066221	20
			451	MS-69	.050565	21
			205	M-1129 4	.027118	22
			206	M-1129 5	.015591	23
3	LOW	FM	209	M-1130 4	.196215	1
			421	M-1498 4	.181676	2
			328	M-1232 3	.174077	3
			413	M-1318 7	.158901	4
			258	M-1159 3	.150427	5
			377	M-1305 2	.134404	6
			211	M-1130 8	.121068	7
			112	M-1042A 3	.111441	8
			390	M-1311 6	.098100	9
			383	M-1308	.075923	10
			404	M-1316 5	.073865	11
			402	M-1316 1	.074420	12
			379	M-1307 1	.054315	13
			221	M-1137 8	.035581	14
			408	M-1317 5	.034366	15
			288	M-1189 3	.028934	16
			286	M-1188 6	.027485	17
4	MEDIUM	IH	292	M-1200	.279280	1
			472	MS-117	.244569	2

4	MEDIUM	US	6	L-72	.314265	1
			295	M-1208	.301639	2
			334	M-1234 1	.299041	3
			116	M-1064	.298482	4
			21	M-72 2	.284673	5
			325	M-1227 4	.278769	6
			467	MS-178	.277836	7
4	LOW	IH	471	MA-16	.237121	1
4	LOW	SH	20	M-72 1	.222120	1
			103	M-1031 6	.205318	2
			250	M-1153 8	.203371	3
			425	MA-18	.202192	4
			101	M-1031 2	.193115	5
			416	M-1319 7	.190368	6
5	HIGH	US	29	M-278 6	.366095	1
			27	M-278 3	.365427	2
			3	L-20	.358425	3
			133	M-1089 4	.348887	4
			33	M-675 4	.347545	5
			121	M-1070	.342612	6
5	MEDIUM	IH	238	M-1149	.336049	1
			14	L-202	.317559	2
			239	M-1150	.289448	3
			17	L-351	.279504	4
	LOW	IH	276	M-1181	.242437	1
			469	M-1180	.241461	2
			4	L-30 T	.185174	3
	MEDIUM	SH	228	M-1144 2	.307375	1
			7	L-81	.275065	2
			277	M-1182 2	.275014	3
			279	M-1182 6	.273562	4
			226	M-1143 3	.252831	5
			227	M-1143 7	.252829	6
			319	M-1225 7	.248728	7
			244	M-1152 1	.247507	8
			247	M-1152 6	.245735	9
			180	M-1113 6	.244642	10
			317	M-1225 3	.228652	11
			364	M-1291 6	.227258	12
			363	M-1291 2	.211815	13

5	HIGH	US	29	M-278 6	.366095	1
			27	M-278 3	.365427	2
			3	L-20	.358425	3
			133	M-1089 4	.348887	4
			33	M-675 4	.348887	5
			134	M-1089 8	.347322	6
			26	M-278 1	.345335	7
			35	M-675 8	.322026	8
			344	M-1240	.301910	9
			342	M-1240 4	.301508	10
5	LOW	US	473	MS-167	.241842	1
			283	M-1183	.219080	2
			418	M-1497 5	.214736	3
			351	M-1254 8	.210732	4
			281	M-1183 3	.205809	5
			260	M-1161 2	.199494	6
			349	M-1254 4	.187462	7
			263	M-1162 2	.176606	8
			222	M-1142 3	.161102	9
			224	M-1142 7	.155793	10
			439	MS-17	.150331	11
			306	M-1217 3	.146778	12
			137	M-1090 4	.143243	13
			307	M-1217 7	.142334	14
			135	M-1090 2	.141335	15
			423	MA-1	.060937	16
5	LOW	FM	306	M-1089 3	.211622	1
			307	M-1142 5	.197189	2
			341	M-1218 5	.185383	3
			305	M-1163 3	.183597	4

NOTE:
D.I. = DIVERSITY INDEX
OBS = NUMBER REFERRING TO THE LINE NUMBER IN THE ORIGINAL DATA FILE.

Mileage Subject to 55 MPH by Region by Raod-Class

Region	I.H.	U.S.	Texas	Other	Total
1	344	2,618	1,918	7,806	12,686
2	704	2,821	1,826	5,507	10,864
3	605	2,885	3,718	8,689	15,898
4	600	2,104	3,150	8,326	14,181
5	521	1,889	2,629	7,195	12,235

Total Mileage in Each Region as a Proportion of Total State Mileage, Before and After Adjustment

Region	Before Adjustment	After Adjustment
1	0.156	0.086
2	0.224	0.187
3	0.140	0.140
4	0.121	0.121
5	0.087	0.124
6	0.071	0.141
7	0.116	0.075
8	0.085	0.126
Total	1.000	1.000

Mileage in Each Region Subject to 55 MPH by Type of Facility

Region	Interstate	U.S.	Texas	Farm to Market	Loop	Spur	Dirt Road	Total
1	232.5	2,076.8	1,581.7	6,474.5	28.6	3.5	17.3	10,414.9
2	715.0	2,237,1	3,186.1	8,478.3	50.6	262.2	6.1	14,935.4
3	322.3	1,314.0	2,076.8	5,449.8	64.6	121.1	2.4	9,351.0
4	248.3	1,341.8	1,566.3	4,827.7	-0-	69.6	12.2	8,065.9
5	279.0	1,353.7	840.6	3,327.7	-0-	-0-	-0-	5,801.0
6	459.9	1,566.6	804.9	1,917.9	-0-	-0-	-0-	4,749.3
7	466.7	1,498.1	1,579.3	4,160.7	-0-	17.1	-0-	7,721.9
8	56.9	944.1	1,622.7	2,935.6	23.5	57.9	11.3	5,652.0
Total	2,780.6	12,332.2	13,258.4	37,572.2	167.3	531.4	49.3	66,691.4
Percent of Total	0.041	0.185	0.199	0.563	0.003	0.008	0.001	1.00

Mileage in Each Region, After Adjustment, Subject to 55 MPH by Type of Facility

Region	Interstate	U.S.	Texas	Farm to Market	Loop	Spur	Dirt Road	Total
1	194.7	1,176.1	1,062.9	3,281.4	6.2	3.5	8.4	5,733.2
2	693.0	1,717.2	2,705.4	7,008.6	50.6	259.6	6.1	12,440.5
3	322.3	1,314.0	2,076.8	5,449.8	64.6	121.1	2.4	9,351.0
4	248.3	1,341.8	1,566.3	4,827.7	-0-	69.6	12.2	8,065.9
5	301.0	1,873.6	1,321.3	4,797.4	-0-	2.6	-0-	8,295.9
6	497.7	2,467.3	1,323.7	5,111.0	22.4	-0-	8.9	9,431.0
7	390.6	967.5	1,018.2	2,624.2	-0-	-0-	-0-	5,000.5
8	133.0	1,474.7	2,183.8	4,472.1	23.5	75.0	11.3	8,373.4
Total	2,780.6	12,332.2	13,258.4	37,572.2	167.3	531.4	49.3	66,691.4

County	Area 1	Districts
Armstrong		4
Bailey		5
Briscoe		25
Carson		
Castro		
Childress		
Cochran		
Collingsworth		
Cottle		
Crosby		
Dallam		
Dawson		
Deaf Smith		
Dickens		
Donley		
Floyd		
Foard		
Gaines		
Garza		
Gray		
Hale		
Hall		
Hansford		
Hardemen		
Hartley		
Hemphill		
Hockley		
Hutchinson		
King		
Knox		
Lamb		
Lipscomb		
Lubboch		
Lynn		
Moore		
Motley		
Ochiltree		
Oldham		
Parmer		
Potter		
Randall		
Roberts		
Sherman		
Swisher		
Terry		
Wheeler		
Yoakum		

Area 2

Counties

Anderson
Archer
Baylor
Bowie
Camp
Cass
Cherokee
Clay
Collin
Cooke
Dallas
Delta
Denton
Ellis
Erath
Fannin
Franklin
Grayson
Gregg
Harrison
Henderson
Hood
Hopkins
Hunt
Jack
Johnson
Kaufman
Lamar
Marion
Montague
Morris
Navarro
Palo Pinto
Panola
Parker
Rains
Red River
Rockwall
Rusk
Smith
Somervell
Tarrant
Throckmoton
Titus
Upshau
Van Zandt
Wichita
Wilbarger
Wise
Wood
Young

Districts

1
2
3
10
18
19

Area 3

Counties		Districts
Angelina	Nacogdoches	11
Austin	Newton	12
Brazoria	Orange	17
Brazos	Polk	20
Burleson	Robertson	
Chambers	Sabine	
Freestone	San Augustine	
Fort Bend	San Jacinto	
Galveston	Shelby	
Grimes	Trinity	
Hardin	Tyler	
Harris	Walker	
Houston	Waller	
Jasper	Washington	
Jefferson		
Leon		
Liberty		
Madison		
Matagorda		
Milam		
Montgomery		

Area 4

Counties		Districts
Bastrop	Mills	9
Bell	San Saba	14
Blanco	Stephens	23
Bosque	Travis	
Brown	Williamson	
Burnet		
Caldwell		
Coleman		
Comanche		
Coryell		
Eastland		
Falls		
Gillespie		
Hamilton		
Hays		
Hill		
Lampasas		
Lee		
Limestone		
Llano		
Mason		
McCulloch		
McLennan		

Counties		Area 5	Districts
Borden	Shackelford		7
Callahan	Sterling		8
Coke	Stonewall		
Concho	Sutton		
Crockett	Taylor		
Fisher	Tom Green		
Glasscock			
Haskell			
Howard			
Irion			
Jones			
Kent			
Kimble			
Menard			
Mitchell			
Nolan			
Reagan			
Runnels			
Schleicher			
Scurry			

Area 6

Andrews	Martin	6
Brewster	Midland	24
Crane	Pecos	
Culberson	Presidio	
Ector	Reeves	
El Paso	Terrell	
Hudspeth	Upton	
Jeff Davis	Ward	
Loving	Winkler	

Area 7

Atascosa	Kerr	13
Bandera	Kinney	15
Bexar	La Salle	22
Calhoun	Lavaca	
Colorado	Maverick	
Comal	McMullen	
Dewitt	Medina	
Dimmit	Real	
Edwards	Uvalde	
Fayette	Val Verde	
Frio	Victoria	
Gonzales	Wharton	
Guadalupe	Wilson	
Jackson	Zavala	
Kendall		

Counties	Area 8	Districts
Aransas		16
Bee		21
Brooks		
Cameron		
Duval		
Goliad		
Hidalgo		
Jim Hogg		
Jim Wells		
Karnes		
Kenedy		
Kleberg		
Live Oak		
Nueces		
Refugio		
San Patricio		
Starr		
Webb		
Willacy		
Zapata		