provide sufficient transportation cost savings to pay for damage done to the highway system under these scenarios. However, if barriers are eliminated or limits are increased without a corresponding increase in expenditures to maintain highway conditions, the net impact of these actions could be a much lower decrease, or even an increase, in total cumulative costs.

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Truck Weight Study Sampling Plan in Wisconsin

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The procedures used by the Wisconsin Department of Transportation for determining the number and locations of sampling stations for its truck weight study are described. The purpose of the program is to collect representative trucking characteristic data for use in pavement design, highway cost allocation, motor carrier enforcement, and other planning and research activities. Previous weight studies have produced data of limited value due to inadequate road type and geographic coverage. In addition, stations are selected without statistical guidelines for sampling. The use of new weighing-in-motion technologies and the emphasis on the collection of basic weight data permit a more random selection of weigh stations and a more comprehensive sample of truck traffic. The sampling plan developed relies heavily on user needs and statistical criteria to help ensure a valid and meaningful sample. By using data from the 1980-1981 highway performance monitoring system Wisconsin truck weight case study, the number of required stations is calculated on the basis of the average variability of truck weights in the state. These stations are distributed across recommended road types in proportion to the size of the total population (truck vehicle miles of travel) on each road type. Stations by road type are assigned to counties by using a weighted random numbers procedure. Criteria are presented for selecting corridors and sites where stations should be established. This type of sampling approach can generate more representative and comprehensive data that better describe the truck population.

Most states, including Wisconsin, determine the number and location of their truck weight study stations on essentially a nonprobability, nonrandom basis. The number of stations operated may be a function of budget constraints. Station locations may be selected for convenience, to minimize travel expenses, or to provide perceived coverage of major truck routes. They may also be limited to certain permanent static scale locations.

The resulting data from the study may be representative, but there is no way of making such a determination. Only with some type of probability sample can definitive statements be made about the statistical validity of the sample. It may well be that cost or technological limitations will be the ultimate determinant of sample design. Within cost and operational constraints, though, it is critical to encourage the greatest possible use of statistical criteria. The flexibility and lower operating costs of new weighing-in-motion technology make such an approach more feasible.

The Division of Planning and Budget of the Wisconsin Department of Transportation (WisDOT) normally conducts a truck weight study every other year. The truck weight study collects a variety of trucking characteristic data by weighing and classifying trucks and interviewing the drivers of trucks on rural Interstate and rural state trunk highways. Wisconsin's truck weight study was suspended in 1981 so that it could be evaluated and restructured as necessary. Concerns about the high cost of the program, the accuracy and statistical reliability of the data collected, and the usefuleness of the data led to this evaluation project.

Several working papers and a final report that contained recommendations for a new truck weight study were developed during the project (1-4). Study phases included identifying and ranking the needs of data users, creating a sampling plan, and exploring options in weighing technology.

The focus of this paper is on the recommended sampling plan for Wisconsin. A methodology that uses statistical criteria in order to determine the number and general locations of sampling stations is described. In addition, some guidelines for selecting precise station sites are presented. The scheduling of operations is not addressed here.

SAMPLING POPULATION

Truck sampling in Wisconsin has been limited to rural Interstate and rural state trunk highways. The data in Table 1 illustrate the lack of adequate coverage by comparing the percentage of trucks sampled by road type in the 1979 truck weight study with the

Table 1. Comparison of Wisconsin truck weight study sample with truck VMT.

Highway Jurisdictional System	Percentage of Vehicles in Truck Weighting Study Sample	Percentage of Truck VMT
Rural		
Interstate	63	12
State trunk highways	37	37
County trunk highways	0	13
Town roads	0	6
Urban[a]		
Interstate	0	5
State trunk highways	0	16
City and village[b]	0	10
Other	0	1

[a]Includes areas inside incorporated municipalities.
[b]Includes urban county trunk highways.

percentage of truck vehicle miles of travel (VMT) on that road type. In addition, sampling was limited to stations in the southern half of the state.

Although data users require different levels of detail (some are interested in site-specific data whereas others are interested in systemwide statistics), the overall objective of the truck weight study is the development of a representative statewide sample of truck weight data. In order to create such a sample, all major road types (including urban roads) and the entire state should be considered as the population from which to sample.

Lower-order roads, such as local and town roads, should be excluded from the regular program, primarily because of the expense involved in obtaining adequate samples. A scarcity of trucks on many of these roads would require extended periods of sampling. Potentially large variations in truck weights across local roads (due to differences in local economic activity) could necessitate many sampling stations to develop a representative sample. Lower-order roads could be sampled on a special study basis.

The statewide sample will include only Interstates and major state and county roads. The road types recommended for sampling along with their percentage of total VMT (rural and urban) are given in the following tables. The table below gives the road types and percentage of total VMT for rural highways:

Rural Jurisdictional Type	Functional Class	Percentage of Total Rural VMT
Interstate	Principal arterial	15.6
State trunk	Principal arterial	32.6
State trunk	Minor arterial	20.3
County trunk	Major collector	10.4
Total		78.9

This next table gives the road types and percentage of total VMT for urban highways:

Urban Jurisdictional Type	Functional Class	Percentage of Total Rural VMT
Interstate	Principal arterial	12.6
State trunk	Principal arterial	32.8
State trunk	Minor arterial	9.7
Total		55.1

The data presented in these tables are from Wisconsin's 1980-1981 highway performance monitoring system (HPMS) truck weight case study, which sampled more road types and more seasons than the regular program. (HPMS data, except where noted, served as the data base used in this project.)

Not surprisingly, average weights of trucks do differ by road type, where higher-order roads generally carry heavier traffic, as indicated in Table 2. (Data on urban Interstates are not available in Wisconsin and cannot be collected with portable scales for safety reasons. Such data will be collected once weighing-in-motion equipment is acquired. The sampling plan may need to be refined to reflect the data.) Stratification by road type should be an effective strategy. Stratification of a sample involves dividing the population into groups or categories (such as road types) and then selecting independent random samples within each group or stratum (5, p. 156). With a stratified sample each stratum should be homogenous with respect to values of the statistic (i.e., mean weights) and different from other strata. Other stratifications could be made, such as stratifying by average daily traffic (ADT) volume group or geographic area. Possible increases in precision from greater stratification, however, must be weighed against the increase in sampling costs (each stratum requires at least one sampling station).

SAMPLING PLAN

Two basic types of trucking characteristic data are of interest to users: (a) weight and classification data and (b) data items obtained through driver interviews such as commodity type carried, origin and destination, and so on.

The primary uses of WisDOT truck weight study data are for pavement design and research, highway cost allocation and planning studies, and motor carrier enforcement. The users of these data require accurate weight and classification data more so than survey data. Survey-type information is requested by these users, but the uses are not as well defined and are generally less critical. The new truck weight study will emphasize the collection of basic weight and classification data, and the sampling plan is designed accordingly.

The sampling plan specifies how many sampling stations are to operate on each road type and locates those stations around the state. The statistical derivation of the number of stations or the sample size is influenced by three factors: the sampling distribution of the statistic, the degree of confidence chosen, and the level of precision desired. The sampling distribution refers to the variability of that characteristic for which WisDOT is interested in obtaining an estimate.

With all other factors held constant, it is the variability of that characteristic in the population that most directly affects the size of the sample. The more variable the characteristic, the larger the sample needed to accurately estimate it. If, for example, the gross operating weights of trucks are highly variable across the state, this suggests the need for a large number of stations for sampling. A

Table 2. Average weight of loaded trucks by truck category and road type.

	Avg Weights (lb) by Road Type					
	Rural Interstate,	Rural State Trunk		Urban State Trunk		Rural County
Truck Size	Principal Arterial	Principal Arterial	Minor Arterial	Principal Arterial	Minor Arterial	Trunk, Major Collector
2P	6,500	6,500	–	–	–	–
2S	9,000	10,000	–	–	–	–
2D	15,862	16,362	15,820	12,851	13,838	12,990
3+ axles	37,241	39,072	40,887	31,400	38,500	38,310
3-axle combination	30,685	25,593	23,442	21,962	18,930	–
4-axle combination	39,157	36,445	34,108	28,700	27,547	31,415
3-S2	62,237	59,333	64,499	51,893	49,592	48,553
Other 5-axle combinations	51,087	40,715	32,500	–	–	–
6+ axle combination	72,910	71,271	70,156	–	–	–

Note: Data are from 1980-1981 Wisconsin HPMS case study, except 2P and 2S, which are from 1979 Wisconsin HPR truck weight study.

reasonable balance must be drawn between how precise the estimate will be (e.g., ±5 or ±10 percent) and the amount of confidence held in that estimate. The greater the precision or confidence level, the larger the required sample size.

By using operating gross vehicle weight as the controlling variable for the collection of weight and classification data, the calculation of station sample size can be guided by the following formula:

$$n = z^2(k^2)/d^2 \quad (1)$$

where

n = sample size,
z = number of standard deviations for the desired confidence interval,
k = coefficient of variation of the variable (standard deviation divided by the mean), and
d = degree of relative accuracy desired.

SAMPLING METHODOLOGY

A four-step methodology that uses a random numbers technique was developed to calculate the necessary number of stations on each road type and general locations for those stations. These steps are described below.

Step 1

In step 1 the state is divided into heterogeneous clusters, where counties are used as clusters within which sample stations will be located.

A cluster sampling approach involves dividing the population into heterogeneous subgroups and then choosing a sample of subgroups. In this step a subsample of counties will be selected, and the field stations will be located within those counties.

Counties represent mutually exclusive and exhaustive subsets of the population. They are well defined and well documented and thus easy to use. Because not all counties will be sampled, they should serve as small-scale models of the population, i.e., they should contain a range of variation in truck weights (heterogeneity). Counties appear to contain such a range due to the variety of road types in each county. Not all counties, however, contain all the recommended road types. In addition, counties are unequal with respect to road mileage. The sampling procedure should be sensitive to these conditions (see step 3).

A cluster sampling approach is usually less statistically efficient than other types of surveys primarily due to the error introduced if nonrepresentative or homogeneous subgroups are chosen. With each stage of the sampling process (defining the clusters, selecting subgroups, and then choosing the actual locations within the subgroups), there is risk of sampling error. For a given sample size (trucks weighed), cluster samples produce greater error than a simple random sample or regular stratified samples.

Nevertheless, cluster sampling is probably the most common sampling procedure used for large-scale field surveys (6). Because of the reduction of the universe down to certain counties, the overall costs of the survey will be less. With regard to the truck weight study, travel and equipment installation costs may be significant. It is more economical to sample just within certain counties than to sample more extensively all over the state as other survey types would dictate. In the case of the truck weight study, it is much less expensive to survey many trucks at fewer stations than a few trucks at many stations, particularly if weighing-in-motion equipment is used, because then the cost per observation will be small. This sampling approach, combined with the proper stratification, will document many of the variations in truck operating weights and generate data that are sufficiently representative.

Step 2

In step 2 the total number of stations and their distribution across road types are determined. There are several ways of calculating station sample size on the basis of variation in truck weights. One approach is to determine the number of stations on each road type by using the total variation in truck weights on that road type. Total variation could be defined as the variation in operating weights of all trucks (empty and loaded trucks combined) across all truck categories. The resulting coefficients of variation (COVs) would be large. If this total COV for each road type was applied to the sample size formula, unrealistically large station sample sizes would be specified with, for example, a 90 percent confidence and 10 percent precision level. The data in the table below indicate the required number of stations by using this technique (note that data on urban Interstates are not available):

Road Type	COV	No. of Stations
Rural Interstate	0.39	41
Rural state trunk		
Principal arterial	0.56	85
Minor arterial	0.67	122
Urban state trunk		
Principal arterial	0.75	153
Minor arterial	0.71	137
Rural county trunk, major collector	0.77	161
Total		699

The high COVs in this table are due in part to the bimodal nature of the population, i.e., there is a clustering of weights around an empty truck mean weight and a loaded truck mean weight. In addition, the variation within each truck category is added to that of all other categories. This type of aggregation procedure inflates the sample size, as does calculating the absolute number of stations on each road type separately.

A more useful alternative would be to define variation in a different manner, calculate the total number of stations statewide, and then distribute this total across road types. An averaging, rather than an aggregating, approach to COV derivation can be used. By averaging and weighting the variation in truck weights across truck categories and road types, a single composite average statewide COV can be calculated and in turn used to determine the total station sample size. The steps in this procedure are detailed below.

1. Determine the COV of each truck category on each recommended road type (urban Interstates are excluded from the analysis). The results of this procedure are given in Table 3.

2. Create a weighted average COV for each road type. First multiply the COV of each truck category on a road type by the total number of empty and loaded trucks (sample size) of that category on that road type. Then add these products and divide by the sample size (all loaded and empty trucks of all categories on that road type) to create a single

Table 3. COV and sample size of each truck category by road type.

Vehicle Type	Rural Interstate COV	Rural Interstate Sample	Rural State Trunk Principal Arterial COV	Rural State Trunk Principal Arterial Sample	Rural State Trunk Minor Arterial COV	Rural State Trunk Minor Arterial Sample	Urban State Trunk Principal Arterial COV	Urban State Trunk Principal Arterial Sample	Urban State Trunk Minor Arterial COV	Urban State Trunk Minor Arterial Sample	Rural County Trunk, Major Collector COV	Rural County Trunk, Major Collector Sample
Single unit												
2P and 2S	0.36	881	0.33	1,064	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]
2D	0.42	585	0.44	767	0.46	559	0.45	603	0.47	514	0.52	391
3 or more axles	0.40	149	0.51	248	0.45	164	0.50	104	0.48	99	0.58	110
Semis and truck-trailers												
3-axle combination	0.30	101	0.38	76	0.39	33	0.36	65	—[a]	—[a]	—[a]	—[a]
4-axle combination	0.29	468	0.29	263	0.32	77	0.28	99	0.29	40	—[a]	—[a]
3-S2	0.29	5,921	0.30	1,629	0.42	715	0.39	315	0.40	107	0.44	98
Other 5-axle combinations	0.47	60	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]
2-S1-2	0.17	213	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]
6 axles or more combinations	0.35	68	0.47	36	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]

Note: COV and sample size are from the number of trucks sampled during the 1980-1981 HPMS case study, except for 2P and 2S data, which are from the 1977-1979 HPR truck weight study.

[a]Insufficient data.

road type COV. The results are given in the following table:

Road Type	Weighted Avg COV
Rural Interstate	2,594/8,446 = 0.31
Rural state trunk	
Principal arterial	1,425/4,047 = 0.35
Minor arterial	669/1,548 = 0.43
Urban state trunk	
Principal arterial	497/1,186 = 0.42
Minor arterial	345/760 = 0.45
Rural county trunk, major collector	310/599 = 0.52

3. The same weighted averaging procedure is then used to calculate a statewide composite COV from the individual road type COVs. The resulting COV is 0.35, i.e.,

$$0.31\ (8{,}446) + 0.35\ (4{,}047) + 0.43\ (1{,}548) + 0.42\ (1{,}186) + 0.45\ (760) + 0.52\ (599) = 5{,}850/16{,}586 = 0.35.$$

Once the composite COV has been established, different total station sample sizes can be calculated by using varying confidence and precision levels:

95 percent confidence/5 percent precision level: $[(1.96 \times 0.35)\ 0.05]^2$ = 188 stations.

95 percent confidence/10 percent precision level: $[(1.96 \times 0.35)\ 0.10]^2$ = 47 stations.

90 percent confidence/5 percent precision level: $[(1.65 \times 0.35)\ 0.05]^2$ = 133 stations.

90 percent confidence/10 percent precision level: $[(1.65 \times 0.35)\ 0.10]^2$ = 33 stations.

80 percent confidence/5 percent precision level: $[(1.29 \times 0.35)\ 0.05]^2$ = 82 stations.

80 percent confidence/10 percent precision level: $[(1.29 \times 0.35)\ 0.10]^2$ = 21 stations.

The accuracy level chosen for the truck weight study is largely a function of cost. Generally, a 90 percent/10 percent accuracy level is sufficient for planning data. However, the costs of establishing a truck weighing station are high; the precise amount depends on the type of equipment used. The 80 percent/10 percent level produces the least number of stations, yet it is acceptable for the objectives of the truck weight study.

Thus there are 21 stations to be distributed across 7 road types. There are two ways of distributing this total. One way is to distribute the stations based on the amount of truck travel on each road type. A second method would be to distribute stations according to the relative variability of truck weights on each road type. Both approaches link sample size to the nature of the population.

The first way sets the amount of sampling on each stratum (road type) according to the size of the stratum in the population. Stratum size can be defined as the amount of truck travel or truck VMT. The share of truck VMT on each road type can be calculated by considering only the recommended road types as the population.

The other approach is to use the relative variability in truck weights as the distribution factor. If the weighted average COVs of each road type are added to produce a total, then the share of the total variability accounted for by each road type can be determined. Assuming that 21 stations is the recommended total, distribution of stations across road types on a VMT-share basis or COV-share basis can be computed, as given in Table 4.

The COV-share distribution method results in more stations on lower-order roads. From the standpoint of statistical efficiency this method is superior. However, the analysis of the data from such a sample

Table 4. Distribution of stations across road type.

Road Type	VMT Share Percent	VMT Share No. of Stations	COV Share Percent	COV Share No. of Stations
Urban Interstate	10	2	11	2[a]
Rural Interstate	19	4	11	2
Rural state trunk				
Principal arterial	23	5	13	3
Minor arterial	17	4	14	3
Urban state trunk				
Principal arterial	13	3	17	4
Minor arterial	6	1	17	3[b]
Rural county trunk, major collector	12	2[c]	18	4
Total		21		21

[a]Because no information exists on the variability of weights on urban Interstates, it is assumed to be equal to that on rural Interstates.
[b]3.57 is rounded off to 3.
[c]2.52 is rounded off to 2.

is more complicated. Special weighting should be conducted to account for the disproportionate sampling (i.e., one road type may account for 40 percent of the total sample size of trucks weighed, but only 25 percent of the population size) when combining data across road types to estimate means and variations.

Users of trucking characteristic data, however, would prefer to have more stations on higher-order roads because those are the major trucking routes and generally are of greater interest. The VMT-share design is proportionate sampling that is self-weighting; thus, no special manipulations of the data would be required. Because of these factors, the proportionate VMT-share distribution method should be employed.

Step 3

In step 3 a subsample of counties is selected and the stations are located by road type in the counties. The procedure used is given below.

First, list each station with its defining road type and number, as shown below:

01. Urban Interstate;
02. Urban Interstate;
03. Rural Interstate;
04. Rural Interstate;
05. Rural Interstate;
06. Rural Interstate;
07. Rural state trunk, principal arterial;
08. Rural state trunk, principal arterial;
09. Rural state trunk, principal arterial;
10. Rural state trunk, principal arterial;
11. Rural state trunk, principal arterial;
12. Rural state trunk, minor arterial;
13. Rural state trunk, minor arterial;
14. Rural state trunk, minor arterial;
15. Rural state trunk, minor arterial;
16. Urban state trunk, principal arterial;
17. Urban state trunk, principal arterial;
18. Urban state trunk, principal arterial;
19. Urban state trunk, minor arterial;
20. Rural county trunk, major collector; and
21. Rural county trunk, major collector.

Second, create a list of counties by arranging all counties in alphabetical order; then number them from 1 to 72.

Third, determine the total state trunk and county trunk mileage of each county and create a code for each (7). (Truck VMT by county would be preferable to use; however, it is not available.) For example, 08-224 would be the eighth county on an alphabetical list that has 224 miles of county and state highways.

Finally, use five-digit random numbers from a random numbers table to select a subsample of counties and assign each station and road type to a county (8); then sample the result with a replacement (i.e., more than one state can be assigned to a county). For example, if the first entry in a random number table is 25350, then the first station should be assigned to county number 25 if it has 350 or more road miles associated with it. If it has fewer than 350 roads miles, if it does not contain any roads of the station 01 type, or if no county 25 exists, this random number should be ignored and the next random number in the table used to identify the next county to be sampled. The results of this procedure are given in Table 5 and shown in Figure 1.

This step of the sampling plan selects the counties and road types in those counties where truck weight study sampling stations will be located. The random selection method will provide a good geographic distribution of stations. The weighting technique based on mileage and sampling with replacement equalizes the chances that any particular location on the recommended road type network will be chosen for any type of station. The actual locations for stations can be determined by using the guidelines set forth in the following section.

Step 4

In step 4 the actual station locations within the selected counties and road types are determined.

The most statistically correct procedure for selecting station locations would be to continue the random selection process down to the road segment level. The relevant road network (e.g., urban state trunk, principal arterial) within a county would be divided into segments, each segment listed and numbered, and then one or more segments randomly selected to serve as truck weight study stations. Ideally, segments would be of equal length, although unequal segments could be weighted. A segment length of 1 mile would provide some flexibility in locating weighing equipment; segment lengths of 5 miles would increase this flexibility and also reduce listing costs.

The advantage of this kind of method is that possible bias introduced by judgmentally selecting sites is minimized. Each segment of a road type in a county theoretically has an equal chance of being selected. The overall probability that any particular road segment would be chosen from the entire state road network would equal the product of the selection probabilities at each stage of the sampling process (9) (that is, when selecting the subsample of clusters, the road type assignment, and ultimately the road segment selection).

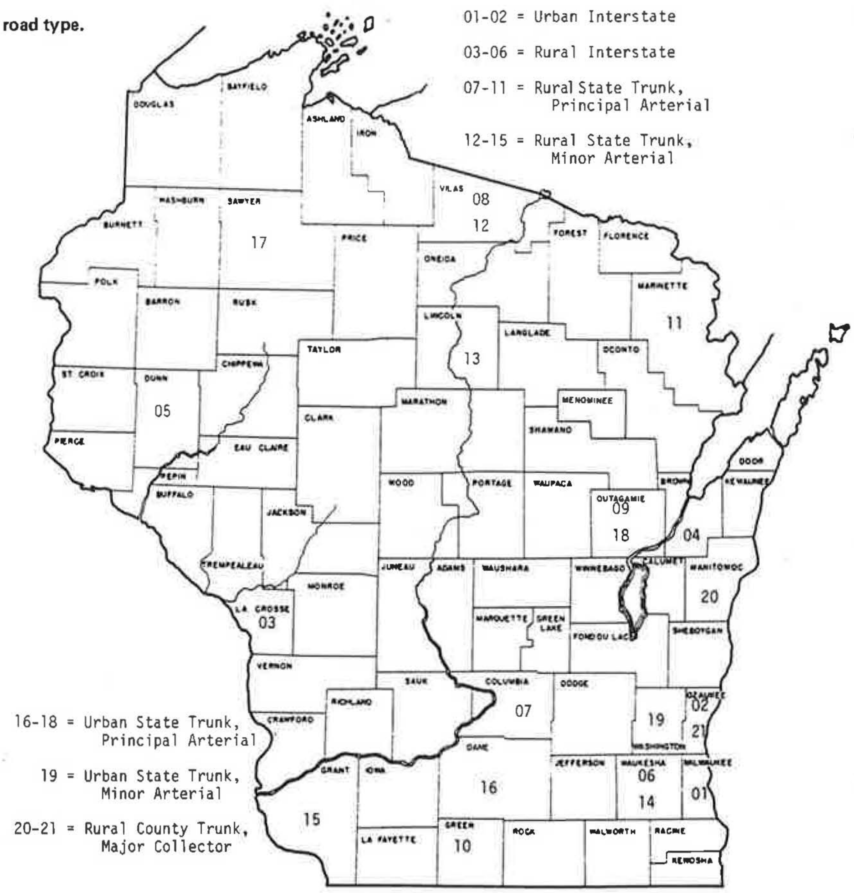
The disadvantages of a random selection of road segments are that listing costs may be significant and the operational limitations of truck weighing are not considered. The listing process would involve either manipulating existing road segment lists into an appropriate format or creating a new list (this would be necessary for county roads). Even with this approach, the selected segment may not be suitable for weighing and classifying trucks.

Many of the restrictions on where weighing can be conducted are related to the type of scale used. If the existing permanent static scales were to be used to the extent possible, then random site selection would not be relevant (new scales could be built at

Table 5. Station types and assigned counties.

Road Type	County
01. Urban Interstate	Milwaukee
02. Urban Interstate	Ozaukee
03. Rural Interstate	La Crosse
04. Rural Interstate	Brown
05. Rural Interstate	Dunn
06. Rural Interstate	Waukesha
07. Rural state trunk, principal arterial	Columbia
08. Rural state trunk, principal arterial	Vilas
09. Rural state trunk, principal arterial	Outagamie
10. Rural state trunk, principal arterial	Green
11. Rural state trunk, principal arterial	Marinette
12. Rural state trunk, principal arterial	Vilas
13. Rural state trunk, minor arterial	Lincoln
14. Rural state trunk, minor arterial	Waukesha
15. Rural state trunk, minor arterial	Grant
16. Urban state trunk, principal arterial	Dane
17. Urban state trunk, principal arterial	Sawyer
18. Urban state trunk, principal arterial	Outagamie
19. Urban state trunk, minor arterial	Washington
20. Rural county trunk, major collector	Manitowoc
21. Rural county trunk, major collector	Ozaukee

Figure 1. Assigned counties by road type.



a randomly selected site but that is probably neither feasible nor likely, given the expense).

Portable static scales can only be used safely where there are turnouts, adequate space for queuing of trucks, level grades, and so forth. High-speed pavement weighing-in-motion scales should not be located near intersections, where severe acceleration or deceleration occurs, where pavement conditions are poor, or on steep slopes. Bridge weighing-in-motion is limited to certain types of bridges.

In addition, a random selection of station sites might produce nonrepresentative stations (for example, adjacent to a major manufacturing facility). Because there are so few stations (out of potentially thousands of locations), it is critical to avoid highly peculiar traffic conditions if the objectives are to obtain representative statewide data and accurate average values.

Because of these restrictions, expanding random selection to this level is not the best approach. Although not statistically pure, it appears that the use of informed judgment at this stage of the sampling process is both reasonable and necessary. Indeed, an FHWA report suggests numerous possible considerations for site selection (10):

1. ADT volume;
2. Percentage of trucks;
3. Percentage of trucks of each type;
4. Variations in the percentages of trucks carrying different types of commodities;
5. Whether there is a seasonable variation in the number of trucks in the ADT and whether within the season there is a variation in the type of commodities carried;
6. Relative amount of interstate and intrastate trips;
7. Land use characteristics, both adjacent to the station site and at origin and destination of the truck traffic;
8. Ease or difficulty of trucks bypassing the station to avoid being weighed; and
9. Nearby alternative routes.

Much of the above information cannot be obtained without first conducting surveys. In addition, precise site requirements cannot be determined without first identifying the weighing technology that will be used. A potentially effective approach is to identify general locations or corridors within which stations can be located once weighing equipment has been selected. Therefore, guidelines should be established for identifying these general locations.

GUIDELINES FOR STATION LOCATIONS

The four guidelines for station location are given below:

1. Where possible, establish stations on routes with high truck volumes. Heavily traveled truck routes should be used because data users (enforcement officials in particular) are interested in documenting the traffic characteristics of major corridors. Almost all Interstates and some state trunks are major truck routes. (The state highway plan identifies major corridors in Wisconsin.)
2. Locate stations on major intercity or interregional routes. The non-Interstate state trunk network serves to connect the various subregions of the state. Where applicable, these routes should be used to monitor regional freight flows.
3. For stations on lower-order roads, special

care should be taken to avoid locations with atypical traffic conditions.

4. Within the above criteria, stations should be located at or near vehicle classification sites, automatic traffic recorder (ATR) sites, or within HPMS sample sections wherever feasible.

This fourth guideline is included to promote a rational and integrated traffic data-collection program. From the perspective of a data user the truck weight study can be thought of as a subfunction of the counting program. For example, in the design of pavements, the critical factor is the projected number of 18-kip equivalent loads. In Wisconsin vehicle classification data from the truck weight study have been used to supplement the vehicle classification and count programs. This practice should continue where possible (not all counties contain these other sites), but the truck weighing sites should be located at the vehicle classification sites or near ATR sites (which are established with their own set of criteria) instead of the opposite approach.

Therefore, where there is an overlap in the criteria of the various programs, station locations should be consolidated. Where possible, HPMS sample sections should be used. In effect, certain "super" traffic data stations could be established that generate data on vehicle weights, classification, counts, and road characteristics. By collecting all data at a single site, more precise and conclusive statements could be made about the relation between vehicle loadings and pavement conditions.

In summary, the county as well as highway jurisdiction and functional class have been selected for each station. Within these strata particular highways should be identified as general station locations that use the above criteria. Once the weighing equipment has been selected, precise station locations can be chosen based on site conditions. This quasi-random approach to selecting the actual station locations introduces an indeterminate amount of error, but it should still produce data sufficiently representative to satisfy the objectives of the program.

SUMMARY

The sampling plan presented in this paper represents one element of a comprehensive planning effort for a new Wisconsin truck weight study. Selecting the number of stations on the basis of variability in the population, distributing stations across road types in proportion to the size of the population (truck VMT) on each road type, and randomly selecting counties for locating stations will help ensure a more representative sample of truck traffic.

Once a new, more representative data base of trucking characteristic data is established, the sampling plan should be evaluated. The number of stations may need to be increased or reduced, or station locations may need to be changed. Although technological and cost constraints necessarily influence any traffic program, they should not be the sole determinants of program structure and scope. User needs and statistical sampling principles must be incorporated to produce valid and meaningful data.

Sampling plans for truck weight studies will vary according to program objectives. In Wisconsin the estimates of the mean weight of trucks by type of highway system are the primary objective. These systemwide estimates are useful in a variety of planning and design applications; i.e., more specialized sampling plans can be created and weight monitoring can be conducted to meet specialized needs to more precisely define truck characteristics in a specific highway corridor.

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